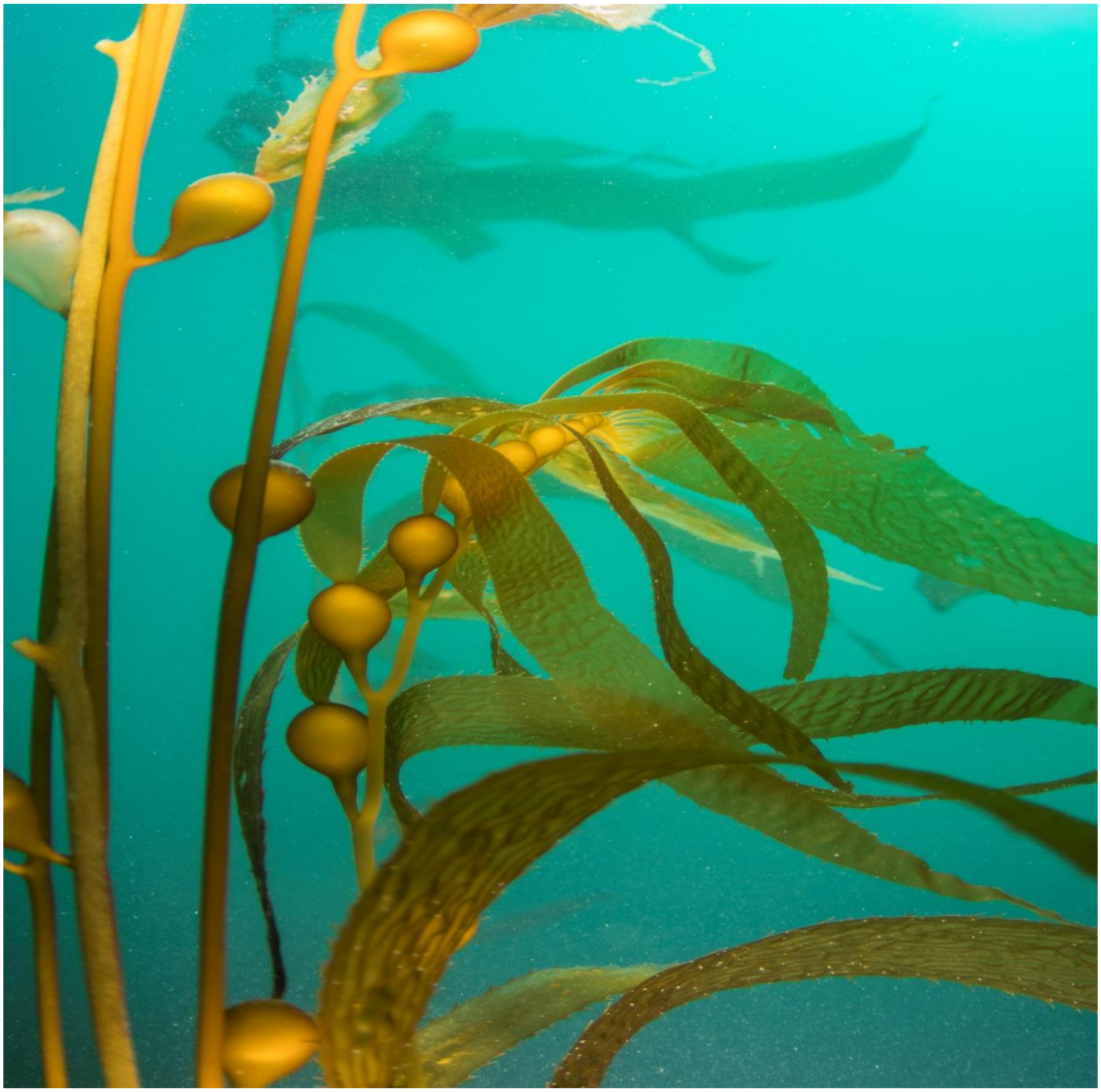

Status of the Kelp Beds in 2020:

Orange County and San Diego County

Prepared for the Region Nine Kelp Survey Consortium

MBC Aquatic Sciences

STATUS OF THE KELP BEDS IN 2020:
Orange County and San Diego County

Prepared for:

Region Nine Kelp Survey Consortium

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EXECUTIVE SUMMARY

Aerial imaging surveys of the 24 giant kelp beds off Orange County and San Diego County were conducted for the Region Nine Kelp Survey Consortium (RNKSC) by MBC Aquatic Sciences on April 15, July 05, September 20, and December 30, 2020. The maximum surface canopy observed during 2020 was quantified from color infrared photos of each kelp bed. To supplement the aerial surveys, vessel surveys of all 24 bed beds were conducted on December 22, 2020 and March 17, 2021 (the second survey was delayed due to adverse ocean conditions) to observe any surface canopy present and subsurface kelp (as indicated by the fathometer). More detailed in-water surveys were conducted by biologist-divers at four kelp beds: Solana Beach and Imperial Beach (on December 22, 2020), and San Clemente and Barn Kelp (on March 17, 2021) to observe any subsurface kelp present and to document bottom conditions.

The total kelp canopy throughout Region Nine covered approximately 3.9 km^2 in 2020, a 25% decrease compared to 2019. This is the fourth time in the past five years (2016, 2017, 2019, and 2020) that the total kelp canopy was less than the long-term average, following nine years (2007 through 2015) with above average total kelp canopies. Ten kelp beds were observed in 2020 with visible surface canopy. Five kelp beds increased in size in 2020 (including four kelp beds that reappeared), while eight decreased in size (including three kelp beds that disappeared). The La Jolla and Point Loma kelp beds were the largest in Region Nine, accounting for 93% of the total canopy coverage in 2020.

Visual observations during the two vessel surveys indicated that surface canopy was present at approximately half of the kelp beds, including from Corona del Mar to South Laguna Beach, at Dana Point/Salt Creek, at San Mateo Point, at Barn Kelp, from Leucadia to Solana Beach, and at La Jolla and Point Loma. Subsurface kelp was observed at many of these kelp bed locations, as well as at two kelp beds without any visible surface canopy (Capistrano Beach and North Carlsbad). The in-water surveys recorded kelp individuals on the bottom at Barn Kelp and Solana Beach, but no kelp was observed at San Clemente or Imperial Beach.

In 2020, water temperatures throughout the RNKSC region were generally warmer than average during the months of January through March, October, and December. Although lower than normal temperatures were recorded occasionally throughout the region from April through September, daily SST values rarely fell below 14ºC, a threshold below which nutrient availability is increased.

The Nutrient Quotient Indices were higher throughout the region than in 2019, and were the highest values recorded since 2017 for Oceanside and since 2012 for Newport Pier, Scripps Pier, and Point Loma. However, these high NQ values for 2020/2021 are primarily due to the low surface temperature values recorded in January, February, March, and April of 2021. Consequently, NQ values from July through December 2020 were very low, as has been the case for several years.

During 2020, upwelling was weak at the beginning of the year (January through March) and at the end of the year (October through December), when water temperatures were lowest, and consequently nutrients would be expected to be more available. Upwelling was strongest from April through August, but this corresponded to the period when surface water temperatures were highest, and therefore nutrient availability would be expected to be low.

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, Appendix A). 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 (Oceanside/Fallbrook, Encina Power Plant/Poseidon, and San Elijo/Escondido) (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 2020, 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 April15, July 05, September 20, and December 30, 2020 (Table 1). The flight path and flight data report from each quarterly aerial survey are included in Appendix C.

II.1.B - VESSEL SURVEYS

Vessel surveys are conducted annually to observe all RNKSC kelp beds. The vessel surveys for the 2020 survey year were conducted on December 22, 2020 from Imperial Beach to North Carlsbad, and on March 17, 2021 from Santa Margarita 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 San Clemente, Barn Kelp, Solana Beach, and Imperial Beach kelp beds. Field data sheets from the vessel surveys are included in Appendix C.

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 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) geo-referencing, 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.

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 2). Kelp beds off La Jolla (CDFW lease bed 4, Figure 2) and Point Loma (CDFW lease beds 2 and 3, Figure 2) 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.

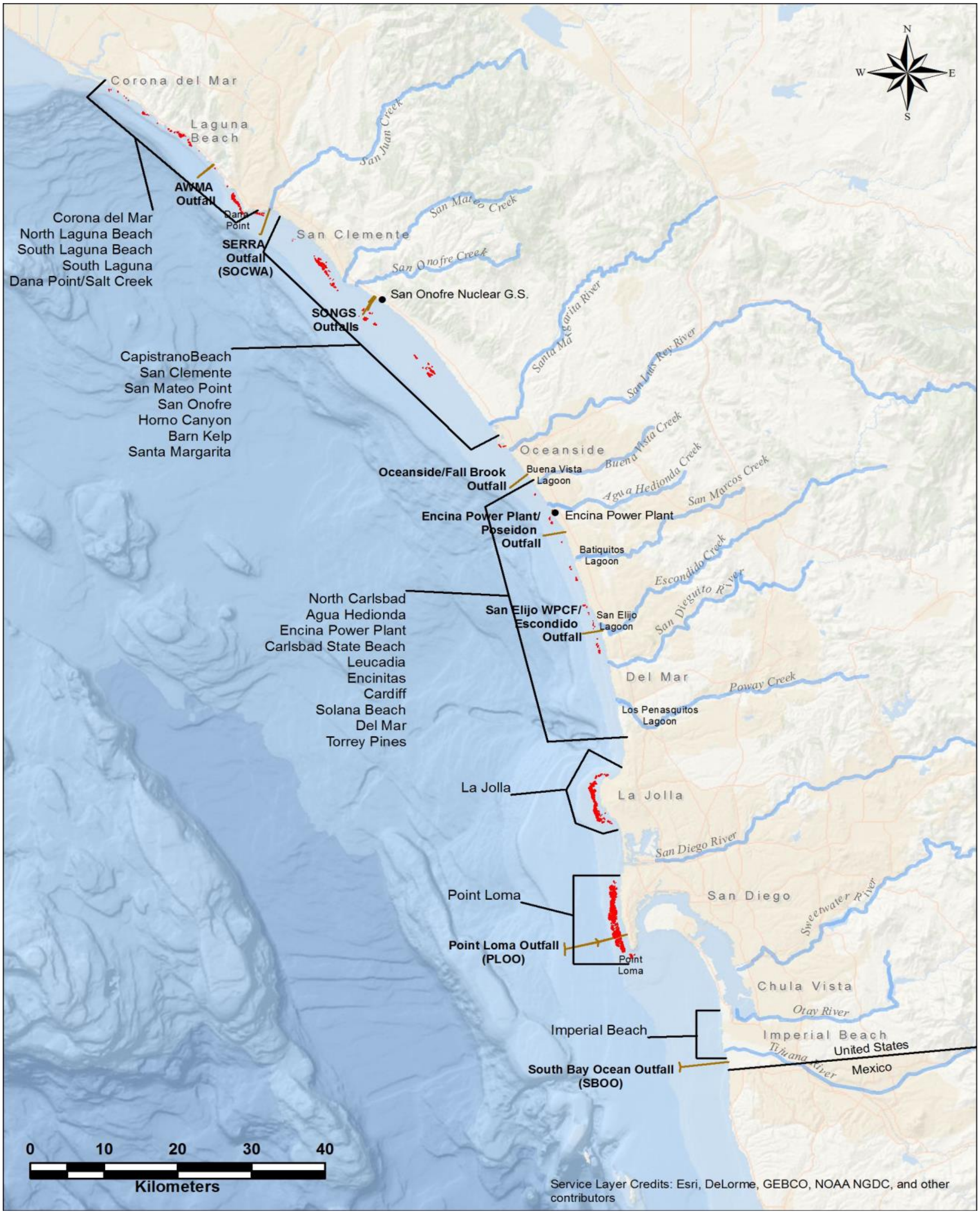


Figure 1. Location of ocean outfalls and designated kelp beds within the Region Nine survey area (red illustrates the approximate areas where surface canopy may occur in a given year within each kelp bed).

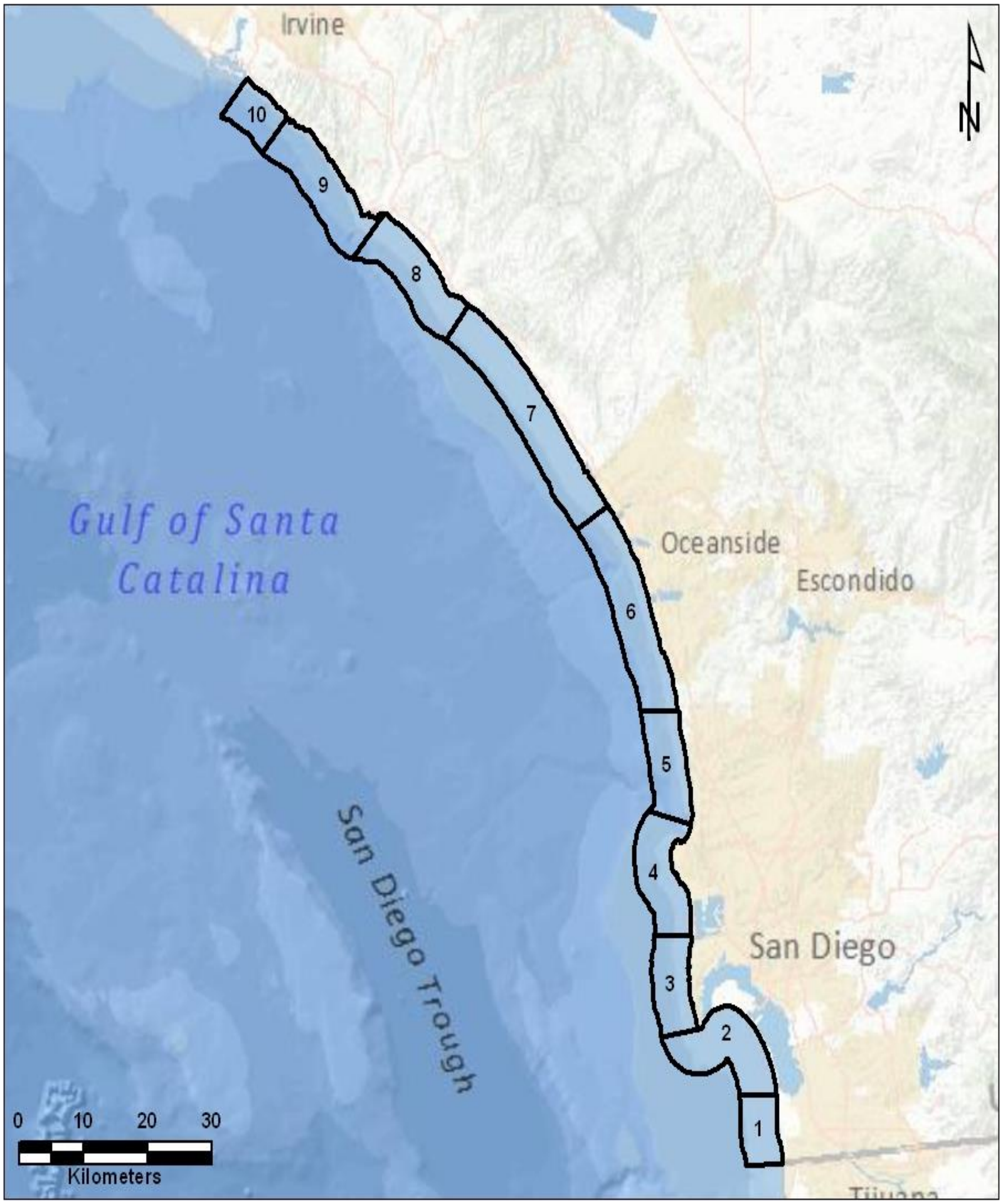
Table 1. Kelp bed overflights in 2020.

Quarter	Target Date	Actual Date	Comments
1st Quarter	**January to March 2020**	April15, 2020	Excellent conditions for photos and observations during overflight (survey delayed due to COVID-19 restrictions)
2nd Quarter	**April to June 2020**	July 5, 2020	Excellent conditions for photos and observations during overflight (survey delayed due to foggy conditions during month of June)
3rd Quarter	**July to September 2020**	September 20, 2020	Good to excellent conditions for photos and observations during overflight
4th Quarter	**October to December 2020**	December 30, 2020	Excellent conditions for photos and observations during overflight

Table 2. Ranking values of canopy coverage assigned to kelp beds from Newport Harbor to Imperial Beach based on aerial photographs from 2020 Region Nine quarterly overflights.

	2020 Quarterly Overflights			
Kelp Beds	**15 April**	**5 July**	**20 September**	**30 December**
Newport Harbor *	-	-	-	-
Corona del Mar	-	-	-	-
No. Laguna Beach	1.0	2.5	-	0.5
So. Laguna Beach	-	0.5	-	0.5
South Laguna	-	-	-	-
Salt Creek-Dana Point	0.5	-	-	2.0
Dana Marina *	-	-	-	-
Capistrano Beach	0.5	-	-	-
San Clemente	-	-	-	0.5
San Mateo Point	-	-	-	-
San Onofre	-	-	-	-
Pendleton Reefs *	-	-	-	-
Horno Canyon	-	-	-	0.5
Barn Kelp	-	-	-	2.5
Santa Margarita	-	-	-	-
Oceanside Harbor *	-	-	-	-
North Carlsbad	NI	-	-	-
Agua Hedionda	-	-	-	-
Encina Power Plant	NI	-	-	-
Carlsbad State Beach	NI	-	-	-
North Leucadia	NI	-	-	-
Central Leucadia	NI	-	-	1.0
South Leucadia	NI	-	-	0.5
Encinitas	-	-	-	0.5
Cardiff	-	-	-	-
Solana Beach	NI	-	-	-
Del Mar	-	-	-	-
Torrey Pines Park	-	-	-	-
La Jolla Upper	1.0	-	1.0	2.5
La Jolla Lower	1.0	0.5	1.0	2.5
Point Loma Upper	2.5	1.5	1.5	3.0
Point Loma Lower	3.0	2.0	1.5	3.0
Imperial Beach	-	-	-	-

Ranking values: 0.5 = trace or very small amount of kelp present; 1 = well below average;
1.5 = somewhat below average; 2 = below average; 2.5 = average;
3 = above average; 3.5 = somewhat above average; and 4 = well above average.
* = not a designated kelp bed
NI = No Image
"-" = no kelp present
Green highlight = survey utilized to quantify surface canopy area



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

Figure 2. Administrative kelp bed lease areas in the Region Nine study area.

III - RESULTS

III.1 – SUMMARY

Maps showing the areal extent of RNKSC surface canopy coverage in 2020 are provided in Appendix A. Tables displaying the historical canopy coverage for Region Nine from 1983 through 2020 are included in Appendix B. Composite photographs of the extent of kelp surface canopy throughout Region Nine in 2020 are included in Appendix D.

All kelp beds in the RNKSC region attained maximum surface canopy area for the year during either the July or December survey (Table 2). The total amount of kelp canopy coverage in the RNKSC region was 3.9 km^2 in 2020, decreasing by 25% from 5.2 km^2 in 2019. In 2020, 10 kelp beds displayed surface canopy (compared to nine in 2019). Five kelp beds increased in size in 2020, including North Laguna Beach plus the four kelp beds that reappeared between 2019 and 2020 (Dana Point/Salt Creek, Horno Canyon, Barn Kelp, and Encinitas). Eight kelp beds decreased in size in 2020, including South Laguna Beach, San Clemente, Leucadia, La Jolla, and Point Loma plus the three kelp beds that disappeared between 2019 and 2020 (Corona del Mar, San Mateo Point, and San Onofre).

The largest beds in the RNKSC region were the La Jolla and Point Loma kelp beds, with Point Loma being the largest at 2.5 km^2 (Figure 3, Panel A). These two large kelp beds accounted for 93% of the total RNKSC kelp coverage in 2020. The surface canopies of seven kelp beds were less than or equal to 11% of the maximum size recorded since 1983. Only three kelp beds were greater than 20% of their historical maximum size (La Jolla at 26%, Barn Kelp at 25%, and Point Loma at 32%) (Figure 3, Panel B).

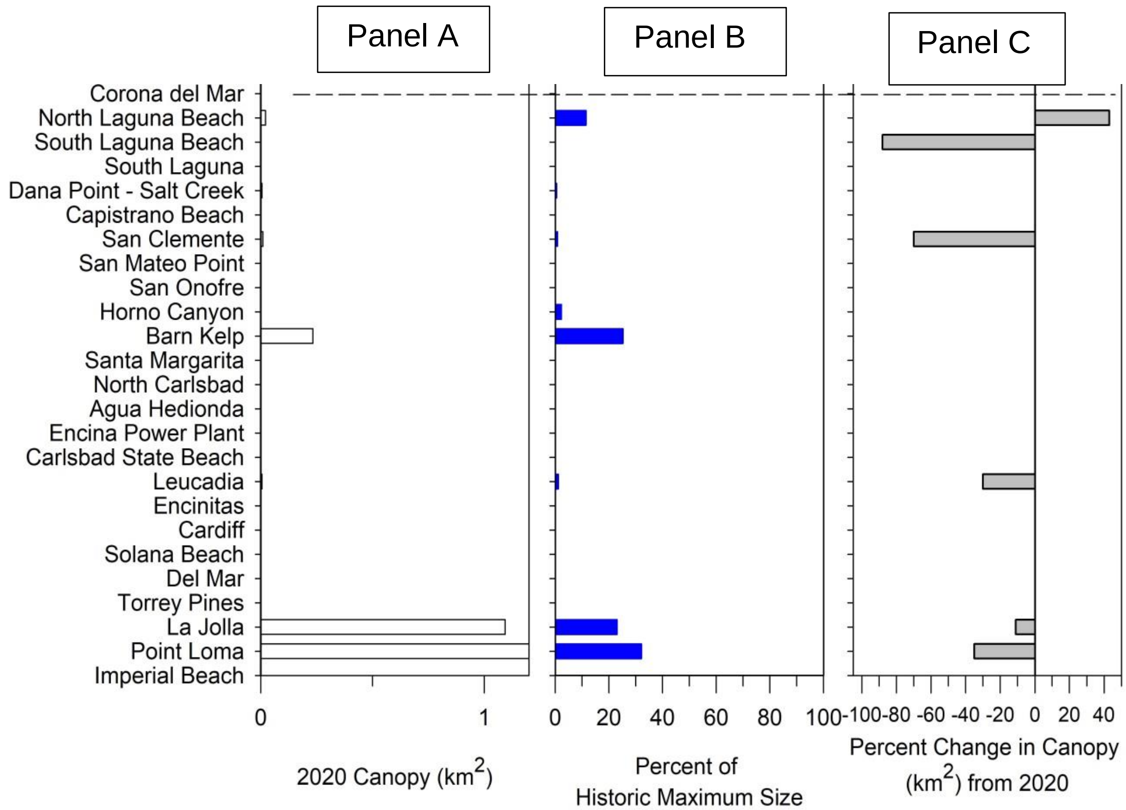
III.2 - SIZE OF KELP BEDS IN REGION NINE

The following is a synopsis of the status of each of the 24 designated individual kelp beds in the Region Nine during the 2020 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 2019 and 2020 for each kelp bed is presented in Table 3. Historical canopy coverage since 1911 is presented in Appendix B (Table B.3). Visual observations of the kelp beds recorded in Table 4 are based on vessel surveys conducted on December 22, 2020 and March 17, 2021. Observations from diver surveys conducted at the San Clemente, Barn Kelp, Solana Beach, and Imperial Beach kelp bed areas are also presented below.

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

Corona del Mar. This kelp bed disappeared in 2020 (Table 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. There was no visible surface canopy in this area from 1992 through 2002, but the kelp bed had been observed every subsequent year until 2020 (Figure 4).



Note: Point Loma 2020 Canopy = 1.54 km^2

Figure 3. Summary of Region Nine kelp canopy coverage in 2020.

During the March 2021 vessel survey (Table 4), the Corona del Mar surface canopy was estimated at approximately 30 by 10 meters with medium density. Tissue color was 50% light yellow and 50% dark yellow, with no encrustation on fronds, and no apical meristems were observed. The kelp bed was composed of approximately 5% senile and 95% mature fronds. No subsurface kelp was visible on the fathometer.

III.2.B - ABALONE POINT TO CAPISTRANO BEACH

There are five kelp beds located between Abalone Point and Capistrano Beach.

North Laguna Beach/South Laguna Beach. The North Laguna Beach kelp bed increased in size by 43%, from 0.015 km^2 in 2019 to 0.022 km^2 in 2020 (Table 3). The canopy area in 2020 was 11% of the maximum recorded in 2012. The South Laguna Beach kelp bed decreased in size by 88%, from 0.007 km^2 in 2019 to 0.001 km^2 in 2020. The canopy area in 2020 was less than 1% of the maximum recorded in 2013 (Appendix B.3; Figure 4).

The North and South Laguna Beach beds were rarely visible after the early 1990s until 2008, when they were reestablished as a result of restoration efforts. The surface canopy area of the North Laguna Beach kelp bed was the second lowest recorded since 2009 despite the increase in size observed in 2020, while the South Laguna Beach kelp bed was the smallest size recorded since 2007 (Figure 4). The decrease in size of the South Laguna Beach kelp bed was similar to the decline of the Orange County ABAPY, but the North Laguna Beach kelp bed increased in size despite this countywide decline.

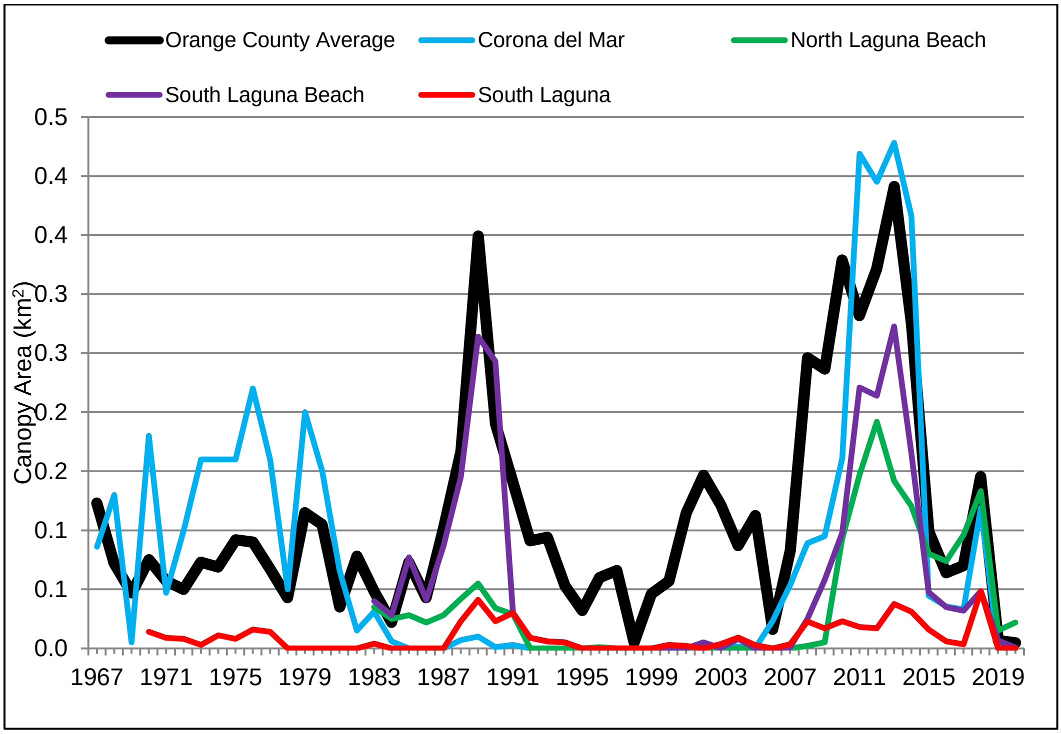


Figure 4. Average Orange County ABAPY compared to canopy coverage of the kelp beds from Corona del Mar to South Laguna from 1967 through 2020.

During the March 2021 vessel survey (Table 4), the North Laguna Beach surface canopy was estimated to extend over an area of approximately 300 by 200 meters with medium density. Tissue color was 30% light yellow and 70% dark yellow with no encrustation on fronds, and less than 5% apical meristems were observed. The kelp bed was composed of 100% mature fronds. Scattered subsurface kelp was visible on the fathometer at a depth of approximately 10 feet. The South Laguna Beach surface canopy was estimated to cover approximately 0.75 miles by 30 to 40 meters with medium density to scattered individuals. Tissue color was 20% light yellow and 80% dark yellow with 50 to 60% encrustation on fronds, and no apical meristems were observed. The kelp bed was composed of 10% senile and 90% mature fronds. No subsurface kelp was visible on the fathometer.

South Laguna. This kelp bed disappeared in 2019 and was still not visible in 2020 (Table 3).

Surface canopy was visible at the South Laguna kelp bed from 2007 through 2018, and in 2018 reached the maximum size recorded since RNKSC surveys began in 1983 (Appendix B.3; Figure 4). The past two years represent the first time that no surface canopy was visible since 2006.

No surface or subsurface kelp was observed at South Laguna during the March 2021 vessel survey (Table 4).

Dana Point/Salt Creek. This kelp bed reappeared in 2020 (Table 3).

Despite the reappearance of the Dana Point/Salt Creek kelp bed in 2020 (Appendix A.46), the surface canopy area was smaller than recorded from 2007 through 2018 (Figure 5).

During the March 2021 vessel survey (Table 4), the Dana Point/Salt Creek surface canopy was estimated to extend over an area of approximately 0.25 to 0.75 miles by 100 to 150 meters with medium density. Tissue color was 90% light yellow and 10% dark yellow with 80% encrustation on fronds, and no apical meristems were observed. The kelp bed was composed of 80% senile and 20% mature fronds. No subsurface kelp was observed on the fathometer.

No kelp was observed along the breakwaters in Dana Point Harbor (Appendix A.47) in 2020. This is not a designated kelp bed.

Capistrano Beach. This kelp bed disappeared in 2019 and was still not visible in 2020 (Table 3).

This was the second year that surface canopy had not been observed at the Capistrano Beach kelp bed since 2005 (Appendix B.3; Figure 5).

During the March 2021 vessel survey, no surface canopy was observed. However, a few scattered kelp individuals were visible on the fathometer at a depth of approximately 20 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 2020 (Table 3).

San Clemente. This kelp bed decreased in size by 79%, from 0.030 km^2 in 2019 to 0.009 km^2 in 2020 (Table 3). The canopy area in 2020 was only 1% of the maximum recorded in 2013 (Appendix B.3; Figure 5).

The surface canopy area at the San Clemente kelp bed in 2020 was the lowest recorded since 2007 (Appendix B.3; Figure 5). The 2020 decrease in size was similar to the decline of the Orange County ABAPY.

No surface canopy or subsurface kelp was visible at the San Clemente kelp bed during the March 2021 vessel survey (Table 4). No kelp individuals were observed on the bottom during the dive survey at this location. The substrate included boulders with some small sand patches.

San Mateo Point. This kelp bed disappeared in 2020 (Table 3).

The disappearance of the San Mateo Point kelp bed in 2020 was the first time that no surface canopy was recorded since 1998 (Appendix A.50; Figure 5).

During the March 2021 vessel survey, only a few scattered individuals were observed at the surface. Tissue color was 100% light yellow with approximately 50% encrustation (heavy on older individuals), and no apical meristems were observed. The kelp bed was composed of 80% senile and 20% young fronds. A few subsurface individuals were present (Table 4).

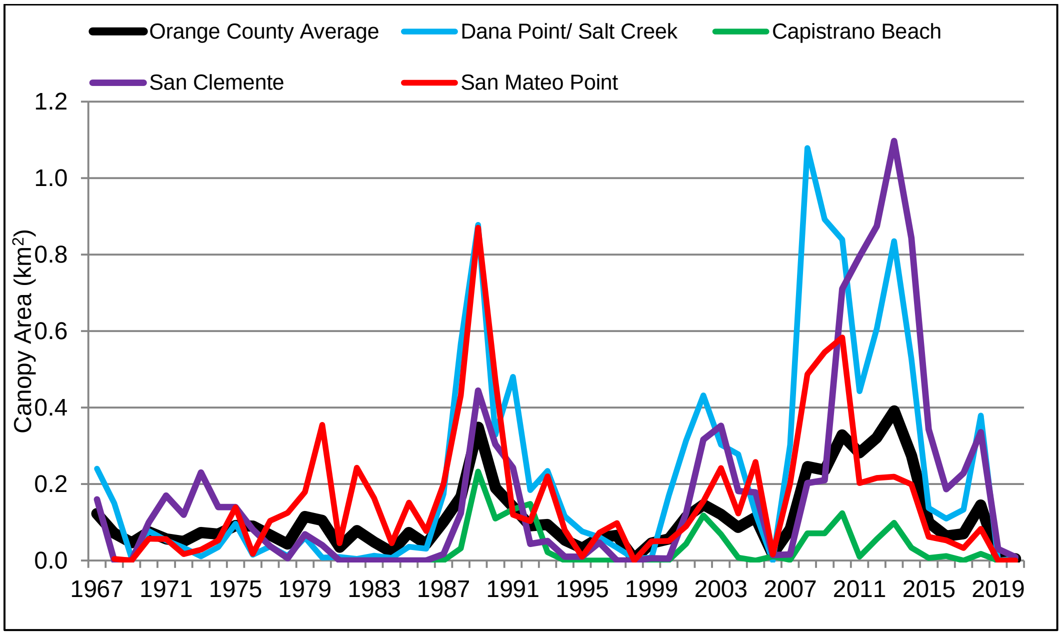


Figure 5. Average Orange County ABAPY compared to the canopy coverage of the kelp beds from Dana Point/Salt Creek to San Mateo Point from 1967 through 2020.

San Onofre. This kelp bed also disappeared in 2020 (Table 3).

The disappearance of the San Onofre kelp bed in 2020 was the first time that no surface canopy was recorded since 2006 (Appendix A.50; Figure 6).

No surface or subsurface kelp was observed during the March 2021 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 reappeared in 2020 (Table 3).

Despite the reappearance of the Horno Canyon kelp bed in 2020, the surface canopy area was smaller in size than the amounts recorded from 2007 through 2018 (Figure 6).

No surface or subsurface canopy was visible during the March 2021 vessel survey (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.

Table 3. Comparison of the canopy coverage of the Region Nine kelp beds from Laguna Beach to Imperial Beach (kelp beds listed north to south) during 2019 and 2020.

Kelp Bed	2019 (km^2)	2020 (km^2)	Percentage Difference
Corona del Mar	0.003	0	Disappeared
North Laguna Beach	0.015	0.022	+43%
South Laguna Beach	0.007	0.001	-88%
South Laguna	0	0	No change
Dana Point/Salt Creek	0	0.005	Reappeared
Capistrano Beach	0	0	No change
San Clemente	0.030	0.009	-70%
San Mateo Point	0.0001	0	Disappeared
San Onofre	0.001	0	Disappeared
Horno Canyon	0	0.003	Reappeared
Barn Kelp	0	0.234	Reappeared
Santa Margarita	0	0	No change
North Carlsbad	0	0	No change
Agua Hedionda	0	0	No change
Encina Power Plant	0	0	No change
Carlsbad State Beach	0	0	No change
Leucadia	0.009	0.006	-30%
Encinitas	0	0.0003	Reappeared

Table 3 (continued)

Kelp Bed	2019 (km^2)	2020 (km^2)	Percentage Difference
Cardiff	0	0	No change
Solana Beach	0	0	No change
Del Mar	0	0	No change
Torrey Pines	0	0	No change
La Jolla	1.227	1.094	-11%
Point Loma	3.923	2.545	-35%
Imperial Beach	0	0	No change
TOTAL	5.213	3.919	-25%

Barn Kelp. This kelp bed also reappeared in 2020 (Table 3).

The surface canopy area observed at Barn Kelp in 2020 was the largest amount recorded since 2014 (Figure 6).

Surface canopy was estimated to extend over an area of 200 x 100 meters with high density at Barn Kelp during the March 2021 vessel survey. Tissue color was 90% light yellow and 10% dark yellow with 30% encrustation on fronds, and 5% apical meristems were observed. The kelp bed was composed of 10% senile, 80% mature, and 10% young fronds. Kelp individuals observed on the bottom during the dive survey at this location included 62 adults, 1 subadult, and 5 juveniles. Tissue color was 70% light yellow and 30% dark yellow with some encrustation on fronds. Some sporophylls and juvenile fronds were observed. The substrate consisted primarily of boulders, along with some sand channels and cobble areas.

Santa Margarita. This kelp bed was not observed during 2019, nor was it visible in 2020 (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.3).

No surface canopy or subsurface kelp was visible at Santa Margarita during the March 2021 vessel survey.

No kelp was observed in Oceanside Harbor (Appendix A.57; Table 3) in 2020. This is not a designated kelp bed.

Table 4. Visual observations of Region Nine kelp beds during December 22, 2020 and March 17, 2021 vessel surveys.

Kelp Bed	Surface Canopy		Subsurface Kelp
	Extent	Appearance	
Corona del Mar	surface kelp canopy estimated at 30 x 10 meters, medium density	50% light yellow, 50% dark yellow; 5% senile, 95% mature; no encrustation; no apical meristems	none
North Laguna Beach	surface kelp canopy estimated at 300 x 200 meters, medium density	30% light yellow, 70% dark yellow; 100% mature; no encrustation; <5% apical meristems	scattered subsurface kelp at depth @10 feet
South Laguna Beach	surface kelp canopy estimated at 0.75 miles x 30 to 40 meters, medium density to scattered individuals	20% light yellow, 80% dark yellow; 10% senile, 90% mature; 50 to 60% encrustation; no apical meristems	none
South Laguna	none		none
Dana Point/Salt Creek	surface kelp canopy estimated at 0.25 to 0.75 miles x 100 to 150 meters, medium density	90% light yellow, 10% dark yellow; 80% senile, 20% mature; 80% encrustation; no apical meristems	none
Capistrano Beach	none		few scattered individuals @20 feet below surface
San Clemente	none		**See discussion of dive survey results**
San Mateo Point	few scattered individuals	100% light yellow; 80% senile, 20% young; @50% encrustation (heavy on older individuals); no apical meristems	few subsurface kelp, individuals
San Onofre	none		none
Pendleton Reefs	none		none
Horno Canyon	none		none
Barn Kelp	surface kelp canopy estimated at 200 x 100 meters, high density	90% light yellow 10% dark yellow; 10% senile, 80% mature, 10% young; 30% encrustation; 5% apical meristems	**See discussion of dive survey results**
Santa Margarita	none		none
North Carlsbad	none		several scattered kelp individuals
Agua Hedionda	none		none
Encina Power Plant	none		none
Carlsbad State Beach	none		none

Table 4 (continued)

Kelp Bed	Surface Canopy		Subsurface Kelp
	Extent	Appearance	
Leucadia-north	surface kelp canopy estimated at 80 x 30 meters, medium density	95% light yellow 5% dark yellow; 20% senile, 80% mature; 60% encrustation; <5% apical meristems	Dense subsurface kelp under main surface canopy area; scattered subsurface kelp individuals outside main area
Leucadia-central	surface kelp canopy estimated at 100 x 30 meters, medium density within this area, scattered kelp elsewhere	5% light yellow 95% dark yellow; 5% senile, 95% mature; 5% encrustation; <5% apical meristems	several kelp individuals on the bottom, 10 to 20 feet tall
Leucadia-south	none		none
Encinitas	surface kelp canopy estimated at 100 x 30 meters	95% light yellow, 5% dark yellow; 95% senile, 5% mature; 80% encrustation; no apical meristems	several kelp individuals on the bottom, up to 10 feet tall
Cardiff	surface kelp canopy estimated at 150 x 150 meters	30% dark yellow, 70% light yellow; 1% senile, 98% mature, 1% young; 40% encrustation; <5% apical meristems	very scattered, 10 to 20 feet below surface
Solana Beach	very scattered	100% dark yellow; 90% senile; 10% mature	**See discussion of dive survey results**
Del Mar	none		none
Torrey Pines	none		none
La Jolla North	scattered canopy with low density	50% light yellow, 50% dark yellow; 50% senile, 50% mature; 50% encrustation; <5% apical meristems	scattered subsurface kelp
La Jolla South	continuous canopy south to north end over an area of 1 to 1.5 miles	20% light yellow, 80% dark yellow; 10% senile, 90% mature; 50% encrustation <5% apical meristems	very scattered subsurface kelp; <5% apical meristems
Point Loma North	scattered kelp approximately 50 meters width, very sparse density; denser canopy 100-150 meters in width at upcoast area	100% light yellow; 99% senile, 1% young; 50% encrustation;	very scattered subsurface kelp
Point Loma South	dense canopy 0.5 miles offshore extending @ 1 mile along the coast	90% dark yellow; 5% senile, 94% mature, 1% young; 5% encrustation; 5% apical meristems	dense kelp below surface down to @ 20 feet
Imperial Beach	none		**See discussion of dive survey results**

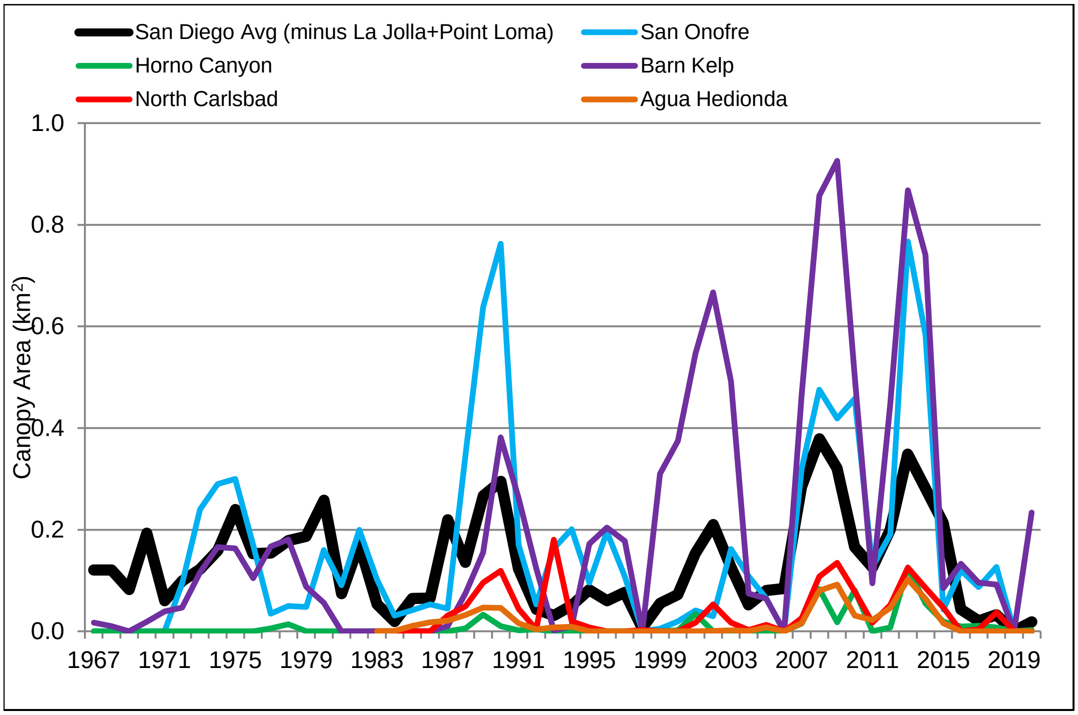


Figure 6. Comparisons between the San Diego average ABAPY and canopy coverage of the kelp beds from San Onofre to Agua Hedionda from 1967 to 2020.

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

There are four kelp beds located between North Carlsbad and Carlsbad State Beach (Table 3).

North Carlsbad. This kelp bed disappeared in 2019 and was not visible in 2020 (Table 3).

The North Carlsbad kelp bed is usually comprised of several small beds (Appendices A.58 and A.59). Visible surface canopy has been recorded every year since 2001, with the exception of 2006, 2016, 2019, and 2020 (Figure 6).

During the December 2020 vessel survey (Table 4), no surface canopy was observed at the North Carlsbad kelp bed. However, several scattered kelp individuals were recorded in subsurface areas.

Agua Hedionda. This kelp bed was not observed in 2019, nor was it visible in 2020 (Table 3).

Visible surface canopy was observed at the Agua Hedionda kelp bed from 2002 through 2015 (Figure 6). However, no surface canopy has been recorded from 2016 through 2020.

No surface canopy or subsurface kelp was observed at the Agua Hedionda kelp bed during the December 2020 vessel survey (Table 4).

Encina Power Plant. This kelp bed disappeared in 2019 and was still not visible in 2020 (Table 3).

This was the second time that no surface canopy was observed at the Encina Power Plant kelp bed since 2006 (Appendix A.60, Figure 7).

No surface canopy or subsurface kelp was observed at the Encina Power Plant kelp bed during the December 2020 vessel survey (Table 4).

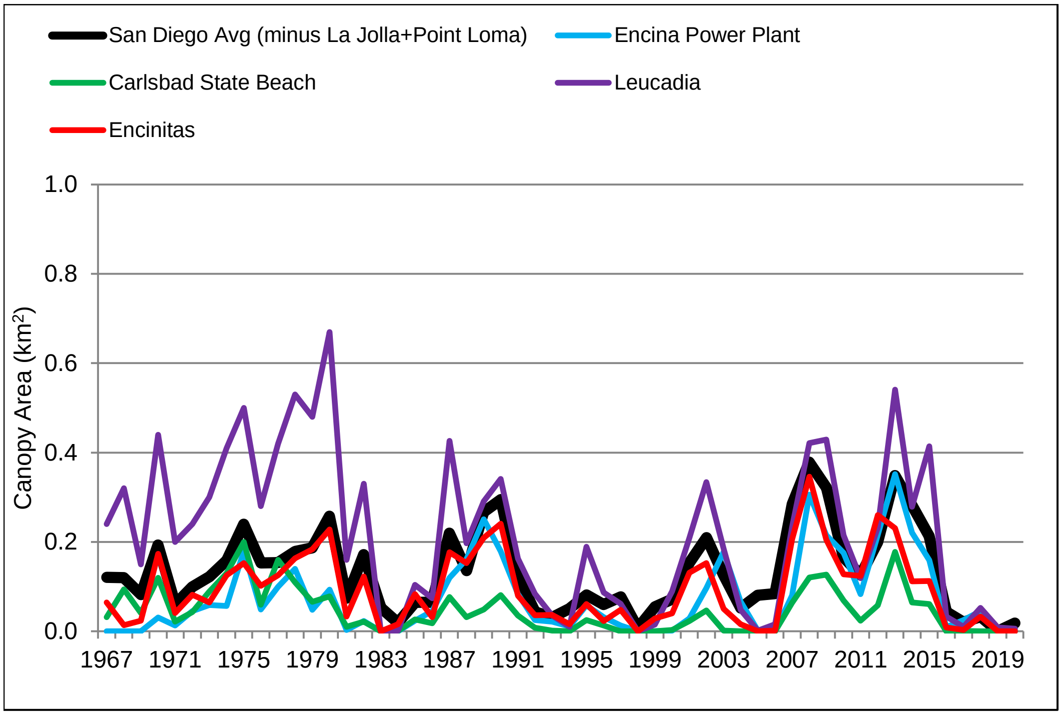


Figure 7. Comparisons between the San Diego average ABAPY and canopy coverage of the kelp beds from Encina Power Plant to Encinitas from 1967 to 2020.

Carlsbad State Beach. This kelp bed was not observed in 2019, nor was it visible in 2020 (Table 3).

The Carlsbad State Beach (Carlsbad State Park) kelp bed (Appendices A.60 and A.61) was very small in 2017 (0.001 km^2), but no surface canopy was visible in 2016, 2018, 2019, or 2020 (Figure 7).

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

III.2.F - LEUCADIA TO TORREY PINES

Leucadia. This kelp bed decreased in size by 30%, from 0.009 km^2 in 2019 to 0.006 km^2 in 2020 (Table 3). The canopy area in 2020 was only 1% of the maximum recorded in 2013 (Appendix B.3; Figure 7).

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, the Leucadia kelp bed increased in size to its highest canopy coverage in the last 30 years (0.541 km^2), but by 2020 had declined to only 1% of its maximum size (Appendix B.3; Figure 6). In 2020, kelp canopy was observed only in the Central and South beds.

The surface canopy was estimated to extend over an area of 80 x 30 meters with medium density at the North Leucadia Bed during the December 2020 vessel survey (Table 4). Tissue color was 95% light yellow and 5% dark yellow with 60% encrustation on fronds, and less than 5% apical meristems were observed. The kelp bed was composed of 20% senile and 80% mature fronds. Dense subsurface kelp was observed underneath the main surface canopy, as well as scattered individuals outside the main canopy area. The surface canopy was estimated to extend over an area of 100 x 30 meters with medium density at the Central Leucadia bed. Tissue color was 5% light yellow and 95% dark yellow with 5% encrustation on fronds, and less than 5% apical meristems were observed. The kelp bed was composed of 5% senile and 95% mature fronds. Several kelp individuals were observed on the bottom, approximately 10 to 20 feet tall. No surface canopy or subsurface kelp was observed at the South Leucadia Bed.

Encinitas. This kelp bed reappeared in 2020 (Table 3).

The surface canopy of the Encinitas kelp bed in 2020 was the smallest amount (0.0003 km^2) observed since 2006, with the exception of 2019 when the kelp bed disappeared for the first time since 2005 (Appendix A.63; Figure 7).

During the December 2020 vessel survey, the surface canopy was estimated to extend over an area of 100 x 30 meters (Table 4). Tissue color was 95% light yellow and 5% dark yellow with 80% encrustation, and no apical meristems were observed. The kelp bed was composed of 95% senile and 5% mature fronds. Several kelp individuals were observed on the bottom, up to 10 feet tall.

Cardiff. This kelp bed disappeared in 2019 and was still not visible in 2020 (Table 3).

This was the second time that no surface canopy has been observed at the Cardiff kelp bed since 2005 (Appendix A.64; Figure 8).

During the December 2020 vessel survey, surface canopy was estimated to extend over an area of 150 x 150 meters (Table 4). Tissue color was 70% light yellow and 30% dark yellow with 40% encrustation. The kelp bed was composed of 1% senile, 98% mature, and 1% young fronds. Subsurface kelp was very scattered 10 to 20 feet below the surface.

Solana Beach. This is another kelp bed that disappeared in 2019 and was still not visible in 2020 (Table 3).

