Status of the Kelp Beds in 2019:

Orange and San Diego Counties

Prepared for the Region Nine Kelp Survey Consortium

MBC Aquatic Sciences

STATUS OF THE KELP BEDS IN 2019:

Orange and San Diego Counties

Prepared for:

Region Nine Kelp Survey Consortium

Prepared by:

MBC *Aquatic Sciences*
3000 Red Hill Avenue
Costa Mesa, California 92626

August 18, 2020

PROJECT STAFF

Region Nine Kelp Survey Consortium

Robin Gartman (Chair), Ami Latker	City of San Diego Public Utilities Dept.
Lori Rigby, Luke Christian	City of Oceanside
Ralph Ginese	City of Escondido
Tim Sisk	Cabrillo Power LLC, Encina Power Station
Doug Campbell, Jeff Parks	Encina Wastewater Authority
Owni Toma	Fallbrook Public Utility District
Gary Merrill, Rebecca Bray	Genentech
Michelle Powelson	Poseidon Water
Chris Trees, Mike Thornton	San Elijo Joint Powers Authority
Keith Bacon, Amber Baylor	South Orange County Wastewater Authority
Brian Metz	Southern California Edison, SONGS
Nicholas Chapa	U.S. Intl. Boundary & Water Commission

Water Board

Brandi Outwin-Beals, Keith Yaeger	San Diego Regional Water Quality Control Board

MBC *Aquatic Sciences*

Marine Scientists

D.S. Beck	D.J. Schuessler
J.M. Lyons	J.J. Sloan
W.H. Dossett	B.L. Smith
R.H. Moore	J.N. Smith
J.R. Nunez	D.G. Vilas
M.R. Pavlick	T.A.Van Duivenbode
J.L. Rankin	

Cover photograph courtesy of D. J. Schuessler

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

EXECUTIVE SUMMARY

Aerial imaging surveys of the 24 giant kelp beds off Orange and San Diego counties were conducted for the Region Nine Kelp Survey Consortium (RNKSC) by MBC Aquatic Sciences on March 31, July 19, September 19, and December 19, 2019. The maximum surface canopy observed during 2019 was quantified from color infrared photos of each kelp bed.

The total kelp canopy throughout Region Nine covered approximately 5.2 km^2 in 2019, a 53% decrease compared to 2018. This was similar to the total kelp canopy coverage recorded in 2016 (5.1 km^2), but considerably larger than the total coverage for 2017 (3.3 km^2), which was the lowest since 2006. More than half of all kelp beds observed in 2018 disappeared in 2019 (10 out of 18), and none reappeared. The La Jolla and Point Loma kelp beds were the largest, accounting for 99% of the total canopy coverage in 2019.

Vessel surveys of all Region Nine kelp beds were scheduled for late 2019, but were not actually conducted until January 7, 15, and 30, 2020. Visual observations indicated that surface canopy was present at North Laguna Beach, Dana Point/Salt Creek, Leucadia Central and South, Encinitas, Solana Beach, La Jolla North and South, and Point Loma North and South. No surface canopy was observed at South Laguna Beach, South Laguna, or from Capistrano Beach through Leucadia North. Subsurface kelp was observed at many kelp bed locations, even those without visible surface canopy. More detailed in-water surveys were conducted by biologist-divers at three kelp bed locations: Dana Point/Salt Creek, Leucadia North, and the Encina Power Plant.

Water temperatures throughout the RNKSC areas generally were warmer than average throughout most of 2019, particularly from September through December. However, lower than normal temperatures were recorded at Newport Pier during most of April, May, and August, and occasionally during March, June, and July. Lower than normal water temperatures were also occasionally recorded at Scripps Pier from February through October, particularly during the months of June, July and August. Daily sea surface temperature (SST) values rarely fell below 14˚C, a threshold below which nutrient availability is much greater than at higher water temperatures, at Newport Pier and Scripps Pier, and never fell below this threshold at Oceanside or Point Loma South.

As in previous years, nutrient availability continued to be low in 2019. Upwelling in 2019 (at a location approximately 161 km west of Solana Beach) generally increased each month from January through August, decreasing through December. Upwelling index values in 2019 were much higher than the long-term mean in July and August, but lower in March, May and June. Upwelling was lower from March through June in 2019 compared with the same time period in 2018, which is when surface water temperatures are generally lower and nutrient availability would be increased. Although upwelling between July and September was higher in 2019 than the previous year, this corresponds to when surface water temperatures are highest and nutrient availability would be decreased.

I - INTRODUCTION

Giant kelp (*Macrocystis pyrifera*) beds along most of the southern California mainland coast have been mapped quarterly by the Region Nine Kelp Survey Consortium (RNKSC) since 1983. The RNKSC participants agreed that the monitoring program would be methodologically based upon aerial kelp surveys that were conducted since 1967 by the late Dr. Wheeler J. North.

I.1 - REGION NINE KELP BEDS

The RNKSC program area extends from Abalone Point in northern Laguna Beach in Orange County southward to the U.S./Mexico Border in San Diego County, and recognizes 24 existing or historic kelp beds (Figure 1). Kelp beds associated with harbors, marinas, or hard substrate also are surveyed. Region Nine supports what are usually the two largest kelp beds in southern California, the La Jolla and Point Loma kelp beds. There are eight ocean outfalls located within the geographical area surveyed on behalf of the RNKSC, including three outfalls that are shared by two different agencies (Figure 1).

One of the objectives of the RNKSC program is to answer several basic monitoring questions regarding the status of kelp beds within the region:

1. What is the maximum areal extent of the coastal kelp bed canopy each year?
2. What is the variability of the coastal kelp bed canopy over time?
3. Are coastal kelp beds disappearing? If yes, what are the factors that could contribute to the disappearance?
4. Are new kelp beds forming?

I.2 - 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, such as temperature and nutrient levels. If not removed prematurely by storms or grazers, large vegetative fronds eventually produce a terminal meristem, stop growing, and senesce. Individual fronds usually live no more than four to nine months, and individual kelp can live up to approximately nine years (Schiel & Foster, 2015). Detailed information on kelp biology is presented in Appendix B.

II - MATERIALS AND METHODS

II.1 - KELP DATA COLLECTION

II.1.A - AERIAL SURVEYS

In the early-1960s, when kelp surveys began, the surface area of coastal kelp beds was calculated via aerial photography by the late Dr. Wheeler J. North of the California Institute of Technology (Pasadena). Later MBC continued the surveys using a method following that of Dr. North's, as it provided a consistent approach for comparing kelp bed size (North 2001). MBC has continued to use this same methodology for the Region Nine surveys since inception of the program in 1983.

In 2019, Ecoscan Resource Data conducted quarterly overflights of the coastline on behalf of the RNKSC from Newport Harbor (Orange County) to the U.S./Mexico border (San Diego County). Direct downward-looking photographs of the kelp beds were taken from an aircraft modified by Ecoscan Resource Data to facilitate aerial photography. Approximately 200 to 225 high-contrast digital color and infrared photos were taken during each survey. Prior to each survey, the flight crew assessed the weather, marine conditions, and sun angle to schedule surveys on dates when optimum photos could be captured. The pilot targeted the following conditions:

- 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 range less than +1.0' Mean Lower Low Water (MLLW) during the survey,
- Sun angle greater than 30 degrees from vertical.

Aerial surveys were flown on March 31, June 19, September 19, and December 19, 2019 (Table 1). The flight path and data sheets from each quarterly aerial survey are included in Appendix D and photographs from each aerial survey are contained in Appendix E.

II.1.B - VESSEL SURVEYS

A vessel survey is conducted annually to observe all RNKSC kelp beds. The vessel survey for the 2019 survey year was scheduled to occur in December, but was delayed by adverse ocean conditions and was conducted on January 7, 2020 from Imperial Beach to Santa Margarita, on January 15, 2020 from Pendleton Artificial Reef to Capistrano Beach, and on January 30, 2020 from Dana Point to Corona del Mar. During the vessel surveys, biologists visually located each kelp bed by the main surface canopies present, or in the absence of surface kelp, relied upon latitude and longitude coordinates for canopies present during prior years. The presence of subsurface kelp was also recorded via visual observations from the vessel and fathometer readings. During the vessel surveys, more detailed in-water surveys were conducted by biologist-divers at the Dana Point/Salt Creek, Encina Power Plant, and Leucadia North kelp beds. Field data sheets from the vessel surveys are included in Appendix D.

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 meristems (scimitar = growing tips),
- Extent of encrustations by hydroids or bryozoans,
- Sedimentation on fronds,
- Any evidence of disease, such as holes or black rot,
- Age composition of fronds: young, mature, or senile.

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 (Table 2). 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 allowed the archiving of the quarterly survey slides for later retrieval and assembly of a digitized photo-mosaic of each kelp bed that represented 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 entire kelp bed areas. Photos of kelp beds that displayed the greatest canopy coverage during a single survey were used to make photo-mosaics. Usually data from one or two surveys were used to for the photo-mosaics to provide the best estimate of maximum canopy coverage for the year. The Photoshop mosaics were then transferred to Geographic Information System (GIS; ArcGIS 10.3.1) to geo-reference them, and placed into specific California Department of Fish and Wildlife (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 another acceptable coordinate system, and subsequently 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.

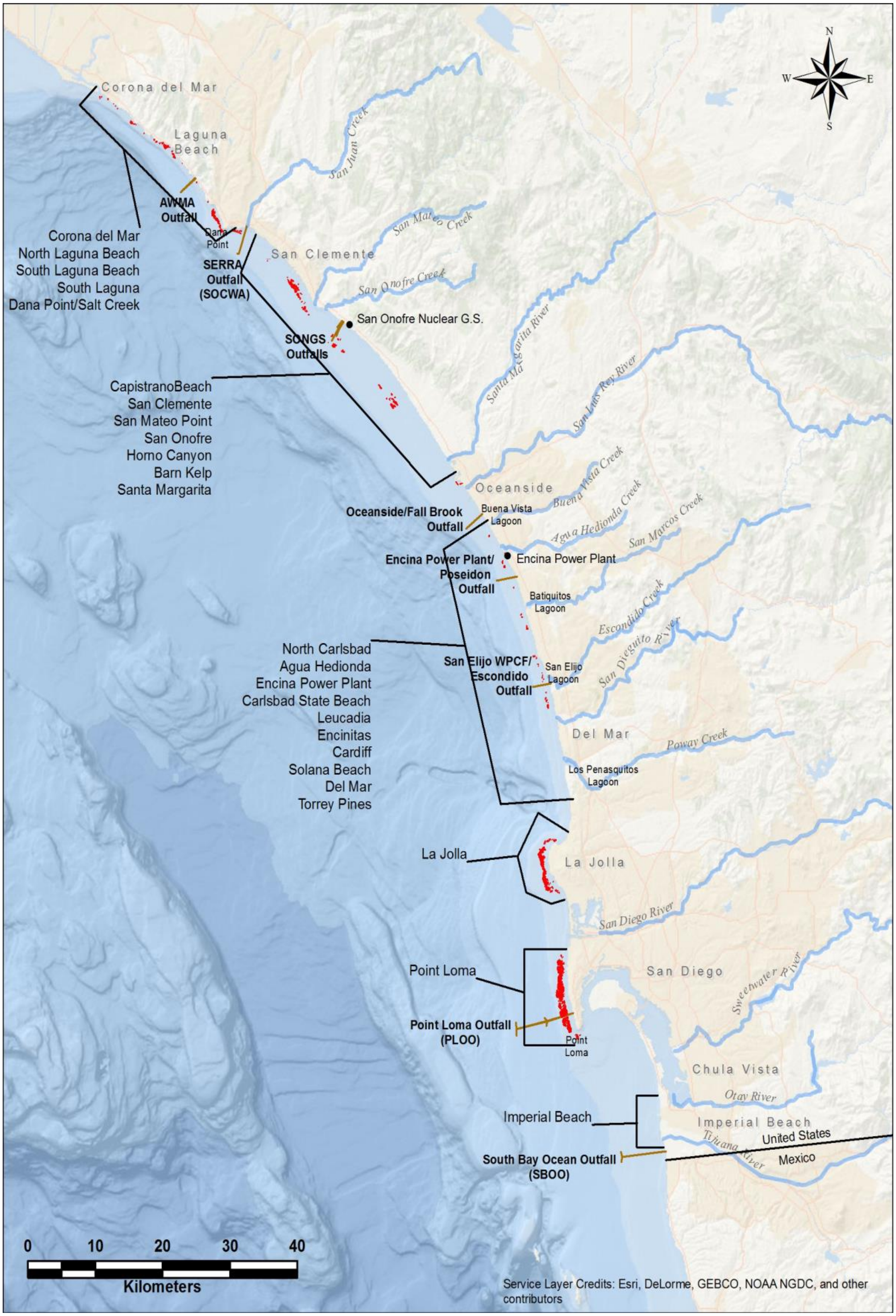


Figure 1. Ocean discharges and kelp beds located within Region Nine kelp survey area.

Table 1. Kelp bed overflights in 2019.

Quarter	Target Date	Actual Date	Comments
1st Quarter	**January to March 2019**	March 31, 2019	Excellent conditions for photos and observations during overflight
2nd Quarter	**April to June 2019**	July 19, 2019	Excellent conditions for photos and observations during overflight (survey delayed due to foggy conditions during month of June)
3rd Quarter	**July to September 2019**	September 19, 2019	Excellent conditions for photos and observations during overflight
4th Quarter	**October to December 2019**	December 19, 2019	Excellent conditions for photos and observations during overflight

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: CDFW lease bed 9 in Orange County and CDFW lease beds 5, 6, 7, and 8 in San Diego County (Figure 24). Kelp beds off La Jolla (CDFW lease bed 4, Figure 24) and Point Loma (CDFW lease beds 2 and 3, Figure 24) were treated separately because they are typically much larger beds which would dominate the ABAPY if included with the smaller beds, potentially skewing the data presentation and masking any changes occurring in the smaller beds. Each ABAPY was calculated by summing the annual canopy estimates for the relevant beds during each year and dividing the total by the number of beds included.

Table 2. Ranking values of canopy coverage assigned to kelp beds from Newport Harbor to Imperial Beach based on aerial photographs from 2019 Region Nine quarterly overflights.

	2019 Quarterly Overflights			
Kelp Beds	**31 March**	**19 July**	**19 September**	**19 December**
Newport Harbor *	–	–	–	–
Corona del Mar	**0.5**	–	–	–
No. Laguna Beach	0.5	**0.5**	–	0.5
So. Laguna Beach	**0.5**	0.5	–	0.5
South Laguna	–	–	–	–
Salt Creek-Dana Point	–	–	–	–
Dana Marina *	–	–	–	–
Capistrano Beach	–	–	–	–
San Clemente	**1.5**	1.0	–	–
San Mateo Point	**0.5**	–	–	–
San Onofre	0.5	**0.5**	–	–
Pendleton Reefs *	–	–	–	–
Horno Canyon	–	–	–	–
Barn Kelp	–	–	–	–
Santa Margarita	–	–	–	–
Oceanside Harbor *	–	–	–	–
North Carlsbad	–	–	–	–
Agua Hedionda	–	–	–	–
Encina Power Plant	–	–	–	–
Carlsbad State Beach	–	–	–	–
North Leucadia	–	**0.5**	–	–
Central Leucadia	–	–	–	–
South Leucadia	–	–	–	–
Encinitas	–	–	–	–
Cardiff	–	–	–	–
Solana Beach	–	–	–	–
Del Mar	–	–	–	–
Torrey Pines Park	–	–	–	–
La Jolla Upper	0.5	**1.5**	1.0	1.0
La Jolla Lower	2.5	**3.0**	1.0	2.5
Point Loma Upper	3.0	**4.0**	1.5	3.5
Point Loma Lower	3.0	**4.0**	1.5	2.5
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
Green highlight = survey utilized to quantify surface canopy area

III - RESULTS

III.1 - SUMMARY

Maps showing the areal extent of RNKSC canopy coverage in 2019 are provided in Appendix A. Tables displaying the historical canopy coverage for Region Nine from 1983 through 2019 are included in Appendix B. Delineation of each kelp bed area is shown in Appendix D. Aerial photographs taken during the four quarterly overflights in 2019 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 June surveys (Table 2). The total amount of kelp canopy coverage in the RNKSC region was 5.2 km^2 in 2019, decreasing by 53% from 11.0 km^2 in 2018. In 2019, nine kelp beds displayed surface canopy, compared to 18 kelp beds with surface canopy in 2018 (10 kelp beds disappeared in 2019). No kelp beds increased in size and no new kelp beds reappeared in 2019. . The largest beds in the RNKSC region were the La Jolla and Point Loma kelp beds, with Point Loma being the largest at 3.9 km^2 (Figure 2, Panel A). These two large kelp beds accounted for 99% of the total RNKSC kelp coverage in 2019. In 2019, every kelp bed was less than 10% of the maximum size recorded since 1983, with the exception of La Jolla (26%) and Point Loma (50%) (Figure 2, Panel B). All nine of the kelp beds with visible surface canopy decreased in size in 2019 (Figure 2, Panel C).

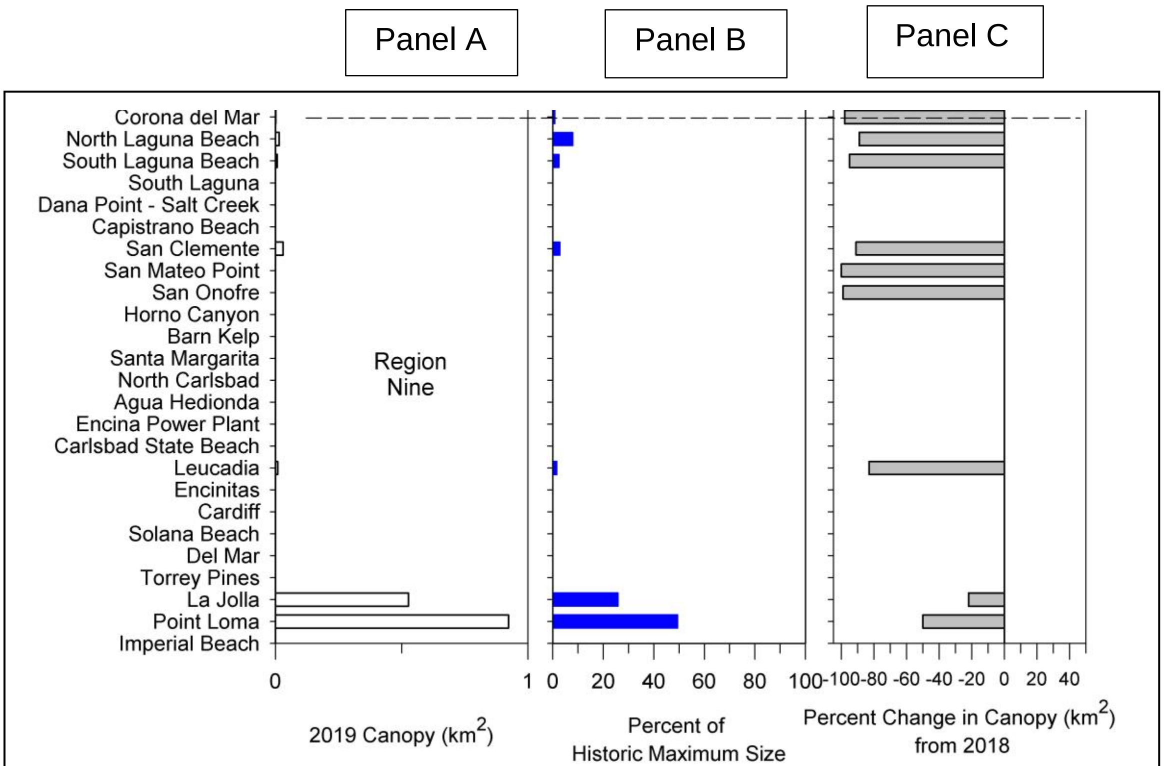
III.2 - SIZE OF KELP BEDS IN REGION NINE

The following is a synopsis of the status of each of the 24 designated individual kelp beds in the Region Nine during the 2019 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 2018 and 2019 for each kelp bed is presented in Table 3. Historical canopy coverage since 1911 is presented in Appendix B.4. Visual observations of the kelp beds recorded in Table 4 are based on vessel surveys conducted in January 2020. Observations from diver surveys conducted at the Dana Creek/Salt Point, North Leucadia and Encina Power Plant (Cabrillo Energy, Carlsbad) kelp bed areas are also presented in Table 4.

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

Corona del Mar. This kelp bed decreased in size by 98%, from 0.119 km^2 in 2018 to 0.003 km^2 in 2019 (Table 3). The canopy area in 2019 was only 1% of the maximum recorded in 2011 (Appendix B.3; Figure 3).

Downcoast from Newport Harbor, giant kelp grows in several small beds collectively referred to as the Corona del Mar kelp bed, or sometimes called the Newport/Irvine Coast kelp bed. The surface canopy area in 2019 was the smallest recorded since 2005. The decrease in size of this bed in 2019 (Figure 3) was similar to the decline of the Orange County ABAPY.



Note: truncated scale in Panel A: La Jolla canopy area = 1.2 km^2; Point Loma canopy area = 3.9 km^2

Figure 2. Summary of Region Nine kelp canopy coverage in 2019.

III.2.B - ABALONE POINT TO CAPISTRANO BEACH

There are five kelp beds located between Abalone Point and Capistrano Beach. In 2019, all five beds decreased in size (Table 3).

North Laguna Beach/South Laguna Beach. The North Laguna Beach kelp bed decreased in size by 89%, from 0.133 km^2 in 2018 to 0.015 km^2 in 2019 (Table 3). The canopy area in 2019 was 8% of the maximum recorded in 2012. The South Laguna Beach kelp bed decreased in size by 95%, from 0.131 km^2 in 2018 to 0.007 km^2 in 2019. The canopy area in 2019 was only 2% of the maximum recorded in 2013 (Appendix B.4; Figure 3).

The North and South Laguna Beach beds were rarely visible after the early 1990s until 2008, when they reestablished as a result of restoration efforts. The surface canopy areas of the North and South kelp beds in 2019 were the lowest recorded since 2009 and 2007, respectively. The decreases in size of both beds in 2019 (Figure 3) were similar to the decline of the Orange County ABAPY.

During the January 2020 vessel survey (Table 4), the North Laguna Beach surface canopy was estimated at approximately 100 by 150 meters. Tissue color was light to medium yellow, with no encrustation on fronds and only a few apical meristems were observed. The kelp bed was composed of approximately 39% senile, 60% mature, and 1% young fronds. Subsurface kelp was visible on the fathometer, extending over a larger area than the surface canopy. No surface canopy was observed at South Laguna Beach, but some subsurface kelp was visible on the fathometer.

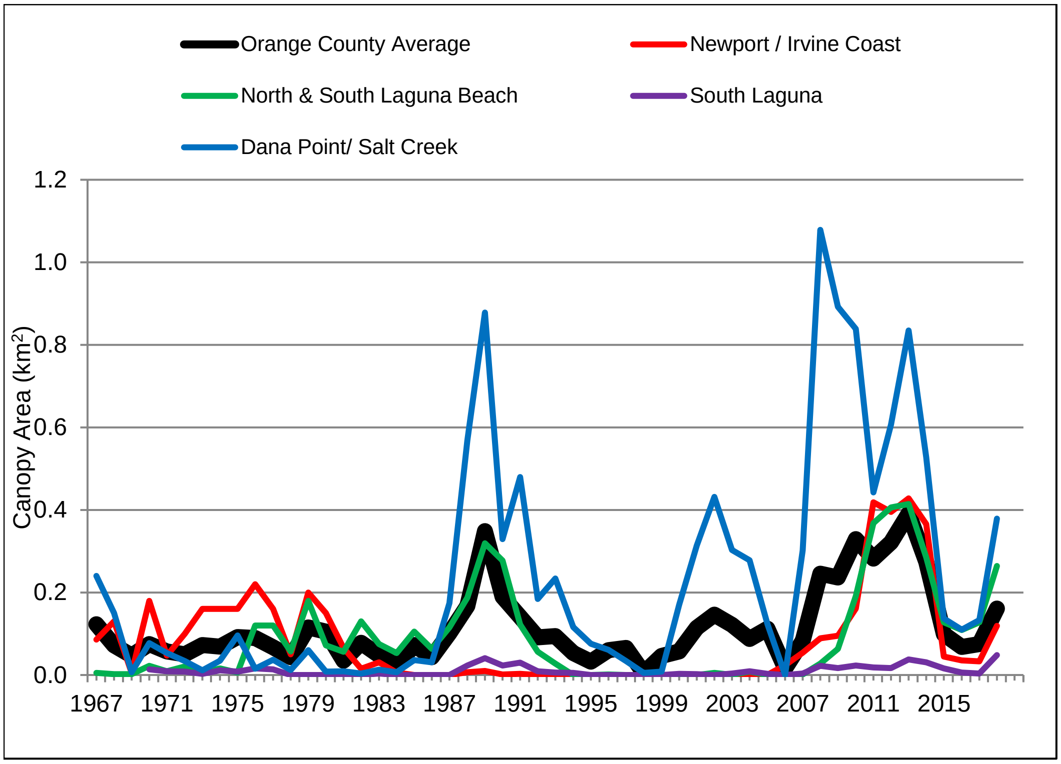


Figure 3. Comparisons between the average Orange County ABAPY and the canopy coverage of the kelp beds from Newport/Irvine Coast (Corona del Mar) to Dana Point/Salt Creek from 1967 through 2019.

South Laguna. This kelp bed disappeared in 2019 (Table 3). This followed 2018, when the surface canopy 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 in size by 1,500% in 2018, reaching the highest level observed (0.048 km^2) since RNKSC surveys began), only to decline once again in 2019. This is the first time that no surface canopy was visible since 2006. The decrease in size of this bed was similar to the decline of the Orange County ABAPY.

No surface or subsurface kelp was observed at South Laguna during the January 2020 vessel survey (Table 4).

Dana Point/Salt Creek. This kelp bed disappeared in 2019 (Table 3).

The Dana Point/Salt Creek kelp bed (Appendix A.46) ranged in size from 0.110 to 0.137 km^2 from 2015 to 2017, then increased to 0.379 km^2 in 2018, although it remained well below the levels observed in 2008, 2009, 2010, and 2013 (Figure 3). This also is the first time that no surface canopy was visible since 2006. The decrease in size of this bed in 2019 was similar to the decline in the Orange County ABAPY.

During the January 2020 vessel survey (Table 4), scattered surface canopy was observed at Dana Point/Salt Creek. Tissue color was medium to dark yellow, with less than 25% encrustation on fronds and no apical meristems were observed. The kelp bed was composed of 100% mature fronds.

An in-water survey of the Dana Point/Salt Creek kelp bed was conducted on January 30, 2020. The bottom was composed of approximately 50% boulder, 40% cobble, and 10% sand. In addition to giant kelp, *Laminaria*, *Egregia*, and *Pterogorgia* species of algae were present on the bottom. Kelp fronds were medium yellow in color, with less than 25% encrustation observed. Many sporophylls and juvenile fronds were observed. Fish observed included kelp bass (more than 5), sheepshead (1), and rock wrasses (more than 5).

No kelp was observed along the breakwaters in Dana Point Harbor (Appendix A.47) in 2019. This is not a designated kelp bed.

Capistrano Beach. This kelp bed disappeared in 2019 (Table 3).

This was the first year that surface canopy had not been observed at the Capistrano Beach kelp bed since 2005 (Appendix B.4; Figure 4). The 2019 decrease in size was similar to the decline of the Orange County ABAPY.

During the January 2020 vessel survey, no surface canopy was observed. However, patches of subsurface kelp were visible on the fathometer at depths of 35 to 45 feet (Table 4).

III.2.C - SAN CLEMENTE TO SAN ONOFRE

Three kelp beds are located between San Clemente and San Onofre. All three beds decreased in size in 2019 (Table 3).

San Clemente. This kelp bed decreased in size by 91%, from 0.335 km^2 in 2018 to 0.030 km^2 in 2019 (Table 3). The canopy area in 2019 was only 3% of the maximum recorded in 2013 (Appendix B.4; Figure 4).

The surface canopy area at the San Clemente kelp bed in 2019 was the lowest amount recorded since 2007 (Appendix B.4; Figure 4). The 2019 decrease in size was similar to the decline of the Orange County ABAPY.

Scattered surface canopy was visible during the January 2020 vessel survey. Tissue color was 5% light yellow, 10% medium yellow, and 85% dark yellow, with 30% encrustation on fronds and 25% apical meristems present. The kelp bed was composed of 10% senile, 85% mature, and 5% young fronds (Table 4).

Table 3. Canopy coverage of the Region Nine kelp beds from Laguna Beach to Imperial Beach (kelp beds listed north to south) during 2018 and 2019.

Kelp Bed	2018 (km^2)	2019 (km^2)	Percentage Difference
Newport Harbor	**0.113**	**0**	**Disappeared**
Corona del Mar	**0.119**	**0.003**	**-98%**
North Laguna Beach	**0.133**	**0.015**	**-89%**
South Laguna Beach	**0.131**	**0.007**	**-95%**
South Laguna	**0.048**	**0**	**Disappeared**
Dana Point/Salt Creek	**0.379**	**0**	**Disappeared**
Capistrano Beach	**0.018**	**0**	**Disappeared**
San Clemente	**0.335**	**0.030**	**-91%**
San Mateo Point	**0.083**	**0.0001**	**-100%**
San Onofre	**0.127**	**0.001**	**-99%**
Horno Canyon	**0.008**	**0**	**Disappeared**
Barn Kelp	**0.092**	**0**	**Disappeared**
Santa Margarita	**0**	**0**	**No change**
North Carlsbad	**0.038**	**0**	**Disappeared**
Agua Hedionda	**0**	**0**	**No change**
Encina Power Plant	**0.045**	**0**	**Disappeared**
Carlsbad State Beach	**0**	**0**	**No change**

Table 3 (continued)

Kelp Bed	2018 (km^2)	2019 (km^2)	Percentage Difference
Leucadia	**0.052**	**0.009**	**-83%**
Encinitas	**0.033**	**0**	**Disappeared**
Cardiff	**0.005**	**0**	**Disappeared**
Solana Beach	**0.024**	**0**	**Disappeared**
Del Mar	**0**	**0**	**No change**
Torrey Pines	**0**	**0**	**No change**
La Jolla	**1.566**	**1.227**	**-22%**
Point Loma	**7.920**	**3.923**	**-50%**
Imperial Beach	**0**	**0**	**No change**
TOTAL	**11.037**	**5.213**	**-53%**

San Mateo Point. This kelp bed virtually disappeared, decreasing in size by 100%, from 0.083 km^2 in 2018 to 0.0001 km^2 in 2019 (Table 3). The canopy area in 2019 was less than 0.1% of the maximum recorded in 1989 (Appendix B.4; Figure 4).

The surface canopy area of the San Mateo Point kelp bed in 2019 was the lowest amount recorded since 1998 (Appendix A.50; Figure 4). The 2019 decrease in size was similar to the decline of the Orange County ABAPY.

No surface canopy was observed during the January 2020 vessel survey. Some subsurface individuals were present, approximately 20-feet tall, and one solid patch was observed 0.25 miles south of San Mateo Point (Table 4).

San Onofre. This kelp bed decreased in size by 99%, from 0.127 km^2 in 2018 to 0.001 km^2 in 2019 (Table 3). The canopy area in 2019 was 0.2% of the maximum recorded in 1989 (Appendix B.4; Figure 4).

Table 4. Visual observations of Region Nine kelp beds during January 2020 vessel surveys.

Kelp Bed	Surface Canopy		Subsurface Kelp
	Extent	Appearance	
Corona del Mar	none		none
North Laguna Beach	estimated at 100 x 150 meters	light and medium yellow; 39% senile, 60% mature, 1% young; no encrustation; a few apical meristems	subsurface kelp beyond the edges of the surface canopy
South Laguna Beach	none		some subsurface kelp
South Laguna	none		none
Dana Point/Salt Creek	scattered canopy estimated at 400 x 800 meters	medium and dark yellow; 100% mature; less than 25% encrustation; no apical meristems	**see discussion of dive survey results**
Dana Point Harbor	none		none
Capistrano Beach	none		patches with approximately 15 to 25-feet tall individuals, scattered at approximately 35 to 45-feet depth
San Clemente	scattered kelp canopy	5% light yellow, 10% medium yellow, 85% dark yellow; 10% senile, 85% mature, 5% young; 30% encrustation; 25% apical meristems	scattered individuals approximately 20 to 30 feet tall in patches
San Mateo Point	none		some subsurface kelp, individuals approximately 20-feet tall, 1 solid patch 0.25 miles south of San Mateo Point
San Onofre	none		none
Pendleton Reefs	none		none
Horno Canyon	none		sparse kelp individuals 20 to 30-feet tall
Barn Kelp	none		20 to 30-feet tall kelp individuals, multiple patches at approximately 20 meters depth
Santa Margarita	none		none
North Carlsbad	none		none
Agua Hedionda	none		10-15 individuals on the bottom (two to three patches with up to six individuals)
Encina Power Plant	none		**see discussion of dive survey results**
Carlsbad State Beach	none		none
Leucadia-north	none		**see discussion of dive survey results**
Leucadia-central	surface kelp canopy estimated at 100 x 30 meters	50% light tissue color 50% senile, 45% mature, 5% young	subsurface kelp present with visible apical meristems

Table 4 (continued)

Leucadia-south	surface kelp canopy estimated at 30 x 30 meters	20% light yellow, 70% medium yellow, 10% dark yellow 18% senile, 80% mature, 2% young	subsurface kelp present with visible apical meristems
Encinitas	surface kelp canopy estimated at 100 x 30 meters	10% light yellow, 70% medium yellow, 20% dark yellow 5% senile, 35% mature, 60% young 40% apical meristems	5- to 10-foot kelp individuals on the bottom; two to three patches of 10-40 individuals scattered over approximately 0.35 miles (some reaching to the surface)
Cardiff	none		several single individuals 10-15 feet tall over approximately 0.25 miles
Solana Beach	scattered surface canopy	30% light yellow, 70% dark yellow	scattered individuals at the south end of the bed, 15-20 feet tall to 30-35 feet tall
Del Mar	none		several individuals 2-3 feet tall over approximately 200 meters
Torrey Pines	none		none
La Jolla North	scattered canopy, estimated at 100 to 200 meters in width		visible subsurface kelp
La Jolla South	continuous canopy south to north end, estimated at 100 to 300 meters in width; lower density inshore than offshore	60% light yellow, 40% dark yellow; 5% senile, 95% mature; 60 to 70% encrustation 2 to 5% apical meristems	subsurface kelp at approximately70 feet depth
Point Loma North	continuous canopy south to north end, approximately 200 meters width	50% light yellow, 50% dark yellow; 9% senile, 90% mature, 1% young; no encrustation; 1-2% apical meristems	visible subsurface kelp
Point Loma South	continuous canopy south to north end, estimated at approximately 200 meters in width	100% dark yellow; 1% senile, 98% mature, 1% young; 30% encrustation; 1% apical meristems	scattered kelp just below the surface, heavy encrustation, many apical meristems
Imperial Beach	none		none

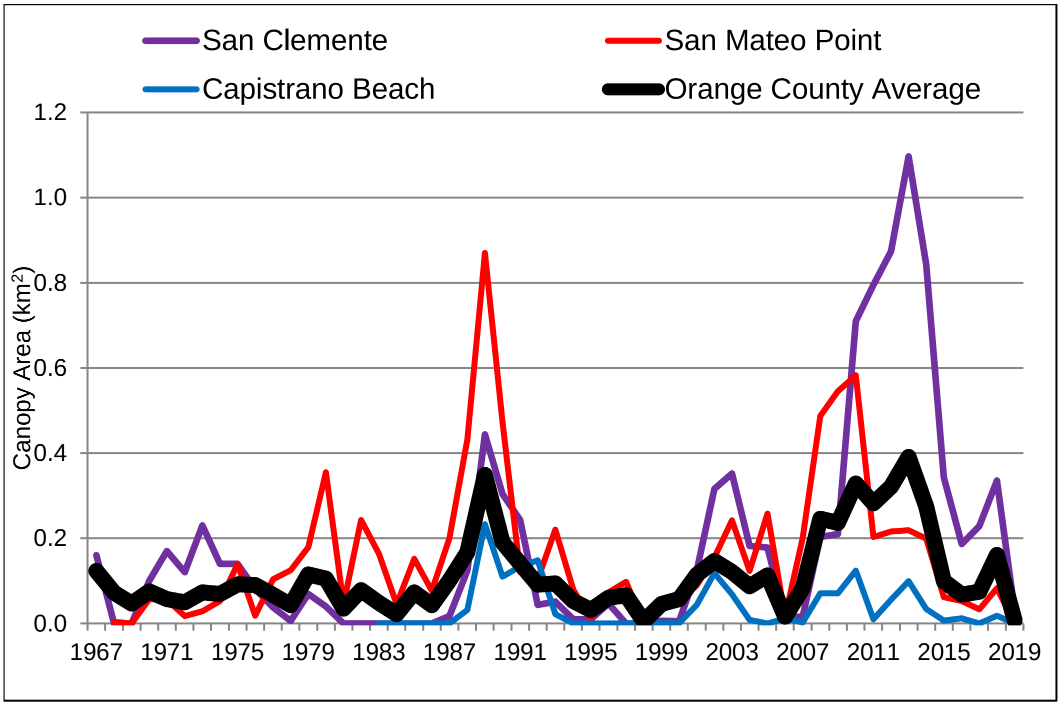


Figure 4. Comparisons between the average Orange County ABAPY and the canopy coverage of the kelp beds from Capistrano Beach to San Mateo Point from 1967 through 2019.

The surface canopy area of the San Onofre kelp bed in 2019 was the lowest amount recorded since 2006 (Appendices A.50 and A.51, Figure 4)). The 2019 decrease was similar to the decline of the San Diego County average ABAPY.

No surface or subsurface kelp was observed during the January 2020 vessel survey (Table 4).

III.2.D - HORNO CANYON TO SANTA MARGARITA RIVER

Three kelp beds are located between Horno Canyon and the Santa Margarita River.

Horno Canyon. This kelp bed disappeared in 2019 (Table 3).

This was the first year that no surface canopy was observed at the Horno Canyon kelp bed since 2011 (Figure 5). The 2019 decrease in size was similar to the decline of the San Diego County ABAPY.

No surface canopy was visible during the January 2020 vessel survey. However, sparse kelp individuals 20 to 20 feet tall were visible on the fathometer (Table 4).

In addition, the Pendleton Artificial Reef (PAR), which is not a designated kelp bed, is just upcoast from Horno Canyon. No surface canopy or subsurface kelp was observed at this location.

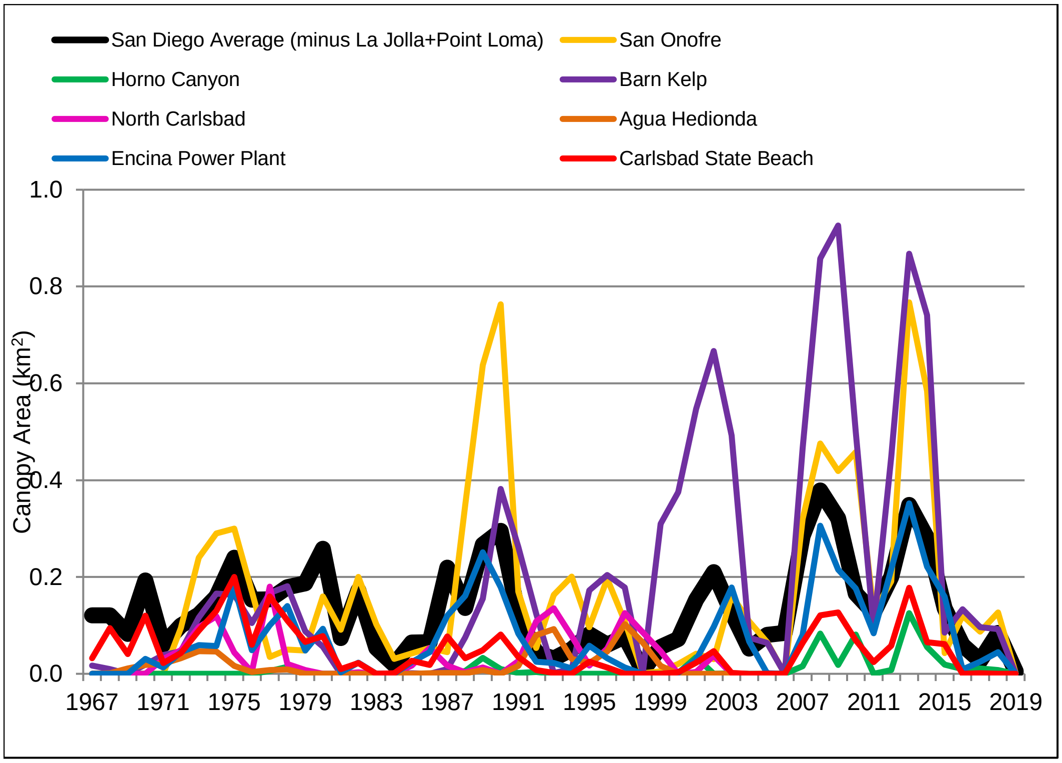


Figure 5. Comparisons between the San Diego average ABAPY and canopy coverage of the kelp beds from San Onofre to Carlsbad State Beach from 1967 to 2019.

Barn Kelp. This kelp bed also disappeared in 2019 (Table 3).

This was the first year that no surface canopy was observed at the Barn Kelp bed since 2006 (Figure 5).

No surface canopy was observed during the January 2020 vessel survey. However, 20- to 30-foot tall kelp individuals were visible on the fathometer in multiple patches at approximately 20 meters depth (Table 4).

Santa Margarita. This kelp bed was not observed during 2019, nor was it visible in 2018 (Table 3).

The Santa Margarita kelp bed is a small bed that occasionally forms a canopy off the Santa Margarita River mouth (Appendix A.56). However, surface canopy has only been observed during one year (2013) since 1993 (Appendix B.4).

No surface canopy or subsurface kelp was visible at Santa Margarita during the January 2020 vessel survey.

No kelp was observed in Oceanside Harbor (Appendix A.57; Table 3) in 2019. This is not a designated kelp bed.

III.2.E - NORTH CARLSBAD TO CARLSBAD STATE BEACH

There are four kelp beds located between North Carlsbad and Carlsbad State Beach. In 2019, three of the beds decreased in size, while the other still was not visible (Table 3).

North Carlsbad. This kelp bed disappeared in 2019 (Table 3).

The North Carlsbad kelp bed is usually comprised of several small beds (Appendices A.58 and A.59). This kelp bed was not observed in 2016 and was very small in 2017, but increased considerably in size in 2018 (21% of the maximum size recorded), before disappearing in 2019 (Appendix B.4; Figure 5).

During the January 2020 vessel survey (Table 4), no surface canopy was observed at the North Carlsbad kelp bed.

Agua Hedionda. This kelp bed was not observed in 2019 (Table 3), nor has it been visible since 2015 (Figure 5).

No surface canopy was observed at the Agua Hedionda kelp bed during the January 2020 vessel survey (Table 4). However, 10 to 15 subsurface individuals were visible on the fathometer in two to three groups of up to six individuals each.

Encina Power Plant. This kelp bed disappeared in 2019 (Table 3).

This was the first time that no surface canopy was observed at the Encina Power Plant kelp bed since 2006 (Appendix A.60, Figure 5)).

No surface canopy was observed at the Encina Power Plant kelp bed during the January 07, 2020 vessel survey (Table 4). Underwater observations were made during a dive survey on the same date. The bottom was composed of flat shale reef, with cobble bottom in some areas. Red alga was the dominant species of algae present. Kelp observed included juvenile individuals; nine new holdfasts were observed. Tissue color of kelp fronds was medium to dark yellow. No encrustation or sediment was observed on the kelp fronds. No fish were observed, but 3 lobsters, 1 white spotted rose anemone (*Urticina eques*), 3 large sea snails (*Kelletia*), 4 turban snails (*Megastraea*), 16 purple sea urchins (*Strongylocentrotus purpuratus*), and 7 red sea urchins (*Mesocentrotus fransciscanus*) were observed on the bottom.

Carlsbad State Beach. This kelp bed was not observed in 2019, nor was it visible in 2018 (Table 3).

The Carlsbad State Beach (Carlsbad State Park) kelp bed (Appendices A.60 and A.61) was very small or absent from 2016 through 2018, before finally disappearing in 2019 (Figure 5).

No surface canopy or subsurface kelp was observed at the Carlsbad State Beach kelp bed during the January 2020 vessel survey (Table 4).

III.2.F - LEUCADIA TO TORREY PINES

Leucadia. This kelp bed decreased in size by 83%, from 0.052 km^2 in 2018 to 0.009 km^2 in 2019 (Table 3). The canopy area in 2019 was only 2% of the maximum recorded in 2013 (Appendix B.4; Figure 6).

The Leucadia kelp bed comprises 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 had remained small through 2019 (Appendix B.4; Figure 6). In 2019, kelp canopy was observed only in the North bed.

No surface or subsurface kelp was observed at the North Leucadia Bed during the January 2020 vessel survey (Table 4). Surface canopy was observed at the Central Leucadia kelp bed. The surface canopy was present as scattered kelp over an estimated 100 x 30 meter area. Half of the fronds were light in color, half were dark. Approximately 50% of the fronds were senile, 45% mature, and 5% young. Surface canopy also was observed at the South Leucadia kelp bed. The surface canopy was present as scattered kelp over an estimated 30 x 30 meter area. Fronds were approximately 20% light yellow, 70% medium yellow, and 10% dark yellow. Approximately 18% of the fronds were senile, 80% mature, and 2% young. Fronds were approximately one to two meters in length. Apical meristems were observed subsurface.

Underwater observations were made during a dive survey on the same date. The bottom was composed of shale reef and plate rock. The dominant algae species present was *Egregia*. Kelp observed included one juvenile individual and four recruits, as well as a few adult individuals. Tissue color of kelp fronds was medium to dark yellow.

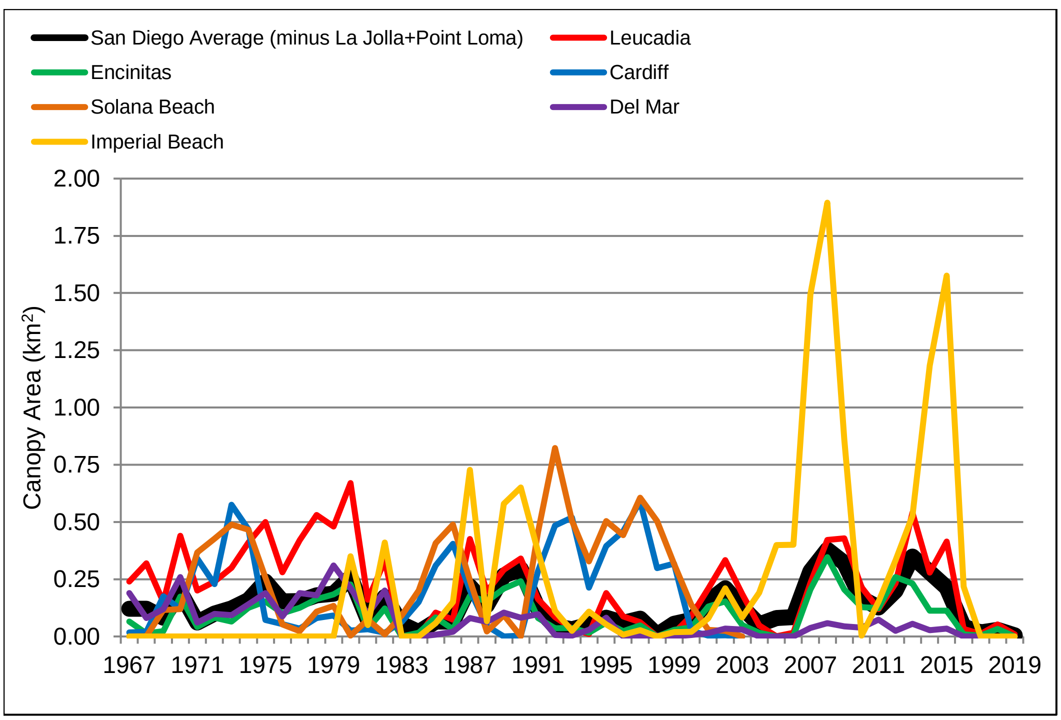


Figure 6. Comparisons between the San Diego average ABAPY and canopy coverage of the kelp beds from Leucadia to Imperial Beach from 1967 to 2019.

Encinitas. This kelp bed disappeared in 2019 (Table 3).

This was the first time that no surface canopy was observed at the Encinitas kelp bed since 2005 (Appendix A.63; Figure 6).

During the January 2020 vessel survey, scattered surface canopy was observed over an estimated 30 x 100 meter area (Table 4). Kelp fronds ranged from light yellow (10%), medium yellow (70%), to dark yellow (20%) in color. Approximately 5% of the fronds were senile, 35% mature, and 60% young. Scattered subsurface kelp was present, consisting of 10 to 40 individuals ranging in height from 5 to 10 feet.

Cardiff. This kelp bed also disappeared in 2019 (Table 3).

This was also the first time that no surface canopy was observed at the Cardiff kelp bed since 2005 (Appendix A.64; Figure 6).

During the January 2020 vessel survey, no surface canopy was visible (Table 4). Subsurface kelp was visible on the fathometer, consisting of several single individuals that were 10- to 15-feet tall over an area of approximately 1,000 feet long.

Solana Beach. This is another kelp bed that disappeared in 2019 (Table 3).

This was the first time that no surface canopy was observed at the Solana Beach kelp bed since 1983 (Appendices A.64 and A.65; Figure 6).

During the January 2020 vessel survey, scattered surface canopy was observed at the Solana Beach kelp bed (Table 4). Kelp fronds were approximately 30% light yellow and 70% dark yellow in color. Scattered subsurface kelp was observed visually and/or on the fathometer, with individuals ranging in height from 15 to 35 feet.

Del Mar. This kelp bed was not observed in 2019, nor was it visible in 2018 (Table 3).

The Del Mar kelp bed (Appendices A.66 and A.67) is typically one of the smallest beds in Region Nine. No surface canopy has been observed at the Del Mar kelp bed since 2015(Appendices A.66 and A.67; Figure 6).

No surface canopy was observed at the Del Mar kelp bed during the January 2020 vessel survey (Table 4). Subsurface kelp was visible on the fathometer as 2- to 3-foot tall individuals over an area of approximately 200 meters.

Torrey Pines. This kelp bed was not observed in 2019, nor was it visible in 2018 (Table 3).

Torrey Pines kelp bed appeared as a small trace of kelp during La Niña conditions in 1988 and 1989. It reappeared in 2006 with a canopy area of 0.010 km^2 with scattered giant kelp concentrations approximately 1.5 km, 3.5 km, and 5 km north of Scripps Pier. Small canopies were observed in various locations in the area from 2008 through 2013, but this bed was not observed from 2014 through 2019 (Appendices A.67 and A.68).

No surface canopy or subsurface kelp was visible during the January 2020 vessel survey (Table 4).

III.2.G - LA JOLLA

La Jolla. This kelp bed decreased in size by only 22%, from 1.566 km^2 in 2018 to 1.227 km^2 in 2019 (Table 3). The canopy area in 2019 was 26% of the maximum recorded in 1989 (Appendix B.4; Figure 7).

La Jolla kelp bed is composed of two canopies: northern La Jolla and southern La Jolla. 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. After more than doubling in size in 2018, the La Jolla kelp bed decreased in size by approximately 20% in 2019 (Appendices A.68 through A.70; Figure 7).

During the January 2020 vessel survey, the La Jolla North kelp bed surface canopy was scattered, covering an estimated area approximately 100 to 200 meters wide (Table 4). Subsurface kelp was visible on the fathometer. The La Jolla South kelp bed surface canopy was continuous from the south to north end, ranging from 100 to 300 meters in width. The density of the surface canopy was lower inshore than offshore. Tissue color was 60% light yellow and 40% dark yellow, with 2 to 5% apical meristems, and the fronds had 60 to 70% encrustation. The kelp bed was composed of approximately 5% senile and 95% mature fronds. Subsurface kelp was visible on the fathometer at a depth of approximately 70 feet.

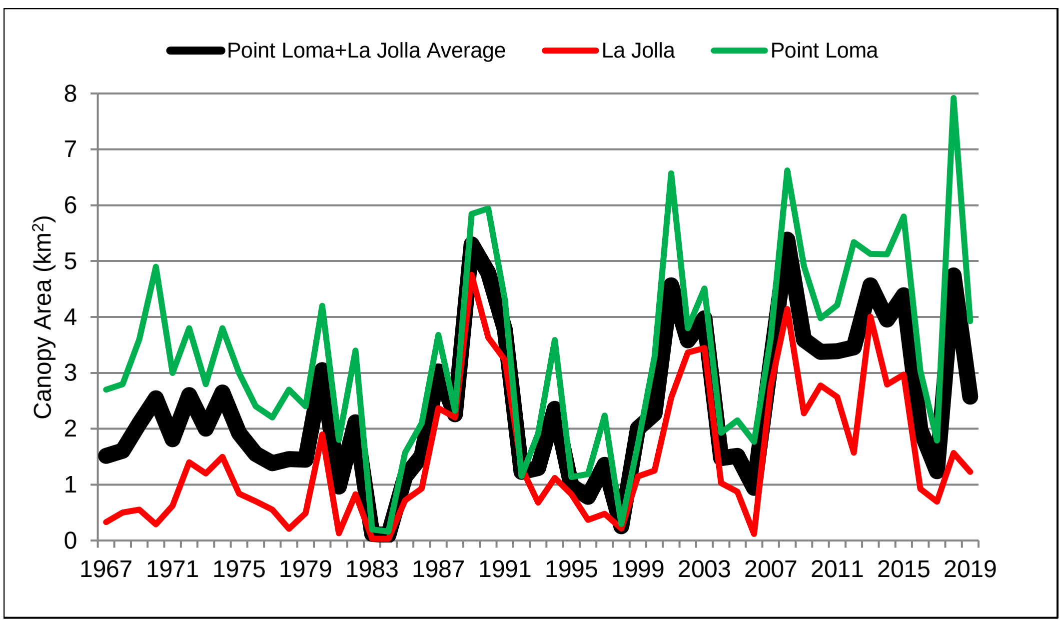


Figure 7. Comparisons between the Point Loma/La Jolla Average ABAPY and canopy coverage of the La Jolla and Point Loma kelp beds from 1967 to 2019.

III.2.H - POINT LOMA TO CORONADO BEACH

Point Loma. This kelp bed decreased in size by 50%, from 7.920 km^2 in 2018 to 3.923 km^2 in 2019 (Table 3). The canopy area in 2019 was 50% of the maximum recorded in 2018 (Appendix B.4; Figure 7).

The Point Loma kelp bed comprises 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 sizes measured since 2006. In 2018, the Point Loma kelp bed increased in size considerably, reaching the maximum size observed since RNKSC surveys began in 1983. Even with the decrease in size observed in 2019, this kelp bed remains larger than in 2016 or 2017 (Appendices A.71 through A.74; Figure 7).

During the January 2020 vessel survey, the surface canopy was continuous from the south to the north end at the Point Loma North kelp bed, and was estimated at approximately 200 meters in width (Table 4). Tissue color was 50% light yellow and 50% dark yellow, with no encrustation on the fronds and 1 to 2% apical meristems. Subsurface kelp was visible on the fathometer. A continuous surface canopy from the south to the north end also was visible at the Point Loma South kelp bed, and also was estimated at approximately 200 meters in width. Tissue color was 100% dark yellow, with 30% encrustation of the fronds and 1% apical blades. The kelp bed was composed of approximately 1% senile, 98% mature and 1% young fronds. Scattered kelp was observed just below the surface, with heavy encrustation of the fronds and many apical meristems.

III.2.I - CORONADO BEACH TO U.S./MEXICO BORDER

No kelp was observed at Coronado Beach (Appendix A.76) or Silver Strand (Appendix A.77), which are not designated kelp beds, during aerial overflights or during the January 2020 vessel survey.

Imperial Beach. This kelp bed was not observed in 2019, nor was it visible in 2018 (Table 3).

The surface canopy area of the Imperial Beach kelp bed has fluctuated considerably from year to year, reaching its highest levels in 2008 and 2015 (Appendices A.79 and A.80; Figure 6). No surface canopy was observed in 2017 for the first time since 1998, nor was it visible in 2018 or 2019.

No surface or subsurface kelp was visible at the Imperial Beach kelp bed during the January 2020 vessel survey (Table 4).

