Status of the Kelp Beds in 2023 and 2024:

Orange County and San Diego County

Prepared for the Region Nine Kelp Survey Consortium

MBC Aquatic Sciences

STATUS OF THE KELP BEDS IN 2023 AND 2024:
Orange County and San Diego County

Prepared for:

Region Nine Kelp Survey Consortium

Prepared by:

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

August 25, 2025

PROJECT STAFF

Region Nine Kelp Survey Consortium

Ami Latker (Chair), Ryan Kempster	City of San Diego Public Utilities Department
Luke Christian, Rosemarie Chora, Loc Tran	City of Oceanside
Ralph Ginese, Byron Odwazny, Oyuna Jenkins	City of Escondido
Alicia Appel, Rachael Morgan	Encina Wastewater Authority
Jess J. Perez, Kayla Ochoa	Fallbrook Public Utility District
Gary Merrill	Genentech
Joel Heywood, Jon C. Butcher	Marine Corps Base Camp Pendleton
Michelle Peters	Channelside Water Resources
Chris Trees, Mike Thornton	San Elijo Joint Powers Authority
Robert Culver, Charles Santos, Amber Baylor	South Orange County Wastewater Authority
Heather Neely	Southern California Edison, SONGS
Wayne Belzer, Morgan Rogers	U.S. International Boundary & Water Commission

Water Board

Brandi Outwin-Beals, Debbie Woodward, James Chhor	San Diego Regional Water Quality Control Board

MBC Aquatic Sciences

Marine Scientists

D.S. Beck	J.L. Rankin
J.M. Lyons	L. MacNair
J.R. Nuñez	D.J. Schuessler
B.L. Smith	J.N. Smith

Cover photograph courtesy of D.J. Schuessler

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Table 12. Large waves (≥3 meters) in 2023 and 2024 94

LIST OF APPENDICES

EXECUTIVE SUMMARY

Aerial imaging surveys of the giant kelp beds off Orange and San Diego counties were conducted for the Region Nine Kelp Survey Consortium by MBC Aquatic Sciences on nine occasions over a two-year period: on April 20, June 20, October 12, and December 23, 2023, on March 8, July 24, October 30, 2024, and on January 2 and 15, 2025. The maximum surface canopy observed during 2023 and 2024 was quantified from color infrared photos of each kelp bed.

The total kelp canopy throughout Region Nine decreased by 58% from 2022 to 2023 (1.9 km^2 in 2022 compared to 0.8 km^2 in 2023) and decreased by an additional 25% from 2023 to 2024 (0.8 km^2 in 2023 compared to 0.6 km^2 in 2024), resulting in an overall decrease of 68% over the two-year period. The total kelp canopy was less than the long-term average (6.7 km^2 for period from 1967 to 2024) during each of the past six years (2019 to 2024). Thirteen kelp beds were observed with visible surface canopy in 2023 (with the inclusion of Corona del Mar), including five kelp beds that increased in size, two that decreased in size, and six that reappeared. No kelp beds disappeared in 2023. The Point Loma kelp bed was the largest bed in Region Nine in 2023, while the La Jolla kelp bed was the fourth largest, with both kelp beds combined accounting for 47% of the total canopy coverage. Thirteen kelp beds were also observed with visible surface canopy in 2024 (also with the inclusion of Corona del Mar), including four kelp beds that increased in size, seven that decreased in size, one that remained the same size, and one that reappeared. One kelp bed disappeared in 2024. The Point Loma kelp bed was the second largest bed in Region Nine in 2024, while the La Jolla kelp bed was the fourth largest, with both kelp beds combined accounting for 34% of the total canopy coverage (North Laguna Beach was the largest kelp bed in the region in 2024). Eleven kelp beds that displayed no surface canopy in 2022 continued to be absent in 2023 and 2024.

Sea Surface Temperature (SST) values were warmer than average during January, much of July and August, and most of September through December 2023, as well as most of 2024. The SST values were below average for much of February, March, and April 2023, with surface water temperatures below 14°C (when nutrient availability is generally favorable for kelp forest growth) often during this period. However, surface temperatures were rarely below 14°C during the remainder of 2023 or most of 2024 (January through November). The very low Nutrient Index values during 2023/24 indicate low nutrient availability, which probably created conditions unfavorable for kelp growth, contributing to the decrease in total kelp canopy observed in 2023. Although Nutrient Index values were high for the 2024/25 period, this was primarily due to low temperatures recorded from January through April 2025; nutrient availability during calendar year 2024 therefore was relatively 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 25 existing or historic kelp beds, including Corona del Mar which is also considered to be part of the Central Region Kelp Survey Consortium program (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.1.