This was the second time that no surface canopy was observed at the Solana Beach kelp bed since 1983 (Appendices A.64 and A.65; Figure 8).

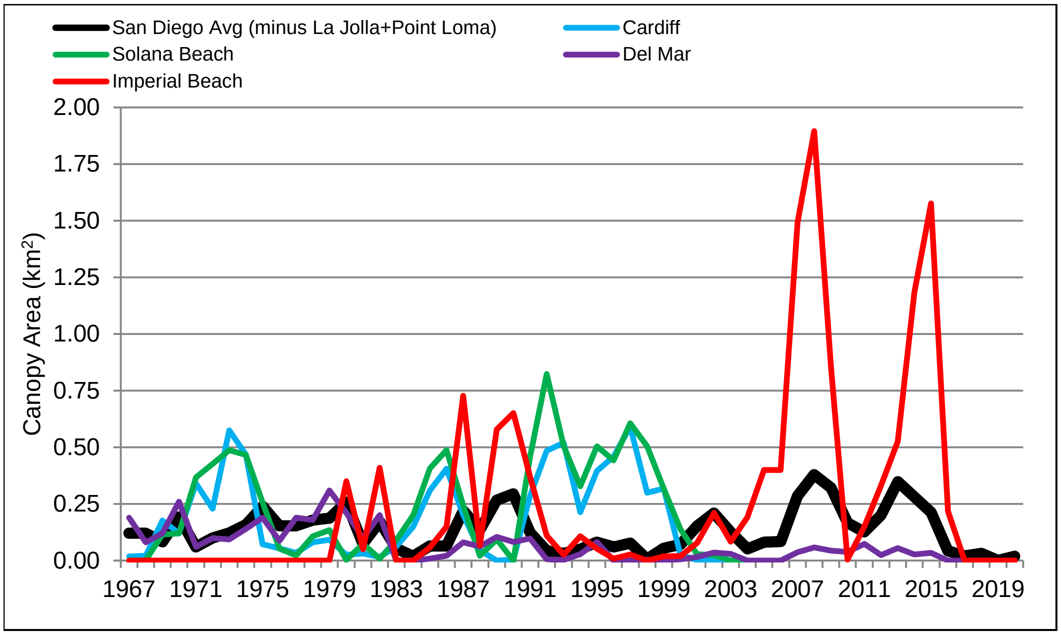


Figure 8. Comparisons between the San Diego average ABAPY and canopy coverage of the kelp beds from Cardiff to Imperial Beach from 1967 to 2020.

During the December 2020 vessel survey, very scattered surface canopy was observed at the Solana Beach kelp bed (Table 4). Kelp fronds were 100% dark yellow and were 90% senile and 10% mature. Eight adult kelp individuals were observed on the bottom during the dive survey at this location. Tissue color was 80% medium yellow and 20% dark yellow in midwater areas, and 50% medium yellow and 50% dark yellow at the bottom with some encrustation on the fronds. Sporophylls and juvenile fronds were observed.

Del Mar. This kelp bed was not observed in 2019, nor was it visible in 2020 (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 8).

No surface canopy or subsurface kelp was observed at the Del Mar kelp bed during the December 2020 vessel survey (Table 4).

Torrey Pines. This kelp bed was not observed in 2019, nor was it visible in 2020 (Table 3).

The 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 2020 (Appendices A.67 and A.68).

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

III.2.G - LA JOLLA

La Jolla. This kelp bed decreased in size by only 11%, from 1.227 km^2 in 2019 to 1.094 km^2 in 2020 (Table 3). The canopy area in 2020 was 23% of the maximum recorded in 1989 (Appendix B.3; Figure 9).

The 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 has been much smaller from 2016 through 2020 (ranging in size from 0.694 km^2 to 1.566 km^2) than the levels observed from 2013 to 2015 (2.790 km^2 to 4.006 km^2) (Appendices A.68 through A.70; Figure 9).

During the December vessel survey, the La Jolla North kelp bed surface canopy was scattered with low density (Table 4). Tissue color was 50% light yellow and 50% dark yellow with 50% encrustation, and less than 5% apical meristems were observed. The kelp bed was composed of 50% senile and 50% mature fronds. Scattered subsurface kelp was visible on the fathometer. The La Jolla South kelp bed surface canopy was continuous from the south to north end, extending over an area of 1 to 1.5 miles. Tissue color was 20% light yellow and 80% dark yellow with 50% encrustation, and less than 5% apical meristems. The kelp bed was composed of 10% senile and 90% mature fronds. Very scattered subsurface kelp was visible on the fathometer.

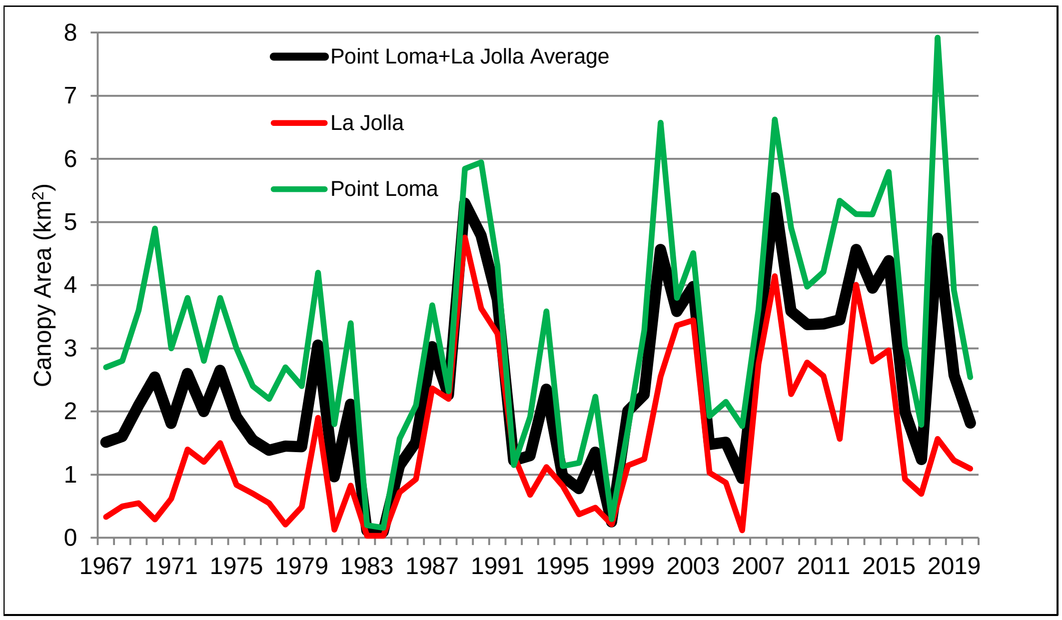


Figure 9. Comparisons between the Point Loma/La Jolla Average ABAPY and canopy coverage of the La Jolla and Point Loma kelp beds from 1967 to 2020.

III.2.H - POINT LOMA TO CORONADO BEACH

Point Loma. This kelp bed decreased in size by 35%, from 3.923 km^2 in 2019 to 2.545 km^2 in 2020 (Table 3). The canopy area in 2020 was 32% of the maximum recorded in 2018 (Appendix B.3; Figure 9).

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. However, with the decreases in size observed in 2019 and 2020, this kelp bed is smaller than it had been from 2007 through 2016 (Appendices A.71 through A.74; Figure 9).

During the December 2020 vessel survey, the surface canopy was scattered over an area approximately 50 meters in width at the Point Loma North kelp bed (Table 4). Tissue color was 100% light yellow with 50% encrustation on the fronds. Subsurface kelp was very scattered. A dense surface canopy approximately 0.5 miles offshore was observed at the Point Loma South kelp bed, extending approximately 1 mile along the coast. Tissue color was 90% dark yellow and 10% light yellow with 5% encrustation of the fronds, and less than 5% apical meristems were observed. The kelp bed was composed of 5% senile, 94% mature, and 1% young fronds. Dense subsurface kelp was observed down to a depth of approximately 20 feet.

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.

Imperial Beach. This kelp bed was not observed in 2019, nor was it visible in 2020 (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 8). No surface canopy was observed in 2017 for the first time since 1998, nor was it visible through 2020.

No surface or subsurface kelp was visible at the Imperial Beach kelp bed during the December 2020 vessel survey (Table 4). No kelp individuals were observed on the bottom at this location during the dive survey. The substrate included approximately 5% cobble and boulder. The divers noted 67 purple urchins, 4 white urchins, and 18 bat stars on the cobbles and boulders.

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 3.9 km^2 in 2020.
2. What is the variability of the coastal kelp bed canopy over time?
    - the total kelp canopy decreased in size in 2020 by 25% (from 5.2 km^2 to 3.9 km^2);
    - one kelp bed with visible surface canopy in 2019 increased in size in 2020 (North Laguna Beach);
    - five kelp beds with visible surface canopy present in 2019 decreased in size in 2020 (South Laguna Beach, San Clemente, Leucadia, La Jolla, and Point Loma).
3. Are coastal kelp beds disappearing? If yes, what are the factors that could contribute to the disappearance?
    - three kelp beds disappeared in 2020: Corona del Mar, San Mateo Point, and San Onofre;
    - higher than normal sea surface temperatures and low nutrient availability could have contributed to the disappearance of these three kelp beds.
    - 12 other kelp beds continued to display no surface canopy in 2020: South Laguna, Capistrano Beach, Santa Maragarita, North Carlsbad, Agua Hedionda, Encina Power Plant, Carlsbad State Beach, Cardiff, Solana Beach, Del Mar, Torrey Pines, and Imperial Beach. 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?
    - four kelp beds reappeared in 2020 (Dana Point/Salt Creek, Horno Canyon, Barn Kelp, and Encinitas).

The total kelp canopy in Region Nine covered approximately 3.9 square kilometers in 2020. This is the fourth time in the past five years (2016, 2017, 2019, and 2020) that the total kelp canopy was less than the long-term average, following nine years (2007 through 2015) with above average total kelp canopies (Figure 10). The largest kelp beds were the La Jolla and Point Loma kelp beds, which accounted for 93 percent of the total canopy coverage in 2020. Only three kelp beds in 2020 were greater than 20% of the maximum extent recorded since 1983: Barn Kelp at 25% of maximum, La Jolla at 23%, and Point Loma at 32% (Figure 3). All of the other kelp beds were at 11% or less than their maximum size (Figure 3), and all but two (North Laguna Beach and Horno Canyon) were less than 1% of maximum.

Vessel surveys of all Region Nine kelp beds were conducted in December 2020 and March 2021. Visual observations indicated that surface canopy was present at approximately half of the kelp beds, including from Corona del Mar to South Laguna Beach, at Dana Point/Salt Creek, at San Mateo Point, at Barn Kelp, from Leucadia to Solana Beach, and at La Jolla and Point Loma. Subsurface kelp was observed at many of these kelp bed locations, as well as at two kelp beds without any visible surface canopy (Capistrano Beach and North Carlsbad). In-water surveys were conducted in December 2020 and March 2021 at four kelp beds (San Clemente, Barn Kelp, Solana Beach, and Imperial Beach). Divers observed 68 kelp individuals on the bottom at Barn Kelp and 8 individuals at Solana Beach, but no kelp was observed at San Clemente or Imperial Beach.

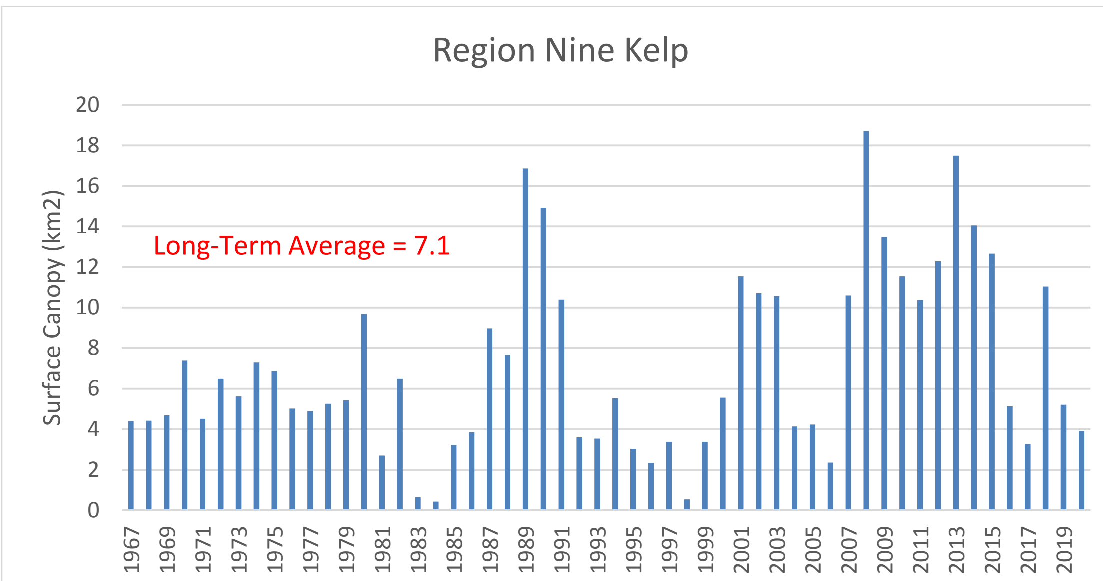


Figure 10. Combined canopy coverage of all kelp beds off Orange and San Diego Counties from 1967 through 2020.

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 (km²) of the kelp beds from Laguna Beach to Imperial Beach (kelp beds listed from north to south) from 2011 through 2020.

Kelp Bed	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
N Laguna Beach	0.147	0.192	0.142	0.120	0.080	0.074	0.096	0.133	0.015	0.022
S Laguna Beach	0.221	0.214	0.273	0.165	0.048	0.035	0.032	0.131	0.007	0.001
South Laguna	0.018	0.017	0.038	0.031	0.016	0.006	0.003	0.048	-	-
Dana Pt/Salt Crk	0.442	0.607	0.835	0.528	0.137	0.110	0.133	0.379	-	0.005
Capistrano Beach	0.010	0.056	0.099	0.034	0.007	0.012	0.0004	0.018	-	-
Total F&W 9	0.838	1.086	1.385	0.879	0.287	0.237	0.264	0.709	0.022	0.028
San Clemente	0.795	0.874	1.097	0.843	0.343	0.187	0.229	0.335	0.031	0.009
San Mateo Point	0.203	0.216	0.219	0.199	0.062	0.053	0.033	0.083	0.0001	-
San Onofre	0.127	0.191	0.767	0.584	0.043	0.120	0.087	0.127	0.001	-
Total F&W 8	1.124	1.281	2.083	1.627	0.449	0.359	0.349	0.545	0.032	0.009
Horno Canyon	-	0.008	0.125	0.055	0.019	0.010	0.011	0.008	-	0.003
Barn Kelp	0.095	0.442	0.868	0.741	0.085	0.133	0.096	0.092	-	0.234
Santa Margarita	-	-	0.080	-	-	-	-	-	-	-
Total F&W 7	0.095	0.450	1.073	0.795	0.104	0.143	0.107	0.100	0.000	0.237
North Carlsbad	0.017	0.052	0.125	0.086	0.047	-	0.004	0.038	-	-
Agua Hedionda	0.022	0.046	0.102	0.065	0.016	-	-	-	-	-
Encina Power Plant	0.084	0.216	0.352	0.221	0.159	0.009	0.025	0.045	-	-
Carlsbad St. Bch	0.024	0.058	0.178	0.065	0.061	-	0.001	-	-	-
Total F&W 6	0.147	0.372	0.757	0.437	0.282	0.009	0.031	0.083	0.000	0.000
Leucadia	0.119	0.232	0.541	0.279	0.414	0.033	0.010	0.053	0.009	0.006
Encinitas	0.124	0.260	0.231	0.112	0.113	0.009	0.003	0.033	-	0.0003
Cardiff	0.395	0.459	0.590	0.299	0.318	0.024	0.003	0.005	-	-
Solana Beach	0.504	0.442	0.606	0.504	0.316	0.138	0.029	0.024	-	-
Del Mar	0.074	0.024	0.056	0.027	0.034	-	-	-	-	-
Torrey Pines	0.031	0.034	0.081	-	-	-	-	-	-	-
Total F&W 5	1.247	1.452	2.106	1.221	1.195	0.204	0.045	0.114	0.009	0.006
La Jolla F&W 4	2.565	1.569	4.006	2.790	2.968	0.927	0.694	1.566	1.227	1.094
Point Loma F&W 3&2	4.212	5.340	5.127	5.121	5.806	3.037	1.787	7.920	3.924	2.545
Imperial Beach F&W 1	0.152	0.333	0.526	1.183	1.576	0.217	-	-	-	-
TOTAL	10.379	11.882	17.064	14.053	12.667	5.134	3.277	11.037	5.213	3.919

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:

- Data from automated shore stations at Newport Pier and Scripps Pier. At these locations, automated samplers measured conductivity, water temperature, and fluorometry at a frequency of one to four minutes. Samplers were mounted at a depth of two meters MLLW at Newport Pier, and at five 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).

- 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.

- Data 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 2020). Sensors recorded water temperature at four-meter intervals from near the sea surface to a depth of 54 meters MLLW.

- Data provided by the Orange County Sanitation District from a monitoring station offshore of the Orange County coastline (Station 2106) in 75 meters of water. Sensors recorded water temperature at five-meter intervals from the sea surface to near the bottom (a depth of 75 meters MLLW).

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 11. Graphs of SST values at each of these individual locations are presented in Appendix E.

In 2020 water temperatures throughout the RNKSC region were generally warmer than average during the months of January through March, October, and December (Figure 11). However, lower than normal temperatures were recorded at all locations in the region at times from April through September, as well as in November. 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. Daily SST values rarely fell below 14ºC, a threshold below which nutrient availability is increased (Schiel and Foster, 2015) except for occasionally at Scripps Pier.

Temperature monitoring was accomplished via a thermistor string deployed off Point Loma in 2020 from January through September (data were missing from October through December). Water temperatures were often warm near the surface from June through September (Figure 12).

However, cool subsurface temperatures (less than 14ºC) below a depth of 10 to 20 meters were common from April through August.

Water temperatures offshore of the Orange County coastline at Station 2106 were consistently warm (above 14ºC) from the surface down to a depth of 10 meters throughout 2019 and 2020, and exceeded 16ºC from May through December 2019 and throughout most of April through November 2020 (Figure 13). Water temperatures from a depth of 45 meters to the bottom were always cooler (nearly always below 14ºC). The lowest water temperatures at depths greater than 45 meters were recorded from March through August 2019 and from April through September 2020 (usually cooler than 12ºC).

The number of days with SST values <14ºC was very low (well below the long-term mean from 1994 to 2019) at Newport Pier and Scripps Pier, as has been the case since 2013 (Figure 14). The combined number of days with water temperatures >16ºC at the two locations was slightly below the long-term average in 2020, and was the lowest total since 2013. The combined number of days with water temperatures >18ºC at the two locations was equal to the long-term average in 2020, and was the lowest total since 2016. The combined number of days with water temperatures >20ºC at the two locations was slightly above the long-term average in 2020, and was similar to 2019.

In 2020, the mean annual SST values at Newport Pier and Scripps Pier were well above the long-term averages (17.4ºC versus 16.6ºC for Newport Pier) and (18.8ºC versus 17.7ºC for Scripps Pier) (Table 6). The mean SST values at Newport Pier have exceeded the long-term average every year from 2013 through 2020 (although the 2020 value was the lowest annual average since 2013), and the mean SST values at Scripps Pier have exceeded the average every year since 2014 (with the exception of 2016, when the mean SST was equal to the average).

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 2020 NQ Index values shown on Figure 15 corresponded to the period from July 1, 2020 to June 30, 2021). 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 17.00ºC, 2 points if between 15.01 and 16.00ºC, 4 points if between 14.01 and 15.00ºC, 8 points if between 13.01 and 14.00ºC, and 14 points if between 12.01 and 13.00ºC. The NQ for the 12-month period was the sum of the monthly point scores.

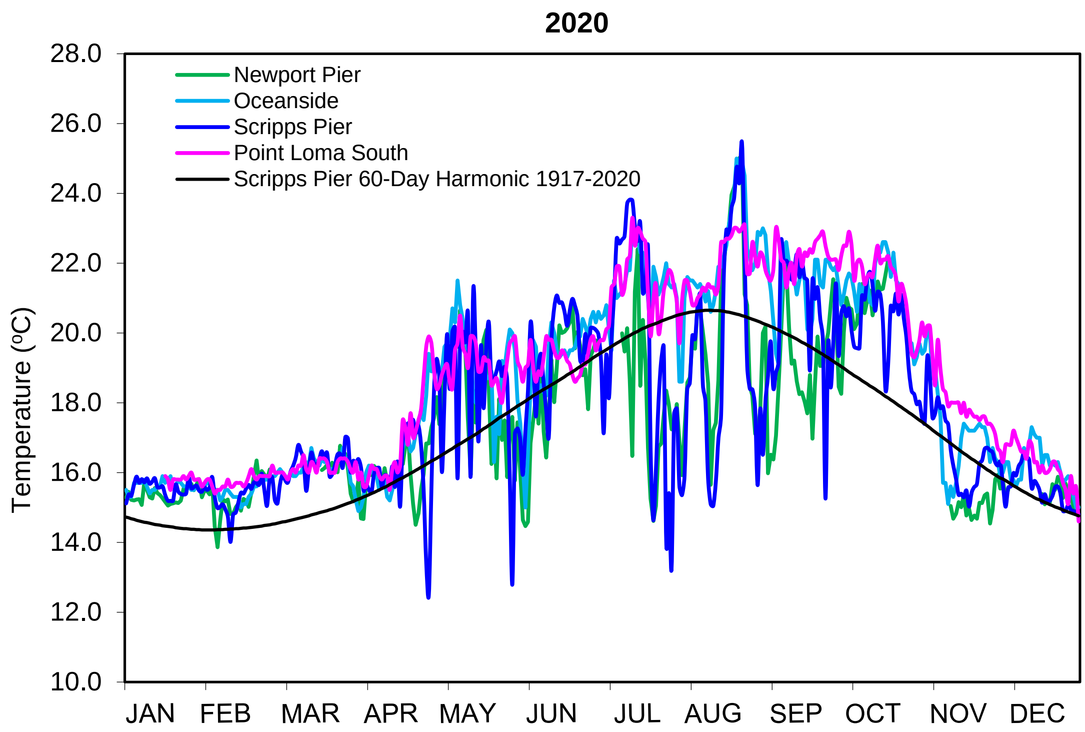


Figure 11. Daily sea surface temperatures (SSTs) at Newport Pier, Oceanside, Scripps Pier, and Point Loma South for 2020, and the long-term harmonic mean for Scripps Pier SIO 60-Day Harmonic calculated from 1917 through 2020). Source: Southern California Coastal Ocean Observation System (SCCOOS) (www.sccoos.org) and National Data Buoy Center (NDBC) (www.ndbc.noaa.gov).

The NQ calculations for four locations in Region Nine in 2020/2021 are shown in Table 7. The 2020/2021 NQ Index was calculated to be 16 for Newport Pier, 14 for Oceanside, 14 for Scripps Pier, and 12 for Point Loma (Table 7). The NQ Indices for all four locations were higher than in 2019, and were the highest values recorded since 2017 for Oceanside and since 2012 for the other three locations (Figure 15). However, these high Nutrient Quotient values for 2020/2021 are primarily due to the low surface temperature values recorded in January, February, March, and April of 2021. Consequently, the higher nutrient availability indicated by these high index values would be expected to affect kelp beds during calendar year 2021 rather than during 2020.

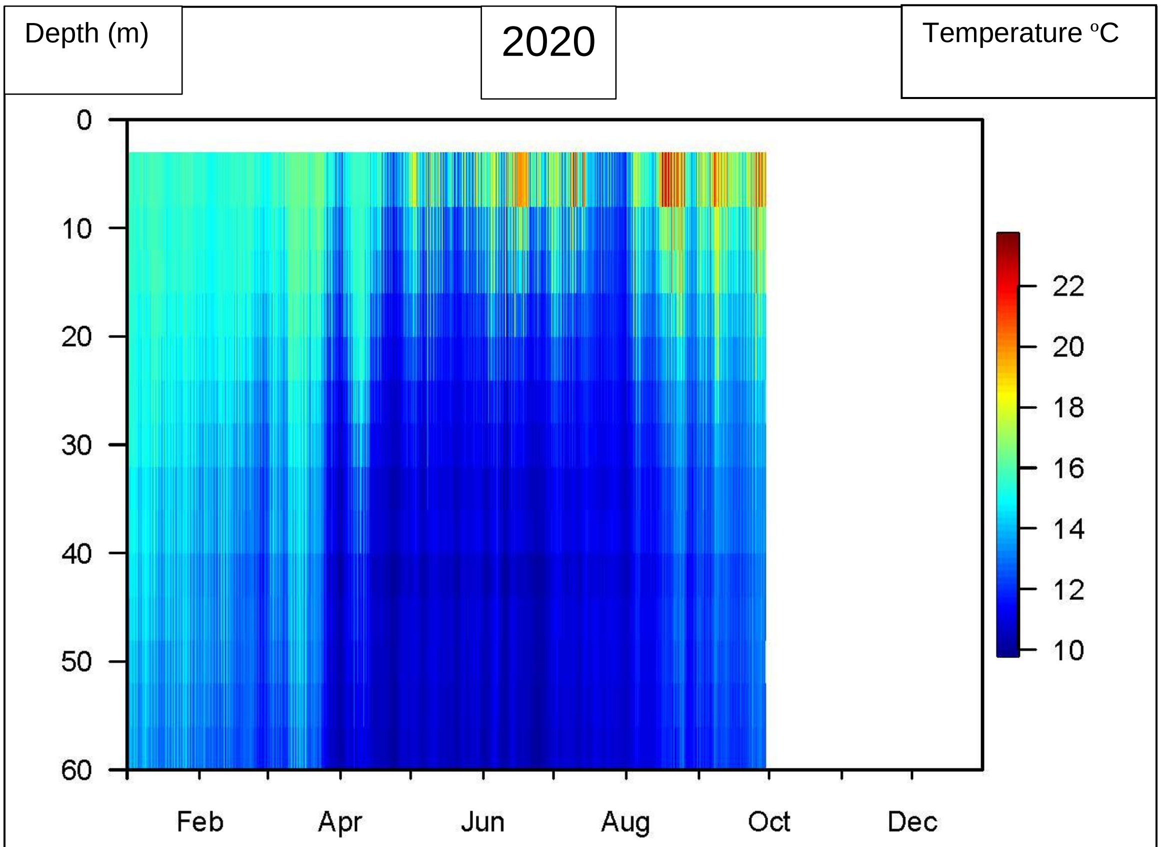


Figure 12. Temperatures (°C) throughout the water column (near surface to a depth of 60 m) off Point Loma during 2020. Source: City of San Diego, 2021.

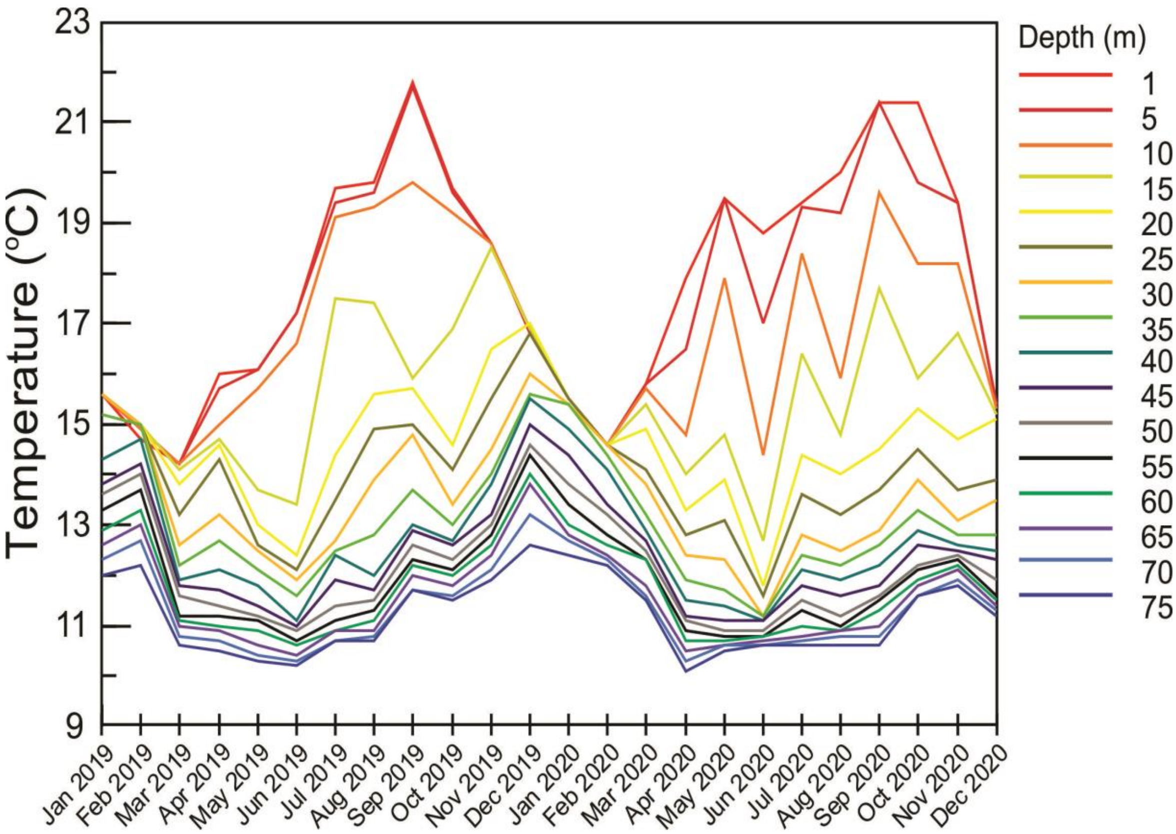


Figure 13. Temperatures (°C) throughout the water column (near surface to a depth of 75 m) off Orange County at Station 2106 during 2019 and 2020. Source: Orange County Sanitation District, 2021.

The low nutrient quotient values recorded for July through December 2020 period coupled with continuing higher than normal surface water temperatures throughout most of 2019 and 2020 would be expected to create conditions unfavorable for kelp canopy growth.

Historically, 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 (δt) 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 2020 versus annual mean temperature from 2011 through 2020 at Newport Pier and Scripps Pier.

		Annual Mean SST (°C)									
	Mean SST (°C) (1994–2020)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Newport Pier	16.6	15.9	16.6	16.7	18.0	18.4	17.8	17.8	17.9	17.6	17.4
Scripps Pier	17.7	15.7	16.6	17.0	18.8	18.9	17.7	17.9	18.6	17.8	18.8

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.

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 flows, toward the surface, from depths of 50 to 100 meters or more. Upwelled water is cooler and saltier than the original surface water, and typically has much greater concentrations of nutrients, such as nitrates, phosphates and silicates, that are key to sustaining biological production.

Upwelling in 2020 (at a location approximately 161 km west of Solana Beach) was low and decreased slightly from January through March, increased through June, then decreased through December (with the exception of a slight increase in upwelling between October and November). During 2020, upwelling was weak at the beginning of the year (January through March) and at the end of the year (October through December). Upwelling was lower than the long-term average during March. Upwelling was strongest from April through August. From April through June, upwelling was similar to the long-term monthly averages (Figure 16, Figure 17). In 2020, upwelling was highest during the month of July, and exceeded the long-term monthly average. In August, upwelling was below average. From September through December, upwelling was similar to the long-term monthly averages.

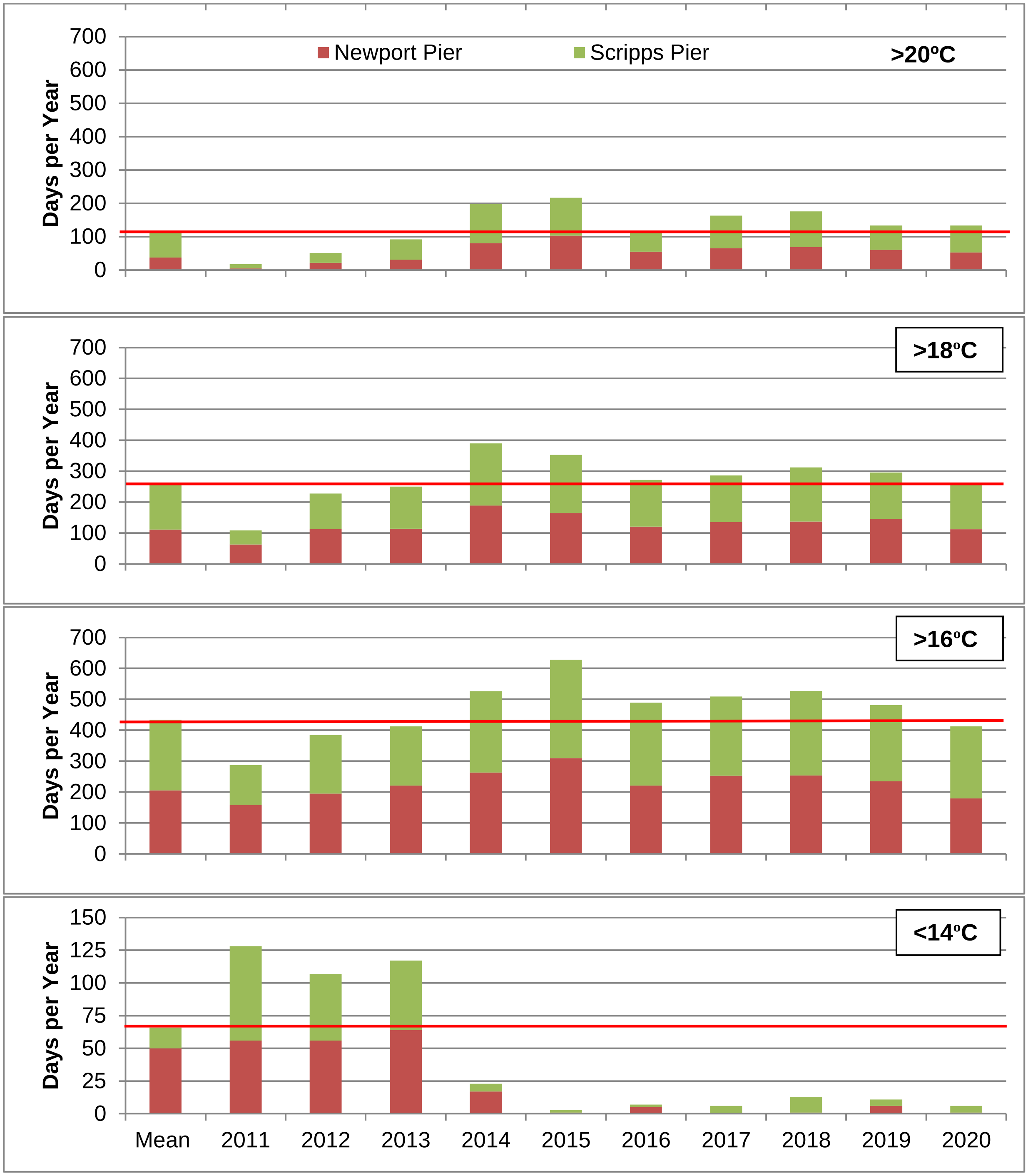


Figure 14. Number of days with SSTs >20ºC, >18ºC, >16ºC, and <14ºC at Newport Pier and Scripps Pier from 2011 to 2020, and the mean from 1994 to 2019 (red line).

Table 7. Nutrient Quotient calculations for period from July 2020 to June 2021.

Sites	Monthly Average Temperature Ranges (°C) (Weighting Factor Per Month)					Total Nutrient Quotient (Calculation Formula)
	12.01 to 13.00 (14 pts)	13.01 to 14.00 (8 pts)	14.01 to 15.00 (4 pts)	15.01 to 16.00 (2 pts)	16.01 to 17.00 (1 pt)	
Newport Pier			Jan 2021 Feb 2021 Mar 2021	Nov 2020 Dec 2020	Apr 2021	**16** (4 pts x 3) + (2 pts x 2) + (1 pt x 1)
Oceanside			Jan 2021 Feb 2021 Mar 2021		Dec 2020 Apr 2021	**14** (4 pts x 3) + (2 pts x 0) + (1 pt x 2)
Scripps Pier			Jan 2021 Feb 2021 Mar 2021		Dec 2020 Apr 2021	**14** (4 pts x 3) + (2 pts x 0) + (1 pt x 2)
Point Loma			Feb 2021 Mar 2021	Jan 2021	Dec 2020 Apr 2021	**12** (4 pts x 2) + (2 pts x 1) + (1 pt x 2)

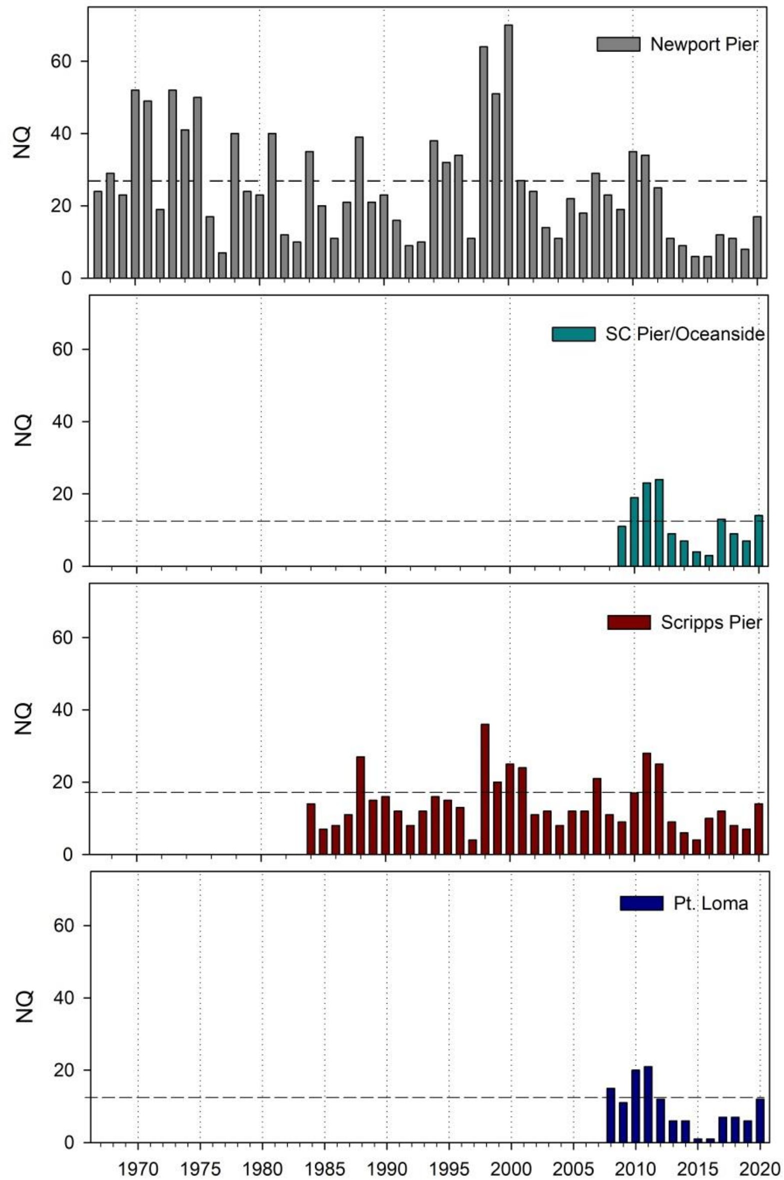
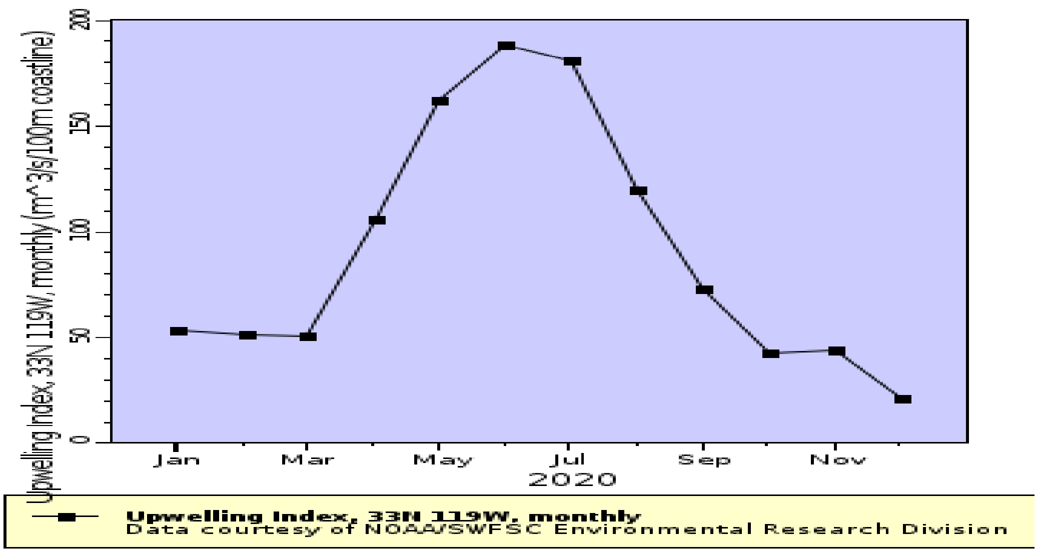


Figure 15. Nutrient Quotient (NQ) values in Region Nine, 1967 to 2020 (dotted line = long-term mean for site).

A



B

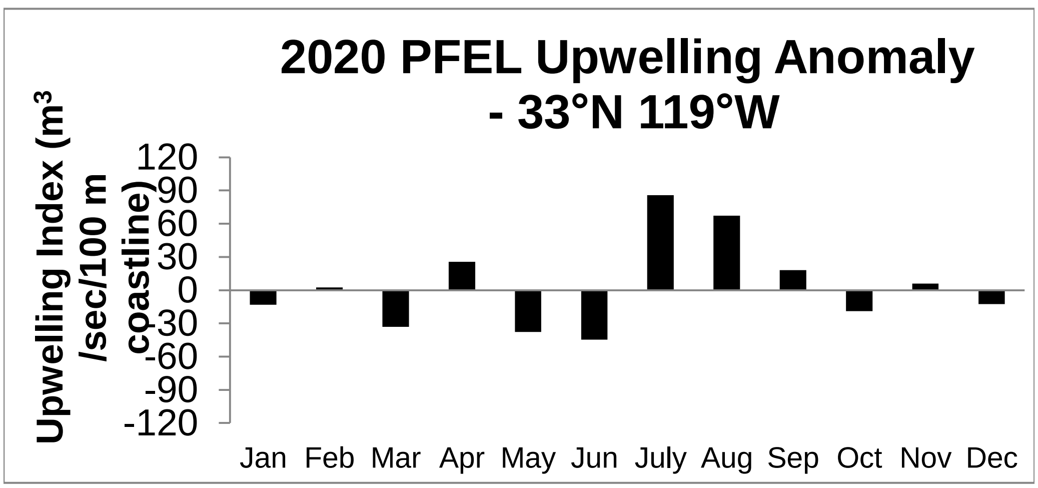


Figure 16. (A) Daily Upwelling Index (UI) at 33°N 119°W for 2020. (B) UI anomaly at 33°N 119°W in 2020 (compared to 71-year monthly mean from 1946 through 2019) (positive values indicate upwelling greater than long-term mean; negative values indicate upwelling less than long-term mean). Source: http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/upwelling/NA).

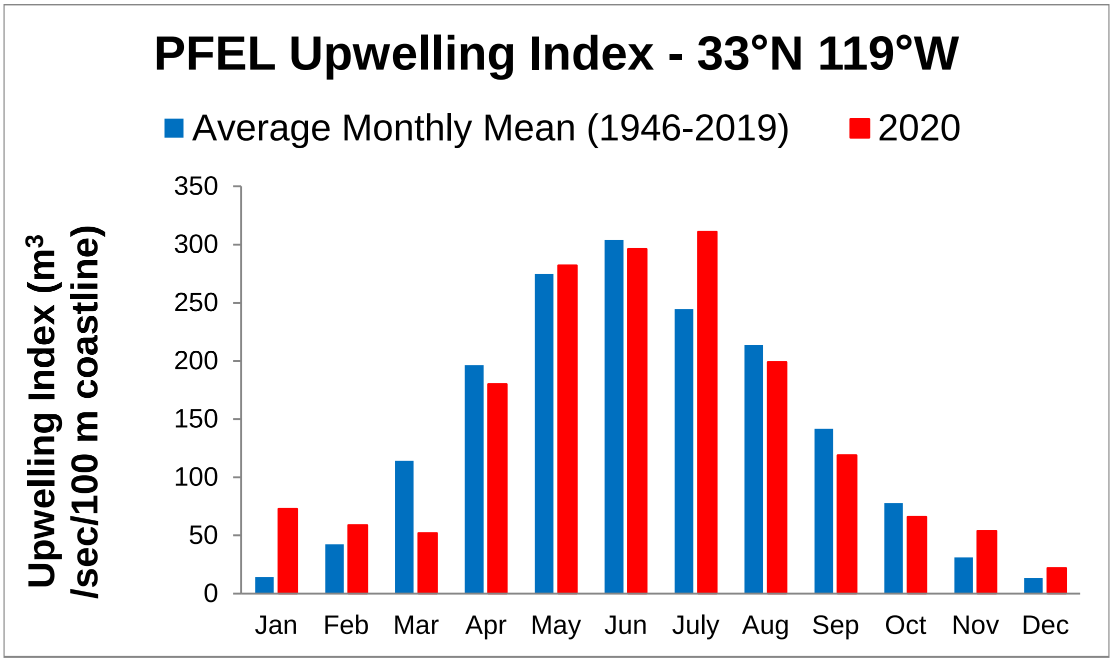


Figure 17. Monthly PFEL upwelling index at 33ºN 119ºW for 2020 (compared to 74-year monthly mean from 1946 through 2019).

Source: http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/upwelling/NA).

IV.2.D - ENVIRONMENTAL INDICES

The El Nino/Southern Oscillation (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, sea surface temperature, surface air temperature, and total cloudiness fraction of the sky) (https://www.esri.noaa.gov/psd/enso/mei/). Negative values of the MEI 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 climate pattern that is based on sea surface height variability in the Northeast Pacific Ocean. The NPGO is significantly correlated with fluctuations of salinity, nutrients, and chlorophyll-a measured in long-term observations in the California Current and Gulf of Alaska. Fluctuations in the NPGO are driven by regional and basin-scale variations in wind-driven upwelling and horizontal advection, which are the fundamental processes controlling salinity and nutrient concentrations. Nutrient fluctuations drive concomitant changes in phytoplankton concentrations and may result in similar variability in higher trophic levels (http://www.o3d.org/npgo/).

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

The MEI was negative in early 2018 but shifted to positive in May and remained positive throughout 2019. The MEI became negative in early 2020 and remained negative for the rest of the year (Figure 18, Mantua, 2017, NOAA-ESRL 2020). The PDO was predominately negative from July 2017 through March 2019 before shifting to mostly positive from April to September 2019 (Figure 18, Mantua 2017, NOAA-ESRL 2020). The PDO has been negative since October 2019. The NPGO values were strongly negative throughout the entire period from 2017 through 2020 (Figure 18; Di Lorenzo 2017, NOAA-ESRL 2020).

The positive MEI values in 2019 were indicative of warm water conditions. However, the transition to negative values in 2020 could indicate a return to cold water conditions. The PDO transition to positive in mid-2019 indicated warmer temperatures in the North Pacific, but the shift to negative values in 2020 also may indicate cooler temperatures in that area. However, the continuing strongly negative NPGO values would be indicative of lower productivity along the Pacific coast (Di Lorenzo et al. 2008; Leising et al. 2015).

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 in 2020 were similar to 2019 (Table 8). Waves approached from the south-southwest (202.5º) approximately 46% of the time (versus 43% in 2019), from the south (180º) approximately 19% of the time (versus 17% in 2019), and from the west (270º) approximately 16% of the time (versus 14% in 2019) (Table 8). Offshore of Point Loma, waves were from the south-southwest (202.5º) about 26% of the time (compared to 29% in 2019), from the west about 25% of the time (compared to 26% in 2019), and from the south (180º) approximately 24% of the time (compared to 17% in 2019).

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 two dates in 2020 (4.2 meters on November 7 and 5.4 meters on November 9) (Table 9). This was similar to 2019, when the wave height exceeded four meters on only one date. Waves originated primarily from the south and south-southwest (Table 8), 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 at Oceanside (on only eight dates).

Waves originated from the west at Point Loma South (CDIP Buoy 191) one-fourth of the time in 2020, as was the case in 2019. However, the largest waves recorded were 4.0 meters on January 29 and March 2. No waves larger than 5 meters were recorded at Point Loma South in 2020, unlike 2019 when waves as large as 5.5 meters were measured and 2018 when waves as large as 7.5 meters were recorded. Waves of three meters or more were recorded on 49 dates throughout 2020 at Point Loma South.