IV – DISCUSSION

IV.1 - REGION NINE KELP BEDS

One objective of the RNKSC program is to answer several basic monitoring questions regarding the status of kelp beds within the region:

1. What is the maximum areal extent of the coastal kelp bed canopy each year?
    - the total kelp canopy covered 5.2 km^2 in 2019.
2. What is the variability of the coastal kelp bed canopy over time?
    - the total kelp canopy decreased in size in 2019 by 53% (from 11.0 km^2 to 5.2 km^2);
    - none of the kelp beds increased in size in 2019
    - all 18 kelp beds with visible surface canopy present in 2018 decreased in size in 2019
3. Are coastal kelp beds disappearing? If yes, what are the factors that could contribute to the disappearance?
    - 10 kelp beds disappeared in 2019: South Laguna, Dana Point/Salt Creek, Capistrano Beach, Horno Canyon, Barn Kelp, North Carlsbad, Encina Power Plant, Encinitas, Cardiff, and Solano Beach. Higher than normal sea surface temperatures and low nutrient availability could have contributed to the disappearance of these 10 kelp beds.
    - Six other kelp beds continued to display no surface canopy in 2019: Santa Maragarita and Torrey Pines, which disappeared in 2014; Agua Hedionda and Del Mar, which disappeared in 2016; Imperial Beach, which disappeared in 2017, and Carlsbad, which disappeared in 2018. Above average sea surface temperatures and low nutrient availability may have contributed to the continued absence of surface canopy at these six kelp beds.
4. Are new kelp beds forming?
    - No kelp beds reappeared in 2019.

The total kelp canopy in Region Nine covered approximately 5.2 square kilometers in 2019, which was similar to the total kelp canopy recorded in 2016 (5.1 square kilometers), but larger than the total for 2017 (3.3 square kilometers), the lowest amount of total kelp canopy since 2006 (Table 5, Figure 8). The largest kelp beds were the La Jolla and Point Loma kelp beds, which accounted for 99 percent of the total canopy coverage in 2019. The surface canopy areas of the La Jolla and Point Loma beds were at 26% and 50% of the maximum extent recorded since 1983. However, all of the other kelp beds were at 10% or less of their maximum size (Figure 2), and most were at their lowest levels in years (Solano Beach canopy area was the smallest since 1983, San Mateo Point was the smallest since 1998, and others were the smallest since 2005 to 2009).

Vessel surveys of all Region Nine kelp beds were conducted in January 2020. Visual observations indicated that kelp canopy was present at North Laguna Beach and Dana Point/Salt Creek, but no surface canopy was observed at South Laguna Beach, South Laguna, or from Capistrano Beach to Leucadia North. Surface canopy was also present at Leucadia Central, Leucadia South, Encinitas, Solana Beach, La Jolla, and Point Loma. Subsurface kelp was observed at many bed locations, even those without visible surface canopy. In-water surveys conducted in January 2020 at three kelp beds, Dana Point/Salt

Creek, Leucadia North, and Encina Power Plant, recorded limited numbers of giant kelp individuals on the bottom at each location.

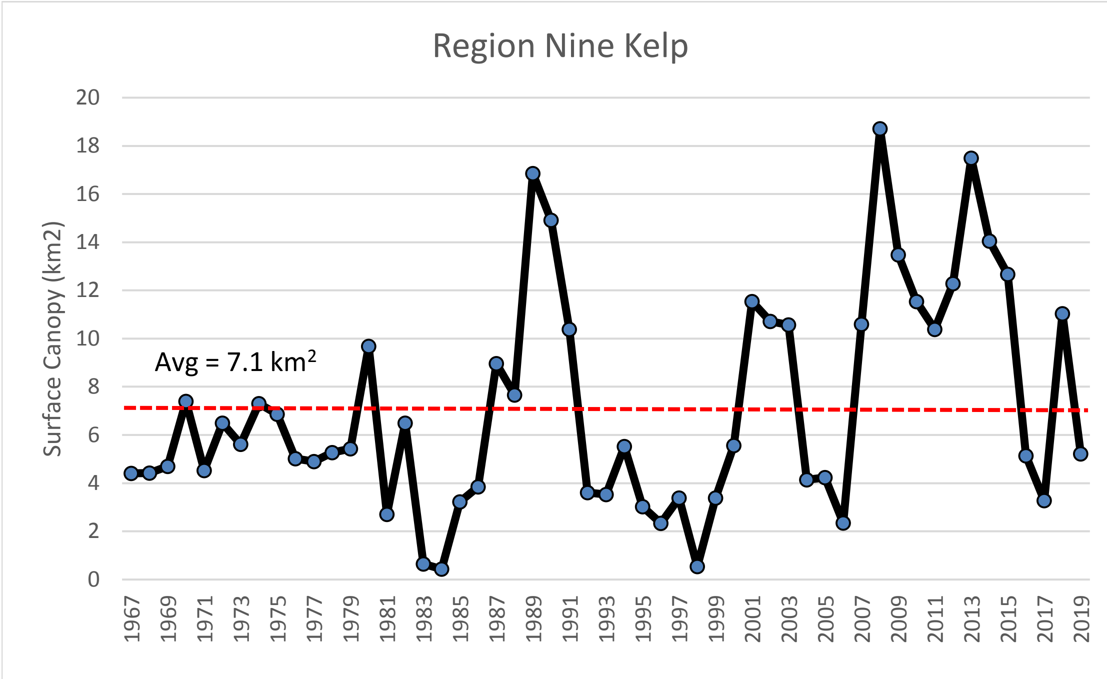


Figure 8. Combined canopy coverage of all kelp beds off Orange and San Diego Counties from 1967 through 2019.

IV.2 - ENVIRONMENTAL VARIABLES

The productivity and growth of giant kelp forests along the west coast of the United States has been shown to be limited by dissolved inorganic nitrogen, mainly in the form of nitrate (Wheeler and North, 1980; Zimmerman and Kremer, 1984). In the upper ocean (depths less than 200 meters), nitrate concentrations were strongly dependent on density and temperature (Kamykowski and Zentara, 1986). However, temperature apparently accounted for less than half of the variability in canopy area or density of giant kelp within the California Current System (CCS) (North et al, 1993; Tegner et al, 1996). Seawater density has been shown to predict nitrate concentrations in nearshore southern California ocean waters better than temperature, and has been utilized to identify the relative contributions of nitrate concentrations within the CCS from different source waters, primarily including subarctic water, upwelled undercurrent water, subtropical water, and surface runoff (Lynn and Simpson, 1987; Parnell et al, 2010).

Table 5. Canopy coverage (km^2) of the kelp beds from Laguna Beach to Imperial Beach (kelp beds listed from north to south) from 2009 through 2019.

Kelp Bed	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
N Laguna Beach	0.093	0.147	0.192	0.142	0.120	0.080	0.074	0.096	0.133	0.015
S Laguna Beach	0.098	0.221	0.214	0.273	0.165	0.048	0.035	0.032	0.131	0.007
South Laguna	0.023	0.018	0.017	0.038	0.031	0.016	0.006	0.003	0.048	-
Dana Pt/Salt Crk	0.839	0.442	0.607	0.835	0.528	0.137	0.110	0.133	0.379	-
Capistrano Beach	0.124	0.010	0.056	0.099	0.034	0.007	0.012	0.0004	0.018	-
Total F&W 9	1.178	0.838	1.086	1.385	0.879	0.287	0.237	0.264	0.709	0.022
San Clemente	0.710	0.795	0.874	1.097	0.843	0.343	0.187	0.229	0.335	0.031
San Mateo Point	0.583	0.203	0.216	0.219	0.199	0.062	0.053	0.033	0.083	0.0001
San Onofre	0.458	0.127	0.191	0.767	0.584	0.043	0.120	0.087	0.127	0.001
Total F&W 8	1.750	1.124	1.281	2.083	1.627	0.449	0.359	0.349	0.545	0.032
Horno Canyon	0.081	-	0.008	0.125	0.055	0.019	0.010	0.011	0.008	-
Barn Kelp	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	0.581	0.095	0.450	1.073	0.795	0.104	0.143	0.107	0.100	0.000
North Carlsbad	0.078	0.017	0.052	0.125	0.086	0.047	-	0.004	0.038	-
Agua Hedionda	0.031	0.022	0.046	0.102	0.065	0.016	-	-	-	-
Encina Power Plant	0.176	0.084	0.216	0.352	0.221	0.159	0.009	0.025	0.045	-
Carlsbad St. Bch	0.069	0.024	0.058	0.178	0.065	0.061	-	0.001	-	-
Total F&W 6	0.354	0.147	0.372	0.757	0.437	0.282	0.009	0.031	0.083	0.000
Leucadia	0.215	0.119	0.232	0.541	0.279	0.414	0.033	0.010	0.053	0.009
Encinitas	0.128	0.124	0.260	0.231	0.112	0.113	0.009	0.003	0.033	-
Cardiff	0.213	0.395	0.459	0.590	0.299	0.318	0.024	0.003	0.005	-
Solana Beach	0.328	0.504	0.442	0.606	0.504	0.316	0.138	0.029	0.024	-
Del Mar	0.038	0.074	0.024	0.056	0.027	0.034	-	-	-	-
Torrey Pines	0.003	0.031	0.034	0.081	-	-	-	-	-	-
Total F&W 5	0.925	1.247	1.452	2.106	1.221	1.195	0.204	0.045	0.114	0.009
La Jolla F&W 4	2.776	2.565	1.569	4.006	2.790	2.968	0.927	0.694	1.566	1.227
Point Loma F&W 3&2	3.977	4.212	5.340	5.127	5.121	5.806	3.037	1.787	7.920	3.924
Imperial Beach F&W 1	0.004	0.152	0.333	0.526	1.183	1.576	0.217	-	-	-
TOTAL	11.545	10.379	11.882	17.064	14.053	12.667	5.134	3.277	11.037	5.213

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

"-" = no canopy area

IV.2.A - WATER TEMPERATURE

Sea surface water temperature (SST) data is discussed below and has been used as a 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 (Parnell et al 2010), long-term measurements of density were not available for broad areas of Region Nine. In contrast, nearshore temperature measurements have been ongoing for decades, resulting in readily accessible data sets.

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 measured conductivity, temperature, and fluorometry at a frequency of one to four minutes. Samplers were mounted at a depth of 2 meters MLLW at Newport Pier, and at 5 meters MLLW at Scripps Pier. These data were 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 Oceanside and Point Loma South were available in real time via the NDBC website (**www.ndbc.noaa.gov**). These data buoys recorded 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 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 2019). Sensors were placed at four-meter intervals from near the sea surface to a depth of 54 meters MLLW.
- Water temperature data were also provided by Orange County Sanitation District from a thermistor mooring located approximately eight kilometers offshore (-118.02220, 33.57620) and upcoast of the outfall in 60 meters of water (Orange County Sanitation District, 2020).

Sea surface temperatures (SST) from Newport Pier, Oceanside, Scripps Pier, and Point Loma South, as well as the Scripps Pier long-term harmonic mean, are presented in Figure 9. Graphs of SST values at each of these individual locations are presented in Appendix C.

Water temperatures throughout the RNKSC region were generally warmer than average throughout most of 2019, particularly from September through December (Figure 9). However, lower than normal temperatures were recorded at Newport Pier during most of April, May, and August, as well as occasionally during March, June, and July. Lower than normal water temperatures were also recorded at Scripps Pier at times from February through October, particularly during the months of June, July and August. Water temperatures at Oceanside and Point Loma South were lower than normal occasionally during the months of February through August and in October, but less frequently than at Newport Pier or Scripps Pier. Daily SST values rarely fell below 14ºC,a threshold below which nutrient availability is increased (Schiel and Foster, 2015)) at Newport Pier and Scripps Pier, but never fell below this threshold at Oceanside or Point Loma South. Overall, the pattern of SST values in 2019 was similar to 2018.

Unfortunately, while SST data were available at several locations in the RNKSC region, sub-surface water temperature data were not as extensive or readily available.

Temperature monitoring accomplished via a thermistor string deployed off Point Loma in 2019 was limited since data for temperatures at the surface down to approximately 15 meters depth were missing from January through August. In September and October, water temperatures were warm in the upper 15 meters of the water column. From November through mid-December, water temperatures were warm to depths up to 50 meters (Figure 10).

Temperature monitoring, also accomplished via a thermistor string deployed offshore of Orange County, was limited since all data from January through August were missing, due to the inability by Orange County Sanitation District personnel to service the mooring due to the COVID pandemic. From June through October, water temperatures in the upper water column from 1 to 10 meters depth were warmer (approximately 17 to 23ºC) than at lower depths from 15 to 60 meters (approximately 11 to 16.5 ºC). In November and December, water temperatures were cool throughout the water column (Figure 11).

The number of days with SST values <14°C increased slightly in 2019 at Newport Pier (from 1 to 6 days) and decreased slightly at Scripps Pier (from 12 to 5 days) (Figure 12). These values were well below the long-term mean (1994-2018) for Newport Pier (52 days) and lower than the long-term mean for Scripps Pier (16 days). This continues the trend observed over the past several years, as the number of days with water temperatures <14°C has been lower than usual since 2014.

The number of days with water temperatures >18°C in 2019 increased slightly at Newport Pier (from 137 to 146 days), but the number of days with water temperatures >16°C and >20°C decreased (from 254 to 235 days, and from 69 to 61 days, respectively (Figure 9). At Scripps Pier, the number of days with warm temperatures decreased for all three thresholds in 2019. Overall, the pattern of unusually warm SST values observed since 2014 has continued.

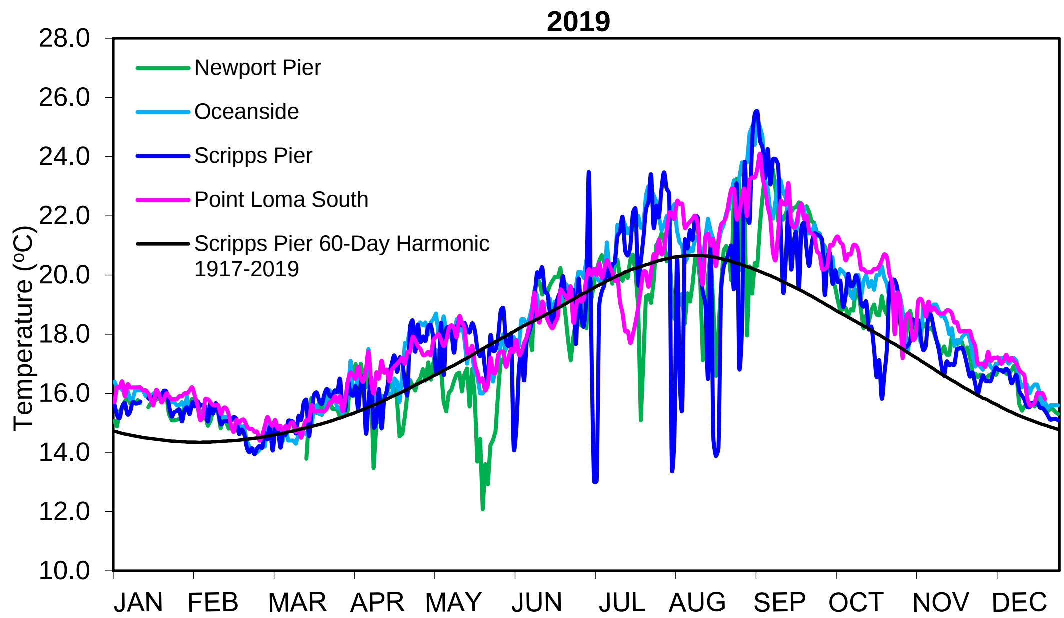


Figure 9. Daily sea surface temperatures (SSTs) at Newport Pier, Oceanside, Scripps Pier, and Point Loma South for 2019, and the long-term harmonic mean for Scripps Pier SIO 60-Day Harmonic calculated from 1917 through 2019). Source: Southern California Coastal Ocean Observation System (SCCOOS) (www.sccoos.org) and National Data Buoy Center (NDBC) (www.ndbc.noaa.gov).

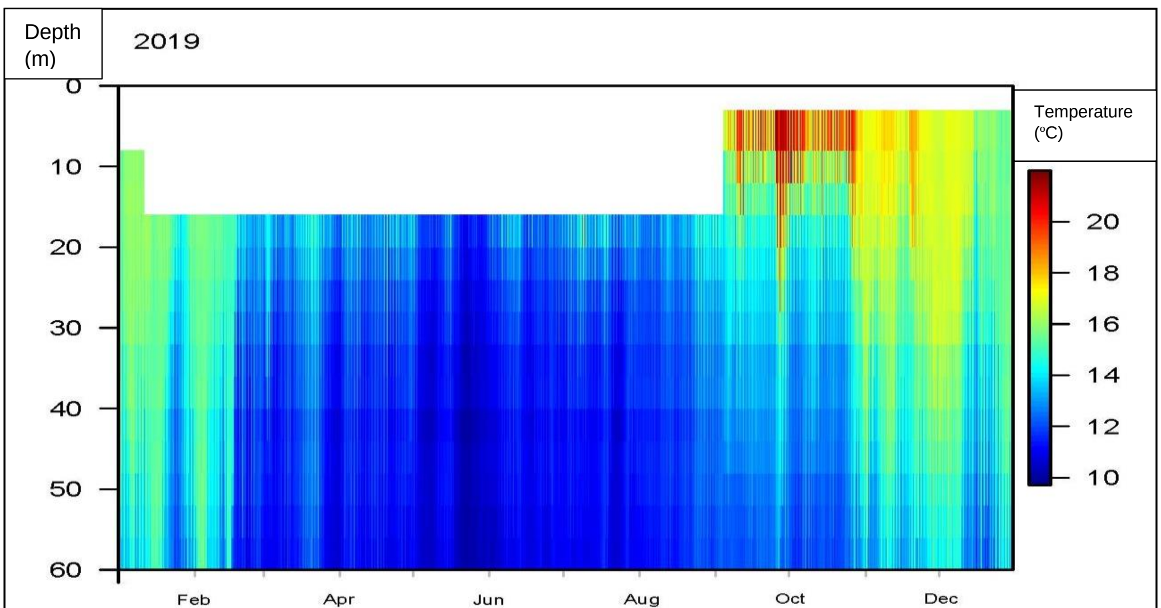


Figure 10. Temperatures (°C) throughout the water column (near surface to a depth of 60 m) off Point Loma during 2019. Source: City of San Diego, 2020.

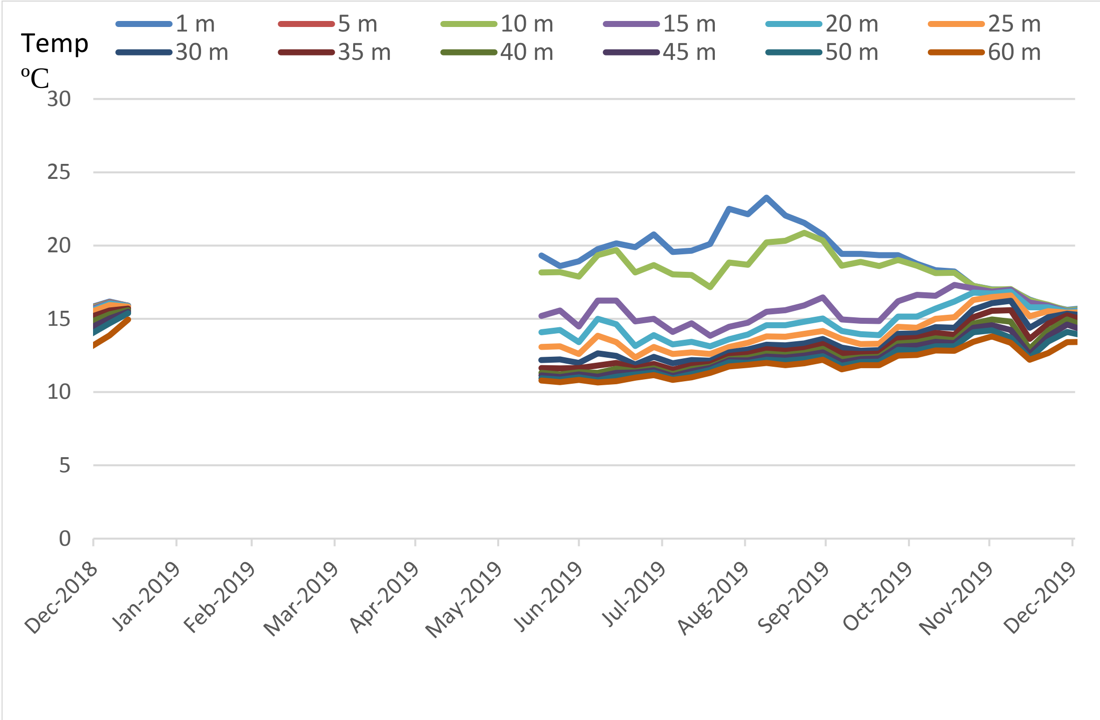


Figure 11. Temperatures (°C) throughout the water column (near surface to a depth of 60 m) off Orange County during 2019. Source: Orange County Sanitation District, 2020.

IV.2.B - NUTRIENTS

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

This index is calculated for the 12-month period from July 1 through June 30 (i.e., the 2019 NQ Index values shown on Figure 13 corresponded to the period from July 1, 2019 to June 30, 2020). The NQ Index was calculated for each of four locations (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 17.00˚C, 2 points if between 15.01 and 16.00˚C, 4 points if between 14.01 and 15.00˚C, 8 points if between 13.01 and 14.00˚C, and 14 points if between 12.01 and 13.00˚C. The NQ for the 12-month period was the sum of the monthly point scores.

The NQ calculations for four locations in Region Nine in 2019/2020 are shown in Table 7. The 2019/2020 NQ Index was calculated to be 8 for Newport Pier, 7 for Oceanside, 7 for

Scripps Pier, and 6 for Point Loma (Table 7). The NQ Indices for all four locations were slightly lower in 2019 than the previous year (Figure 13). This continues the pattern of below average NQ Index levels observed since 2013.

The size of kelp beds in 2019 were likely influenced by the 2018/2019 NQ Index (covering the period from July 2018 through June 2019), since the maximum extent of surface canopy at all of the Region Nine kelp beds occurred in March or June. Although nutrient availability appeared to be similar in 2018 and 2019 based on the NQ Index, the size of the kelp beds in Region Nine decreased considerably in 2019. Upwelling was lower in 2019 than in 2018 during the months of March, May, and June, which may have reduced nutrient availability in 2019, resulting in decreased surface canopy coverage. Overall, the pattern of low nutrient availability observed since 2013 has continued.

The nutrient climate has shifted from waters with sufficient nitrate prior to the 1976/1977 regime shift, to depleted conditions thereafter (Parnell et al. 2010). The sensitivity of kelp canopies to nutrient limitation appeared to have increased after 1977 and was evident by the strong correlation of seawater density (δ_t) and density of giant kelp (Parnell et al. 2010). Unfortunately, density data were not available throughout the RNKSC region. The NQ index recorded during the 1997/1998 El Niño indicated a particularly bad year for kelp beds in the Southern California Bight. During that season, NQ values ranged from 3 to 11. In contrast, during 1988/1989, a year in which kelp beds reached their maximum extents in several decades, NQ values ranged from 27 to 39 (Figure 13). The variability in SSTs and nutrients was driven by prevailing flow characteristics and bathymetric features that resulted in periodic upwelling along the rocky shores of the coastline, particularly at the Dana Point, La Jolla, and Point Loma kelp beds.

Table 6. Comparison of mean temperature from 1994 through 2019 versus annual mean temperature from 2011 through 2019 at Newport Pier, and Scripps Pier.

		Annual Mean SST (°C)								
	Mean SST (°C) (1994–2018)	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Newport Pier	**16.7**	15.9	16.6	16.7	18.0	18.4	17.8	17.8	17.9	17.6
Scripps Pier	**17.7**	15.7	16.6	17.0	18.8	18.9	17.7	17.9	18.6	17.8

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.

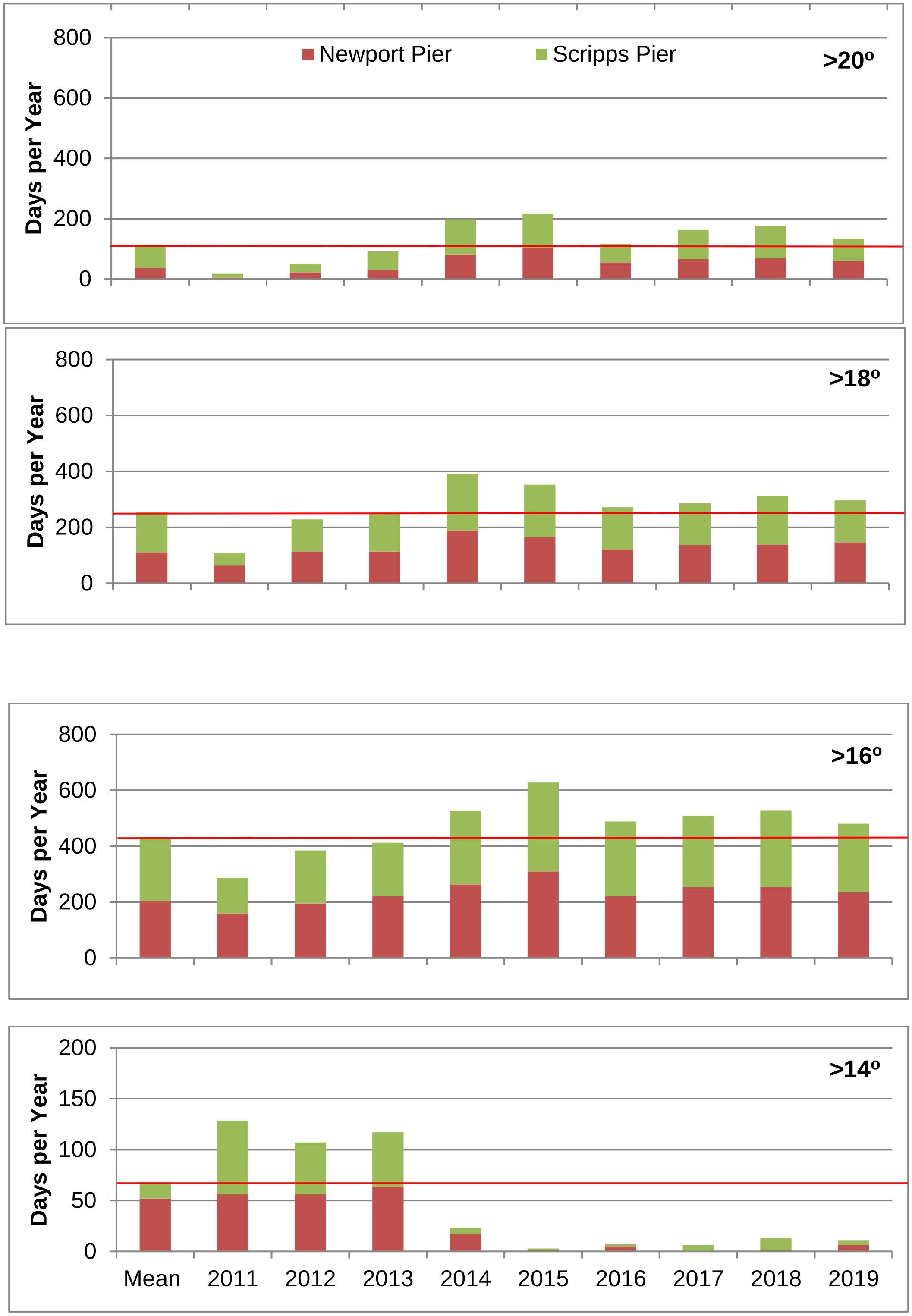


Figure 12. Number of days with SSTs >20°C, >18°C, >16°, and <14°C at Newport Pier and Scripps Pier from 2011 to 2019, and the mean from 1994 to 2018 (red line).

Table 7. Nutrient Quotient calculations for period from July 2019 to June 2020.

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)	
Newport Pier				Jan 2020 Feb 2020 Mar 2020	Dec 2019 Apr 2020	(4 pts x 0) + (2 pts x 3) + (1 pt x 2) = 8
Oceanside				Jan 2020 Feb 2020	Dec 2019 Mar 2020 Apr 2020	(4 pts x 0) + (2 pts x 2) + (1 pt x 3) = 7
Scripps Pier				Jan 2020 Feb 2020	Dec 2019 Mar 2020 Apr 2020	(4 pts x 0) + (2 pts x 2) + (1 pt x 3) = 7
Point Loma				Jan 2020 Feb 2020	Dec 2019 Mar 2020	(4 pts x 0) + (2 pts x 2) + (1 pt x 2) = 6

IV.2.C – UPWELLING

The frictional stress of equatorial 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.

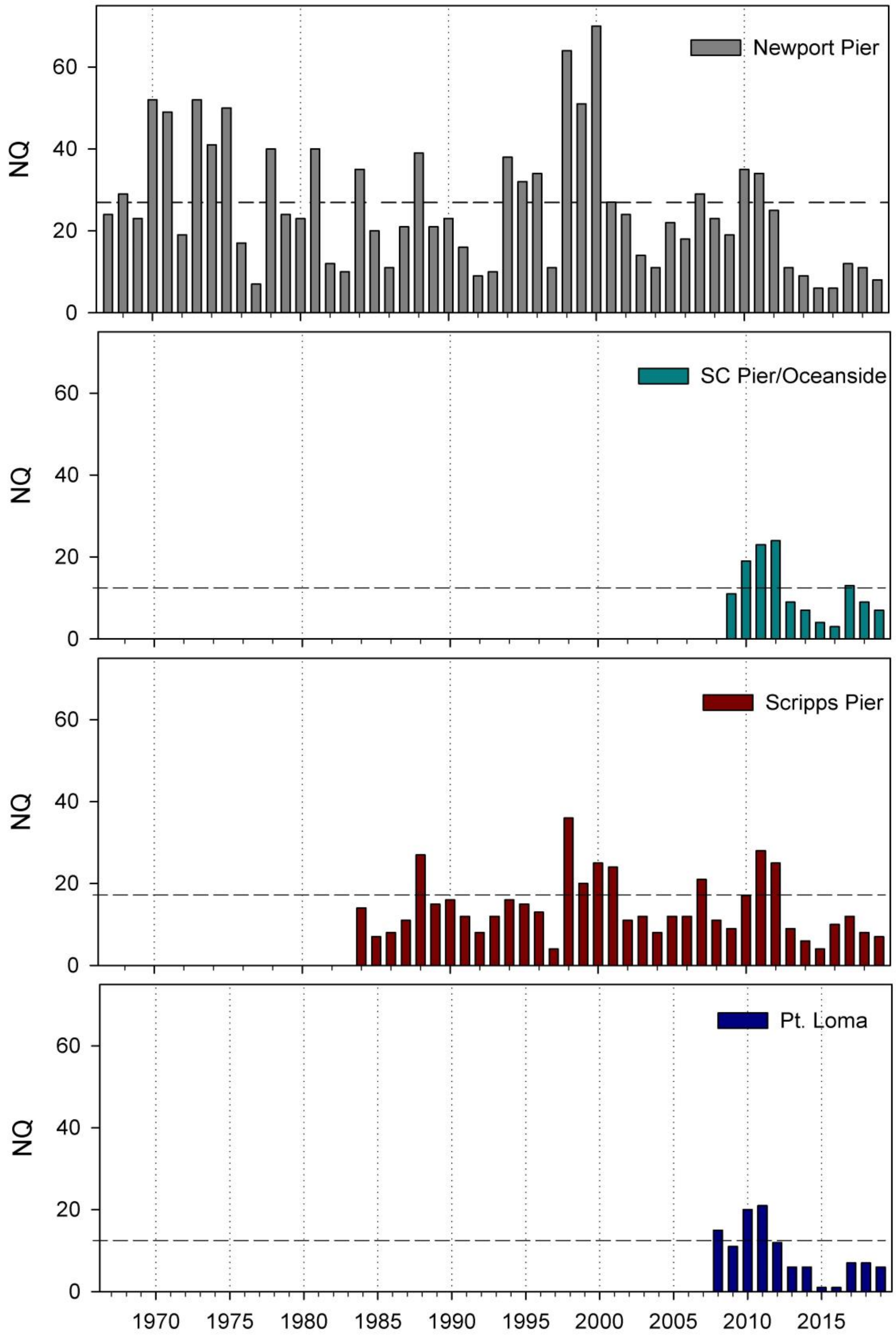


Figure 13. Nutrient Quotient (NQ) values in Region Nine, 1967 to 2019 (dotted line = long-term mean for site).

The upwelling index in 2019 (at a location approximately 161 km west of Solana Beach) generally increased each month from January through August, then decreased through December (Figure 14 A). The Upwelling Anomaly Index demonstrates that upwelling in 2019 was much higher than the long-term mean (1946-2018) during the months of July and August, but lower than usual during March, May, and June (Figure 14 B). The monthly PFEL Upwelling Index was lower in 2019 than during 2018 for the months of March, April, May and June (Figure 15), when surface water temperatures generally were lower and more nutrients would be available. However, upwelling was higher in 2019 than the previous year during the months of July, August, and September. Unfortunately, this corresponded to the period of the year when surface water temperatures were highest and nutrient availability was lowest.

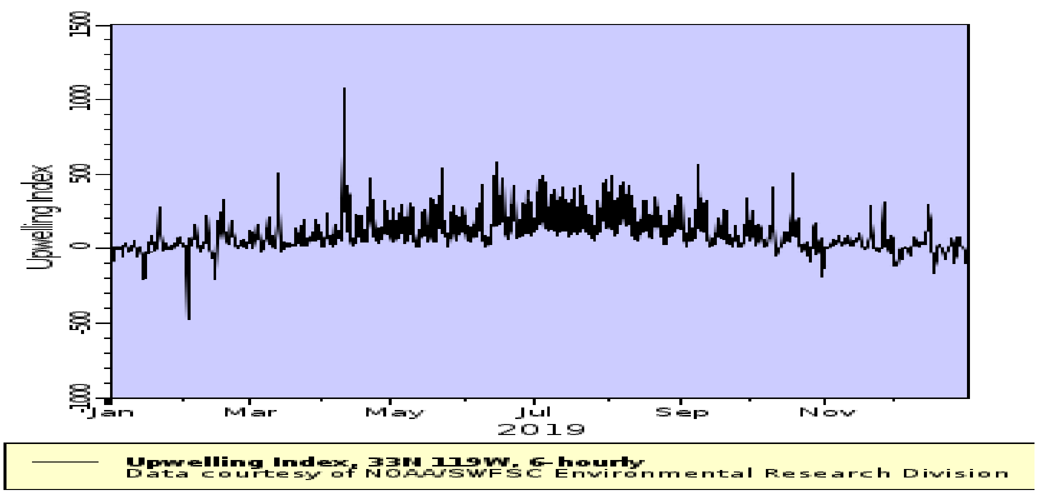
IV.2.D - ENVIRONMENTAL INDICES

The ENSO is the most important coupled ocean-atmosphere phenomenon affecting inter-annual climate variability. 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, the sea surface temperature, the surface air temperature, and the total cloudiness fraction of the sky) (**https://www.esri.noaa.gov/psd/enso/mei/**). Negative values of the MEI represented the cold ENSO phase (i.e., La Niña), while positive MEI values represented the warm ENSO phase (El Niño).

The North Pacific Gyre Oscillation (NPGO) is a climatic pattern that is based on sea surface height variability in the Northeast Pacific Ocean. The NPGO was 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 were driven by regional and basin-scale variations in wind-driven upwelling and horizontal advection, which were the fundamental processes controlling salinity and nutrient concentrations. Nutrient fluctuations drove concomitant changes in phytoplankton concentrations and may have resulted in similar variability in higher trophic levels (**http://www.o3d.org/npgo/**).

The Pacific Decadal Oscillation (PDO) is a long-lived El Niño-like pattern of Pacific climate variability. The PDO and ENSO had similar spatial climate fingerprints but exhibited very different behavior in time. While twentieth century PDO events typically persisted for 20 to 30 years, typical ENSO events tended 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 correlated with enhanced coastal ocean biological productivity in Alaska and inhibited productivity off the west coast of the United States, while cold PDO eras produced the opposite (**http://research.jisao.washington.edu/pdo**). Causes for PDO fluctuations are not currently known.

A



B

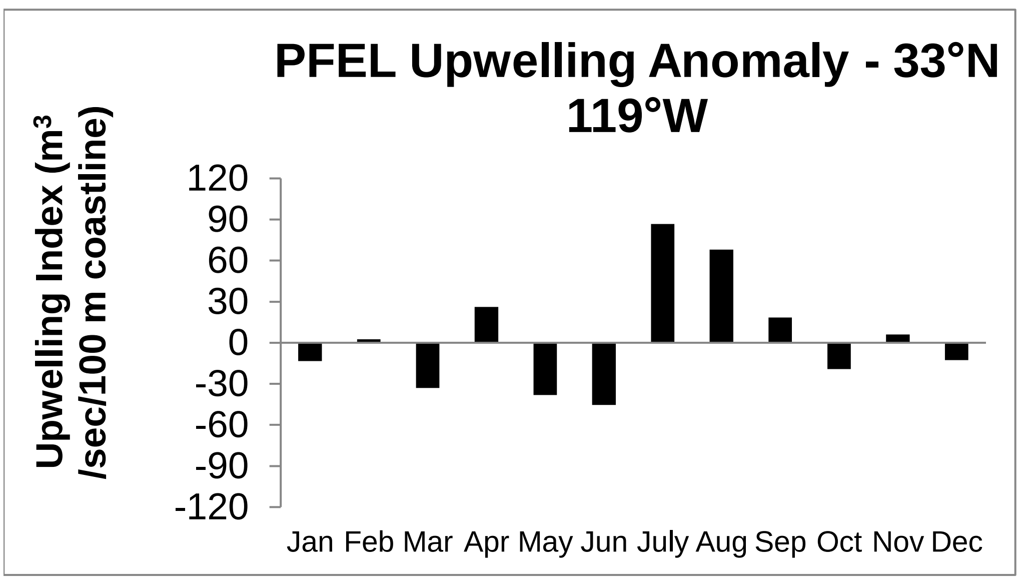


Figure 14. (A) Daily Upwelling Index (UI) at 33°N 119°W for 2019. (B) UI anomaly at 33°N 119°W in 2019 (compared to 71-year monthly mean from 1946 through 2018) (positive values indicate upwelling greater than long-term mean; negative values indicate upwelling less than long-term mean). Source: http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/upwelling/NA).

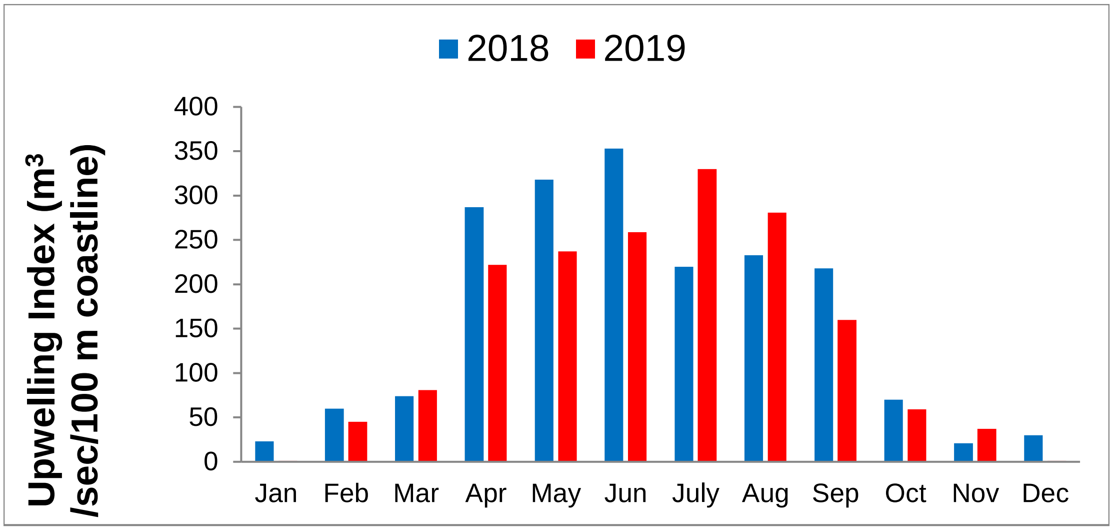


Figure 15. Monthly PFEL upwelling index at 33ºN 119ºW for 2018 and 2019. Source: http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/upwelling/NA).

The MEI and 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 16). The MEI continued to be negative in early 2018 but shifted to positive in May and continued to be positive throughout 2019, indicating a warm ENSO phase which probably was unfavorable for kelp growth. The PDO remained positive since 2014, but index values indicated that more neutral conditions were present in 2018. However, higher values were recorded in 2019, also indicating a warm ocean regime which probably was unfavorable to kelp (Figure 16). 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, 2018, and 2019 (Figure 16; 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), conditions that would be expected to adversely affect kelp beds.

IV.2.E - WAVE HEIGHTS

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

The directions of swells off Oceanside and Point Loma in 2019 were very similar to 2018 (Table 8). Off Oceanside, waves approached from the south-southwest (202.5º) approximately 43% of the time in 2019, from the south (180º) approximately 17% of the time, and from the west (270º) approximately 14% of the time (Table 8, Figure 17). Offshore of Point Loma, waves were from the south-southwest (202.5º) about 29% of the time, from the west about 26% of the time, and from the south (180º) approximately 17% of the time.

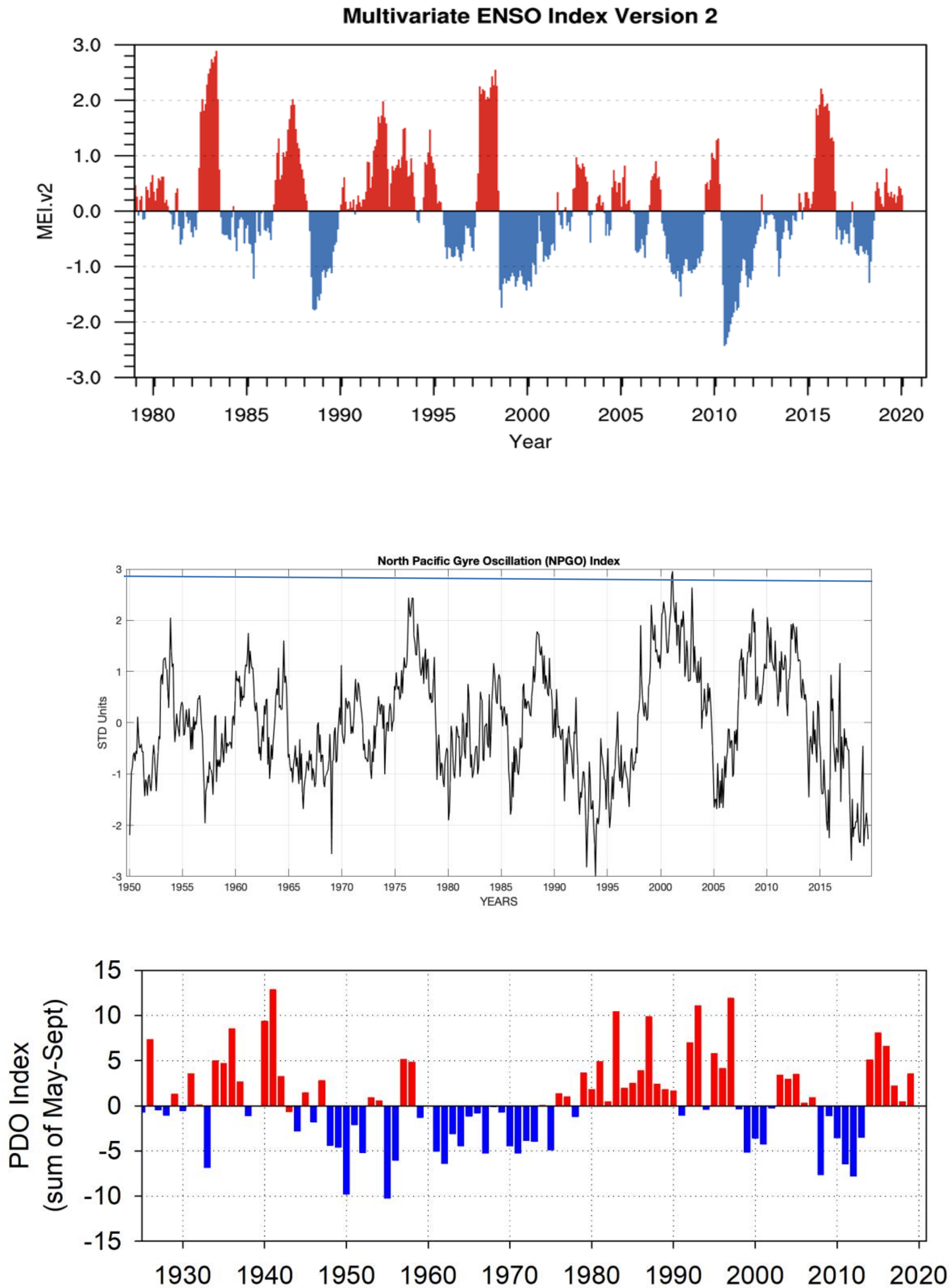


Figure 16. The Multivariate Enso Index (MEI), the North Pacific Gyre Oscillation Index (NPGO), and the Pacific Decadal Oscillation Index (PDO).

Table 8. Direction of swells in 2019. Source: http://cdip.ucsd.edu.

Direction	Oceanside	Pont Loma South
West (270º)	14%	26%
South (180º)	17%	17%
West-southwest (247.5º)	10%	7%
South-southwest (202.5º)	46%	29%
Southwest (225º)	13%	10%
West-northwest (292.5º)	2%	10%

High-energy waves that negatively affect kelp beds usually are low-frequency, high-amplitude waves approaching from the west. Wave heights at Oceanside (CDIP Buoy 045) only exceeded four meters on one date in 2019 (4.2 m on May 22) (Table 9). Wave heights were not as high as in 2018, when waves exceeded four meters in late February and late November/early December and reached a maximum of 4.9 m on both occasions (MBC 2019). 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 throughout the year.

Waves originated from the west at Point Loma South (CDIP Buoy 191) approximately one-fourth of the time in 2019. The largest waves (five meters or more) were recorded on April 10 (5.3 meters), May 23 (5.0 meters), and November 21 (5.5 meters). However, none of these waves were as large as those recorded in 2018, which exceeded six meters in early January (maximum of 7.5 meters), mid-January, mid-February, and late November/early December (MBC 2019). Waves larger than four meters were recorded on fewer occasions in 2019 than in 2018.

The storms that occurred from March 12 through 14 produced large wave heights (Table 9) and large nearshore swells were evident along the coastline from Oceanside to San Diego on March 13, 2019 (Figure 18), although the largest waves were observed offshore. The storms that occurred from April 10 through 13 also produced large swells along the coastline from Oceanside to San Diego, but once again the largest waves were offshore (Figure 19). Similar conditions were produced by the storms that occurred on May 22 and 23 (Figure 20).

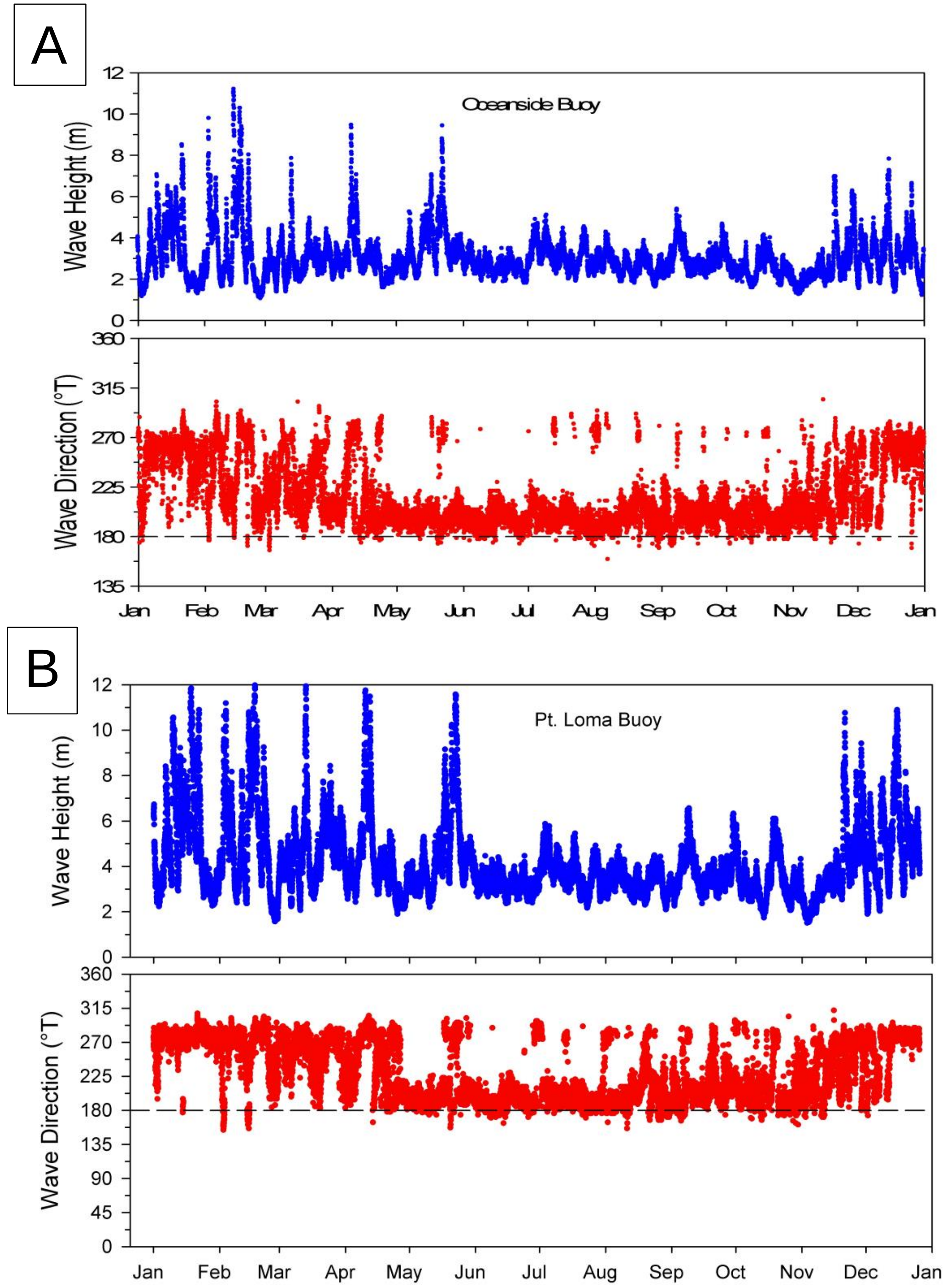


Figure 17. Wave height (blue) and direction (red) at: A) Oceanside Buoy and B) Point Loma Buoy from January through December 2019.

•

IV.2.F - RAINFALL

Periods of sustained high turbidity in southern California waters often result from high rainfall. Rainfall data for Costa Mesa and San Diego are shown in Figure 21.

The total amount of rainfall in 2019 was a little higher than normal for Costa Mesa (12.6 inches versus the long-term average of 11.4 in). Rainfall was much higher than normal during the months of February and December, lower than normal in January, March, April, September and October, and close to normal during November. Total rainfall in 2019 was approximately 50% higher than normal for San Diego (15.3 in versus the long-term average of 10.1 in). Rainfall in San Diego was higher than normal during the months of January, February, May, November, and December, but lower than normal during the months of March, April, September, and October.

These low rainfall levels were unlikely to generate any extended periods of high turbidity and would not be expected to have affected kelp beds in 2019.

Table 9. Large waves in 2019.

Date	Oceanside (maximum height in meters)	Point Loma South (maximum height in meters)
February 22	---	3.3
March 5	---	3.0
March 7/8/9	---	3.4/3.1/---
March 12/13/14	---/3.1/---	3.7/4.2/4.1
March 20/21/22/23/24	---/---/---/---/---	3.3/3.7/3.3/3.0/3.6
March 26/27	---/---	3.2/3.1
March 30	---	3.1
April 7/8	---/---	3.1/3.1
April 10/11/12/13	---/---/3.9/---	5.3/3.3/4.8/3.3
April 21/22	---/---	3.0/3.0
May 7	---	3.0
May 16/17/18	3.2/3.8/---/	---/---/3.4

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

Table 9 (continued). Large waves in 2019.

Date	Oceanside (maximum height in meters)	Point Loma South (maximum height in meters)
May 20	---	4.8
May 22/23	4.2/3.2	---/5.0
July 17	---	3.1
September 9	---	3.1
October 1	---	3.0
October 18/19	---/---	3.5/3.3
November 21	3.6	5.5
November 26	---	3.4
November 28/29	3.7/3.4	4.1/3.3
December 3	---	3.4
December 8	---	3.7
December 12/13/14/15/16/17	---/---/3.0/---/---/---	3.0/3.7/3.4/5.2/4.5/3.3
December 19/20/21	---/---/---	3.3/3.0/3.1
December 25/26	---/3.6	3.2/---

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

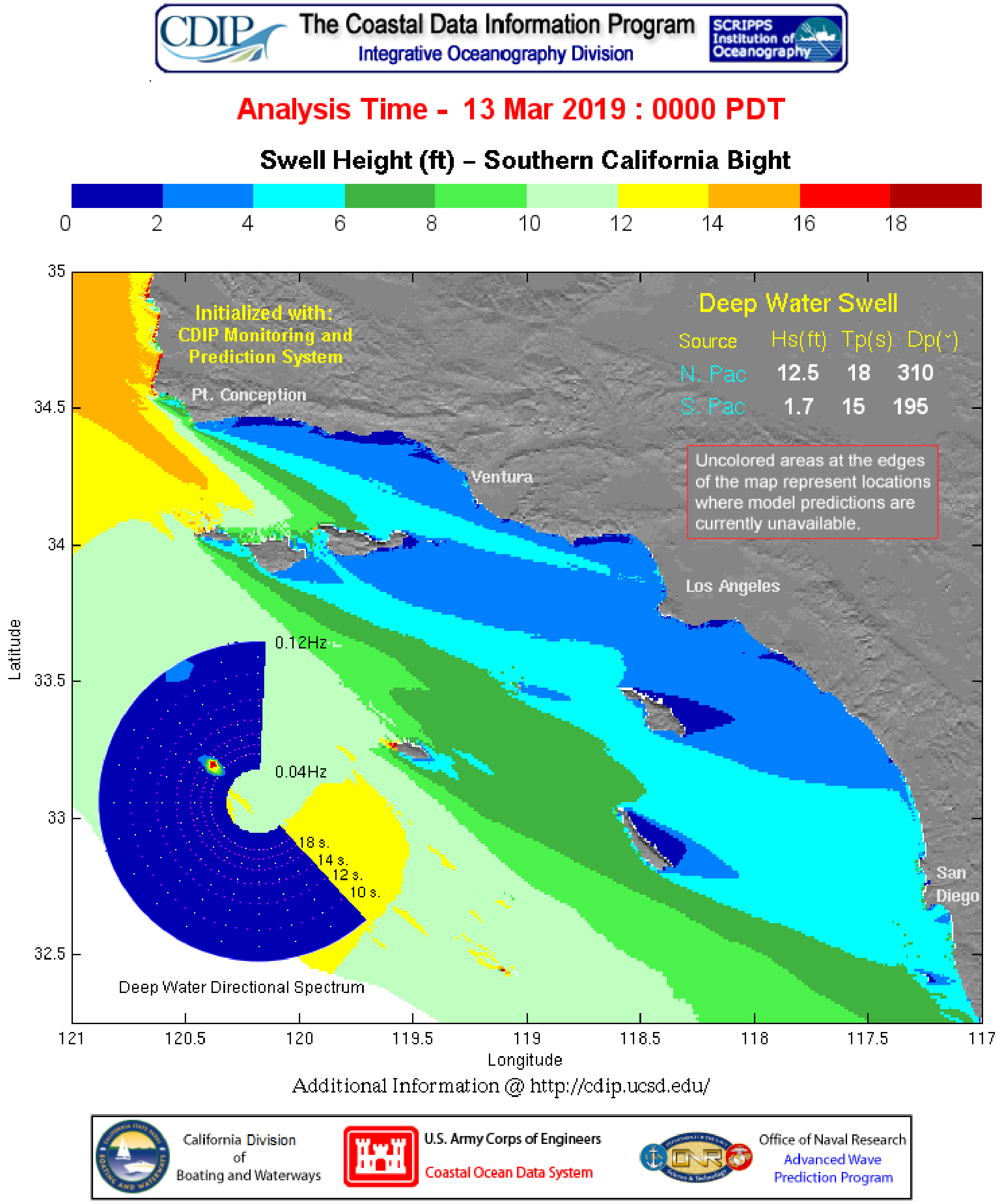


Figure 18. Swell height and direction in the Southern California Bight on March 13, 2019. Source: Coastal Data Information Program (CDIP), http://cdip.ucsd.edu/.