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 and MBC Applied Environmental Sciences 2001). MBC has continued to use this same methodology for the Region Nine surveys since inception of the program in 1983.

In 2023 and 2024, 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 April 20 (delayed from March due to bad weather), June 20, October 20, and December 26, 2023, on March 8, July 24 (delayed from June due to foggy conditions), October 30, 2024, and on January 2 and 15, 2025 (delayed from December 2024 due to foggy conditions) (Tables 1 and 2). The flight path and flight data report from each quarterly aerial survey are included in Appendix C.

II.1.B - KELP DATA ANALYSIS

All photographs were reviewed after each overflight and the canopy surface area of each kelp bed was ranked in size by subjectively comparing the extent of canopy coverage shown in the photographs to the average historical bed size and photographs from previous surveys (Tables 3 and 4). The ranking scale ranged from 0 (no kelp) to 4 (well above average kelp), with 0.5-point increments representing gradations relative to historical average canopy coverage. These rankings allowed the archiving of the quarterly survey photos for later retrieval and assembly of a digitized photo-mosaic composite of each kelp bed that represented the greatest areal extent for each survey year using Photoshop. 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.

For each year of surveys, photographs from quarterly surveys during which the greatest aerial coverage was observed for each kelp bed were assembled into a composite photo-mosaic representing an annual overview of the region's kelp beds canopy coverage. To provide a better annual estimate of maximum canopy coverage, data from at least two surveys were usually used for the photo-mosaics. The photo-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, 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 that 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.

III - RESULTS

III.1 – SUMMARY

Maps showing the areal extent of RNKSC surface canopy coverage in 2023 and 2024 are provided in Appendix A. Tables displaying the historical canopy coverage for Region Nine from 1983 through 2024, life history information for giant kelp, and historical kelp surveys (including Crandall's maps) are provided in Appendix B. The flight path and flight data reports from each quarterly aerial survey in 2023 and 2024 are included in Appendix C. Composite photographs of the extent of kelp surface canopy throughout Region Nine in 2023 and 2024 are included in Appendix D. Sea surface temperatures at Newport Pier, Oceanside, Point Loma, and Scripps Pier for 2023 and 2024 are presented in Appendix E.

In 2023, most kelp beds (12, with Upper and Lower La Jolla, as well as Upper and Lower Point Loma, counted separately) in the RNKSC region attained maximum surface canopy area for the year during the fourth quarterly surveys. However, three kelp beds peaked during the second quarter (Table 3). The total amount of kelp canopy coverage in the RNKSC region was 0.8 km^2 in 2023, decreasing by 58% from the total of 1.9 km^2 recorded in 2022 (Table 5). Of the 25 designated RNKSC kelp beds (including Corona del Mar, which is also included in the Central Region), 13 displayed surface canopy in 2023, including six that reappeared, four that increased in size, and two that decreased in size. No kelp beds disappeared in 2023. The Point Loma kelp bed was the largest (0.3 km^2) in 2023, followed by the North Laguna Beach kelp bed (0.22 km^2), the Capistrano Beach kelp bed (0.08 km^2) and the La Jolla kelp bed (0.07 km^2) (Table 5). The Point Loma and La Jolla kelp beds accounted for only 47% of the total RNKSC kelp coverage in 2023. Only three of the 13 kelp beds with visible surface canopy) were at more than 25% of their maximum size recorded since 1983, while eight kelp beds were less than 10% of their historical maximum size (Table 6, Figure 3).