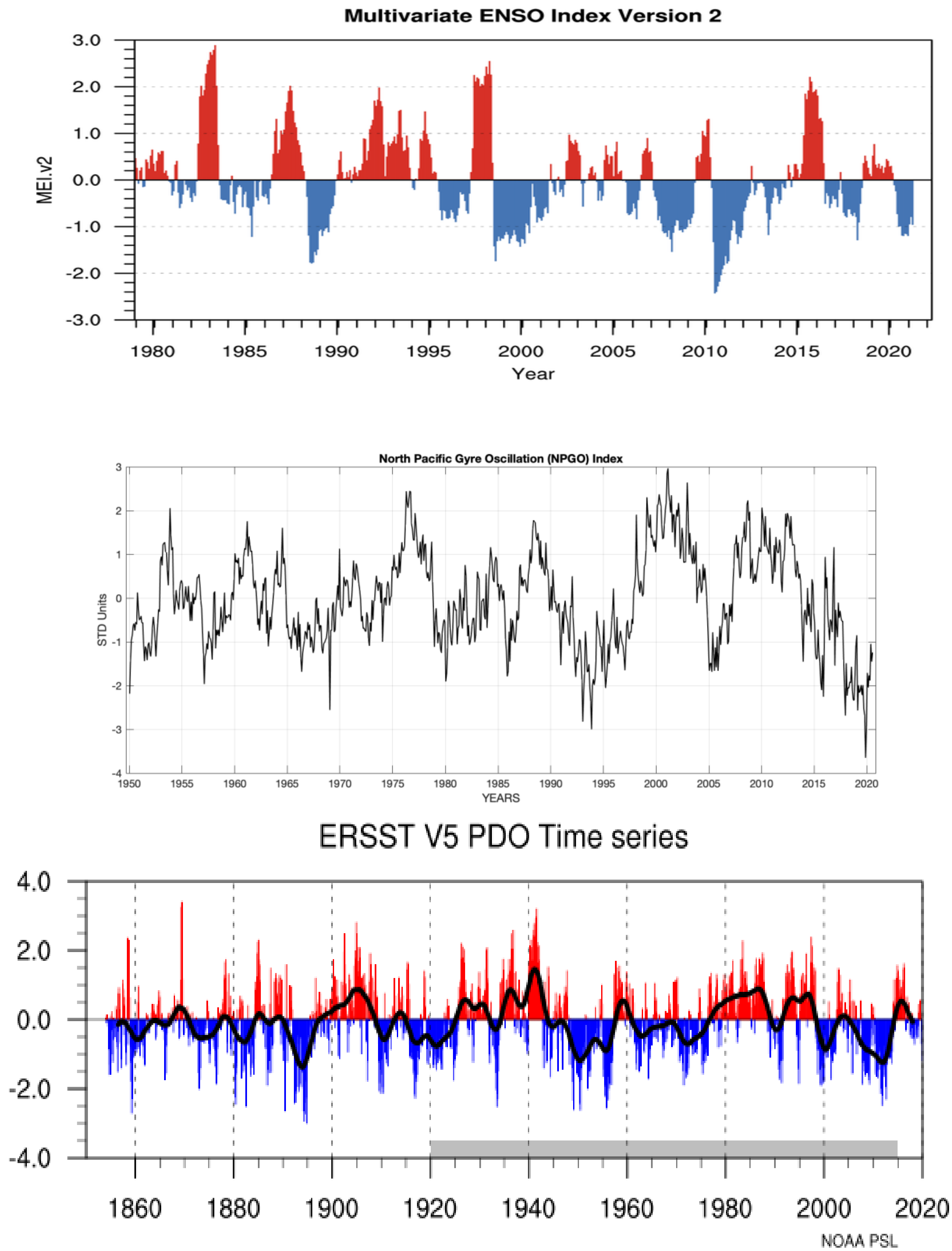


Figure 18. The Multivariate Enso Index (MEI), the North Pacific Gyre Oscillation Index (NPGO), and the Pacific Decadal Oscillation Index (PDO). [Note that the time scales displayed on the x-axis are different for each index]

Table 8. Direction of swells in 2020. Source: http://cdip.ucsd.edu.

Direction	Oceanside	Pont Loma South
West-northwest (292.5°)	2%	9%
West (270°)	16%	25%
West-southwest (247.5°)	7%	7%
Southwest (225°)	10%	9%
South-southwest (202.5°)	46%	26%
South (180°)	19%	24%

The storm that occurred on January 29 produced large wave heights at Oceanside (3.3 meters) and Point Loma South (4.0 meters) (Table 9). Large nearshore swells up to 4 feet were evident along the coastline throughout Region Nine, with swells up to 6 feet in some areas near San Diego (Figure 19). The storm that occurred on May 16 only produced a maximum wave height of less than 3 meters at Oceanside and 3.5 meters at Point Loma South (Table 9). The May storm produced smaller swells (up to 2 feet throughout most of the region and up to 3 feet in some areas near San Diego (Figure 20). The storm that occurred on November 9 produced the largest wave height of the year at Oceanside (5.4 meters), but the maximum wave height was less than 3 meters at Point Loma South (Table 9). Large nearshore swells up to 4 feet were evident along the coastline throughout Region Nine, with swells up to 6 feet in some areas near San Diego (Figure 21).

Table 9. Large waves (≥3 meters) in 2020.

Date	Oceanside (maximum height in meters)	Point Loma South (maximum height in meters)
1/9/20	3.1	
1/10/20	3.7	
1/22/20		3.1
1/25/20		3.3
1/26/20		3.4
1/27/20		3.2
1/29/20	3.3	4.0
1/30/20		3.6
1/31/20		3.0
2/23/20		3.3
3/1/20		3.2
3/2/20		4.0
3/13/20		3.2
3/18/20		3.1
3/26/20		3.1
3/27/20		3.3
3/28/20		3.2
4/2/20		3.3
4/3/20		3.1
4/8/20		3.1
4/9/20		3.1
4/22/20		3.4
4/28/20		3.2

Table 9 (continued). Large waves (≥3 meters) in 2020.

Date	Oceanside (maximum height in meters)	Point Loma South (maximum height in meters)
5/4/20		3.2
5/7/20		3.2
5/11/20		3.4
5/12/20		3.8
5/13/20		3.2
5/14/20		3.1
5/16/20		3.5
5/19/20		3.3
5/20/20		3.2
5/21/20		3.1
5/31/20		3.3
6/2/20		3.2
6/7/20		3.4
6/9/20		3.3
6/14/20		3.1
7/1/20		3.1
7/4/20		3.5
8/28/20		3.3
9/17/20		3.5
11/7/20	4.2	
11/8/20	3.7	
11/9/20	5.4	
11/20/20		3.1

Table 9 (continued). Large waves (≥3 meters) in 2020.

Date	Oceanside (maximum height in meters)	Point Loma South (maximum height in meters)
11/27/20		3.1
12/9/20		3.5
12/10/20		3.5
12/13/20		3.2
12/18/20		3.4
12/27/20		3.3
12/28/20		3.5
12/29/20	4.0	
12/30/20		3.3
12/31/20	3.6	

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 22.

Rainfall was lower than normal (38% less) for Costa Mesa in 2020 (7.1 inches in 2020 versus the long-term average of 11.4 inches). Rainfall was much lower than normal during the months of January, February, November, and December, with no rainfall or only trace amounts from May through October. However, rainfall was much higher than normal during the months of March and April. Rainfall was also lower than normal (23% less) in San Diego (7.8 inches in 2020 versus the long-term average of 10.1 inches). Rainfall was much lower than normal during the months of January, February, October, November, and December. However, rainfall was higher than normal in March and much higher than normal rainfall in April. These low annual rainfall levels were unlikely to generate any extended periods of high turbidity and would not be expected to have affected kelp beds in 2020.

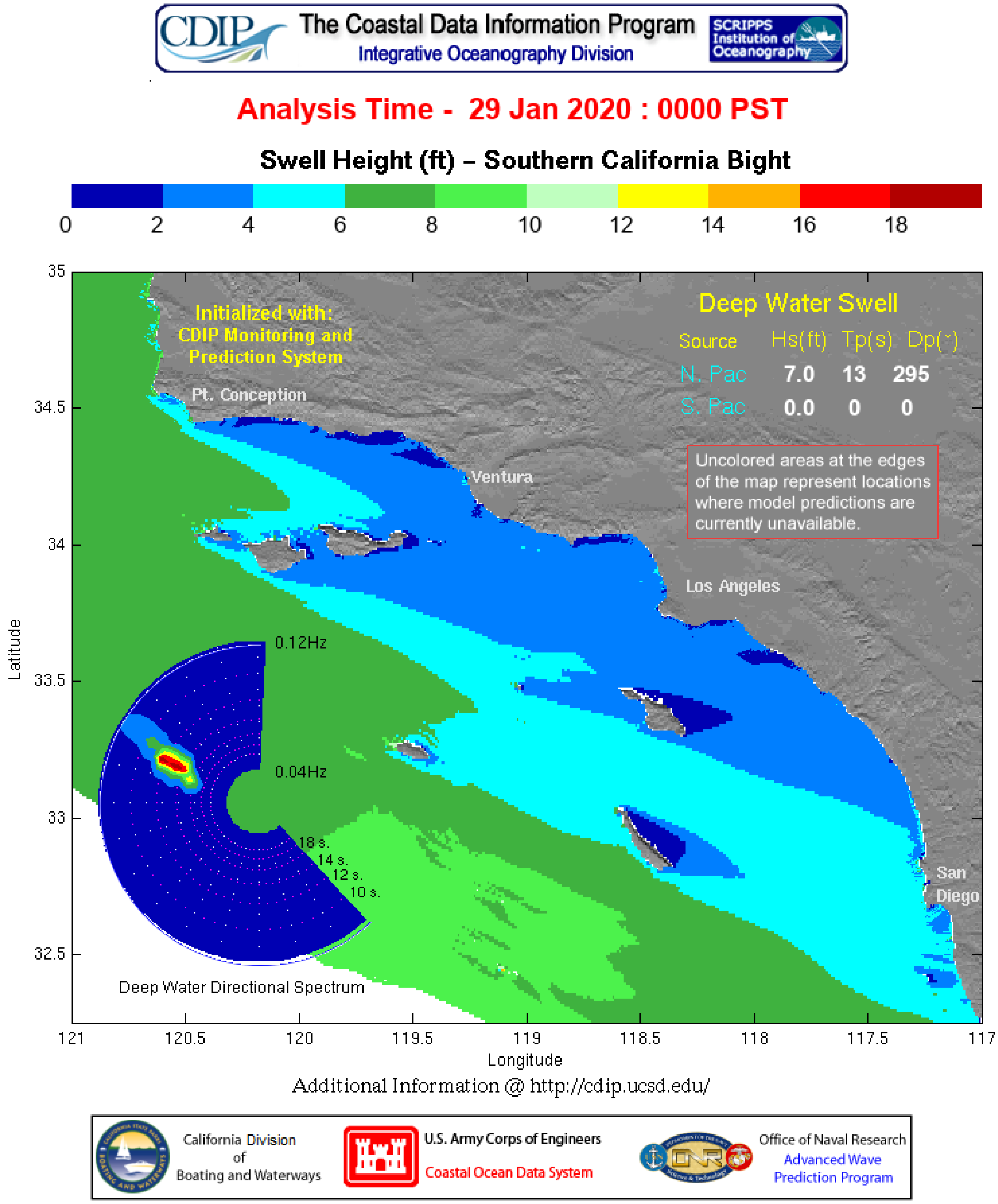


Figure 19. Swell height and direction in the Southern California Bight on January 29, 2020. Source: Coastal Data Information Program (CDIP), http://cdip.ucsd.edu/.

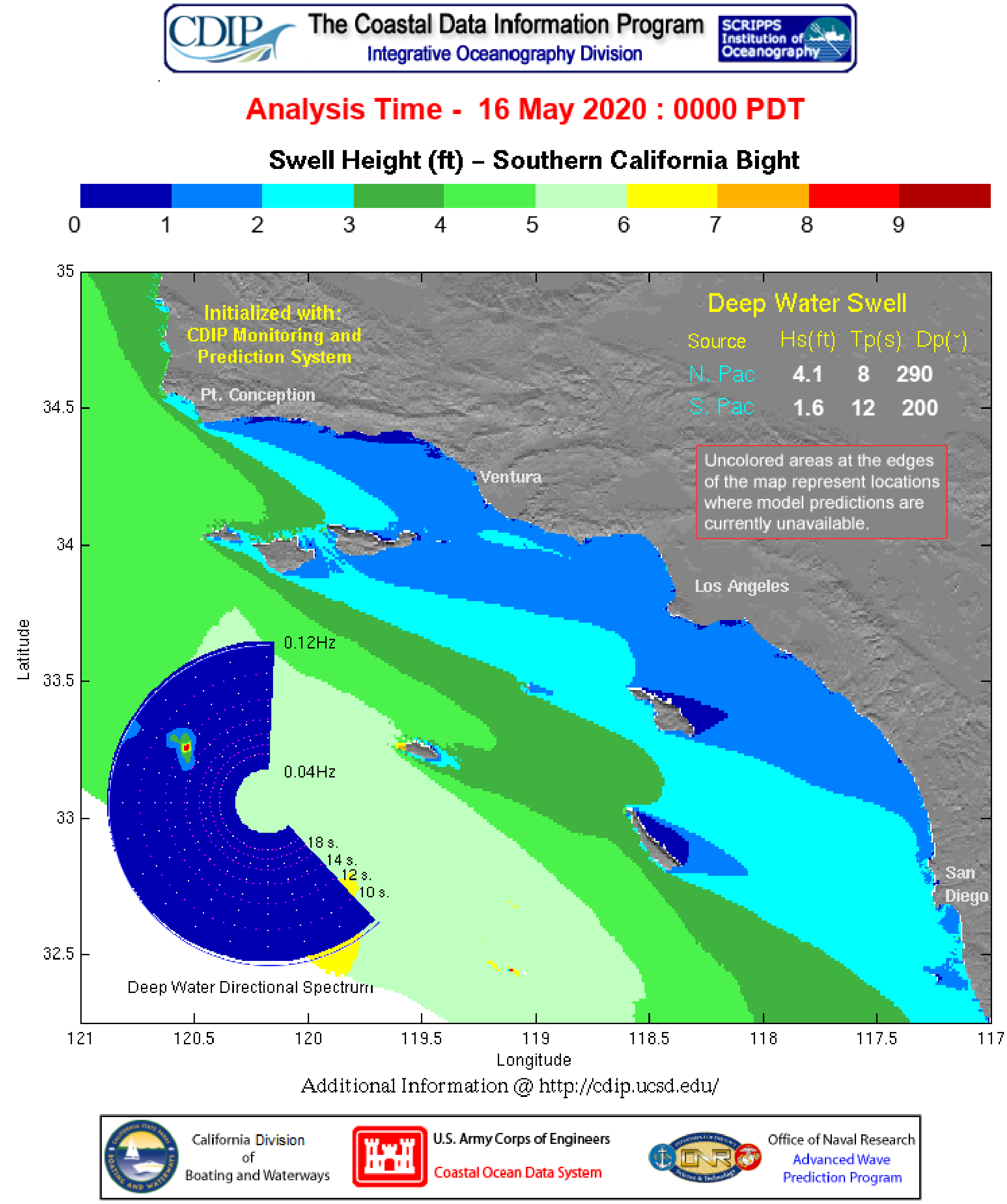


Figure 20. Swell height and direction in the Southern California Bight on May 16, 2020. Source: Coastal Data Information Program (CDIP), http://cdip.ucsd.edu/.

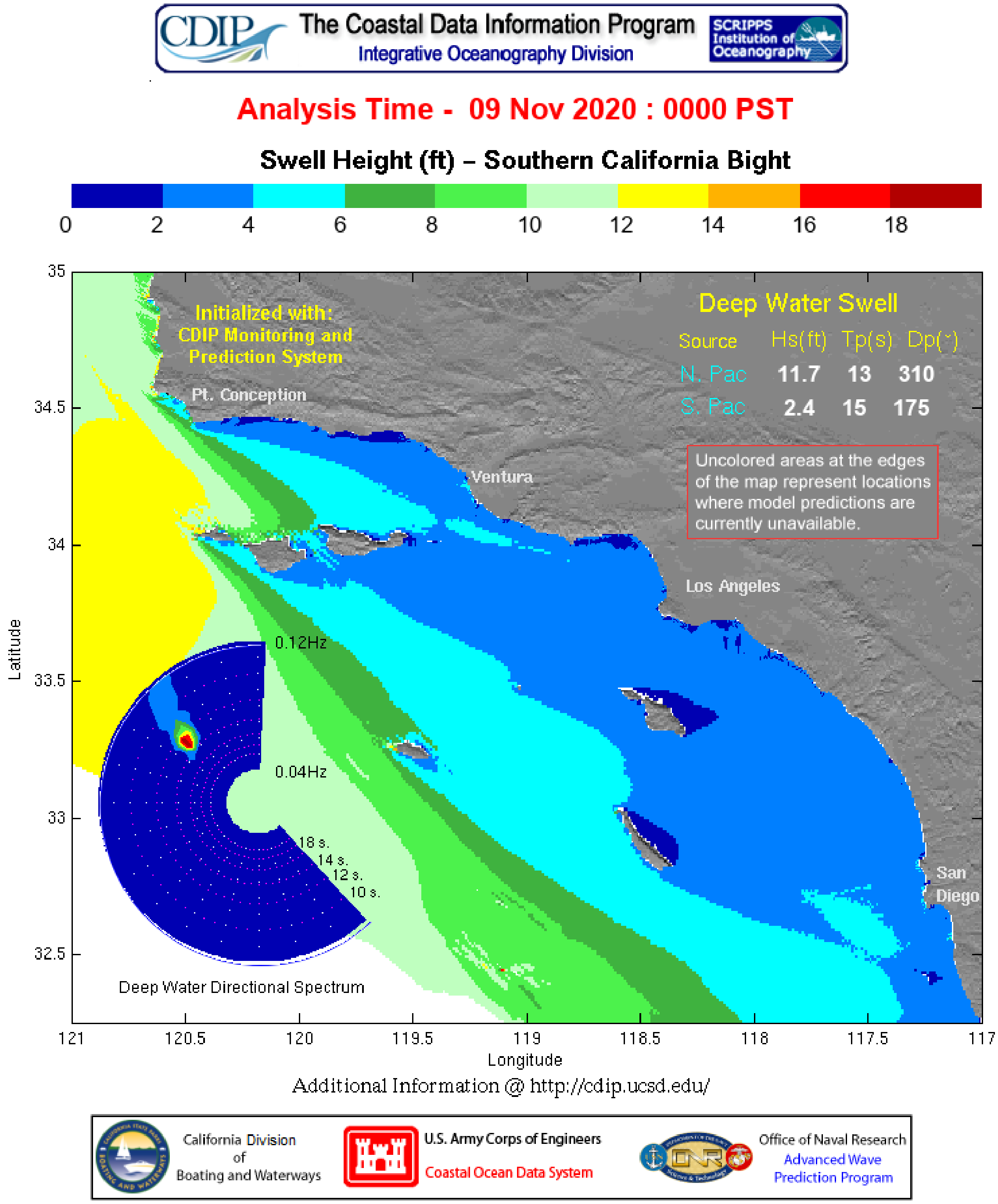


Figure 21. Swell height and direction in the Southern California Bight on November 9, 2020. Source: Coastal Data Information Program (CDIP), http://cdip.ucsd.edu/.

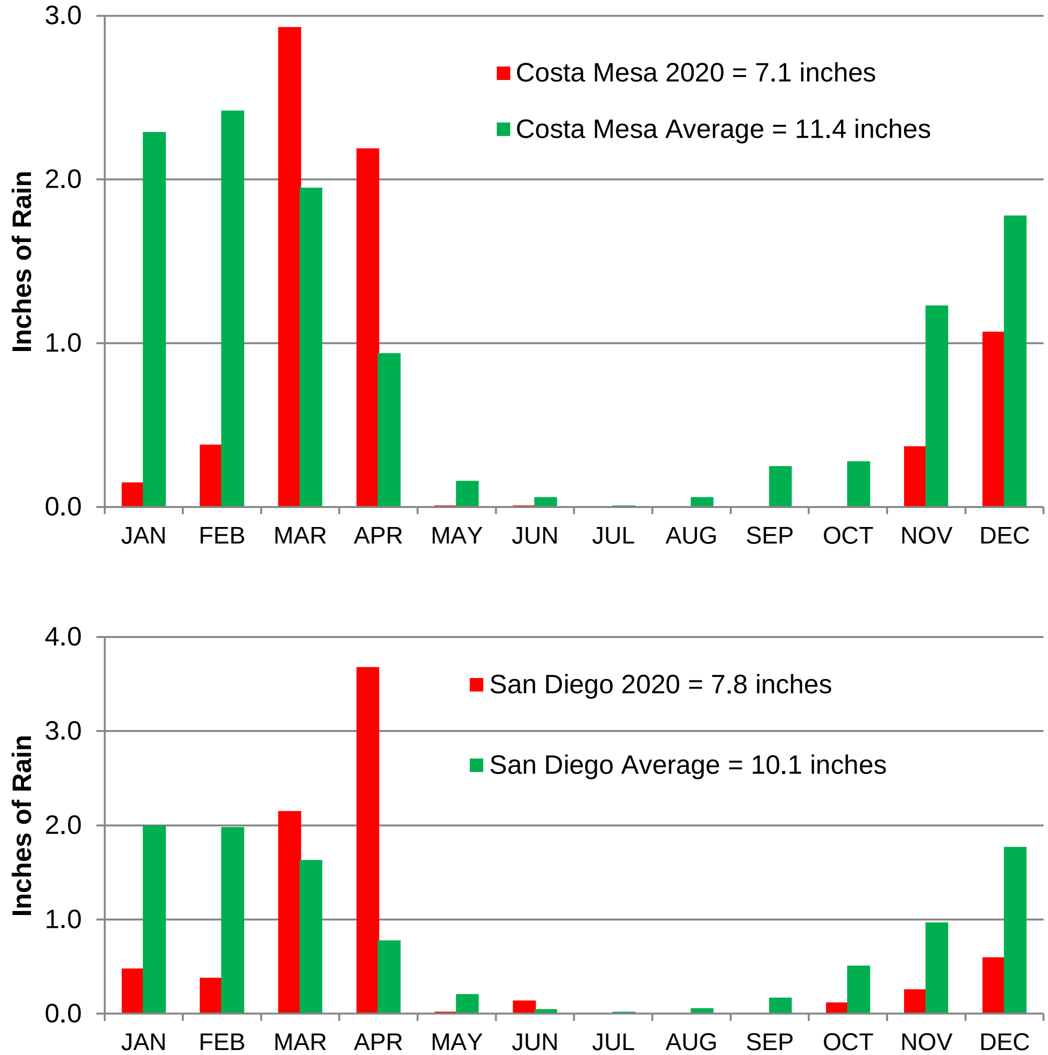


Figure 22. Monthly 2020 rainfall and average monthly rainfall recorded for (A) John Wayne Airport (Costa Mesa), and (B) Lindbergh Field (San Diego).

IV.2.G - PHYTOPLANKTON

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

At Newport Pier, high concentrations of both the *Pseudo-nitzschia seriata* group and *Pseudo-nitzschia delicatissima* group were observed throughout most of the year (Figure 23). Domoic acid, a toxin produced by these phytoplankton, was not recorded at Newport Pier in 2020. At Scripps Pier, high concentrations of the *Pseudo-nitzschia seriata* group and the *Pseudo-nitzschia delicatissima* group were found at times during January, February, and March (Figure 24); data is not available for the remainder of the year. However, domoic acid was not recorded at this location any time in 2020.

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 2020 appear unlikely to have impacted kelp beds.

IV.3 - KELP RESTORATION

Kelp forest restoration aims to reverse the loss of these ecologically and economically important coastal ecosystems. To be successful, restoration projects must first mitigate or remove the cause of decline, which can include ocean warming, overgrazing, habitat destruction, pollution, and overfishing. If there is sufficient propagule supply, removing grazers, adding hard substrate, remediating water quality, or a combination of each, may be enough to restore populations. Additional actions are required when local propagule supply is insufficient or recruitment is limited. Methods to overcome these barriers include introducing reproductive material or donor plants into degraded areas via seeding or transplanting. Notwithstanding these advances, most kelp restoration projects to date have been small scale and short in duration (less than 2 years), and academically motivated. As a result, questions remain about how the field of kelp restoration can meet its goal of restoring populations at scales that match those of degradation or loss (Eger et al., 2020).

General ecosystem restoration principles are well-established and can help guide kelp restoration. These steps involve defining clear goals and criteria to evaluate success, which then allows for (1) designing and (2) implementing the project, followed by (3) evaluating programs to determine if the performance criteria are met. If criteria are not met, these previous steps allow for (4) identifying reasons for failure and (5) using adaptive management to remediate the project to meet its goals (Eger et al., 2020).

Substantial financial resources are needed to support restoration activity. Ecosystem restoration is cost and labor intensive, with median costs of hundreds of thousands of dollars per hectare in marine ecosystems. In addition, failure to engage with local stakeholders is likely to negatively influence the success of restoration projects. Strong institutional support (national, regional, or local) from trusted institutions (such as non-governmental organization, private industry, and community groups) can increase community support for and participation in restoration projects. In addition, government institutions often have considerable resources to fund projects, as well as the legal authority to mandate restoration work and incentivize restoration projects (Eger et al., 2020).

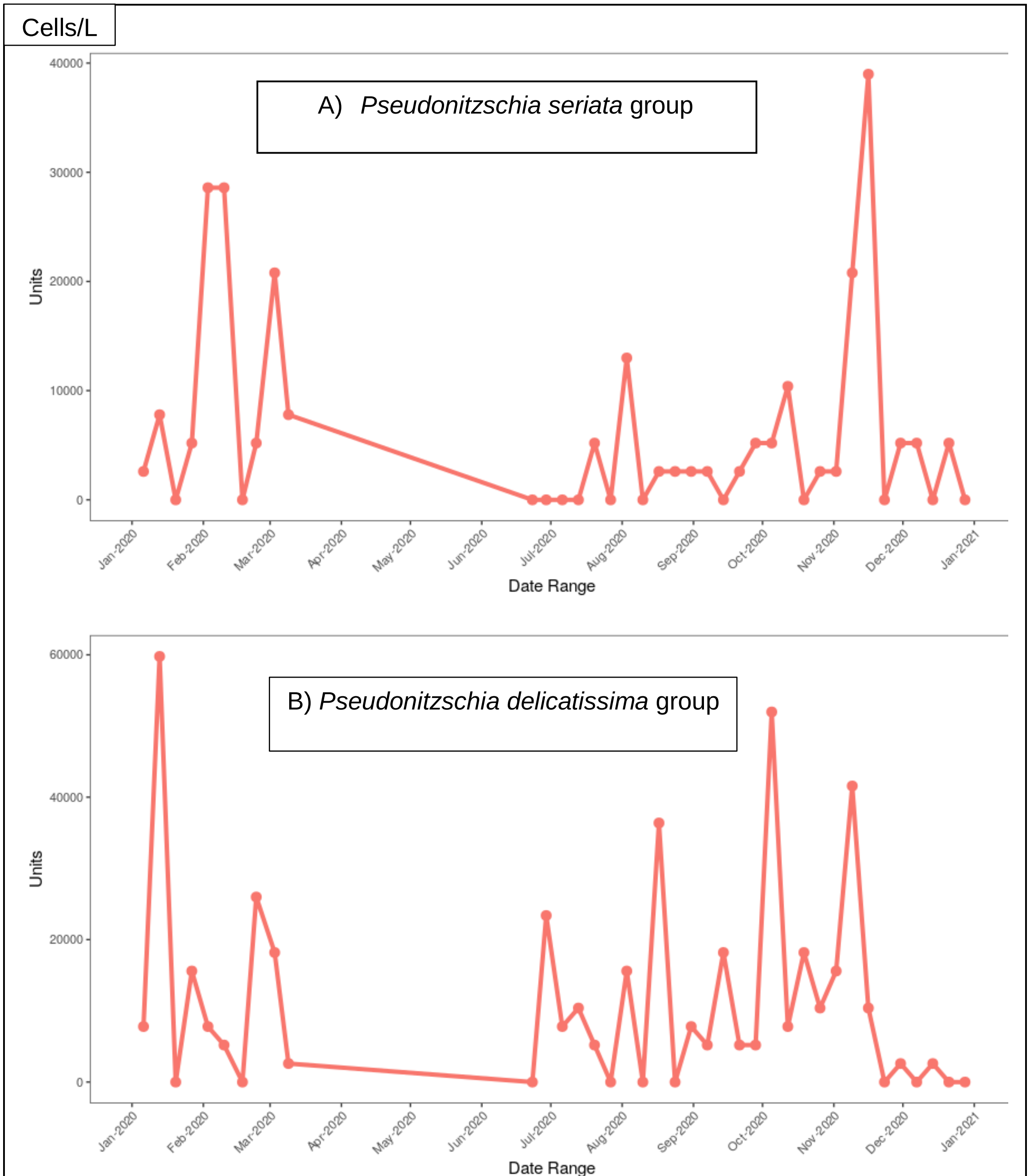


Figure 23. Phytoplankton Concentrations at Newport Pier in 2020.

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

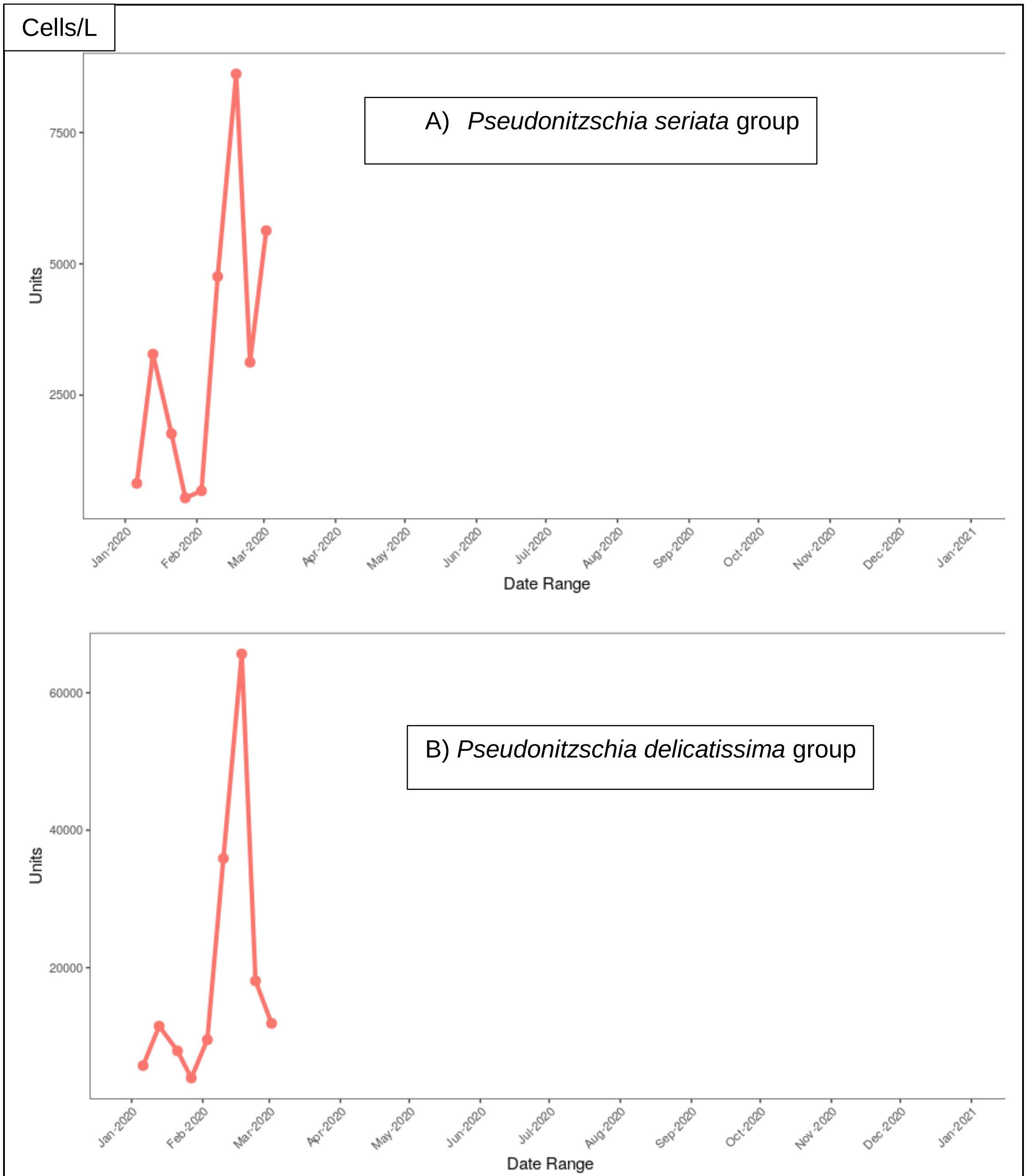


Figure 24. Phytoplankton Concentrations at Scripps Pier in 2020.

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

IV.3.1 Orange County

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. Following these projects, there was more kelp in the area than had been observed for the previous 30 years. However, the warm water conditions since 2013 have contributed to decreases in the sizes of kelp beds in these areas. One factor that may be impeding recovery of the kelp beds is the abundance of an invasive species known as devil weed (*Sargassum horneri*). This species forms dense beds and may crowd out giant kelp. Nancy Caruso is currently seeking permission from CDFW to remove devil weed from a number of experimental sites to determine whether this action would promote recovery of giant kelp. However, since these areas fall within a marine protected area, legislative action would be required to allow this work to proceed.

IV.3.2 San Diego County

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. The project started in July 2019, but was paused in October 2019 at the beginning of the lobster season. Construction resumed in early June 2020 and was completed in July 2020, ahead of schedule.

IV.4 - KELP HARVESTING

The California Department of Fish and Wildlife (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 four management categories: open, leasable, lease only, or closed (Table 10). 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 (see Figure 2 for designated kelp areas).

Table 10. Administrative management categories for California kelp beds.

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 CDFW 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* spp.). Recreational harvest regulations are also under review (Rebecca Flores-Miller, personal communication). CDFW may propose a take limit on giant kelp, may prohibit the take of bull kelp, impose maximum harvest limits for recreational harvesting, clarify regulations for harvesting specific species, and limit harvesting to hand methods. However, there is no timetable to bring any proposed regulations to the CDFW Commission for adoption.

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).

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**). Kelp harvesting peaked in the 1970s, exceeding 150,000 metric tons per year in some years.

However, kelp harvesting has been relatively low (less than 5,000 to 10,000 metric tons per year) since 2006. It is unlikely that this low amount of kelp harvesting would have any impact on the health of the kelp beds in the Region Nine.

Table 11 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.

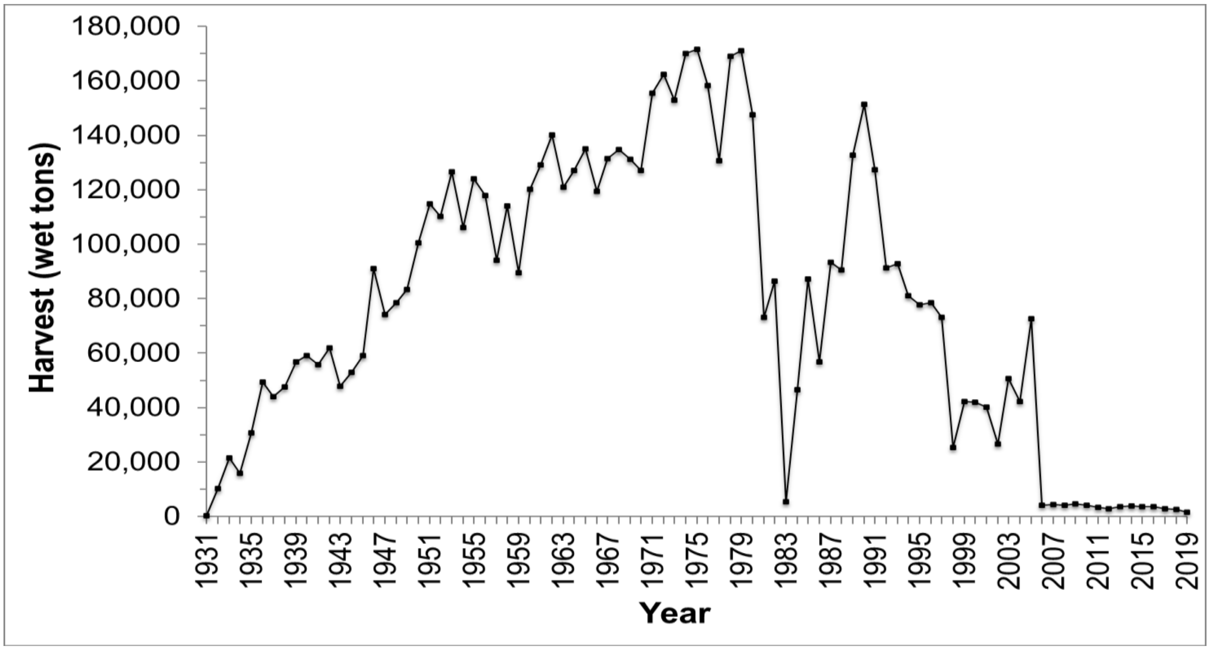


Figure 25. Commercial kelp harvest landings for giant and bull kelp from 1931 through 2020. Source: California Department of Fish and Wildlife (https://www.wildlife.ca.gov/Conservation/Marine/Kelp/Commercial-Harvest).

Table 11. 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 - CONCLUSIONS

The total kelp canopy in Region Nine covered approximately 3.9 square kilometers in 2020. This represented a 25% decrease compared to 2019. This is the fourth time in the past five years (2016, 2017, 2019, and 2020) that the total kelp canopy was less than the long-term average, following nine years (2007 through 2015) with above average total kelp canopies (Figure 8). Three kelp beds observed in 2019 disappeared in 2020; however, four kelp beds reappeared. The largest kelp beds were the La Jolla and Point Loma kelp beds, which accounted for 93% of the total canopy coverage in 2020. Surface canopy area was less than one-third of historical maximum levels at every kelp bed in the region, and only four kelp beds exceeded 10% of their historical highs.

In 2020 water temperatures throughout the RNKSC region were generally warmer than average during the months of January through March, October, and December (Figure 9). However, lower than normal temperatures were recorded at all locations in the region at times from April through September, as well as in November. 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. Daily SST values rarely fell below 14ºC at Scripps Pier, a threshold below which nutrient availability is increased, and never fell below this level at Newport Pier, Oceanside, or Point Loma South.

The Nutrient Quotient Indices throughout the region were higher than in 2019, and were the highest values recorded since 2017 for Oceanside and since 2012 for Newport Pier, Scripps Pier, and Point Loma South. However, these high Nutrient Quotient values for 2020/2021 are primarily due to the low surface temperature values recorded in January, February, March, and April of 2021. Consequently, the higher nutrient availability indicated by these high index values would be expected to affect kelp beds during calendar year 2021 rather than during 2020. NQ values for the period from July through December 2020 were very low, as has been the case for the past several years.

Upwelling in 2020 (at a location approximately 161-km west of Solana Beach) decreased slightly from January through March, increased through June, then decreased through December (with the exception of a slight increase in upwelling between October and November). Upwelling was weak at the beginning of the year (January through March) and at the end of the year (October through December), when surface water temperatures generally were lower and nutrient availability would be increased. Although upwelling was strongest from April through August, this corresponded to the period of the year when surface water temperatures tend to be higher and nutrient availability would be decreased.

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PERSONAL COMMUNICATIONS

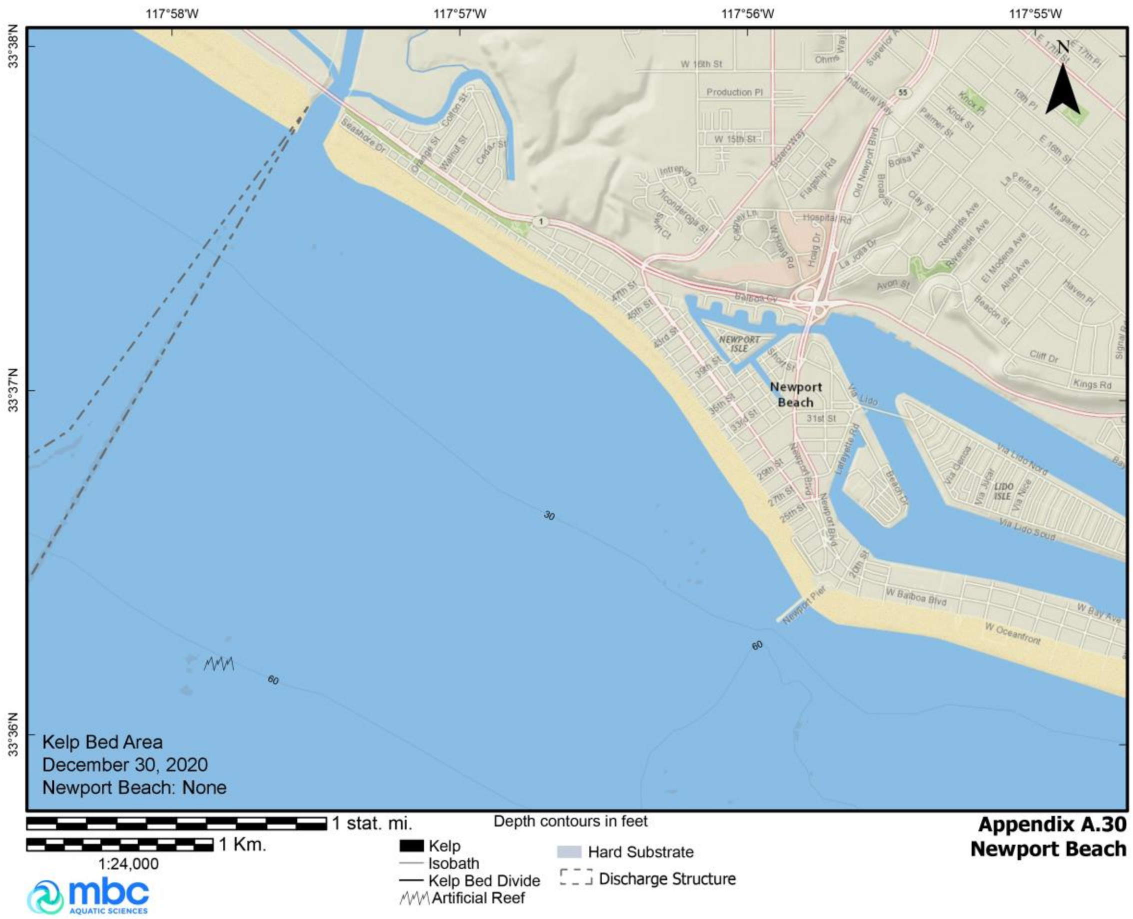
Flores-Miller, R. 2020. Rebecca Flores-Miller, California Department of Fish and Wildlife, Environmental Scientist. Commercial Kelp and Other Marine Algae Outreach Meeting, June 2, 2020.

APPENDIX A

KELP CANOPY MAPS

(A.30 TO A.71)

MAP A.30



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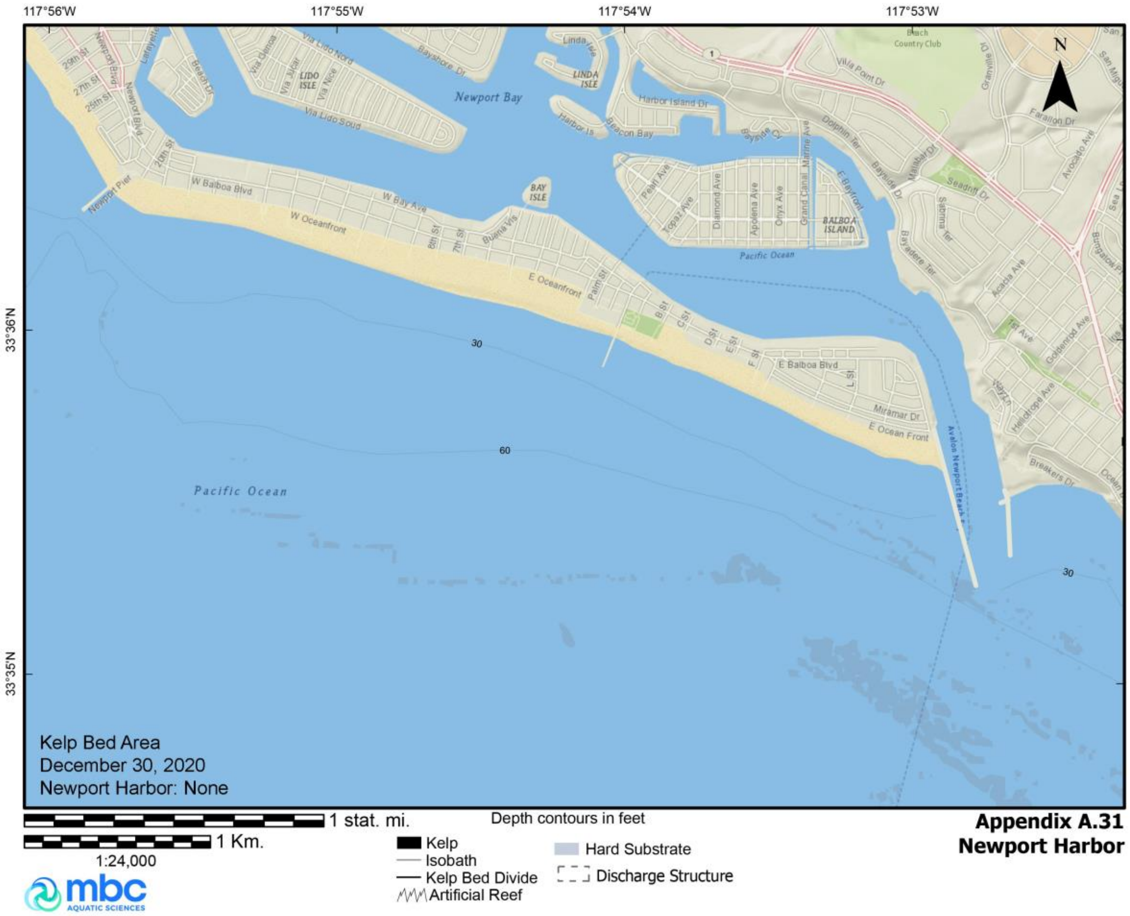
MAP A.31



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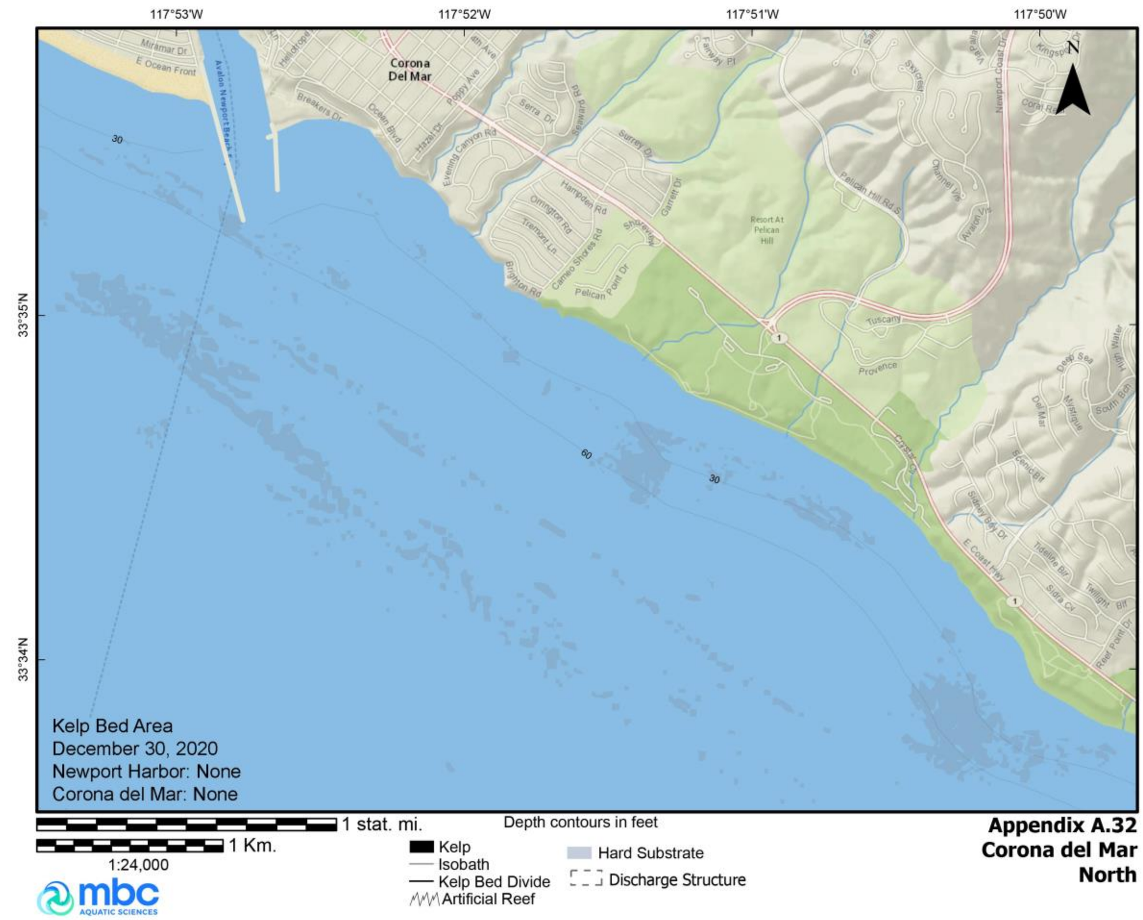
MAP A.32



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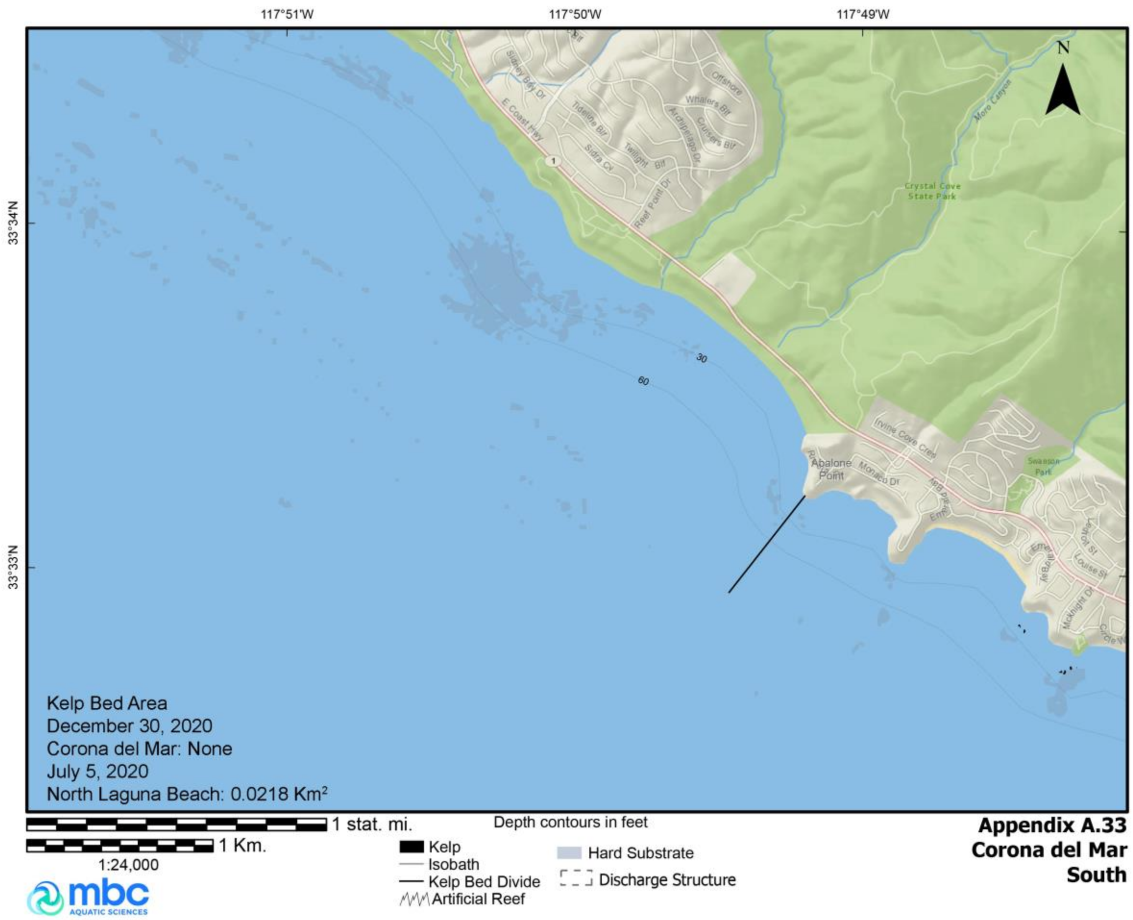
MAP A.33