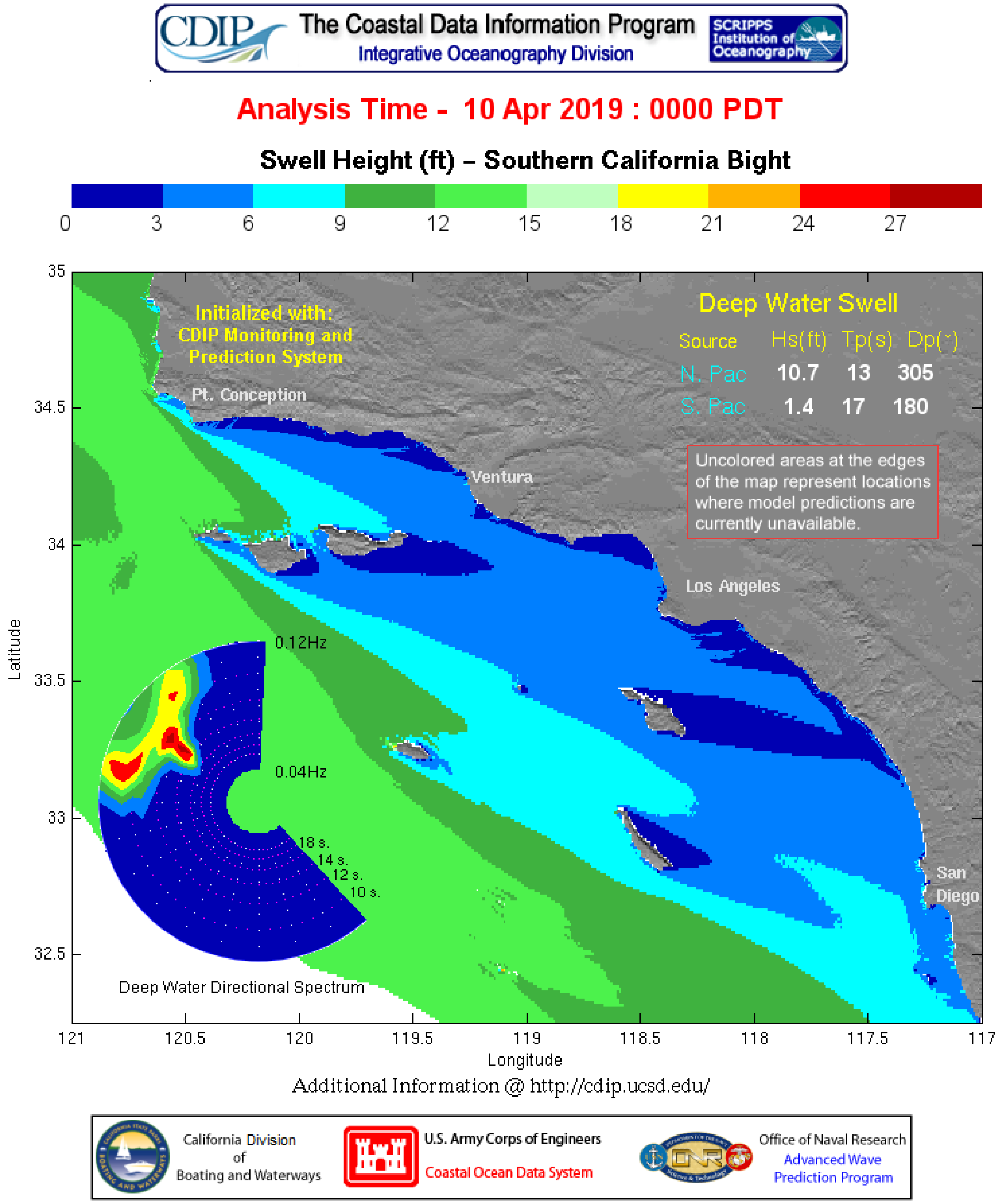


Figure 19. Swell height and direction in the Southern California Bight on April 10, 2019. Source: Coastal Data Information Program (CDIP), http://cdip.ucsd.edu/.

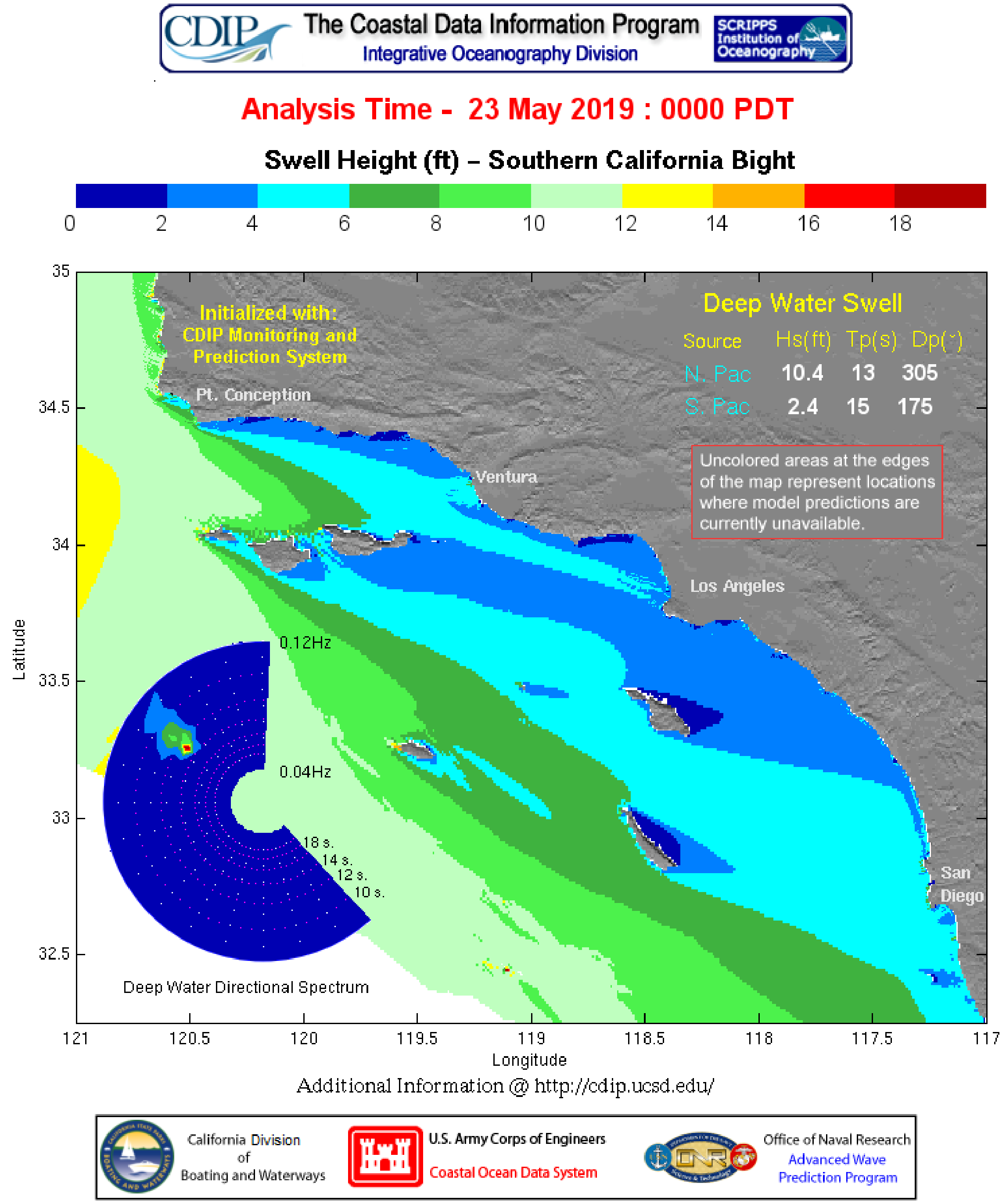


Figure 20. Swell height and direction in the Southern California Bight on May 23, 2019. Source: Coastal Data Information Program (CDIP), http://cdip.ucsd.edu/.

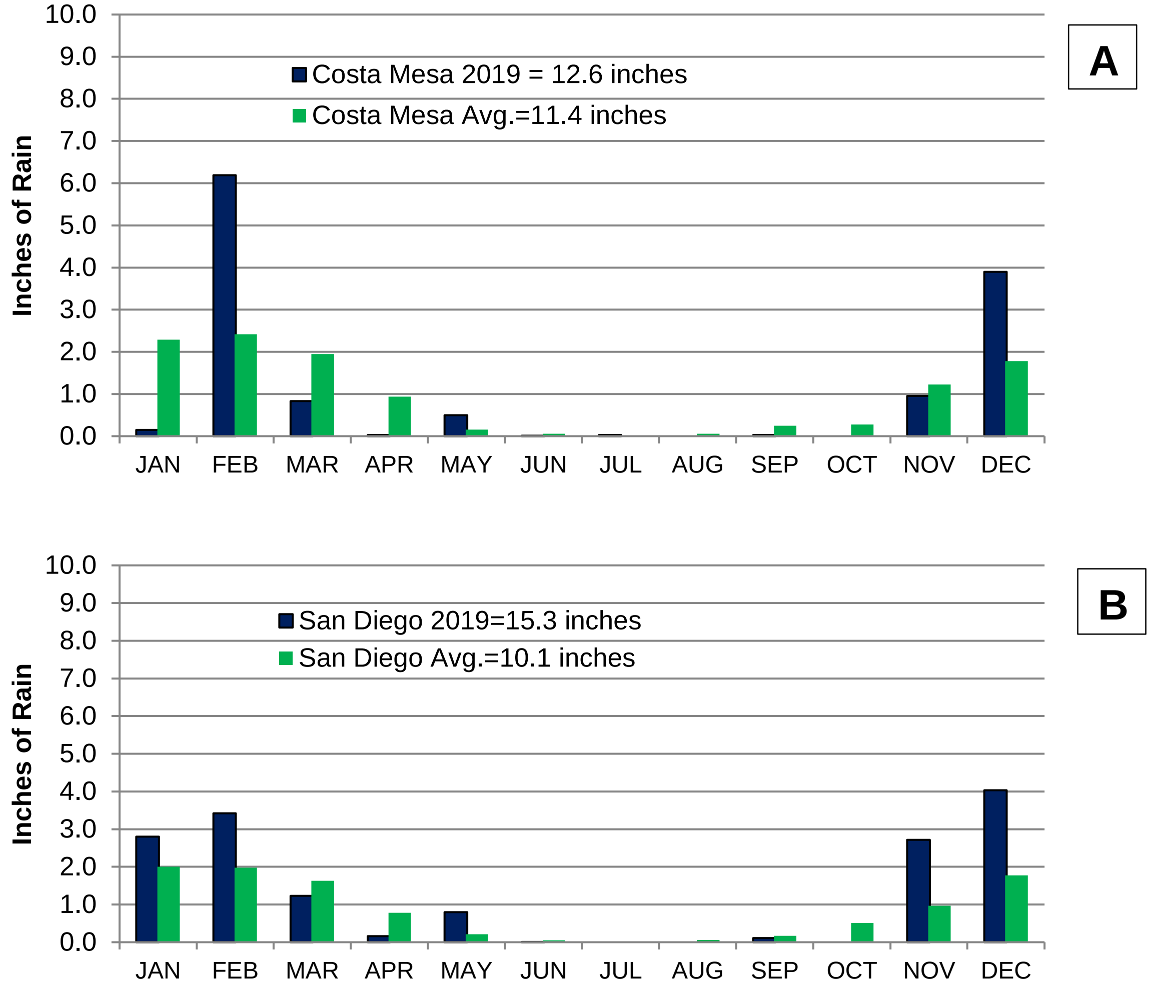


Figure 21. Monthly 2019 rainfall and average monthly rainfall recorded for (A) Costa Mesa, and (B) Lindbergh Field (San Diego).

IV.2.G - PHYTOPLANKTON

Harmful Algal Bloom (HAB) data were available in real time for certain locations via the SCCOOS website (**www.sccoos.org**).

Two phytoplankton groups associated with harmful algal blooms *Pseudo-nitzschia seriata* group and *Pseudo-nitzschia delicatissima* group were only recorded at Newport Pier during June 2019 (Figure 22 A and B). Domoic acid, a toxin produced by these groups, was not recorded at this location at any time throughout 2019. High concentrations of the *Pseudo-nitzschia seriata* group were recorded at Scripps Pier during April and June 2019, while high concentrations of the *Pseudo-nitzschia delicatissima* group were found throughout the year (March, April, June, September, October, and December) (Figure 23 A and B). However, domoic acid was not recorded at this location any time in 2019.

High concentrations of phytoplankton can effectively exclude light from all but the shallowest depths, which could limit 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 2019 appear unlikely to have impacted kelp beds.

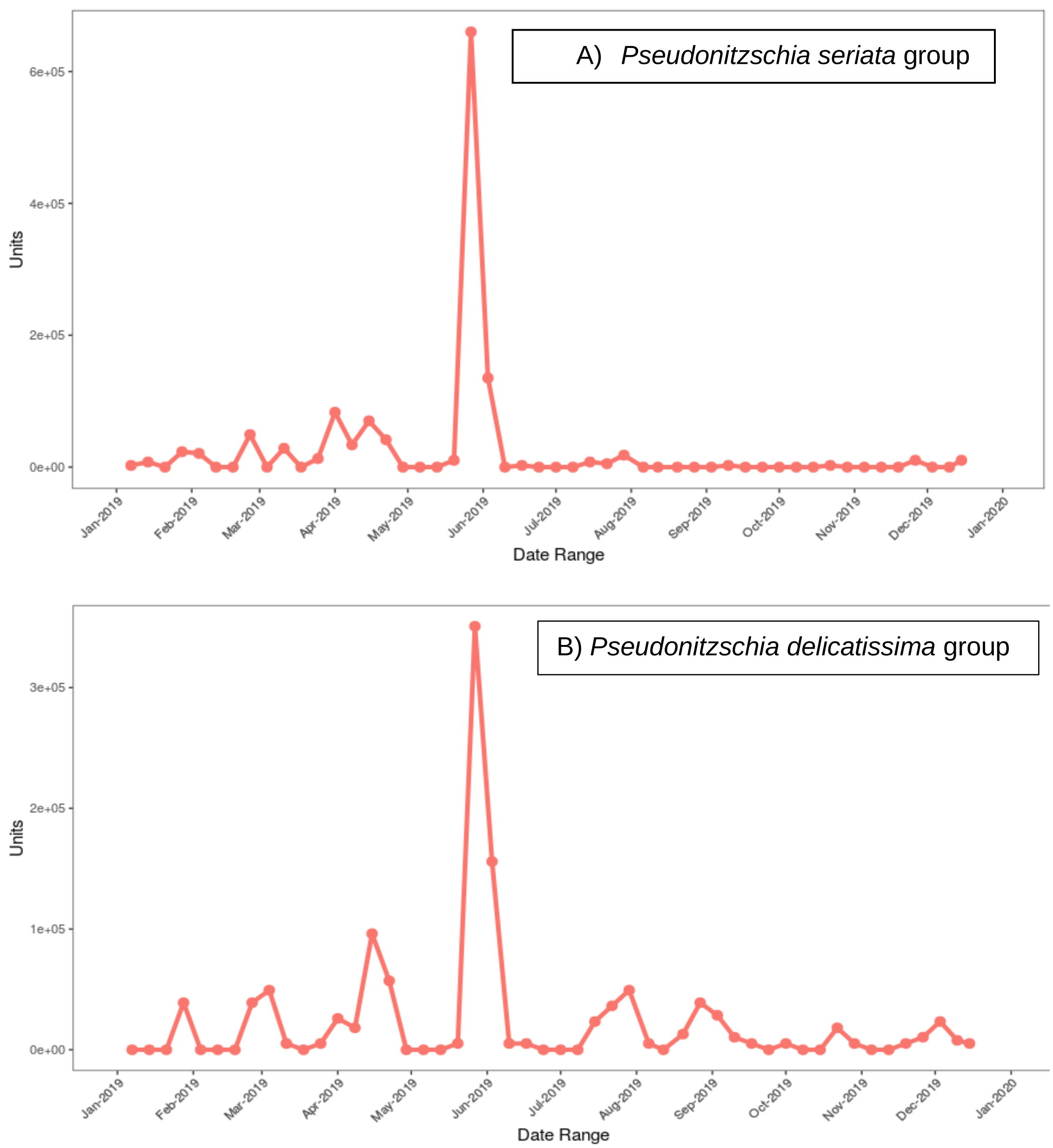


Figure 22. Phytoplankton Concentrations at Newport Pier in 2019.

Source: https://sccoos.org/harmful-algal-bloom/

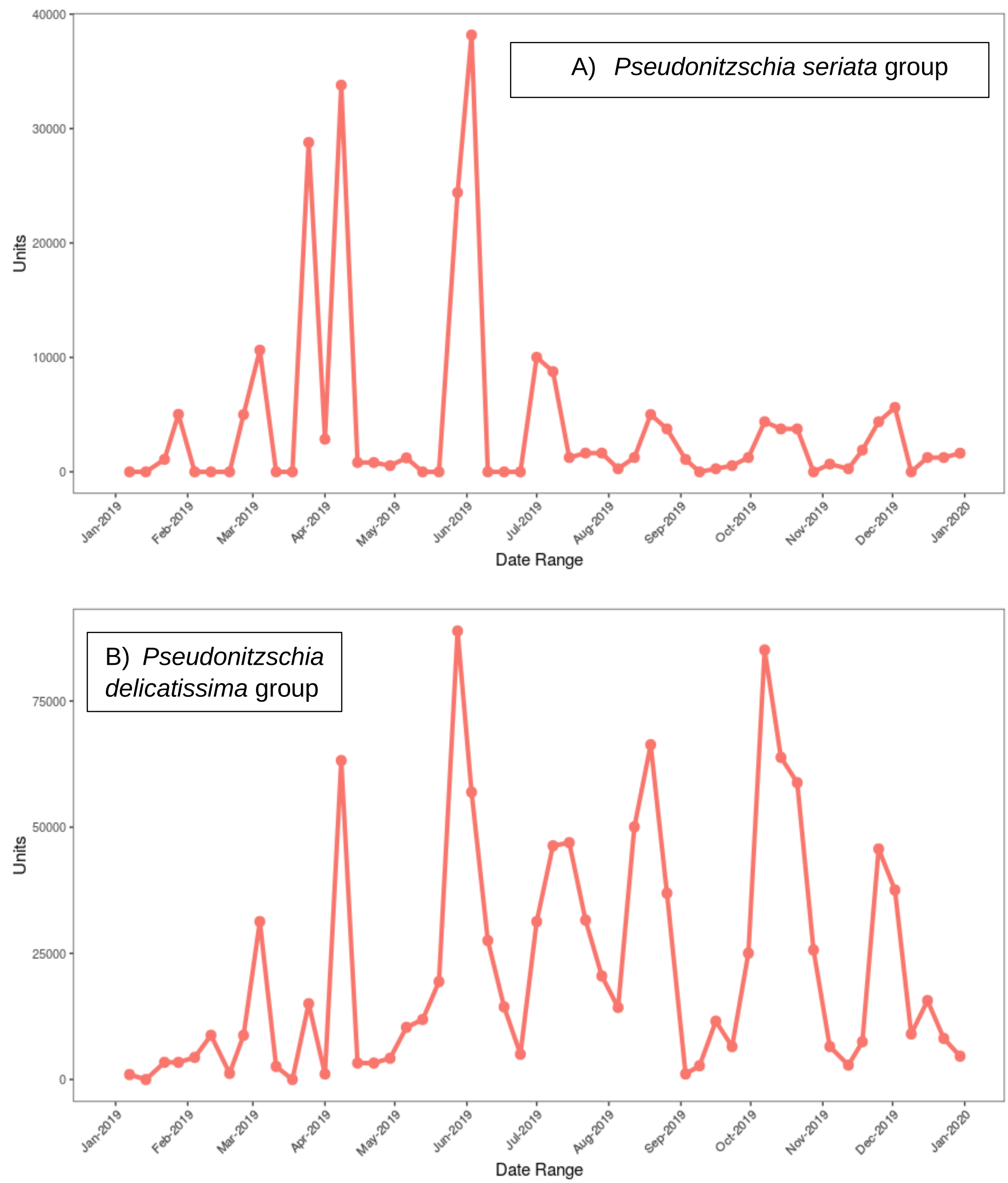


Figure 23. Phytoplankton Concentrations at Scripps Pier in 2019.

Source: https://sccoos.org/harmful-algal-bloom/

IV.3 - KELP RESTORATION

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 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. However, SCE determined that the 174-acre San Clemente reef was 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 construct an additional 210-acre kelp reef to expand the existing 174-acre Wheeler North Reef. SCE proposed to place 175,000 tons of quarried rock in 23 new polygons north and inshore of the existing reef. The expansion project was scheduled to begin in July 2019 and is expected to be completed in 2020.

IV.4 - KELP HARVESTING

CDFW has designated 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, may not allow cut kelp to escape from harvest, must weigh and report the amount harvested, and must 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.

CDFW is currently reviewing its Management Policies and Harvest Methods guidance document and is drafting several proposed new regulations governing commercial harvest of wild kelp and algae (Rebecca Flores-Miller, pers. comm.). There is no timetable to bring these proposed regulations to the CDFW Commission for adoption during 2020, due to a shortage of staff resources during the COVID 19 pandemic. In the near future, CDFW also plans to review its Royalty Rates and License Fees schedule for commercial harvesters. The royalty rates for kelp were established 24 years ago at $1.71 per wet ton, and the rates for edible seaweed and agar were established 35 years ago at $24 and $17 per wet ton, respectively.

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* spp.), and sea lettuce (*Ulva* species).

Recreational harvesters are prohibited from harvesting or disturbing eelgrass (*Zostera* spp.), surfgrass (*Phyllospadix* spp.), 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 Region Nine study area is shown in Figure 24. Kelp areas 1 and 2 are open, 3 is leased, 4, 5, and 6 are leasable (except for portions that are closed within marine protected areas), 7, 8, and 9 are open (except for portions of 9 that are closed within marine protected areas), and 10 is closed.

Commercial marine algae harvest data are shown in Figure 25 for the period from 1931 to 2019 (**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 (fewer than 5,000 metric tons per year).

Table 10 shows how the RNKSC kelp bed designations correspond to the State of California's administrative lease kelp bed designations. Multiple RNKSC kelp beds fall within each of 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 the California Department of Fish and Wildlife (CDFW) 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 m^2. 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 Fish & Game Commission of $3.00 per wet ton of kelp harvested. Knocean Sciences planned to harvest giant kelp from May through November via mechanical harvesting from vessels specially modified for this purpose. The lease renewal was approved by CDFW in June 2018. CDFW 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 25). However, kelp harvesting has been relatively low (fewer than 5,000 metric tons per year) since 2006. It is unlikely that this low amount of kelp harvesting has had any impact on the health of the kelp beds in Region Nine.

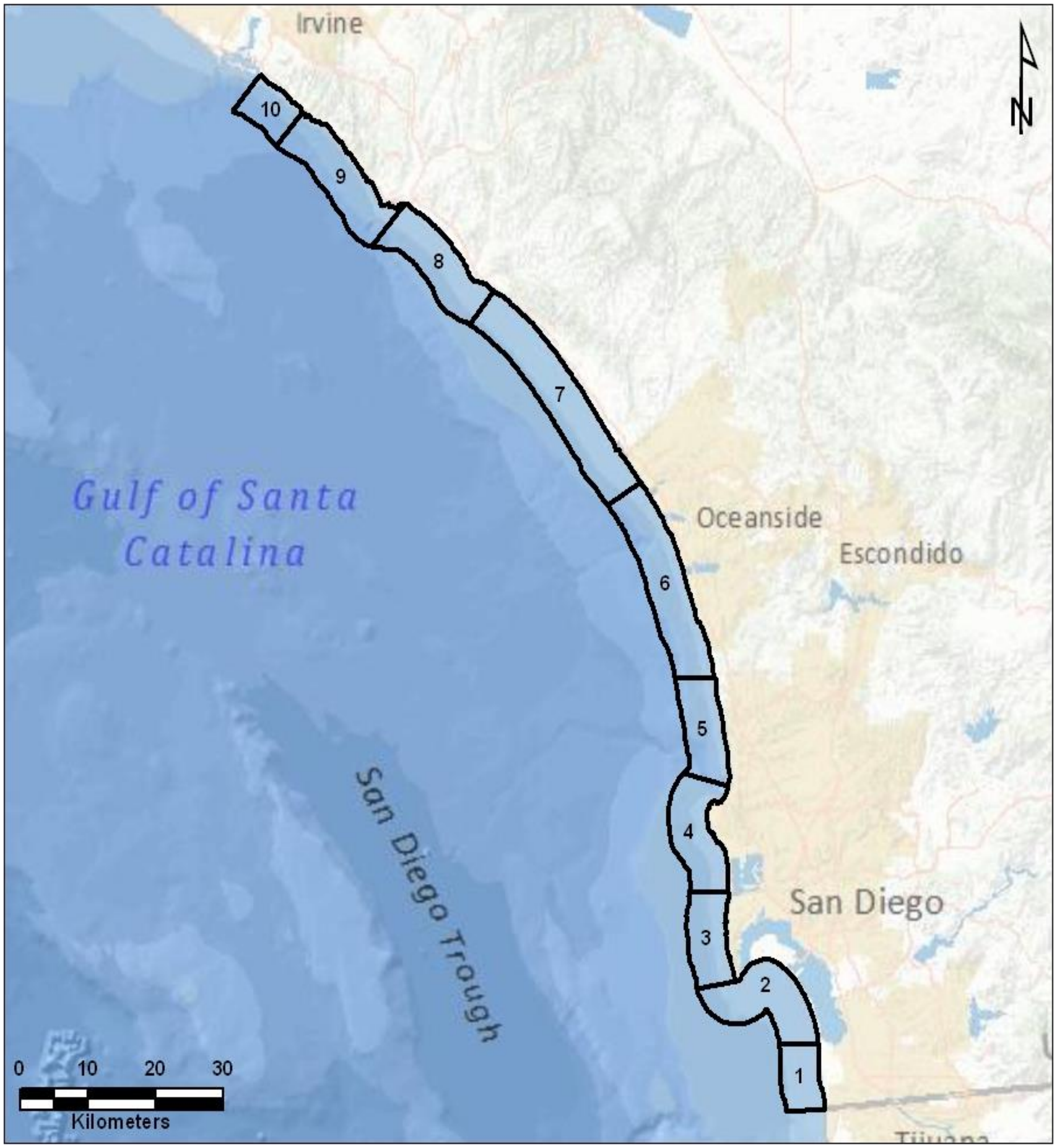


Figure 24. Administrative kelp bed lease areas in the Region Nine study area.

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

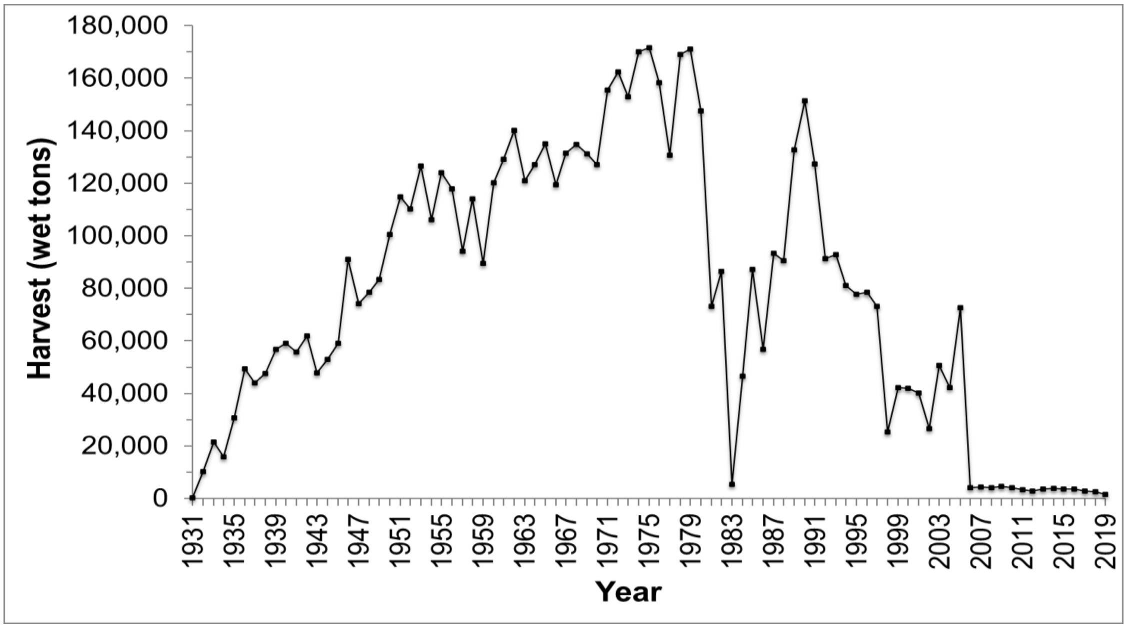


Figure 25. Commercial kelp harvest landings for giant and bull kelp from 1931 through 2019. Source: California Department of Fish and Wildlife (https://www.wildlife.ca.gov/Conservation/Marine/Kelp/Commercial-Harvest).

Table 10. Region Nine kelp bed designations compared to California Department of Fish and Wildlife kelp bed designations.

F & W Lease Area	Region Nine Kelp Bed Designations
Bed 1	Imperial Beach
Beds 2 and 3	Point Loma
Bed 4	La Jolla
Bed 5	Leucadia, Encinitas, Cardiff, Solana Beach, Del Mar, Torrey Pines
Bed 6	North Carlsbad, Agua Hedionda, Encina Power Plant, Carlsbad State Beach
Bed 7	Horno Canyon, Barn Kelp, Santa Margarita
Bed 8	San Clemente, San Mateo Point, San Onofre
Bed 9	North Laguna Beach, South Laguna Beach, South Laguna, Dana Point/Salt Creek, Capistrano Beach

V - UPDATE TO PRESENT

The first aerial survey for 2020 was conducted on April 15, 2020. Little or no kelp surface canopy was observed throughout most of Region Nine. However, the La Jolla Lower and Point Loma kelp beds were extensive, although surface canopy was lower than the maximum observed in 2019 (except for lower Point Loma, which was similar). The second aerial survey was conducted on July 5, 2020. Once again, little or no kelp surface canopy was observed throughout most of the region.

VI - CONCLUSIONS

Total combined kelp surface canopy decreased substantially (by 53%) in 2019 in Region Nine. More than half of the kelp beds observed in 2018 disappeared in 2019 (10 out of 18), while none reappeared. The total kelp canopy in Region Nine covered approximately 5.2 km^2 in 2019, similar to the total amount recorded in 2016 (5.1 km^2), but larger than the total for 2017 (3.3 km^2), which was the lowest amount of total kelp canopy since 2006. The largest beds were the La Jolla and Point Loma kelp beds, accounting for 99% of the total canopy coverage in 2019.

Water temperatures throughout the RNKSC areas generally were warmer than average throughout most of 2019, particularly from September through December. However, lower than normal temperatures were recorded at Newport Pier during most of April, May, and August, as well as at times during March, June, and July. Lower than normal water temperatures also were recorded at Scripps Pier at times from February through October, particularly during the months of June, July and August. Daily sea surface temperature values rarely fell below 14°C (a threshold below which nutrient availability is much greater than at higher water temperatures) at Newport Pier and Scripps Pier, and never fell below this threshold at Oceanside or Point Loma South.

Nutrient availability continued to be low in 2019. Upwelling in 2019 (at a location approximately 161-km west of Solana Beach) generally increased each month from January through August, then decreased through December. Upwelling in 2019 was much higher than the long-term mean during the months of July and August, but lower during March, May and June. Upwelling was lower in 2019 than during 2018 for the months of March, April, May and June, when surface water temperatures generally were lower and nutrient availability would be increased. Although upwelling was higher in 2019 than the previous year during the months of July, August, and September, this corresponded to the period of the year when surface water temperatures were highest and nutrient availability would be decreased.

VII - REFERENCES

California Dept. of Fish and Wildlife. 2019. Commercial marine algae harvest data. Web site: https://www.wildlife.ca.gov/Conservation/Marine/Kelp/Commercial Harvest.

City of San Diego. 2020. Thermistor data from offshore Point Loma.

Di Lorenzo, E. 2017. Monthly North Pacific Gyre Oscillation (NPGO) index values. Web site: http://www.o3d.org/npgo/npgo.php

Di Lorenzo, E., N. Schneider, K. Cobb, P. Franks, K. Chhak, A. Miller, J. Mcwilliams, S. Bograd, H. Arango, and E. Curchitser. 2008. North Pacific Gyre Oscillation links ocean climate and ecosystem change. Geophys. Res. Lett. 35:L08607.

Gallegos, C.L. and T.E. Jordan. 2002. Impact of the Spring 2000 phytoplankton bloom in Chesapeake Bay on optical properties and light penetration in the Rhode River, Maryland. Estuaries 25(4A): 508-518.

Gallegos, C.L. and P.W. Bergstrom. 2005. Effects of a *Prorocentrum* minimum bloom on light availability for and potential impacts on submersed aquatic vegetation in upper Chesapeake Bay. Harmful Algae 4(3): 553-574.

Gerard, V.A. 1982. *In situ* rates of nitrate uptake by giant kelp, *Macrocystis pyrifera* (L.) C. Agardh: tissue differences, environmental effects, and predictions of nitrogen limited growth. Journal of Experimental Marine Biology and Ecology 62: 211-224.

Haines, K.C. and P.A. Wheeler. 1978. Ammonium and nitrate uptake by the marine macrophytes *Hypnea musciformes* (Rhodophyta) and *Macrocystis pyrifera* (Phaeophyta). Journal of Phycology 14: 319-324.

Kamykowski, D. and S.J. Zentara. 1986. Predicting plant nutrient concentrations from temperature and sigma-t in the world ocean. Deep Sea Research 33:89-105.

Leising, A.W., I.D. Schroeder, S.J. Bograd, J. Abell, R. Durazo, G. Gaxiola-Castro, CICESE, E. Bjorkstedt, J. Field, K. Sakuma, R. Goericke, W.T Peterson, R.D. Brodeur, C. Barcelo, T.D. Auth, E.A. Daly, R.M. Suryan, A.J. Gladics, J.M. Porquez, S. McClatchie, E.D. Weber, W. Watson, J.A. Santora, W.J. Sydeman, S.R. Melin, F.P. Chavez, R.T. Golightly, S.R. Schneider, J. Fisher, C. Morgan, R. Bradley, and P.Warybok. 2015. State of the California Current 2014–15: Impacts of the Warm-Water “Blob”. CalCOFI Rep. 56:31-68.

Mantua, N. 2017. Standardized values for the Pacific Decadal Oscillation (PDO) index. Web site: http://research.jisao.washington.edu/pdo/PDO.latest

MBC Applied Environmental Sciences. 2019. Status of the Kelp Beds 2016 Survey. Prepared for the Central Region Kelp Survey Consortium and the Region Nine Kelp Survey Consortium. 86 p. plus appendices.

National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory (ESRL). 2019. Multivariate ENSO Index. Web site: http://www.esrl.noaa.gov/psd/enso/mei/index.html

National Oceanic and Atmospheric Administration (NOAA) National Data Buoy Center (NDBC). 2019. Data Buoys. Web site: http://www.ndbc.noaa.gov

National Oceanic and Atmospheric Administration (NOAA) Pacific Fisheries Env. Lab. (PFEG). 2019. Web site: http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/upwelling/NA

National Oceanic and Atmospheric Administration (NOAA) Southwest Fisheries Sci. Center (SWFSC) Env. Res. Div. (ERD). 2019. Web site: https://swfsc.noaa.gov/erd/

North, W.J., D.E. James and L.G. Jones. 1993. History of kelp beds in Orange and San Diego Counties, California. Hydrobiologia 260/261:277-283.

North, W.J. 2001. Analysis of aerial survey data & suggestions for follow-up activities. Prepared for the Region Nine Kelp Survey Consortium. 27 p. plus appendices.

North, W.J. and MBC Applied Environmental Sciences. 2001. Status of the kelp beds of San Diego and Orange Counties for the years 1990 to 2000. Prepared for the Region Nine Kelp Survey Consortium. Costa Mesa, CA.

Orange County Sanitation District. 2020. Thermistor data from offshore Orange County.

Parnell, P.E., E.F. Miller, C.E. Lennert-Cody, P.K. Dayton, M.L Carter, and T.D. Stebbins. 2010. The response of giant kelp (*Macrocystis pyrifera*) in southern California to low-frequency climate forcing. Limnology and Oceanography 55(6) 2686-2702.

SCCOOS (Southern California Coastal Ocean Observing System). 2019. HAB and ROMS data. Web site: http://www.sccoos.org.

Schiel, D.R. and M.S. Foster. 2015. The biology and ecology of giant kelp forests. University of California Press. 395 pages.

Tegner, M.J., P.B. Edwards and K.C. Riser. 1996. Is there evidence for long-term climatic changes in southern California kelp forests? California Cooperative Fisheries Investigative Report 37:111-126.

Wheeler, P.A. and W.J. North. 1980. Effect of nitrogen supply on nitrogen content and growth rates of juvenile *Macrocystis pyrifera* (Phaeophyta) sporophytes. Journal of Phycology 16:577-582.

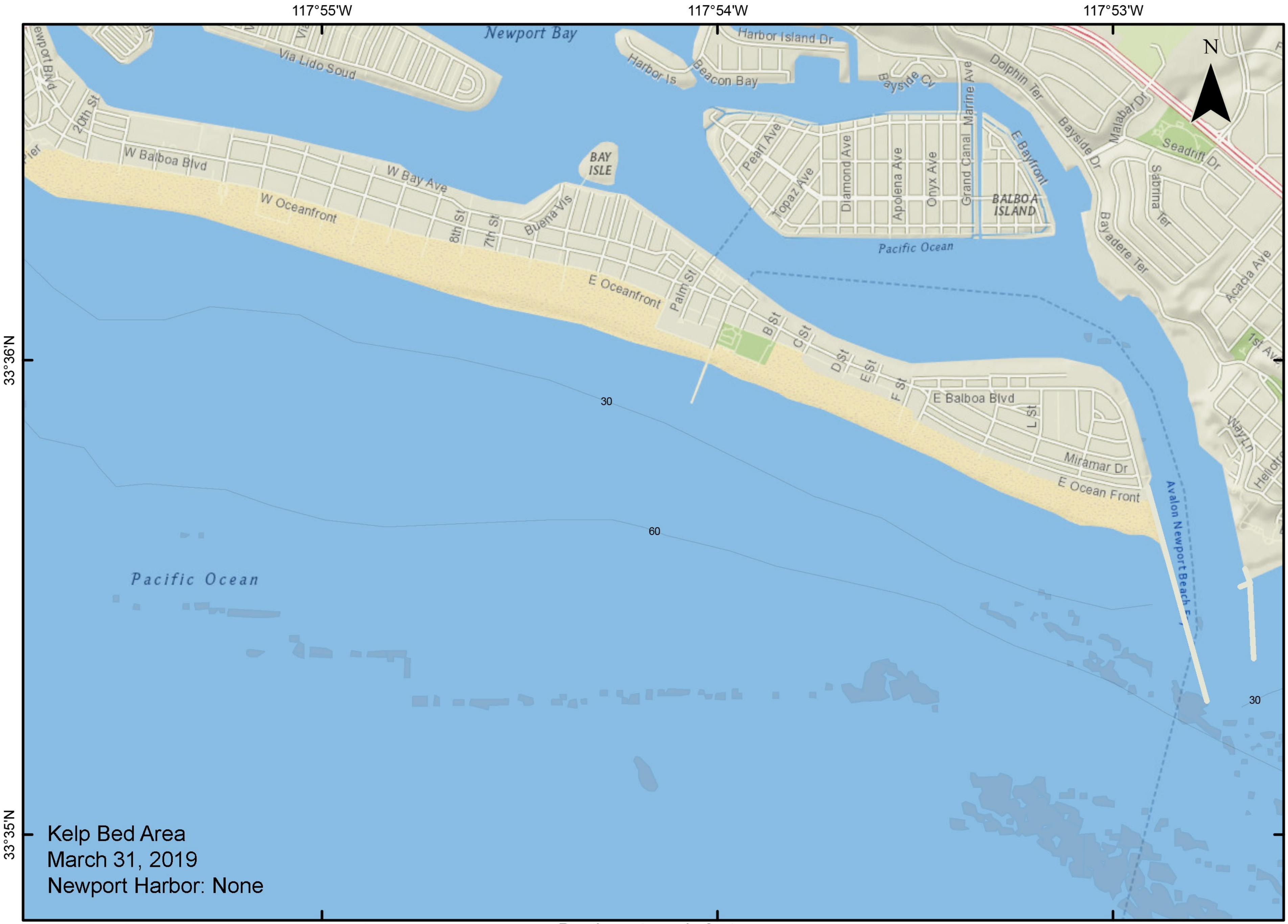
Zimmerman, R.C. and J.N. Kremer. 1984. Episodic nutrient supply to a kelp forest ecosystem in southern California. Journal of Marine Research 42:591-604.

PERSONAL COMMUNICATIONS

Flores-Miller, R. 2020. Rebecca Flores-Miller, California Department of Fish and Wildlife, Environmental Scientist. Commercial Kelp and Other Marine Algae Outreach Meeting, June 2, 2020.

APPENDIX A

Kelp Canopy Maps



1 stat. mi.

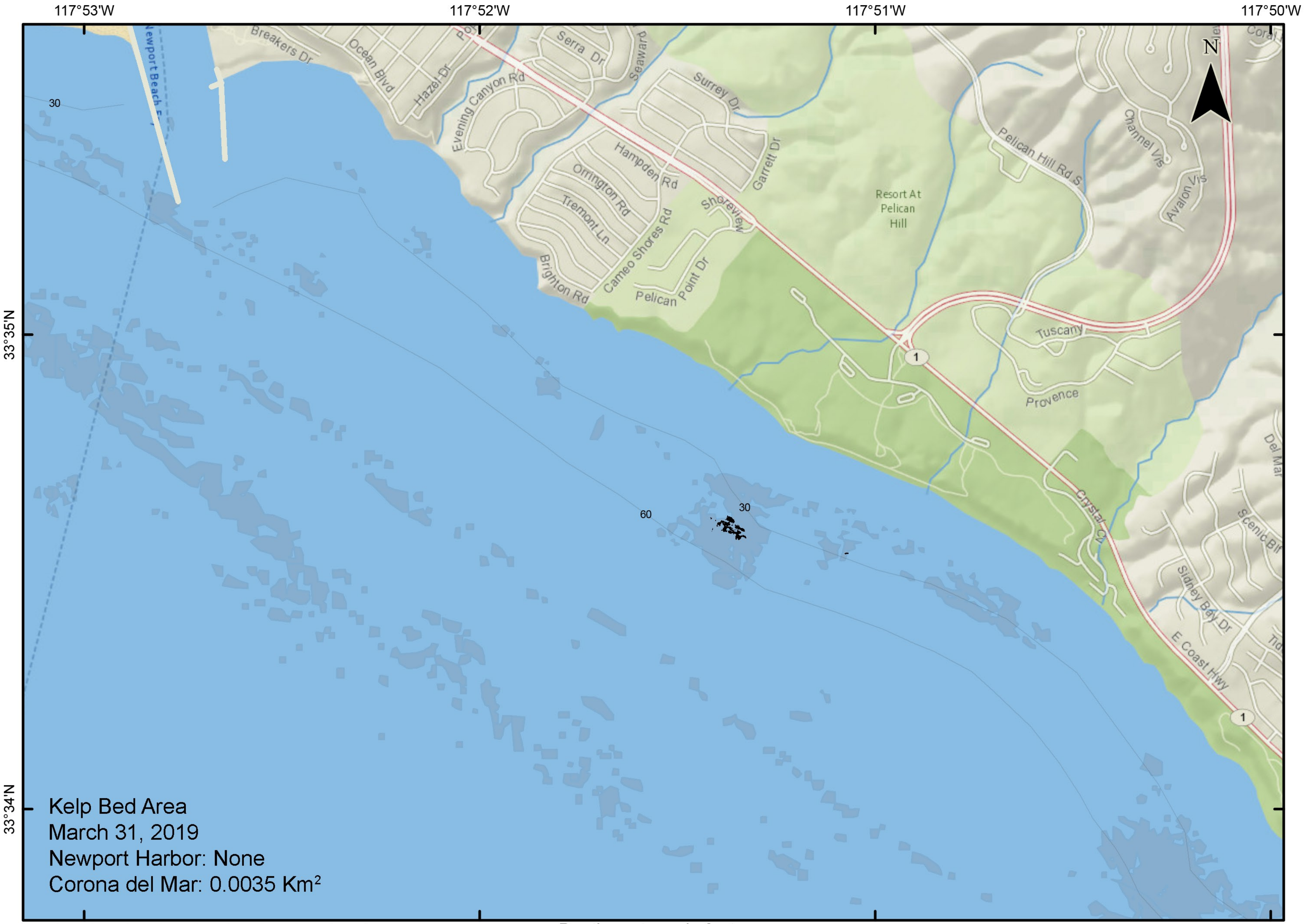
1 Km.

1:24,000

Depth contours in feet

Kelp	Artificial Reef
Isobath	Discharge Structure
Kelp Bed Divide	Hard Substrate

Appendix A.40
Newport Harbor



1 stat. mi.

1 Km.

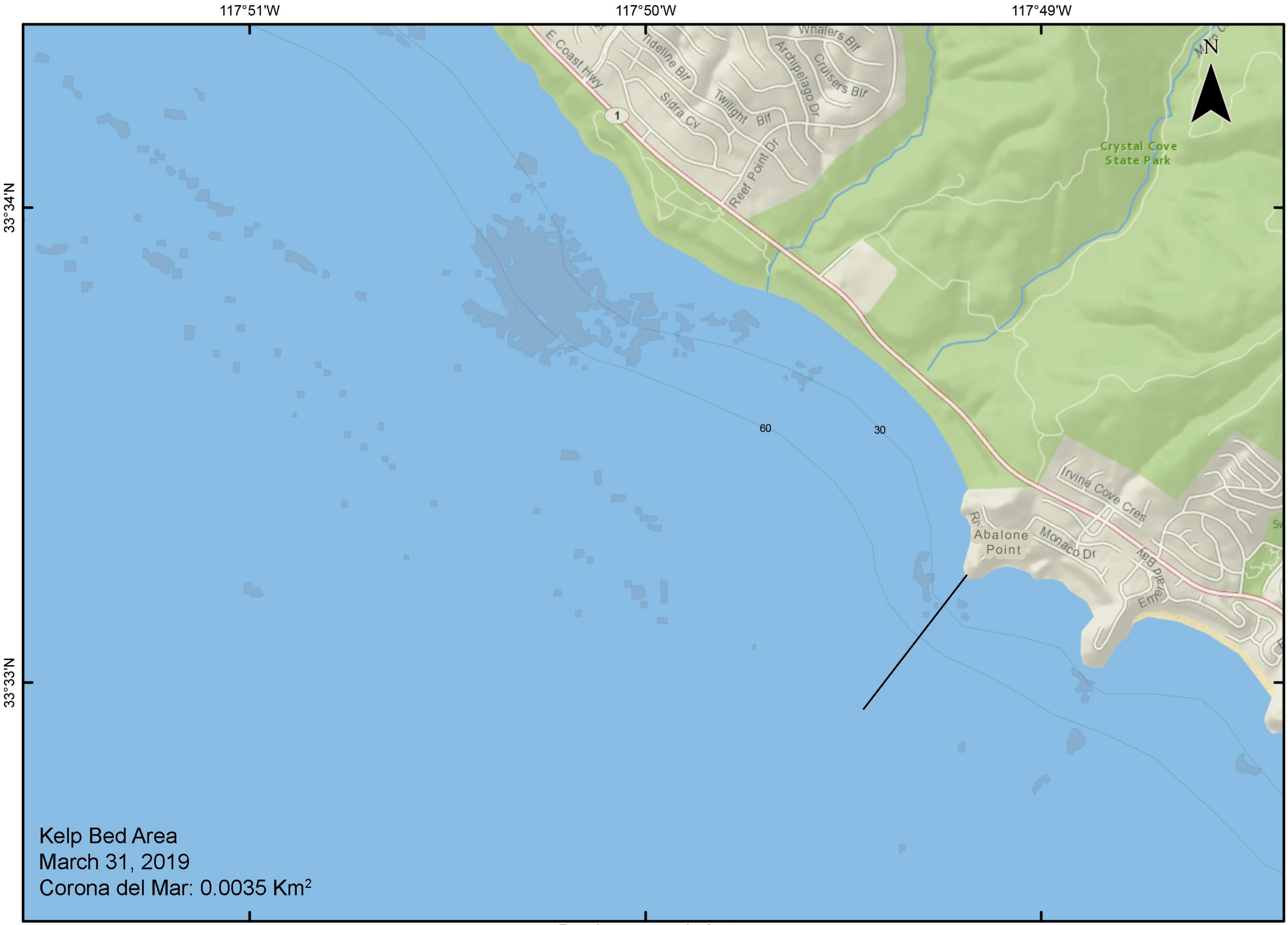
1:24,000

Depth contours in feet

Kelp	Artificial Reef
Isobath	Discharge Structure
Kelp Bed Divide	Hard Substrate

mbc AQUATIC SCIENCES

Appendix A.41
Corona del Mar North



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

Kelp

Isobath

Kelp Bed Divide

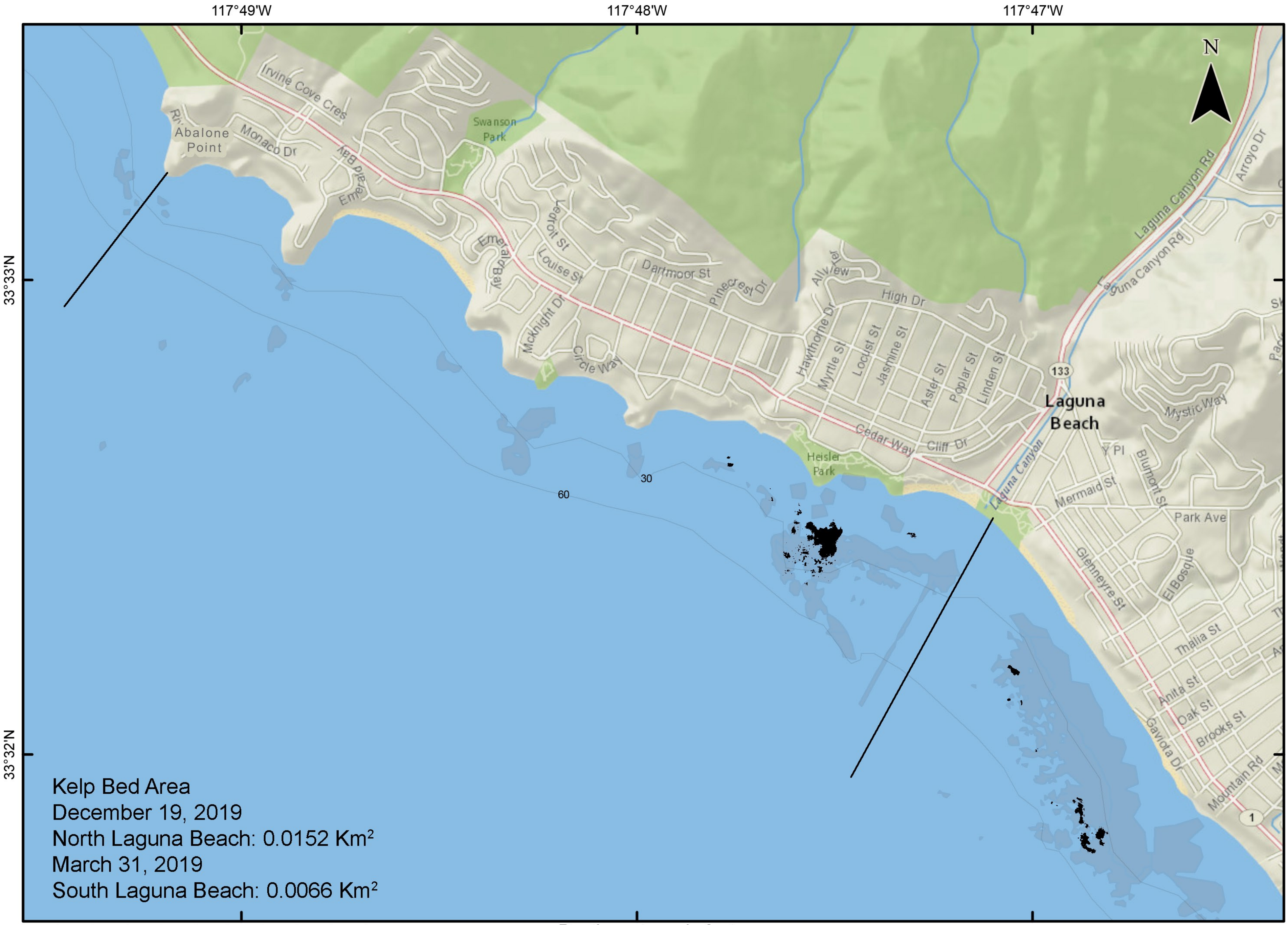
Artificial Reef

Discharge Structure

Hard Substrate

Appendix A.42
Corona del Mar South

mbc AQUATIC SCIENCES



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

Kelp

Isobath

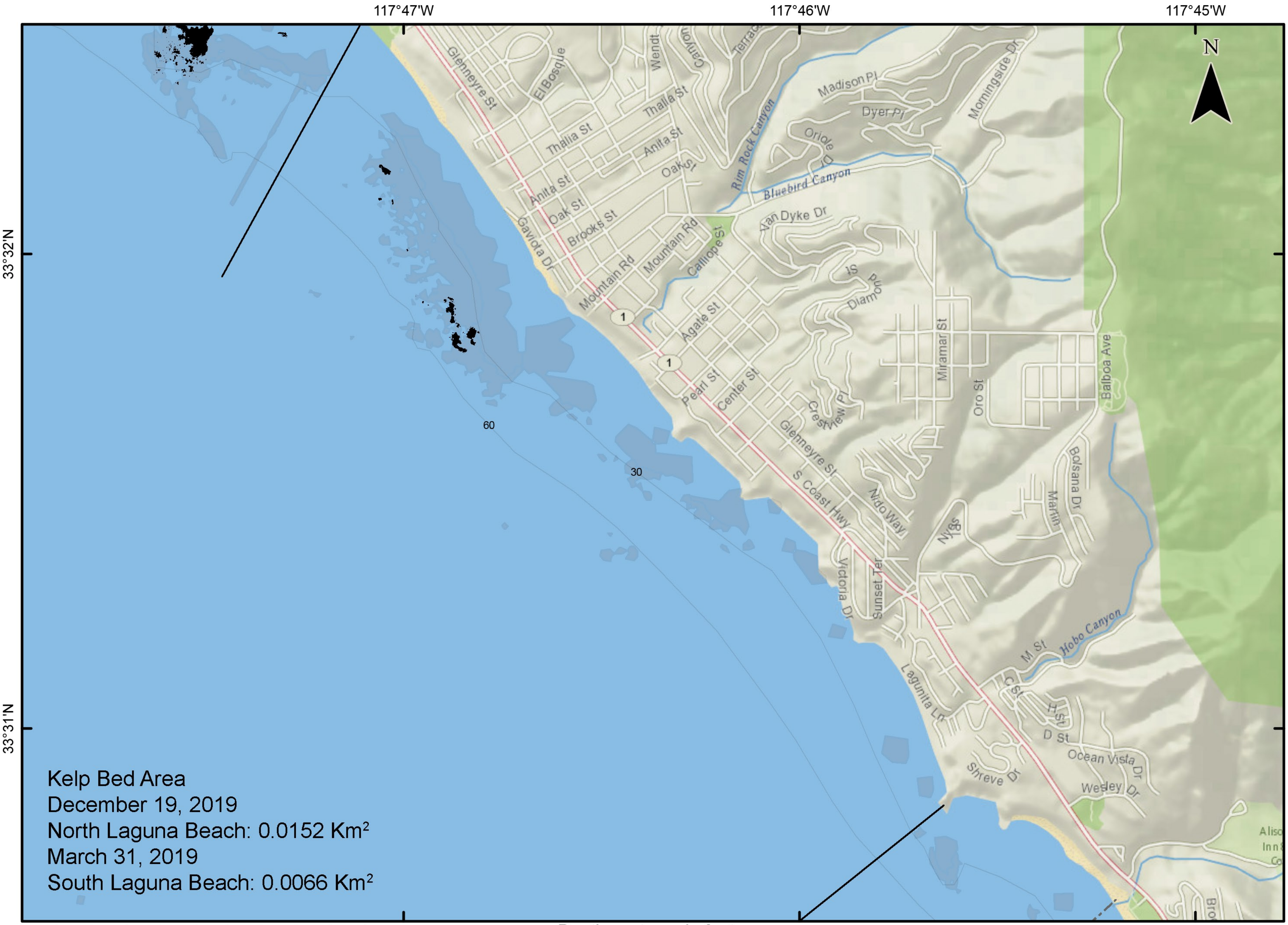
Kelp Bed Divide

Artificial Reef

Discharge Structure

Hard Substrate

Appendix A.43
Laguna North



Kelp Bed Area
December 19, 2019
North Laguna Beach: 0.0152 Km²
March 31, 2019
South Laguna Beach: 0.0066 Km²

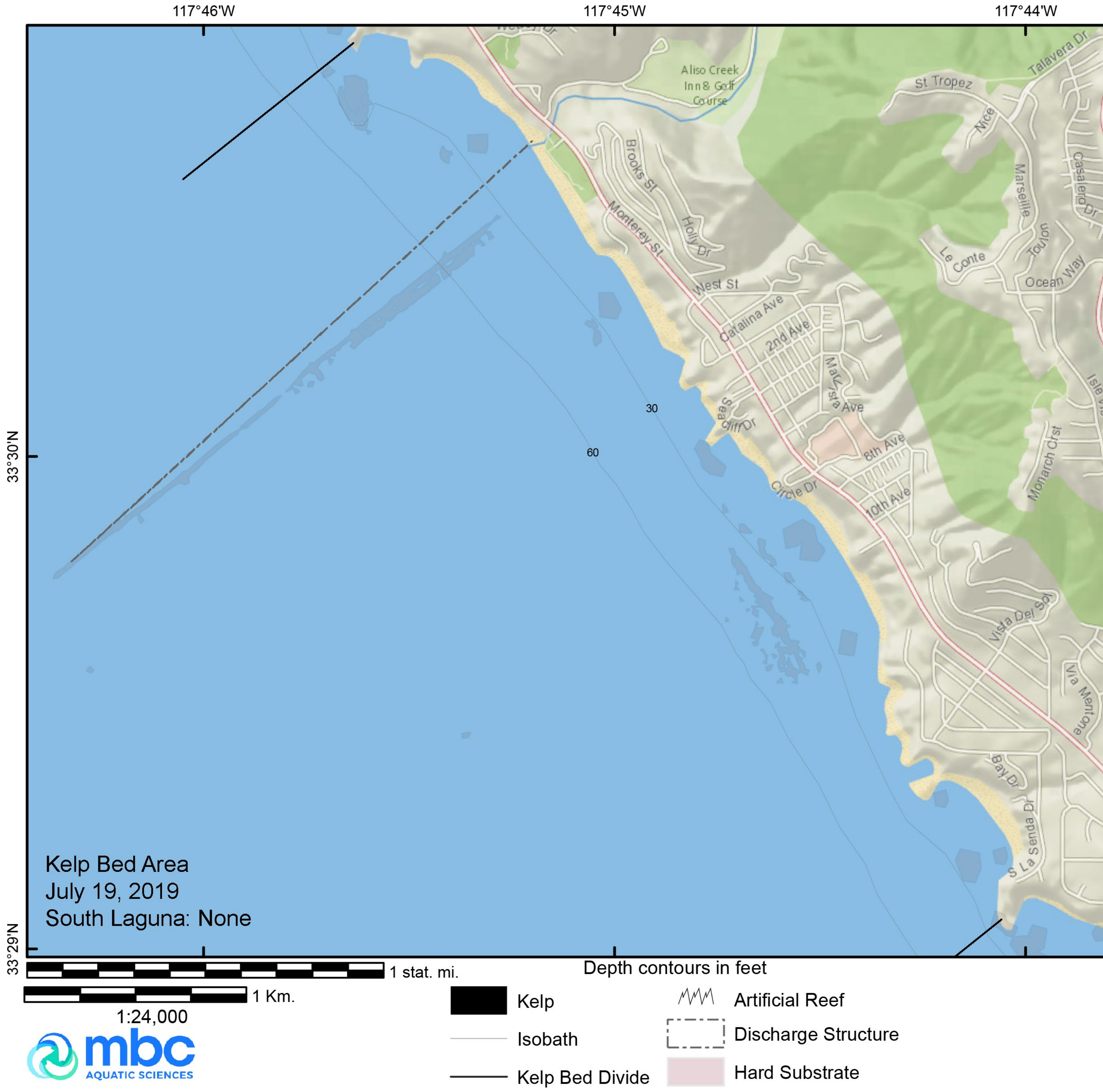
1 stat. mi.
1 Km.
1:24,000

Depth contours in feet

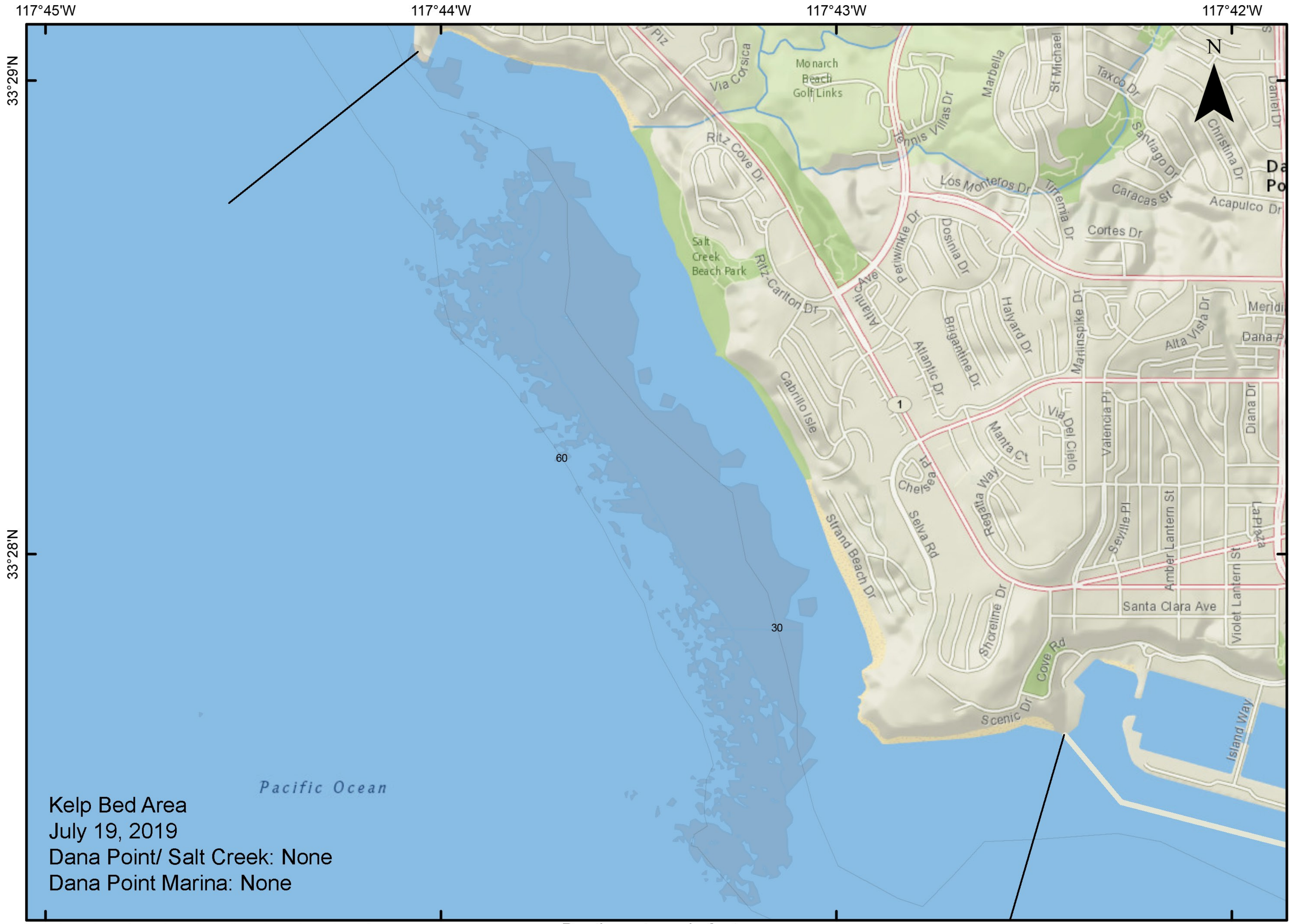
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

mbc AQUATIC SCIENCES

Appendix A.44
Laguna South



Appendix A.45
Laguna South



1 stat. mi.