In 2024, most kelp beds (10) in the RNKSC region attained maximum surface canopy for the year during the first quarterly surveys. However, one kelp bed peaked during the second quarter, one during the third quarter, and two during the fourth quarter (Table 4). The total amount of kelp coverage in the RNSKC region in 2024 was 0.6 km^2, decreasing by 25% from 2023 (Table 5). Of the 25 designated RNKSC kelp beds (including Corona del Mar), 13 displayed surface canopy in 2024, including one that reappeared, three that increased in size, and seven that decreased in size. One kelp bed disappeared in 2024. The North Laguna Beach kelp bed was the largest (0.17 km^2) in 2024, followed by the Point Loma kelp bed (0.16 km^2), and the Capistrano Beach kelp bed (0.06 km^2). The Point Loma and La Jolla kelp beds accounted for only 34% of the total RNKSC kelp coverage in 2024. Only three of the 13 kelp beds with visible surface canopy were at more than 25% of their maximum size recorded since 1983, while nine kelp beds were less than 10% of their historical maximum size since 1983 (Table 6, Figure 3).

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 Region Nine (including Corona del Mar) during the 2023 and 2024 survey years based upon the quarterly surveys. Information also is presented on several other areas where kelp beds were present. The comparison of canopy coverage among 2022, 2023, and 2024 for each kelp bed is presented in Table 5, and comparison to historical maximum size is presented for these three years in Table 6 and Figure 3. Historical canopy coverage since 1911 is presented in Appendix B.3.

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

Newport Harbor. This is not a designated kelp bed. Kelp was not observed within the harbor in 2023 or 2024 (Appendix A.5, A.6, A.51, and A.52).

Corona del Mar. This is a designated kelp bed within the Central Region but is included here for information purposes. This kelp bed increased in size by 2,600% between 2022 and 2023 (from 0.003 km^2 to 0.081 km^2), then increased by an additional 9% in 2024 (to 0.088 km^2), for an overall increase of 2,833% from 2022 to 2024 (Table 5). The canopy area in 2024 was 21% of the maximum recorded in 2011 (Table 6, Figure 3, Appendix A.7, A.8, A.53, and A.54).

Surface canopy has been observed every year since 2003, except in 2020. The kelp beds in 2023 and 2024 were the largest observed since 2018 (Figure 4).

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 448% between 2022 and 2023 (from 0.040 km^2 to 0.219 km^2), then decreased by 23% in 2024 (to 0.169 km^2), resulting in an overall increase of 322% from 2022 to 2024 (Table 5). The canopy area in 2023 established a new historical maximum size and in 2024 was 77% of the maximum recorded in 2023 (Table 6, Figure 3, Appendix A.9, A.10, A.55, and A.56). The South Laguna Beach kelp bed increased in size by 1,180% between 2022 and 2023 (from 0.005 km^2 to 0.064 km^2), then decreased by 66% in 2024 (to 0.022 km^2), resulting in an overall increase of 340% from 2022 to 2024 (Table 5). The canopy area in 2024 was 8% of the maximum recorded in 2013 (Table 6, Figure 3, Appendix A.9, A.10, A.55, and A.56).

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 (Figure 4). In 2023 and 2024, the North Laguna Beach kelp bed was larger than any time during the period from 2013 to 2022, while the South Laguna kelp bed was larger than observed since 2018 (Figure 4).

South Laguna. This kelp bed increased in size by 2,200% between 2022 and 2023 (from 0.001 km^2 to 0.023 km^2), then increased by an additional 126% in 2024 (to 0.052 km^2), resulting in an overall increase of 5,100% from 2022 to 2024 (Table 5). The canopy area in 2024 established a new historical maximum size (Table 6, Figure 3, Appendix A.11, and A.57).

Surface canopy has been observed at the South Laguna kelp bed during most years from 2000 to 2018 but disappeared in 2019 and was also absent in 2020 (Figure 4). Surface canopy was observed every year from 2021 to 2024, reaching the largest size ever recorded in 2024.

Dana Point/Salt Creek. This kelp bed increased in size by 200% between 2022 and 2023 (from 0.002 km^2 to 0.006 km^2), then increased by an additional 267% in 2024 (to 0.022 km^2), resulting in an overall increase of 1,000% from 2022 to 2024 (Table 5). The canopy area in 2024 was only 2% of the maximum size attained in 2008 (Table 6, Figure 3, Appendix A.12, and A.58).

Although the Dana Point/Salt Creek kelp bed reappeared in 2020, the surface canopy area has been much smaller from 2020 to 2024 than the levels observed from 2007 to 2018 (Figure 5).