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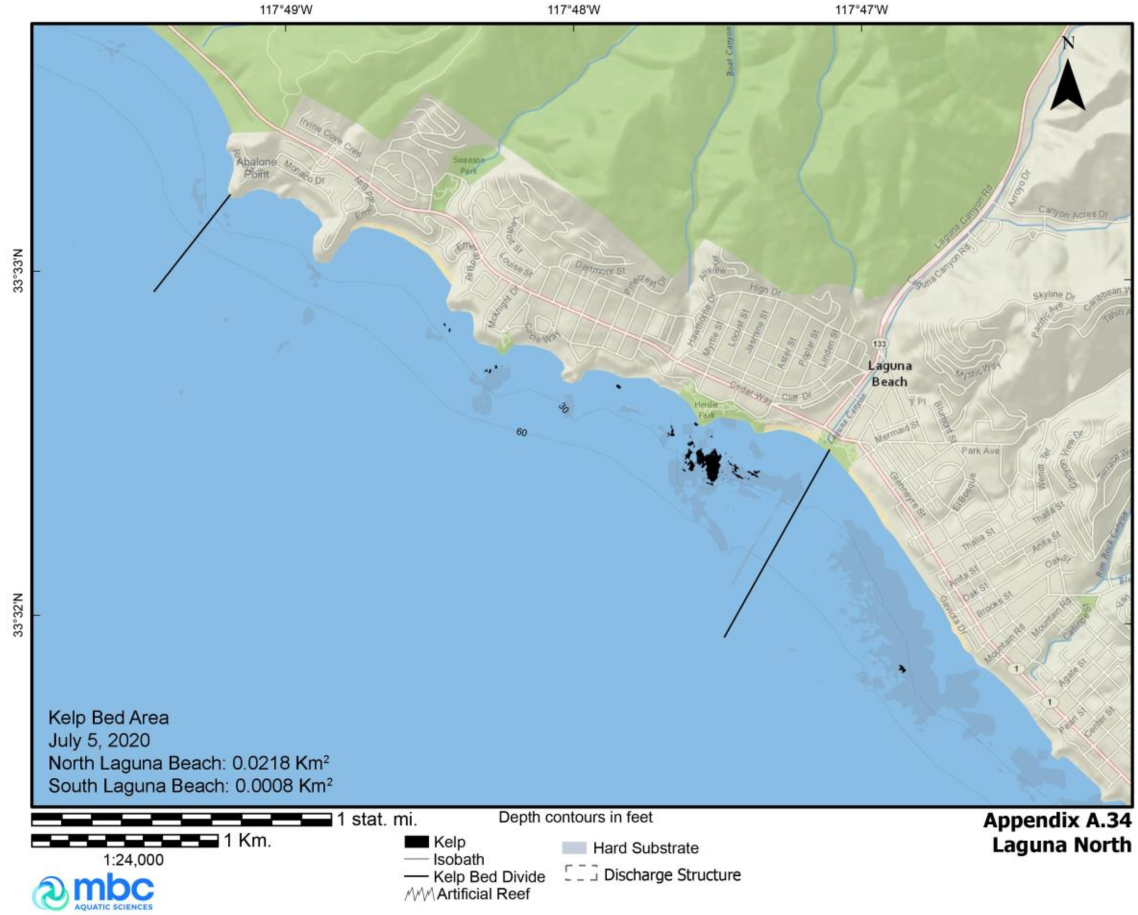
MAP A.34



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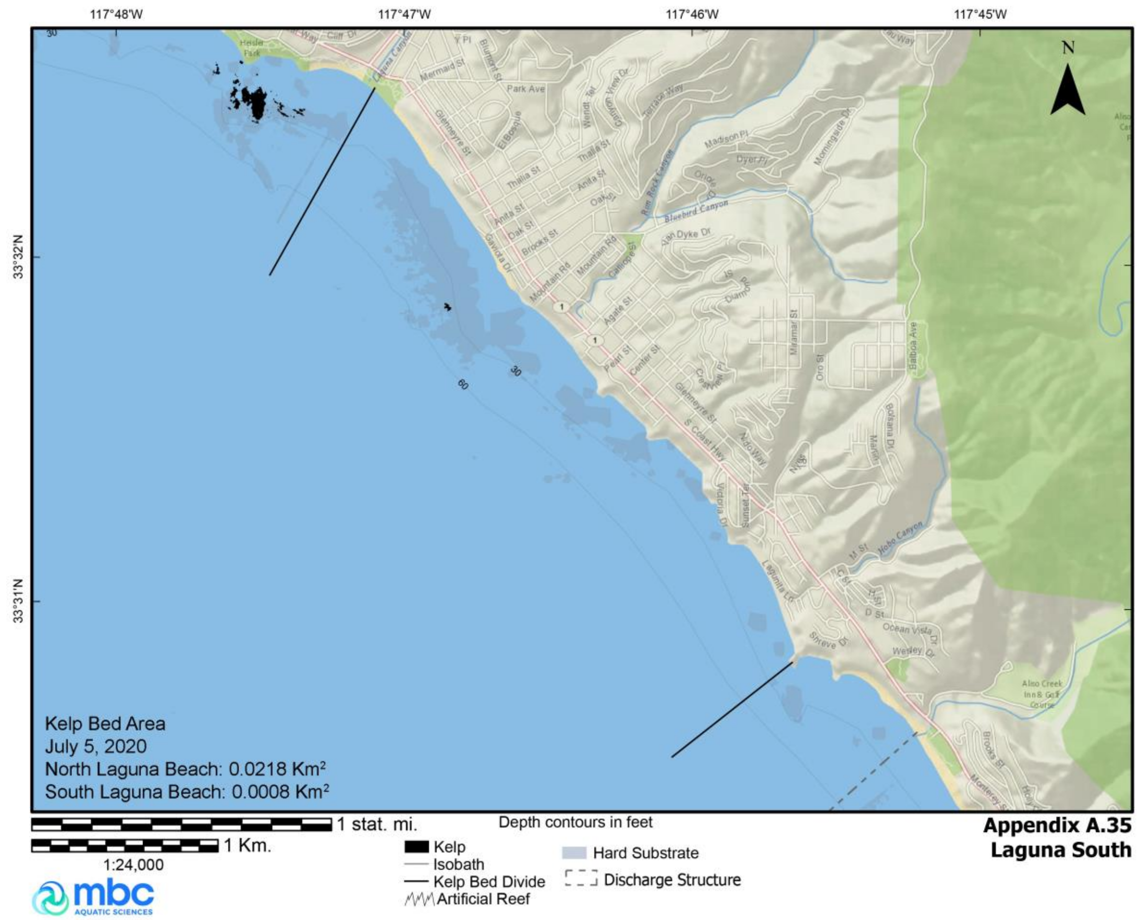
MAP A.35



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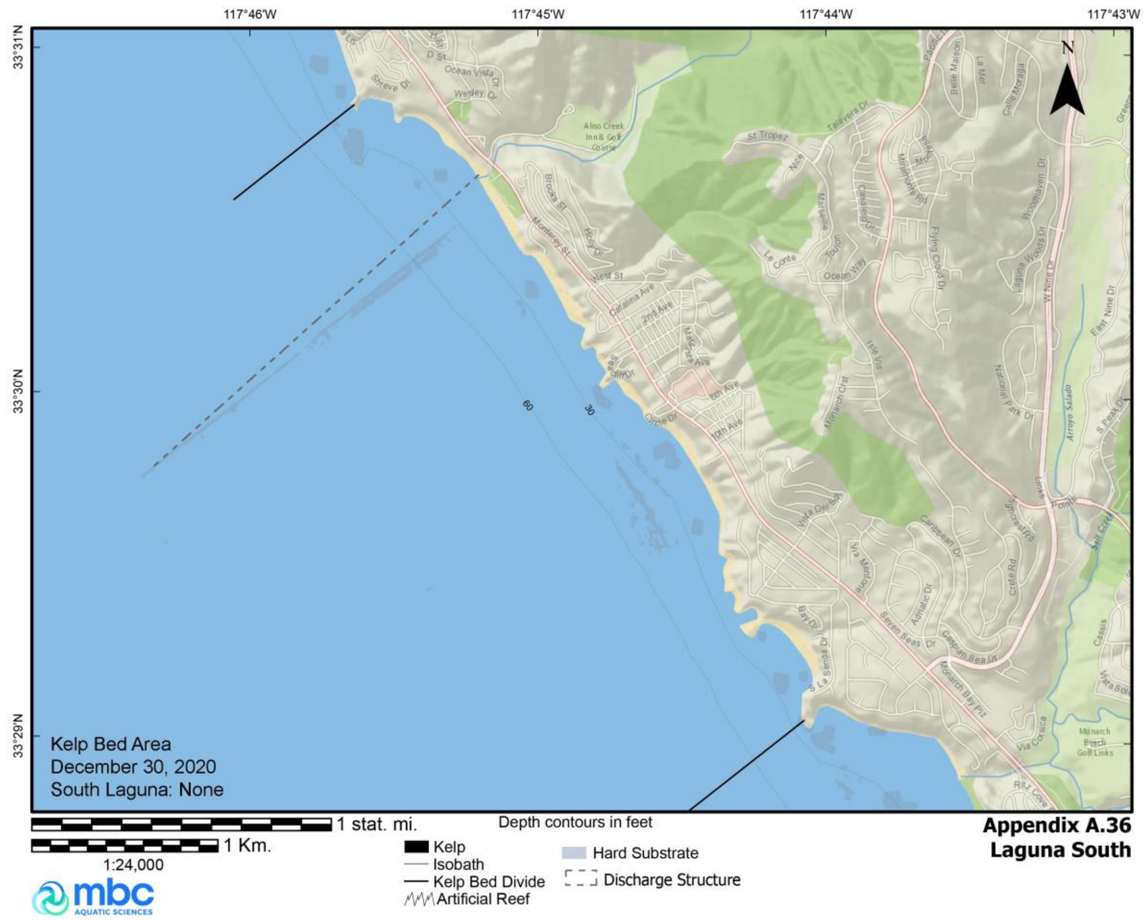
MAP A.36



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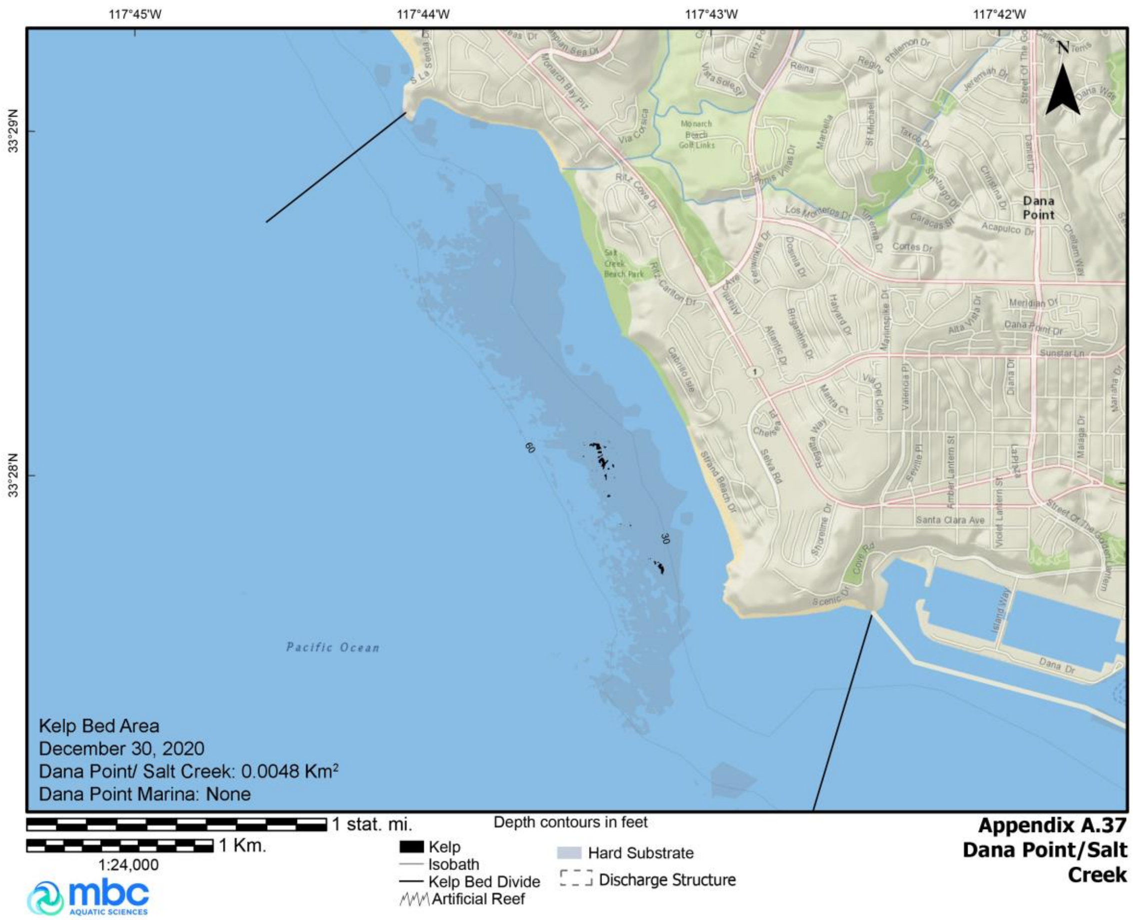

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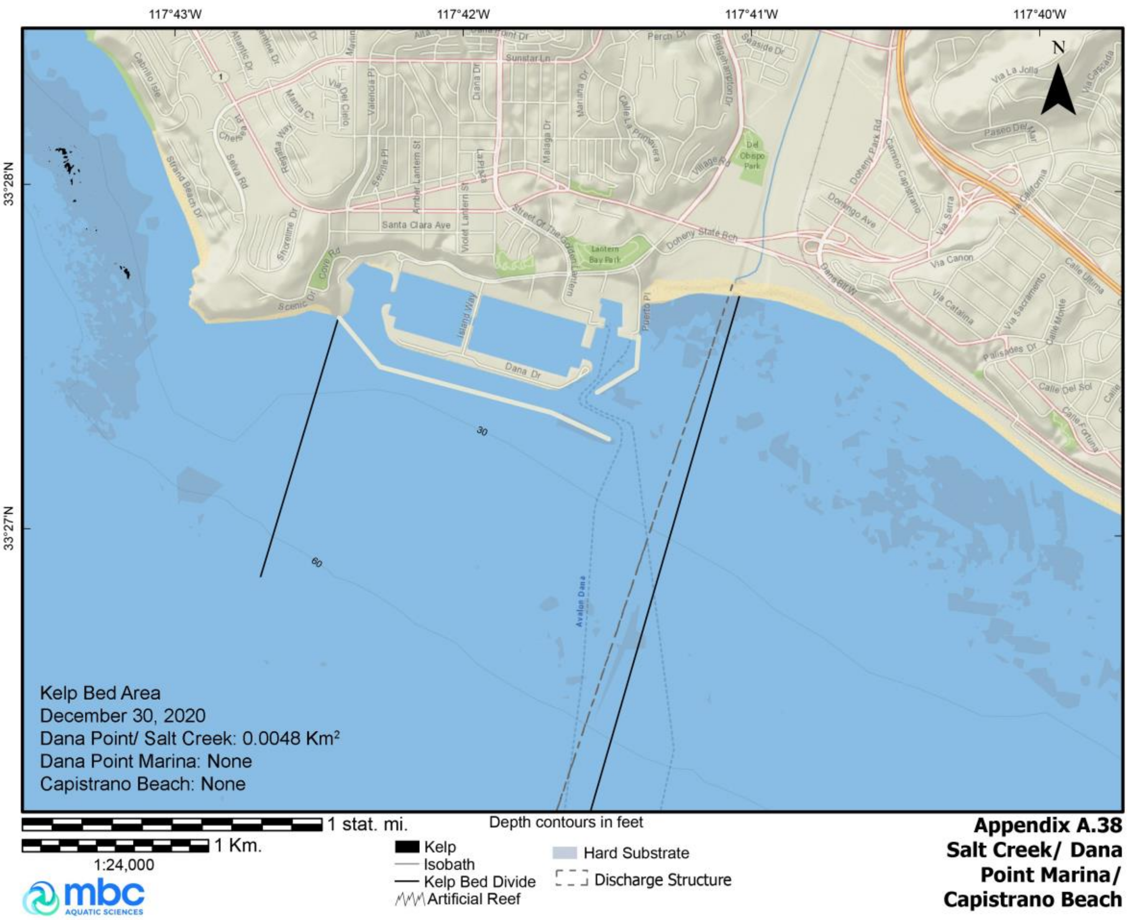
MAP A.38



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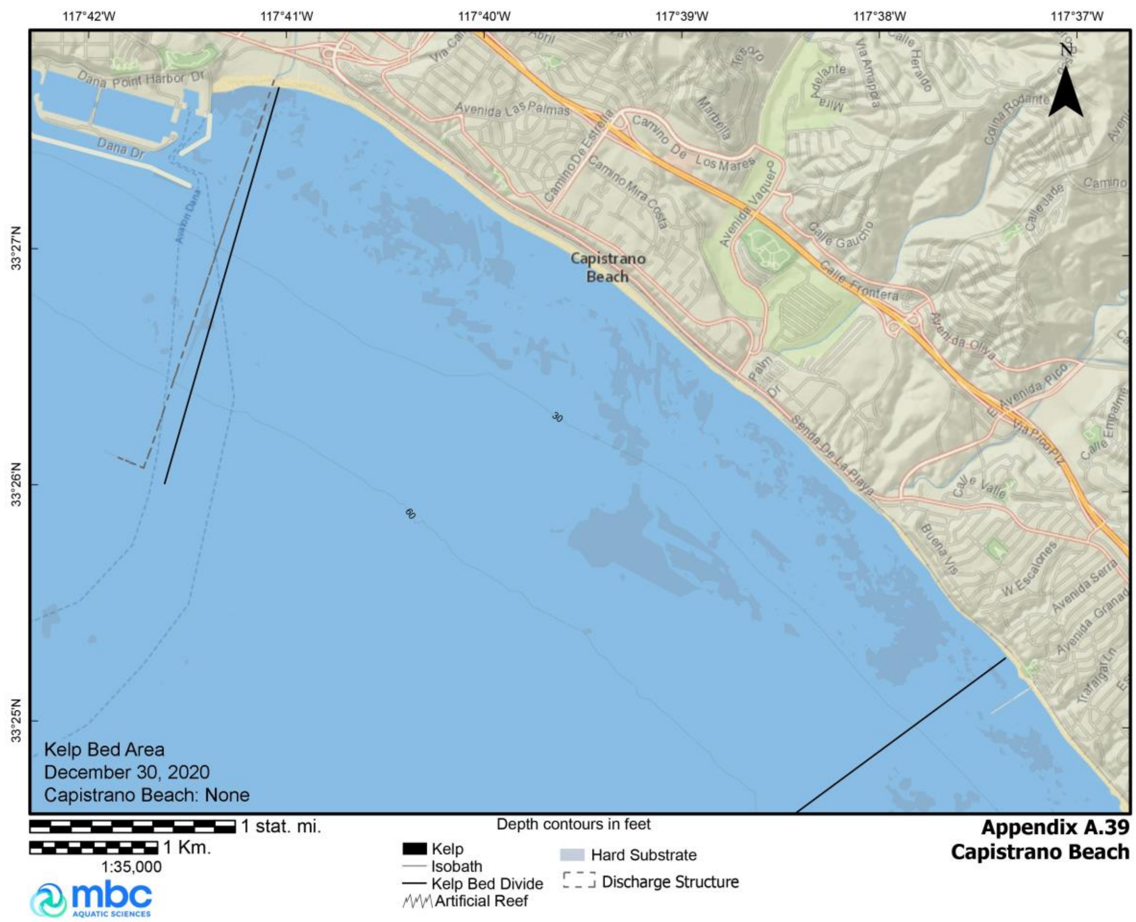
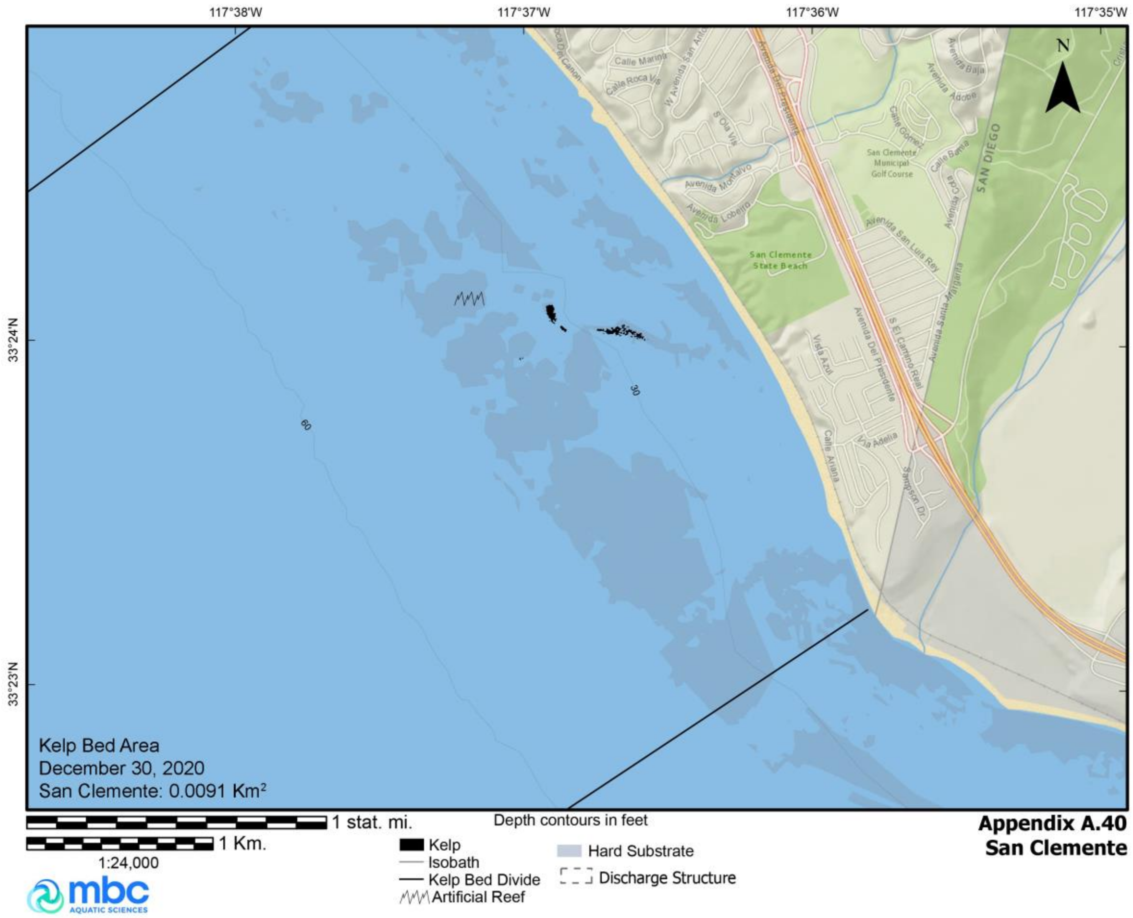
MAP A.39


117°42'W
117°41'W
117°40'W
117°39'W
117°38'W
117°37'W
33°27'N
33°26'N
33°25'N
Dana Point Harbor Dr
Dana Dr
Avenida Las Palmas
Camino De Los Mares
Capistrano Beach
Calle Frontera
Avenida Pico
Senda De La Playa
30
60
Kelp Bed Area
December 30, 2020
Capistrano Beach: None
1 stat. mi.
1 Km.
1:35,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.39
Capistrano Beach
mbc
AQUATIC SCIENCES

MAP A.40



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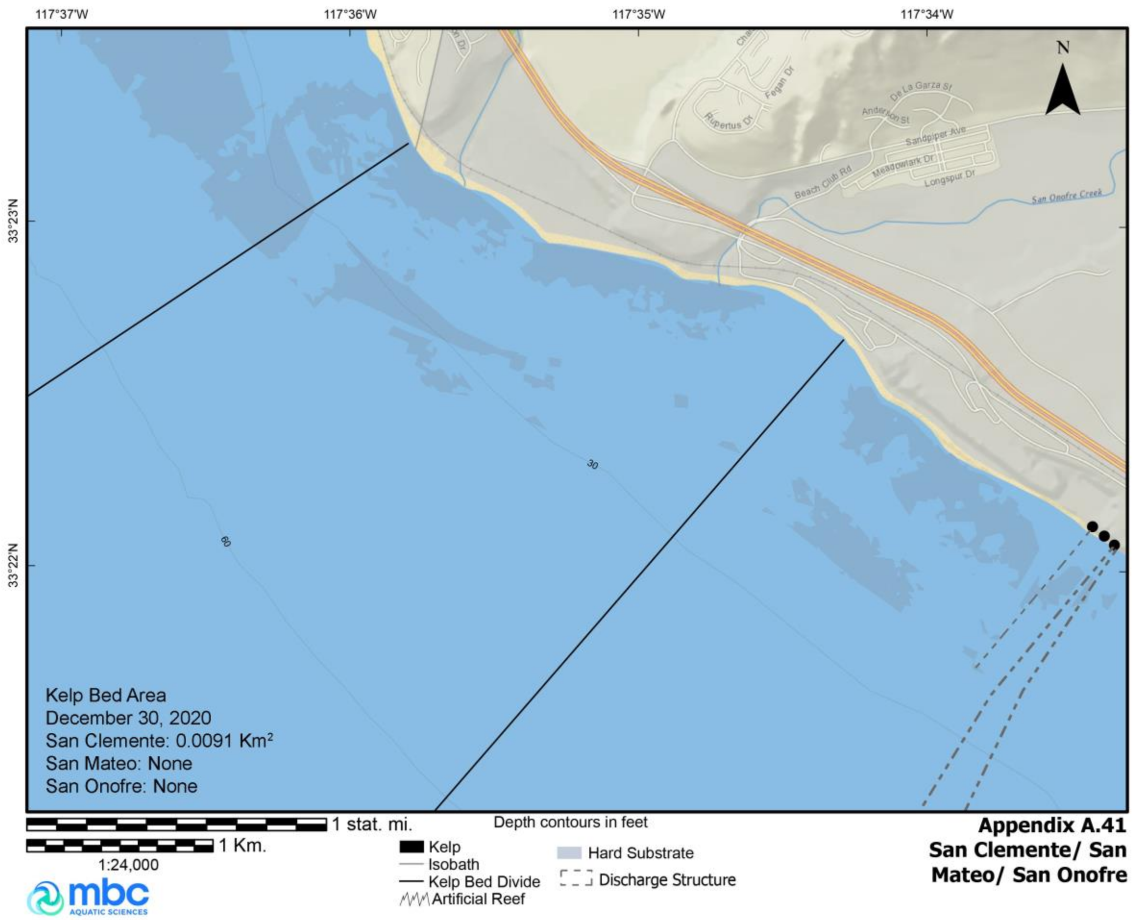
MAP A.41



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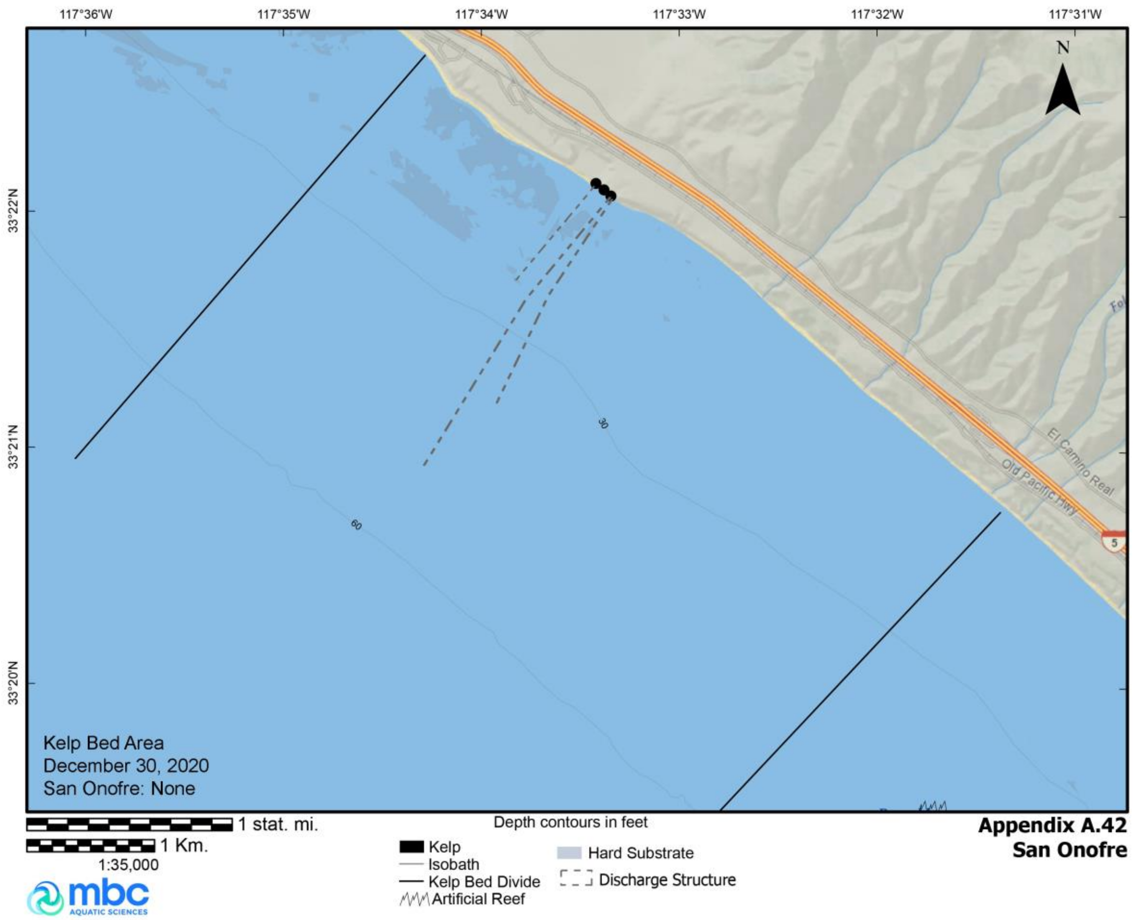
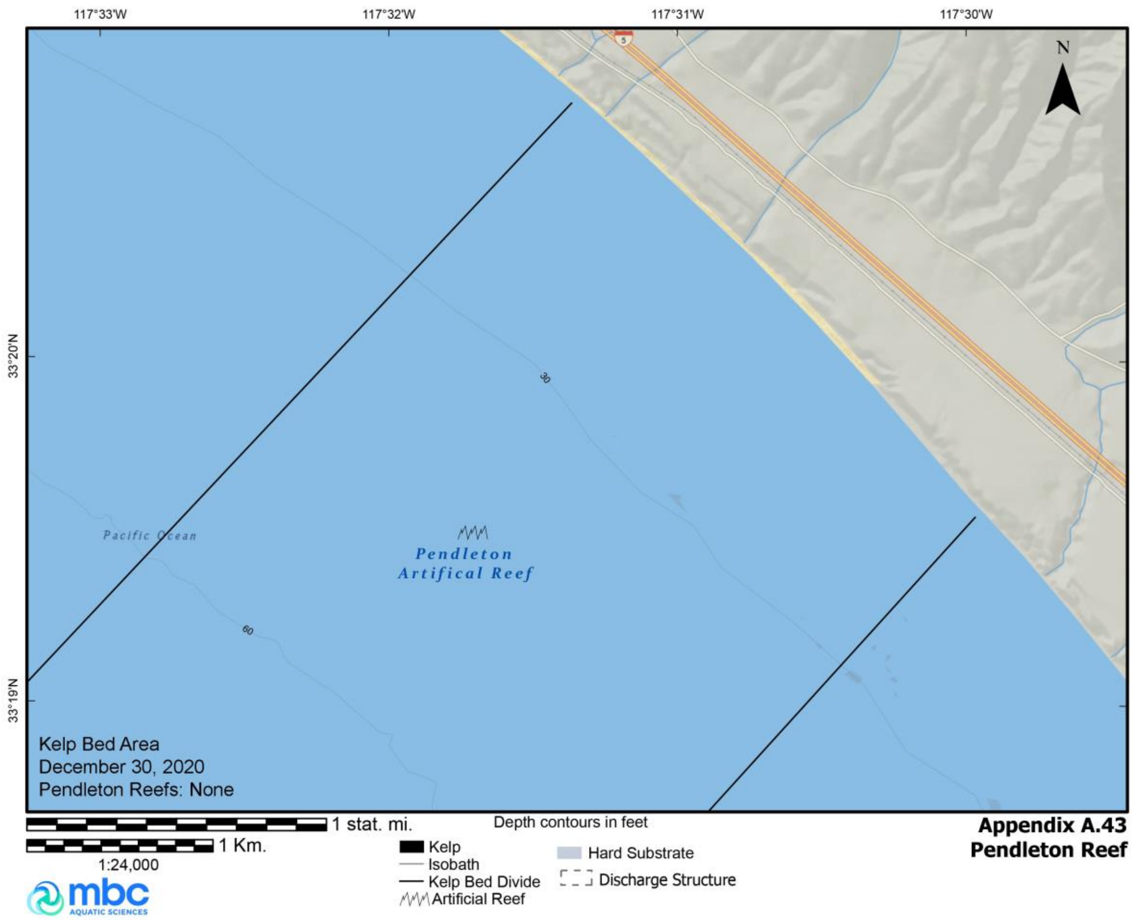
MAP A.42


117°36'W
117°35'W
117°34'W
117°33'W
117°32'W
117°31'W
33°22'N
33°21'N
33°20'N
N
30
60
El Camino Real
Old Pacific Hwy
Kelp Bed Area
December 30, 2020
San Onofre: None
1 stat. mi.
1 Km.
1:35,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.42
San Onofre

MAP A.43



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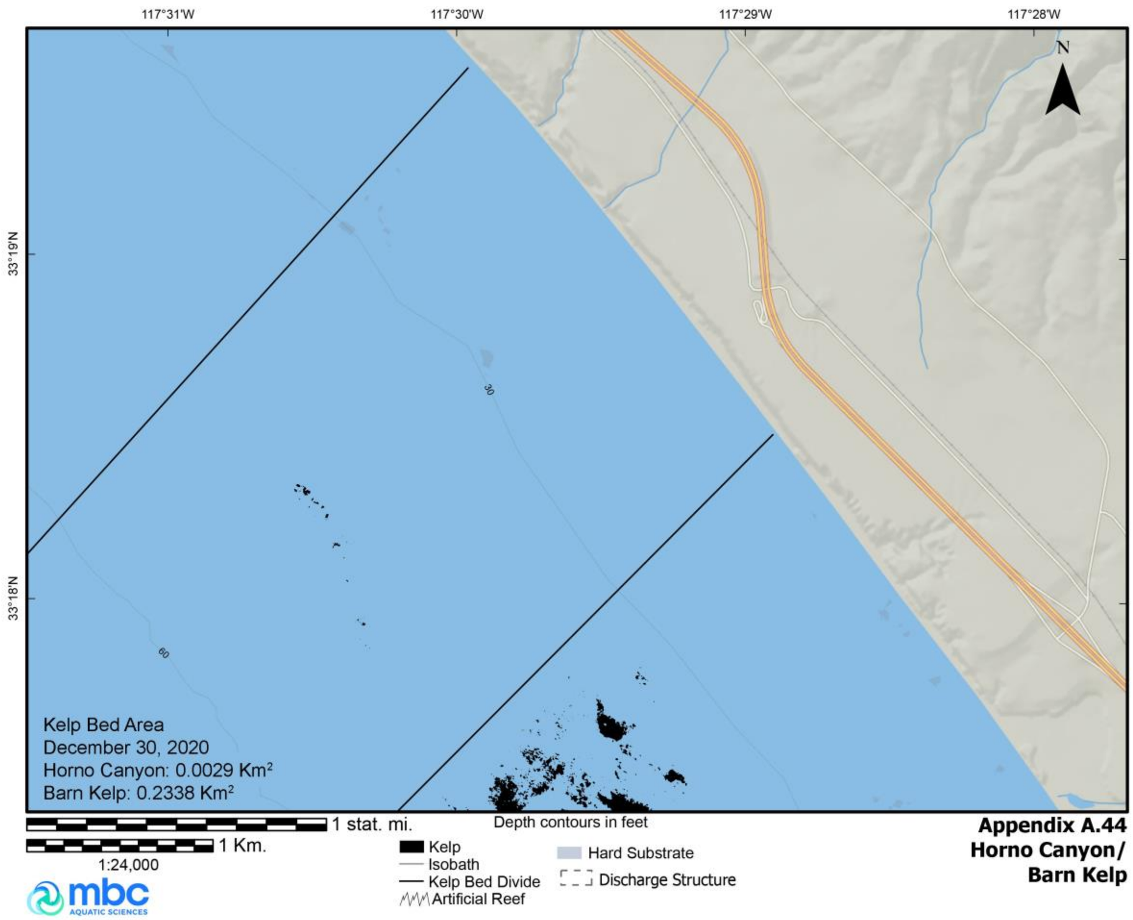
MAP A.44



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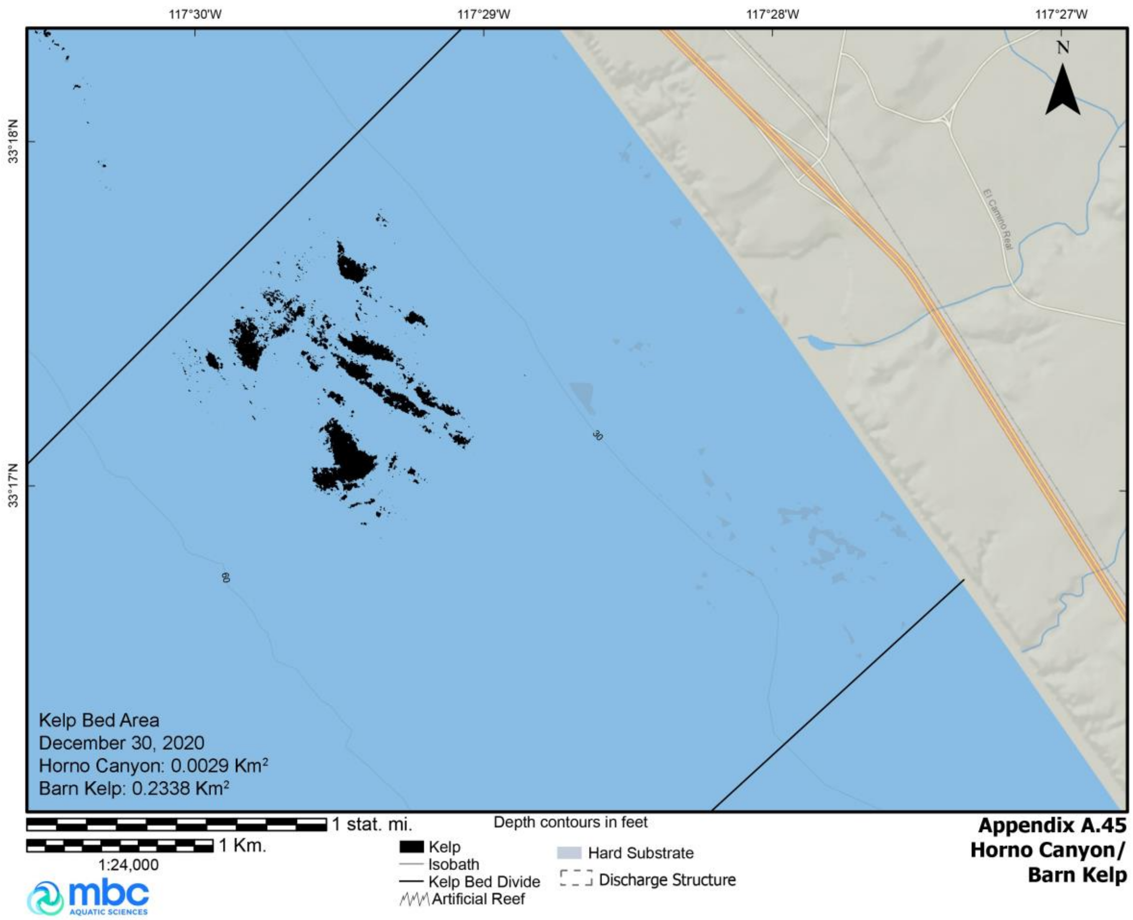
MAP A.45



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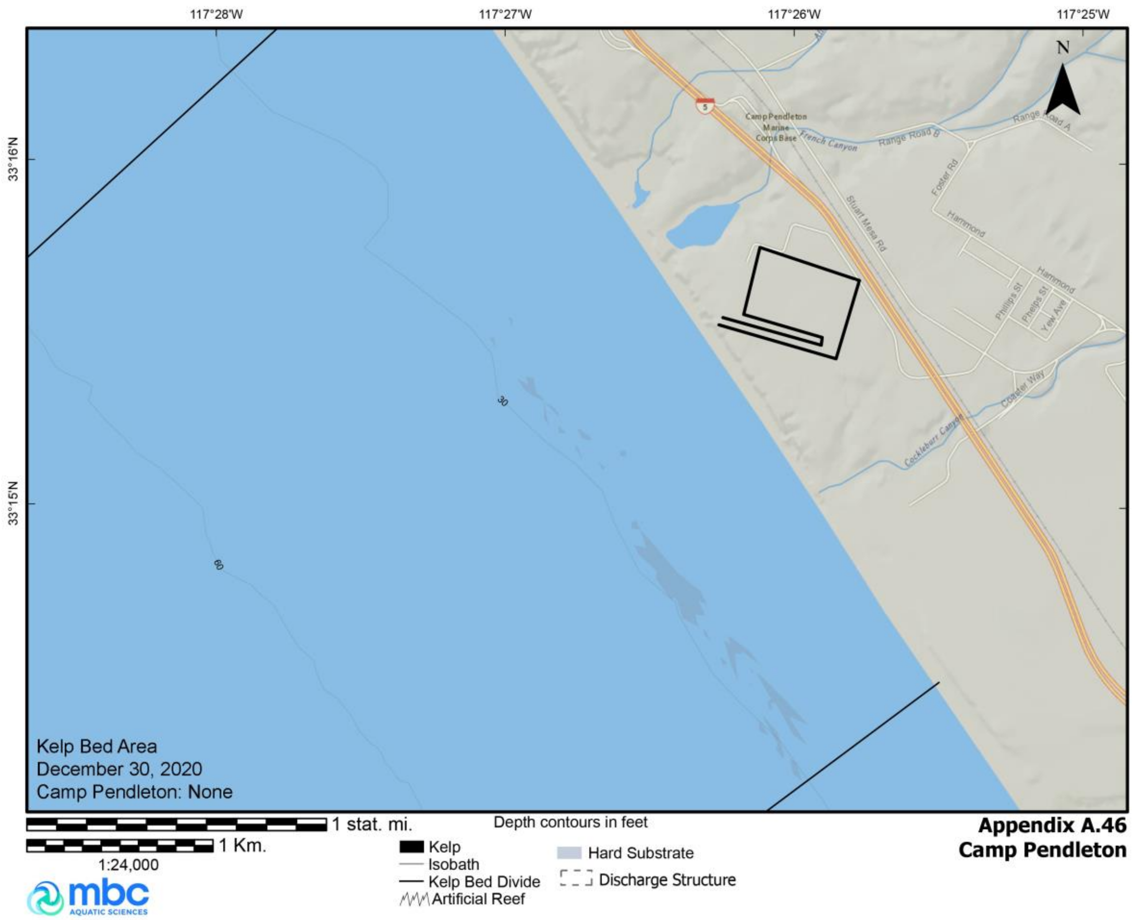
MAP A.46



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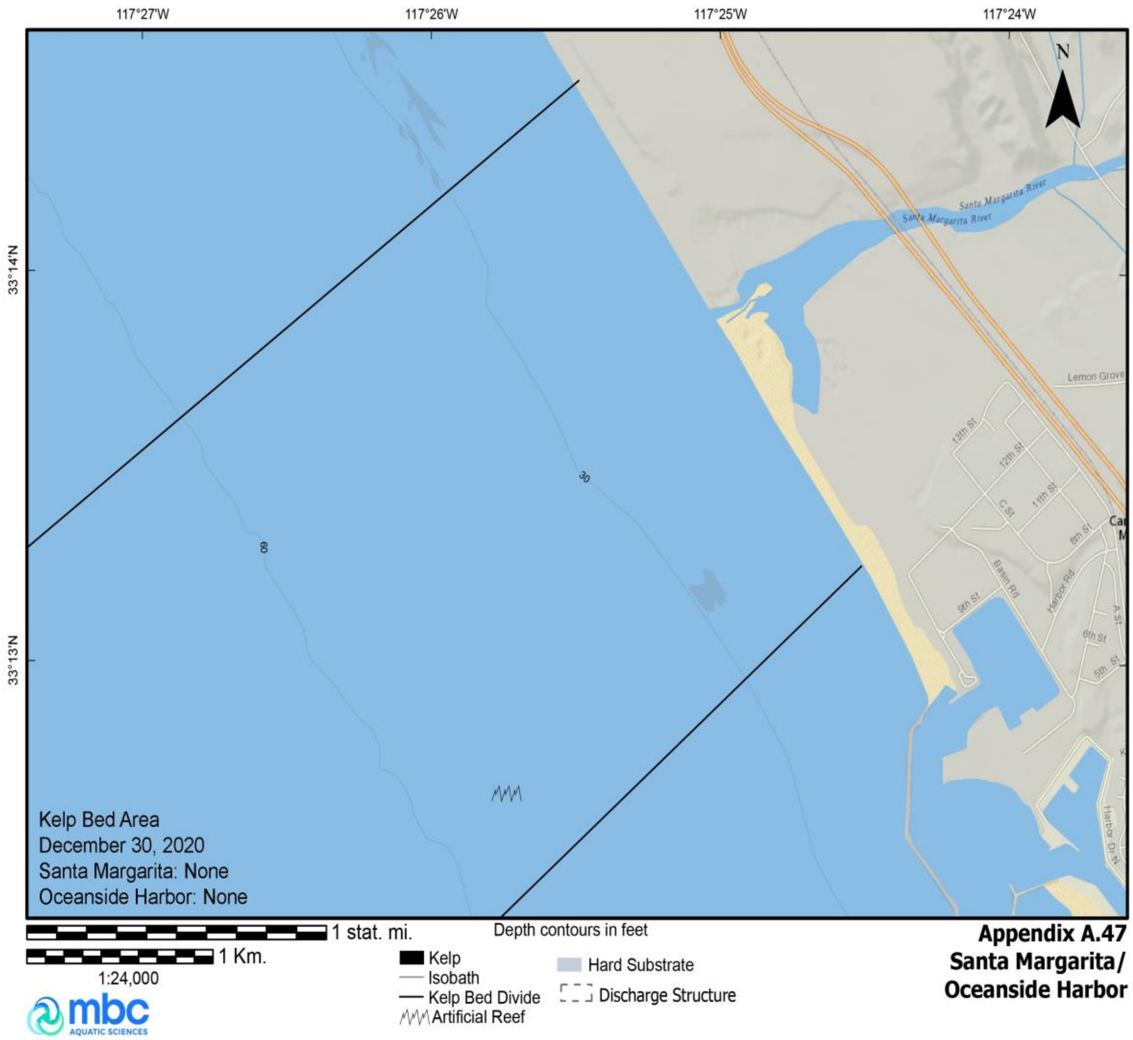
MAP A.47