1 Km.

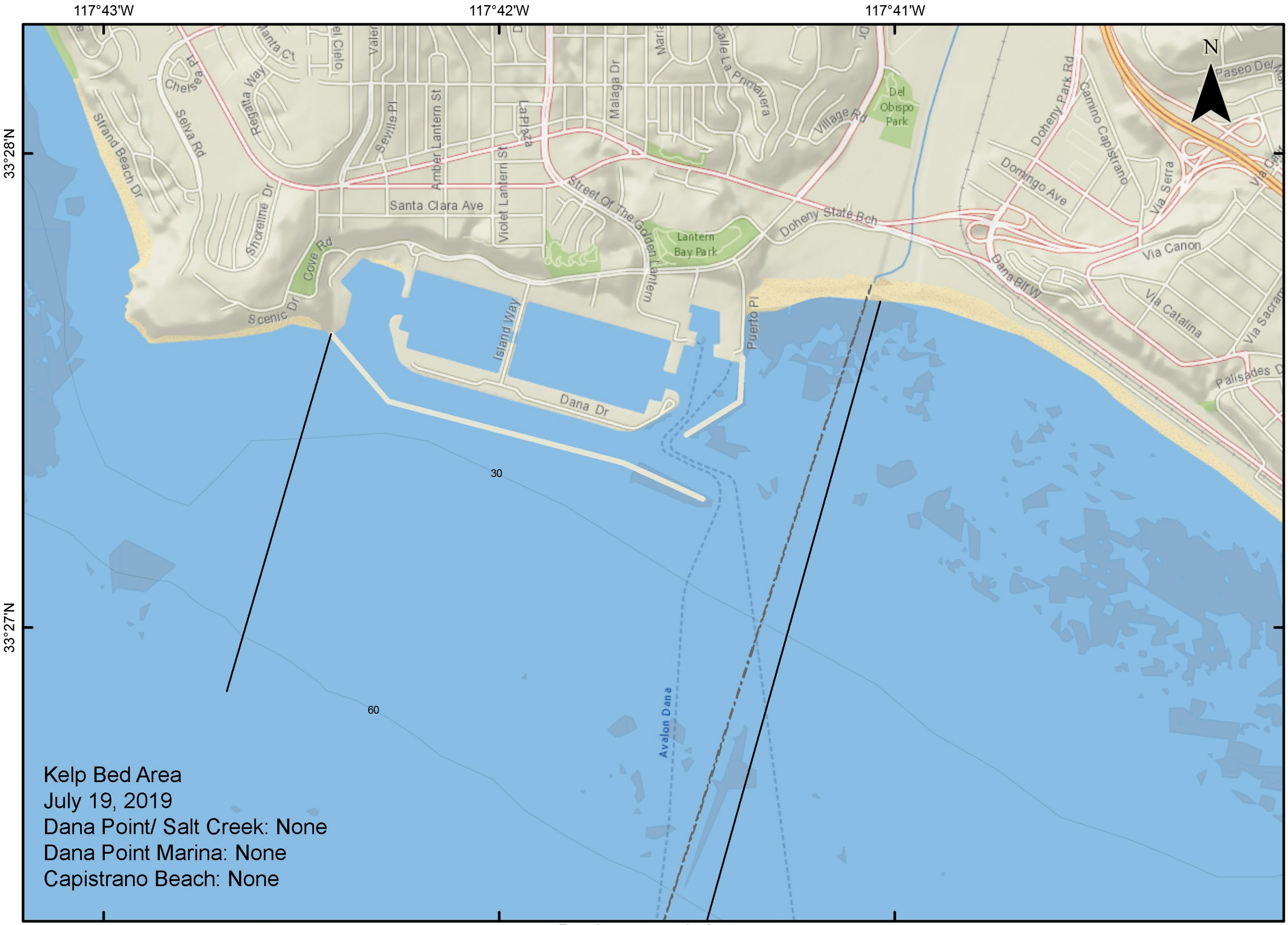
1:24,000

Depth contours in feet

Kelp	Artificial Reef
Isobath	Discharge Structure
Kelp Bed Divide	Hard Substrate

mbc AQUATIC SCIENCES

Appendix A.46
Dana Point/Salt Creek



1 stat. mi.

1 Km.

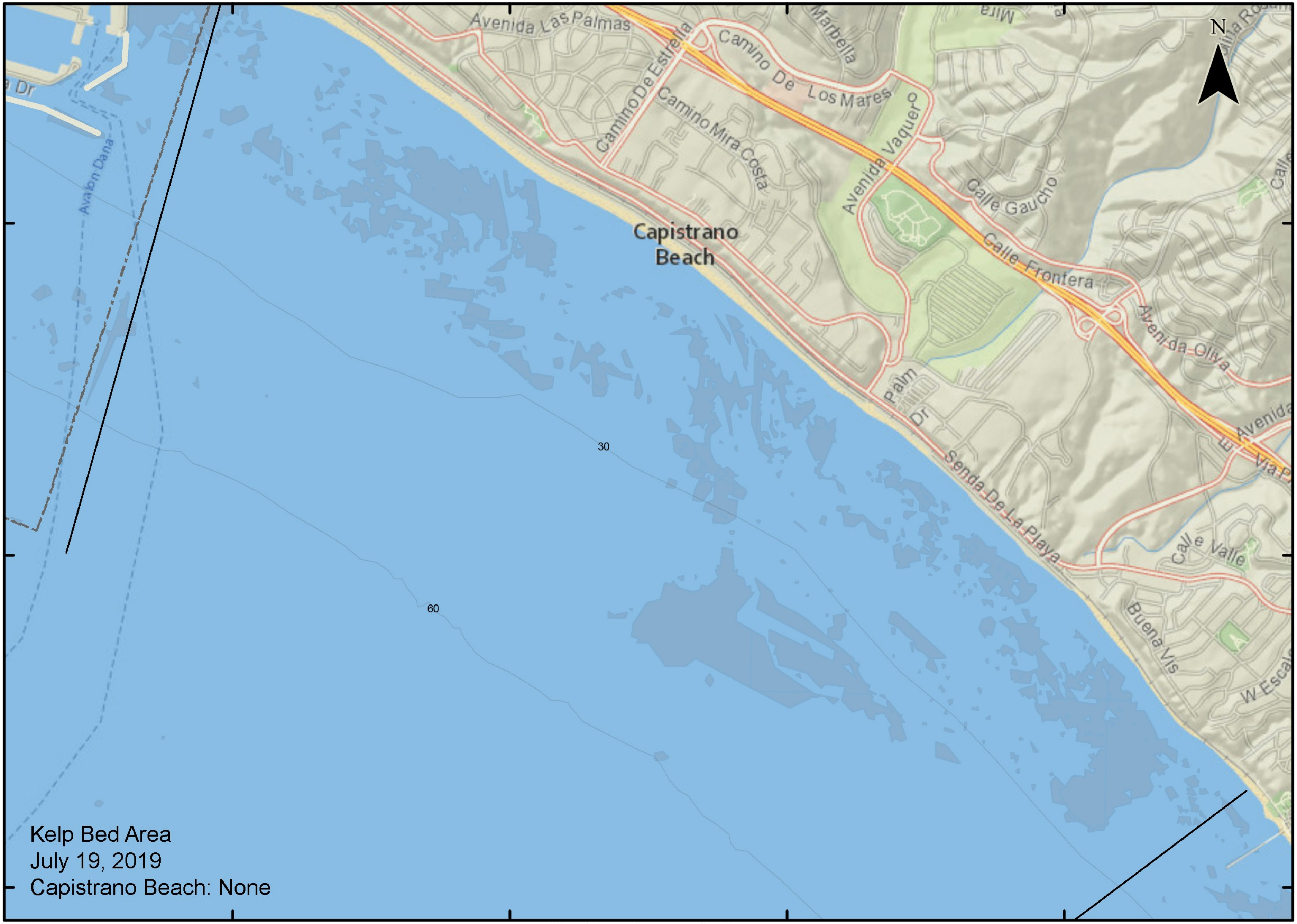
1:24,000

Depth contours in feet

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

mbc AQUATIC SCIENCES

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



1 stat. mi.

1 Km.

1:35,000

Depth contours in feet

Kelp

Isobath

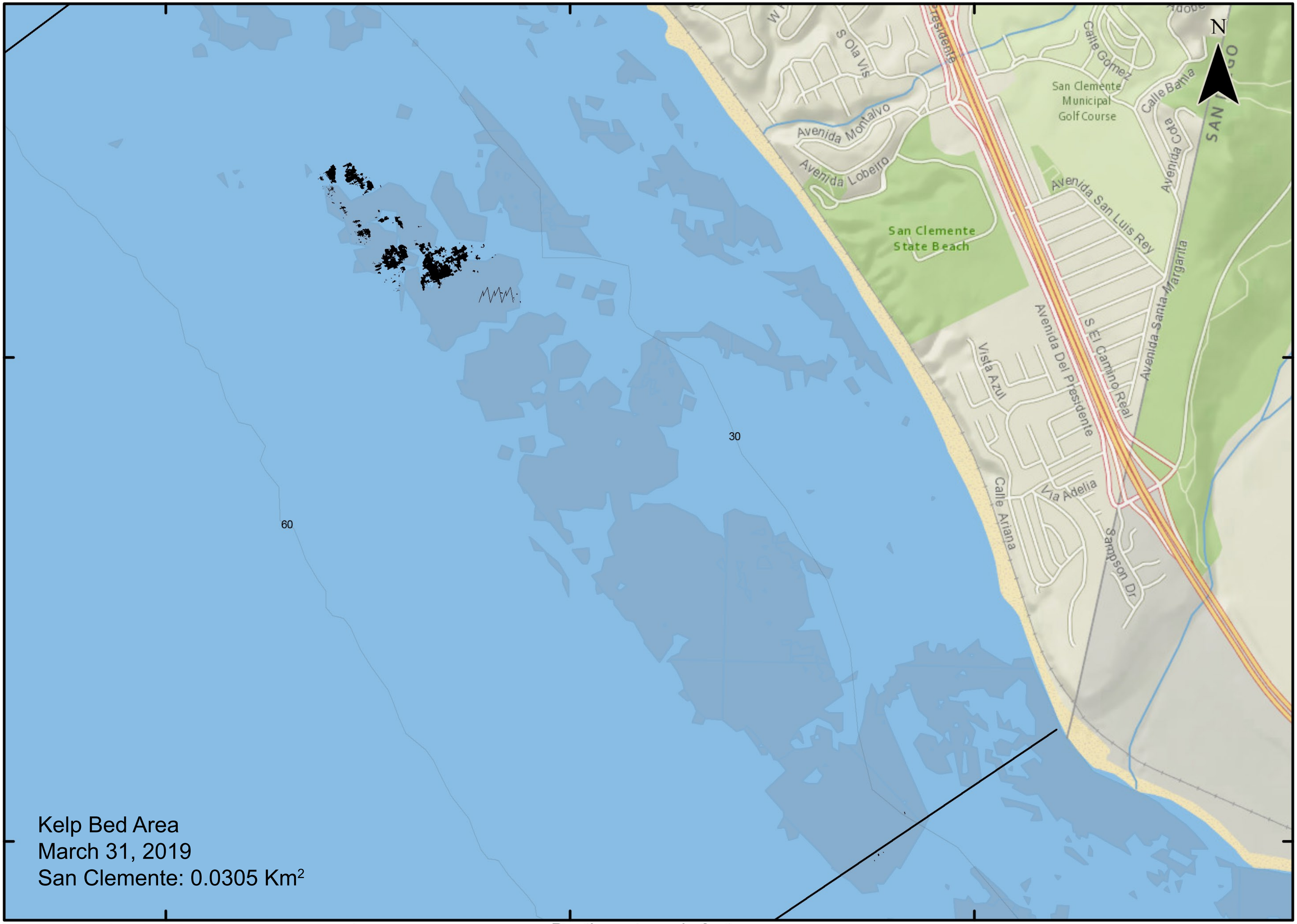
Kelp Bed Divide

Artificial Reef

Discharge Structure

Hard Substrate

Appendix A.48
Capistrano Beach



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

Kelp

Isobath

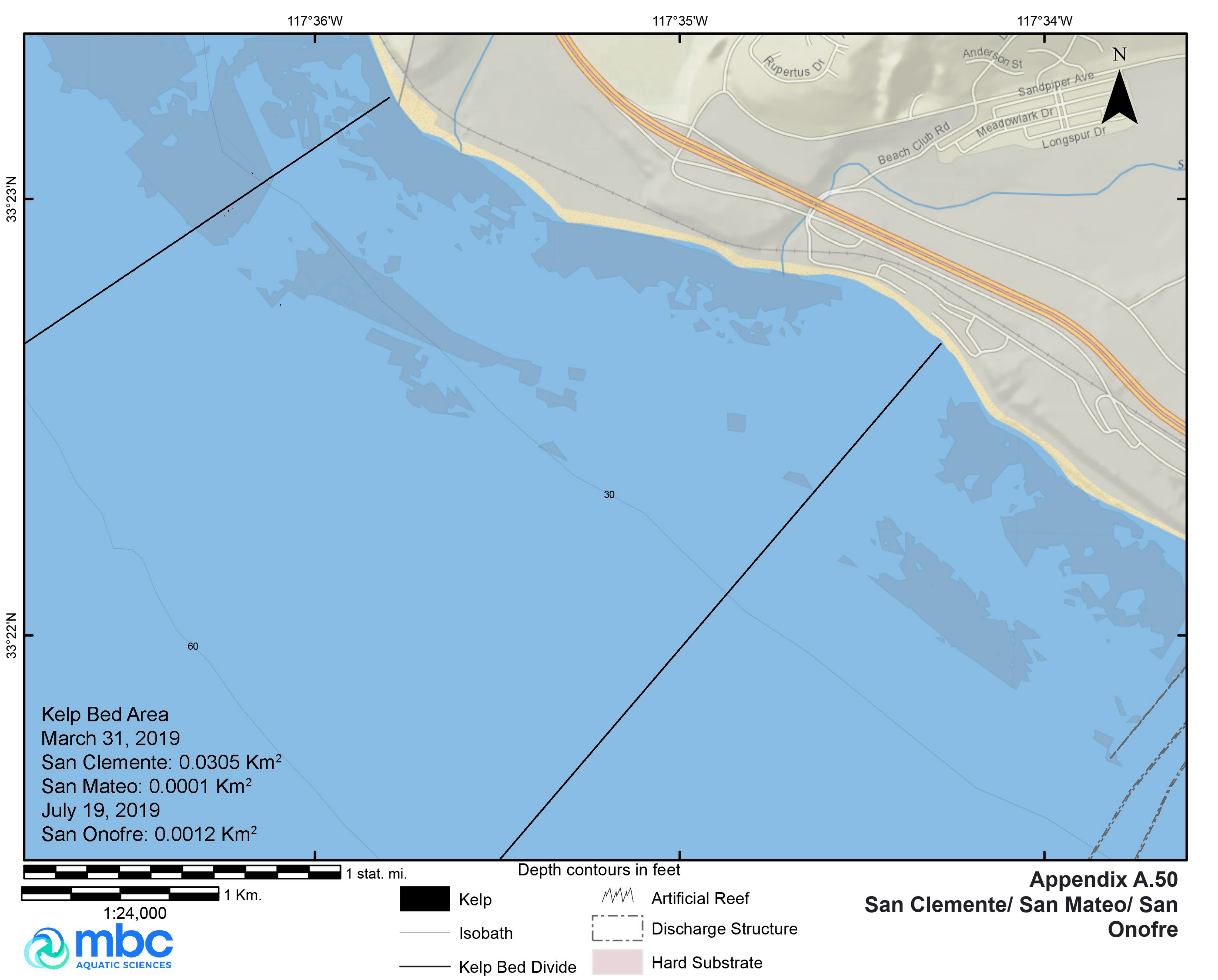
Kelp Bed Divide

Artificial Reef

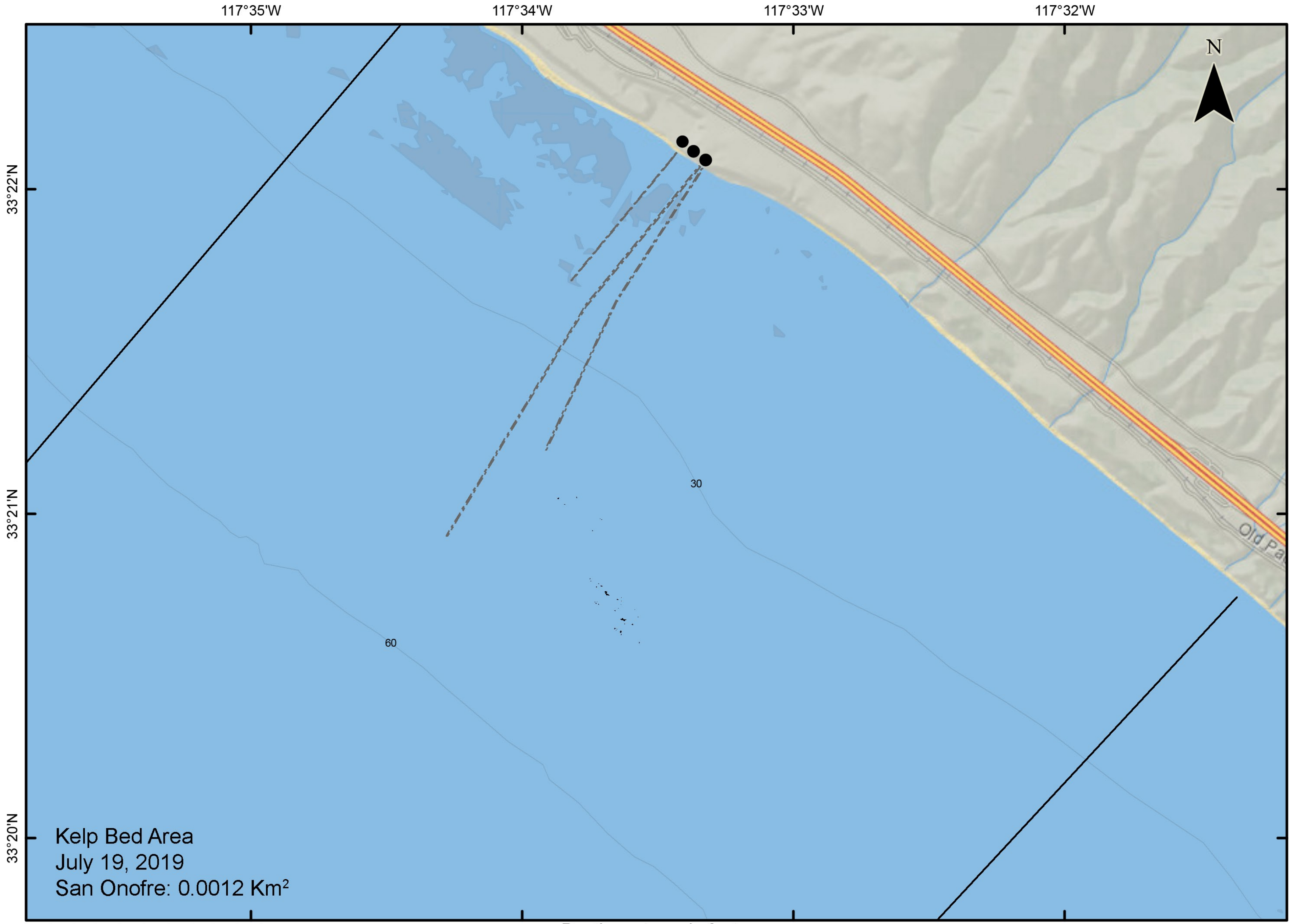
Discharge Structure

Hard Substrate

Appendix A.49
San Clemente



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



1 stat. mi.

1 Km.

1:35,000

Depth contours in feet

Kelp

Isobath

Kelp Bed Divide

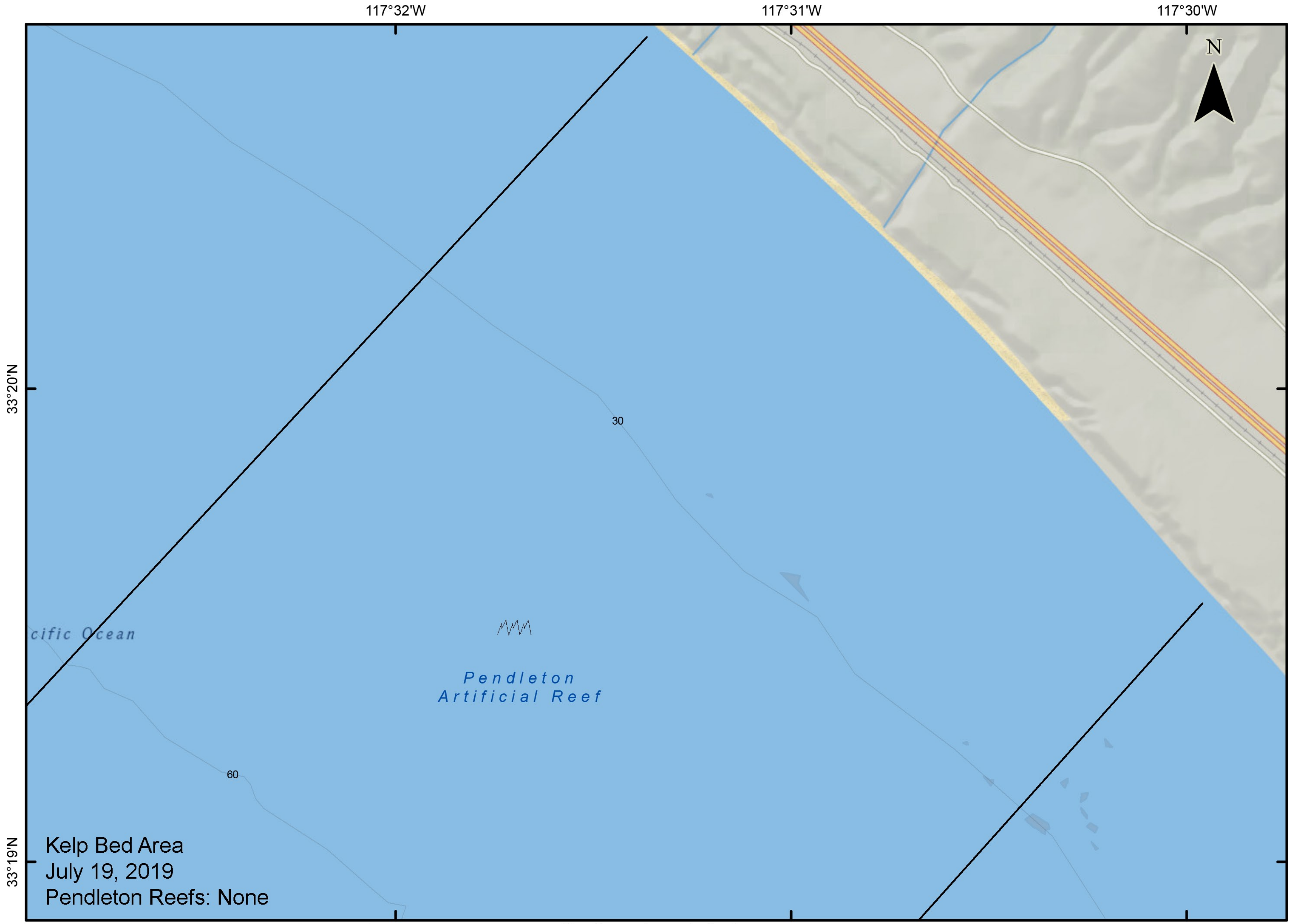
Artificial Reef

Discharge Structure

Hard Substrate

mbc AQUATIC SCIENCES

Appendix A.51
San Onofre



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

Kelp

Isobath

Kelp Bed Divide

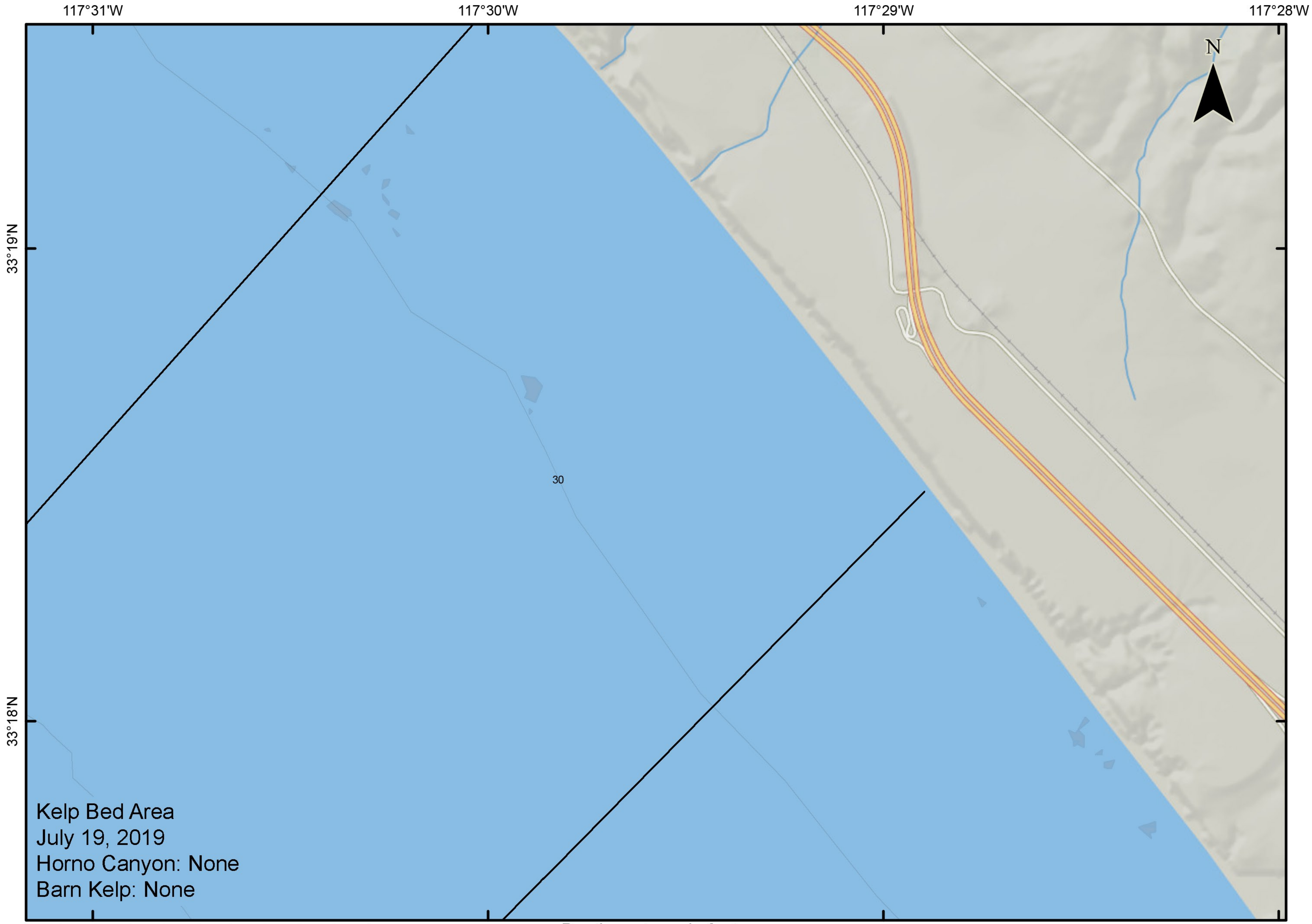
Artificial Reef

Discharge Structure

Hard Substrate

mbc AQUATIC SCIENCES

Appendix A.52
Pendleton Reef



1 stat. mi.

1 Km.

1:24,000

Depth contours in feet

Kelp

Isobath

Kelp Bed Divide

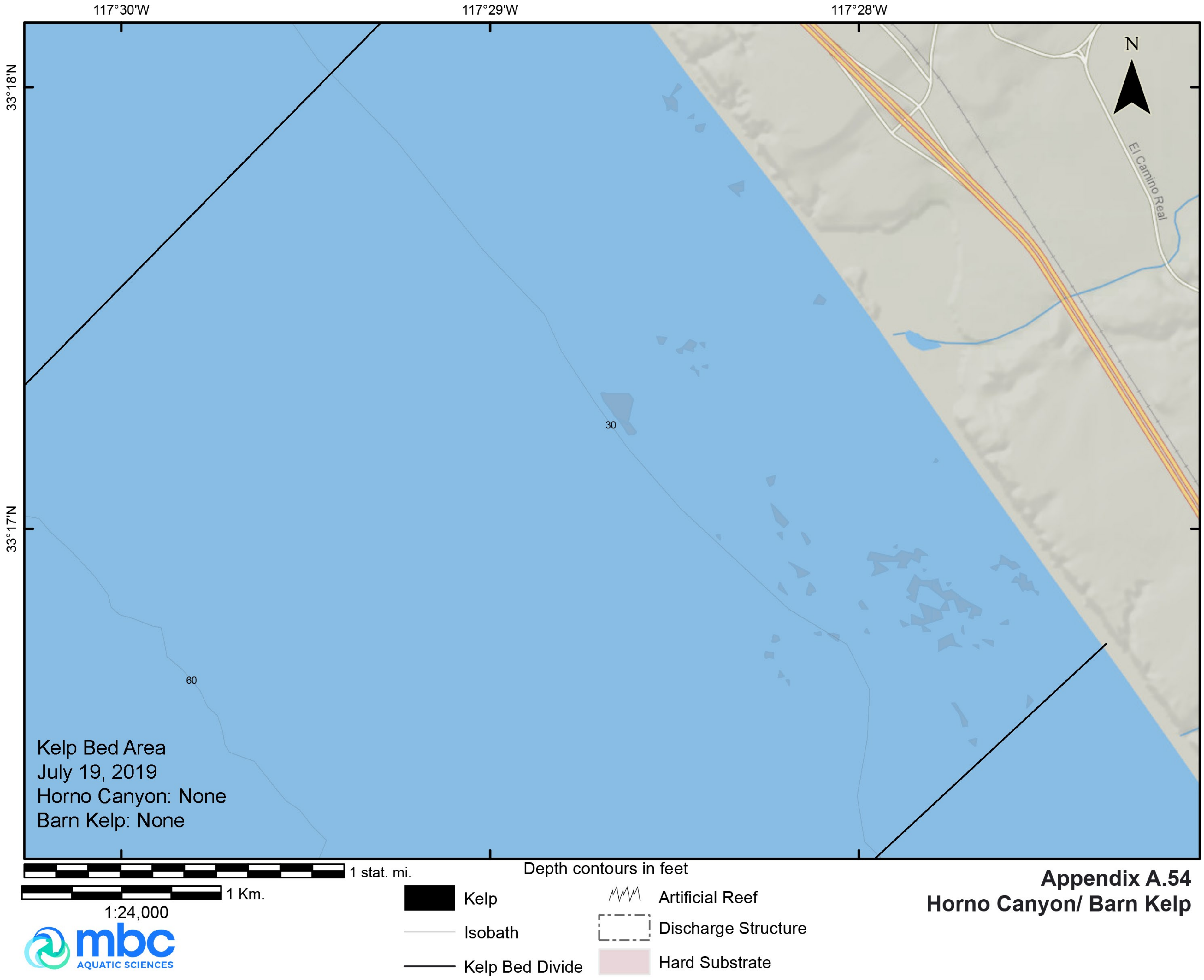
Artificial Reef

Discharge Structure

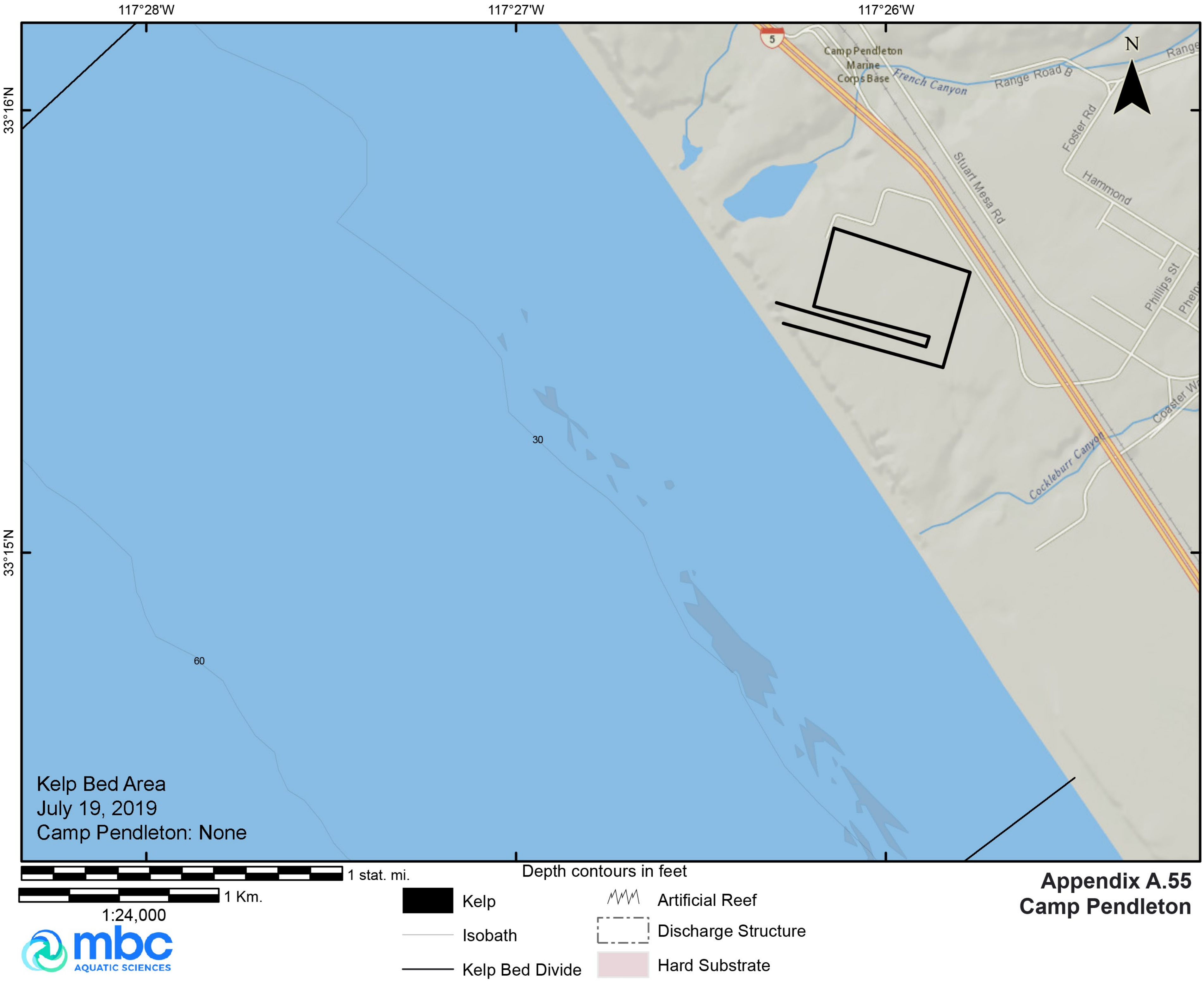
Hard Substrate

Appendix A.53
Horno Canyon/ Barn Kelp

mbc AQUATIC SCIENCES

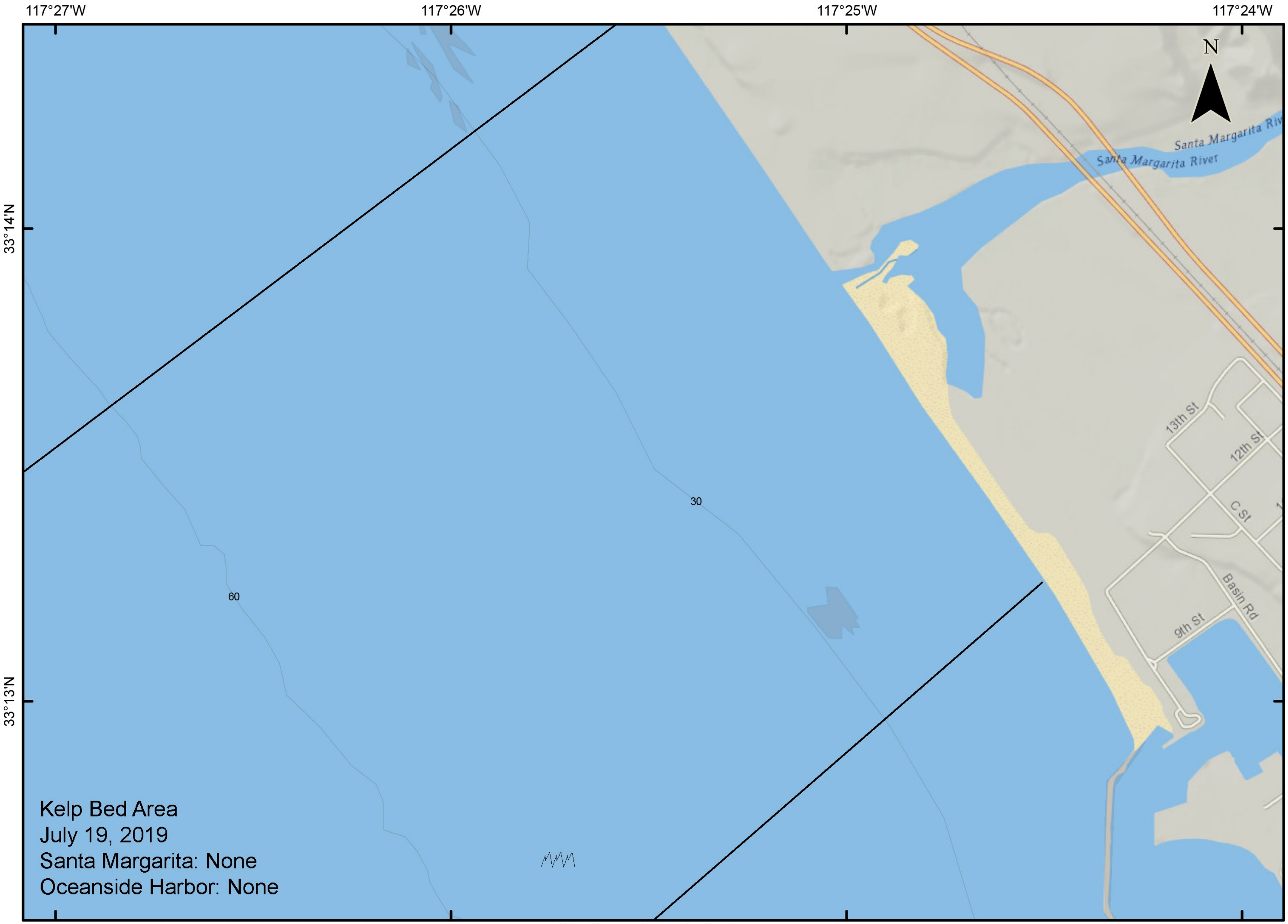


Appendix A.54
Horno Canyon/ Barn Kelp



Appendix A.55
Camp Pendleton

mbc AQUATIC SCIENCES



1 stat. mi.

1 Km.

1:24,000

mbc AQUATIC SCIENCES

Depth contours in feet

Kelp

Isobath

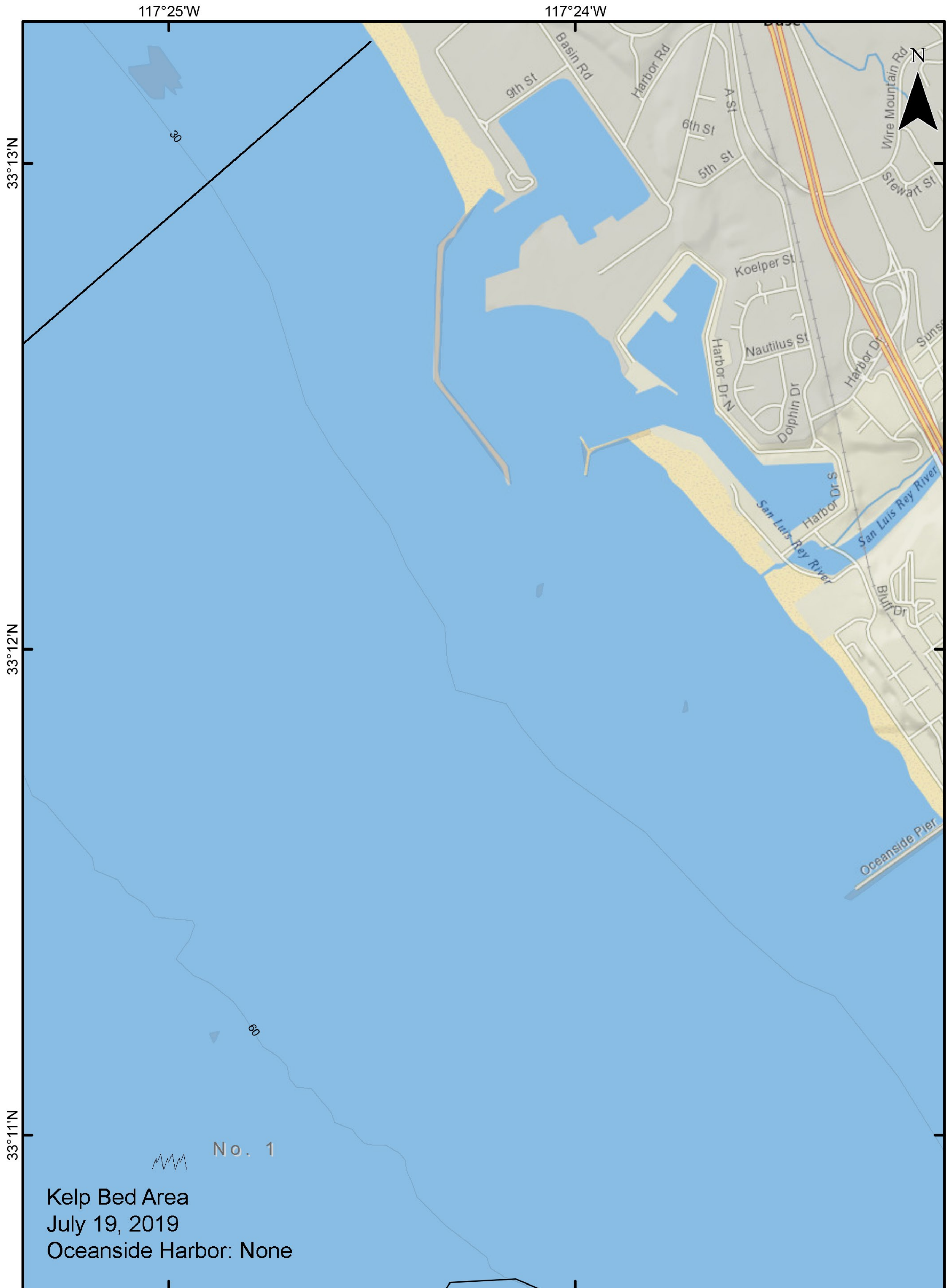
Kelp Bed Divide

Artificial Reef

Discharge Structure

Hard Substrate

Appendix A.56
Santa Margarita/ Oceanside Harbor



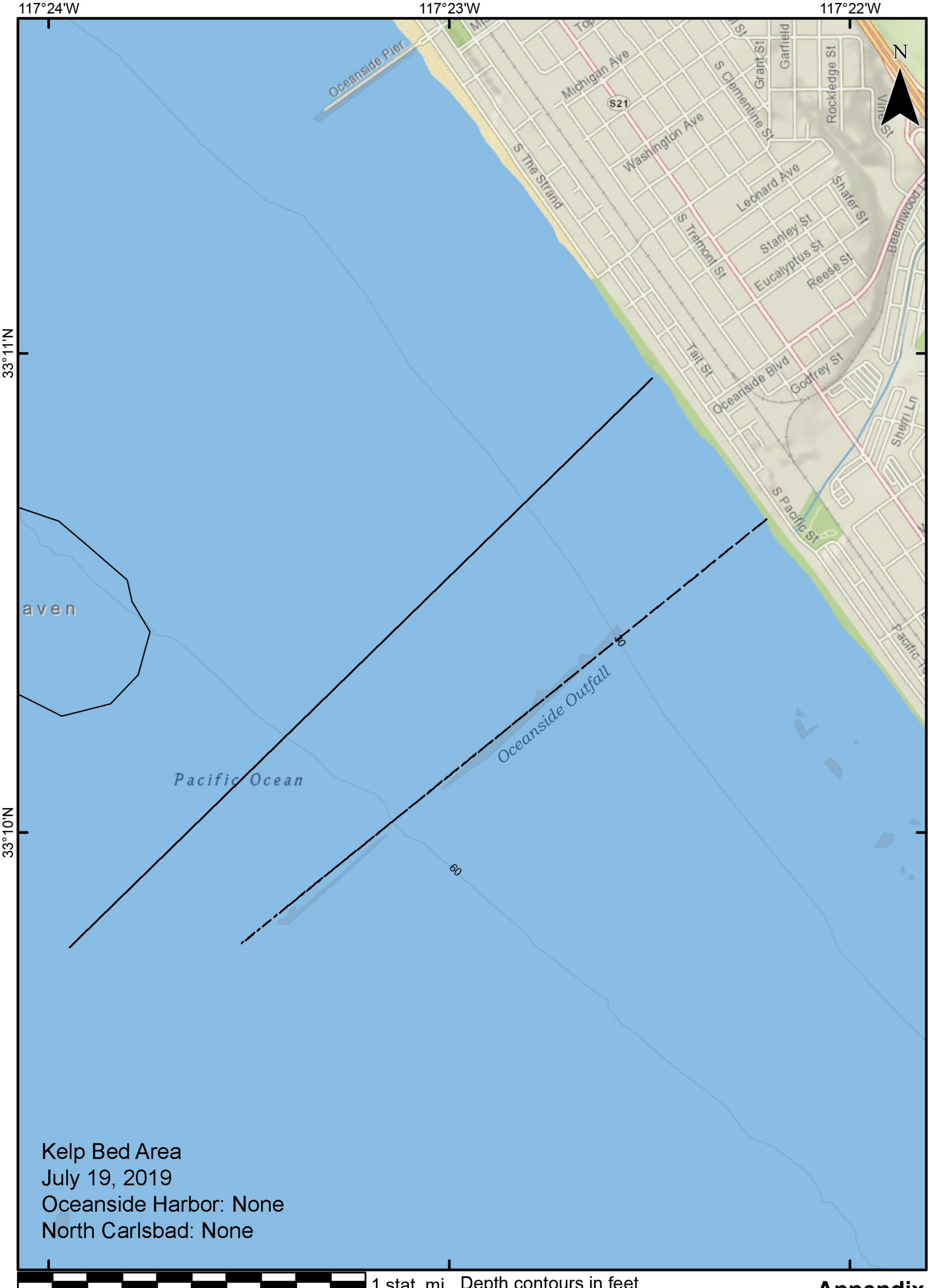
1 stat. mi. Depth contours in feet

1 Km. 1:24,000

Kelp 2018 | Artificial Reef | Discharge Structure

Isobath | Kelp Bed Divide | Hard Substrate

Appendix A.57
Oceanside Harbor and Pier



1 stat. mi. Depth contours in feet

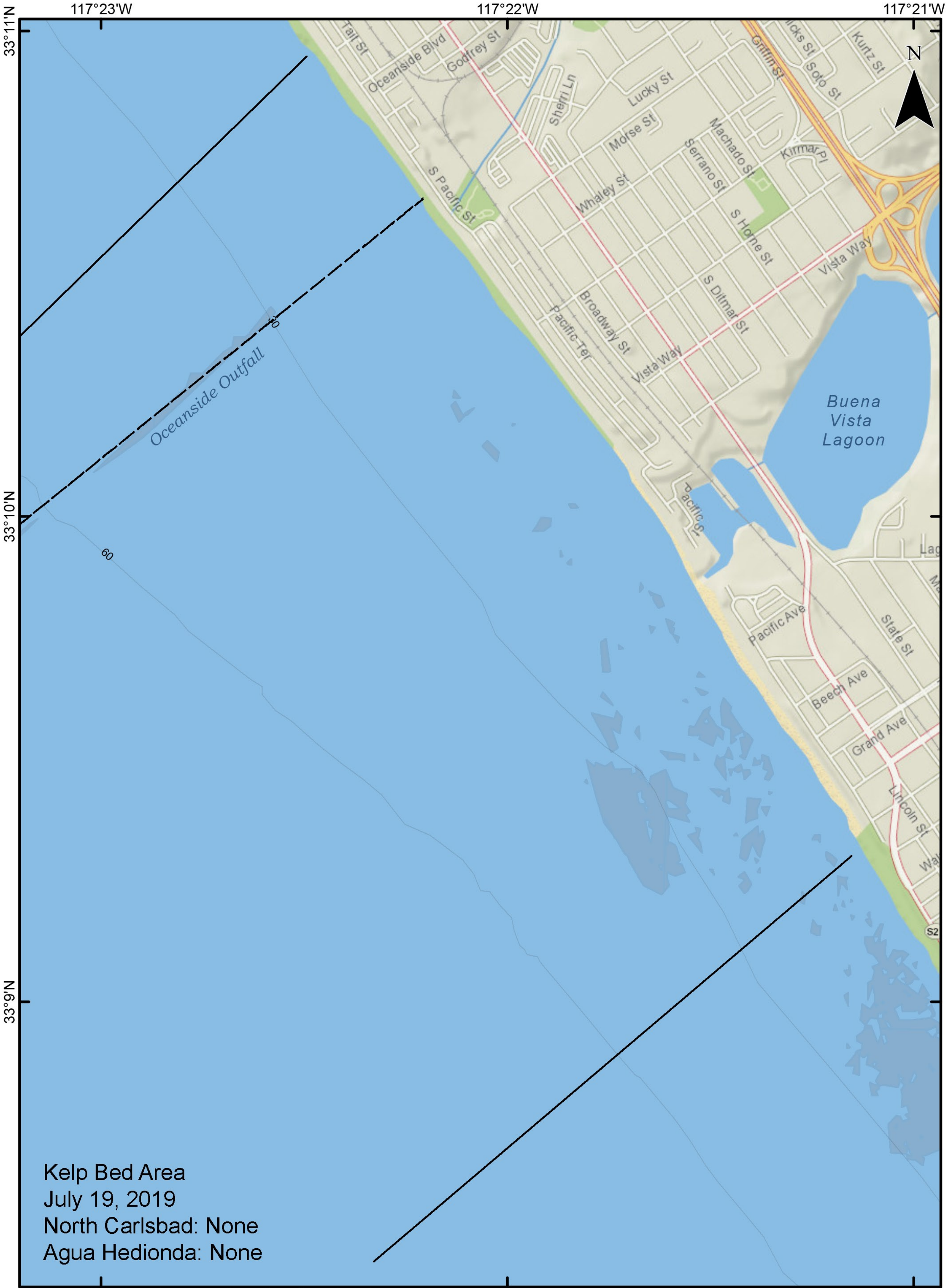
1 Km. 1:24,000

Appendix A.58
Oceanside Harbor/ Pier/ North Carlsbad

mbc AQUATIC SCIENCES

Kelp 2018 | Artificial Reef | Discharge Structure

Isobath | Kelp Bed Divide | Hard Substrate



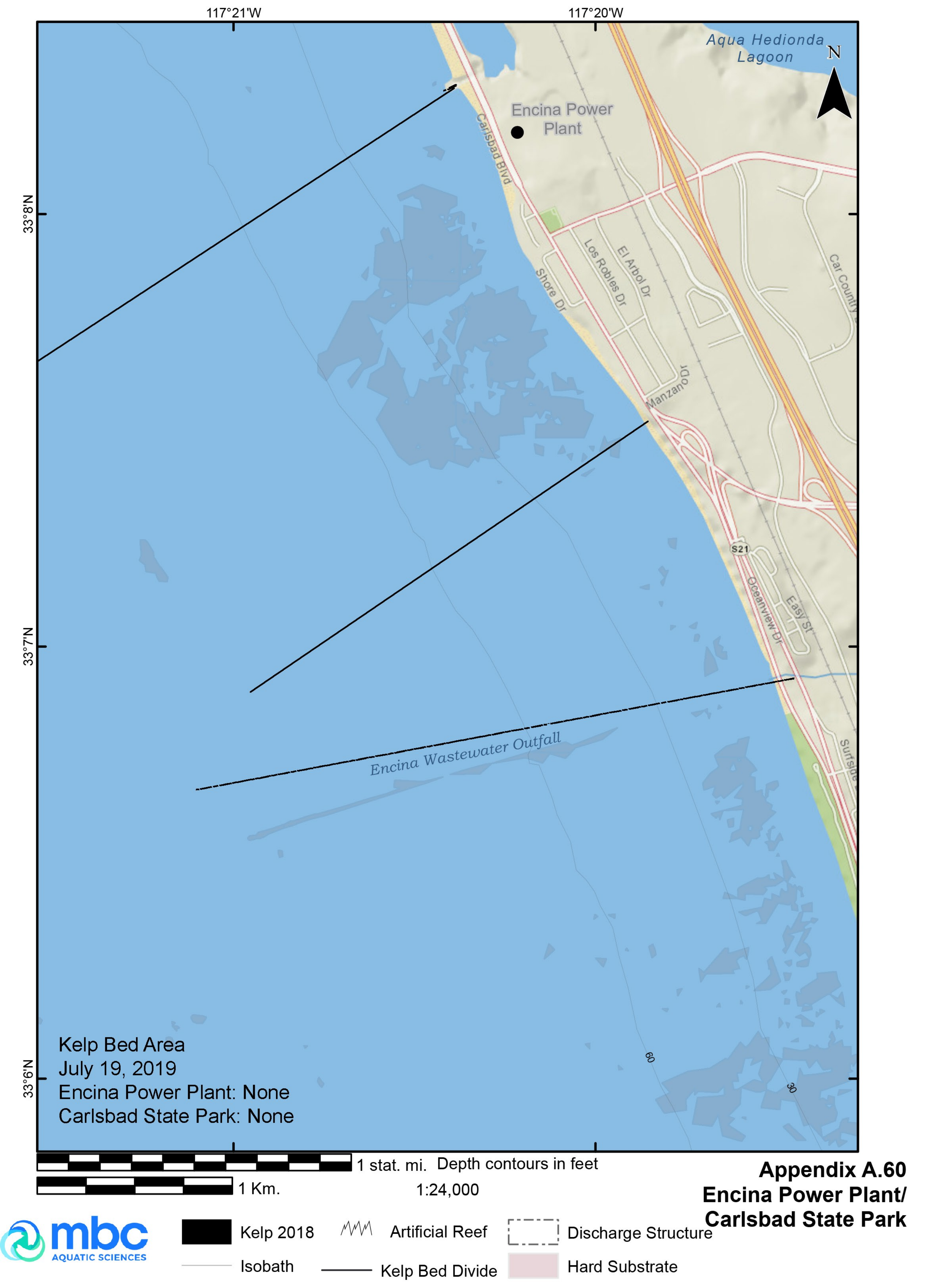
1 stat. mi. Depth contours in feet

1 Km. 1:24,000

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

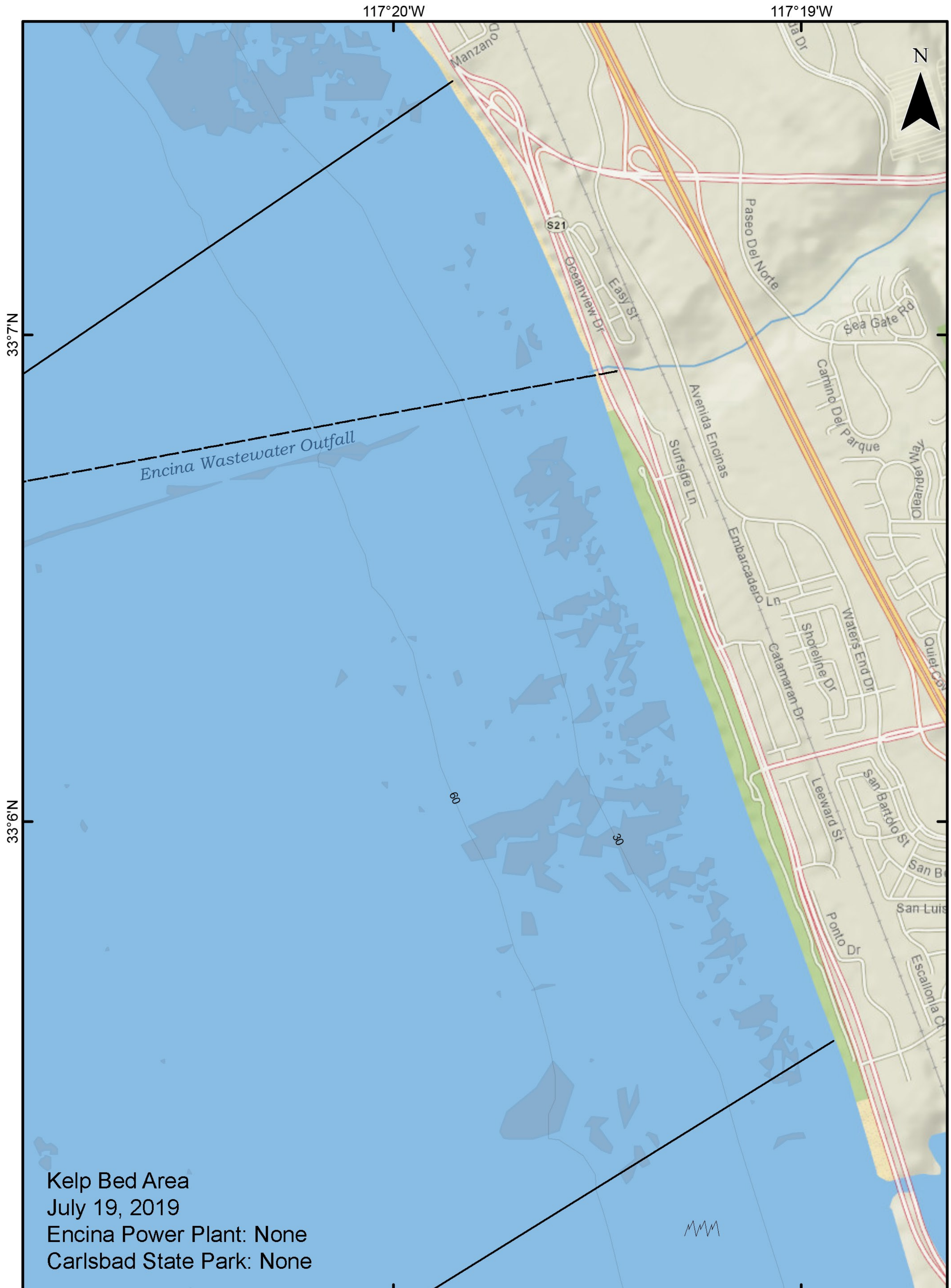
MBC Aquatic Sciences

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



mbc AQUATIC SCIENCES

Appendix A.60
Encina Power Plant/ Carlsbad State Park



1 stat. mi.

1 Km.

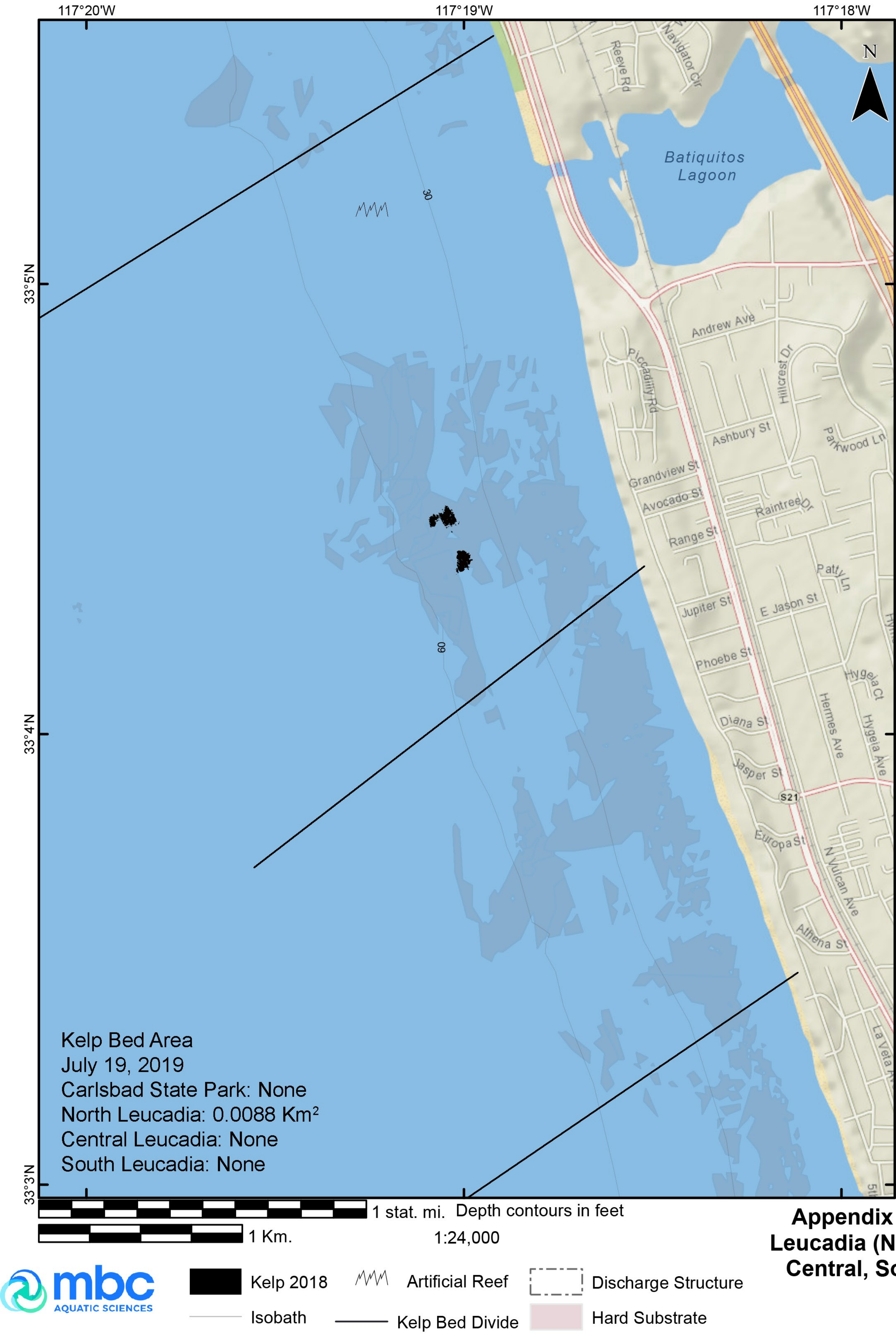
Depth contours in feet

1:24,000

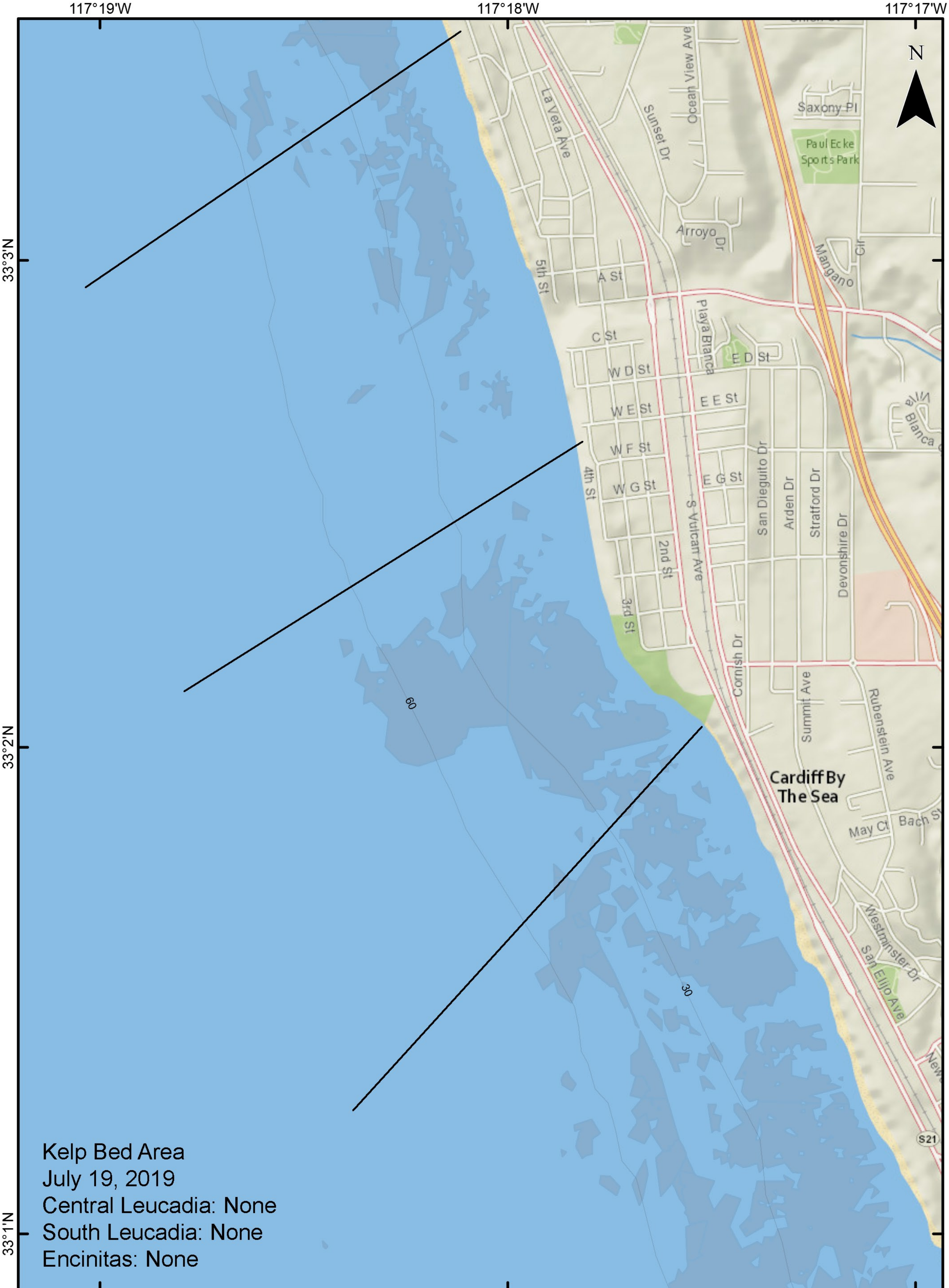
Appendix A.61
Encina Power Plant/
Carlsbad State Park

mbc AQUATIC SCIENCES

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



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



1 stat. mi. Depth contours in feet

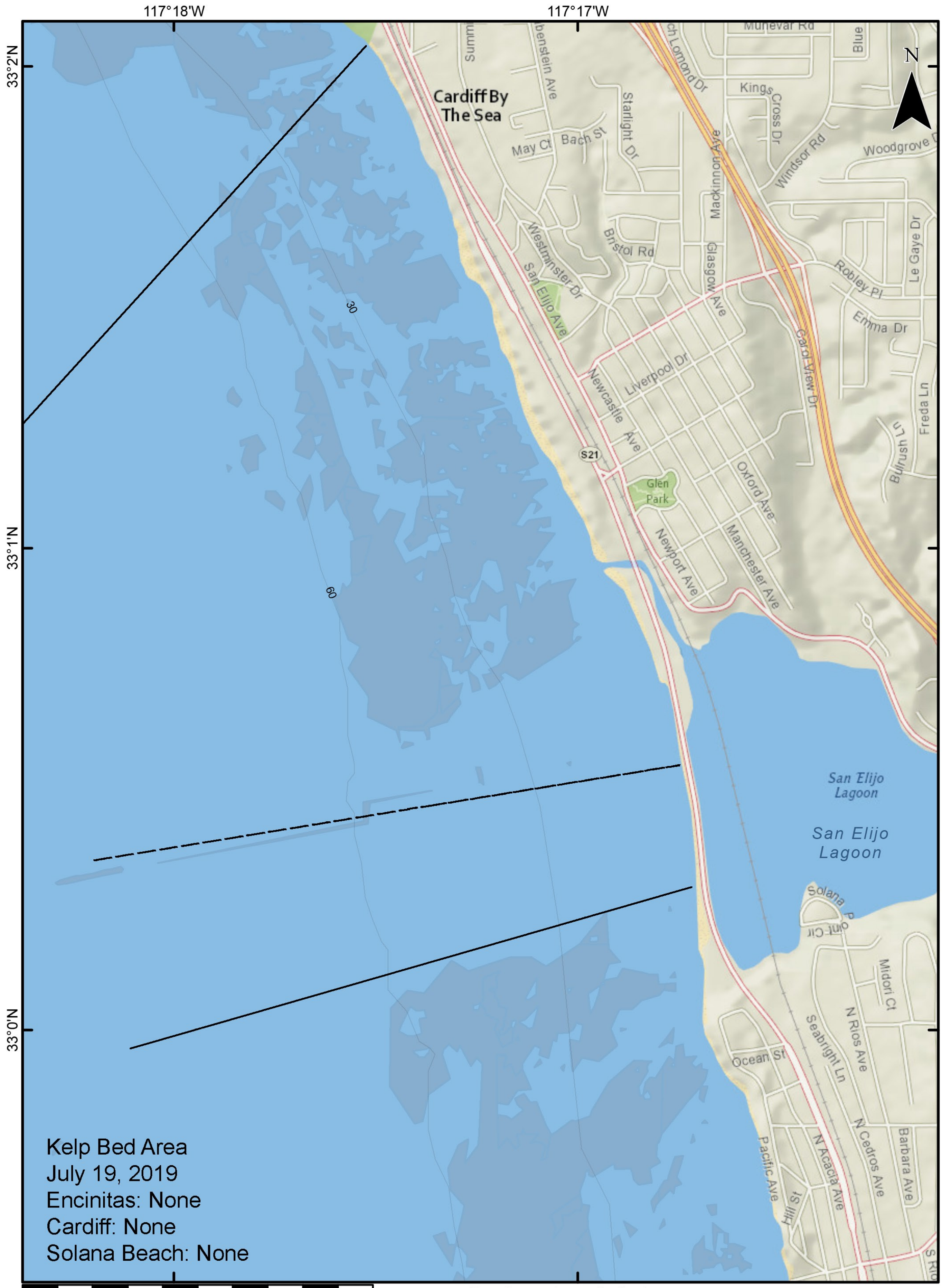
1 Km. 1:24,000

Kelp 2018 | Artificial Reef | Discharge Structure

Isobath | Kelp Bed Divide | Hard Substrate

mbc AQUATIC SCIENCES

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



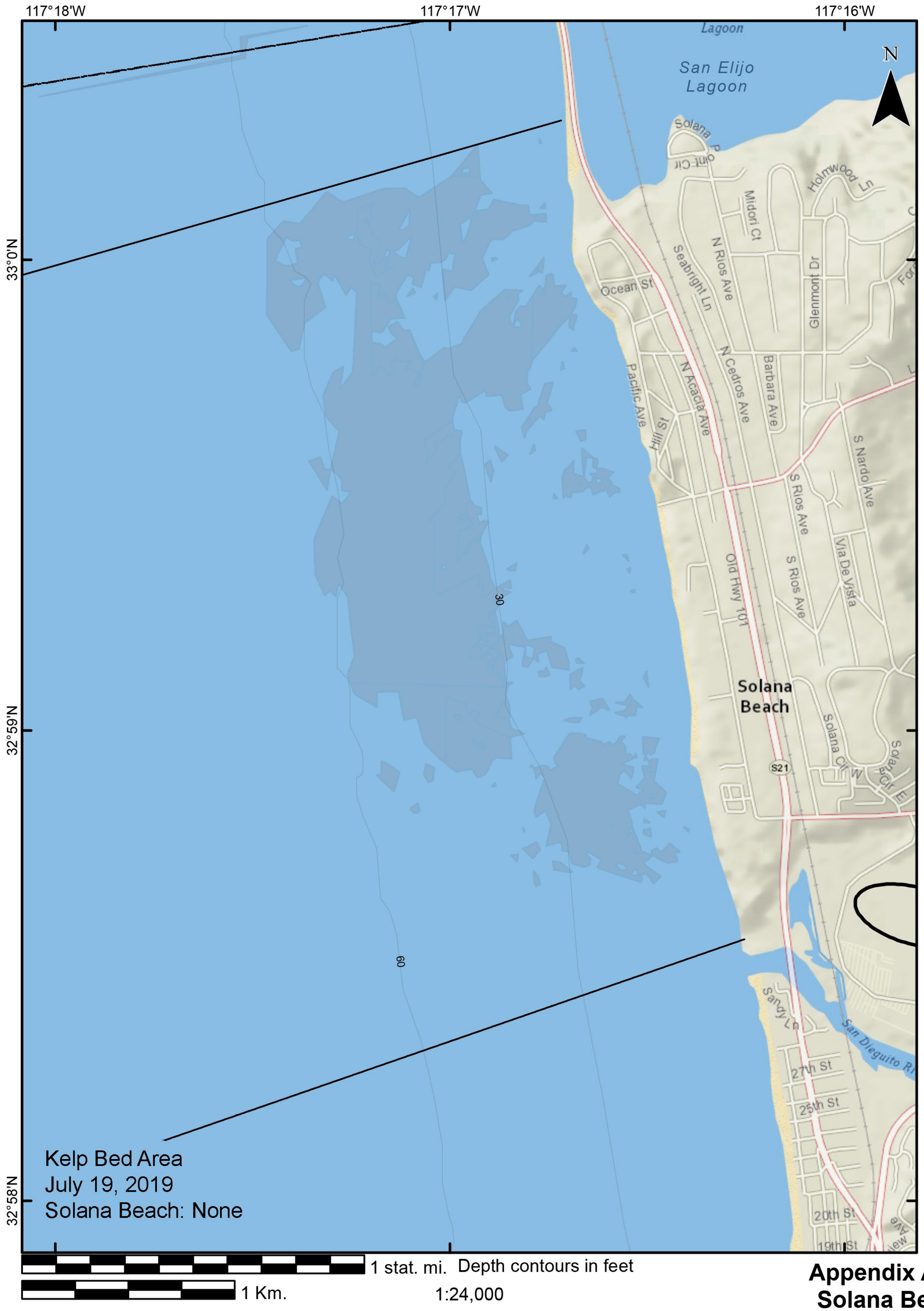
1 stat. mi. Depth contours in feet

1 Km. 1:24,000

Appendix A.64
Encinitas/ Cardiff/ Solana Beach

mbc AQUATIC SCIENCES

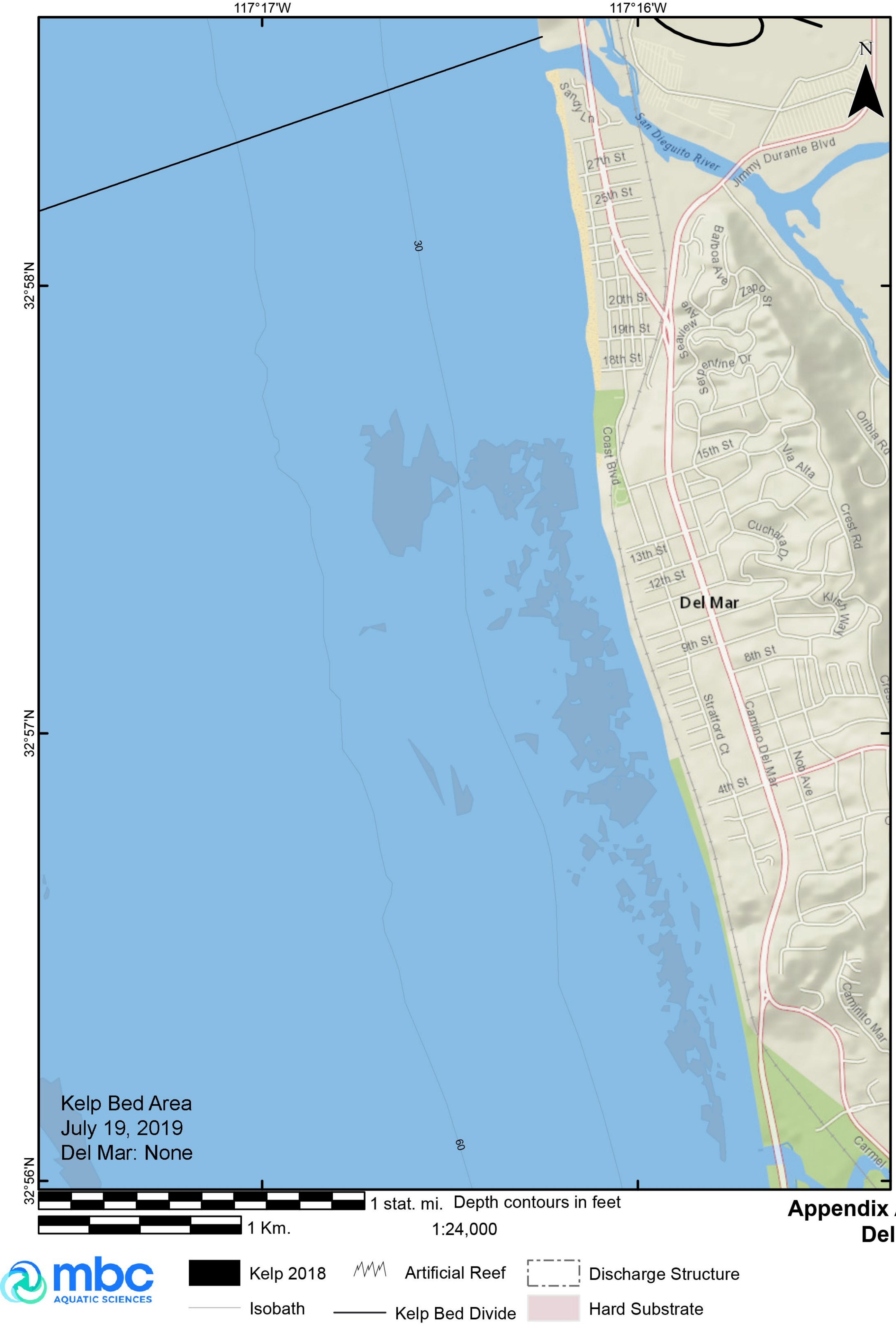
Kelp 2018
Artificial Reef
Discharge Structure
Isobath
Kelp Bed Divide
Hard Substrate



Appendix A.65
Solana Beach

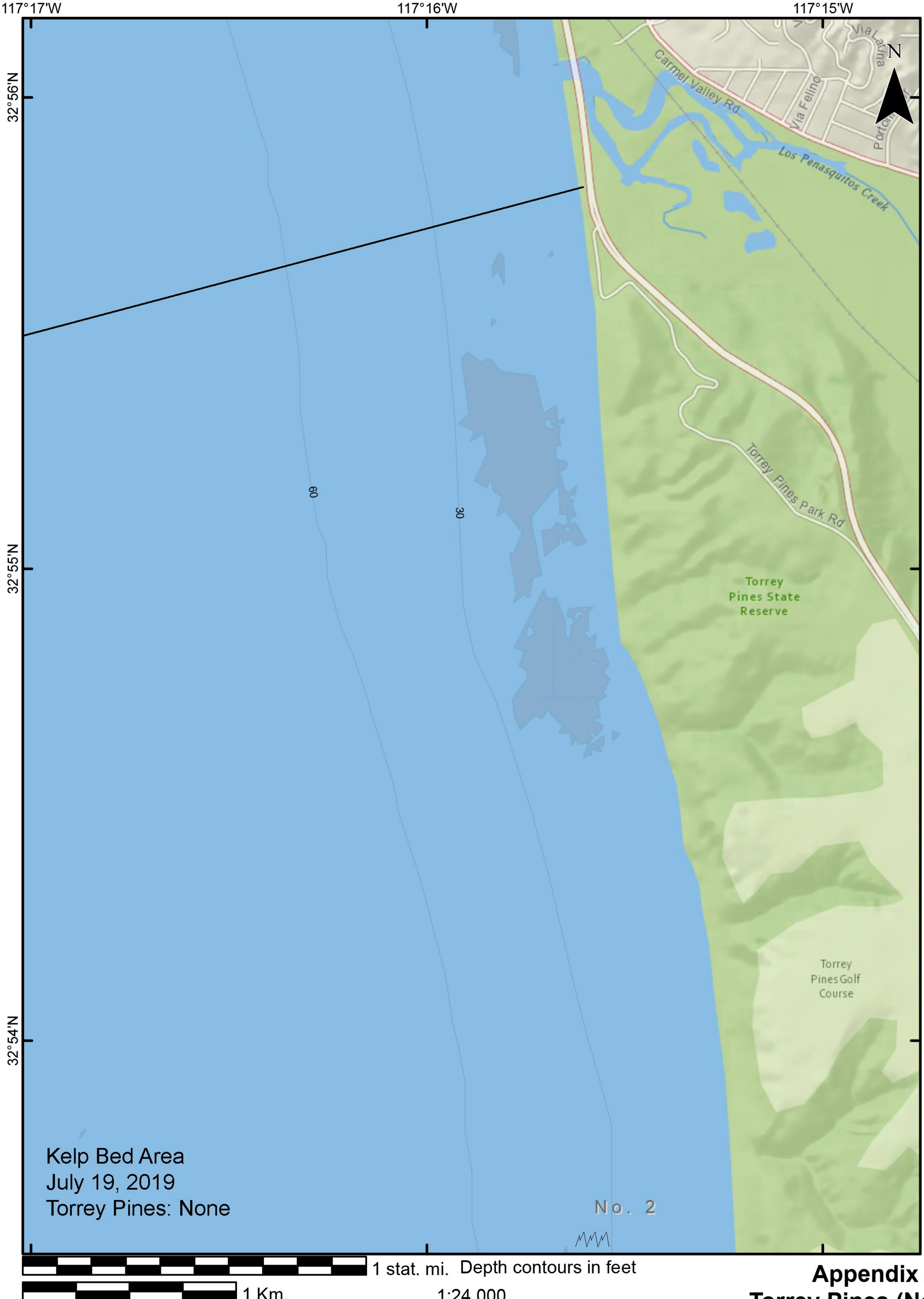
mbc AQUATIC SCIENCES

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



Appendix A.66
Del Mar

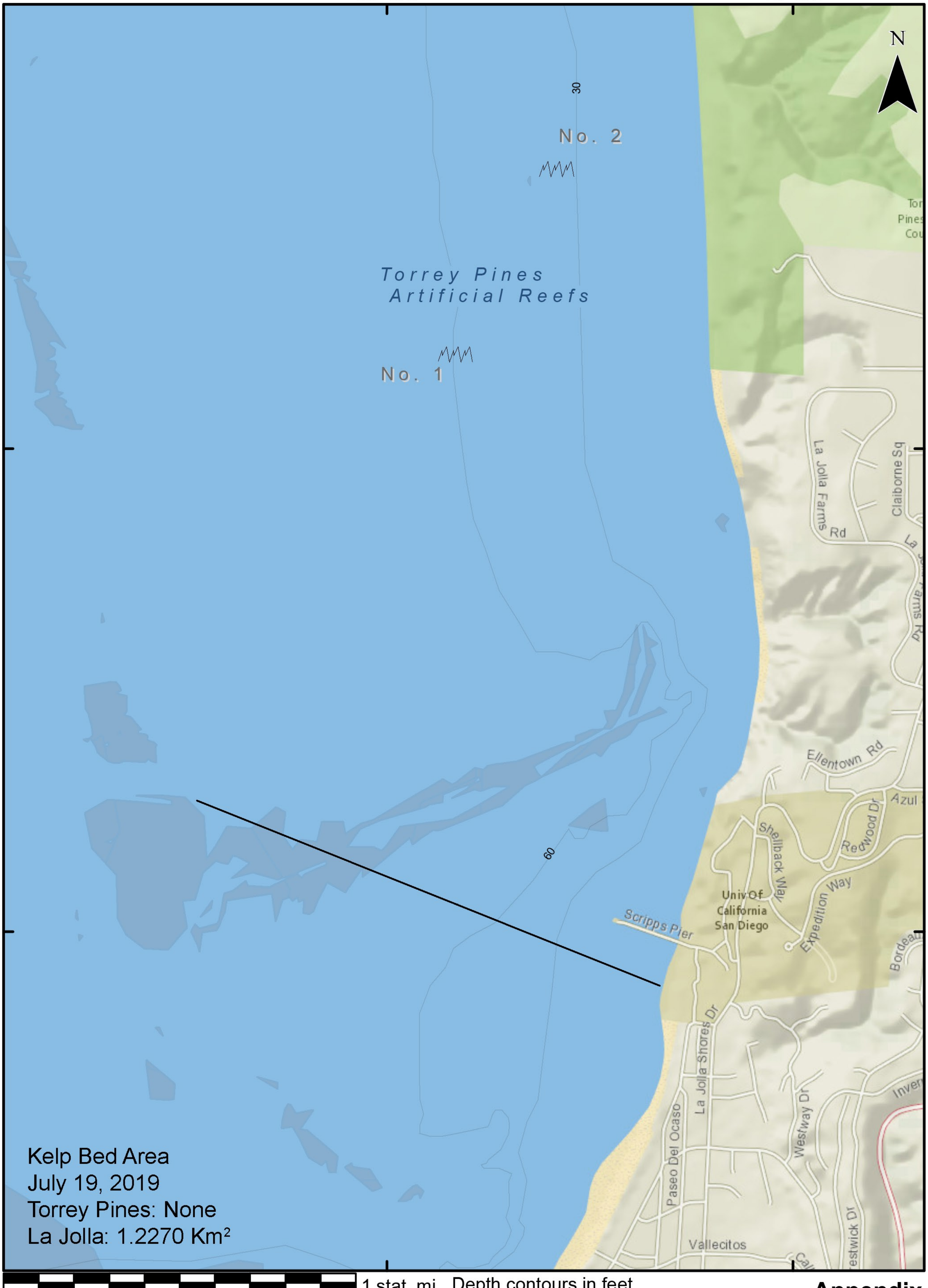
mbc AQUATIC SCIENCES



Appendix A.67
Torrey Pines (North)

mbc AQUATIC SCIENCES

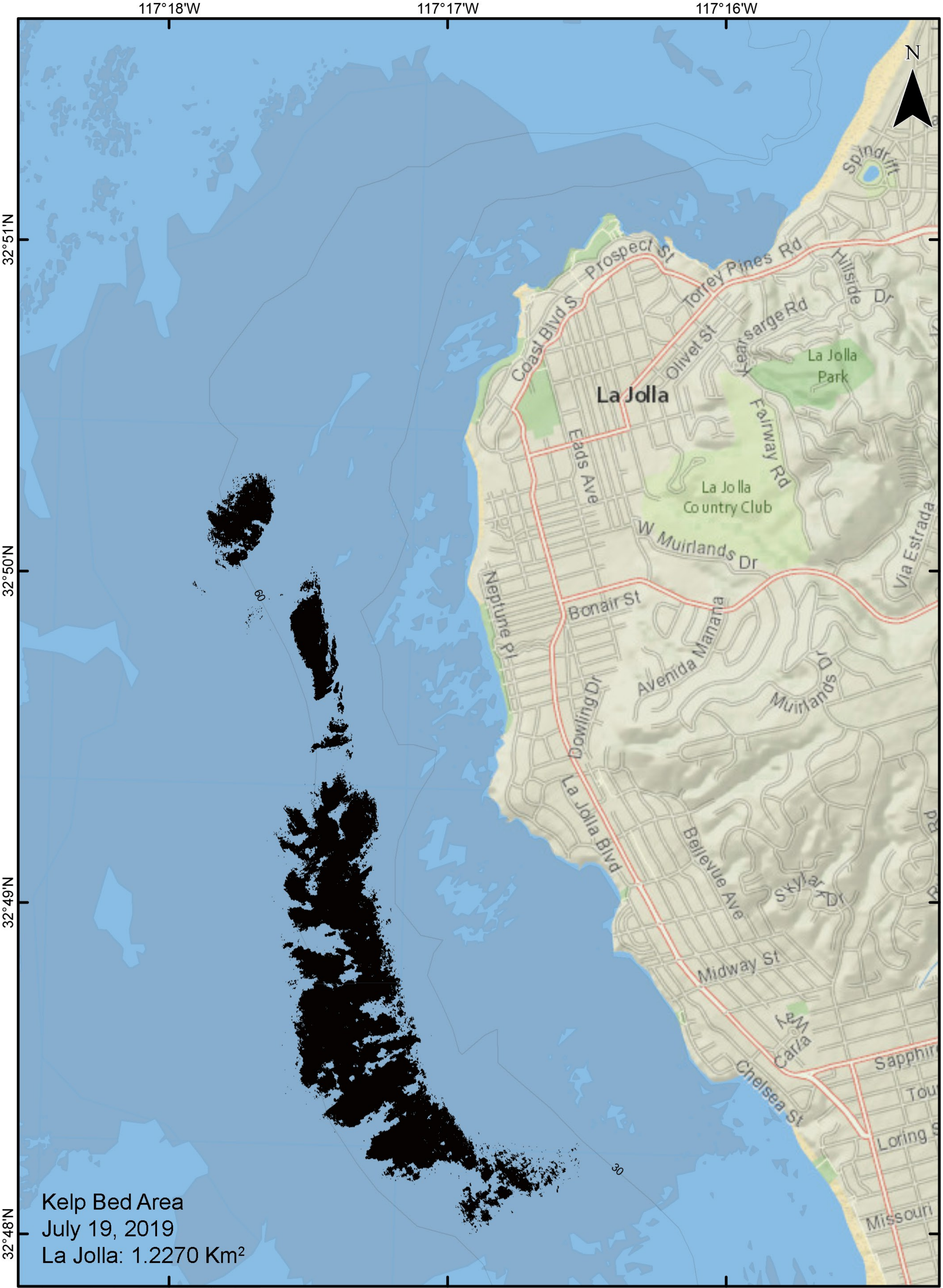
Kelp 2018 | Artificial Reef | Discharge Structure
Isobath | Kelp Bed Divide | Hard Substrate



Appendix A.68
Torrey Pines Reef
(South)

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.69
La Jolla

Kelp 2018

Artificial Reef

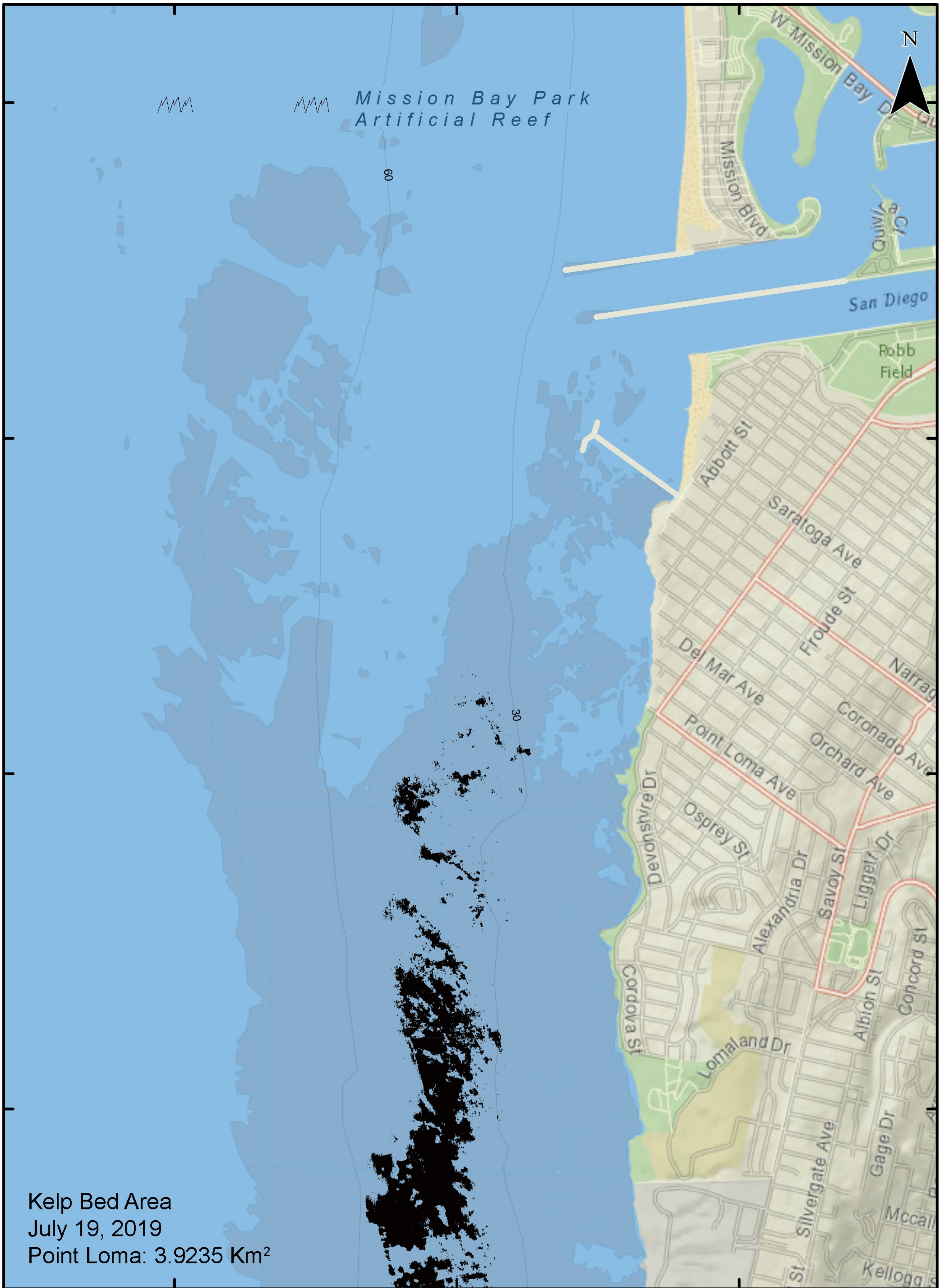
Discharge Structure

Isobath

Kelp Bed Divide

Hard Substrate

Appendix A.70
La Jolla/ Mission Bay



1 stat. mi.

1 Km.

Depth contours in feet

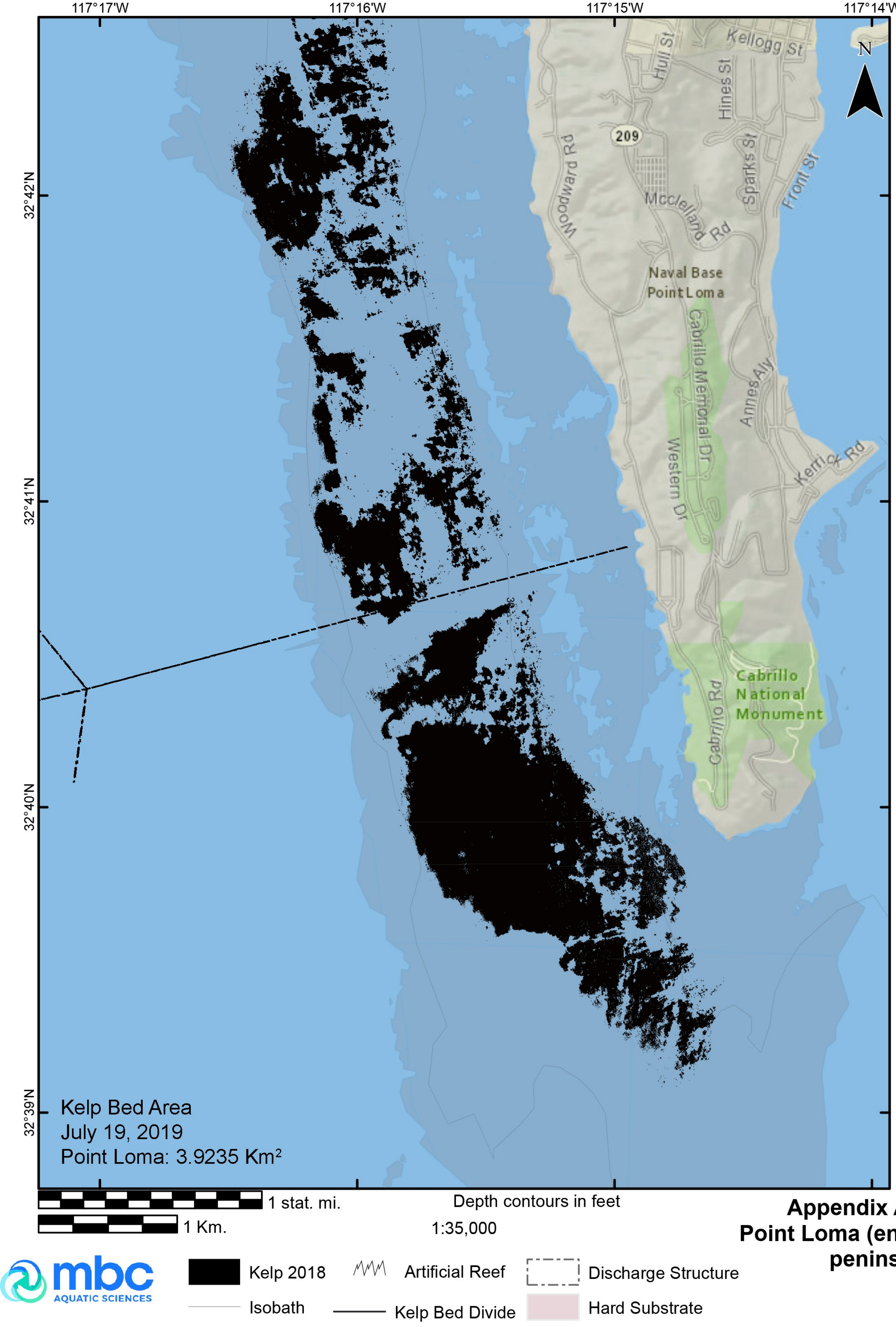
1:35,000

Appendix A.71
Point Loma (Sunset Cliffs)

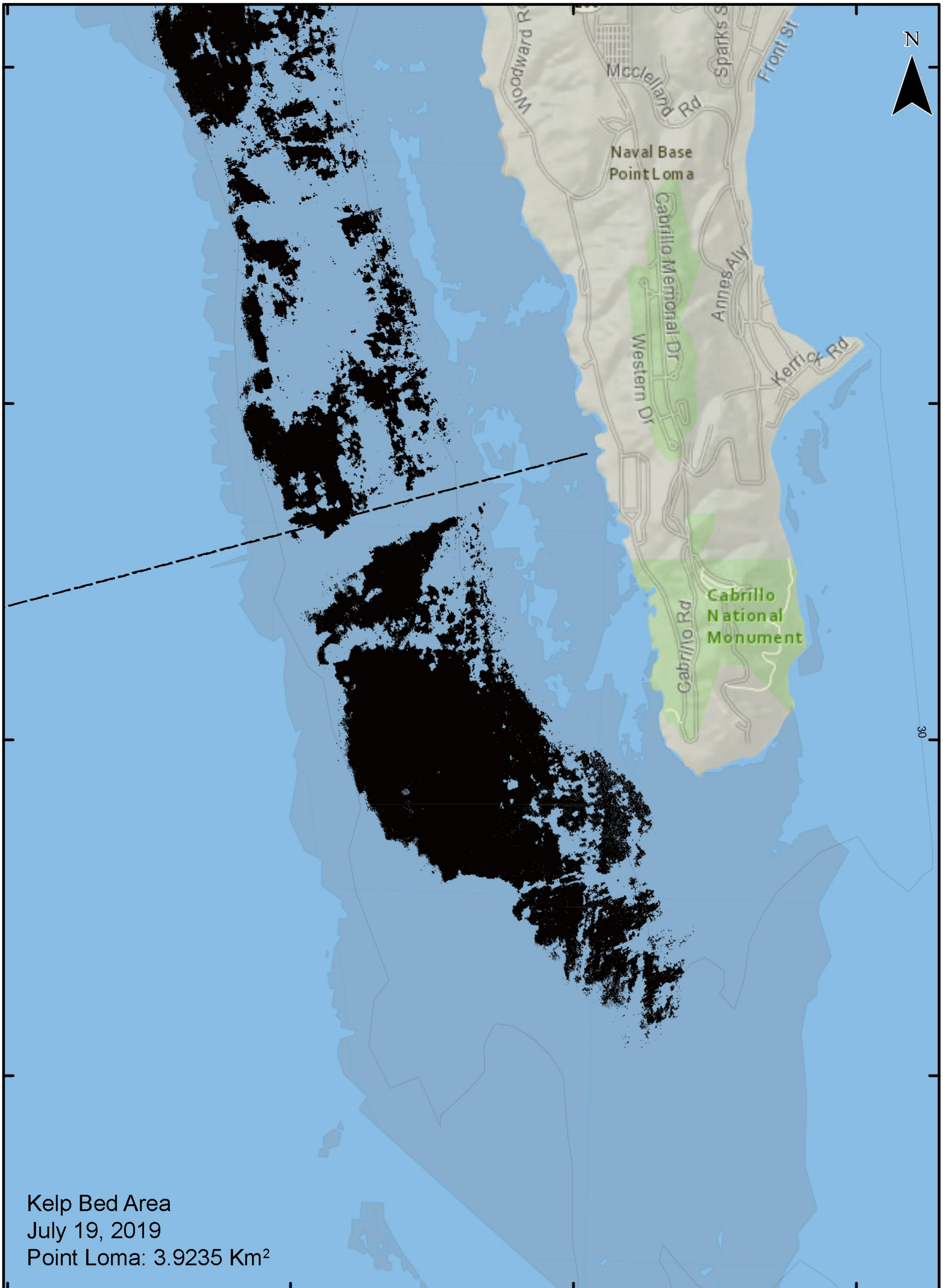
mbc AQUATIC SCIENCES

Kelp 2018 | Artificial Reef | Discharge Structure

Isobath | Kelp Bed Divide | Hard Substrate



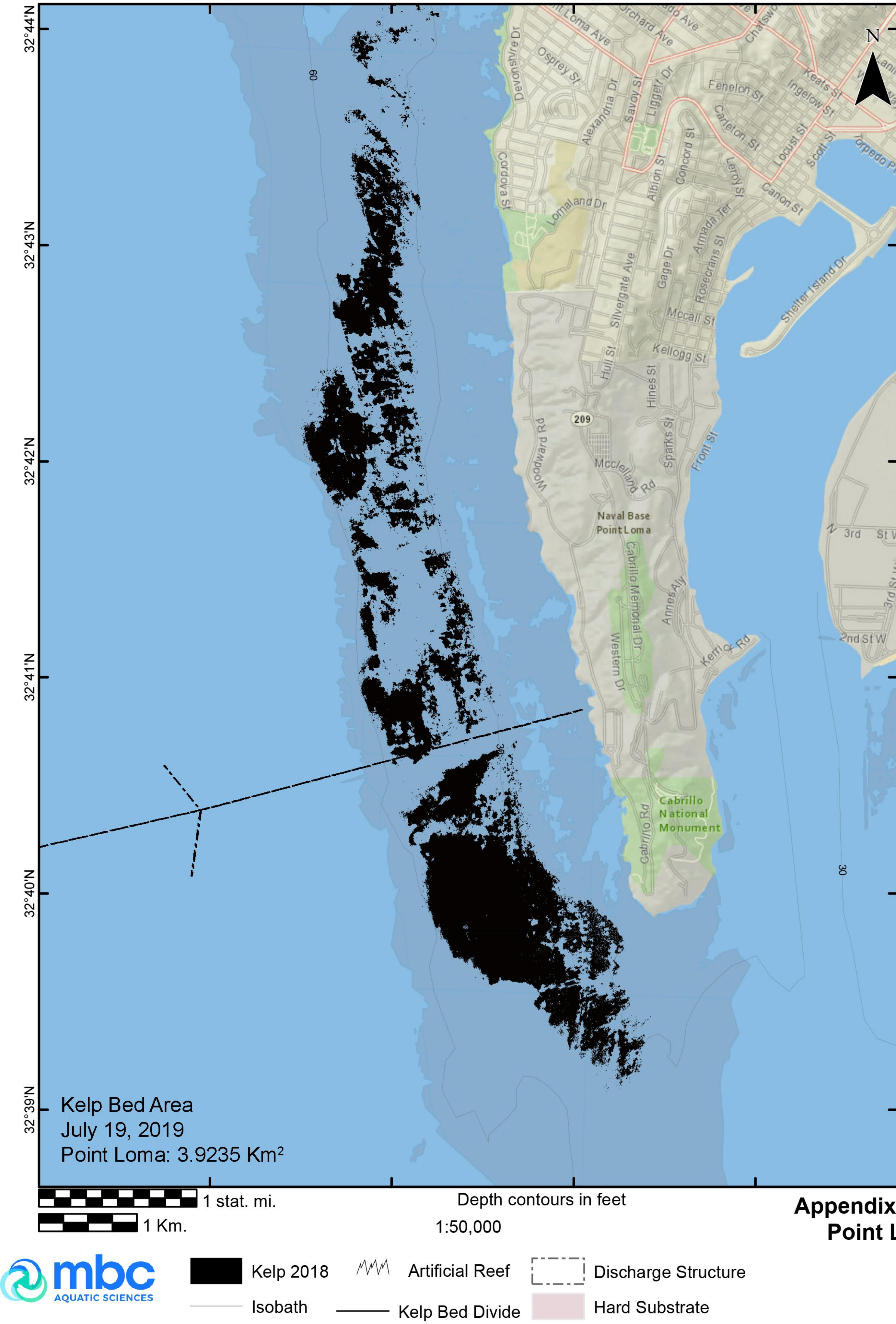
Appendix A.72
Point Loma (end of peninsula)



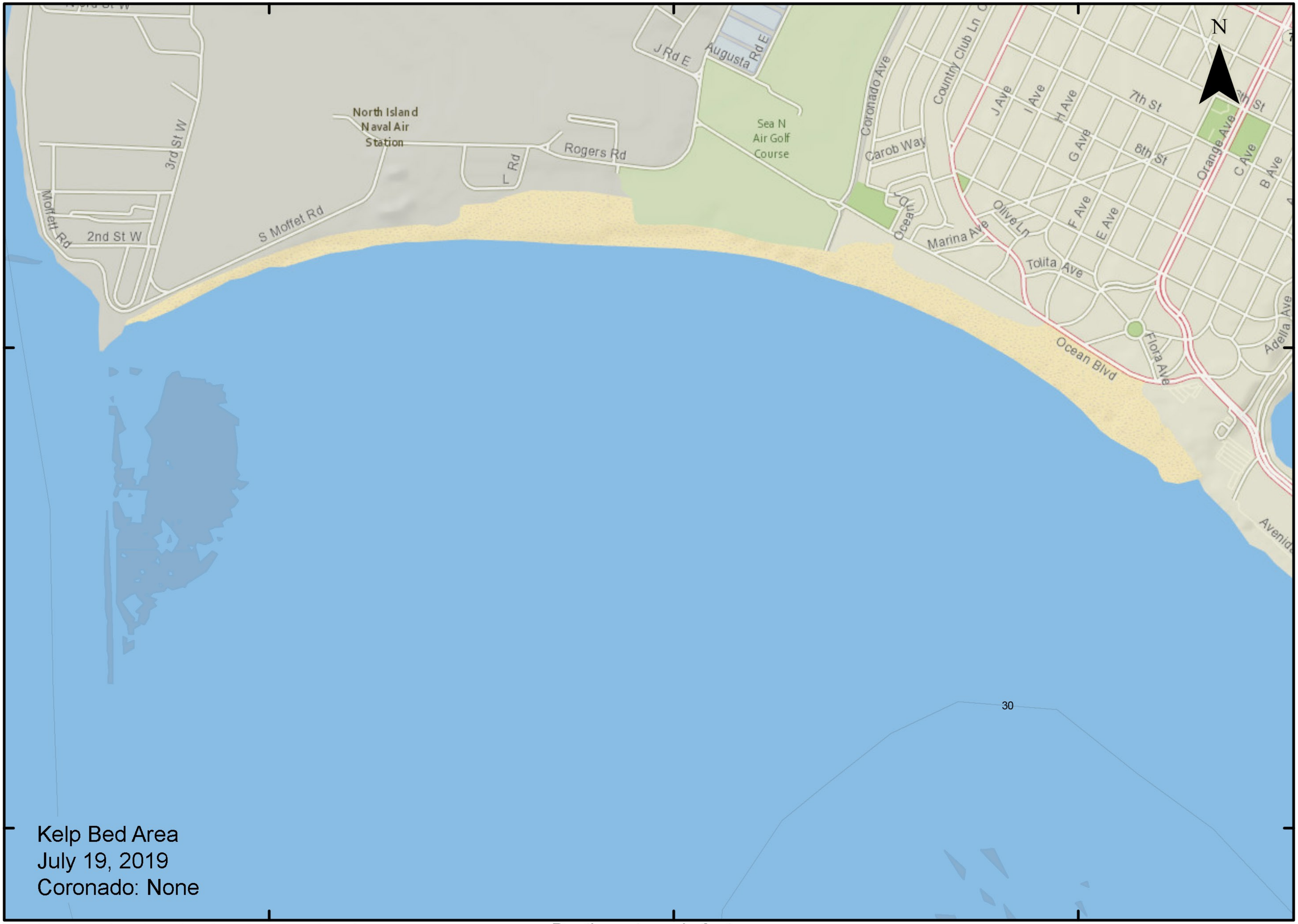
Appendix A.73
Point Loma (bay entrance)

mbc AQUATIC SCIENCES

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



Appendix A.74
Point Loma



1 stat. mi.