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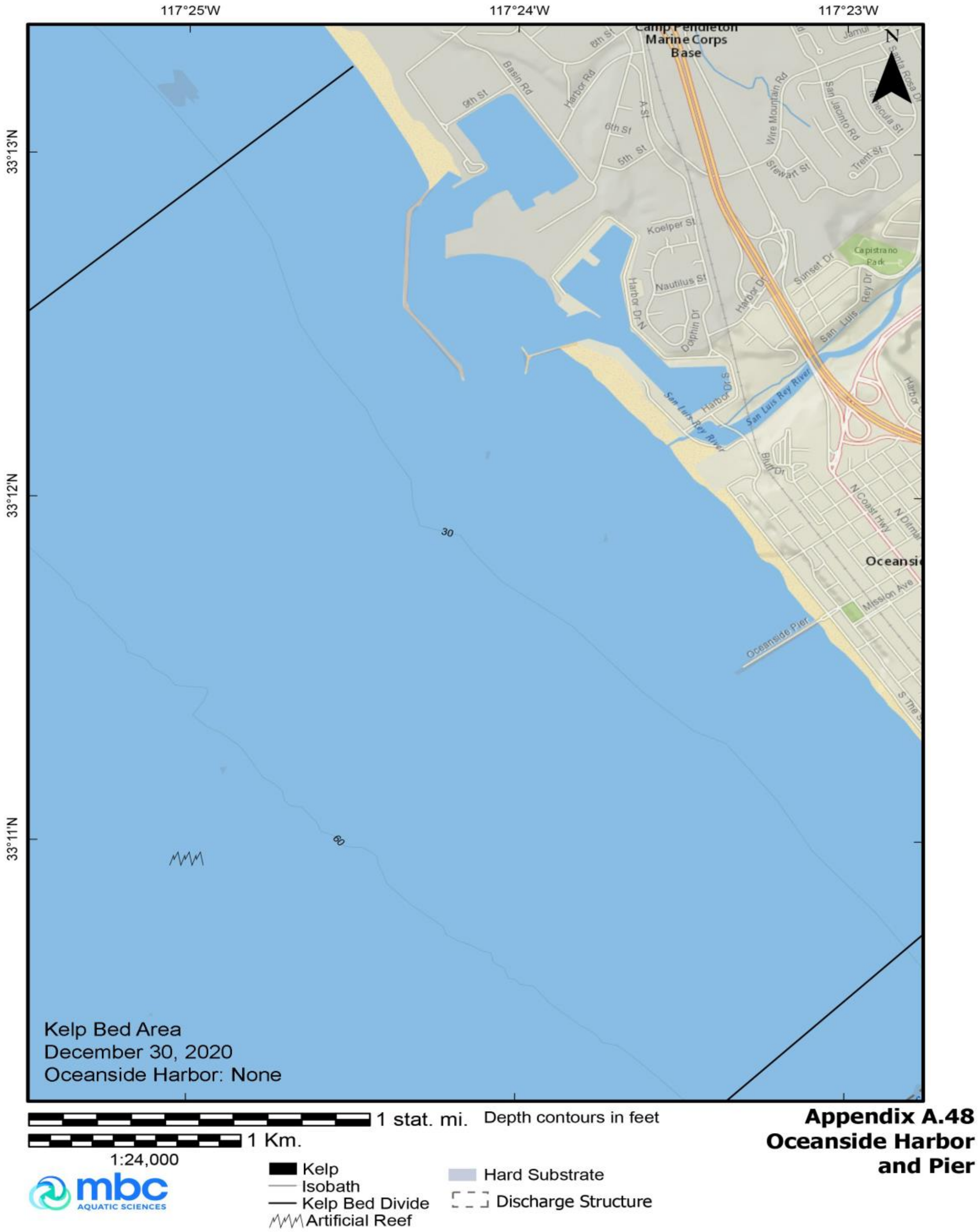
MAP A.48



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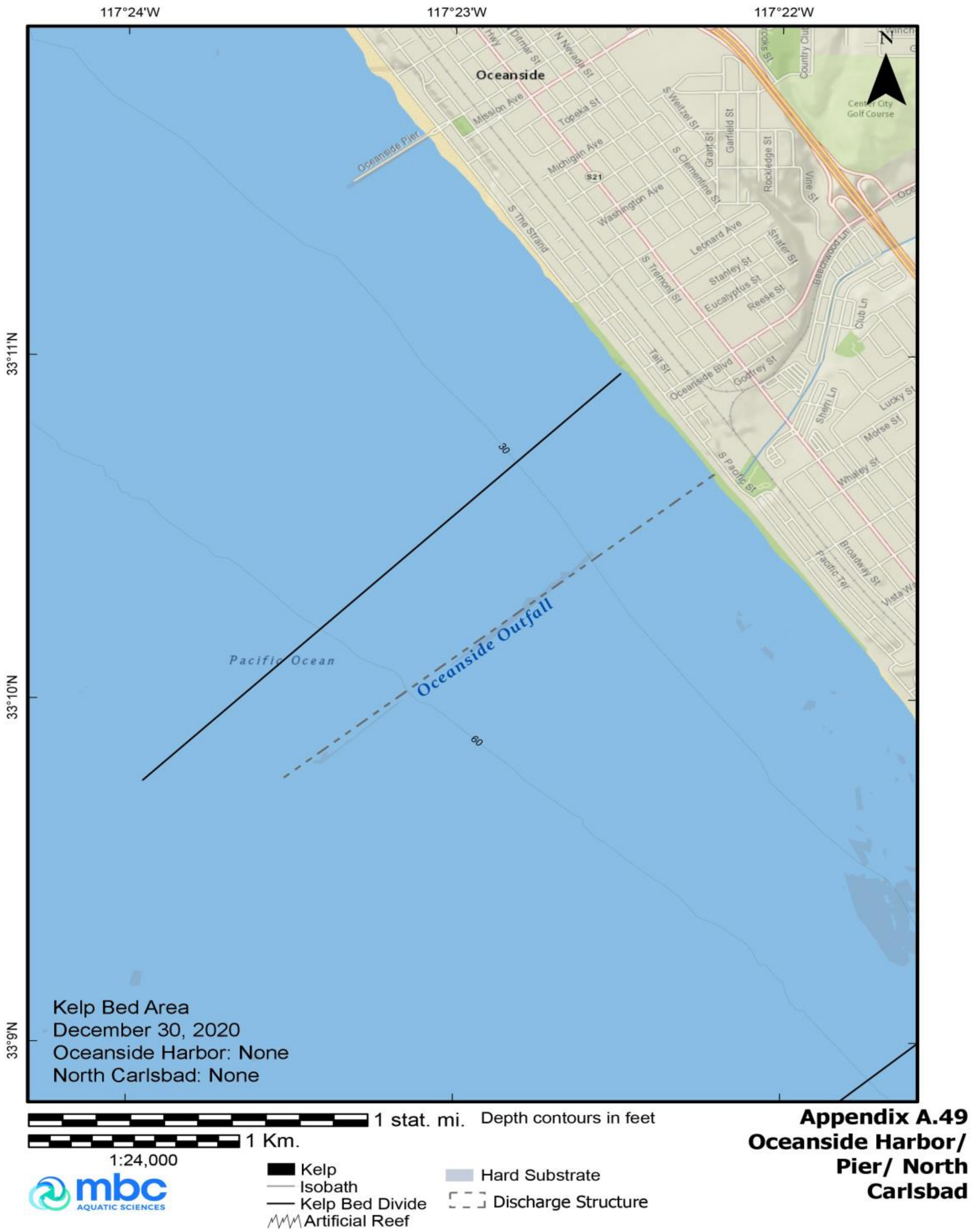

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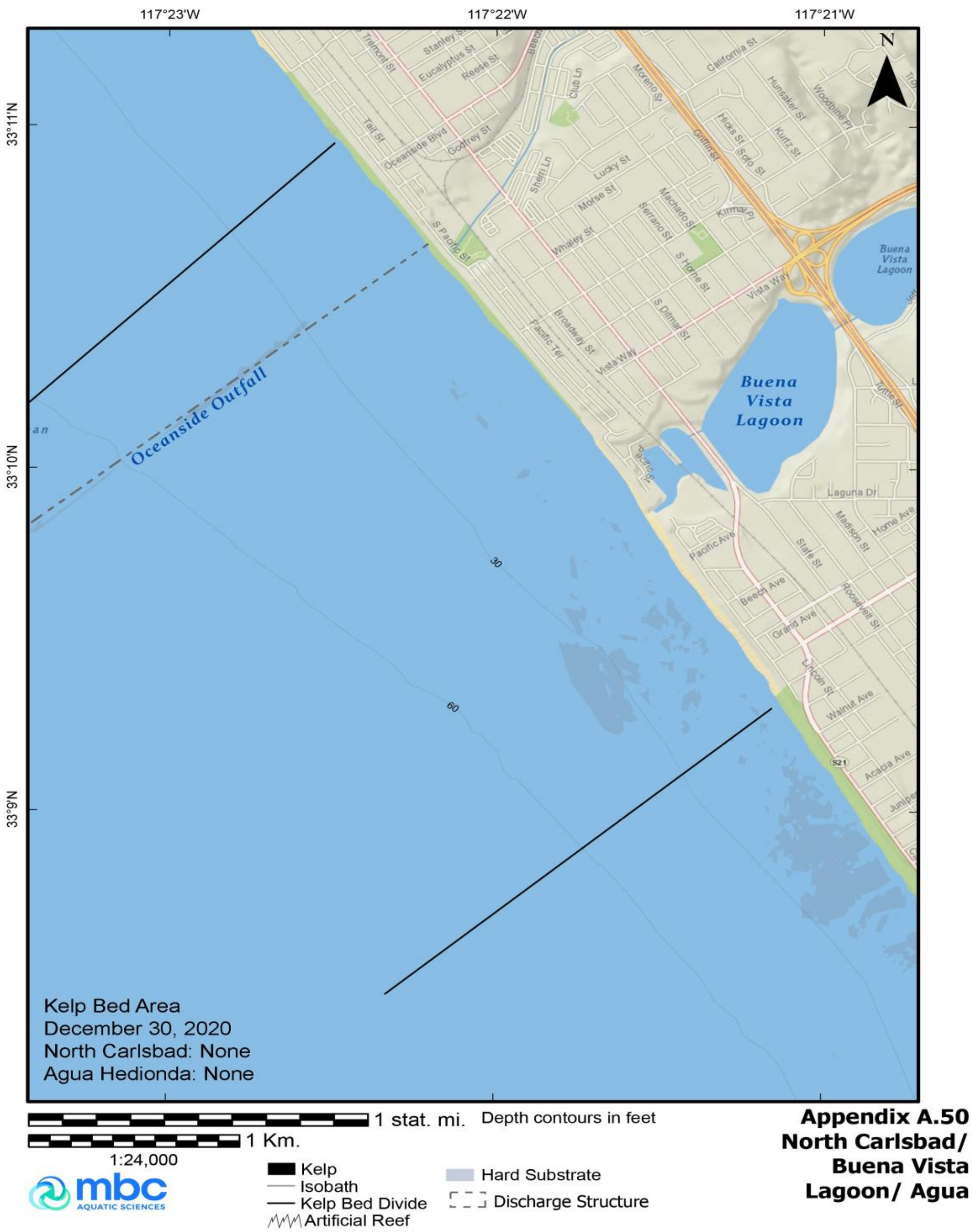
MAP A.50



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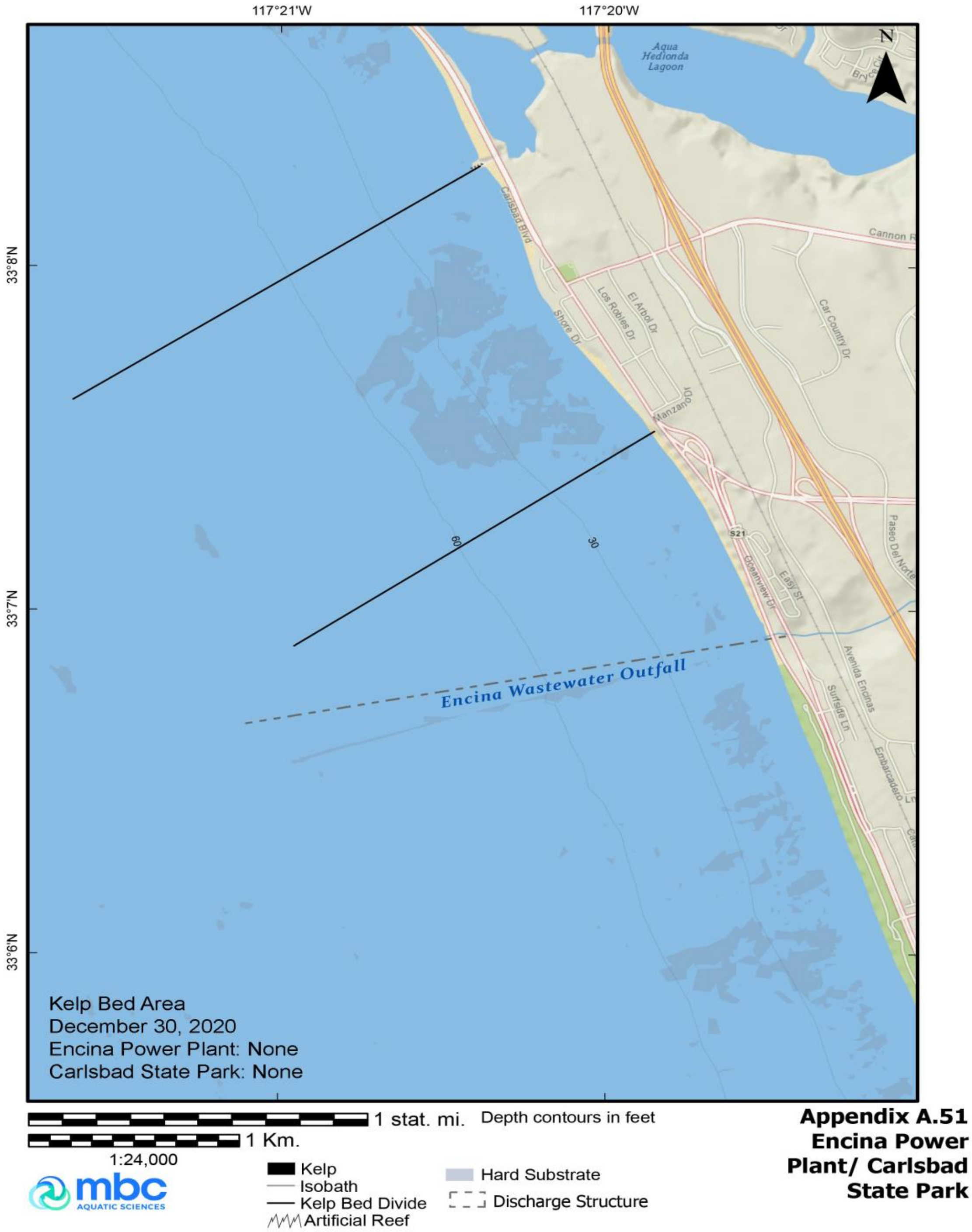
MAP A.51



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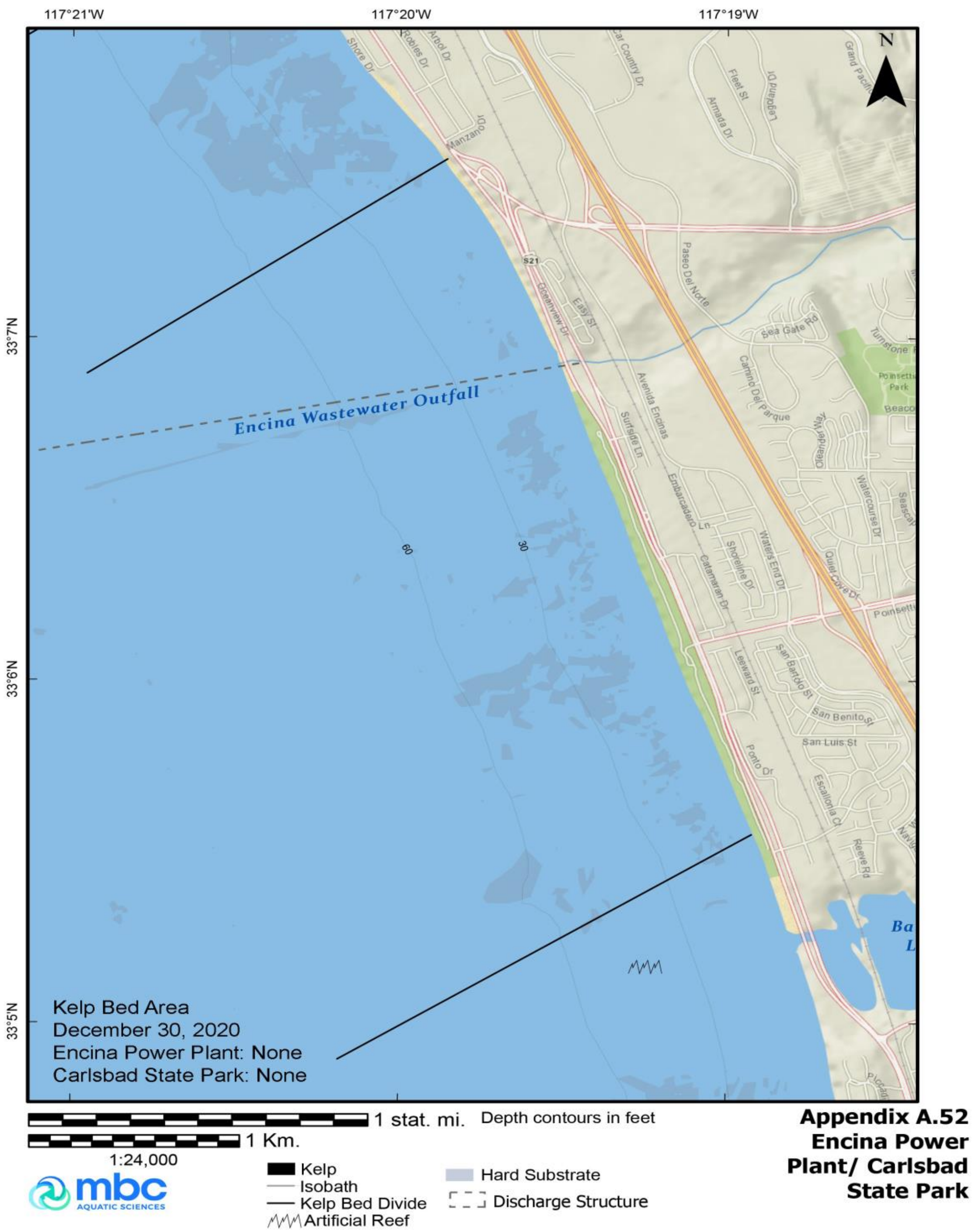
MAP A.52



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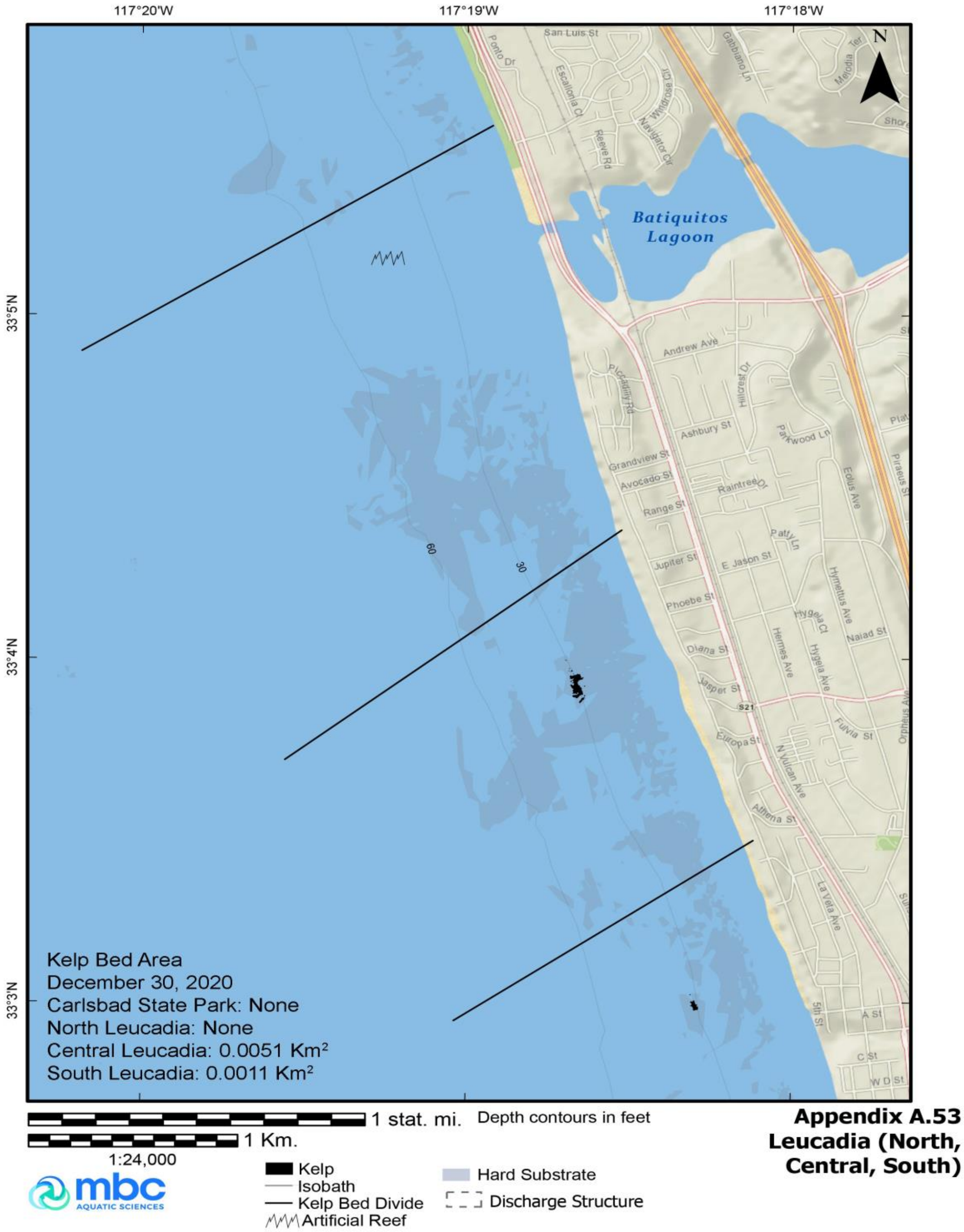

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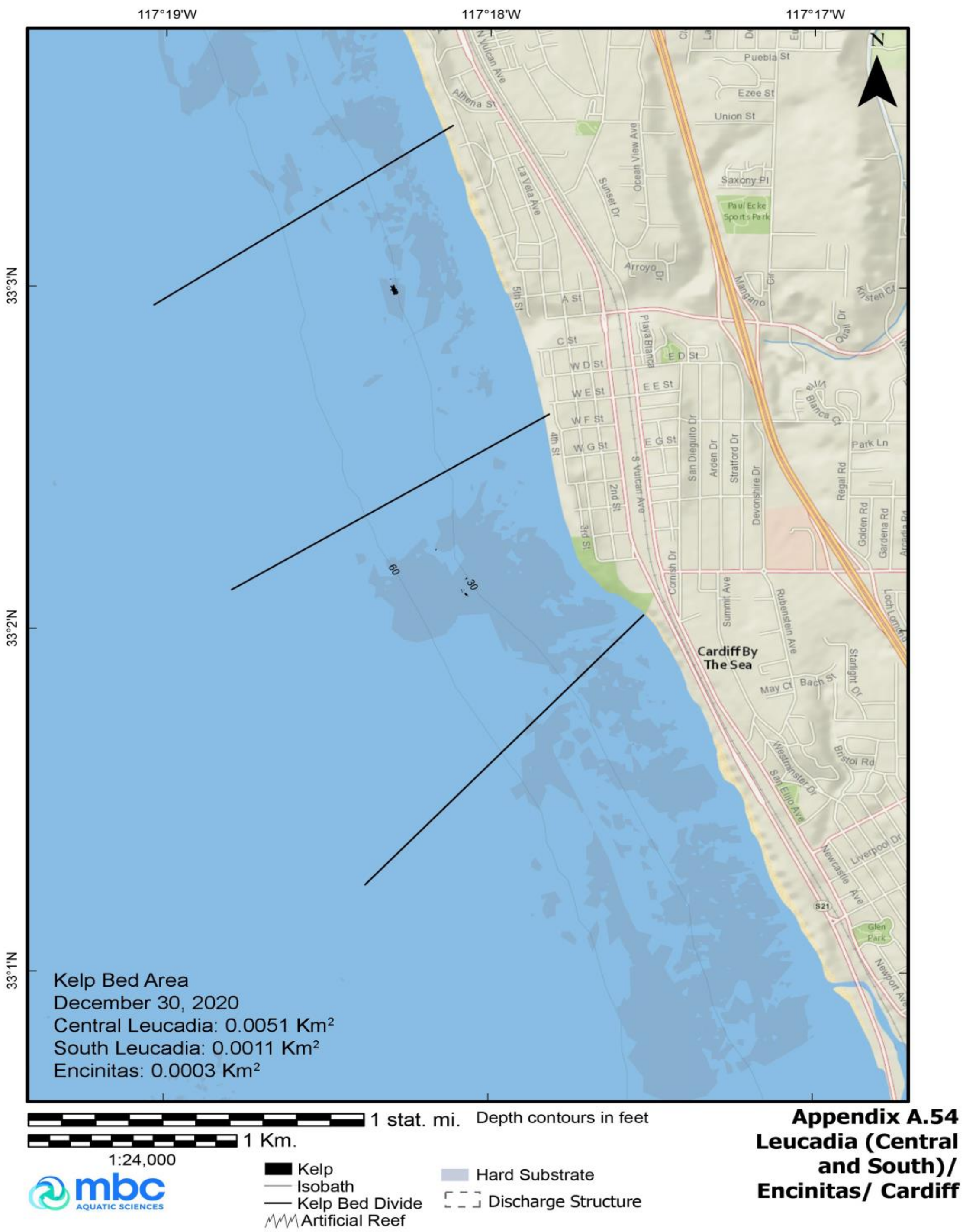

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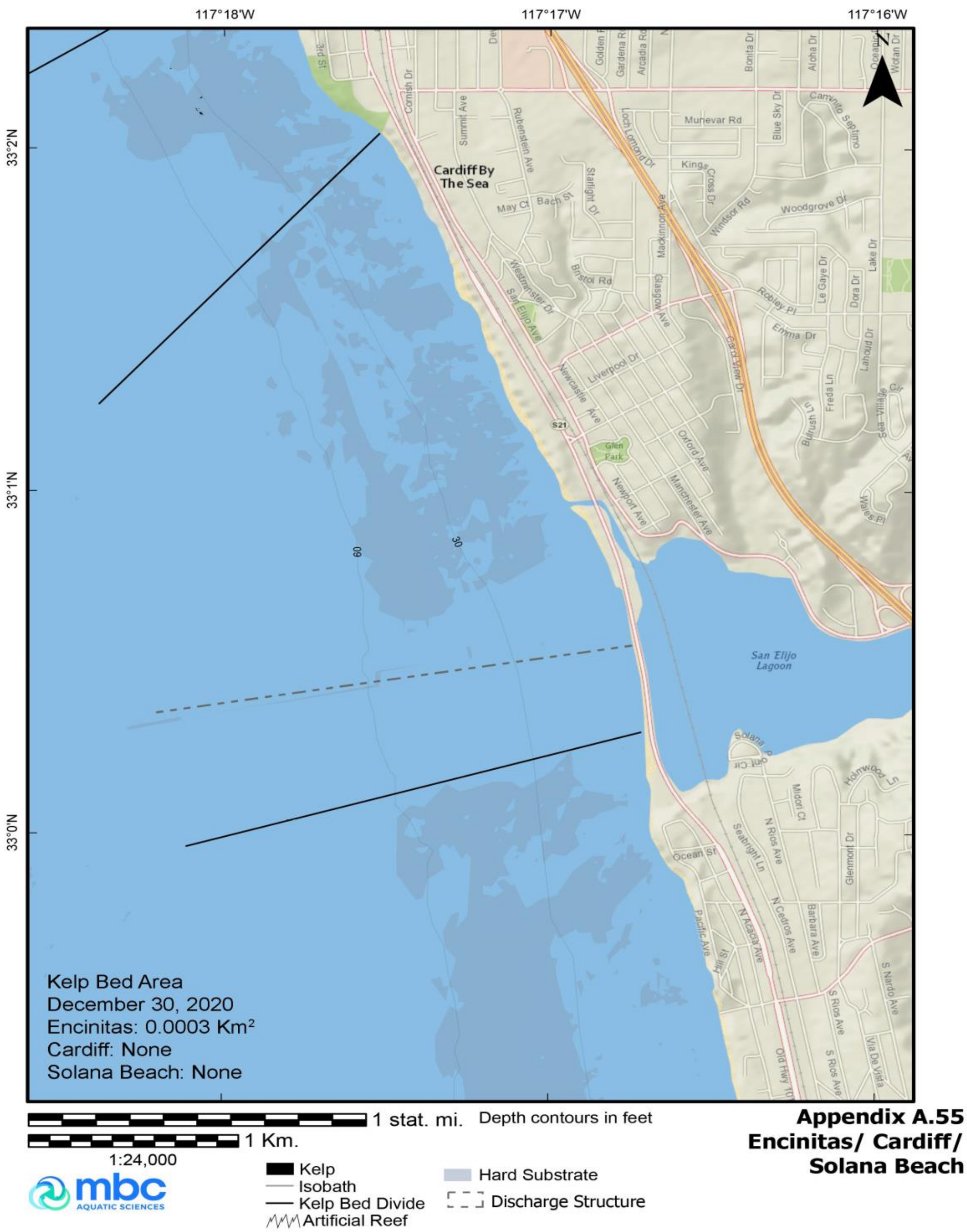
MAP A.55



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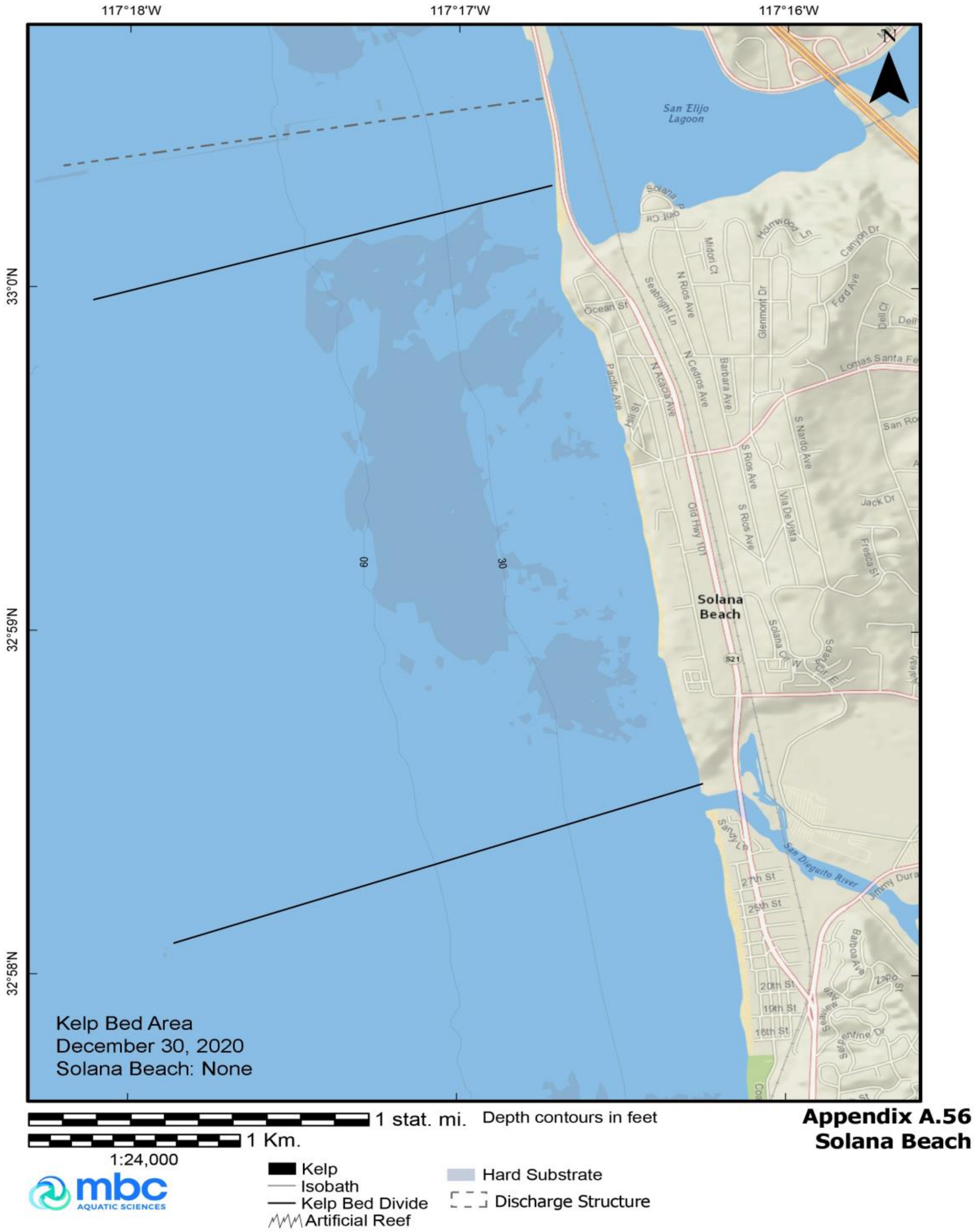

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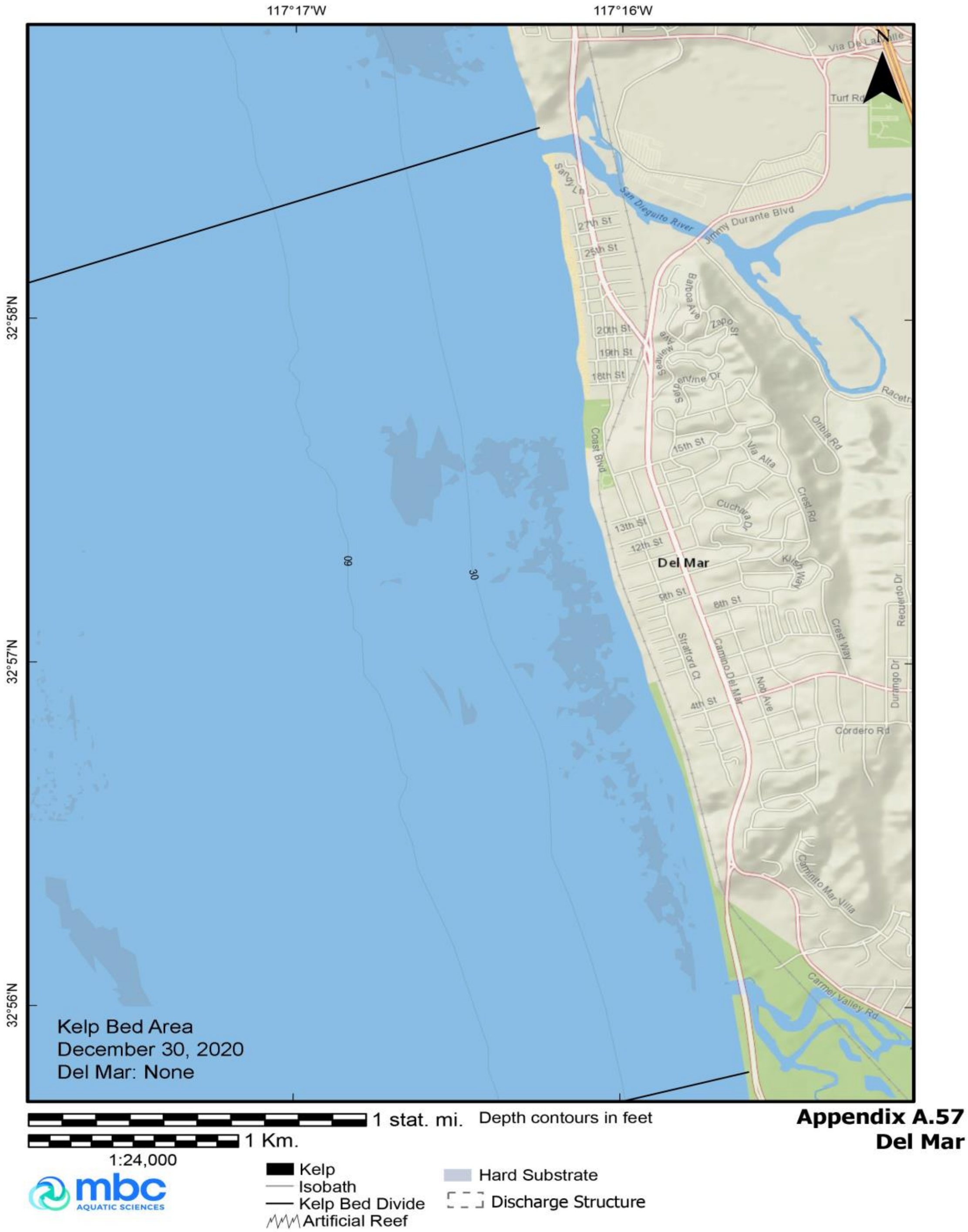

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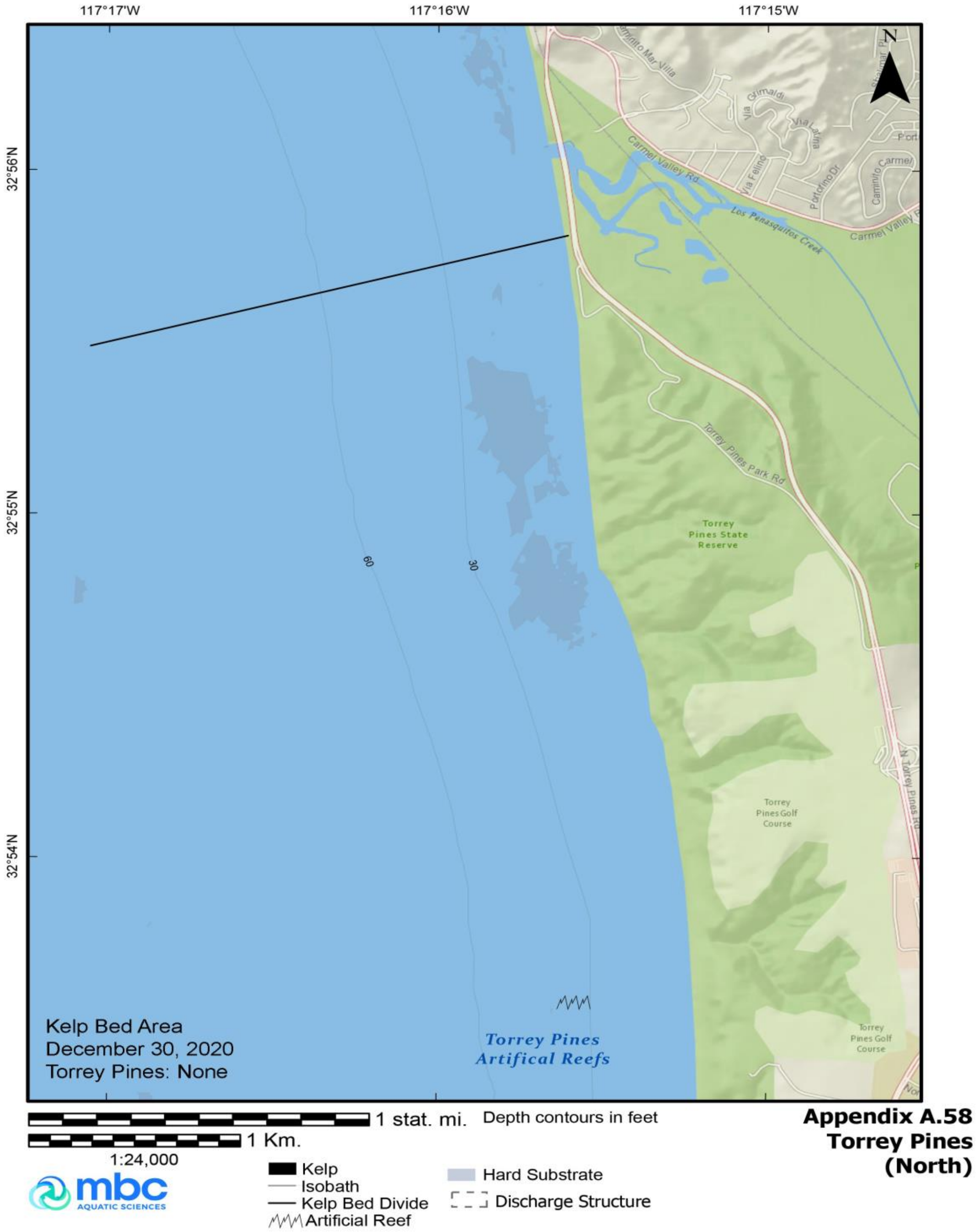
MAP A.58



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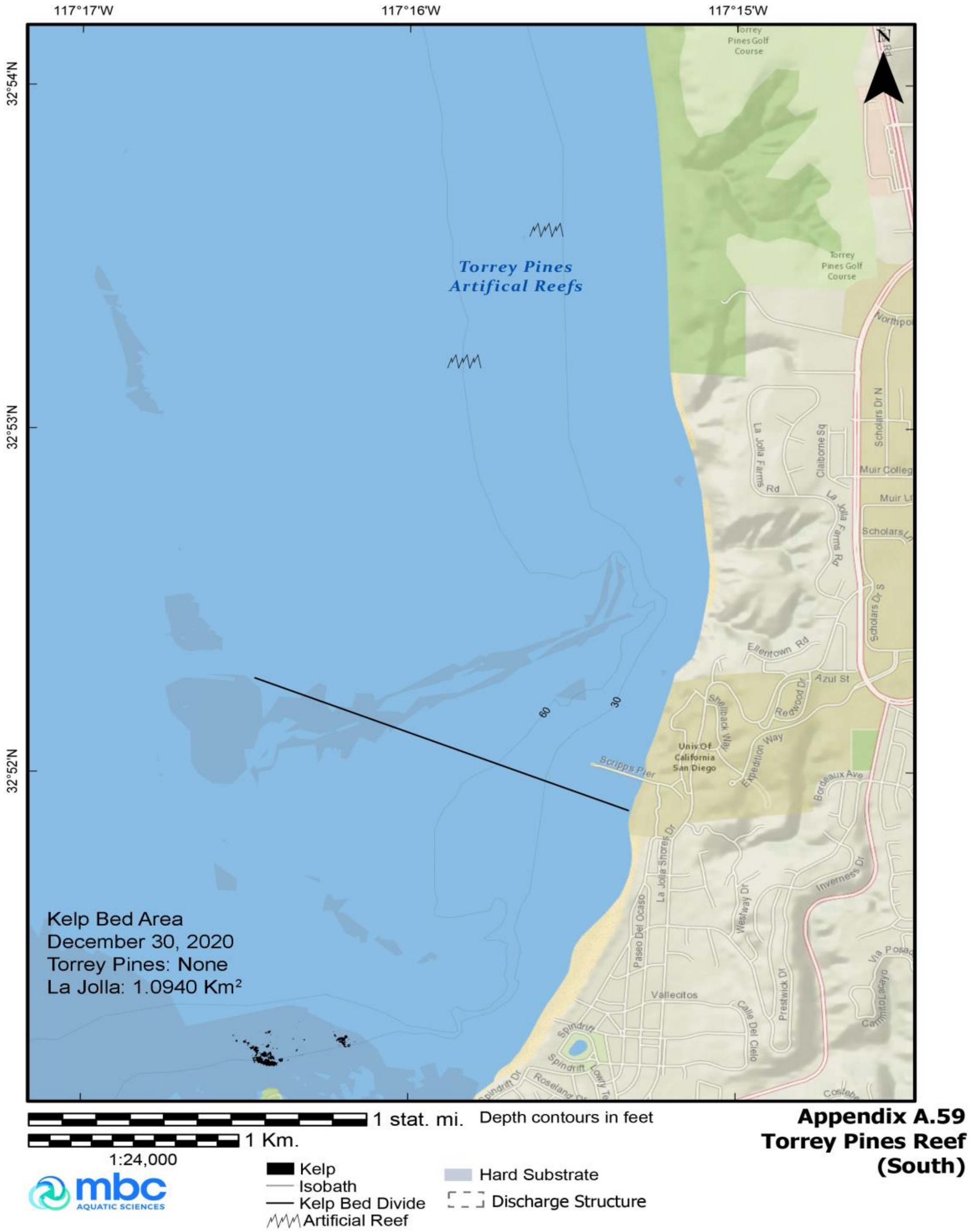

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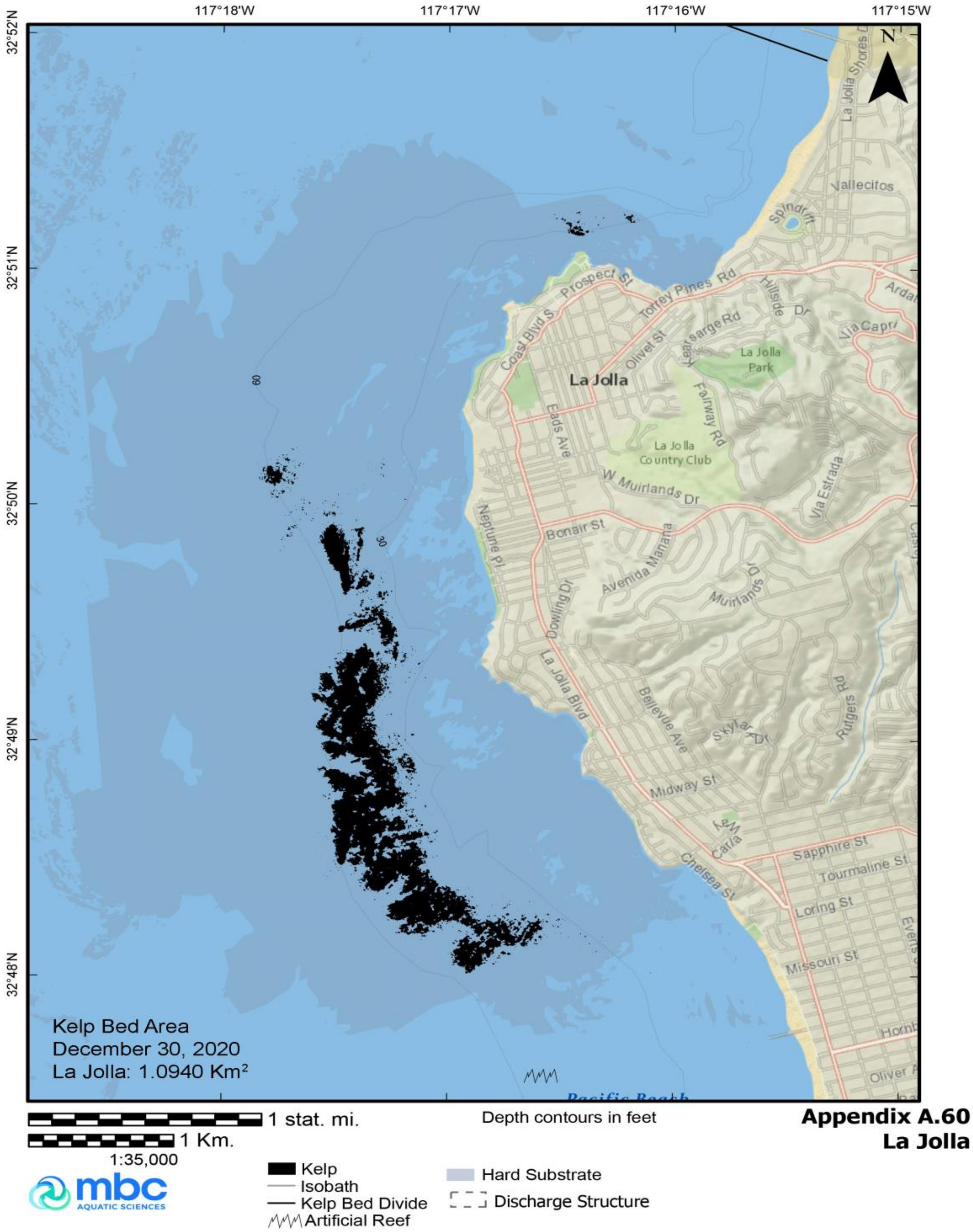
MAP A.60



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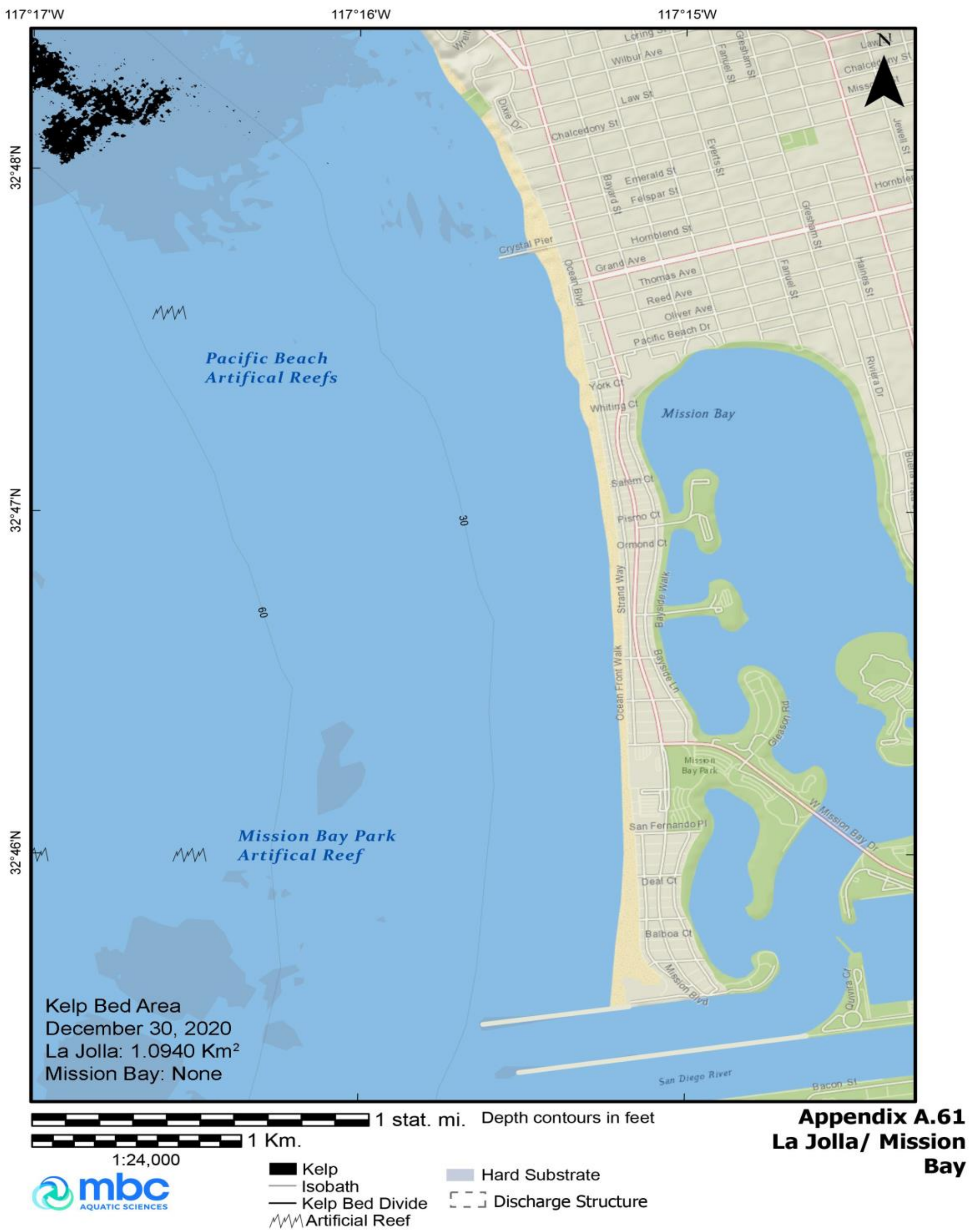
MAP A.61