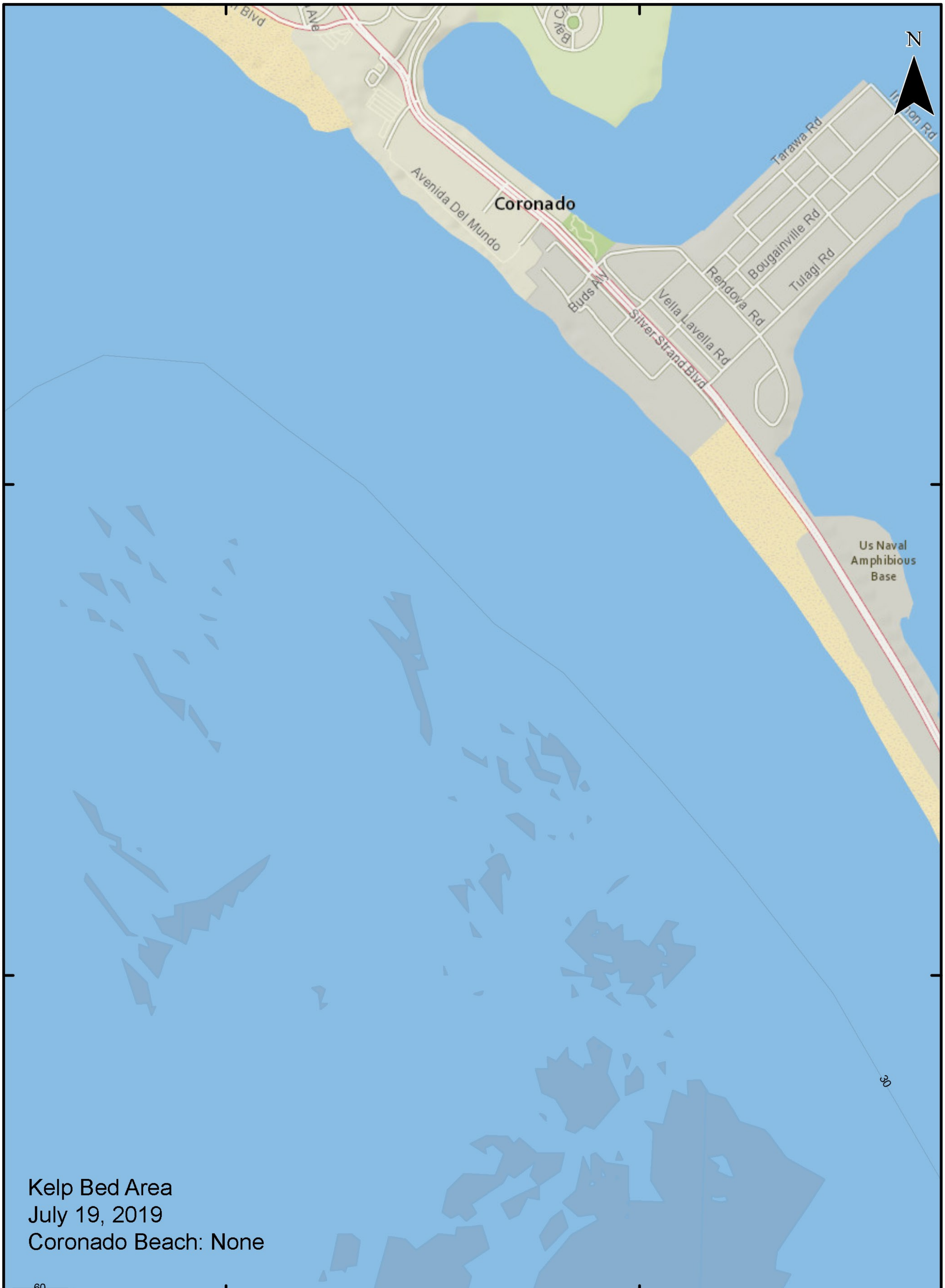
1 Km.

1:24,000

Depth contours in feet

Kelp	Artificial Reef
Isobath	Discharge Structure
Kelp Bed Divide	Hard Substrate

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



1 stat. mi. Depth contours in feet

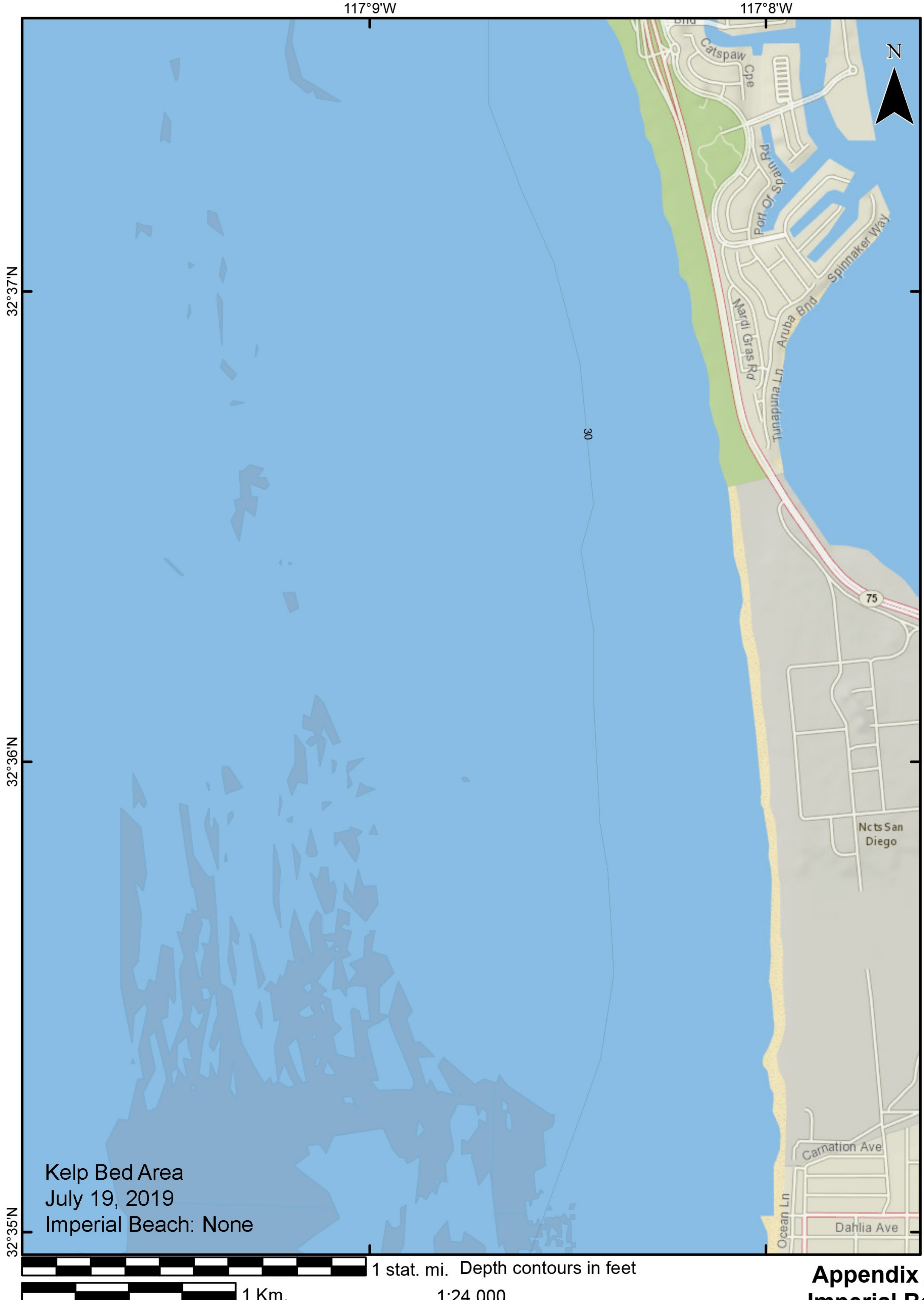
1 Km. 1:24,000

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

mbc AQUATIC SCIENCES

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

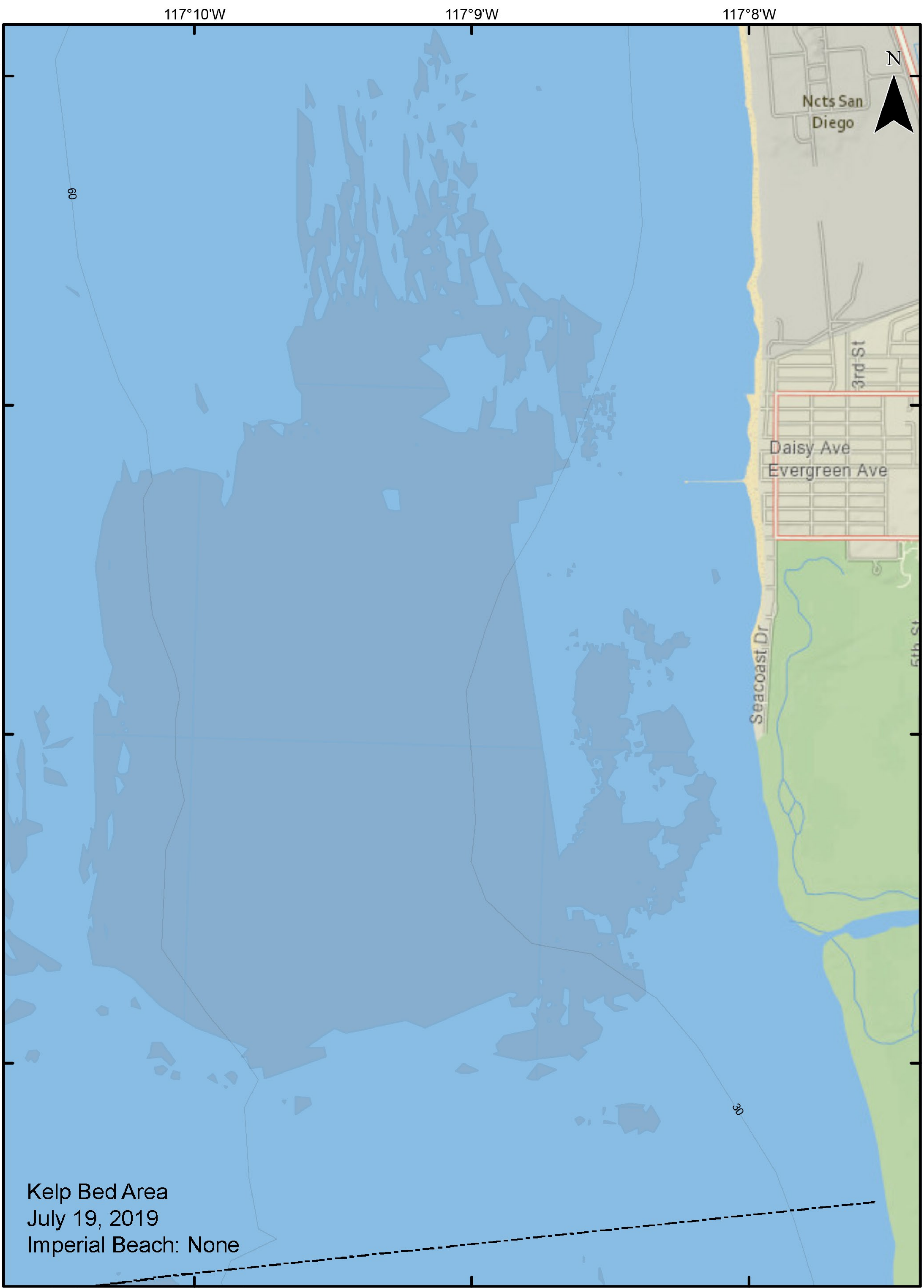
Appendix A.77
Coronado Beach/
Silver Strand
(Central)



Appendix A.78
Imperial Beach

mbc AQUATIC SCIENCES

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



1 stat. mi.

1 Km.

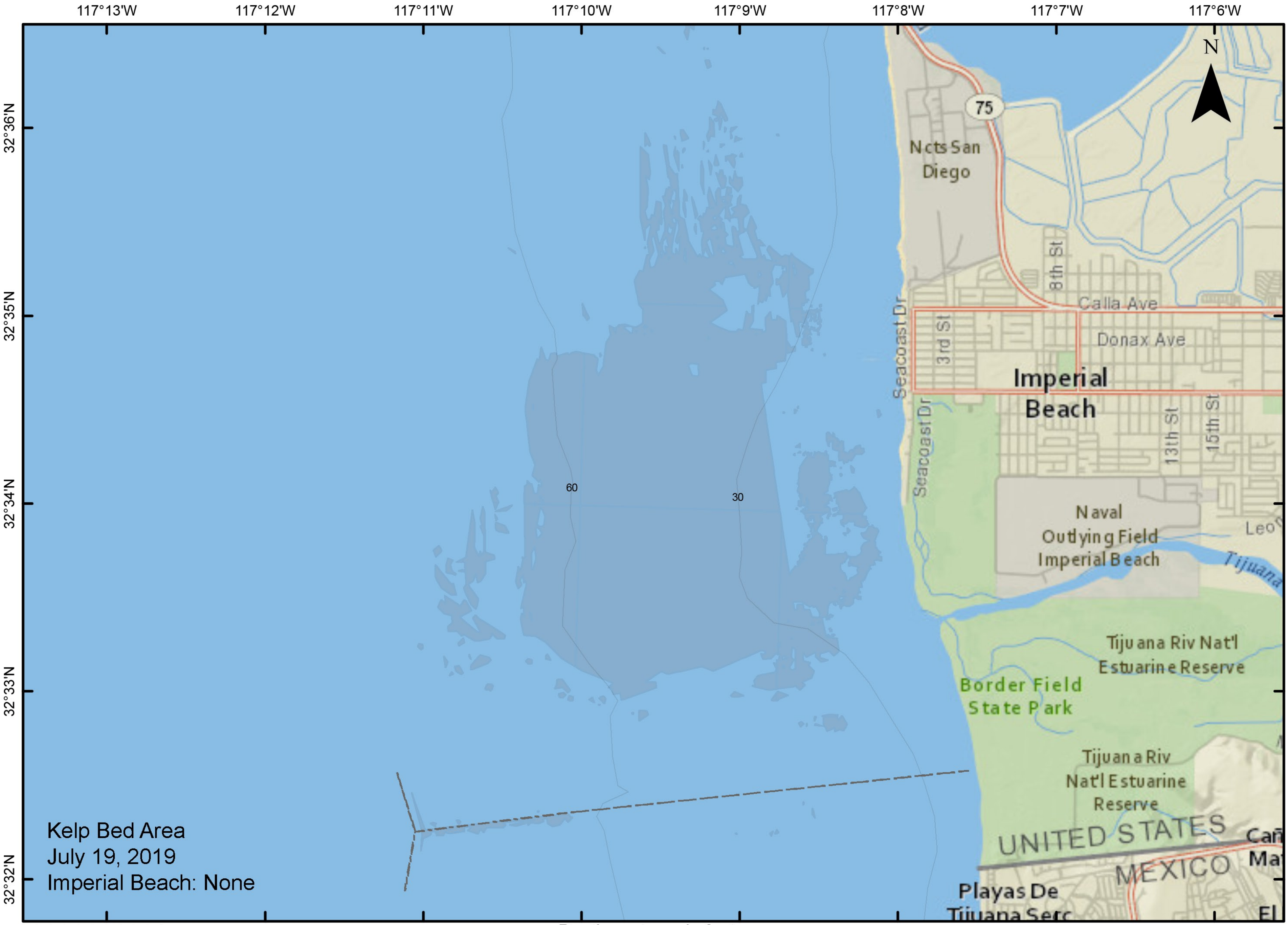
Depth contours in feet

1:35,000

Appendix A.79
Imperial Beach

mbc AQUATIC SCIENCES

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



1 stat. mi.
1 Km.
1:60,000

Depth contours in feet

Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Discharge Structure
Hard Substrate

Appendix A.80
Imperial Beach

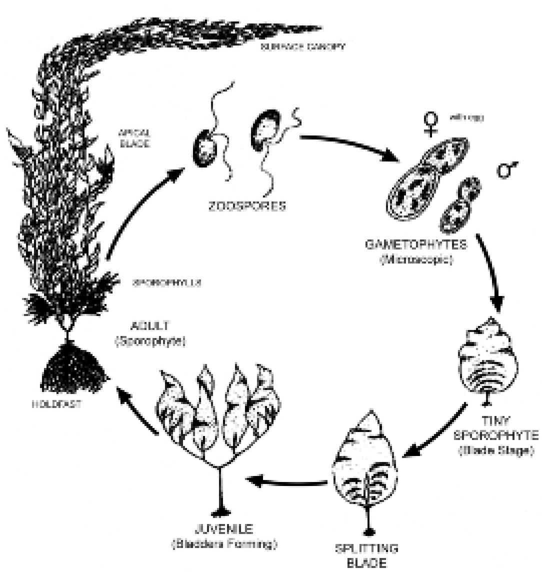
APPENDIX B

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

LIFE HISTORY OF GIANT KELP

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

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



Appendix B.1 Life cycle for giant kelp.

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

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

HISTORICAL KELP SURVEYS

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

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

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

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

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

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

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

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

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

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

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

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

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

Appendix B.3 Historical canopy coverage of the kelp beds from Laguna Beach to Imperial Beach from 1911 through 2019. 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.3 (Cont.).

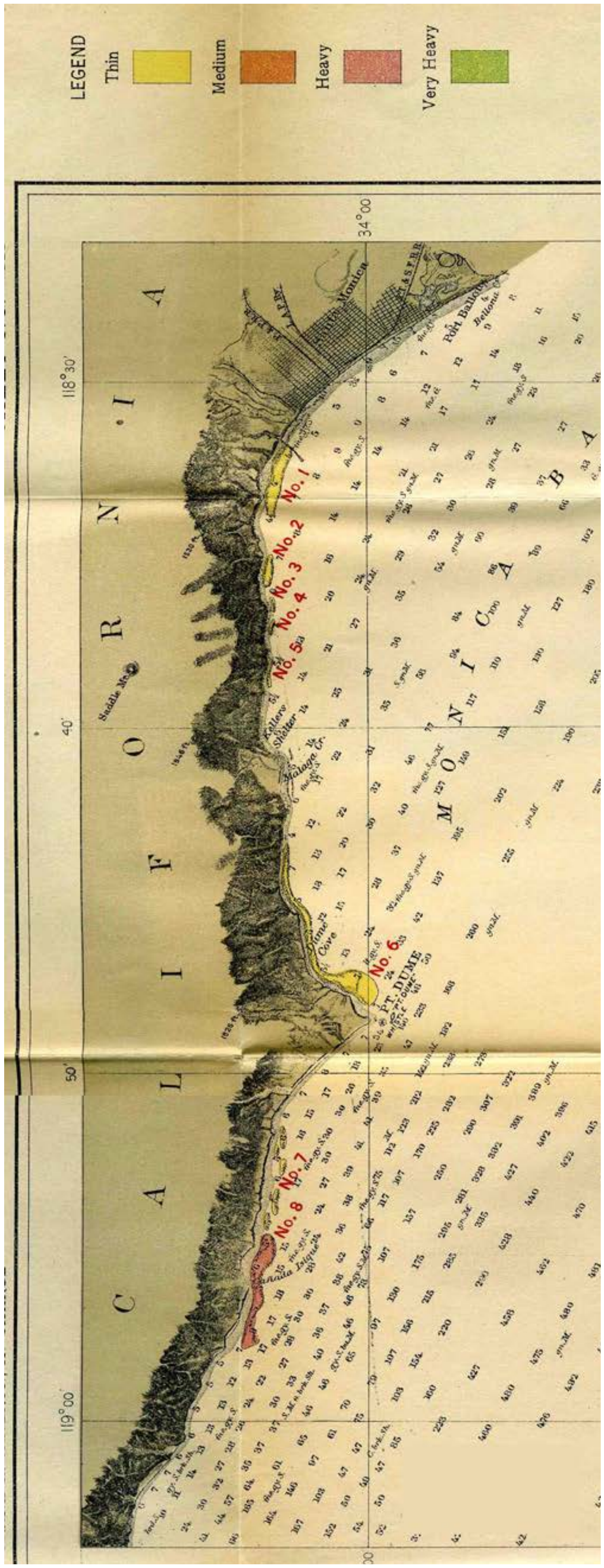
Kelp Bed	Canopy Area (km²)											
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
North Laguna Beach	0.028	0.022	0.028	0.042	0.055	0.034	0.029	—	—	—	—	0.001
South Laguna Beach	0.077	0.041	0.087	0.145	0.264	0.243	0.093	0.056	0.028	—	—	—
South Laguna	—	—	—	0.023	0.041	0.023	0.030	0.009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

Appendix B.3 (Cont.).

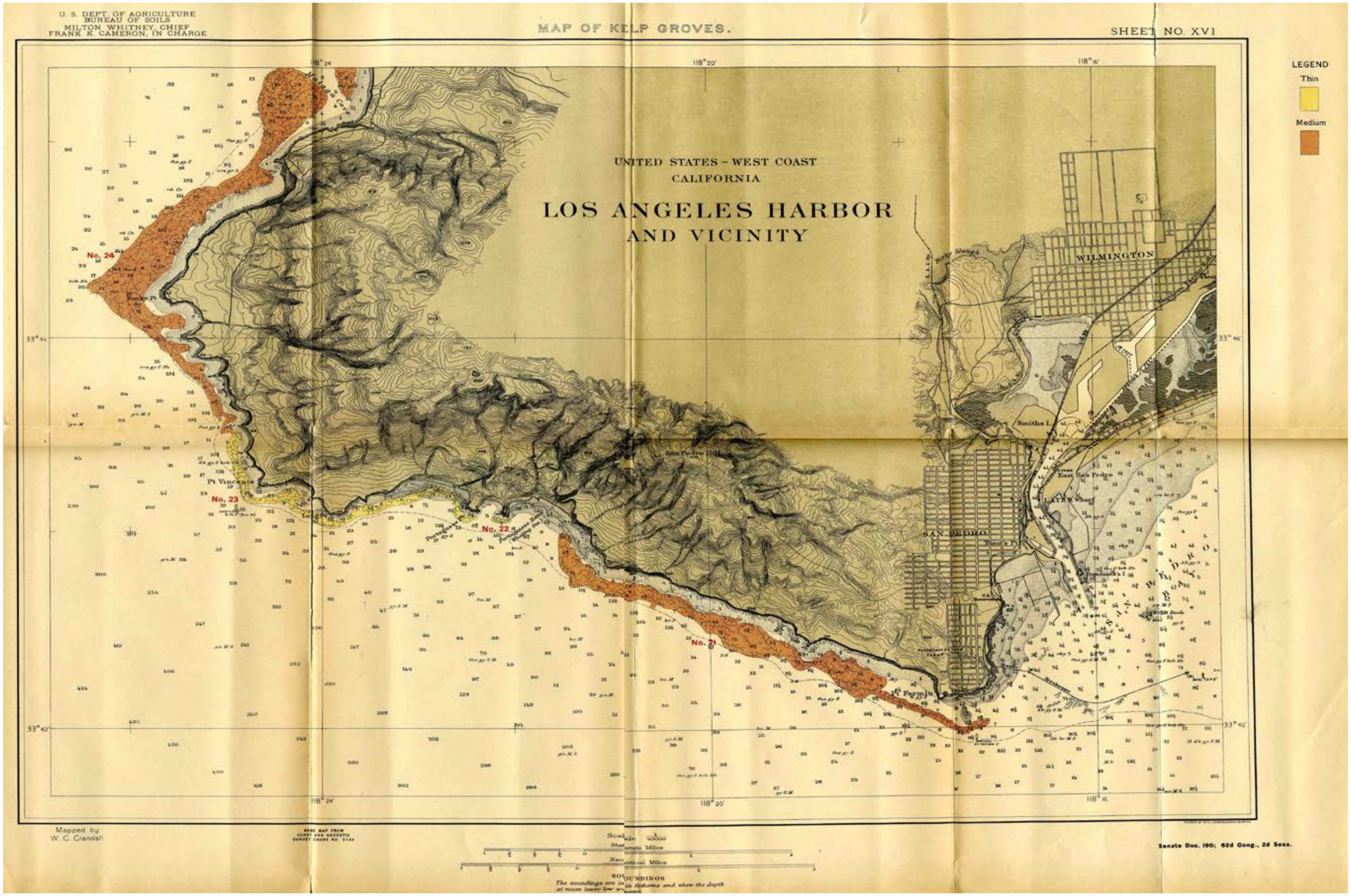
Kelp Bed	Canopy Area (km²)											
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
North Laguna Beach	—	—	—	—	—	—	0.0004	—	—	—	—	0.002
South Laguna Beach	—	—	—	—	—	0.005	0.0002	0.008	—	—	0.001	0.025
South Laguna	—	—	—	0.003	0.002	<0.001	0.004	0.009	0.003	—	0.004	0.023
Dana Point-Salt Creek	0.034	0.005	0.080	0.170	0.314	0.432	0.303	0.278	0.123	—	0.302	1.068
Capistrano Beach	—	—	<0.001	<0.001	0.044	0.118	0.069	0.008	—	0.011	0.002	0.071
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	1.189
San Clemente	—	—	0.006	0.005	0.124	0.316	0.352	0.182	0.178	0.014	0.016	0.203
San Mateo Point	0.098	—	0.051	0.050	0.090	0.155	0.242	0.123	0.258	0.016	0.201	0.487
San Onofre	0.108	<0.001	0.005	0.020	0.041	0.030	0.162	0.109	0.065	—	0.320	0.476
Total F&W 8	0.206	—	0.062	0.075	0.255	0.501	0.755	0.414	0.501	0.030	0.536	1.166
Horno Canyon	—	—	—	0.002	0.034	—	0.001	—	—	—	0.015	0.083
Barn Kelp	0.178	—	0.310	0.375	0.547	0.667	0.492	0.075	0.064	—	0.466	0.858
Santa Margarita	—	—	—	—	—	—	—	—	—	—	—	—
Total F&W 7	0.178	—	0.310	0.377	0.581	0.667	0.494	0.075	0.064	—	0.481	0.941
North Carlsbad	—	0.003	—	—	0.017	0.053	0.017	0.003	0.013	—	0.026	0.108
Agua Hedionda	—	—	—	—	—	<0.001	0.002	0.001	0.008	—	0.016	0.080
Encina Power Plant	0.013	—	—	0.002	0.029	0.097	0.178	0.067	0.001	—	0.081	0.306
Carlsbad State Beach	—	—	—	0.003	0.023	0.047	0.002	0.0001	—	—	0.064	0.121
Total F&W 6	0.013	0.003	—	0.005	0.069	0.197	0.199	0.070	0.023	—	0.187	0.615
Leucadia	0.062	—	0.015	0.090	0.209	0.334	0.185	0.048	0.001	0.016	0.233	0.421
Encinitas	0.048	—	0.029	0.040	0.131	0.153	0.050	0.016	—	0.002	0.205	0.346
Cardiff	0.031	0.016	0.063	0.150	0.309	0.405	0.202	0.045	—	0.004	0.286	0.484
Solana Beach	0.073	0.009	0.091	0.200	0.407	0.488	0.245	0.022	0.093	0.0003	0.457	0.823
Del Mar	Tr	0.004	—	0.006	0.015	0.035	0.030	—	—	—	0.037	0.057
Torrey Pines	—	—	—	—	—	—	—	—	—	0.010	—	0.001
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	2.133
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	4.145
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	6.623
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	1.895
TOTAL	3.385	0.547	3.540	5.676	11.542	10.710	10.572	4.136	4.233	2.358	10.591	18.706

Appendix B.3 (Cont.).

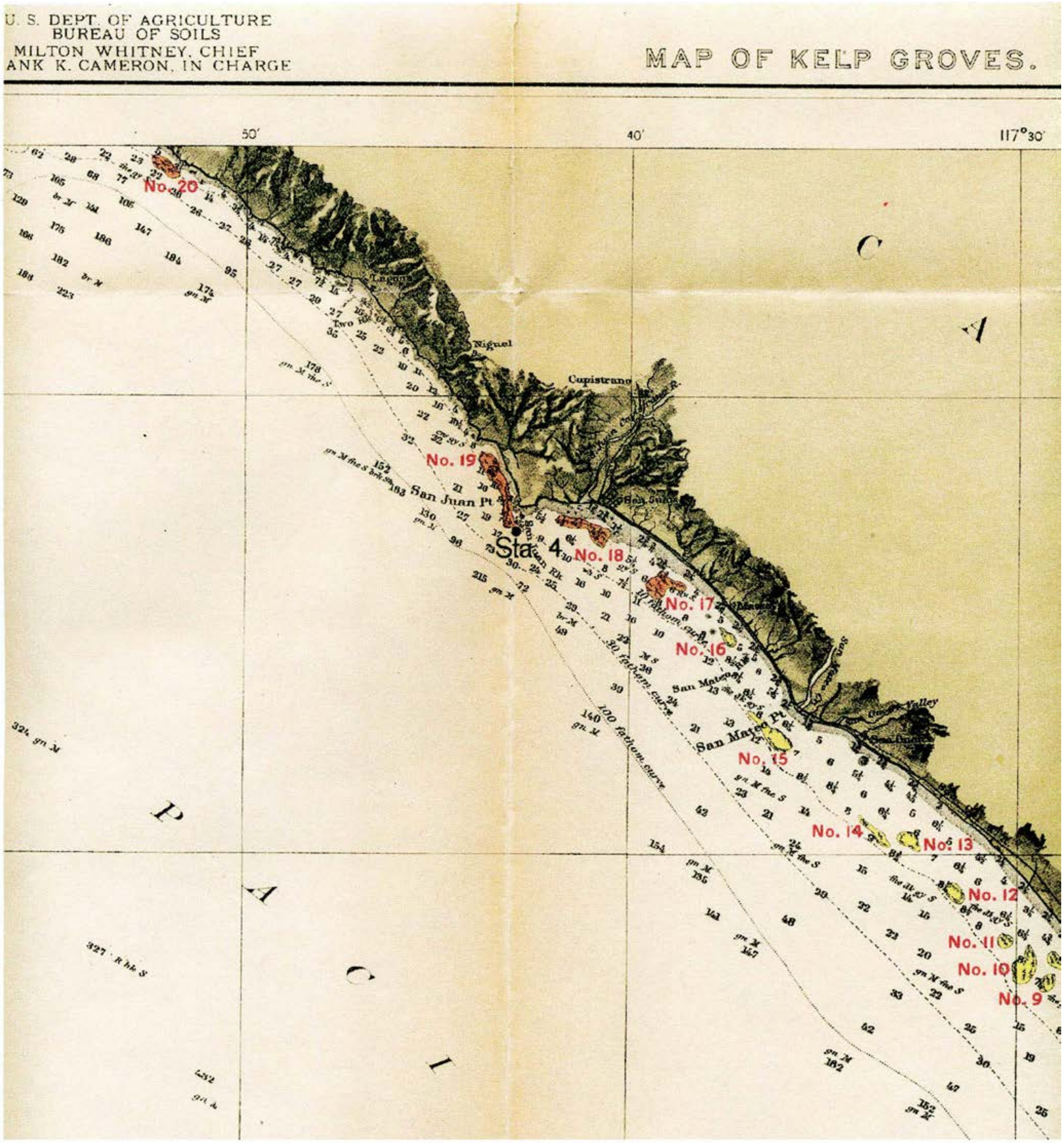
Kelp Bed	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
North Laguna Beach	0.005	0.093	0.147	0.192	0.142	0.120	0.080	0.074	0.096	0.133	0.015
South Laguna Beach	0.058	0.098	0.221	0.214	0.273	0.165	0.048	0.035	0.032	0.131	0.007
South Laguna	0.017	0.023	0.018	0.017	0.038	0.031	0.016	0.006	0.003	0.048	—
Dana Point-Salt Creek	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	0.022
San Clemente	0.210	0.710	0.795	0.874	1.097	0.843	0.343	0.187	0.229	0.335	0.031
San Mateo Point	0.545	0.583	0.203	0.216	0.219	0.199	0.062	0.053	0.033	0.083	0.0001
San Onofre	0.419	0.458	0.127	0.191	0.767	0.584	0.043	0.120	0.087	0.127	0.001
Total F&W 8	1.174	1.750	1.124	1.281	2.083	1.627	0.449	0.359	0.349	0.545	0.032
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	0.000
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 State Beach	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	0.000
Leucadia	0.429	0.215	0.119	0.232	0.541	0.279	0.414	0.033	0.010	0.053	0.009
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	0.009
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	1.227
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	3.924
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	5.213



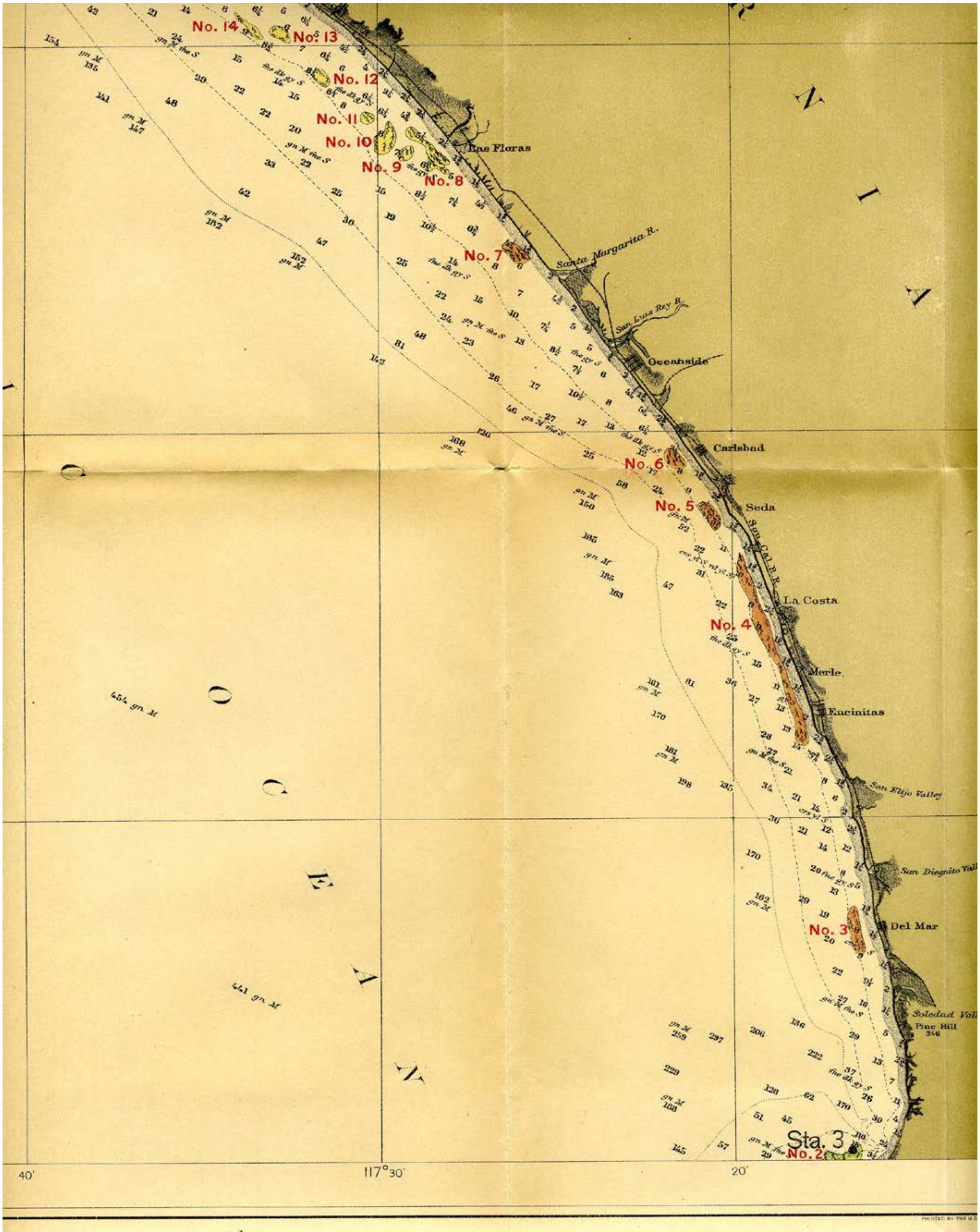
Appendix B.4 Crandall's 1911 kelp survey Deer Creek to Ballona Creek.



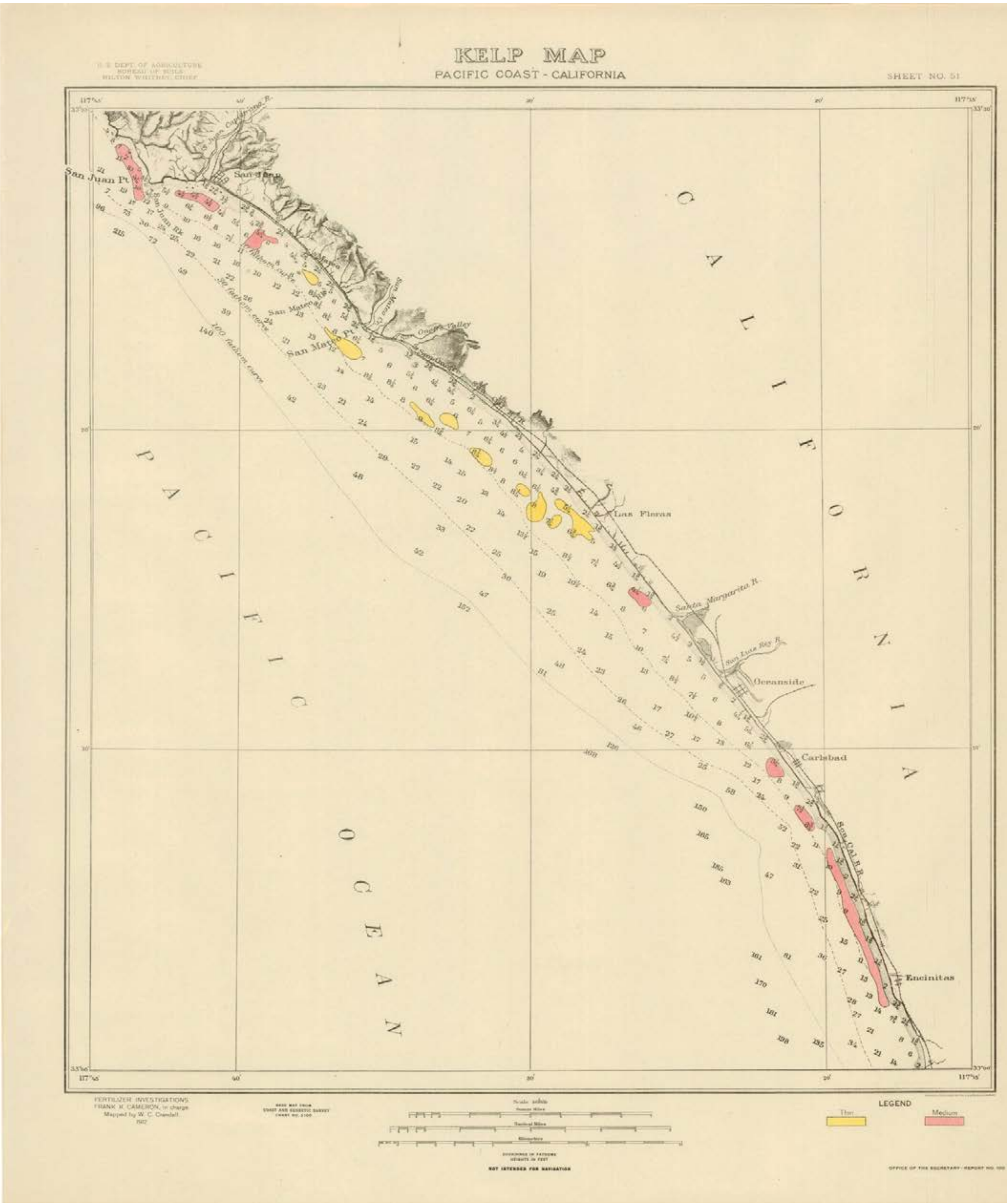
Appendix B.5 Crandall's 1911 kelp survey Palos Verdes to Los Angeles Harbor.



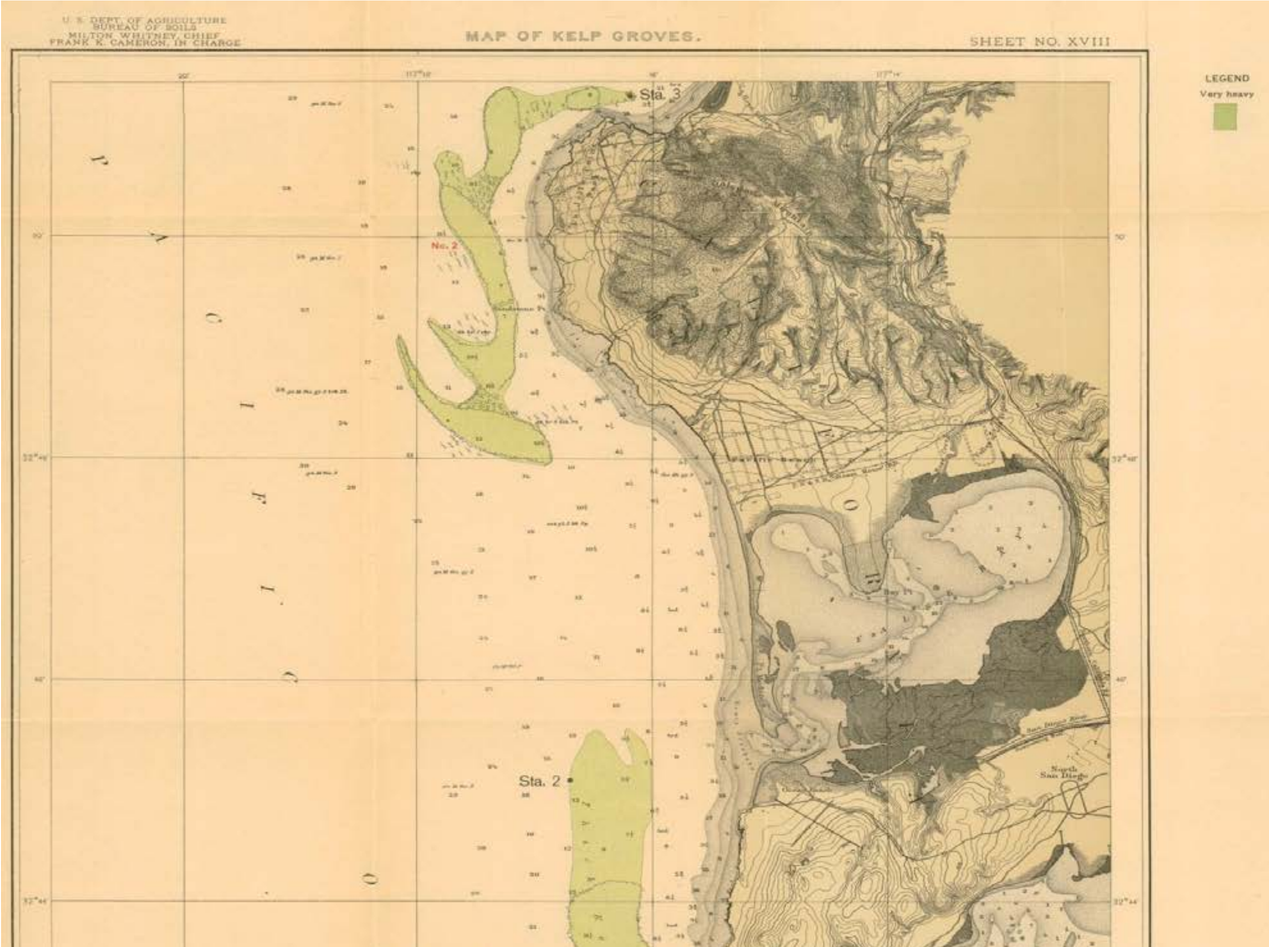
Appendix B.6 Crandall's 1911 kelp bed survey Newport to San Onofre.



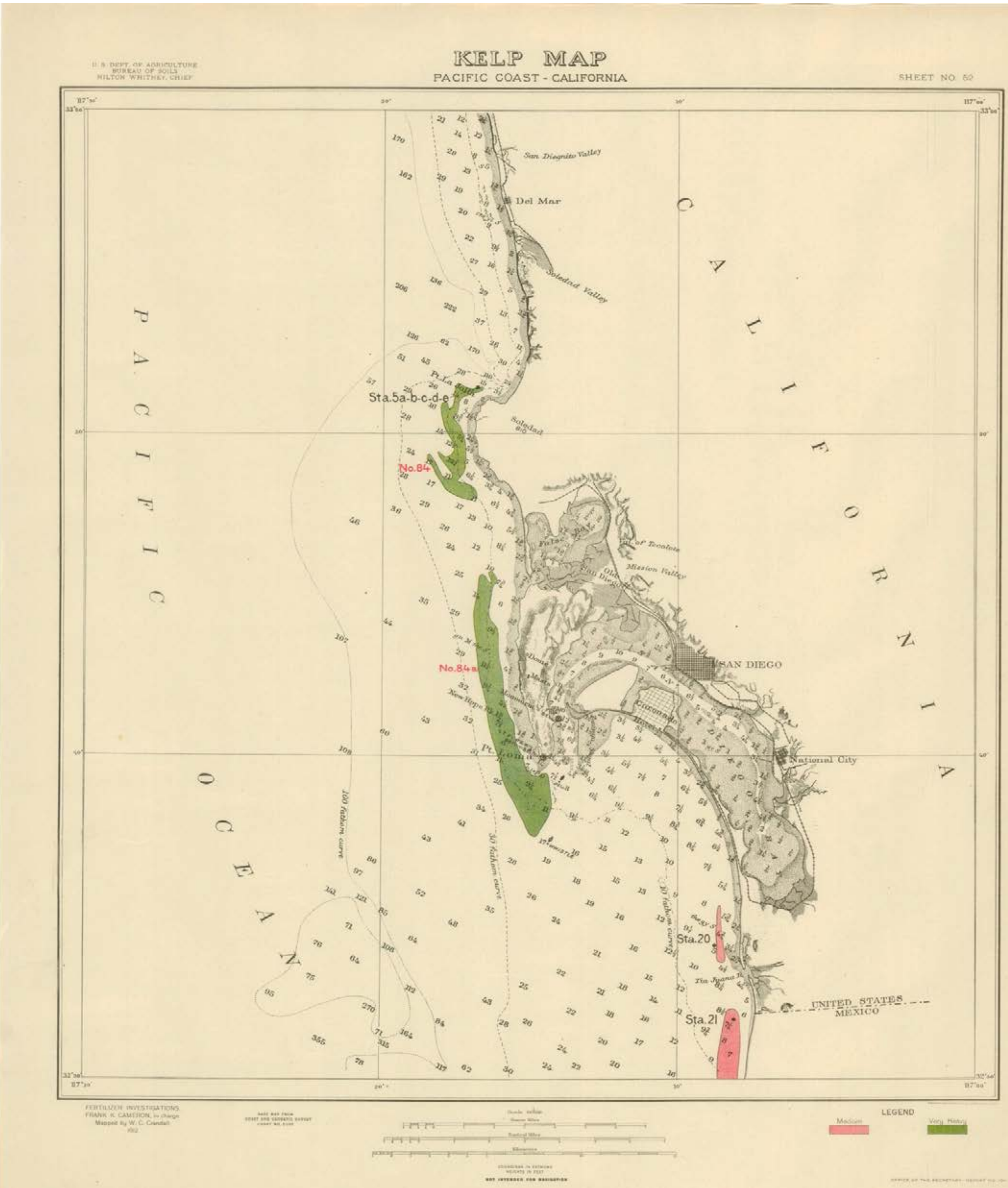
Appendix B.7 Crandall's 1911 kelp bed survey San Onofre to Del Mar.



Appendix B.8 Crandall's 1911 kelp bed survey San Juan to Encinitas.



Appendix B.9 Crandall's 1911 kelp bed survey La Jolla to Point Loma.

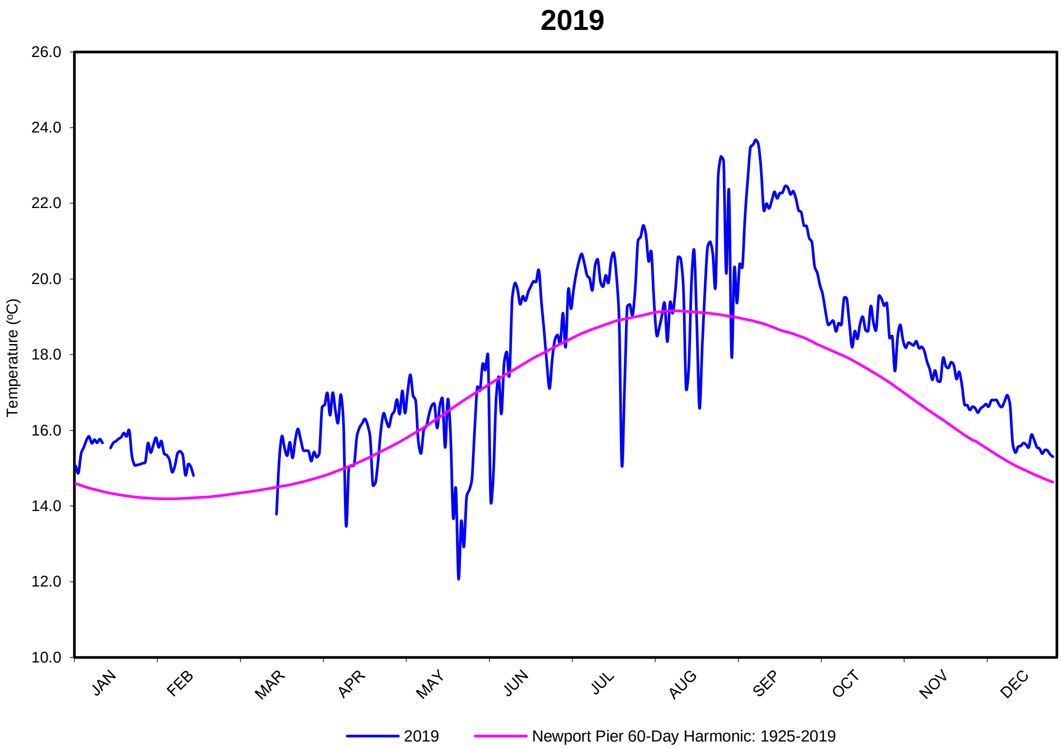


Appendix B.10 Crandall's 1911 kelp bed survey La Jolla to Imperial Beach.