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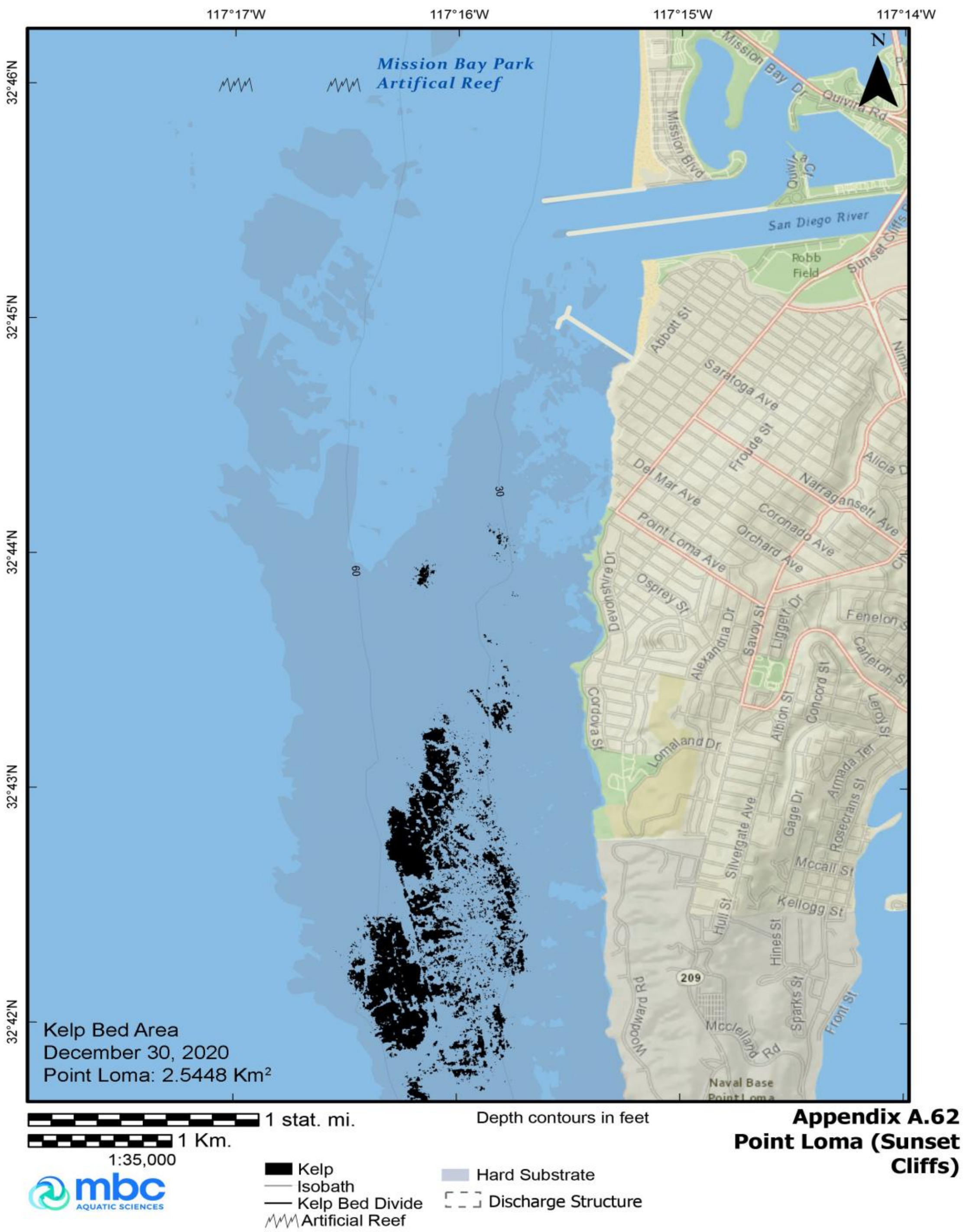

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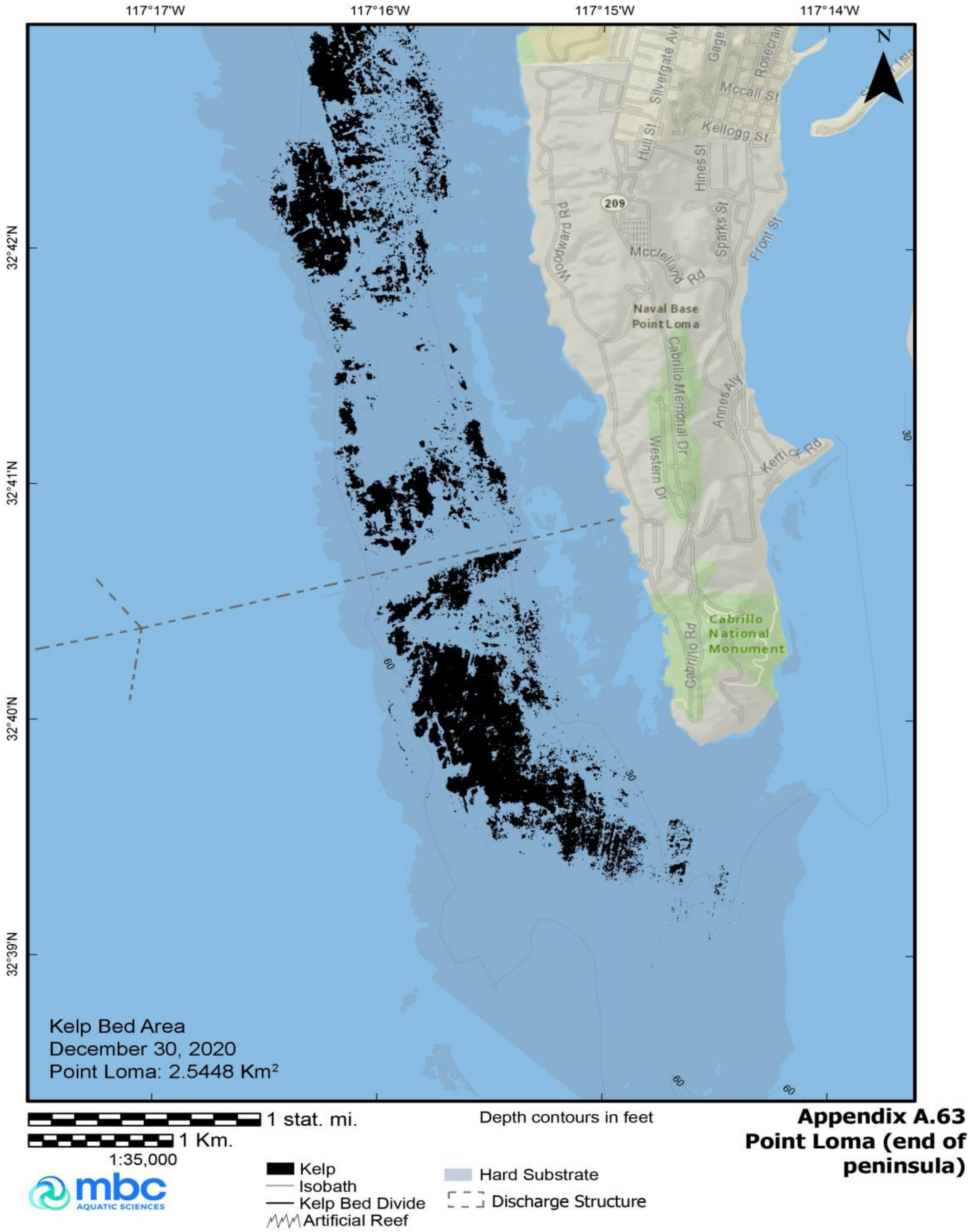
MAP A.63



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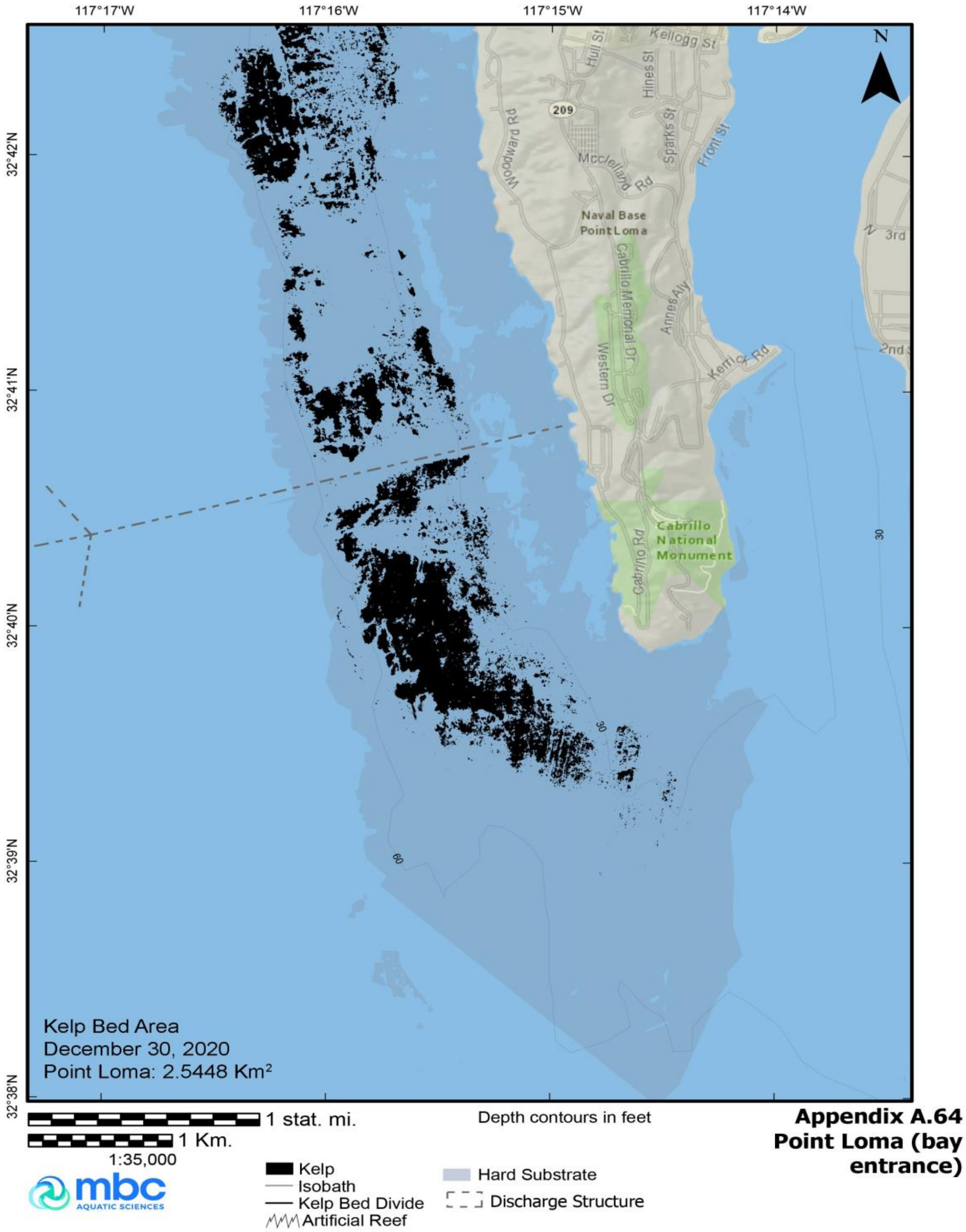
MAP A.64



Appendix A.64
Point Loma (bay entrance)

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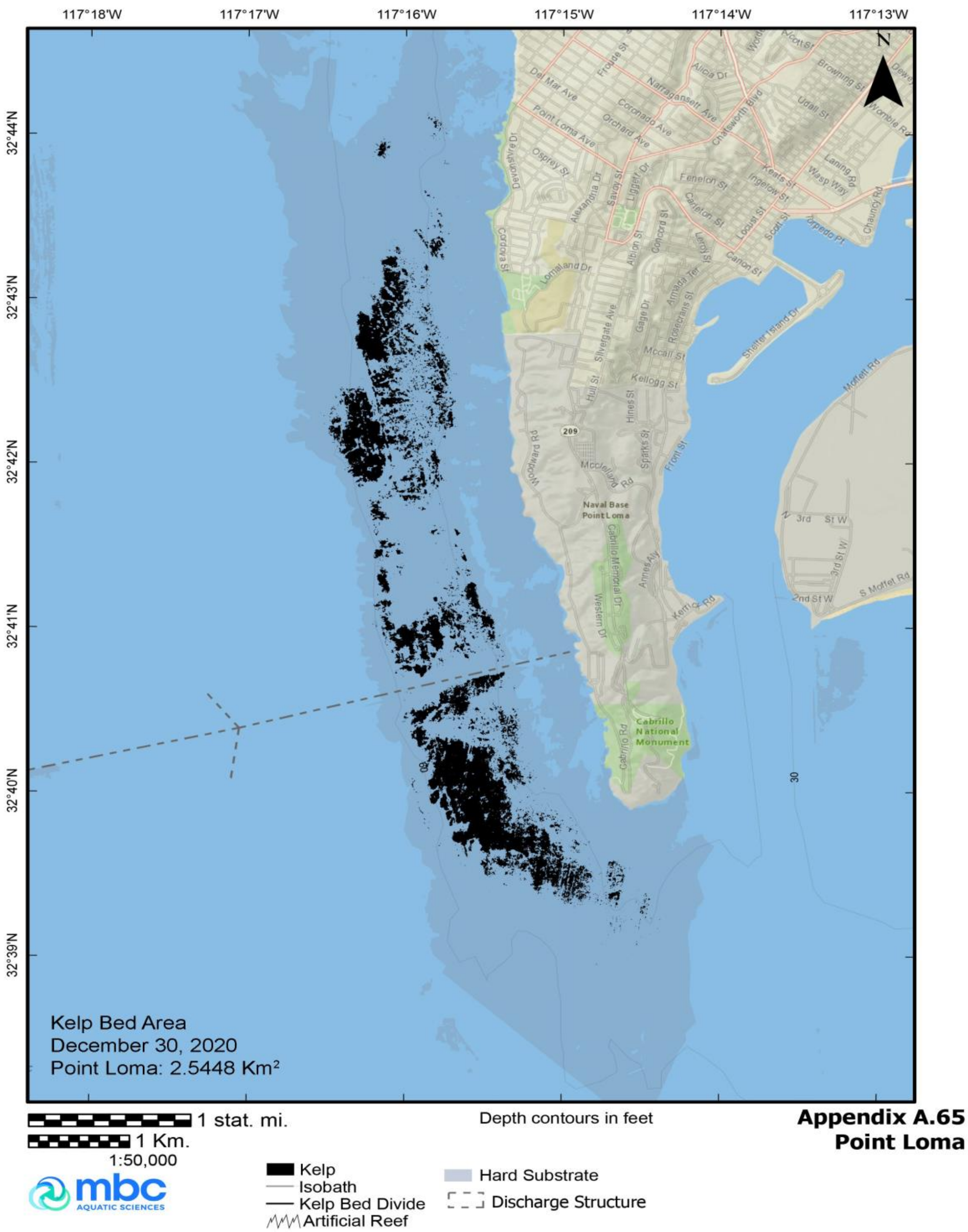
MAP A.65



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MAP A.66

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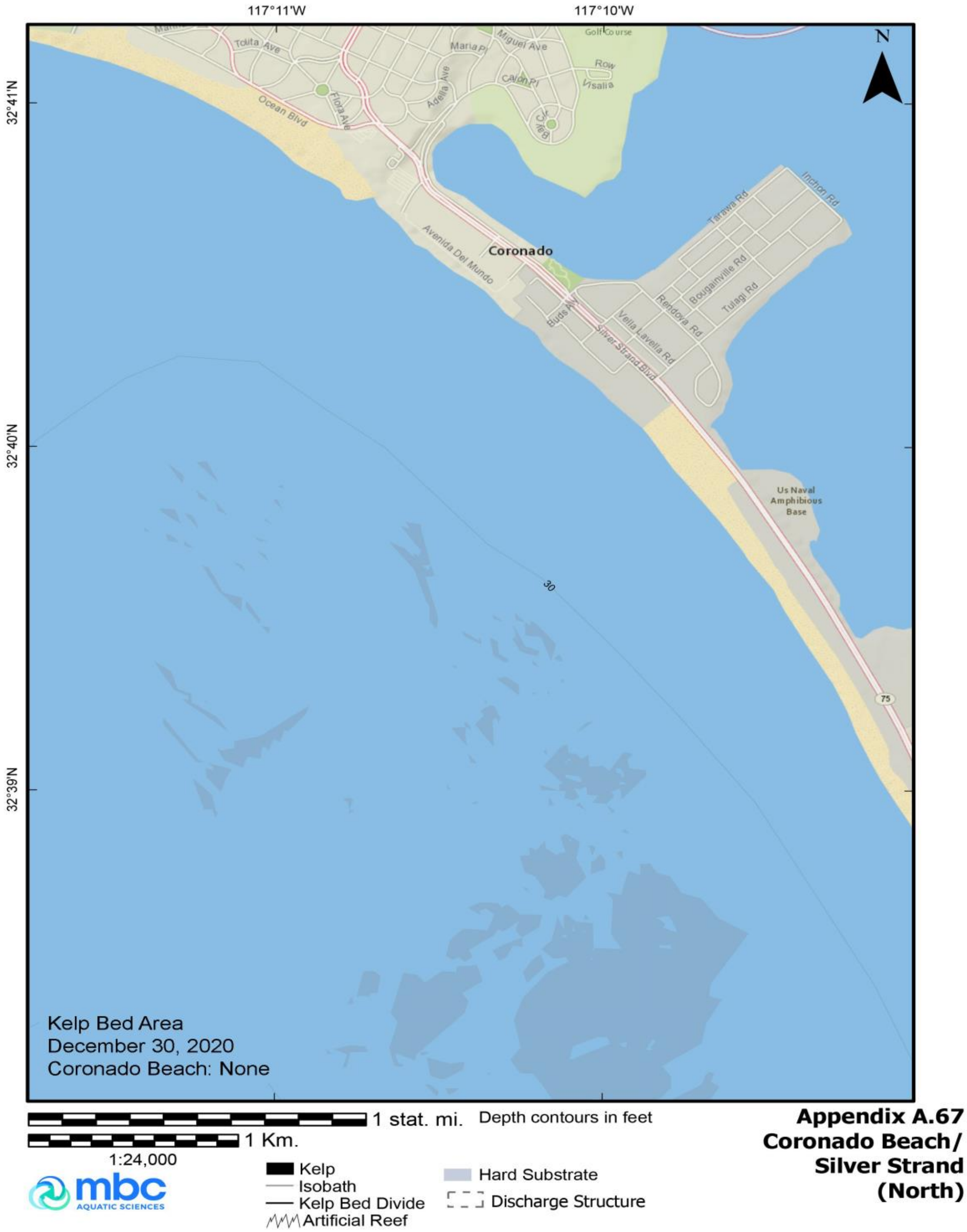
MAP A.67



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MAP A.68

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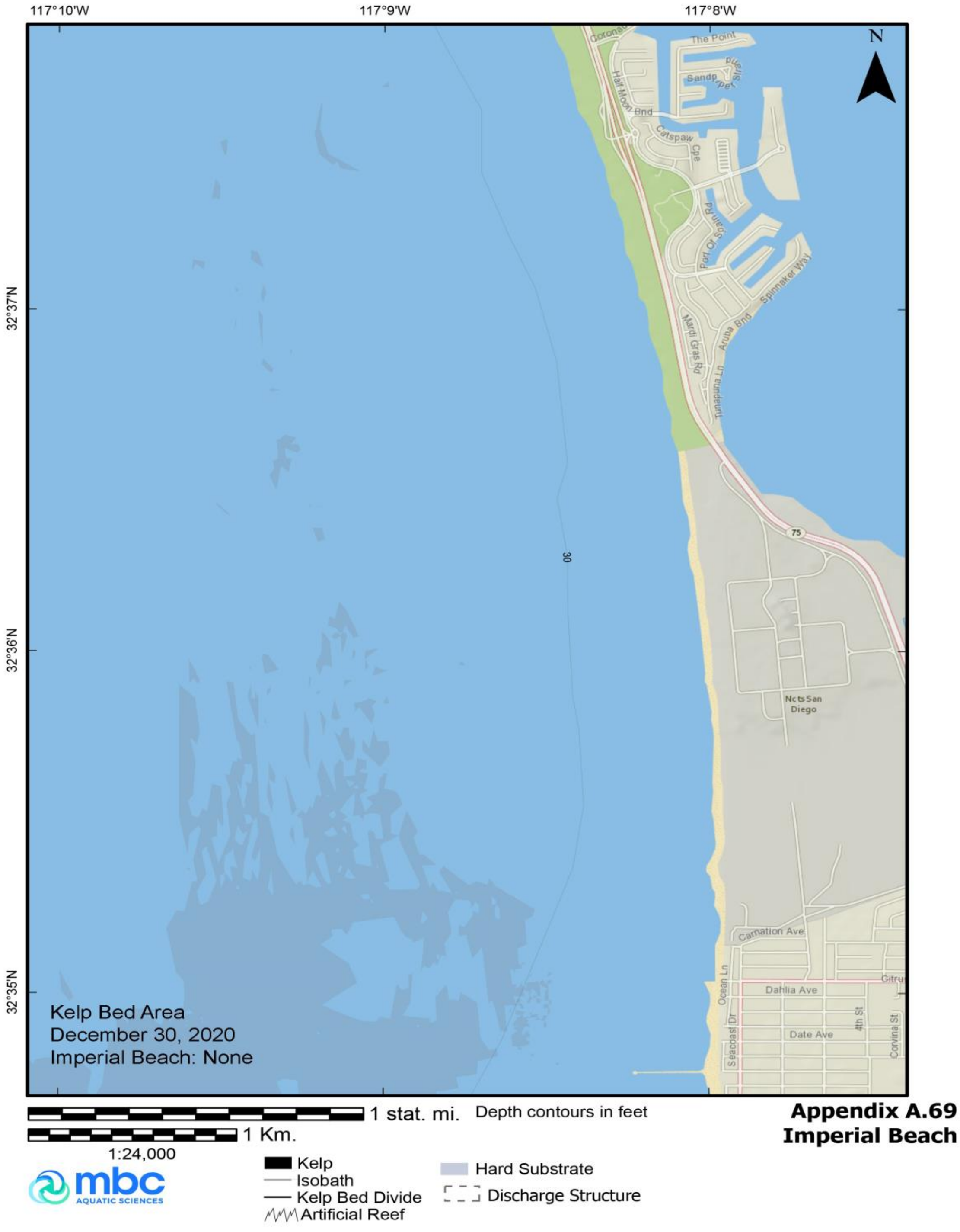
MAP A.69



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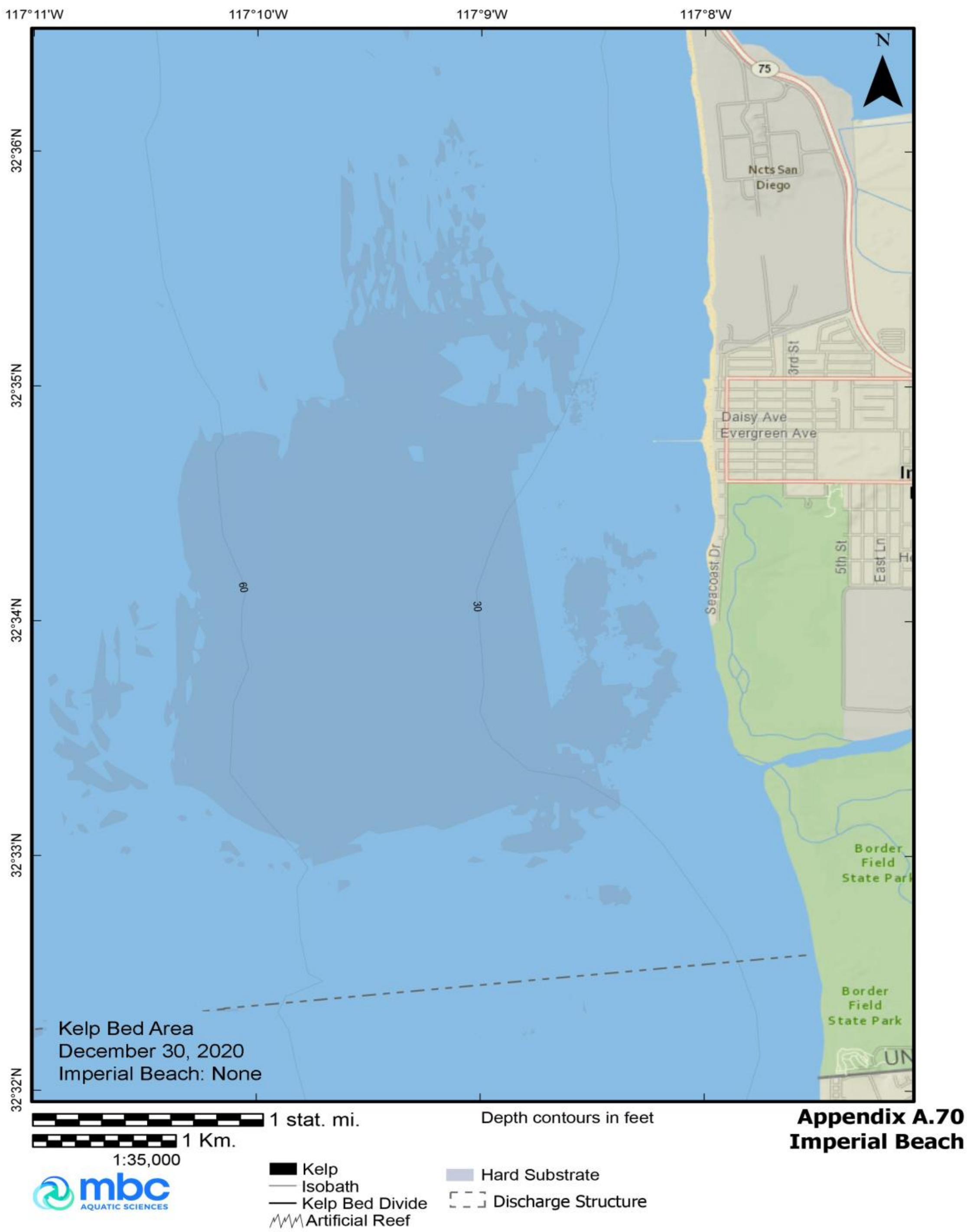
MAP A.70



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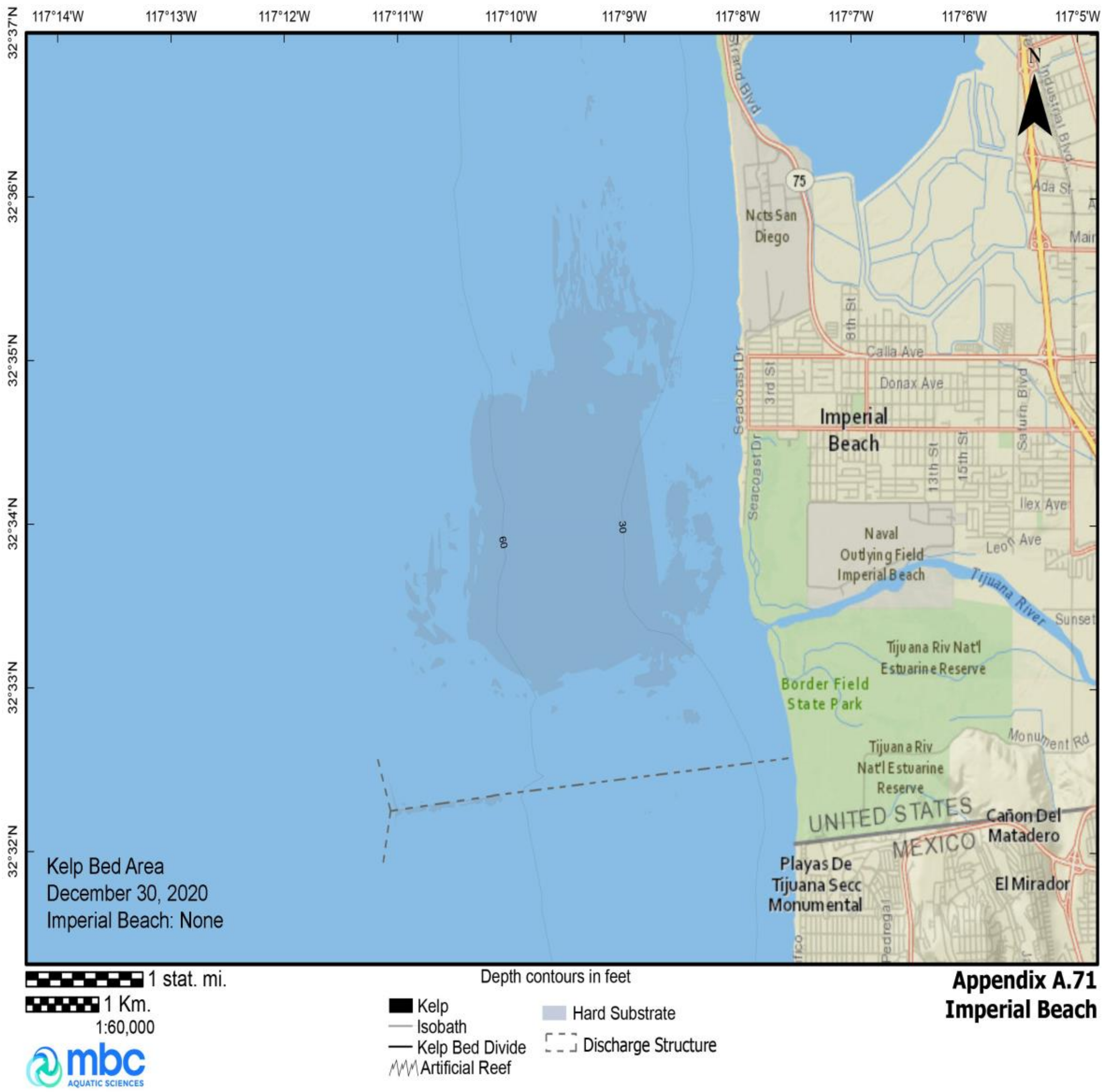
MAP A.71



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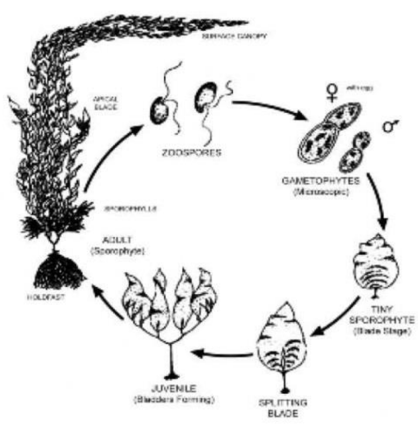
APPENDIX B

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). *Macrocystis* 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 and B.3).

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.4-B.10; 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 (Appendix B.3).

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.3). However, by the end of 2007, Imperial Beach kelp bed measured 1.493 km^2 (Appendix B.3, 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 (km²)											
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).

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Appendix B.3 (Cont.).

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

Appendix B.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

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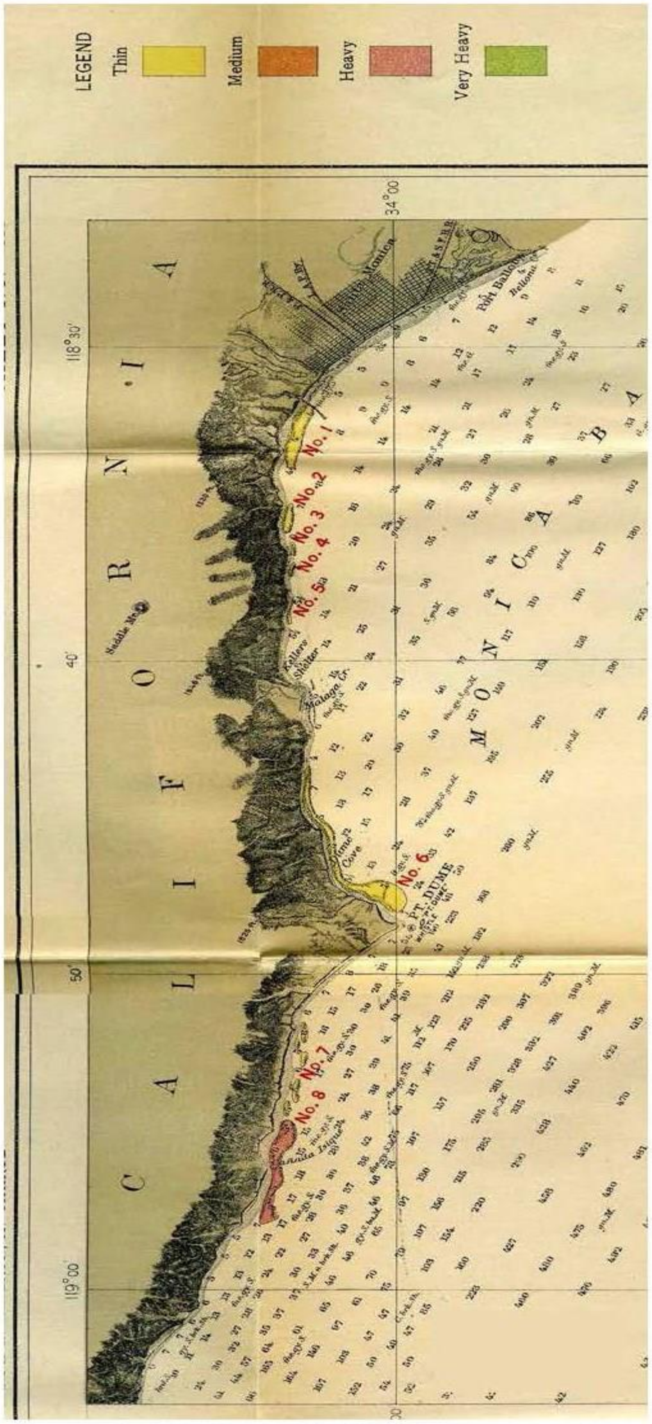
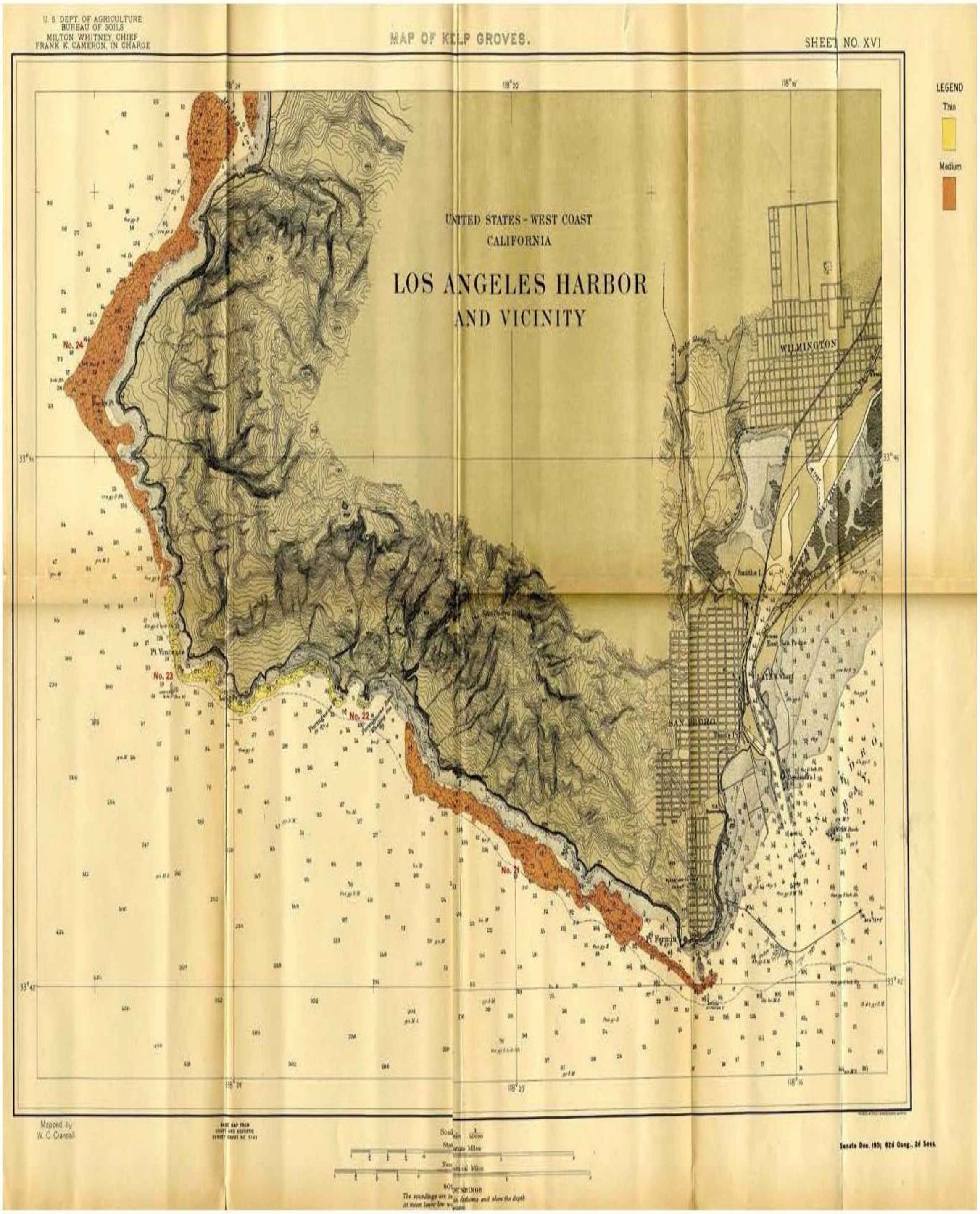


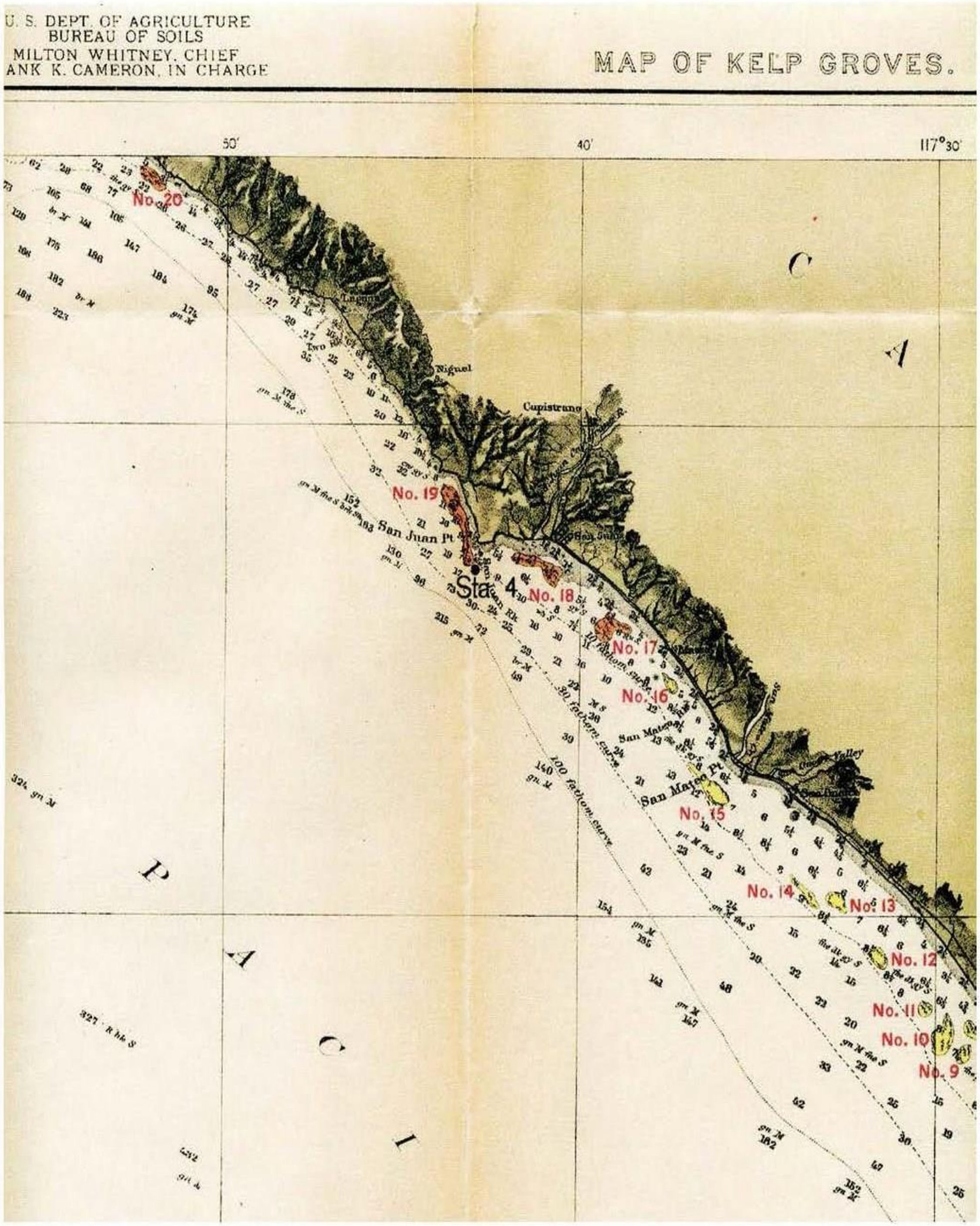
Appendix B.4 Crandall's 1911 kelp survey Deer Creek to Ballona Creek.

Page B-11



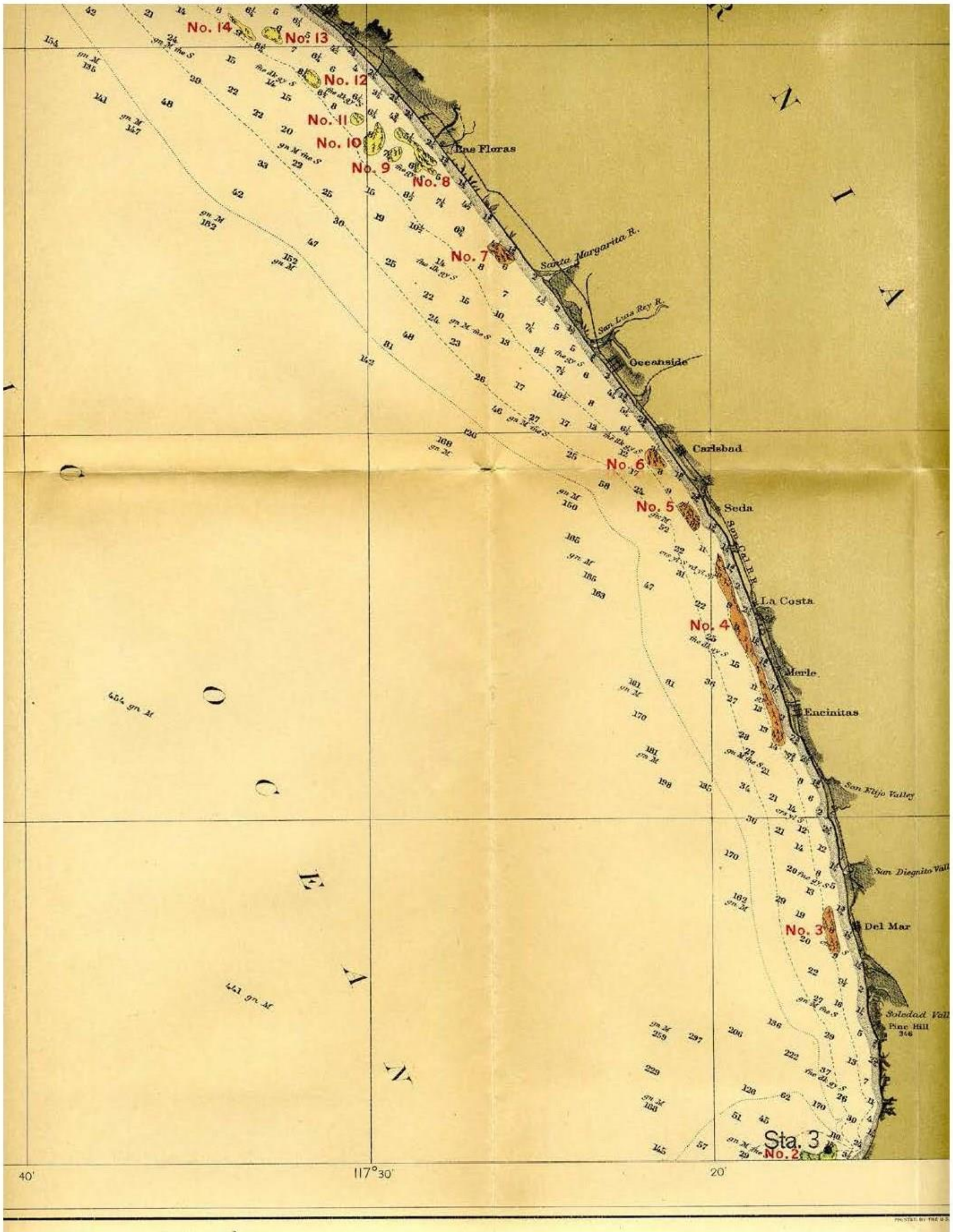
Appendix B.5 Crandall's 1911 kelp survey Palos Verdes to Los Angeles Harbor.

Page B-12



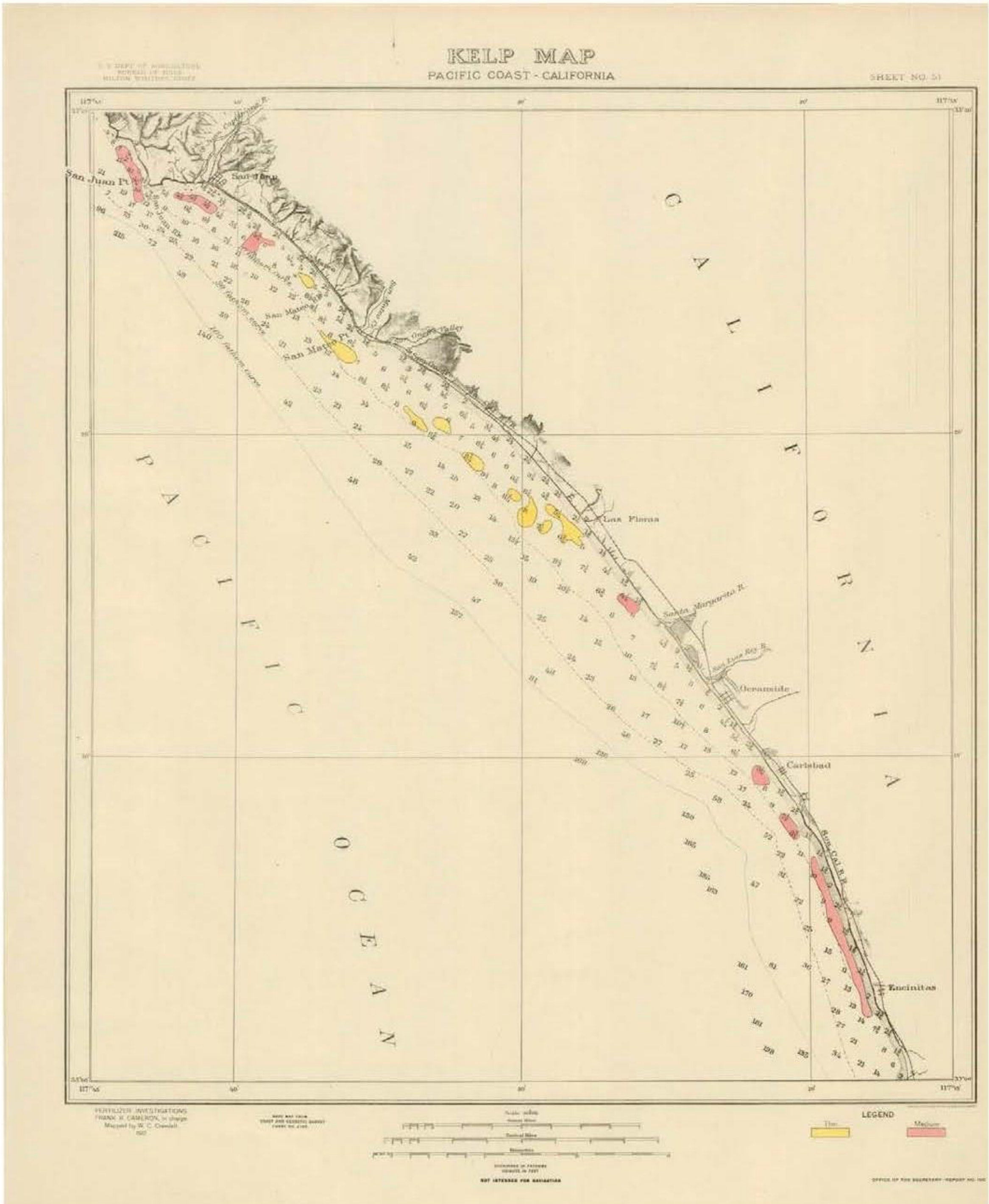
Appendix B.6 Crandall's 1911 kelp bed survey Newport to San Onofre.