APPENDIX C

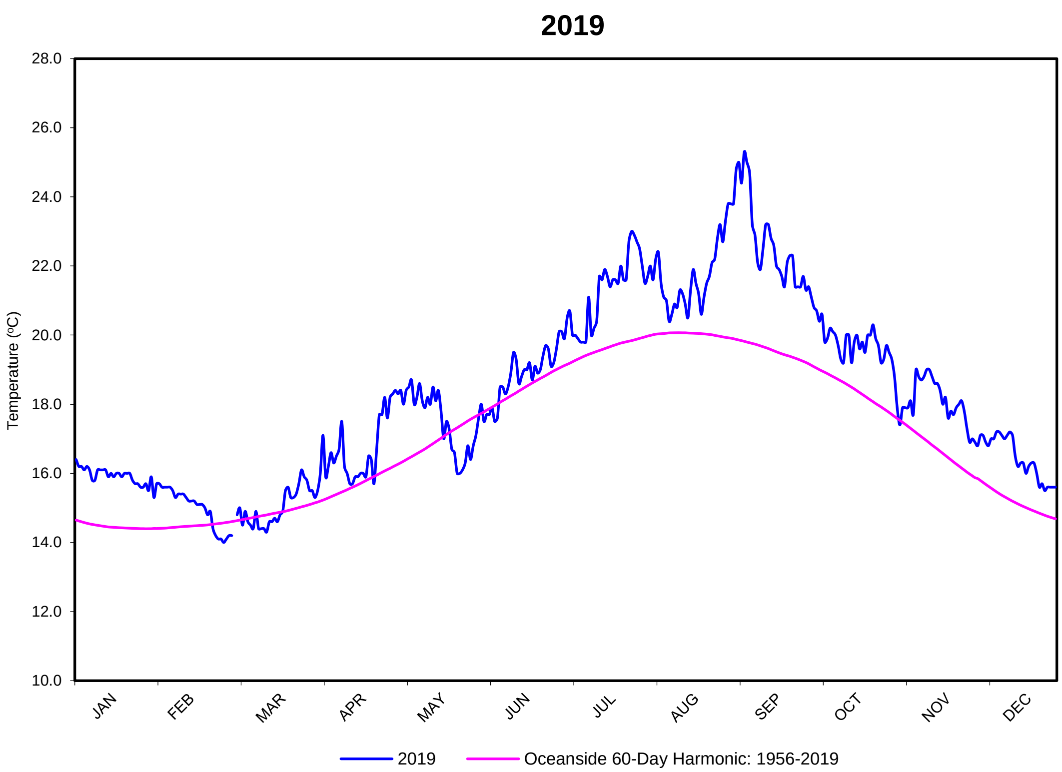
Sea Surface Temperatures

Newport Pier
Sea Surface Temperature



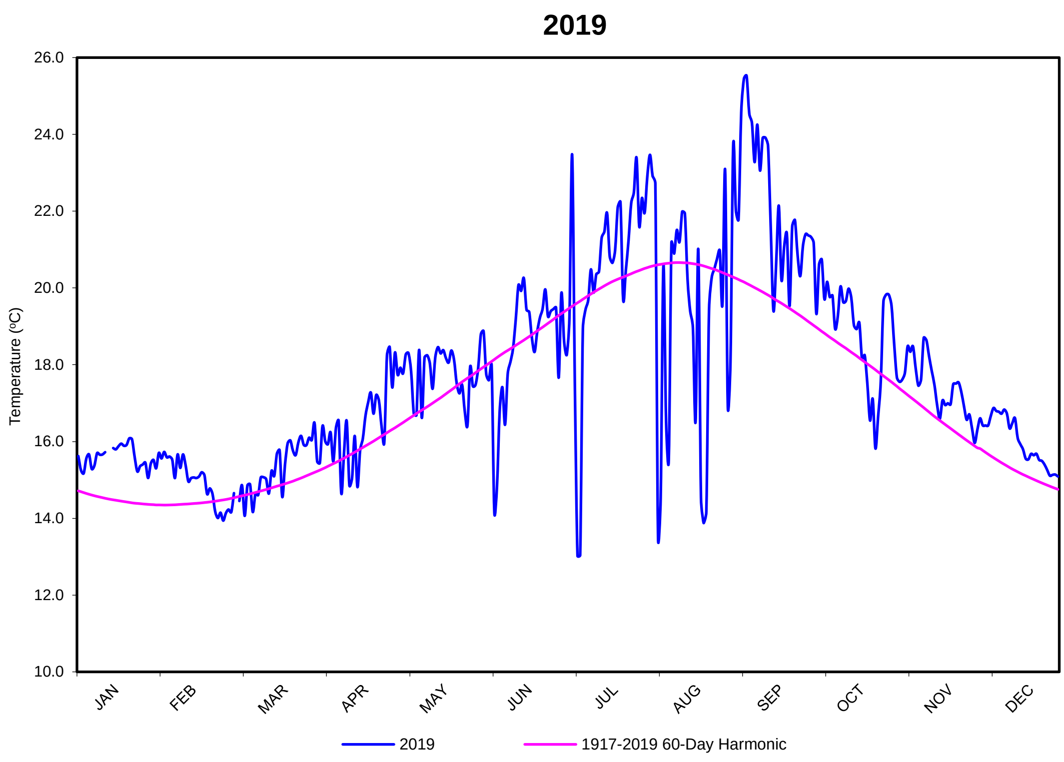
Appendix C.1 Daily sea surface temperatures (SST) at Newport Pier for 2019.

Oceanside
Sea Surface Temperature



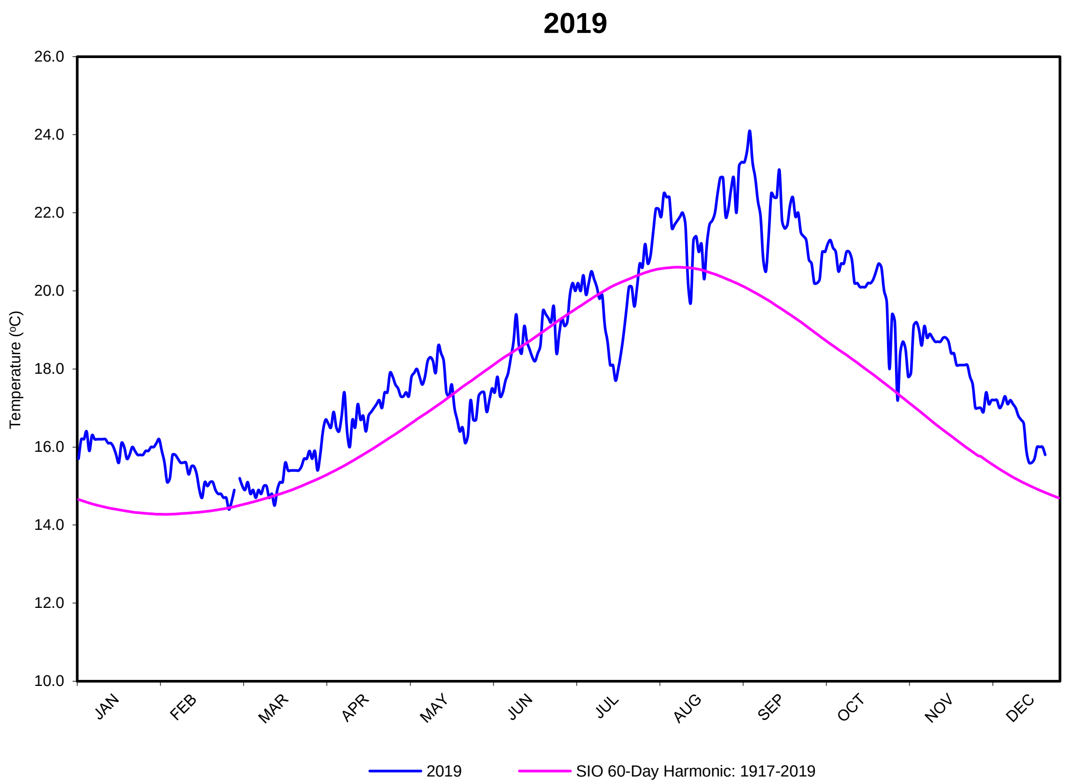
Appendix C.2 Daily sea surface temperatures (SST) at Oceanside for 2019.

Scripps Pier
Sea Surface Temperature



Appendix C.3 Daily sea surface temperatures (SST) at Scripps Pier for 2019.

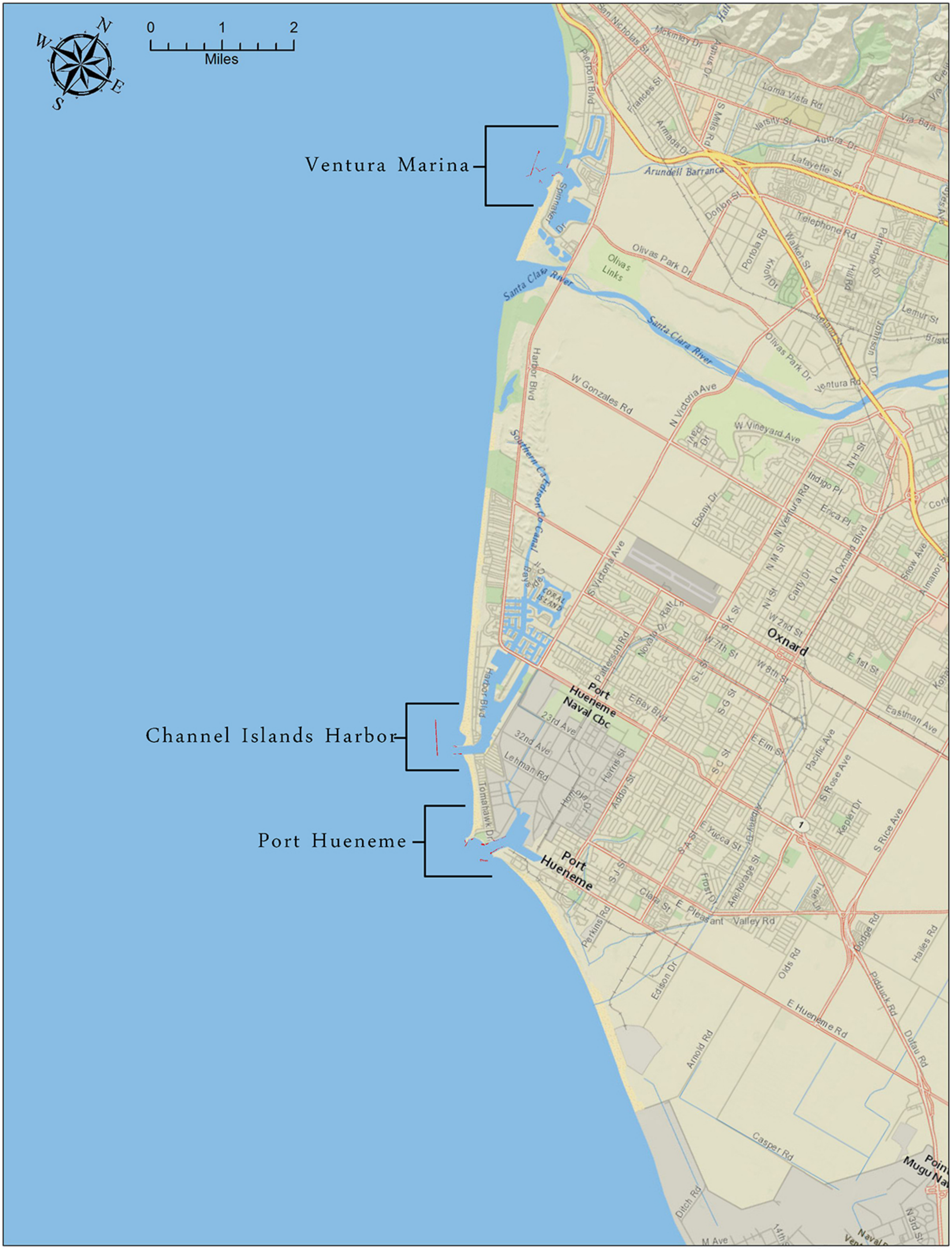
Point Loma South
Sea Surface Temperature



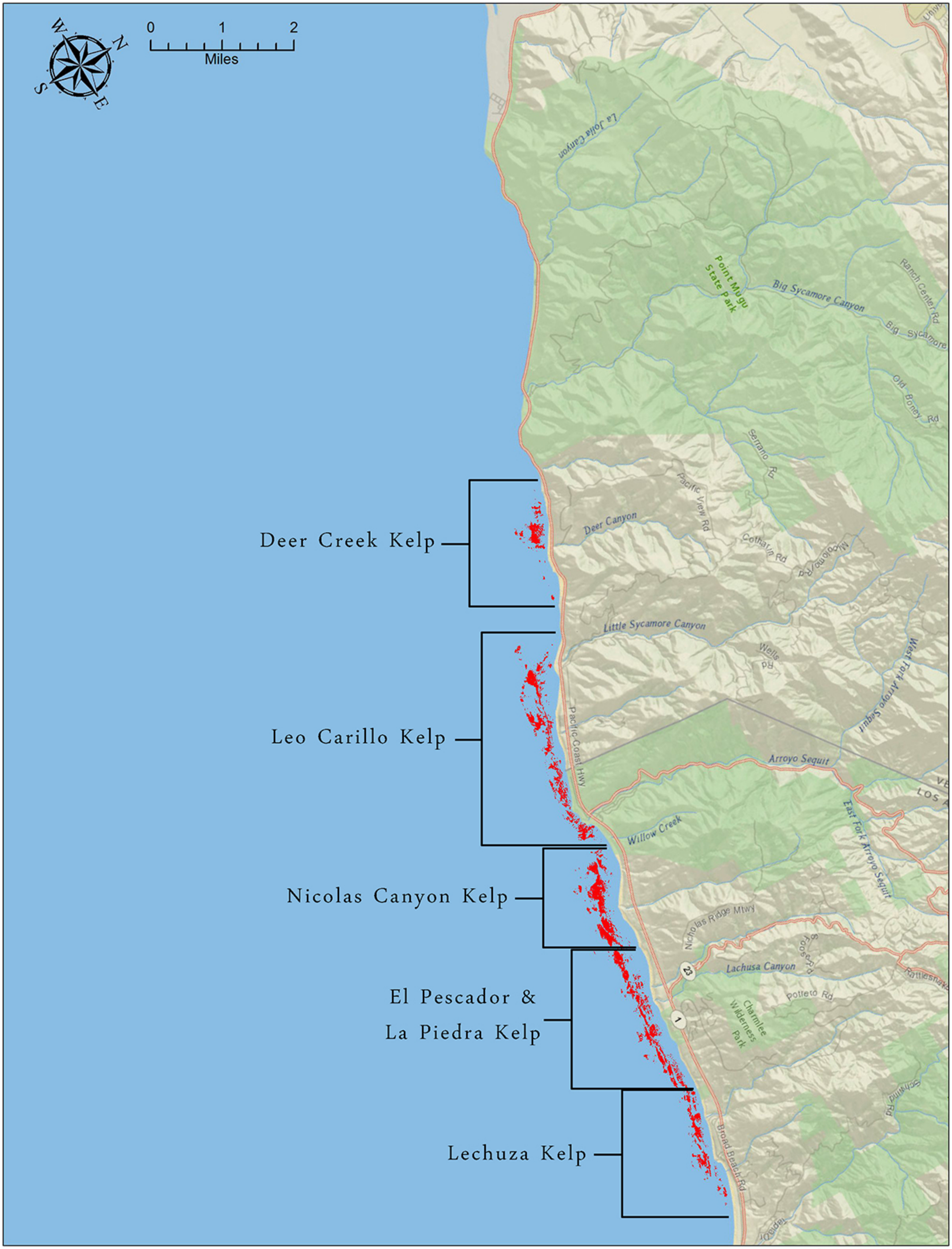
Appendix C.4 Daily sea surface temperatures (SST) at Point Loma South for 2019.

APPENDIX D

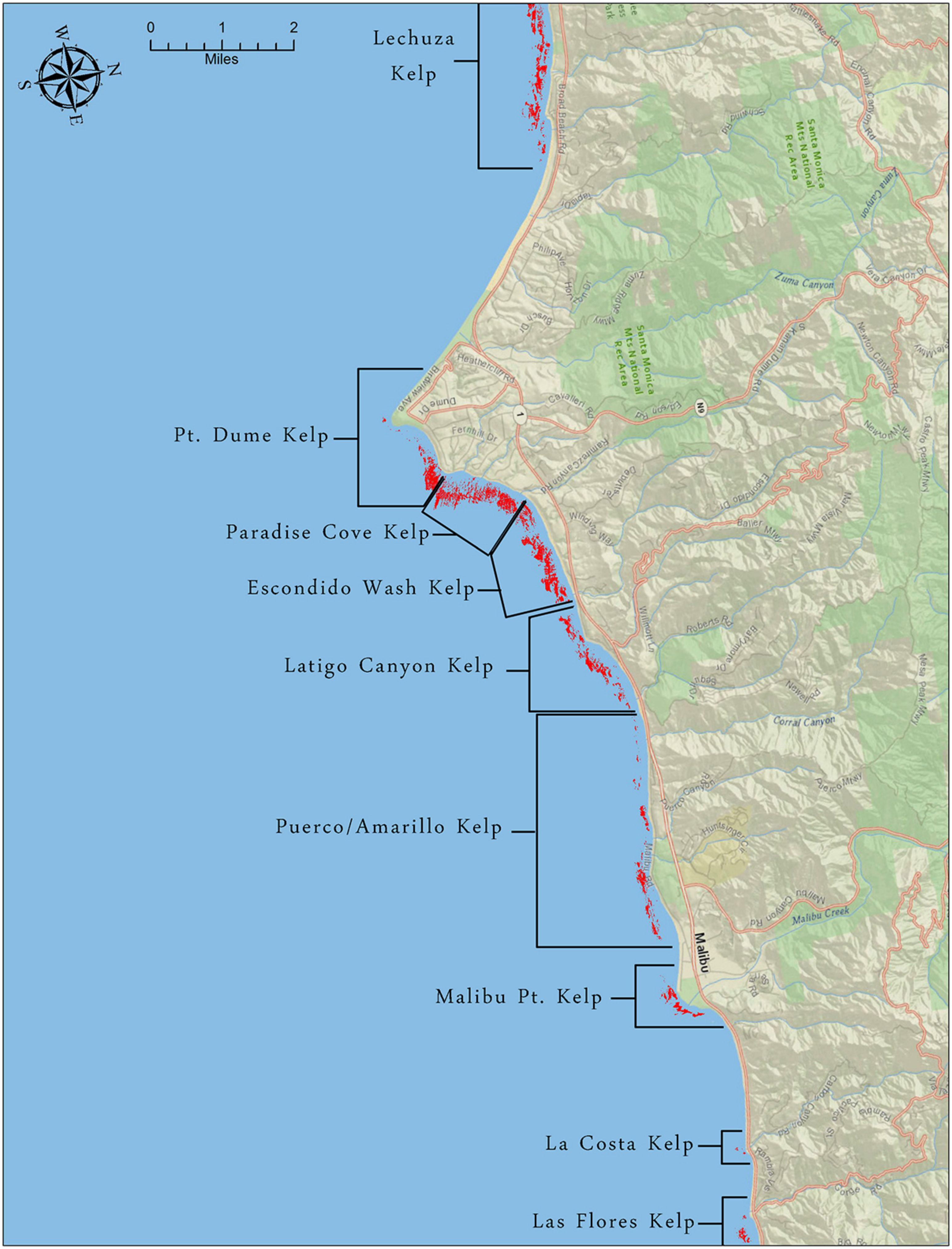
Flight Path
Flight Data Reports
Field Data Sheets


0 1 2
Miles
Ventura Marina
Channel Islands Harbor
Port Hueneme
Oxnard
Port Hueneme Naval Cbc
Santa Clara River

Appendix D.1

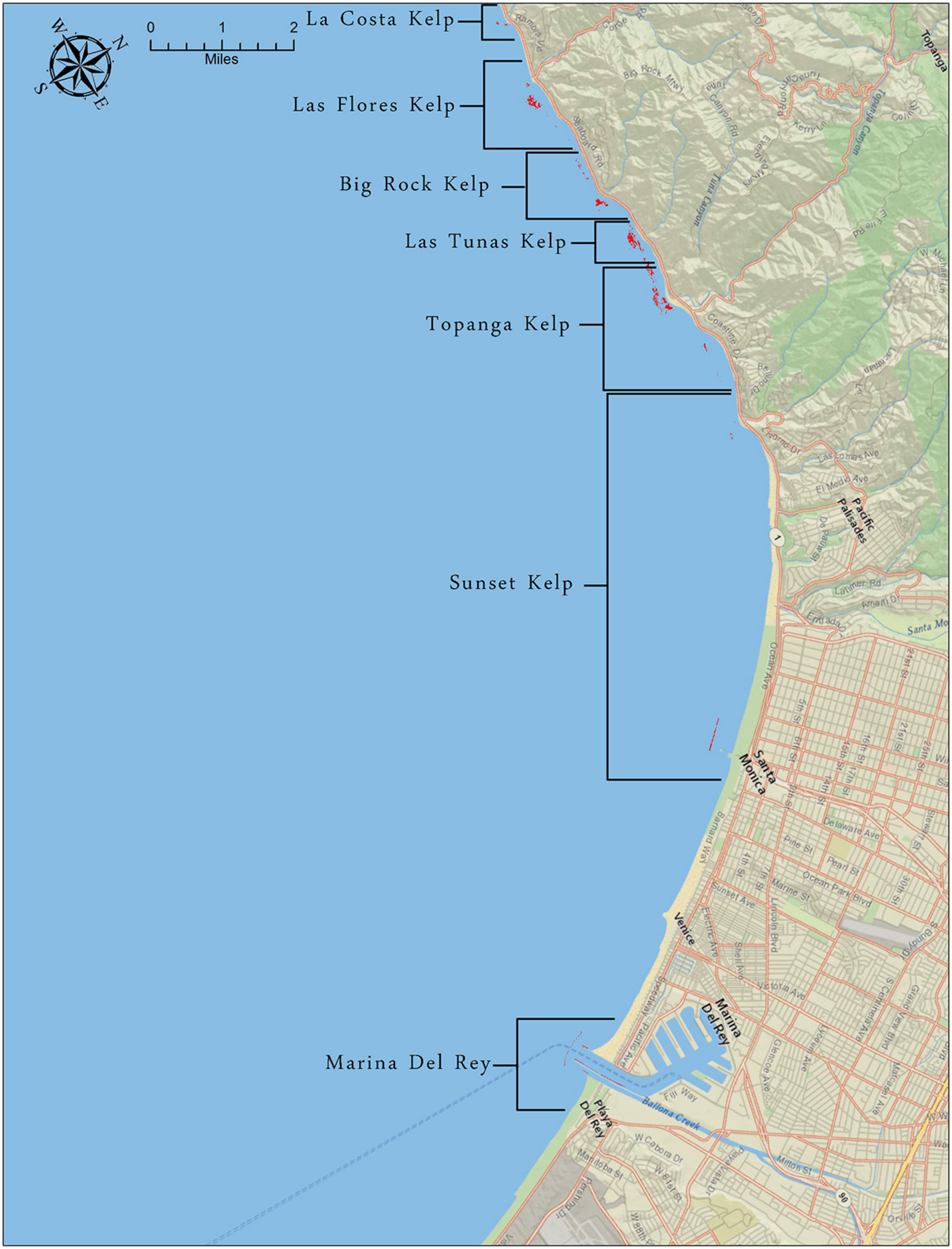


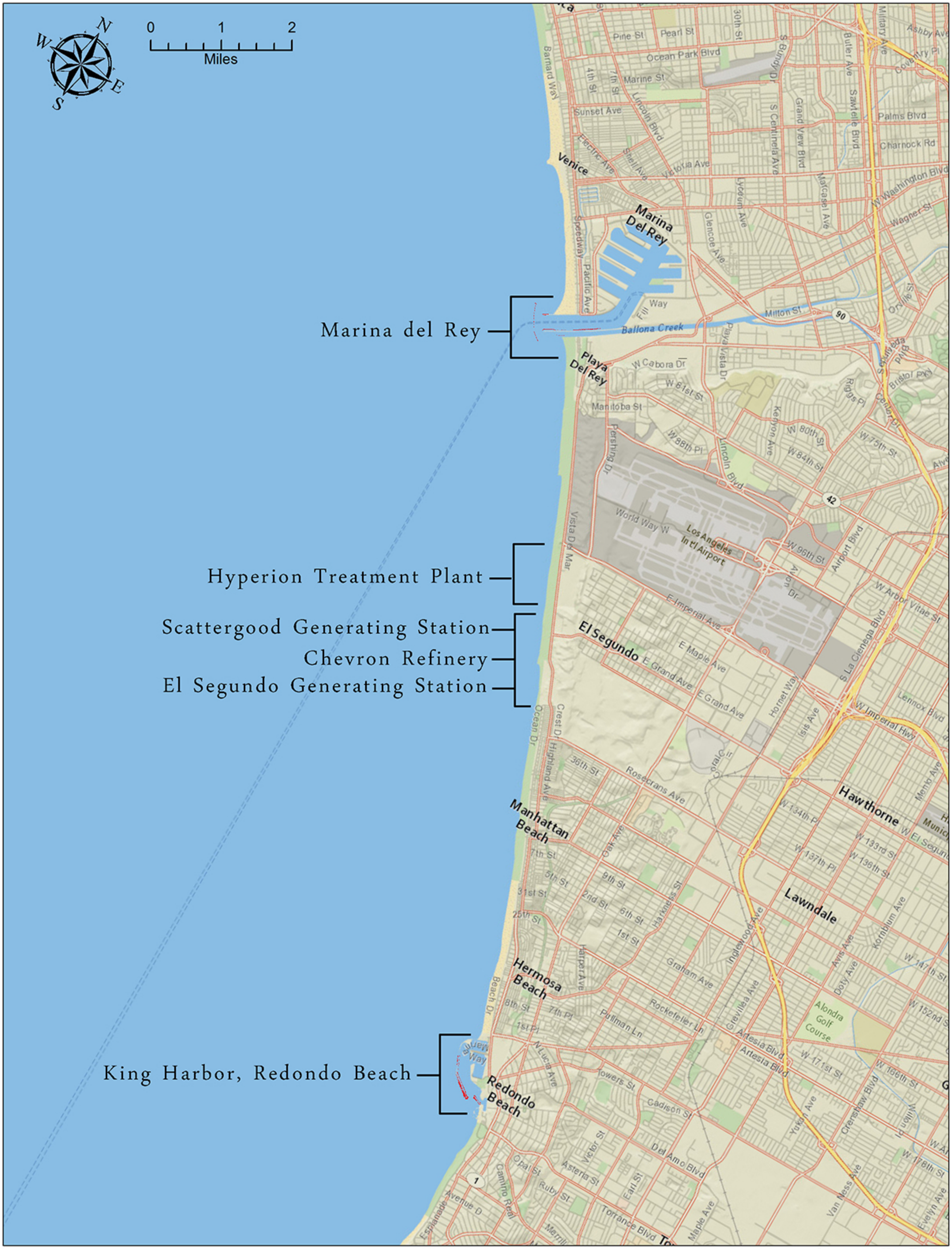
0
1
2
Miles
Deer Creek Kelp
Leo Carillo Kelp
Nicolas Canyon Kelp
El Pescador & La Piedra Kelp
Lechuza Kelp
Point Mugu State Park
La Jolla Canyon
Big Sycamore Canyon
Deer Canyon
Little Sycamore Canyon
Pacific Coast Hwy
Arroyo Sequit
Willow Creek
East Fork Arroyo Sequit
West Fork Arroyo Sequit
Nicholas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



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
Zuma Canyon
Corral Canyon
Malibu Creek

Appendix D.3


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



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
Alondra Golf Course
Ballona Creek

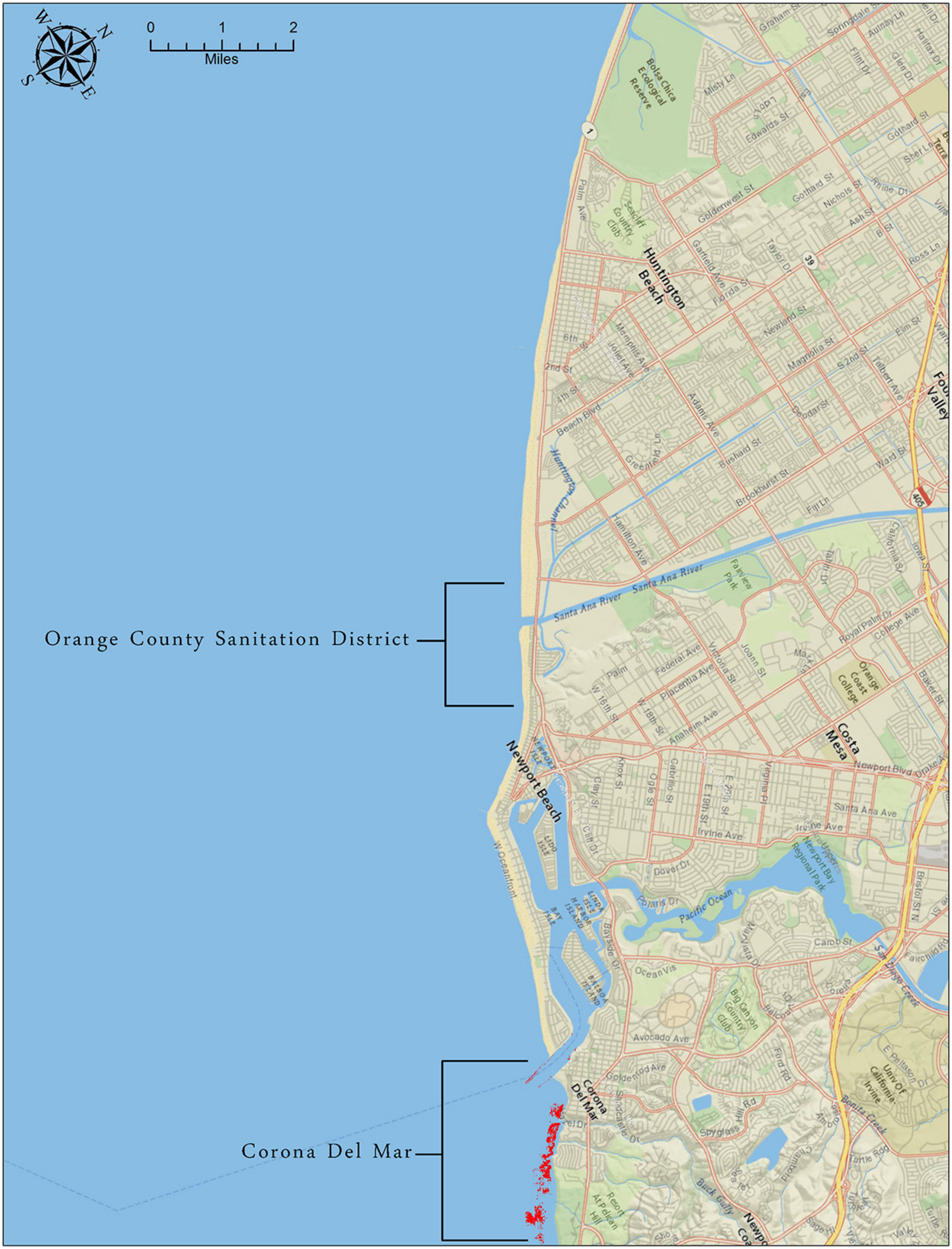
Appendix D.5

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
Torrance
Palos Verdes Estates
Palos Verdes Peninsula
Rancho Palos Verdes
Rolling Hills Estates
Rolling Hills
Torrance Municipal Airport
Lomita
Harbor City
Defense Fuel Supply Point San Pedro
Wilmington
San Pedro
Los Angeles Harbor
Terminal Island

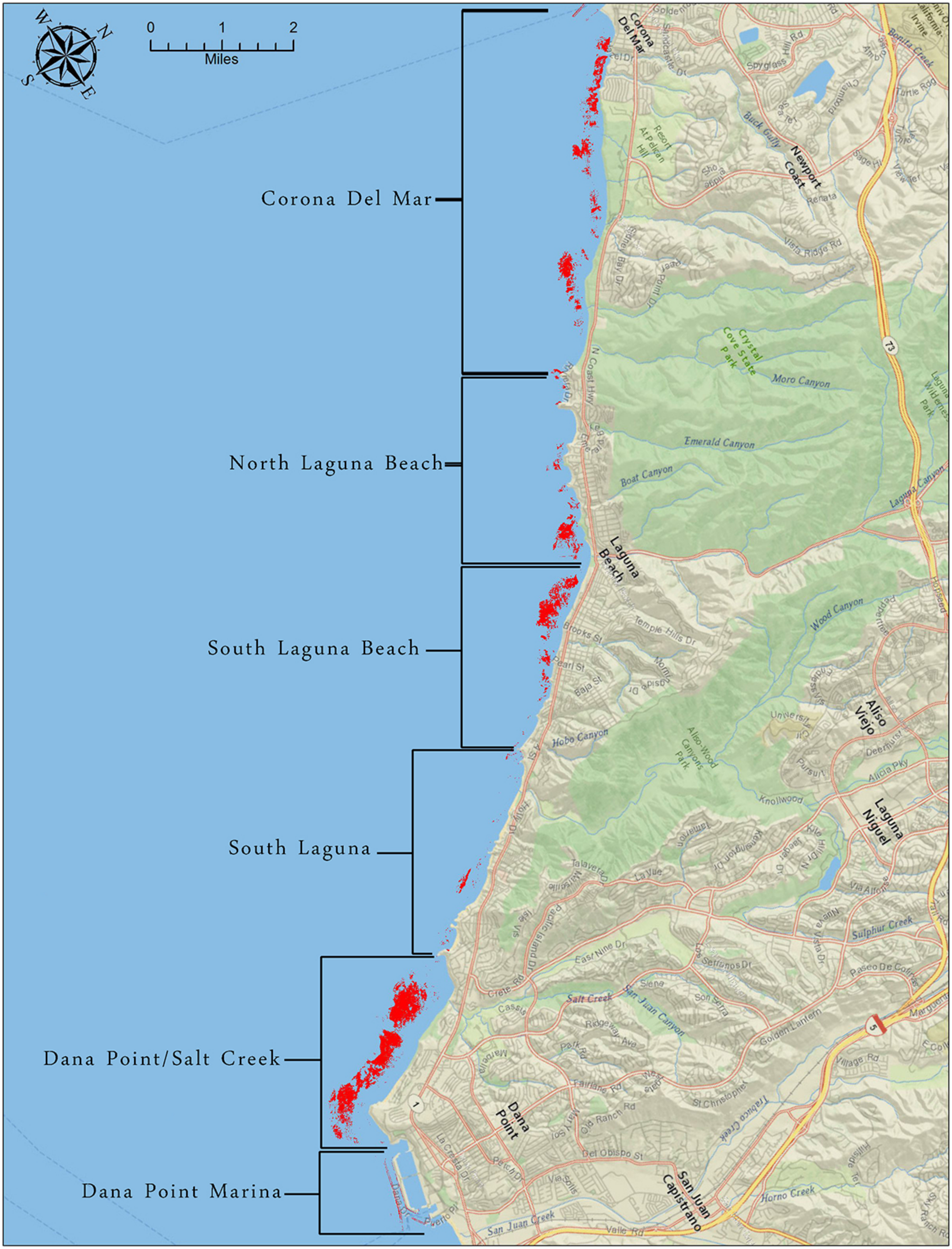
Appendix D.6


0
1
2
Miles
N
E
S
W
POLA/POLB
San Pedro
Wilmington
Los Angeles Harbor
Long Beach Harbor
Long Beach Harbor
Terminal Island
Pacific Ocean
Seal Beach
Surfside
Sunset Beach
Los Angeles River
Island Grissom
Island White
Island Freeman
Island Chaffee
Paseo Del Mar
W 25th St
W 20th St
W 22nd St
W 37th St
W 29th St
W 32nd St
W 38th St
W 9th St
W 6th St
W 14th St
W 8th St
W 3rd St
Miner St
Berth
Terminal Way
Earle St
Pier A St
S Fries Ave
Yacht St
Alameda St
New Dock St
Anchorage Rd
W Ocean Blvd
Harbor Scenic Way
Pier E St
Pier F Ave
Pier J Ave
Pico Ave
E Ocean Blvd
Quay Ave
Coil Ave
S Alameda St
Eubank Ave
E Sepulveda Blvd
Wilmington Ave
E 230th St
Caspian Ave
Harbor Ave
San Francisco Ave
Delta Ave
Daisy Ave
Pine Ave
Long Beach Blvd
Lime Ave
Olive Ave
Linden Ave
Alamitos Ave
Orange Ave
Ohio Ave
Obispo Ave
Redondo Ave
Termino Ave
Argonne Ave
E Appian Way
Lido Ln
16th St
Catalina Ave
Seal Way
Pacific Coast Hwy
Edinger Ave
Heil Ave
N Gaffey St
47
103
1

Appendix D.7

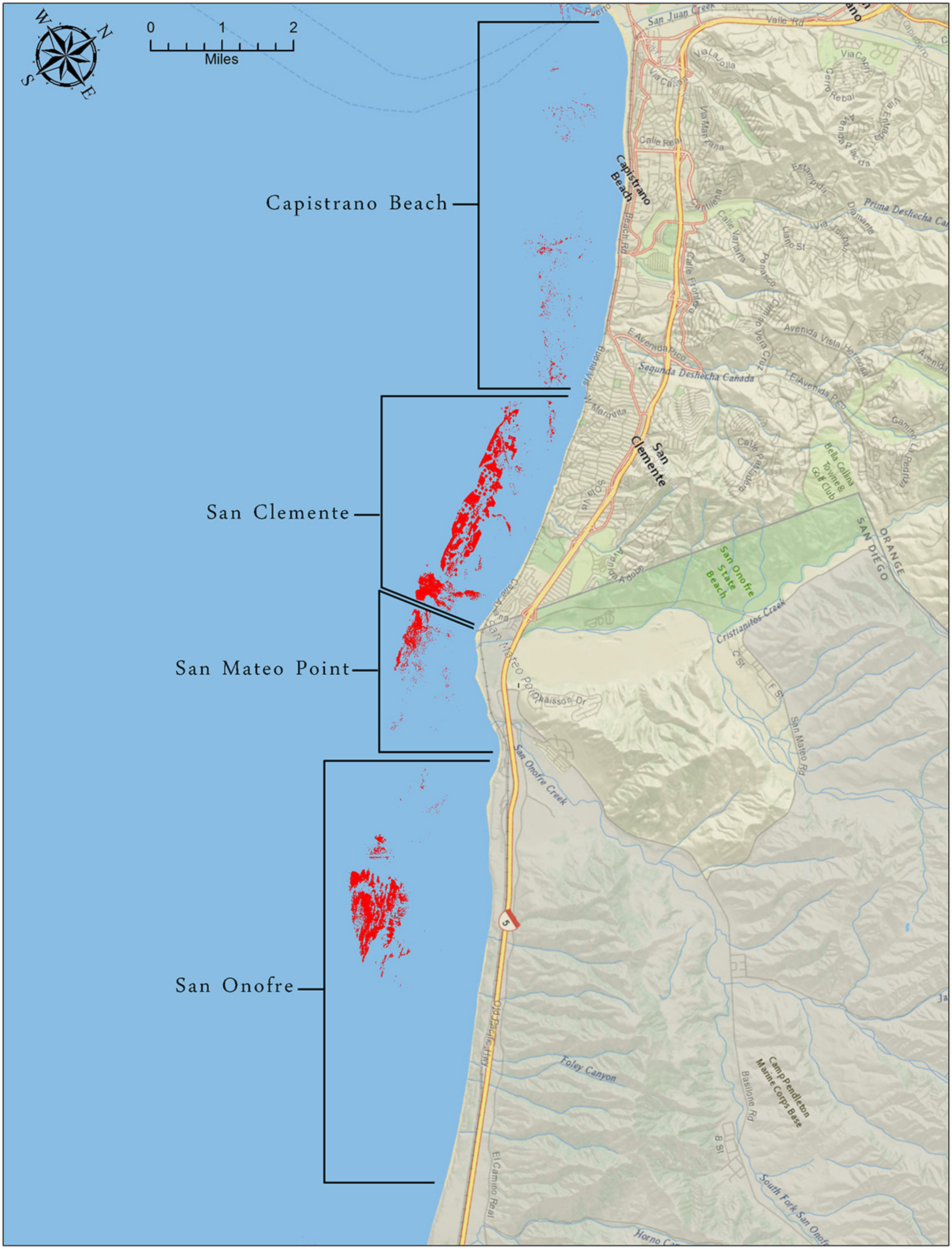

W
N
S
E
0
1
2
Miles
Orange County Sanitation District
Corona Del Mar
Bolsa Chica Ecological Reserve
Seacliff Country Club
Huntington Beach
Huntington Channel
Santa Ana River
Fairview Park
Orange Coast College
Costa Mesa
Newport Beach
Lido Isle
Harbor Island
Bay Isle
Balboa Island
W Oceanfront
Pacific Ocean
Upper Newport Bay Regional Park
Big Canyon Country Club
Corona Del Mar
Buck Gully
Resort At Pelican Hill
Univ Of California-Irvine
San Diego Creek
Bonita Creek
Palm Ave
Goldenwest St
Garfield Ave
Magnolia St
Beach Blvd
Brookhurst St
Adams Ave
Hamilton Ave
Placentia Ave
Victoria St
Newport Blvd
Irvine Ave
Bristol St N
Avocado Ave
Goldenrod Ave
Spyglass Hill Rd

Appendix D.8

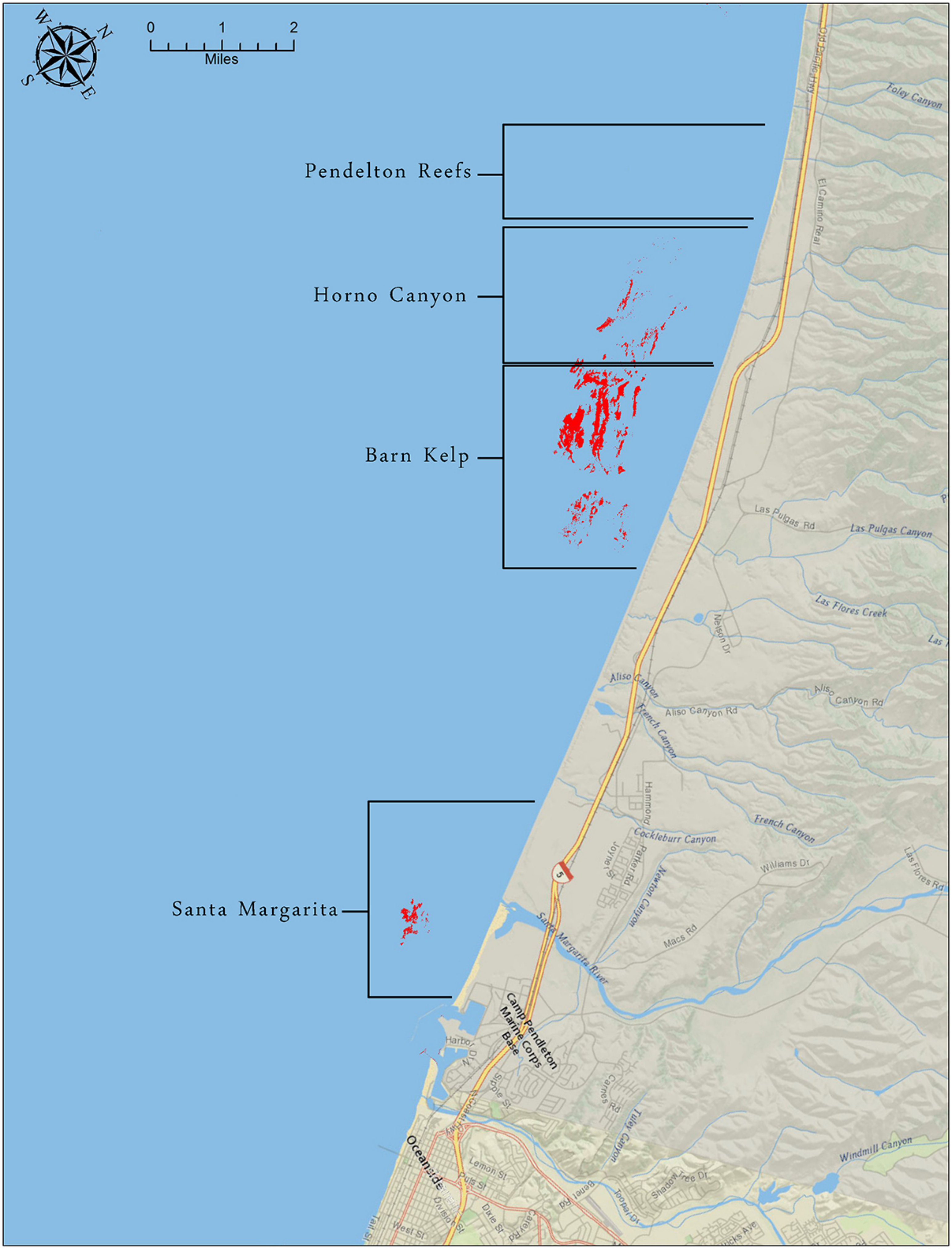


0 1 2
Miles
Corona Del Mar
North Laguna Beach
South Laguna Beach
South Laguna
Dana Point/Salt Creek
Dana Point Marina
Corona Del Mar
Newport Coast
Crystal Cove State Park
Laguna Beach
Aliso Viejo
Laguna Niguel
Dana Point
San Juan Capistrano

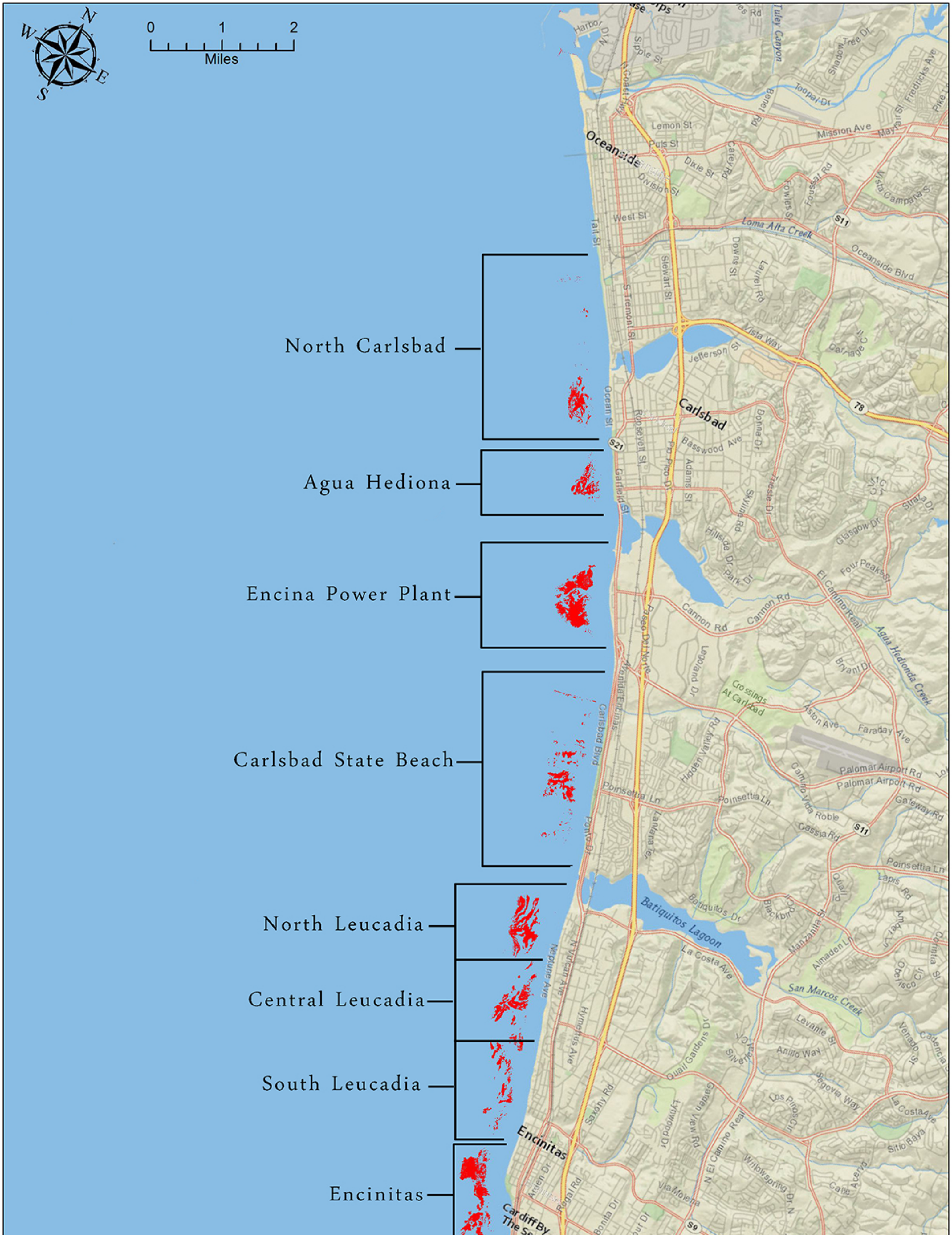
Appendix D.9



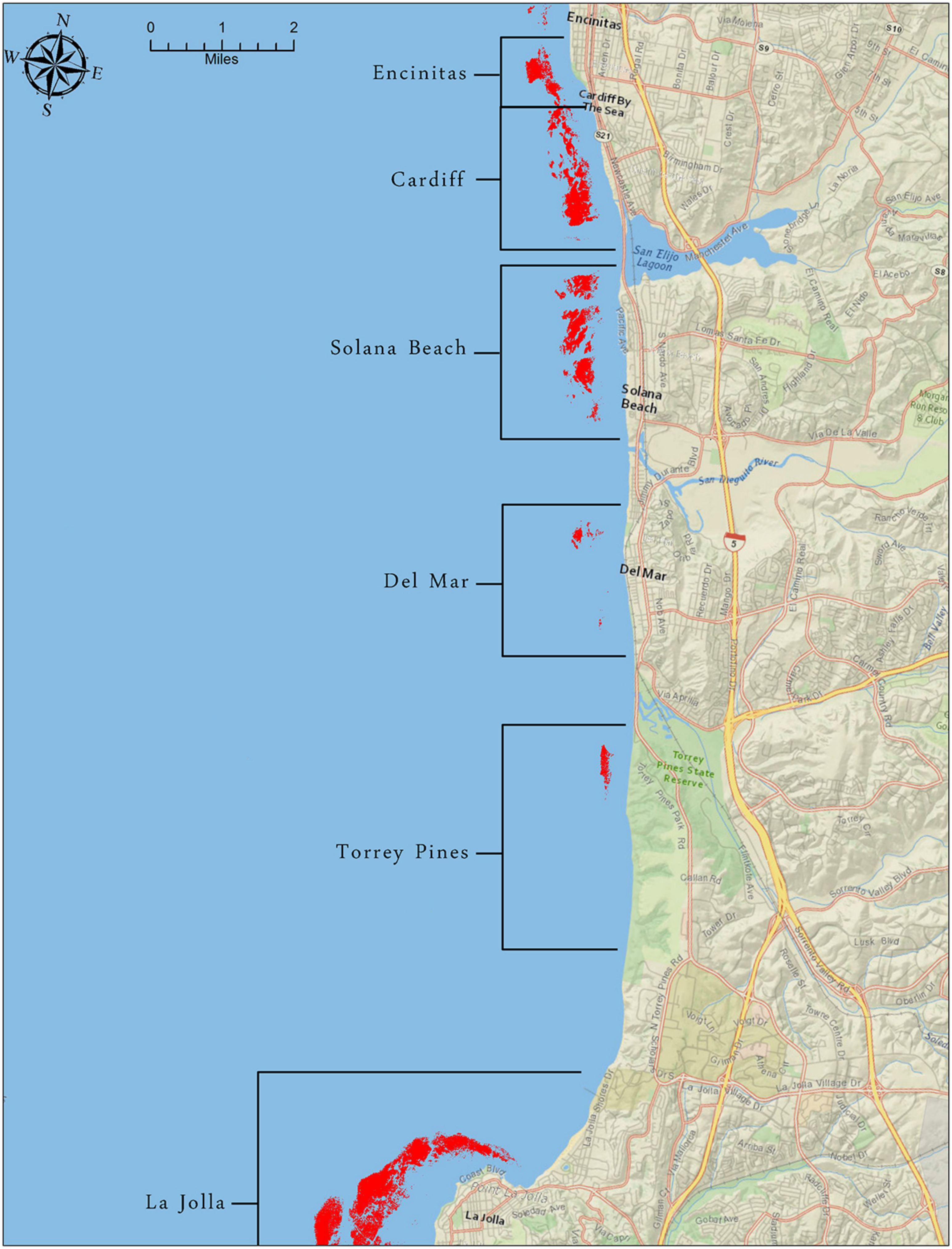
0
1
2
Miles
Capistrano Beach
San Clemente
San Mateo Point
San Onofre
San Juan Creek
Valle Rd
Capistrano Beach
San Clemente
Prima Deshecha Canada
Segunda Deshecha Canada
E Avenida Pico
San Onofre State Beach
Cristianitos Creek
San Mateo Point
San Onofre Creek
San Mateo Rd
ORANGE
SAN DIEGO
Bella Collina Towne & Golf Club
Old Pacific Hwy
Foley Canyon
Camp Pendleton Marine Corps Base
Basilone Rd
El Camino Real
South Fork San Onofre
5



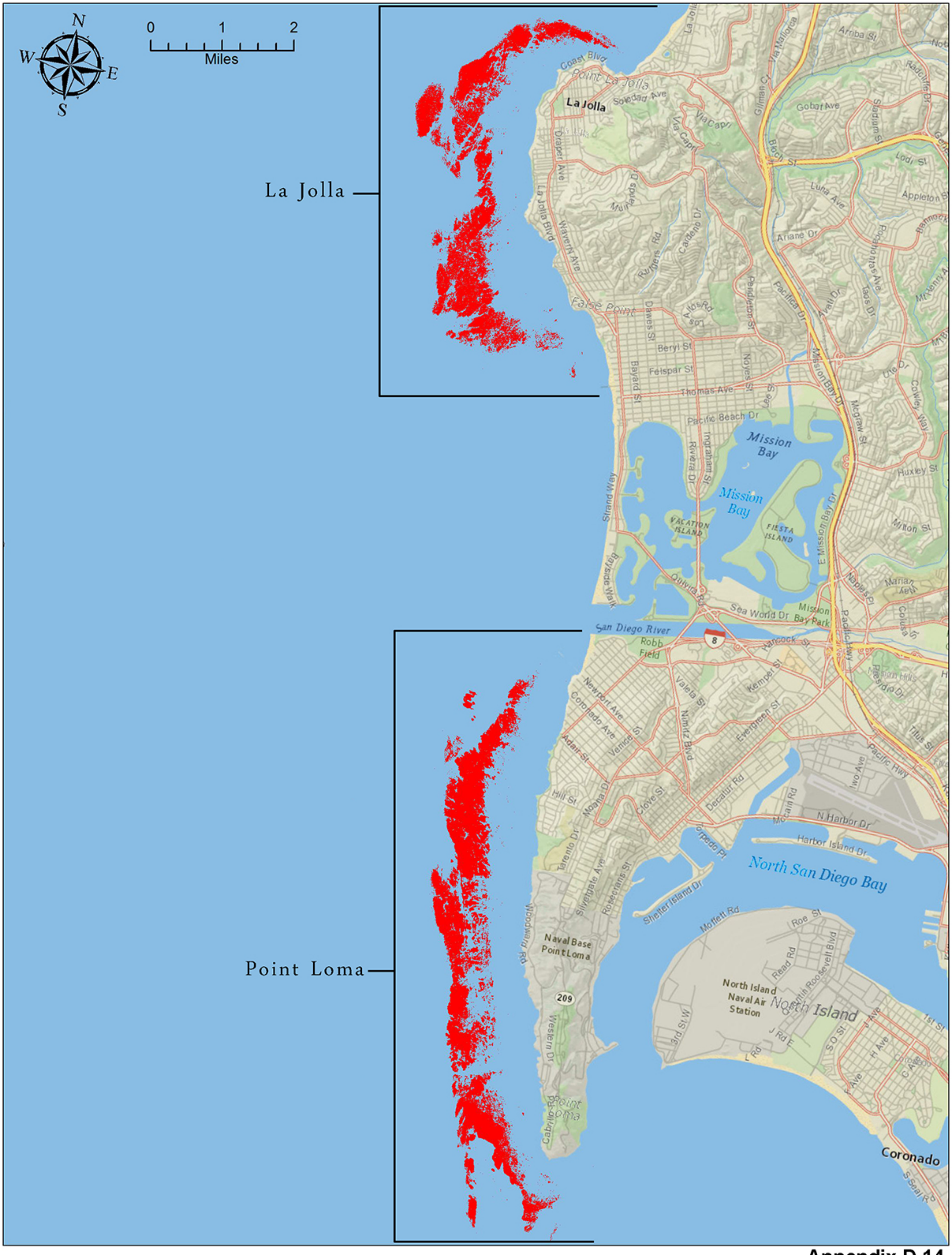
Appendix D.11



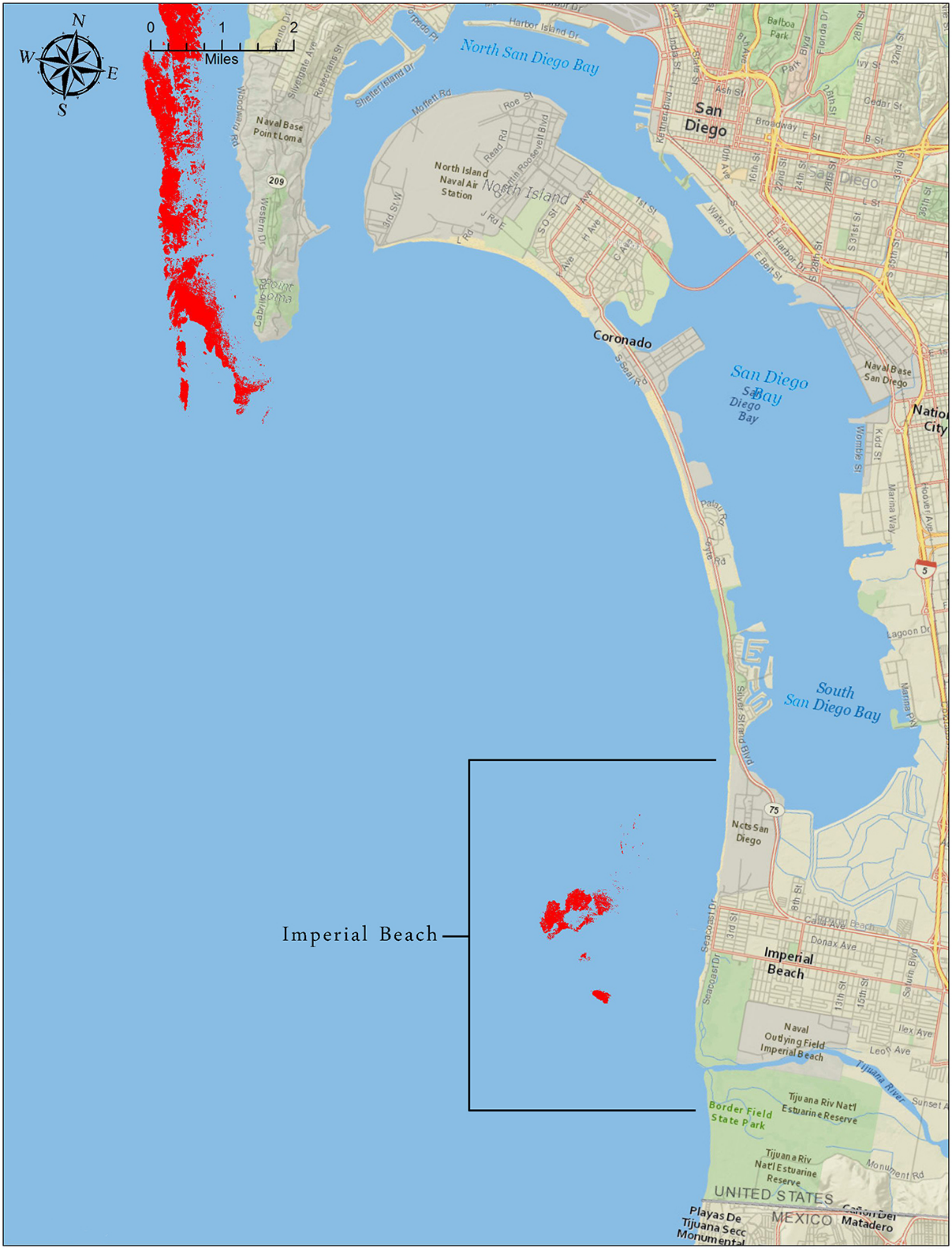
Appendix D.12



Appendix D.13



Appendix D.14



Appendix D.15

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:**	03/19
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	03/31/19
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	5/19

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - 03/31/19**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura Harbor to Imperial Beach
Survey Data Flow	**Acquisition** Processing Analysis Presentation	Vertical color IR digital imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC for further processing and analysis All survey imagery presented with 8"x10" contact sheets (12 images/per page)

Aerial Resource Survey Flight Data for: March 31, 2019

	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:	1237-1413
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	0.2' (+) to 0.1' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

Range (s) Surveyed	Ventura Harbor to Imperial Beach. Imagery Date Note: Imagery EXIF data shows imagery date as: 3/27/19 and time between 1937 and 2113 PDT. A weak camera data battery caused this error and the correct date and time is as shown above.	
Target Resource Observations	Kelp Canopies	Kelp canopies throughout the range showed significant increases in surface extent from that observed in the December 2018 survey
Imagery Quality/ Comments	Excellent Lens Note	All surface kelp canopies were photographed within the above range, and the image processing was conducted normally. All of the imagery was judged of excellent quality and was useable for the subsequent 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. 16B. Flight record for July 26, 2019

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:**	6/19
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	07/26/19
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	8/19

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - 07/26/19**
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 26, 2019**

	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:	1555-1745
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	4.7' (+) to 5.1' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

Range (s) Surveyed	Ventura Harbor to Imperial Beach. Imagery Date Note: Imagery EXIF data shows imagery date as: 7/7/19 and time between 1320 and 1446 PDT. A faulty camera data battery caused this error, and has been replaced. The correct date and time is as shown above.	
Target Resource Observations	Kelp Canopies	Kelp canopies throughout the range showed a slight increase in surface extent from that observed in the March 2019 survey, especially the range between La Jolla and Point Loma where the increases were more significant.
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. 16C. Flight record for September 24, 2019

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:**	9/19
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	09/24/19
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	10/19

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - 09/24/19**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Newport 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 24, 2019**			
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:	1632-1719
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	4.9' (+) to 5.2' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

Range (s) Surveyed	Newport Harbor to Imperial Beach.	
Target Resource Observations	Kelp Canopies	Kelp canopies throughout the range showed a significant decrease in surface extent from that observed in the July 2019 survey. The only kelp observed was that between La Jolla and Point Loma.
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 12, 2019

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

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - 12/19/19**
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 19, 2019**			
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:	1147-1318
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	2.6' (+) to 3.3' (+) 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 a reduction in surface extent, and the only significant kelp observed was that between La Jolla and Point Loma.
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:

mbc AQUATIC SCIENCES

PROJECT FIELD LOG

Client: Region 9 Job No: 14315 Date: 7 Jan 20

Work Site: Imp Bch → O'side Personnel: RHM JJS SME

Team Leader: Vessel: Scorpaena

Time	Work Related Activities:
0530	Arrive & finish load Plot Sta L/L's on map
0550	Depart MBC
0645	Stop O'side to p/u Wayne
0735	Launch Shelter Island
0840	Imp Bch 0918 - Pt. Loma S 0945 pt Loma N
1020	La Jolla S. 1115 Torrey Pines 1145 Del Mar
1155	Sol 1220 Card 1230 Encinitas
1235	S Leu 1245 C. Leuc
1325 - 1353	S Dive N Leu 1410 - Cars St Park
1433 - 1458	Dive Encina PP
1520	Agua Hed 1530 N Carlsbad 1600 Santa Margarita
1628	Arrive at Oceanside
1640	Depart Oceanside
1740	Arrive MBC

Bad L/L's La Jollas ESP Sm Marg

Page_____of_____

mbc AQUATIC SCIENCES

PROJECT FIELD LOG

Client: SONGS Job No: 17562 B Date: 15JAN2020

Work Site: SONGS Personnel: JJS, SME

Team Leader: – Vessel: Scorpaena

Time	Work Related Activities:
0630	Arrive at MBC, mob
0650	Depart MBC
0720	Arrive at Dana Point
0730	Launch Scorpaena
0735	Arrive at Fuel Dock
0820	Depart Fuel Dock
0925	FZS - thermistors
1000	PAR 1010 Barn Kelp 1020 Horno Canyon
1039	C2S - thermistors
1122	C223 - thermistors
1155	A - water
1201	C - "
1207	B - "
1210	San Onofre 1235 San Mateo 1245 San Clemente
1300	Capistrano Beach
1330	Pull scorpaena
	lunch
1425	Arrive @ MBC, demob
1530	Done.

mbc AQUATIC SCIENCES

PROJECT FIELD LOG

Client: R9 Kelp Job No: 74325 Date: 30 Jan 20

Work Site: Dana -> Newport Personnel: RHm DJS

Team Leader: Vessel: Poco Loco

Time	Work Related Activities:
0630	Arrive + load
0703	Depart
0730	Arrive Dana Pt 0740 Launch MMSI NHF
0830	Anchor DP Kelp 0913 26m 51' Metered 2 areas w/ Scatt sfc
—	+ lots subsurface
1000	S. Lag
1030	Laguna 1054-18 min 52'
	N Lag Reef Pt Whistler
1300	Corona del Mar
1340	dock - pulled boat 276 hrs
1405	MBC
1500	Finish

mbc AQUATIC SCIENCES

PROJECT FIELD LOG

Client: Region 9 Job No: 14315 Date: 7 Jan 20

Work Site: Imp Bch → O'side Personnel: RHM JJS SMC

Team Leader: Vessel: Scorpaena

Time	Work Related Activities:
0530	Arrive & finish load Plot Sta L/L's on map
0550	Depart MBC
0645	Stop O'side to p/u Wayne
0755	Launch Shelter Island
0840	Imp Bch 0918 - Pt. Loma S 0945 pt Loma N
1020	La Jolla S. 1115 Torrey Pines 1145 Del Mar
1155	Sol 1220 Card 1230 Encinitas
1235	S Leuc 1245 S Leuc
1325 -	1353 S Dive N Leu 1410 - Cars St Park
1433 -	1458 Dive Encina PP
1520	Agua Hed 1530 N Carlsbad 1600 Santa Margarita
1625	Arrive at Oceanside
1640	Depart Oceanside
1740	Arrive MBC

Bad L/L's LaJollas
ESP
S Marg

CONDITION OF MACROCYSTIS BED

Observer: SME
Lat/Long: 33° 07.517' 117° 20.441'

Date 7 JAN 2020
Location Encina PP
Time
Wind/Direction
Current
Weather
UW Visibility
Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

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

Remarks

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color Med - dark yellow
Encrustation N
Disease N
Sediment on blades N
Sinking fronds N
Grazed tissues Y
Sporophyllis
Juvenile fronds Y
Holdfasts 6+3 = 9
Old holdfasts N
Recruitment Y

Community

Litter 5% coverage
Turf algae Y - Red
Turf invert. N
Shrub algae ~~Y - Red~~ N
Large Invert. snail anemone urchin
White-spotted Rose anemone 1
3 lobster (CA spiny)
3 Kelletia
4 Megastraea
Fishes N
Disease N
Sed. on rocks Y
Urchin status ~~llll~~ + 3 + 3 + 5 L Purp → Purple urchin = 16
Dark Purp = 3 + 4 → Red urchin = 7

Bottom characteristics

cobble rock
shelf bottom

grazed @ mid, not bottom

REMARKS Recr : ll = 2
Juv : lll = 3
Ad : l + ll + 3 + ll = ~~20~~ = 17

* Scattered gorgonians

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: RHM

Lat/Long: 33° 04.450' 117° 18.964'

Date 7 JAN 2020

Location North Leucadia

Time

Wind/Direction

Current

Weather

UW Visibility

Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy 2m X 50m

Extent Sporophyll blades w/

Density jagged edges

Tissue color

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

Disease not carrying spores, right now

Encrustation

Apical blades

Sediment on blades

Remarks Depth 35'

LAMINARIA

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Bottom 5m/vis

Tissue color

Encrustation

Disease

Sediment on blades N

Sinking fronds N

Grazed tissues N

Sporophyllis Y

Juvenile fronds Y

Holdfasts

Old holdfasts N

Recruitment Y

Community

Litter

Turf algae Acrosorium

Turf invert.

Shrub algae Egregia

Large Invert. 1 lobster, Bulletta

Fishes

Disease

Sed. on rocks

Urchin status

Bottom characteristics

Shelf rock / Plate rock 90%

Sand channel 05m

REMARKS Recruits |||| = 4 , Mostly Egregia

Juvenile | = 1

Adult ||| = 3

Lat /long's incorrect — checked 2 sites @ 1600 + 1615.

CONDITION OF MACROCYSTIS BED

SME
9' 117°27.249' ???
S ' 117°25.192' ?

Date 7 JAN 2020
Location Santa Margarita
Time 1600 / 1615
Wind/Direction
Current
Weather P. Cloudy
UW Visibility 10 ft
Swell Ht/Period 2-3 ft W

Kelp Canopy

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

Remarks Depth: 35'

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: RHM, SME

Lat/Long: 33° 09.321' 117° 21.685'

Date 7 JAN 2020

Location North Carlsbad

Time 1530

TOPSIDE OBSERVATIONS

Wind/Direction

Current

Kelp Canopy

Weather P. Cloudy

UW Visibility 15 ft.

Swell Ht/Period 2-3 ft W

Extent None

Density

Tissue color

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

Disease

Encrustation

Apical blades

Sediment on blades

Remarks Depth: 43'

Subsurface Scattered subsurface ~10 ft tall, patches ~ ~~10~~ lots plants

UNDERWATER OBSERVATIONS

Midwater

Tissue Color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Community

Litter

Turf algae

Turf invert.

Shrub algae

Large Invert.

Fishes

Disease

Sed. on rocks

Urchin status

Bottom

Tissue color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Sporophyllis

Juvenile fronds

Holdfasts

Old holdfasts

Recruitment

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: RHM, SME
Lat/Long: 33°08.664' 117°21.119'

Date 7 JAN 20
Location Agua Hed.
Time 1520
Wind/Direction
Current
Weather P. cloudy
UW Visibility 15 ft.
Swell Ht/Period 2-3 ft. W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent None
Density
Tissue color
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease
Encrustation
Apical blades
Sediment on blades
Remarks Depth 40'

Subsurface 10-15 ft. plants on bottom, patch of ~6 plants, 2-3 patches

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: RHM, SME
Lat/Long: 33° 06.036' 117° 19.561'

Date 7 JAN 2020
Location ~~North Leucadia~~ CSP
Time 1410
Wind/Direction
Current
Weather P. Cloudy
UW Visibility 10 ft.
Swell Ht/Period 2-3 ft. 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: RHM, SME

Lat/Long: 33° 03.916' 117° 18.656'

Date 7 JAN 2020

Location Central Leucadia

Time 1245

Wind/Direction 3 W

Current

Weather P. Cloudy

UW Visibility 10'-15'

Swell Ht/Period 2-3 ft. W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent medium-scattered

Density 100 m x 30 m

Tissue color 50% light,

% Frond comp. 50% Senile 45% Mature 5% Young ___ Other

Disease None

Encrustation 50%

Apical blades 5%

Sediment on blades None

Remarks Depth 31'

Subsurface apical blades on subsurface, not on canopy

UNDERWATER OBSERVATIONS

Midwater

Tissue Color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Bottom

Tissue color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Sporophyllis

Juvenile fronds

Holdfasts

Old holdfasts

Recruitment

Community

Litter

Turf algae

Turf invert.

Shrub algae

Large Invert.

Fishes

Disease

Sed. on rocks

Urchin status

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: RHM, SME
Lat/Long: 33°02.979' 117° 18.321'

Date 7 JAN 2020
Location S. Leucadia
Time 1235
Wind/Direction 3 W
Current
Weather P. Cloudy
UW Visibility 20 ft.
Swell Ht/Period 2-3 ft. W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent 30m x 30m
Density medium-scattered
Tissue color 20% light yellow, 70% medium, 10% dark
% Frond comp. 20% Senile 80% Mature 2% Young ______ Other
Disease None
Encrustation 20%
Apical blades 5%
Sediment on blades None
Remarks 1-2 m length fronds Depth: 34'

Subsurface apical tips 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: RHM, SME
Lat/Long: 33°02.314' 117° 18.148'

Date 7 JAN 2020
Location Encinitas
Time 1230
Wind/Direction 3 W
Current
Weather P. Cloudy
UW Visibility 10'-15'
Swell Ht/Period 2-3 ft. W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent 30 m wide, 100 m long
Density scattered to the north
Tissue color Medium yellow 70%, Dark Yellow 20%, 10% light
% Frond comp. 5% Senile 35% Mature 60% Young ______ Other
Disease None
Encrustation 5%
Apical blades 40%
Sediment on blades
Remarks 2-3 m frond length Depth: 36'

Subsurface 5'-10' algae (kelp) on bottom
2-3 patches to the surface of 10-40 plants - scattered over 0.35 Miles

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:	DHM, SME	Date	7JAN2020
Lat/Long:	south: 33° 01.039' 117° 17.385'	Location	Cardiff
		Time	1220
		Wind/Direction	3 W
		Current	
		Weather	p. cloudy
		UW Visibility	10 ft.
		Swell Ht/Period	2-3 ft. W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent None

Density

Tissue color

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

Disease

Encrustation

Apical blades

Sediment on blades

Remarks Depth · 40'

Subsurface metering ~5 ft. tall algae 10'-15' tall for ~2-3/10 mile (0.25 mi)
several scattered breaching 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: RHM, SME
Lat/Long: 32° 59.425' 117° 16.960'
South: 32° 59.082' 117° 16.946' 37'

Date 7 JAN 2020
Location Solana Beach
Time 1155
Wind/Direction 3 W
Current
Weather p. cloudy
UW Visibility 10-15 ft.
Swell Ht/Period 2-3 ft. W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent scattered
Density
Tissue color 70% dark yellow, 30% light yellow
% Frond comp. 30% Senile 70% Mature 1% Young ____ Other
Disease None
Encrustation 20%
Apical blades 2%
Sediment on blades None
Remarks 2 m length fronds at surface

Depth 37'

Subsurface

Scattered @ south end 15-20' tall can't see, 30-35 ft tall - can see (50% senile, 50% mature)

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: RHM, SME
Lat/Long: 32° 57.512' 117°16.539'
560 537

Date 7JAN2020
Location Del Mar
Time 1145
Wind/Direction 3 kn W
Current
Weather P. Cloudy
UW Visibility 10 ft.
Swell Ht/Period 2-3 ft. W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent None
Density
Tissue color
% Frond comp. ____ Senile ____ Mature ____ Young ____ Other
Disease
Encrustation
Apical blades
Sediment on blades
Remarks Depth 37'

Subsurface 2-3 ft. tall algae on fathometer for 200 m distance

UNDERWATER OBSERVATIONS

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

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

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

Bottom characteristics

REMARKS 32°57.590' 117°16.705'

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: RHM, SME

Lat/Long: 32° 53.561' 117°15.633'

Date 7 JAN 2020

Location Torrey Pines

Time 1115

Wind/Direction

Current

Weather P. Cloudy

UW Visibility 10 ft

Swell Ht/Period 2-3 ft. 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: RHm, SmE	**Date** 7 Jan 20
Lat/Long: 32°48.922' 117°17.538' (central) 32°48.088' 117°16.479' (south)	**Location** La Jolla/South
	Time 1020
TOPSIDE OBSERVATIONS 32°50.651' 117°17.926' (North)	**Wind/Direction** 3W
	Current
Kelp Canopy central = 300 m width	**Weather** P. cloudy
100-200m (~100m width)	**UW Visibility** 15-20 ft.
Extent ~~1/4 mi~~ width, continuous south to north end	**Swell Ht/Period** 2-3ft
Density medium inshore, thick offshore	
Tissue color 60% light yellow, 40% dark yellow	

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

Disease None

Encrustation 60% - 70%

Apical blades 2-5%

Sediment on blades None

Remarks 42 ft. scattered plants at surface - None reaching subsurface Depth 42'-70'
3m length fronds

Subsurface offshore subsurface kelp ~70' depth
central → 70% dark yellow, 10% encrusted, 4-5 m ~~at~~ frond length, 85% mature, 1% apical, 65'-75'

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: RHM, SME
Lat/Long: 32° 42.639' 117° 16.307'
North edge: 32° 43.545' 117° 16.264'

Date: 7 Jan 20
Location: Pt Loma North
Time: 0945
Wind/Direction: 3 W
Current: downcoast
Weather: p. cloudy 10%
UW Visibility: 10 ft.
Swell Ht/Period: 2-3 ft W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: ~200m wide, continuous to south
Density: solid
Tissue color: 50% dark yellow 50% light yellow
% Frond comp.: 10% Senile 90% Mature 1% Young ______ Other
Disease: None
Encrustation: 50%
Apical blades: 1-2%
Sediment on blades: None
Remarks Depth 55ft

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: RHM, SME
Lat/Long: 32° 39.159' 117°15.085'
32° 39.578' 117° 15.630'

Date: 7 Jan 20
Location: Pt Loma South
Time: 0918
Wind/Direction: Ø
Current:
Weather: P. Cloudy
UW Visibility:
Swell Ht/Period: 2-3 ft. W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 200m w X 0.25 mile long continuous to N
Density: Solid
Tissue color: Dark yellow gri
% Frond comp. 1% Senile 98% Mature 1% Young ____ Other 50'
Disease: N
Encrustation: 30%
Apical blades: 1%
Sediment on blades: N
Remarks: Bg area scattered @ 0.25 mile long Depth 60'

Subsurface: Just below surface Heavy concentration lots of apical blades 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

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: RHM, SME
Lat/Long: 32° 34.548' 117° 09.163'

Date: 7 Jan 20
Location: Imperial Beach
Time: 0840
Wind/Direction: 3-5 E
Current:
Weather: ~~Clear Sky~~ P.Cldy (10%)
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 No canopy Depth 55'-36'

Subsurface Hard Bottom - nothing subsurface @ 0.25 diameter circle

UNDERWATER OBSERVATIONS

Midwater

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

Community

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

Bottom

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

Bottom characteristics

REMARKS >2m <2m

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: SME
Lat/Long: N 33°19.466' W 117° 31.643'

Date 15 JAN 20
Location Pendleton Artificial Reef
Time 1000
Wind/Direction 3-5 NW
Current South
Weather P. Cloudy
UW Visibility 10 ft.
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

Depth: 42'

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: SMF
Lat/Long: N 33° 17.132' W 117° 29.376'

Date 15JAN20
Location Barn kelp
Time 1010
Wind/Direction 3-5 NW
Current South
Weather P. Cloudy
UW Visibility 10ft.
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 Depth: 49'

Subsurface ~20 ft. depth → 20-30 ft tall, multiple patches over ½ mile

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: SME
Lat/Long: N 33 · 18.212' W 117° 30.408'

Date 15 JAN 20
Location Horno Canyon
Time 1020
Wind/Direction 3-5 NW
Current South
Weather P. cloudy
UW Visibility 10 ft.
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

Depth: 46'

Subsurface sparse plants – 20 - 30ft. tall @ Horno Canyon on GPS (HORCYN)
R9K11HC → wrong lat/longs – 2.5mi N of barn kelp, 0.5mi S PAR

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: SME
Lat/Long: N 33°20.588' W 117°33.509'

Date 15 JAN 20
Location San Onofre
Time 1210
Wind/Direction 3-5 NW
Current South
Weather P Cloudy
UW Visibility 10 ft.
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

Depth: 46'

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: SME

Lat/Long: N 33°22.697' W117°36.189'

* N33°22.466' W117°35.832'

Date 15JAN20

Location San Mateo

Time 1235

Wind/Direction 3-5 NW

Current South

Weather P. Cloudy

UW Visibility 10 ft.

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 Depth 47' *42'

Subsurface Some scattered plants

* ~~scattered~~ plants ~ 20 ft. tall, 1 solid patch 0.25 mi south of San Mateo Waypoint

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: SME
Lat/Long: N 33° 23.804' W117° 37.032'

Date 15JAN20
Location San Clemente
Time 1245
Wind/Direction ~~P. Cloudy~~ SE 3-5 NW
Current South
Weather P. Cloudy
UW Visibility 10'
Swell Ht/Period 2-3

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent None
Density Scattered
Tissue color Medium = 10%. Dark = 85%. ~~Senile~~ Light = 5%
% Frond comp. 10 Senile 85 Mature 5 Young ______ Other
Disease NO
Encrustation Yes – 30%.
Apical blades 25%.
Sediment on blades No
Remarks Fronds 3m on surface Depth: 46'
- scattered canopy, plants ~100 m apart.
Subsurface scattered plants ~20-30 ft tall, in patches

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: SME
Lat/Long: N 33° 25.460' W 117° 38.910'

Date 15JAN20
Location Capistrano Beach
Time 1300
Wind/Direction 3-5 NW
Current South
Weather p. cloudy
UW Visibility 10 ft.
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 Depth: 44'

Subsurface patches ~ 15-25 ft. tall plants, scattered @ 45-35' depth.

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: RLh
Lat/Long: 33°29.884' 117°44 760'

Date: 30 Jan 20
Location: South Laguna
Time: 1000 - 1010
Wind/Direction: 2-3 NE
Current: N
Weather: P. Cloudy
UW Visibility:
Swell Ht/Period: 2-3 WSW

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: RHm

Lat/Long: 33°32.401' 117°47.476'

Date: 30 Jan 20

Location: N. Laguna

Time: 1210

Wind/Direction: 2-3 NW

Current: None

Weather: Mostly Cloudy

UW Visibility: 15'-20'

Swell Ht/Period: 2-3 WSW

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 100m x 150m

Density: Full - Thick

Tissue color: Med & Light Yellow

% Frond comp. 40% Senile 60% Mature 1% Young ____ Other

Disease: N

Encrustation: N

Apical blades: Y

Sediment on blades: N

Remarks

Subsurface Yes beyond edges of canopy

UNDERWATER OBSERVATIONS

Midwater

Tissue Color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Bottom

Tissue color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Sporophyllis

Juvenile fronds

Holdfasts

Old holdfasts

Recruitment

Community

Litter

Turf algae

Turf invert.

Shrub algae

Large Invert.

Fishes

Disease

Sed. on rocks

Urchin status

Bottom characteristics

REMARKS

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: RHn

Lat/Long: 1) 33°33.781' 117° 50.054' Reef Pt.
2) 33°34.564' 117° 51.365 Whistlers Reef

Date: 30 Jan 20
Location: Reef Pt / Whistlers Reef
Time: 1220 / 1250
Wind/Direction: 2-3 NE
Current: None
Weather: Mostly Cloudy
UW Visibility: 30'+
Swell Ht/Period: 2-3 wsl

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: None / Few

Density:

Tissue color:

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

Disease:

Encrustation:

Apical blades:

Sediment on blades:

Remarks

Subsurface 1) 40+ subsurface v. shallow reef
2) 2-3 @ sfc ; visible is senile ; ≥50 plants → lots near surface very ragged -

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:	RHu	Date	30 Jan 20
Lat/Long:	33° 35.258' 117° 52.186'	Location	Corona delMar
		Time	1300
TOPSIDE OBSERVATIONS		Wind/Direction	2-3 NE
		Current	None
Kelp Canopy		Weather	Mostly Cloudy
		UW Visibility	15'
Extent	None	Swell Ht/Period	2-3 WSW

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 Hm & DJS
Lat/Long: 33° 27.715' 117°43.283'

Date: 30 Jan 20
Location: Dana Point
Time: 0800
Wind/Direction: 5 East
Current: None
Weather: P. Cloudy
UW Visibility: 20'
Swell Ht/Period: 3-4' WSW

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 0.25 - 0.5 mi
Density: Scattered
Tissue color: Med - Dark Yellow
% Frond comp. ✓ Senile 100 Mature ✓ Young ___ Other
Disease: No
Encrustation: Yes
Apical blades: No
Sediment on blades: No
Remarks: Fronds @ 2-3 when present 30-35' to 50'

Subsurface: Most metered subsurface 10-15' below sfc Depth range 35 inshore to 53' lots

UNDERWATER OBSERVATIONS @ 33° 28.174' 117°43.495'

Midwater

Tissue Color: Med Yellow
Encrustation: Yes
Disease: No
Sediment on blades: No
Sinking fronds: No
Grazed tissues: Yes

Bottom

Tissue color: Med Yellow
Encrustation: No
Disease: No
Sediment on blades: No
Sinking fronds: No
Grazed tissues: Yes
Sporophyllis: Yes adult
Juvenile fronds: Yes
Holdfasts: Yes
Old holdfasts: No
Recruitment: ? see note ↓

Community

Litter: No
Turf algae: Sm. Red
Turf invert.:
Shrub algae: Pterygophora / Egregia / Laminaria
Large Invert.:
Fishes: ↓ below
Disease: N
Sed. on rocks:
Urchin status: low

Bottom characteristics

Mix 50% Boulder 40 Cobble
10% Sand
scattered ledge/shelf rock

S. franciscanus - 6
Megastr - 1
Kelp Bass - 5-6+
Halichoeres - 1
Sheephead - 1

REMARKS Ad - 2 (two)
Juv - 2 (two)
Rec. - lots laminariales recruits
Dominant bottom algae Pterygophora 2-4/m², @1 Laminaria/m²

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer:	RHm	**Date**	30 Jan 20
Lat/Long:	33° 31.887' 117° 46.893'	**Location**	Laguna Beach
		Time	1030
		Wind/Direction	N
		Current	N
		Weather	P Cloudy
		UW Visibility	15-20'
		Swell Ht/Period	2-3 WSW

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent 300m x 100m

Density Medium

Tissue color Med + Dark Yellow

% Frond comp. 5% **Senile** 95% **Mature** 1% **Young** ____ **Other**

Disease No

Encrustation 10%

Apical blades No

Sediment on blades No

Remarks 1-2m length Depth 38'-55'

Subsurface

UNDERWATER OBSERVATIONS

3m vis

Midwater

Tissue Color	Med/Light Yel
Encrustation	No
Disease	No
Sediment on blades	Yes
Sinking fronds	No
Grazed tissues	Yes

Bottom

Tissue color	Med Yel
Encrustation	None
Disease	None
Sediment on blades	None
Sinking fronds	None
Grazed tissues	None
Sporophyllis	Yes all adults
Juvenile fronds	Yes
Holdfasts	Yes
Old holdfasts	None
Recruitment	None

Community

Litter	No
Turf algae	Corallina
Turf invert.	
Shrub algae	Pterygophora / Laminaria
Large Invert.	Megastrea
Fishes	Sheephead, Kelp + Barred Bass
Disease	
Sed. on rocks	
Urchin status	

Bottom characteristics

40 Boulder / 40% Cobble / 10% sand

Shell Hash - 10%

REMARKS Ad 11 eleven

Juv — none

Recr — None

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: DJS

Lat/Long: 33° 27.715' 117° 43.283'

Date 30 JAN 2020

Location [redacted]

Time 0800

Wind/Direction 3-4 E

Current

Weather Clear, Sunny

UW Visibility 20'

Swell Ht/Period 3-4 WSW

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent SEE RHM'S DATA

Density

Tissue color

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

Disease

Encrustation

Apical blades

Sediment on blades

Remarks

Subsurface

UNDERWATER OBSERVATIONS @ 33°28.174' 117°43.495'

Midwater

Tissue Color Med - light yellow

Encrustation None

Disease None

Sediment on blades ~~None~~ Yes

Sinking fronds None

Grazed tissues ~~None~~ Yes

Bottom

Tissue color Dark & med. yellow

Encrustation None

Disease None

Sediment on blades None

Sinking fronds None

Grazed tissues None

Sporophyllis Yes, many

Juvenile fronds 5

Holdfasts 2

Old holdfasts 0

Recruitment 0

Community

Litter None

Turf algae Reds

Turf invert. None

Shrub algae Reds

Large Invert. Megastrea undosa (4), Kelletia kelletii (2)

Fishes 6 Kelp Bass, 4 Sheephead

Disease None

Sed. on rocks Light

Urchin status None

Bottom characteristics

75% Cobble

15% Boulder

10% Sand

Laminaria 20% macro

Pterygophora 80% Algae

REMARKS A 11 (TWO)

J 0

R 0

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: DJS
Lat/Long:

Date: 30 JAN 2020
Location: LAGUNA (Brooks St.)
Time: 1040
Wind/Direction:
Current:
Weather:
UW Visibility:
Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: SEE RHM's Data
Density:
Tissue color:
% Frond comp. ____ Senile ____ Mature ____ Young ____ Other
Disease:
Encrustation:
Apical blades:
Sediment on blades:
Remarks:

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color: Med-light yellow
Encrustation: light
Disease: None
Sediment on blades: None
Sinking fronds: None
Grazed tissues: Slight

Bottom

Tissue color: Medium yellow
Encrustation: None
Disease: None
Sediment on blades: None
Sinking fronds: None
Grazed tissues: Very little
Sporophyllis: Yes, many
Juvenile fronds: 7
Holdfasts: 7 holdfasts hollowed, one encrusted
Old holdfasts: None
Recruitment: None

Community

Litter: Slight red & surfgrass
Turf algae: reds
Turf invert.:
Shrub algae: pterogophora, laminaria, reds
Large Invert.: megastrea undosa, norrisia norrisii,
Fishes: kelp bass, barred bass, sheephead
Disease: None
Sed. on rocks: yes
Urchin status: S. purpuratus (1); S. franciscanus 2

Bottom characteristics

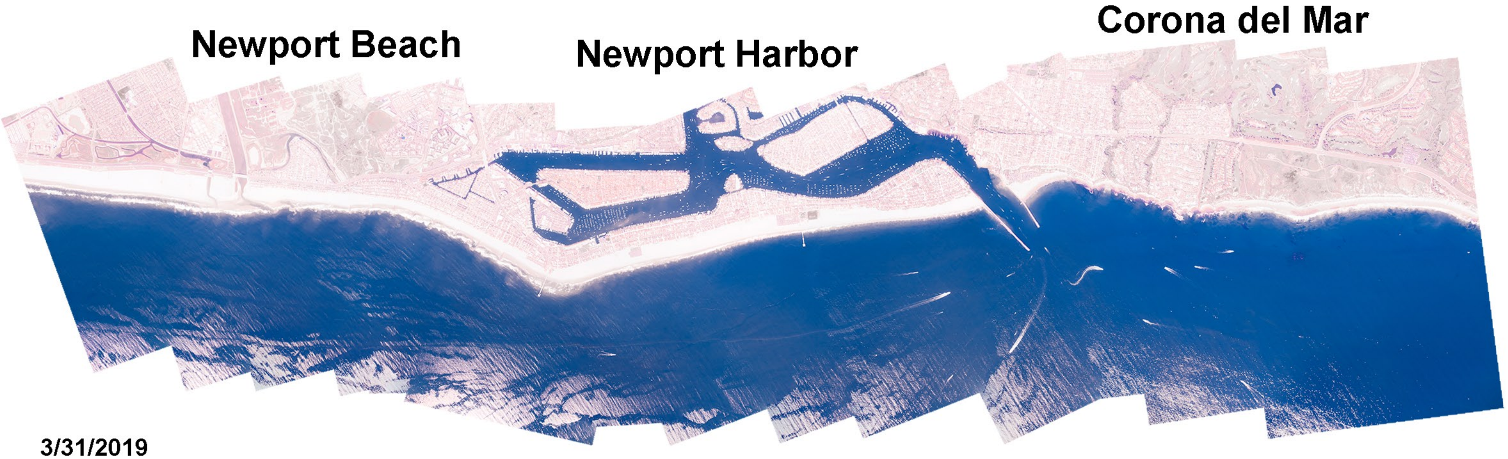
40% boulder
30% cobble
30% sand

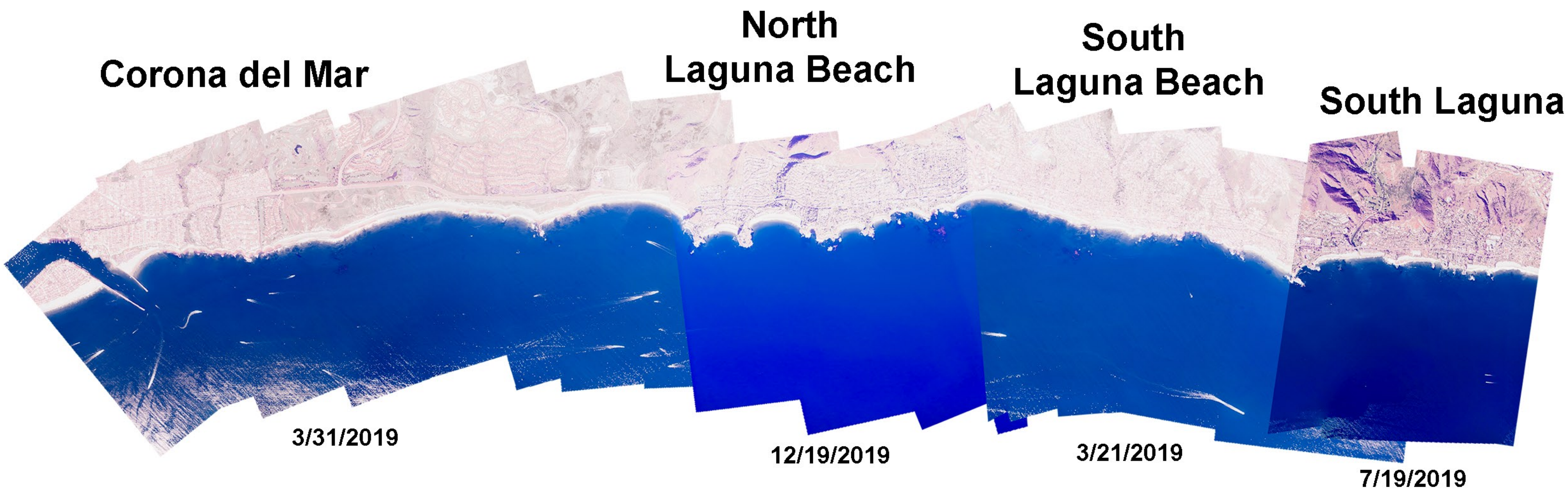
REMARKS

A = 8
J = 0
R = 0

APPENDIX E

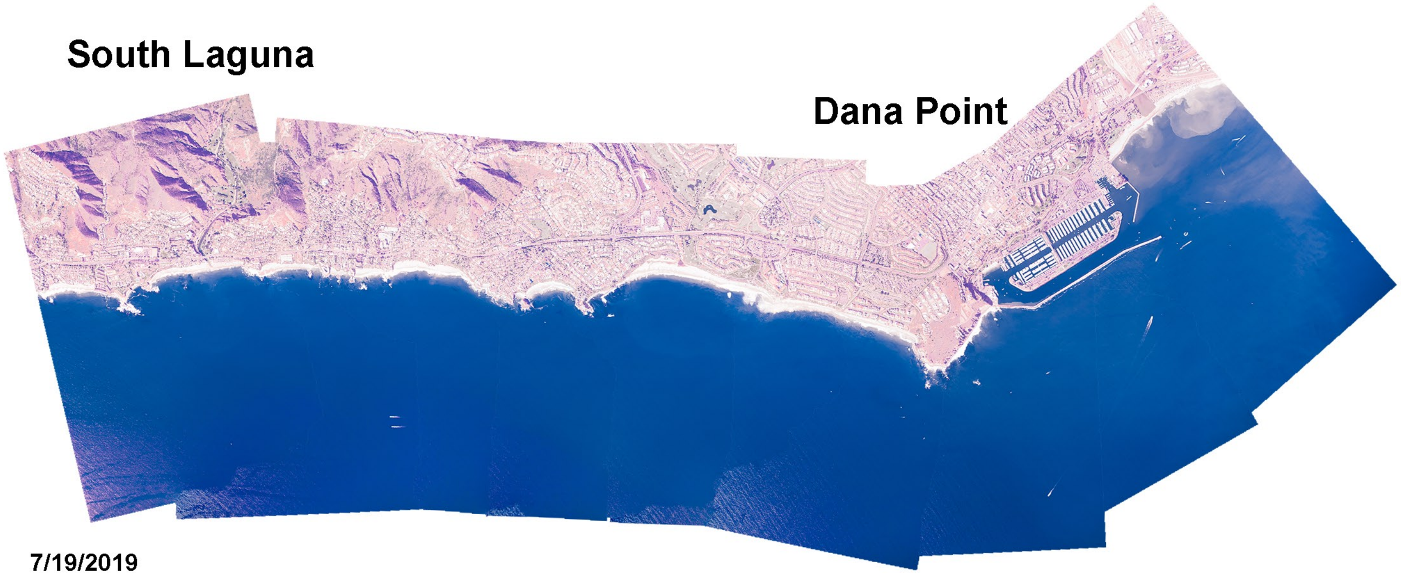
Kelp Canopy Aerial Photographs

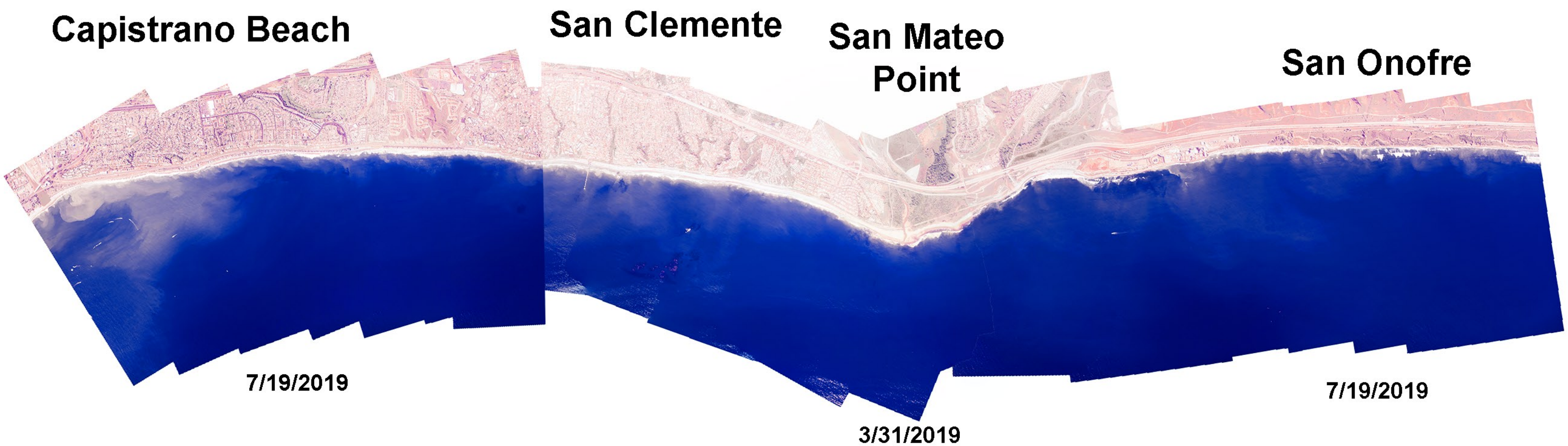




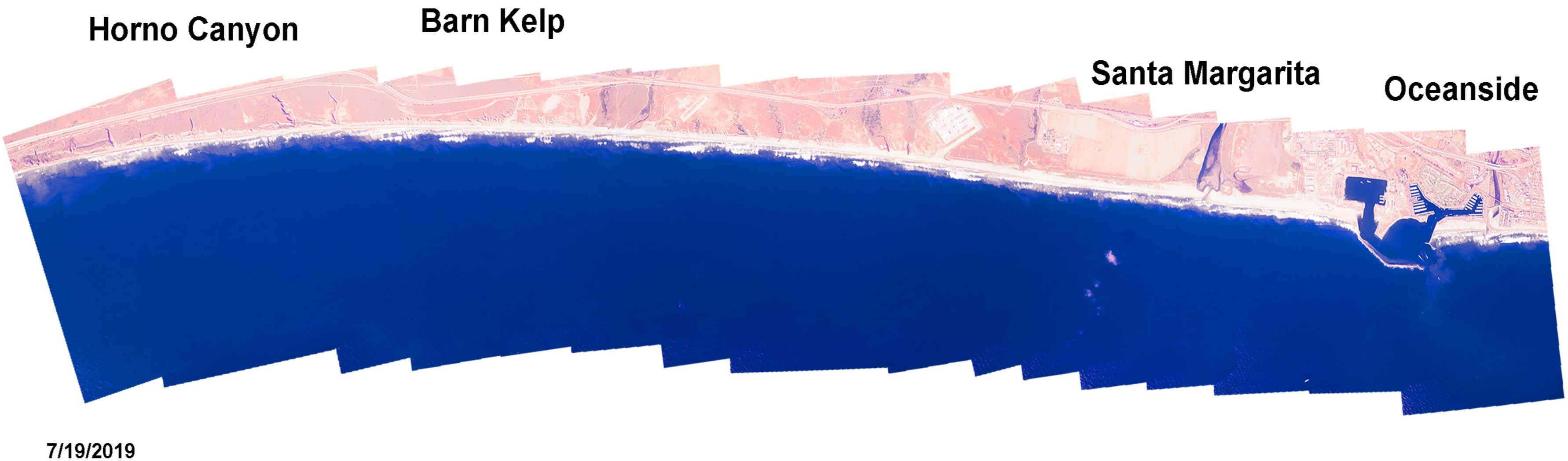
mbc AQUATIC SCIENCES

Appendix E.5

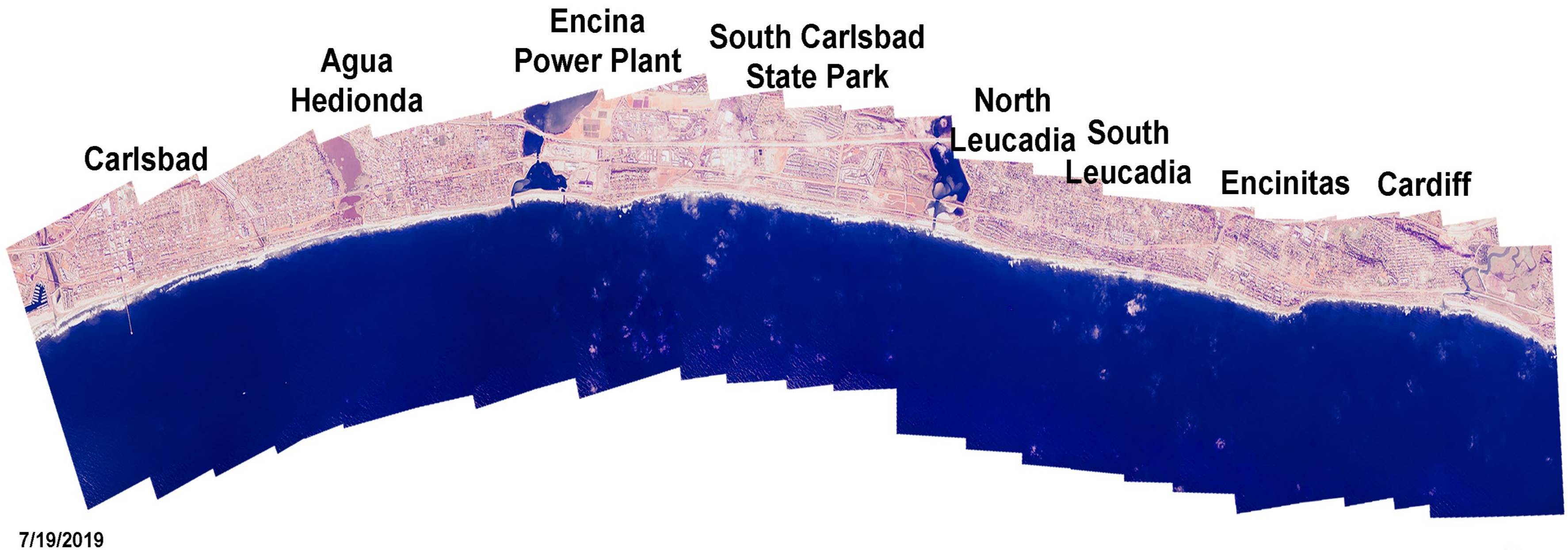

South Laguna
Dana Point
7/19/2019


Capistrano Beach
San Clemente
San Mateo Point
San Onofre
7/19/2019
3/31/2019
7/19/2019

Appendix E.6

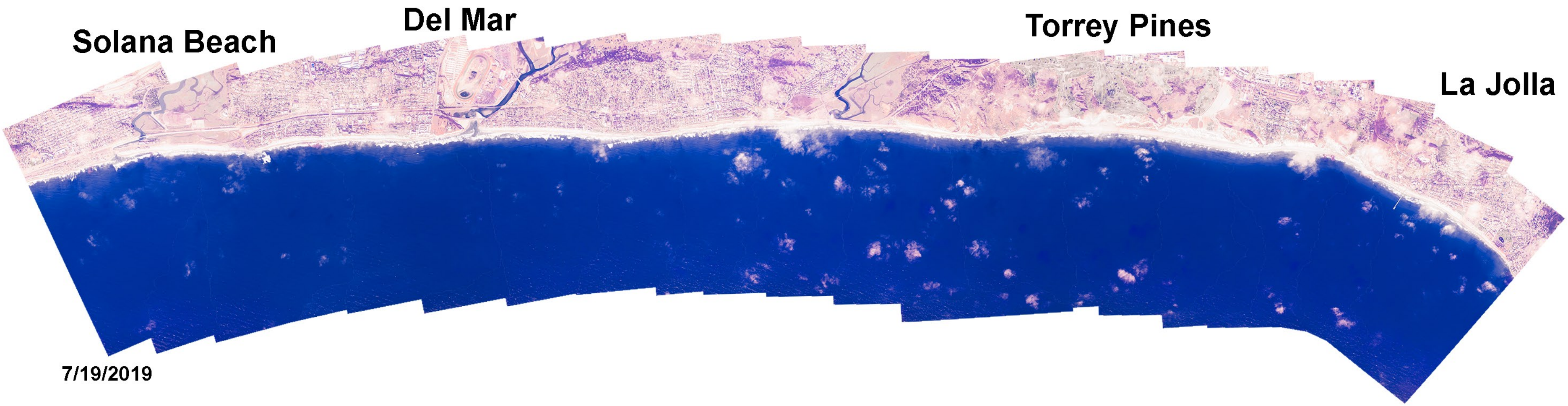


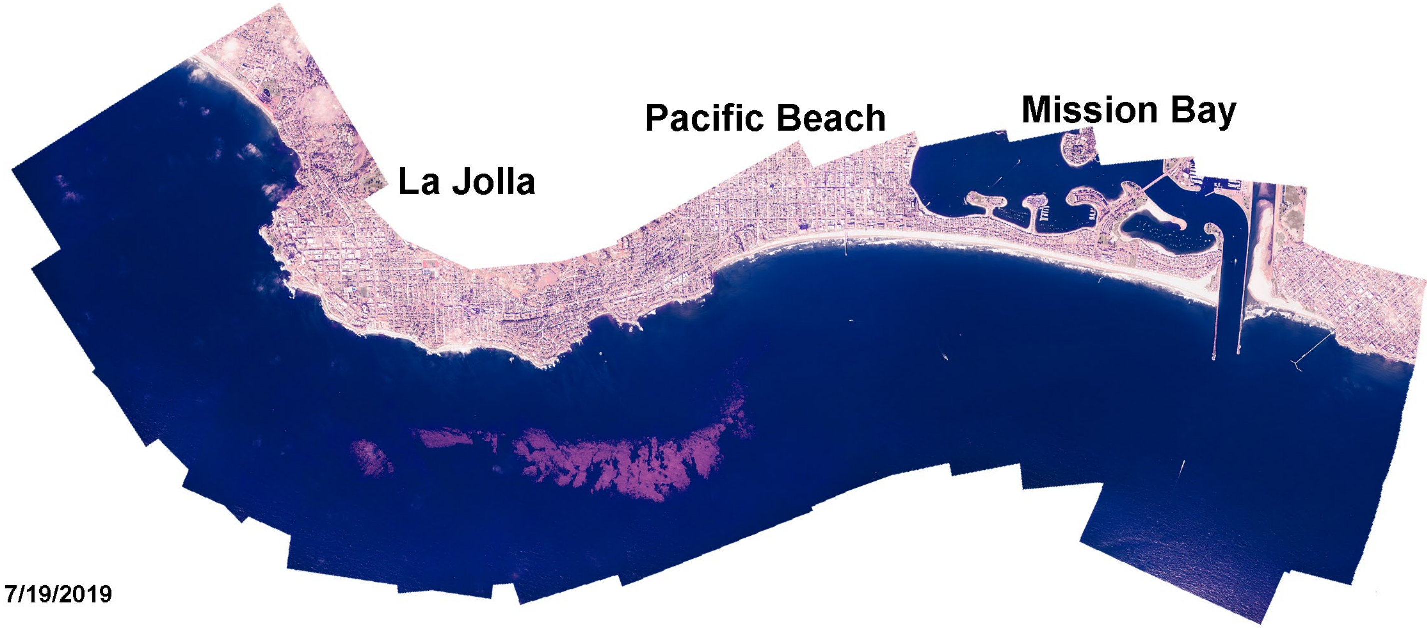
Horno Canyon
Barn Kelp
Santa Margarita
Oceanside
7/19/2019



Carlsbad
Agua Hedionda
Encina Power Plant
South Carlsbad State Park
North Leucadia
South Leucadia
Encinitas
Cardiff
7/19/2019

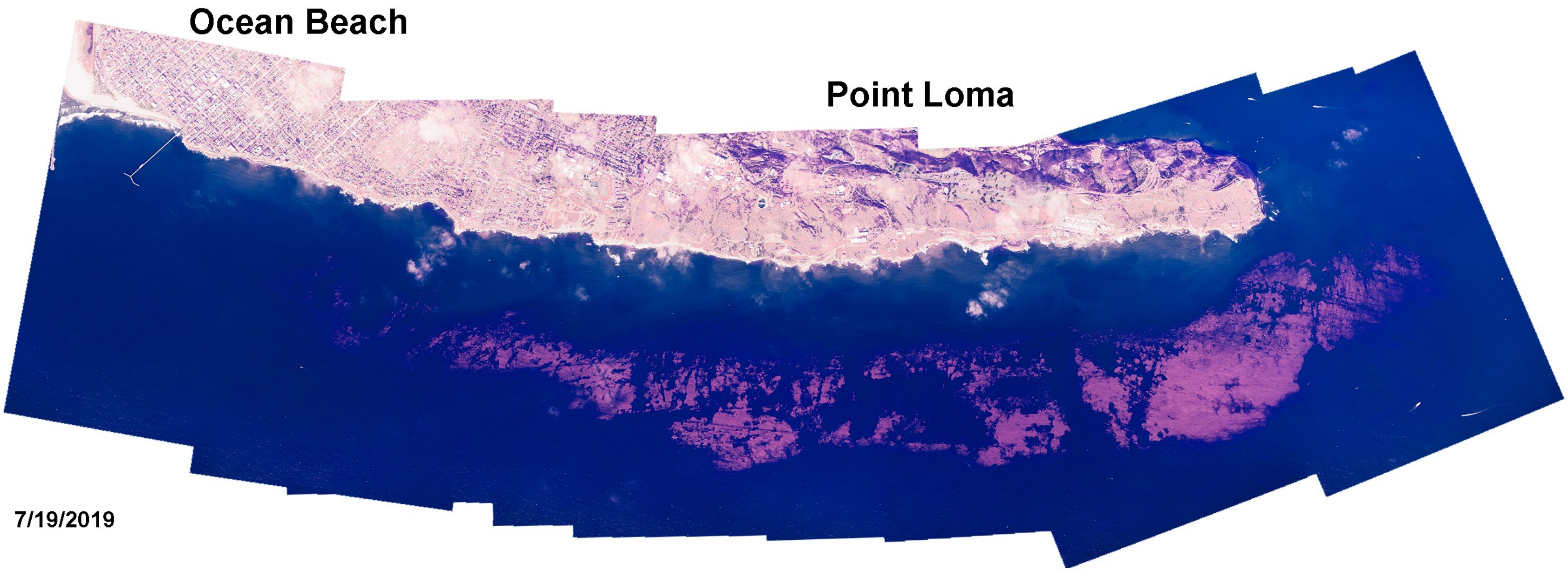
Appendix E.7



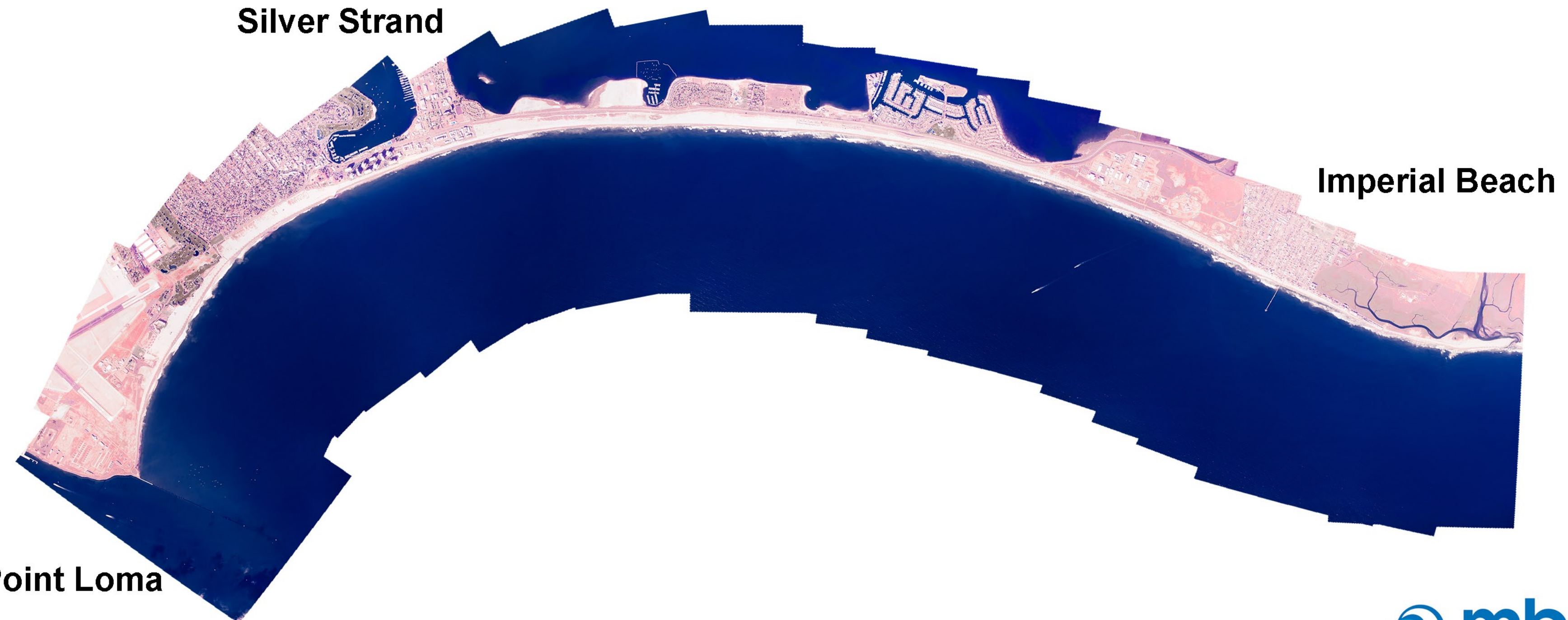


mbc AQUATIC SCIENCES

Appendix E.8



7/19/2019



7/19/2019

mbc AQUATIC SCIENCES

Appendix E.9