Page B-13



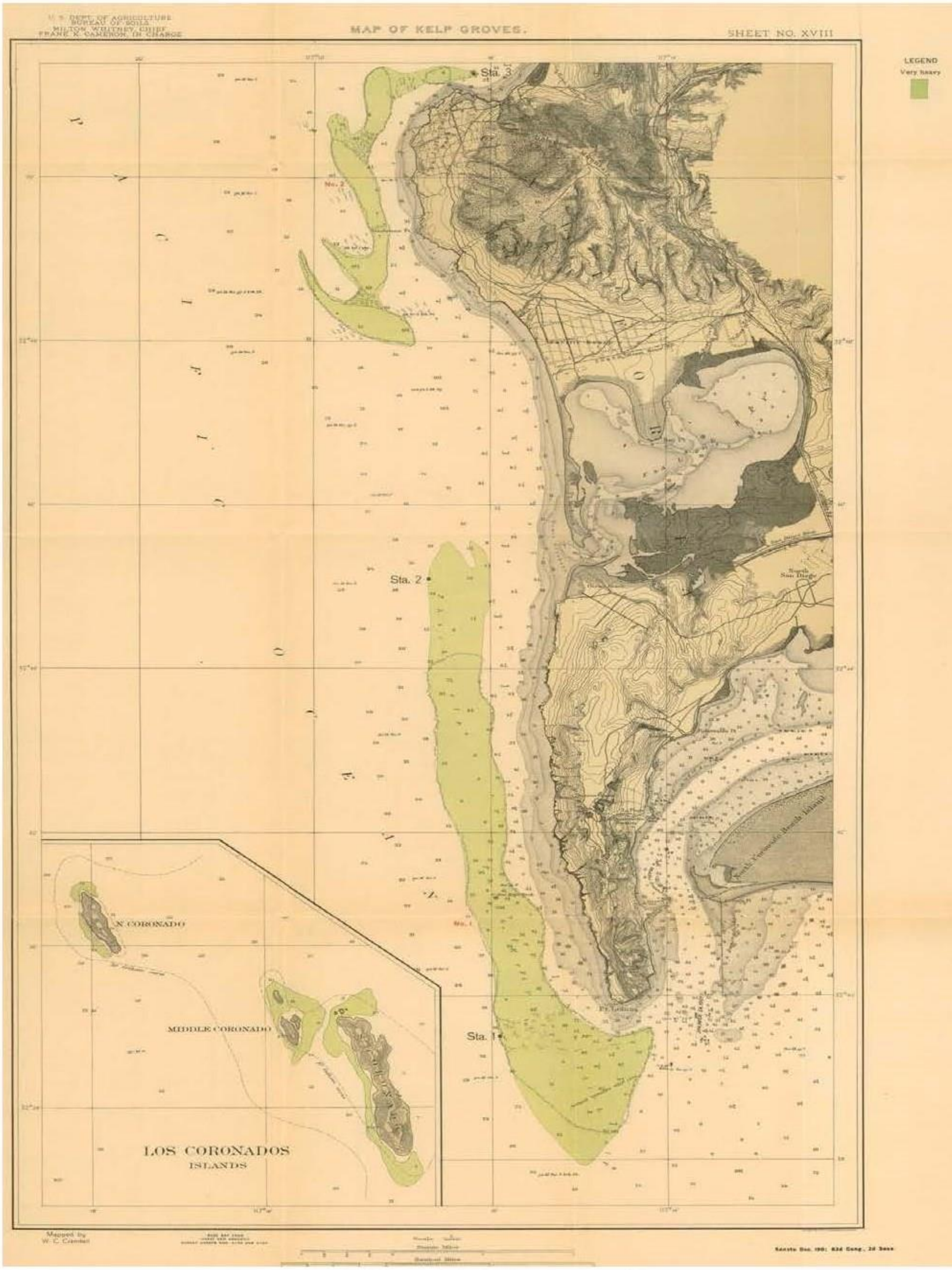
Appendix B.7 Crandall's 1911 kelp bed survey San Onofre to Del Mar.

Page B-14



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

Page B-15



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

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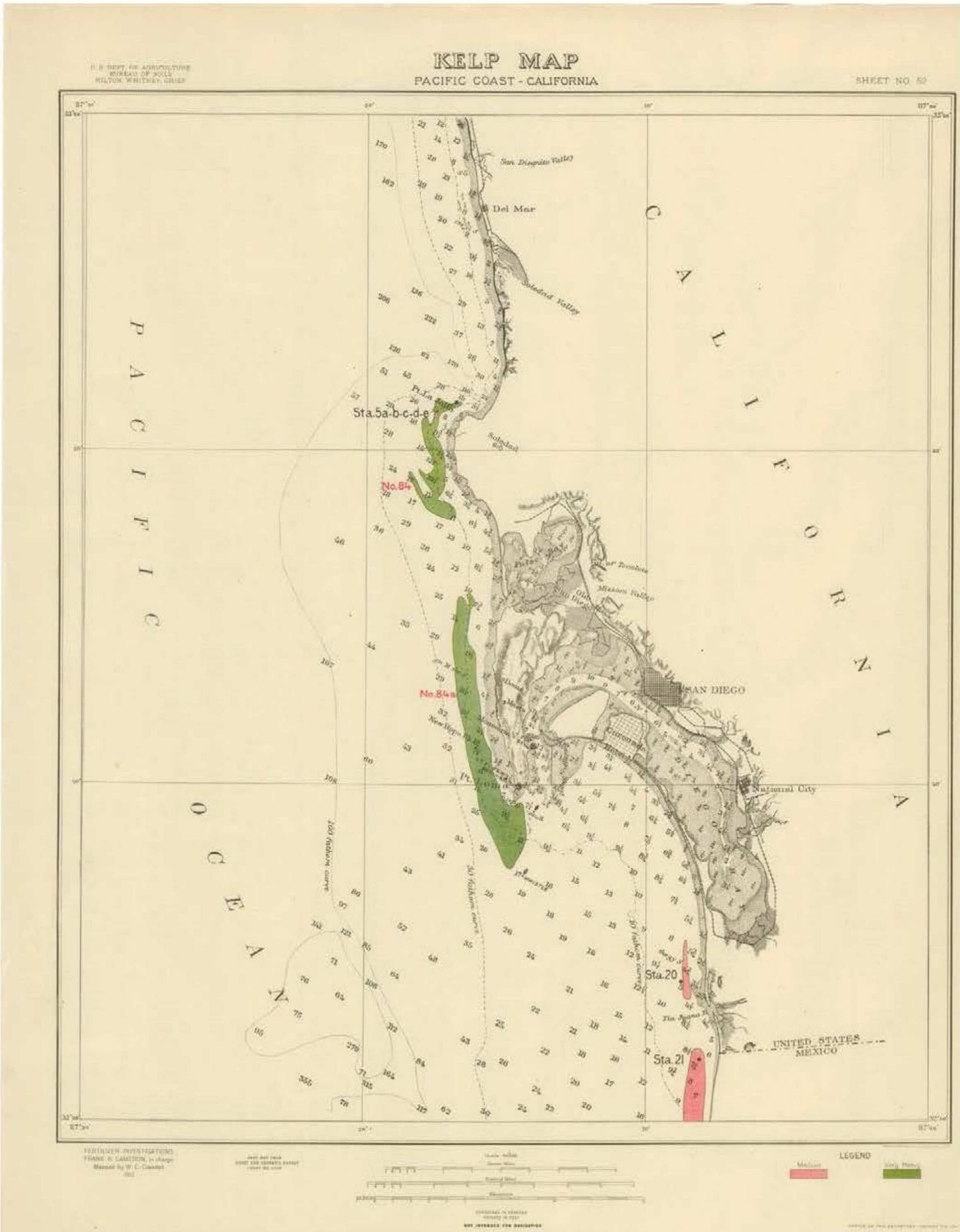

Appendix B.10 Crandall's 1911 kelp bed survey La Jolla to Imperial Beach.

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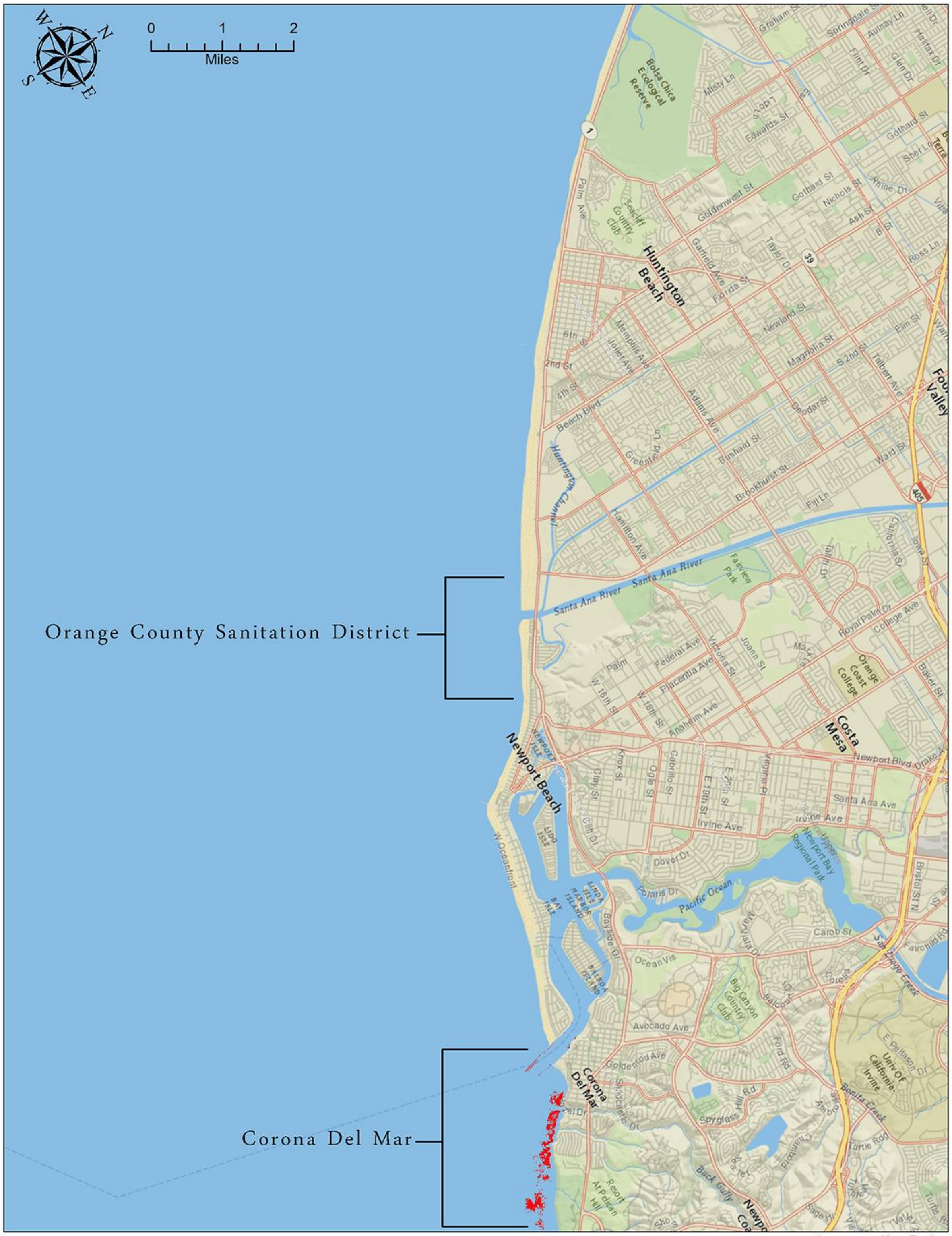
APPENDIX C

FLIGHT PATH

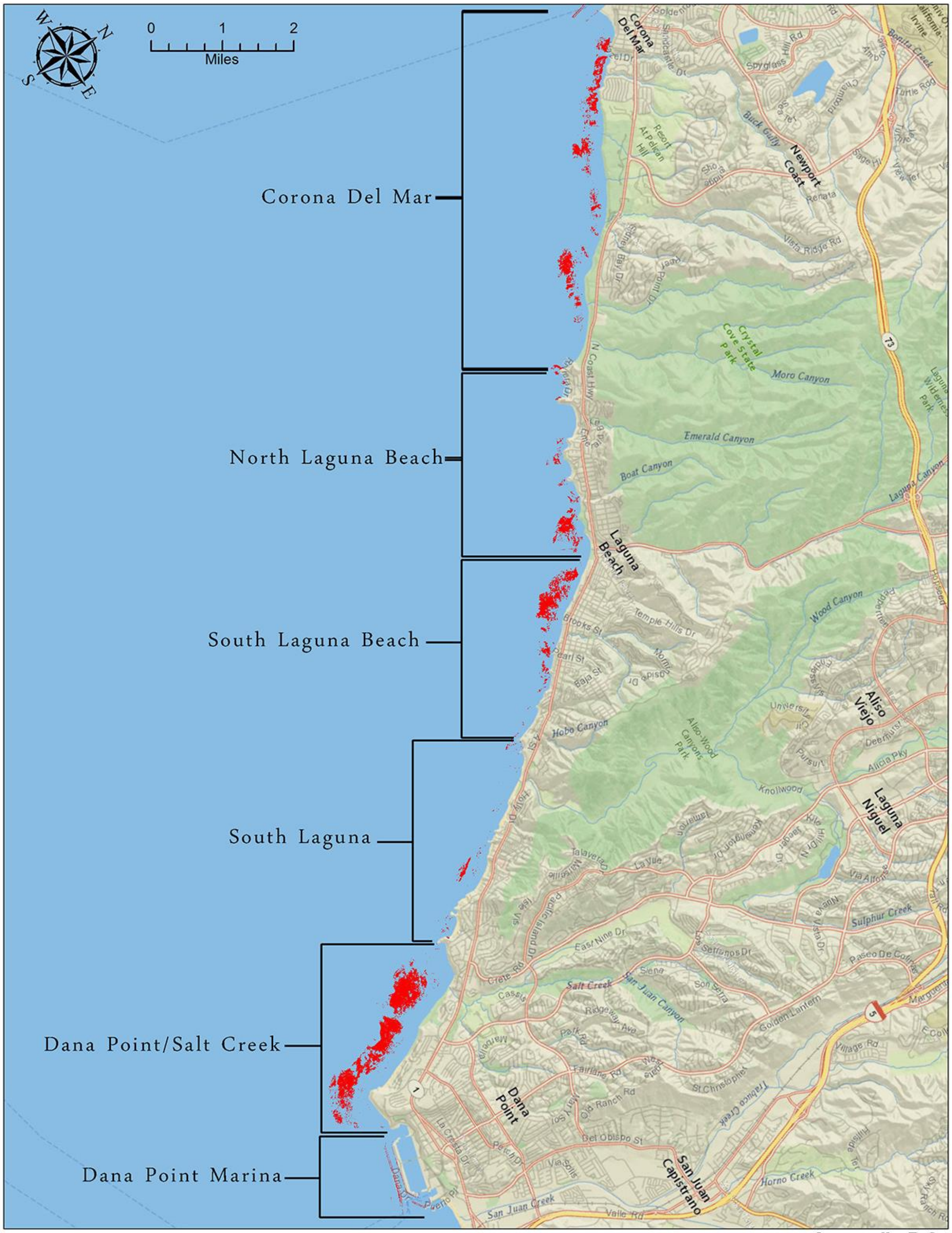
FLIGHT DATA REPORTS

FIELD DATA SHEETS



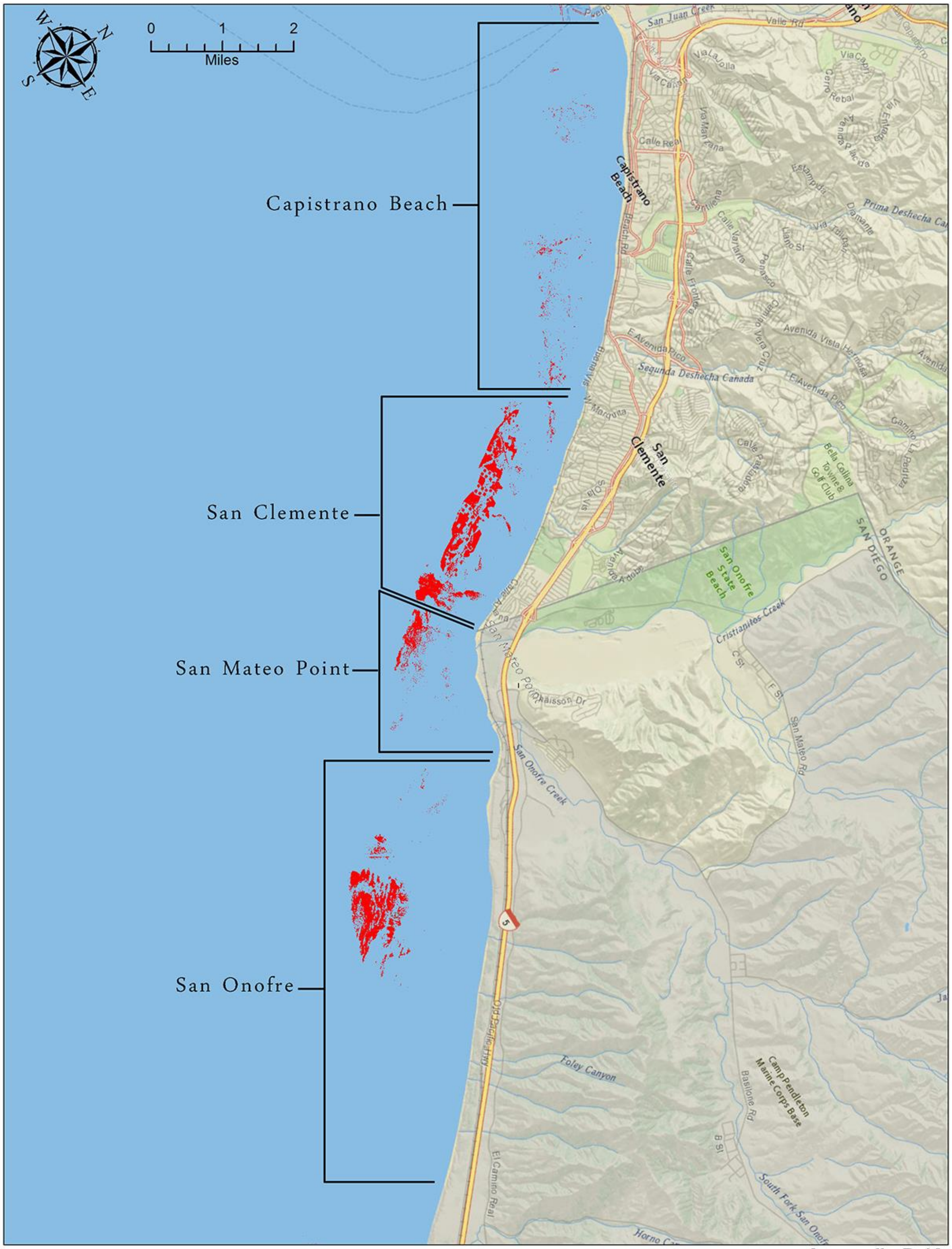
Appendix D.8

Page C-1



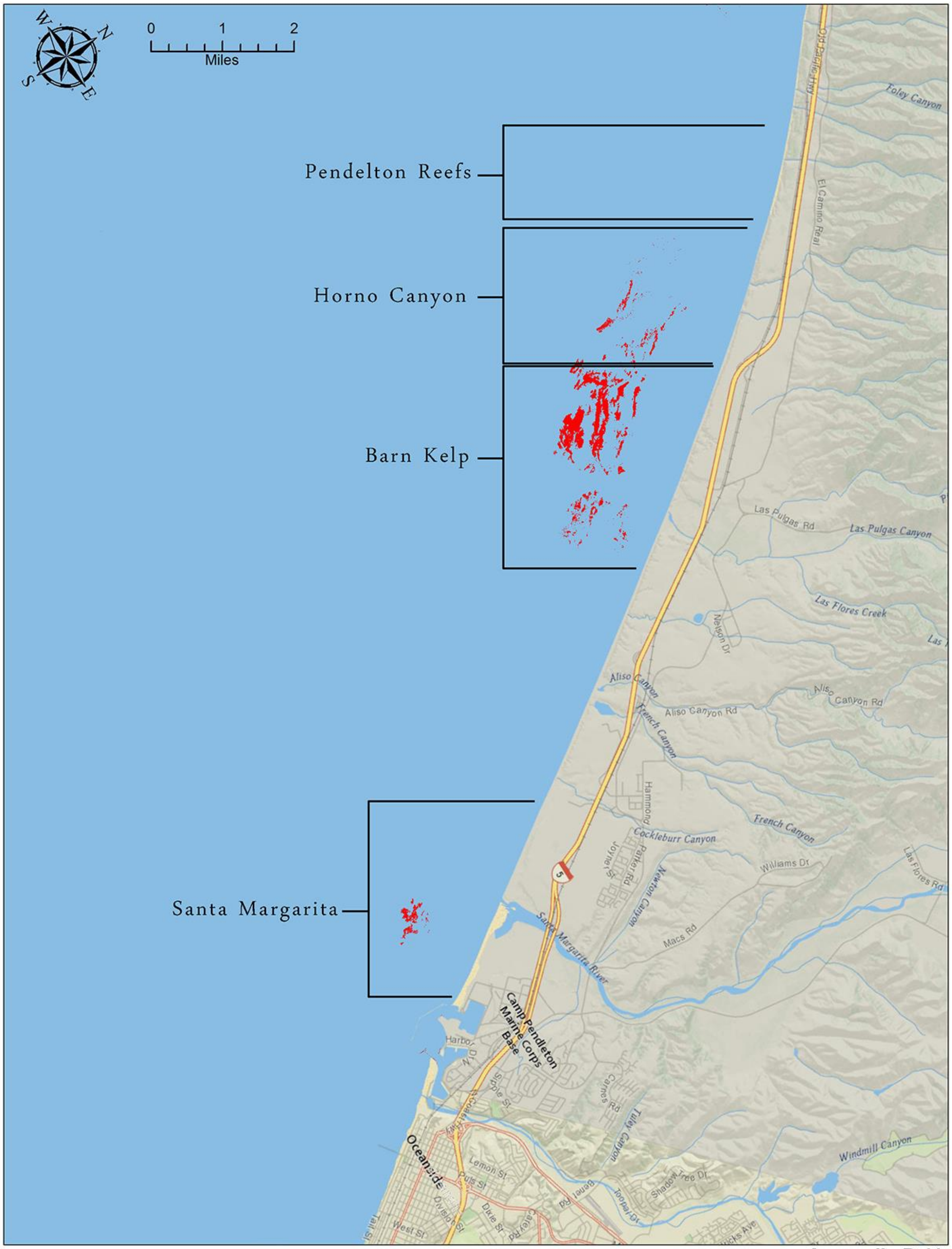
Appendix D.9

Page C-2



Appendix D.10

Page C-3



Appendix D.11

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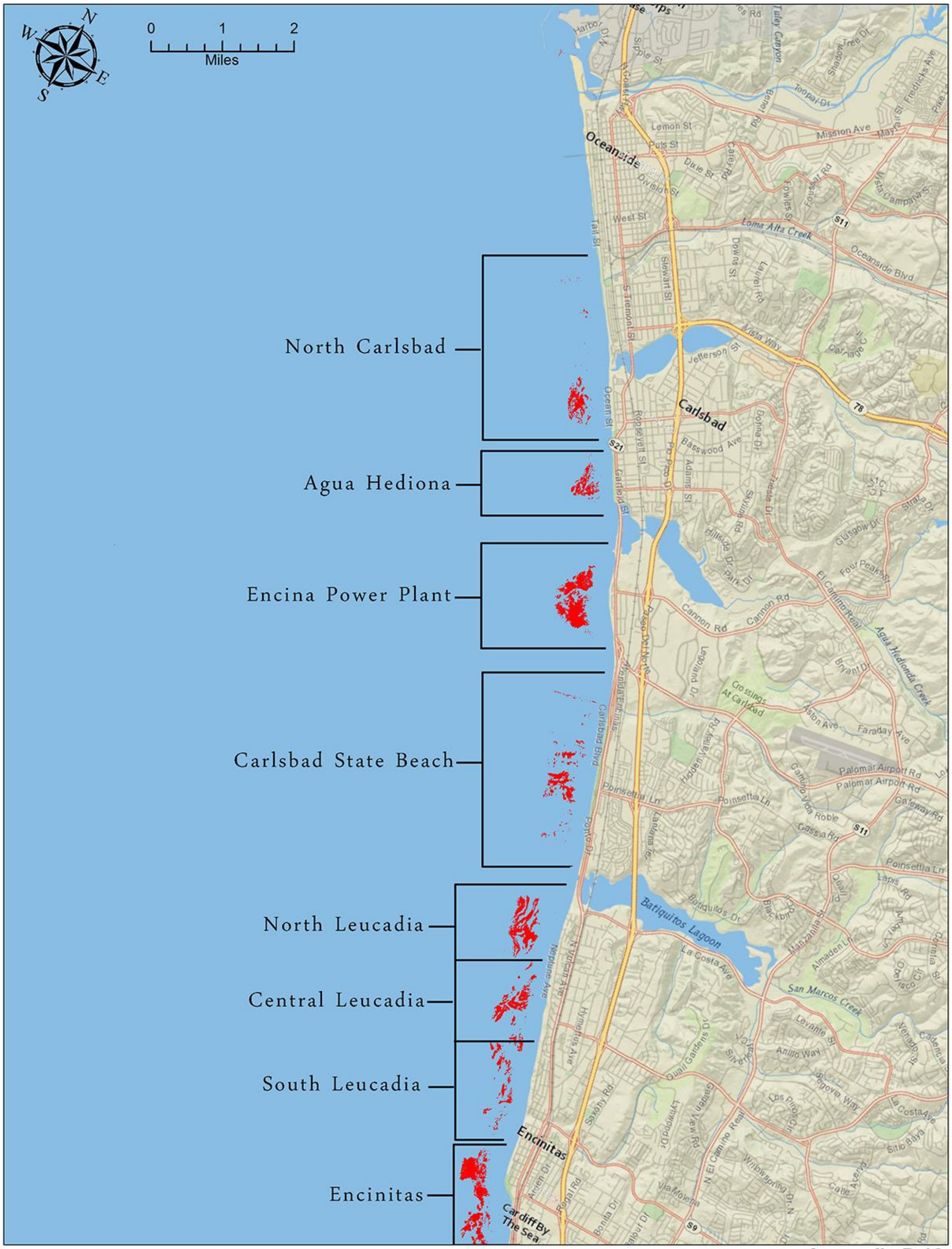

Appendix D.12

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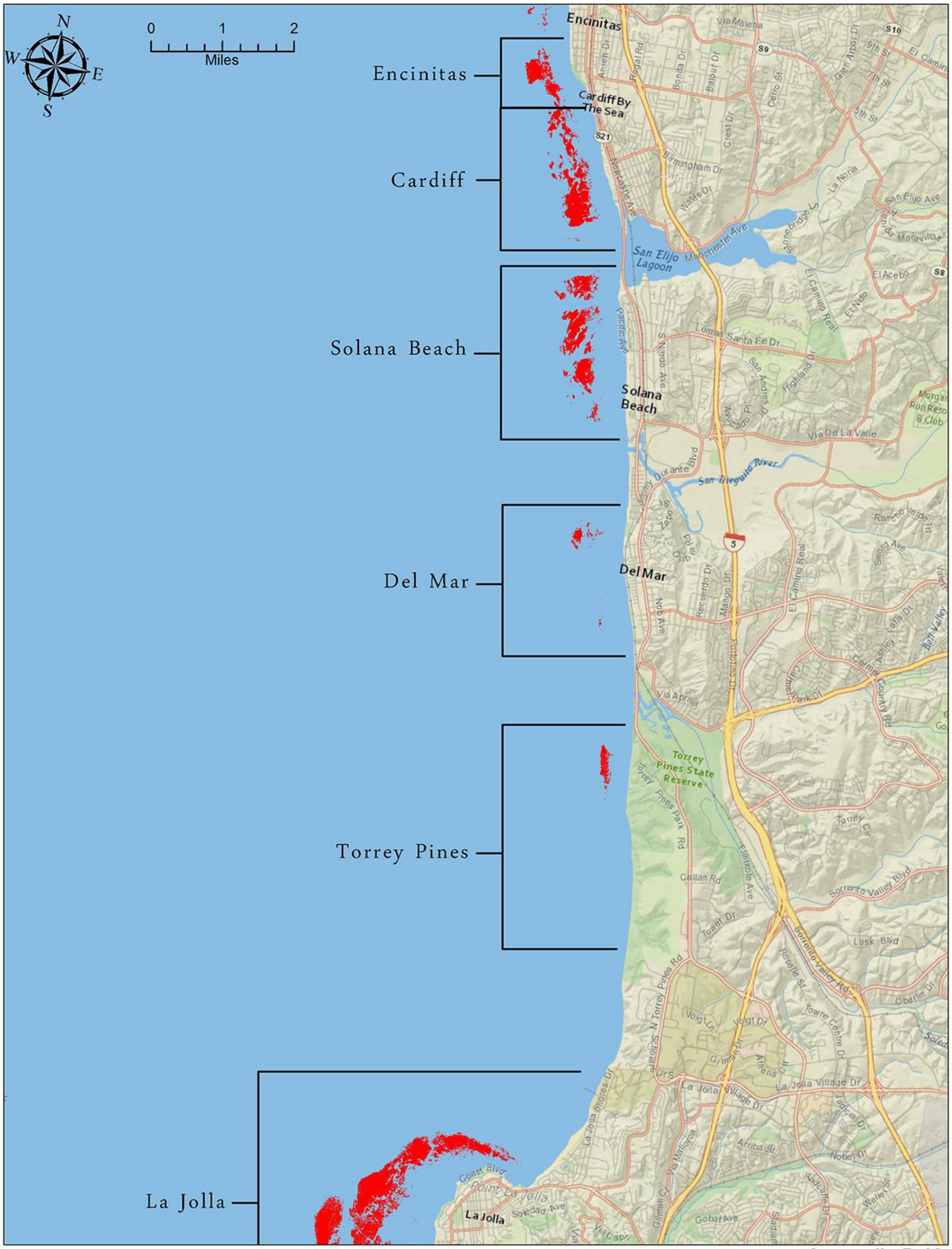

Appendix D.13

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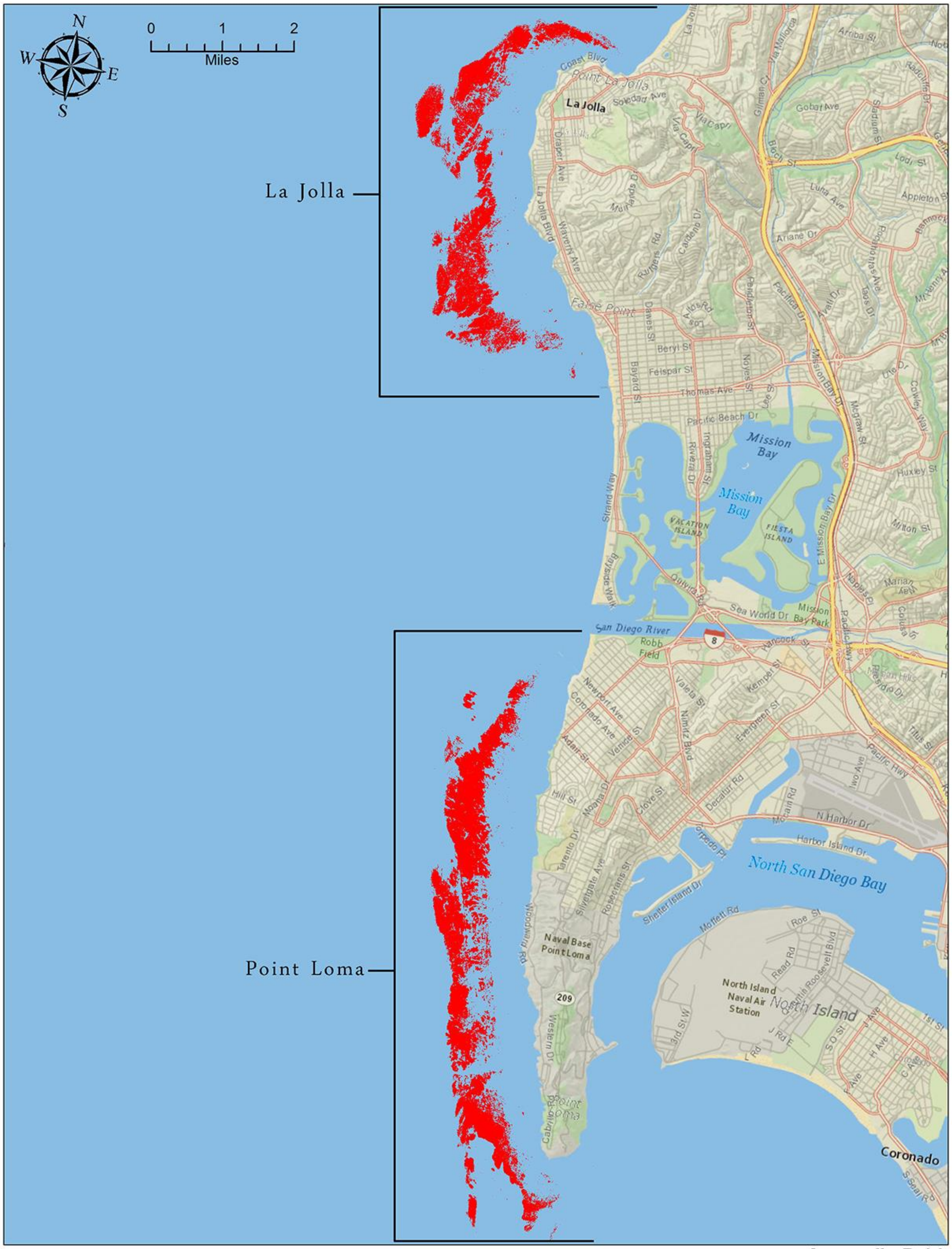

Appendix D.14

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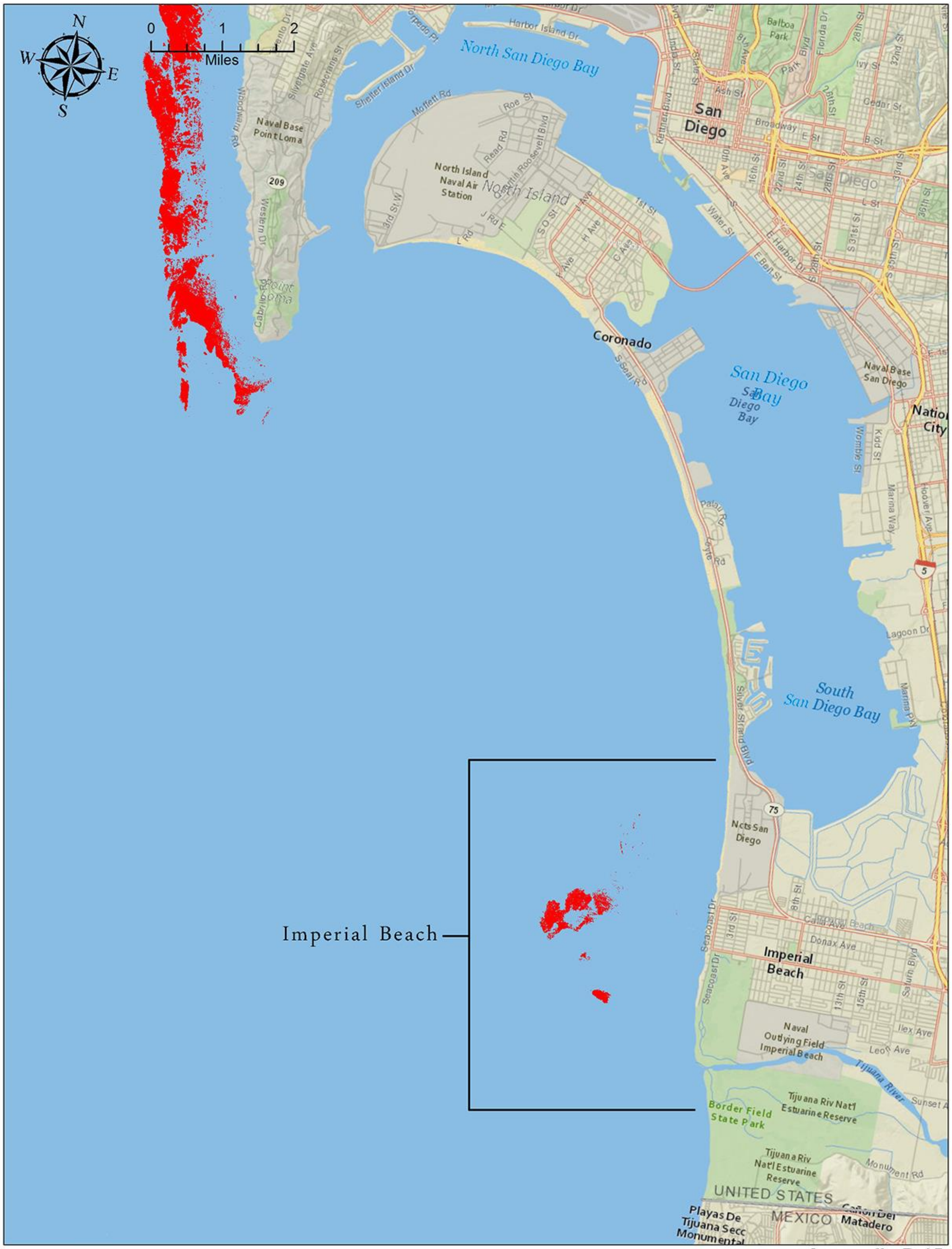

Appendix D.15

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Ecoscan Resource Data
Data Acquisition
Flight Data Report

Contracting Agency/Contact		Contract/Order #/Agency File #	
Contracting Agency:	MBC Applied Environmental Sciences	**Contract/Order #:**	
Division:		**Agency File #:**	
Contact/Title:	Michael Lyons	**Calendar**	
Address:	3000 Redhill Ave.	**Services Ordered:**	03/20
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	04/15/2020
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	04/20

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

Project Title	**California Coastal Kelp Resources - Ventura to Imperial Beach - April 15, 2020**
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:		**April 15, 2020**			
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:	1401-1534
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	0.8' (+) to 2.0' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

Range (s) Surveyed	Ventura Harbor to Imperial Beach.	
Target Resource Observations	Kelp Canopies	Kelp canopies throughout the range showed a continued reduction in surface extent, and the only significant kelp observed was that along the Palos Verdes Penninsula. A significant red tide was observed in several of the kelp bearing areas. The surface kelp canopy in these areas may be observed as distinct patches within the red tide, which apears as a "fog" covering large areas.
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

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Ecoscan Resource Data
Data Acquisition
Flight Data Report

Contracting Agency/Contact		Contract/Order #/Agency File #	
Contracting Agency:	MBC Applied Environmental Sciences	**Contract/Order #:**	
Division:		**Agency File #:**	
Contact/Title:	Michael Lyons	**Calendar**	
Address:	3000 Redhill Ave.	**Services Ordered:**	06/20
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	07/05/2020
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	07/20

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - July 5, 2020**
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: **July 5, 2020**

	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:	1502-1644
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	2.2' (+) to 2.5' (+) 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, again, showed a reduction in surface extent, and the only significant kelp observed was that along the Palos Verdes Penninsula, and to a leser extent, from Pt. Mugu to Malibu and LaJolla to Pt. Loma.
Imagery Quality/ Comments	Excellent	All surface kelp canopies were photographed within the above range. All of the imagery was judged of good/excellent quality. Some patchy fog was present from La Jolla to Pt. Loma. Imagery from two passes was included to insure that no kelp was obscured by the fog.
	Lens Note	30mm (digital SLR camera) is similiar focal length to 50mm (35mm film SLR camera)

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Signed: ______________________ Bob Van Wagenen, Director

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Ecoscan Resource Data
Data Acquisition
Flight Data Report

Contracting Agency/Contact		Contract/Order #/Agency File #	
Contracting Agency:	MBC Applied Environmental Sciences	Contract/Order #:	
Division:		Agency File #:	
Contact/Title:	Michael Lyons	Calendar	
Address:	3000 Redhill Ave.	Services Ordered:	09/20
City/State/Zip:	Costa Mesa, CA 92626	Data Acquisition Completed:	09/18/2020
Phone 1/Phone 2:	(714) 850-4830	Draft Report Materials Due:	
Fax/E-Mail:	(714) 850-4840	Final Report Materials Due:	09/20

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - September 18, 2020**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Newport Pier to Imperial Beach (map pages 65-72)
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 18, 2020

	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:	5 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1712-1804
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	0.5' (+) to 1.1' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Good-Excellent Conditions

Range (s) Surveyed	Ventura Harbor to Imperial Beach.	
Target Resource Observations	Kelp Canopies	Kelp canopies throughout the range, again, showed a reduction in surface extent, and the only significant kelp observed was that from LaJolla to Pt. Loma.
Imagery Quality/ Comments	Good-Excellent Lens Note	All surface kelp canopies were photographed within the above range. All of the imagery was judged of good/excellent quality. Significant smoke from several wildfires was present throughout the survey range. Images were "dehazed" within Photoshop to fully reveal surface kelp canopies. 30mm (digital SLR camera) is similiar focal length to 50mm (35mm film camera)

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Signed: ______________________ Bob Van Wagenen, Director

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Ecoscan Resource Data
Data Acquisition
Flight Data Report

Contracting Agency/Contact		Contract/Order #/Agency File #	
Contracting Agency:	MBC Applied Environmental Sciences	**Contract/Order #:**	
Division:		**Agency File #:**	
Contact/Title:	Michael Lyons	**Calendar**	
Address:	3000 Redhill Ave.	**Services Ordered:**	12/20
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	12/30/2020
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	01/21

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - December 30, 2020**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura Harbor to Imperial Beach (map pages 57-72)
Survey Data Flow	**Acquisition** Processing Analysis Presentation	Vertical color IR digital imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC for further processing and analysis All survey imagery presented with 8"x10" contact sheets (12 images/per page)

Aerial Resource Survey Flight Data for:		**December 30, 2020**			
	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:	3-4 feet
	Radio Telemetry	Film:	Digital Color IR	Time:	1300-1430
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	1.3' (+) to 0.3' (-) 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, again, showed a reduction in surface extent, and the only significant kelp observed was on the north side of the Palos Verdes peninsula and from LaJolla to Pt. Loma.
Imagery Quality/ Comments	Excellent	All surface kelp canopies were photographed within the above range. All of the imagery was judged of excellent quality.
	Lens Note	30mm (digital SLR camera) is similiar focal length to 50mm (35mm film camera) SLR)mera)

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

Signed: ______________________ Bob Van Wagenen, Director

Copy To:

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: CRHarneberg
Lat/Long: 32° 34.212' 117°09.332'

Date: 22 Dec 20
Location: Imperial Beach
Time: 0840

TOPSIDE OBSERVATIONS

Wind/Direction
Current

Kelp Canopy

Weather
UW Visibility (est.)

Extent: None
Swell Ht/Period
Density
Tissue color
% Frond comp. ____ Senile ____ Mature ____ Young ____ Other
Disease
Encrustation
Surface Stipe Length
Apical blades
Depth (offshore)
Sediment on blades
Depth (other[note])

Remarks

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color: None
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color: None
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
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

Bat Seastar 𝍸 ||||| |||| 3 =18
P. urchin 𝍸 𝍸 𝍸 𝍸 ||||| 14 8 2 13 = 67
Kellet Snail (1)
White urchin |||| =4

REMARKS Total Juv Recruit

Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: RHMoore
Lat/Long: 32°33.222' 117°09.694'
Historical Bed Persistency

Date: 22 Dec 20
Location: Imperial Beach
Time: 0900
Wind/Direction:
Current:
Weather:
UW Visibility (est.):
Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: None
Density:
Tissue color:
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease:
Encrustation:
Apical blades:
Sediment on blades:
Surface Stipe Length:
Depth (offshore):
Depth (other[note]):

Remarks

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color: None
Encrustation:
Disease:
Sediment on blades:
Sinking fronds:
Grazed tissues:

Bottom

Tissue color: None
Encrustation:
Disease:
Sediment on blades:
Sinking fronds:
Grazed tissues:
Sporophylls:
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

Cobble / Boulder 5'

S purp - 5f3+III =11
S franc 14+5+12+10+11+13+10 =65
Patiria ~~HH~~ ~~HH~~ ~~HH~~ IIII =19
Cytechinus 2+2 =4
Abalone 1

REMARKS Adult Abalone Juven. Recruit

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer:	R. Moore L. Hornsby	Date	22 Dec 20
Lat/Long:	32°39.378' 117°15.120'	Location	Pt Loma S
		Time	1025
TOPSIDE OBSERVATIONS		Wind/Direction	2 kn S
		Current	Up c
Kelp Canopy		Weather	P. Cloudy
		UW Visibility (est.)	10-15'
Extent	@ 0.5 in /off + mile up/down	Swell Ht/Period	2-3' W
Density	Thick		
Tissue color	Dk Yellow 90%		
% Frond comp.	5% Senile 95% Mature	1% Young	Other
Disease	N		
Encrustation	Y 5%	Depth (offshore)	~70'
Apical blades	Y 5%	Depth (other)	55' Downcoast
Sediment on blades	N		
Remarks		3m on Sfc	55'

Subsurface @ 0.5 m downcoast to 20' below Sfc

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
Sporophylls
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 Density decreased @ 0.8 miles - mid P.Loma
Scattered out to 70/80', Patches inshore

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer:	R Moore L. Hornsby	Date	22 Dec 20
Lat/Long:	32°43.562' 117°16.245'	Location	P. Loma N
		Time	1050
TOPSIDE OBSERVATIONS		Wind/Direction	~ Lt S
		Current	
Kelp Canopy		Weather	P. Cloudy
		UW Visibility (est.)	10'-15'
Extent	~~Scatt~~ ~50m wide very sparse	Swell Ht/Period	2-3' WSW
Density	Scattered		
Tissue color	Lt Yellow		

% Frond comp. 99 Senile ____ Mature 1% Young ____ Other

Disease	N		
Encrustation	Y - Heavy	Depth (offshore)	50'
Apical blades	(1)	Depth (other)	
Sediment on blades	N		

Remarks Some Larger patches upcoast C 3m long on surface

Subsurface V. Scattered

UNDERWATER OBSERVATIONS

Midwater		**Community**	
Tissue Color		Litter	
Encrustation		Turf algae	
Disease		Turf invert.	
Sediment on blades		Shrub algae	
Sinking fronds		Large Invert.	
Grazed tissues		Fishes	
		Disease	
Bottom		Sed. on rocks	
Tissue color		Urchin status	
Encrustation			
Disease		**Bottom characteristics**	
Sediment on blades			
Sinking fronds			
Grazed tissues			
Sporophylls			
Juvenile fronds			
Holdfasts			
Old holdfasts			
Recruitment			

REMARKS Density thick @ 1mi S. PLN @ 100-150m wide

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer:	R Moore L. Hornsby	Date	22 Dec 20
Lat/Long:	32° 48.104' 117° 16.774'	Location	La Jolla S
		Time	1114
TOPSIDE OBSERVATIONS		Wind/Direction	2 kn S
		Current	
Kelp Canopy		Weather	P. Cloudy
		UW Visibility	20'
Extent	Mile + ~1.7 miles	Swell Ht/Period	2-3' SW
Density	Thick		
Tissue color	80% dk Yellow 10% Light		

% Frond comp. 10% Senile 90 Mature ______ Young ______ Other

Disease N

Encrustation Y 50%

Apical blades Y below surface

Sediment on blades N

Remarks

55' depth
Frond Length 3-4m
V. Visibility ~ 20'
Offshore depth 70'

Subsurface Very scattered

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

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: R. Moore L. Hornsby
Lat/Long: 32° 51.2691 117° 16.6471

Date: 22 Dec 20
Location: La Jolla N
Time: 1137
Wind/Direction: 2-3 S
Current:
Weather: P. Cloudy
UW Visibility (est.):
Swell Ht/Period: 2-3' SW

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: V. Scattered
Density: V. Scatter
Tissue color:
% Frond comp. 50% Senile 50% Mature ____ Young ____ Other
Disease: N
Encrustation: Y - 50%
Apical blades: ~~N~~ Y
Sediment on blades: N

Depth (offshore): 50'
Depth (other): ~~50~~
Frond length 3 to 5m

Remarks

Subsurface

UNDERWATER OBSERVATIONS

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

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

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

Bottom characteristics

REMARKS from 1.6 miles v. scattered but ~~steady~~ irregular subsurface Patch inshore

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer:	R. Moore L. Hangsby	Date	22 Dec 20
Lat/Long:	32° 53.546 117° 15.601	Location	Torrey Pines
		Time	1150
TOPSIDE OBSERVATIONS		Wind/Direction	~5 kn S
		Current	
Kelp Canopy		Weather	P. Cloudy
		UW Visibility (est.)	
Extent	N	Swell Ht/Period	2-3' WSW
Density			
Tissue color			

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

Disease			
Encrustation		Depth (offshore)	
Apical blades		Depth (other)	
Sediment on blades		Frond length	

Remarks

Subsurface

UNDERWATER OBSERVATIONS

Midwater		**Community**	
Tissue Color		Litter	
Encrustation		Turf algae	
Disease		Turf invert.	
Sediment on blades		Shrub algae	
Sinking fronds		Large Invert.	
Grazed tissues		Fishes	
		Disease	
Bottom		Sed. on rocks	
Tissue color		Urchin status	
Encrustation			
Disease		**Bottom characteristics**	
Sediment on blades			
Sinking fronds			
Grazed tissues			
Sporophylls			
Juvenile fronds			
Holdfasts			
Old holdfasts			
Recruitment			

REMARKS

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: RMoore
Lat/Long: 32° 59.154' 117° 16.9621

Date 22 Dec 20
Location Solana Beach
Time 1220
Wind/Direction
Current
Weather
UW Visibility (est.)
Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

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

Surface Stipe Length
Depth (offshore)
Depth (other[note])

Remarks

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color Md Yellow 80% Dk Yel 20%
Encrustation Y
Disease N
Sediment on blades N
Sinking fronds N
Grazed tissues

Community

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

Bottom

Tissue color Med Yellow Dk Yellow 50%
Encrustation N
Disease N
Sediment on blades N
Sinking fronds N
Grazed tissues N
Sporophylls Yes
Juvenile fronds Y
Holdfasts Y
Old holdfasts N
Recruitment N

Bottom characteristics

REMARKS Adult ~~||||~~ ||| = 8 Juv None Recruit (1)

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: LRH
Lat/Long: 32° 59.154 117° 16.962

Date 2? Dec 20
Location [illegible] Beach
Time 12:20
Wind/Direction
Current
Weather
UW Visibility (est.)
Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent Same
Density V. Scattered
Tissue color
% Frond comp. 90% Senile ___ Mature ___ Young ___ Other
Disease
Encrustation
Apical blades
Sediment on blades

Surface Stipe Length
Depth (offshore)
Depth (other[note])

Remarks

Subsurface Extends c 0.5 mi along reef

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 Med/dk yellow
Encrustation N
Disease N
Sediment on blades N
Sinking fronds
Grazed tissues N
Sporophylls Y
Juvenile fronds Y
Holdfasts
Old holdfasts N
Recruitment N

Bottom characteristics

REMARKS adult: IIII =4 juve. [illegible] [illegible]=2

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: R. Moore L. Hornsby
Lat/Long: 32° 57.484 117°16.605

Date 22 Dec 20
Location Del Mar
Time 1207
Wind/Direction S
Current
Weather
UW Visibility (est.)
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

Depth (offshore)
Depth (other) 40'
Frond length

Remarks

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
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

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Field Data Sheet

mbc AQUATIC SCIENCES

CONDITION OF MACROCYSTIS BED

Observer: R Moore L. Hornsby
Lat/Long: 33°00.494' 117 17.40'

Date 22 Dec 20
Location Cardiff
Time 1320
Wind/Direction 5 <5 kn
Current 0.5 kn Upc
Weather P. Cloudy
UW Visibility (est.) 15'
Swell Ht/Period 2-3' WSW

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent 150m x 150m
Density Medium
Tissue color Dk Yellow 30% lt yellow 30% 76%
% Frond comp. 1% Senile 98% Mature 1% Young ____ Other
Disease N
Encrustation Y 40%
Apical blades Y
Sediment on blades N
Remarks

Depth (offshore) 47'
Depth (other)
Frond 2-5m

Subsurface Yes @ 2/3rds Water depth 10-20' below surface

V. Scattered to upcoast

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
Sporophylls
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

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

MBC AQUATIC SCIENCES

Observer: R. Moore L. Hornsby
Lat/Long: 33 02.099 18.094'

Date 22 Dec 20
Location Encinitas
Time 1330
Wind/Direction
Current
Weather
UW Visibility (est.)
Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent ~ 100 m x 30 m
Density Medium
Tissue color 95 Lt Yellow 5% dk Yellow
% Frond comp. 95% Senile 5% Mature ____ Young ____ Other
Disease N
Encrustation 80%
Apical blades N
Sediment on blades N

Depth (offshore) 41'
Depth (other)

Remarks V. Scattered upcoast

Subsurface Y ~ 10' tall extends upcoast ~ 0.2 mi

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
Sporophylls
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

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: R. Moore L. Hornsby
Lat/Long: 33° 02.034' 117° 17.907'

Date: 22 Dec 20
Location: S. Leucadia
Time: 1335
Wind/Direction:
Current:
Weather:
UW Visibility (est.):
Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: None
Density:
Tissue color:
% Frond comp. ______ Senile ______ Mature ______ Young ______ Other
Disease:
Encrustation:
Apical blades:
Sediment on blades:
Depth (offshore):
Depth (other):

Remarks

Subsurface None

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:
Sporophylls:
Juvenile fronds:
Holdfasts:
Old holdfasts:
Recruitment:

Bottom characteristics

REMARKS

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R Moore L. Hornsby
Lat/Long: 33°03.900' 117°18.650'

Date 22 Dec 20
Location Cent. Leucadia
Time 1340
Wind/Direction
Current
Weather
UW Visibility 20'
Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent 150 m x 30 m
Density Medium in Patch, Scattered outside
Tissue color 95% dk yellow
% Frond comp. 5% Senile 95% Mature + Young ____ Other
Disease N
Encrustation 5%
Apical blades Y
Sediment on blades N
35'
Remarks

Subsurface Yes medium @ 10-20' tall

UNDERWATER OBSERVATIONS

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

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

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

Bottom characteristics

REMARKS

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

Observer: R Moore, L. Hornsby
Lat/Long: 33° 04.481' 117°19.012'

Date 22 Dec 20
Location N. Leucadia
Time 1345
Wind/Direction
Current
Weather
UW Visibility
Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent 80m x 30m
Density Medium
Tissue color Lt Yellow 95%, 5% dk Yell
% Frond comp. 20% Senile 80% Mature ______ Young ______ Other
Disease N
Encrustation 60%
Apical blades (1)
Sediment on blades N
Remarks 45' deep
3 m fronds
Subsurface Yes - Thick around patch thin scattered

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

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer:	R. Moore L. Hornsby	Date	22 Dec 20
Lat/Long:	33°05.959 117°19.737'	Location	Carlsbad St. Beach
		Time	1355
TOPSIDE OBSERVATIONS		Wind/Direction	<5 kts S
		Current	
Kelp Canopy		Weather	P. Cloudy
		UW Visibility (est.)	
Extent	None	Swell Ht/Period	
Density			
Tissue color			

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

Disease			
Encrustation		Depth (offshore)	
Apical blades		Depth (other)	
Sediment on blades			

Remarks

Subsurface None

UNDERWATER OBSERVATIONS

Midwater		**Community**	
Tissue Color		Litter	
Encrustation		Turf algae	
Disease		Turf invert.	
Sediment on blades		Shrub algae	
Sinking fronds		Large Invert.	
Grazed tissues		Fishes	
		Disease	
Bottom		Sed. on rocks	
Tissue color		Urchin status	
Encrustation			
Disease		**Bottom characteristics**	
Sediment on blades			
Sinking fronds			
Grazed tissues			
Sporophylls			
Juvenile fronds			
Holdfasts			
Old holdfasts			
Recruitment			

REMARKS

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: R Moore L. Hornsby
Lat/Long: 33° 07.509' 117° 20.370'

Date 22 Dec 20
Location Encina Power Plant
Time 1408
Wind/Direction
Current
Weather
UW Visibility (est.)
Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

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

Depth (offshore)
Depth (other)

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
Sporophylls
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

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer:	R. Moore L. Hornsby	Date	22 Dec 20
Lat/Long:	33° 08.692' 117° 21.134'	Location	Agua Hedionda
		Time	1410
TOPSIDE OBSERVATIONS		Wind/Direction	<5 kn S
		Current	
Kelp Canopy		Weather	P. Cloudy
		UW Visibility (est.)	10-15'
Extent	None	Swell Ht/Period	2-3' WSW
Density			
Tissue color			

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

Disease			
Encrustation		Depth (offshore)	
Apical blades		Depth (other)	
Sediment on blades			

Remarks

Subsurface None

UNDERWATER OBSERVATIONS

Midwater		**Community**	
Tissue Color		Litter	
Encrustation		Turf algae	
Disease		Turf invert.	
Sediment on blades		Shrub algae	
Sinking fronds		Large Invert.	
Grazed tissues		Fishes	
		Disease	
Bottom		Sed. on rocks	
Tissue color		Urchin status	
Encrustation			
Disease		**Bottom characteristics**	
Sediment on blades			
Sinking fronds			
Grazed tissues			
Sporophylls			
Juvenile fronds			
Holdfasts			
Old holdfasts			
Recruitment			

REMARKS

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: R. Moore L. Hornsby
Lat/Long: 33° 09.441' 117° 21.727'

Date 22 Dec 20
Location N. Carlsbad
Time 1414
Wind/Direction
Current
Weather
UW Visibility (est.)
Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

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

Depth (offshore)
Depth (other) 39'

Remarks

Subsurface Several scattered

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
- Sporophylls
- 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

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer:	R Moore L. Hornsby	Date	17 Mar 21
Lat/Long:	33° 13.000' 117° 25.487'	Location	Santa Margarita
		Time	0830
TOPSIDE OBSERVATIONS		Wind/Direction	2 kn East
		Current	
Kelp Canopy		Weather	Overcast Clear - 20% Cloudy
		UW Visibility (est.)	
Extent	None	Swell Ht/Period	1-2' W
Density			
Tissue color			

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

Disease			
Encrustation		Depth (offshore)	
Apical blades		Depth (other)	
Sediment on blades			

Remarks

Subsurface None metered

UNDERWATER OBSERVATIONS

Midwater		**Community**	
Tissue Color		Litter	
Encrustation		Turf algae	
Disease		Turf invert.	
Sediment on blades		Shrub algae	
Sinking fronds		Large Invert.	
Grazed tissues		Fishes	
		Disease	
Bottom		Sed. on rocks	
Tissue color		Urchin status	
Encrustation			
Disease		**Bottom characteristics**	
Sediment on blades			
Sinking fronds			
Grazed tissues			
Sporophylls			
Juvenile fronds			
Holdfasts			
Old holdfasts			
Recruitment			

REMARKS

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: Robert Moore
Lat/Long: 33° 17.074' 117° 29.496'

Date: 17 Mar 21
Location: Bato Kelp
Time: 0910
Wind/Direction: NE 2 kn
Current:
Weather: P. Cloudy 30%
UW Visibility (est.):
Swell Ht/Period: 1-2' W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: Thick 200m x 100m
Density: Thick
Tissue color: 10% Dark Yellow 90% Lt yellow
% Frond comp.: 10% Senile 80% Mature 10% Young ____ Other
Disease: No
Encrustation: 30%
Apical blades: 5:1
Sediment on blades: No
Surface Stipe Length: 3m
Depth (offshore): 48'
Depth (other[note]):

Remarks

Subsurface Mature @ 0.25m downcoast from canopy

UNDERWATER OBSERVATIONS

Midwater
Tissue Color: 30% Dk 70% Lt Yellow
Encrustation: Yes
Disease: No
Sediment on blades: No
Sinking fronds: Y
Grazed tissues: Y

Bottom
Tissue color: Lt Yellow
Encrustation: No
Disease: No
Sediment on blades: No
Sinking fronds: Yes
Grazed tissues: N
Sporophylls: Yes (Lt. Yel)
Juvenile fronds: Yes
Holdfasts: —
Old holdfasts: No
Recruitment: Yes

Community
Litter: No
Turf algae: Ptero + Laminaria
Turf invert.:
Shrub algae: Ptero & Laminaria
Large Invert.:
Fishes: Blacksmith
Disease:
Sed. on rocks:
Urchin status: S. franc @ 3

Bottom characteristics
Boulders 80%
Sand channels
Cobble

3 lobster

Juvenile Subadult

REMARKS Adult - 6t 15 #41 (= 62) Subadult-1 (=1) JW-5 (=5)

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: Lindsay Hornsby
Lat/Long:

Date: 17 Mar 21
Location: BARN KELP
Time: 0910
Wind/Direction: NE 2kn
Current:
Weather: P. Cloudy 30%
UW Visibility (est.):
Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: (See R.Moore)
Density:
Tissue color:
% Frond comp. ____ Senile ____ Mature ____ Young ____ Other
Disease:
Encrustation:
Apical blades:
Sediment on blades:

Surface Stipe Length:
Depth (offshore):
Depth (other[note]):

Remarks

Subsurface

UNDERWATER OBSERVATIONS

Midwater

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

Bottom

Tissue color: light yellow
Encrustation:
Disease:
Sediment on blades: yes (2)
Sinking fronds:
Grazed tissues: yes (1)
Sporophylls:
Juvenile fronds: NO
Holdfasts: ||||||||| + 20 (= 28)
Old holdfasts: | (= 1)
Recruitment: |||| (= 4)

Community

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

Bottom characteristics

rocky

REMARKS holdfasts contain 9+ stipes
2 stations

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer:	R. Moore L. Hornsby	Date	17 Mar 21
Lat/Long:	33° 18.219 117° 30.321'	Location	Horno Canyon
		Time	0925

TOPSIDE OBSERVATIONS

Wind/Direction

Current Downcoast 1+kn

Kelp Canopy

Weather

UW Visibility (est.)

Extent None

Swell Ht/Period 2' W

Density

Tissue color

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

Disease

Encrustation

Depth (offshore)

Apical blades

Depth (other)

Sediment on blades

Remarks

Subsurface None observed some low profile (shrub?)

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
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Bottom characteristics

REMARKS

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: R Moore
Lat/Long: 33° 19.493 117° 31.626'

Date: 17 Mar 21
Location: Pendleton
Time: 1009
Wind/Direction:
Current:
Weather:
UW Visibility (est.):
Swell Ht/Period:

TOPSIDE OBSERVATIONS

Kelp Canopy

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

Surface Stipe Length:
Depth (offshore):
Depth (other[note]):

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:
Sporophylls:
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

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: R. Moore
Lat/Long: 33° 20.583' 117° 33.481'

Date 17 Mar 21
Location San Onofre
Time 1020
Wind/Direction
Current
Weather
UW Visibility (est.)
Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent None
Density
Tissue color
% Frond comp. ____ Senile ____ Mature ____ Young ____ Other
Disease
Encrustation
Apical blades
Sediment on blades
Surface Stipe Length
Depth (offshore)
Depth (other[note])

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
Sporophylls
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

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: R. Moore
Lat/Long: 33 22.686 117 36.192

Date 17 Mar 20
Location San Mateo
Time 1155

TOPSIDE OBSERVATIONS

Wind/Direction W 6 Kn
Current

Kelp Canopy

Weather 70 % Clouds
UW Visibility (est.)
Swell Ht/Period 2-3' W

Extent Very Scattered individuals
Density
Tissue color Lt. Yellow
% Frond comp. 80 % Senile ____ Mature 20 % Young ____ Other
Disease No
Encrustation Heavy on older
Apical blades No
Sediment on blades No

Depth (offshore) 44'
Depth (other)

Remarks 2 m on sfc.

Subsurface Metered Subsurface @ 0.2 nm from L/L

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
- Sporophylls
- Juvenile fronds
- Holdfasts
- Old holdfasts
- Recruitment

Bottom characteristics

REMARKS

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: R. Moon
Lat/Long: 33°23.786' 117°36.988'

Date 17 Mar 21
Location San Clemente
Time 1215
Wind/Direction 6 W
Current
Weather
UW Visibility (est.) 3-5m
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
Surface Stipe Length
Depth (offshore)
Depth (other[note])

Remarks

Subsurface None

UNDERWATER OBSERVATIONS

Midwater
Tissue Color None
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom
Tissue color None
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
Juvenile fronds
Holdfasts
Old holdfasts
Recruitment

Community
Litter –
Turf algae –
Turf invert. –
Shrub algae –
Large Invert. Para. parvimensis (15) Pis. ochra (1)
Fishes Sheephead (10) Black Surfperch (100)
Disease
Sed. on rocks N
Urchin status 3 S. franc.

Bottom characteristics
Boulders some small sand patches

REMARKS Kelp Bass (1) Barred Sand (8) Blacksmith (20) Lobster (2)

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: Lindsay Hornsby
Lat/Long:

Date 17 Mar 21
Location San Clemente
Time
Wind/Direction
Current
Weather
UW Visibility (est.)
Swell Ht/Period

TOPSIDE OBSERVATIONS

Kelp Canopy

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

Surface Stipe Length
Depth (offshore)
Depth (other[note])

Remarks

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues

Bottom

Tissue color
Encrustation
Disease
Sediment on blades
Sinking fronds
Grazed tissues
Sporophylls
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 3 lobster, 15 sea cucumber, calicat, kelp bass, horn shark, sheephead, black smith

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: R. Moore
Lat/Long: 33° 25.689' 117°38.956'

Date: 17 Mar 21
Location: Capistrano Beach
Time: 1300
Wind/Direction: 6 kn W
Current: Downcoast
Weather: 80% Cloud
UW Visibility (est.):
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 (offshore):
Depth (other):

Remarks

Subsurface Some @20' below sfc

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:
Sporophylls:
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

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: R. Moore

Lat/Long: 33°27.643' 117°43.208'

Date 17 Mar 21

Location Dana Pt / Salt Creek

Time 1315

Wind/Direction W 6 kn

Current

Weather 80 % Clouds

UW Visibility (est.)

Swell Ht/Period 2-3' W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent 0.25 -0.75 mi x 100/150 m

Density Medium

Tissue color Mostly Lt. Yellow 10 % dark Yellow

% Frond comp. 80 % Senile 20 % Mature ____ Young ____ Other

Disease No

Encrustation 80 %

Depth (offshore) 50'

Apical blades No

Depth (other)

Sediment on blades No

Remarks 2-3 m frond length

Subsurface

UNDERWATER OBSERVATIONS

Midwater

Tissue Color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Bottom

Tissue color

Encrustation

Disease

Sediment on blades

Sinking fronds

Grazed tissues

Sporophylls

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 Thick patches inshore

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer:	R. Moore	Date	17 Mar 21
Lat/Long:	33° 28.628' 117° 44.594'	Location	South Laguna
		Time	1340
TOPSIDE OBSERVATIONS		Wind/Direction	6 Kn. W
		Current	
Kelp Canopy		Weather	80% Clouds
		UW Visibility (est.)	
Extent	None	Swell Ht/Period	2-3' W.
Density			
Tissue color			

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

Disease			
Encrustation		Depth (offshore)	
Apical blades		Depth (other)	
Sediment on blades			

Remarks

Subsurface None

P

UNDERWATER OBSERVATIONS

Midwater		**Community**	
Tissue Color		Litter	
Encrustation		Turf algae	
Disease		Turf invert.	
Sediment on blades		Shrub algae	
Sinking fronds		Large Invert.	
Grazed tissues		Fishes	
		Disease	
Bottom		Sed. on rocks	
Tissue color		Urchin status	
Encrustation			
Disease		**Bottom characteristics**	
Sediment on blades			
Sinking fronds			
Grazed tissues			
Sporophylls			
Juvenile fronds			
Holdfasts			
Old holdfasts			
Recruitment			

REMARKS Passed over hardbottom

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer: R. Moore
Lat/Long: 33° 31.744' 117° 46.310'

Date: 17 Mar 21
Location: S. Laguna Beach
Time: 1355
Wind/Direction: 6 kn W
Current:
Weather: 90% clouds
UW Visibility (est.):
Swell Ht/Period: 2-3' W

TOPSIDE OBSERVATIONS

Kelp Canopy

Extent: 0.75mi long 30-40m in/off
Density: Medium to Scattered
Tissue color: 80% dk Yellow 20% Lt Yellow
% Frond comp. 10% Senile 90% Mature ____ Young ____ Other
Disease: No
Encrustation: No
Apical blades: No
Sediment on blades: No
Depth (offshore): 50-52'
Depth (other):

Remarks 3-4m Frond length

Subsurface

UNDERWATER OBSERVATIONS

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

Bottom
- Tissue color
- Encrustation
- Disease
- Sediment on blades
- Sinking fronds
- Grazed tissues
- Sporophylls
- 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

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer:	R. Moore	Date	17 Mar 21
Lat/Long:	33° 32.359' 117° 47.513'	Location	N. Laguna Beach
		Time	1405
TOPSIDE OBSERVATIONS		Wind/Direction	6-8 kn W
		Current	
Kelp Canopy		Weather	90% Cloudy
		UW Visibility (est.)	
Extent	300 m⁺ x 200 m⁺	Swell Ht/Period	
Density			
Tissue color	70% dk Yellow		
% Frond comp.	5% Senile, 95% Mature	Young	Other
Disease			
Encrustation	10%	Depth (offshore)	50'
Apical blades	Y	Depth (other)	
Sediment on blades			

Remarks ~3 m frond length

Subsurface Scattered subsurface @ 10' below

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
Sporophylls
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

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Field Data Sheet

CONDITION OF MACROCYSTIS BED

mbc AQUATIC SCIENCES

Observer:	RMoore	Date	17 Mar 21
Lat/Long:	33°34.372 117° 50.650'	Location	Corona del Mar
		Time	1430
TOPSIDE OBSERVATIONS		Wind/Direction	6-8 kn
		Current	
Kelp Canopy		Weather	90% Cloudy
		UW Visibility (est.)	
Extent	30m x 10 m	Swell Ht/Period	
Density	Medium		
Tissue color	50/50 Lt - Dk Yellow		
% Frond comp.	___ Senile 100% Mature	___ Young	___ Other
Disease	No		
Encrustation	~ 50-60%	Depth (offshore)	
Apical blades		Depth (other)	
Sediment on blades	No		

Remarks

Subsurface

UNDERWATER OBSERVATIONS

Midwater		**Community**	
Tissue Color		Litter	
Encrustation		Turf algae	
Disease		Turf invert.	
Sediment on blades		Shrub algae	
Sinking fronds		Large Invert.	
Grazed tissues		Fishes	
		Disease	
Bottom		Sed. on rocks	
Tissue color		Urchin status	
Encrustation			
Disease		**Bottom characteristics**	
Sediment on blades			
Sinking fronds			
Grazed tissues			
Sporophylls			
Juvenile fronds			
Holdfasts			
Old holdfasts			
Recruitment			

REMARKS 33° 33'.924' 117° 50.349' Subsurface metered 1425

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APPENDIX D

KELP CANOPY AERIAL PHOTOGRAPHS

Photo D-1

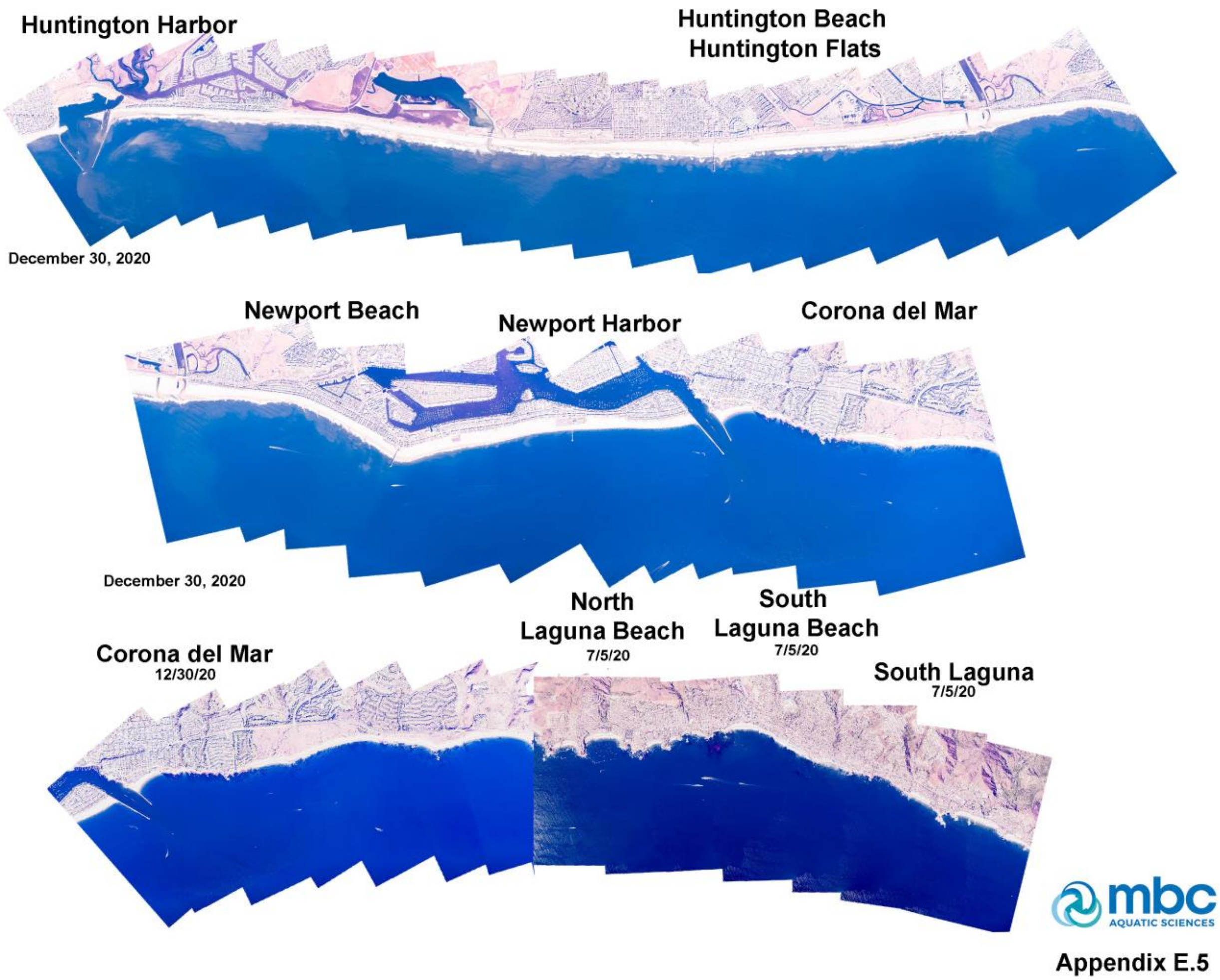

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Photo D-2

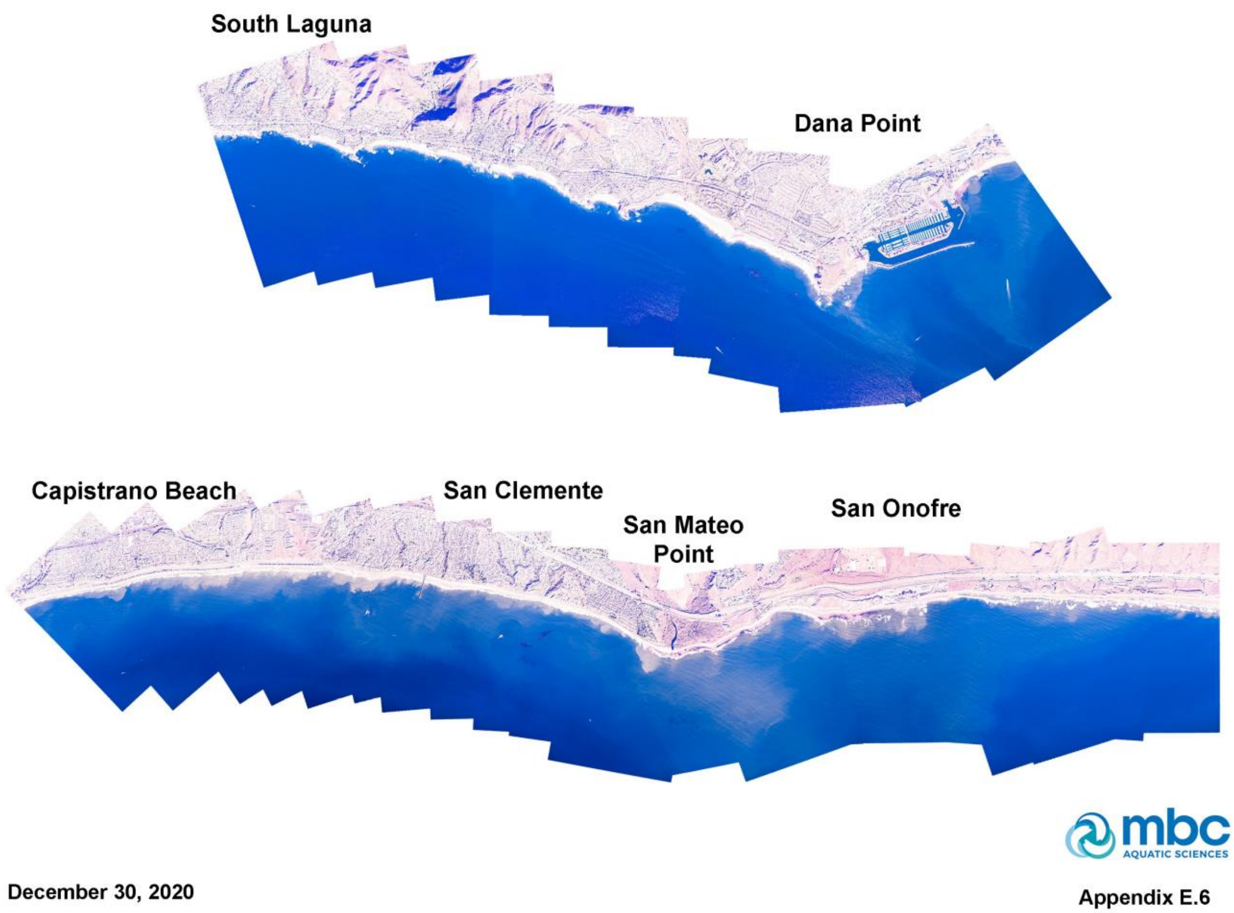

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Photo D-3

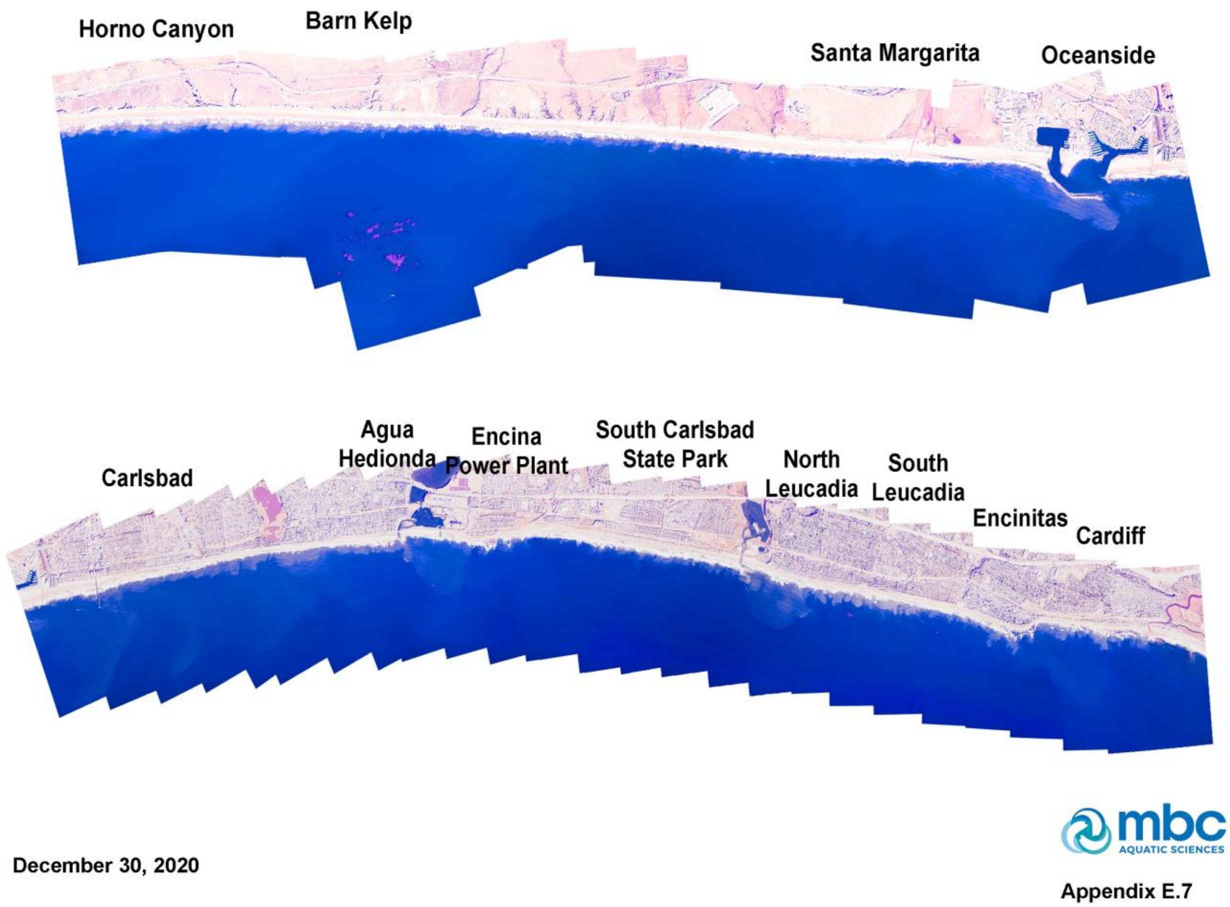

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Photo D-4

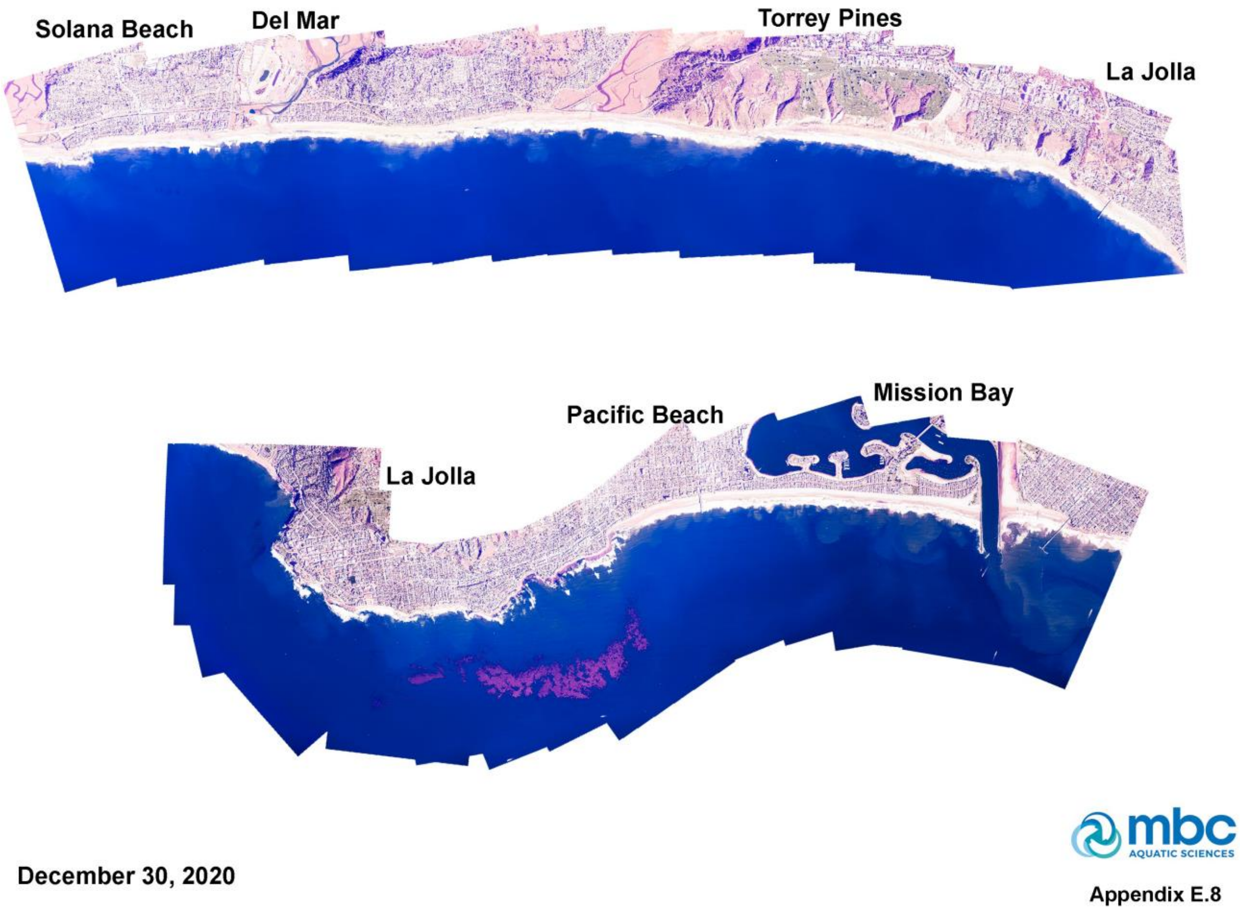

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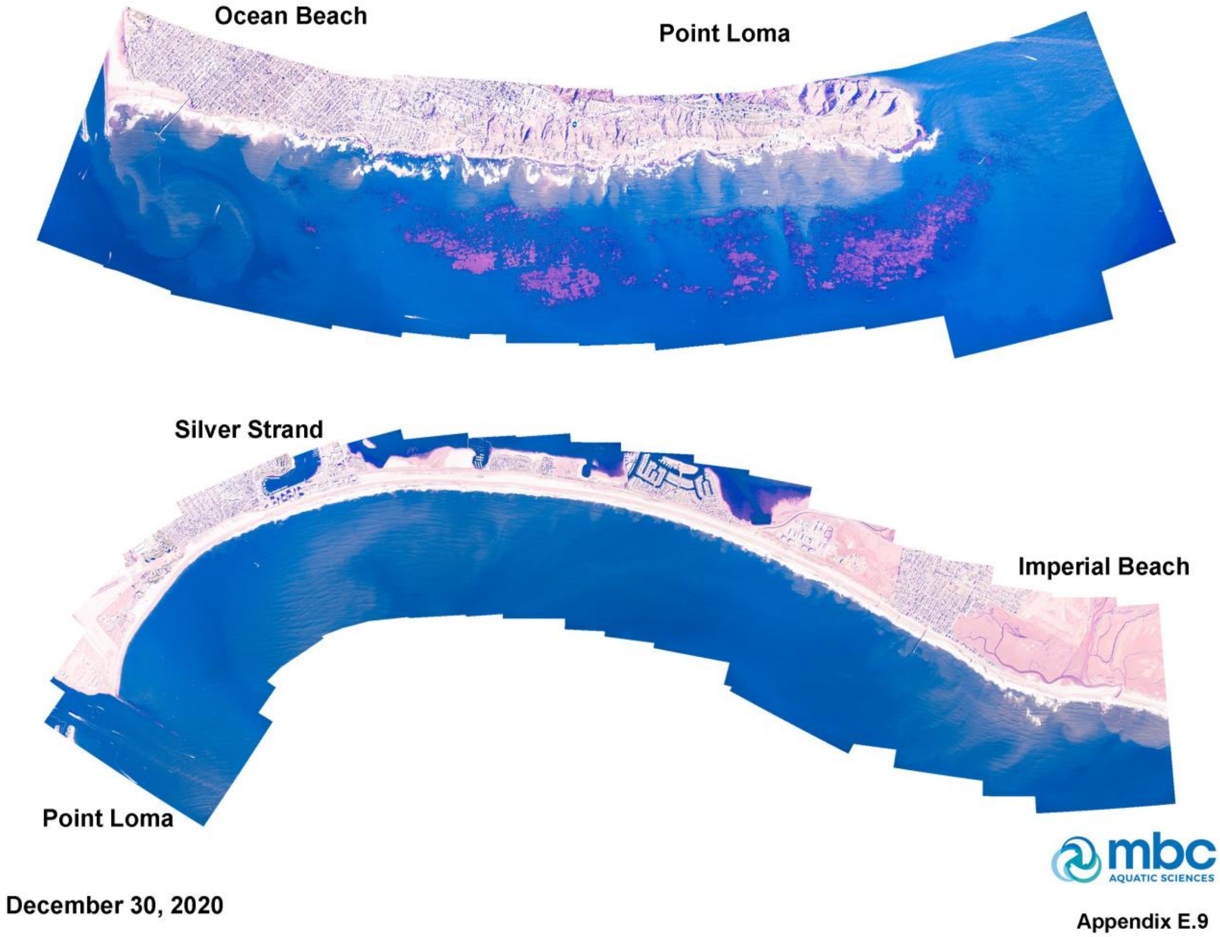
Photo D-6



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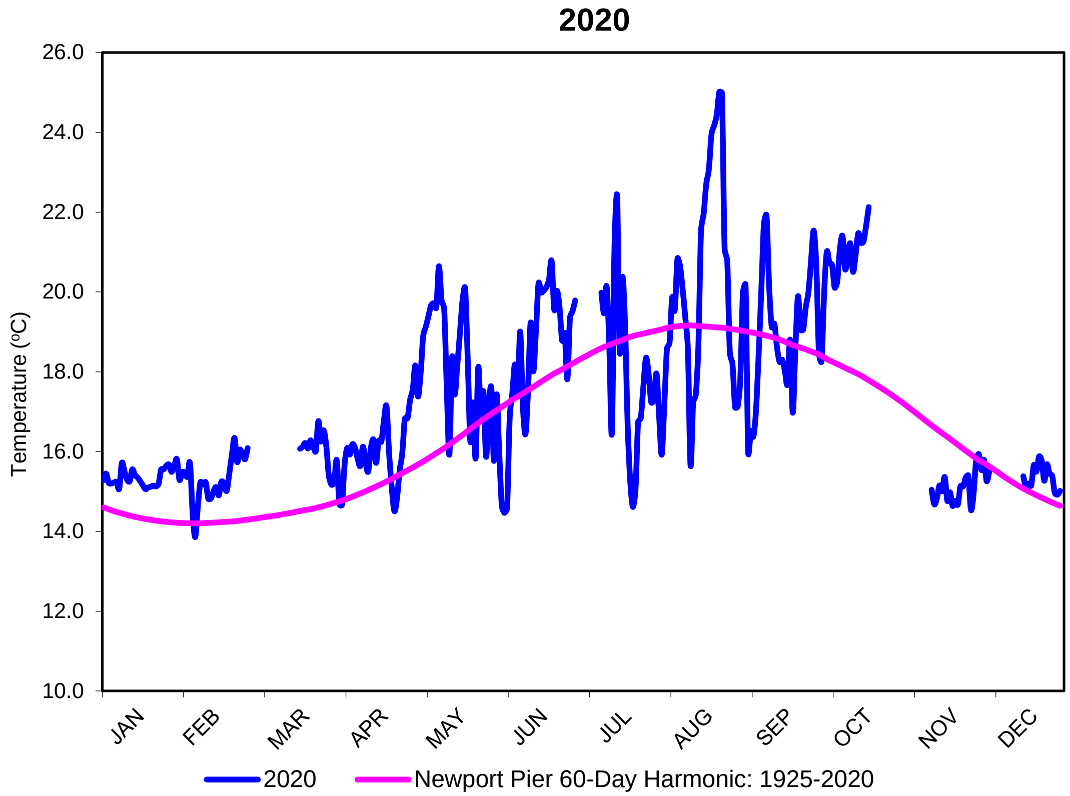
APPENDIX E

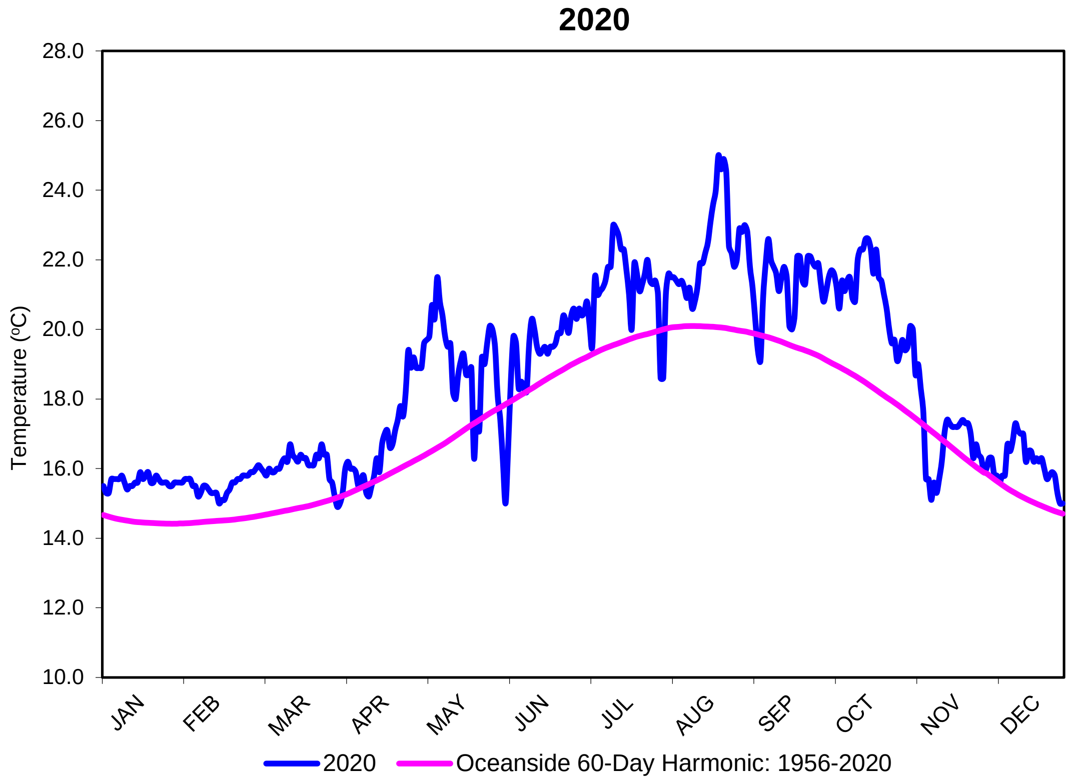
SEA SURFACE TEMPERATURES

Appendix E.1 Newport Pier



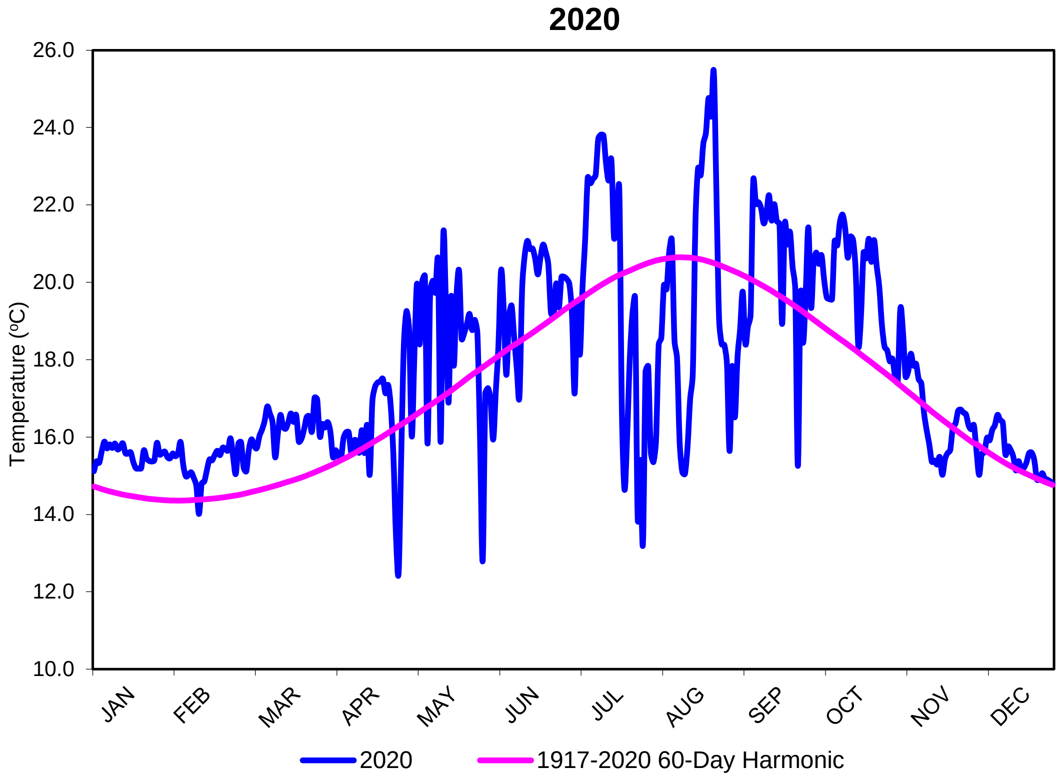
Daily Sea Surface Temperatures (SST) at Newport Pier for 2020.

Appendix E.2 Oceanside



Daily Sea Surface Temperatures (SST) at Oceanside for 2020.

Appendix E.3 Scripps Pier



Daily Sea Surface Temperatures (SST) at Scripps Pier for 2020.

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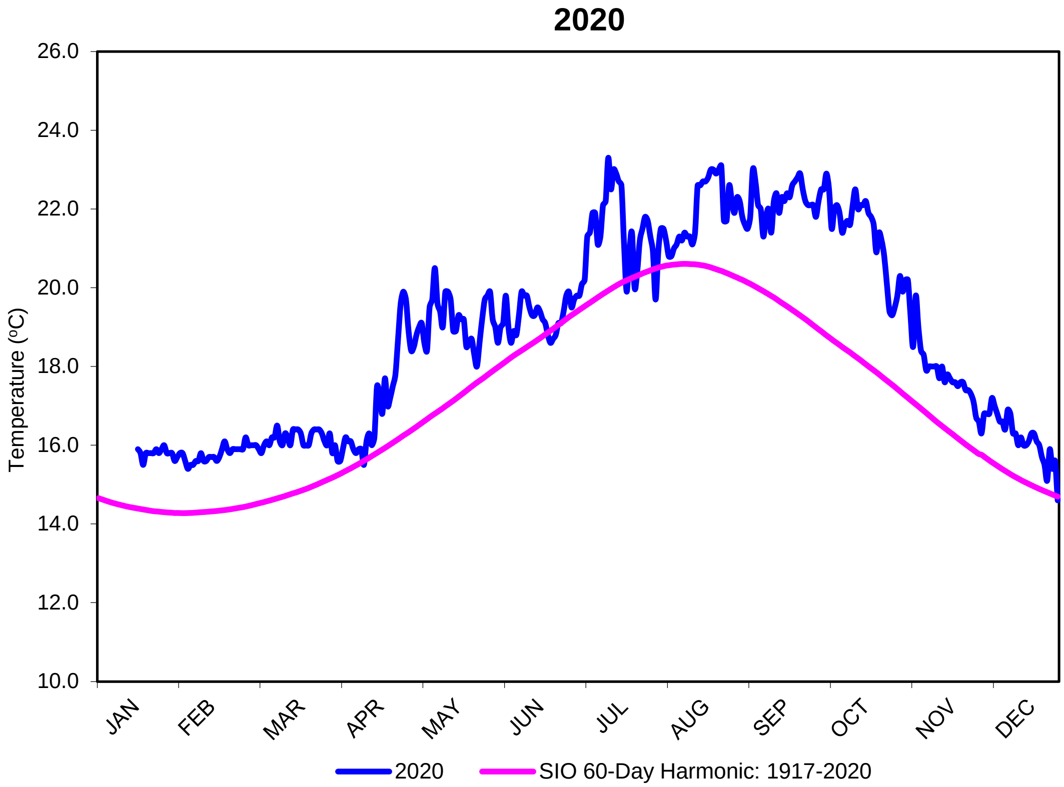
Appendix E.4 Point Loma



Daily Sea Surface Temperatures (SST) at Point Loma South for 2020.

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