No kelp was observed along the breakwaters in Dana Point Harbor (Appendix A.13 and A.59) in 2023 or 2024. This is not a designated kelp bed.

Capistrano Beach. This kelp bed reappeared in 2023, then decreased in size by 21% in 2024 (from 0.075 km^2 to 0.059 km^2) (Table 5). The canopy area in 2024 was 26% of the maximum size attained in 1989 (Table 6, Figure 3, Appendix A.14, and A.60).

Although this kelp bed was absent in 2019, 2020, and 2022, the levels observed in 2023 and 2024 were the highest since 2013 (Figure 5).

III.2.C - SAN CLEMENTE TO SAN ONOFRE

Three kelp beds are located between San Clemente and San Onofre.

San Clemente. This kelp bed reappeared in 2023 and remained the same size in 2024 (0.001 km^2) (Table 5). The canopy area in 2024 was less than 1% of the maximum recorded in 2013 (Table 6, Figure 3, Appendix A.15, and A.61).

This kelp bed was present every year from 1999 to 2021; however, it was very small in 2021 and disappeared in 2022 (Figure 3, Appendix B.3). Although surface canopy was observed in 2023 and 2024, the kelp bed was very small (Figure 5).

San Mateo Point. This kelp bed disappeared in 2022 and no surface canopy was observed in 2023 or 2024 (Table 5). The canopy area in 2024 was 0% of the maximum recorded in 1989 (Table 6).

This kelp bed was present nearly every year from 1983 to 2019 (except in 1998) but has been absent in four of the last five years (Figure 5, Appendix A.16, and A.62).

San Onofre. This kelp bed was absent in 2022 and continued to be absent in 2023 and 2024 (Table 5). The canopy area in 2024 was 0% of the maximum recorded in 1990 (Table 6).

Surface canopy was observed at the San Onofre kelp bed nearly every year from 1983 to 2019 (except in 2006) (Figure 6, Appendix A.17, andA.63). However, this kelp bed has been absent for the past five years.

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 was absent in 2022 and continued to be absent in 2023 and 2024 (Table 5, Appendix A.19, and A.65). The canopy area in 2024 was 0% of the maximum recorded in 2013 (Table 6).

Surface canopy was observed every year from 2007 to 2018 but has been absent each of the past six years (Figure 6).

The Pendleton Artificial Reef (PAR), which is not a designated kelp bed, is just upcoast from Horno Canyon. No kelp was observed at this location during 2023 or 2024 (Appendix A.18 and A.64).

Barn Kelp. This kelp bed disappeared in 2022 and was also absent in 2023 but reappeared in 2024 (Table 5). The surface canopy in 2024 was 5% of the maximum attained in 2009 (Table 6, Figure 3, Appendix A.21, and A.67).

Surface canopy has been observed at this kelp bed most years since 1967 (Figure 6). Although Barn Kelp reappeared in 2024, it was relatively small in size.

Santa Margarita. This kelp bed was absent in 2022 and continued to be absent in 2023 and 2024 (Table 5, Appendix A.22, and A.68). The canopy area in 2024 was 0% of the maximum recorded in 2013 (Table 6).

The Santa Margarita kelp bed is a small bed that occasionally forms a canopy off the Santa Margarita River mouth. However, surface canopy has only been observed during three years since 1983 (1991, 1992, and 2013).

No kelp was observed in Oceanside Harbor in 2023 or 2024 (Table 3, Appendix A.23, and A.69). This is not a designated kelp bed.

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

There are four kelp beds located between North Carlsbad and Carlsbad State Beach.

North Carlsbad. This kelp bed was absent in 2022 and continued to be absent in 2023 and 2024 (Table 5, Appendix A.25, and A.71). The canopy area in 2024 was 0% of the maximum recorded in 1993 (Table 6).

The North Carlsbad kelp bed usually is comprised of several small beds. Visible surface canopy was recorded every year from 1986 to 2017, but this kelp bed has been absent since 2018 (Figure 6).

Agua Hedionda. This kelp bed was absent in 2022 and continued to be absent in 2023 and 2024 (Table 5, Appendix A.25, A.26, A.71, and A.72). The canopy area in 2024 was 0% of the maximum recorded in 2013 (Table 6).

The Agua Hedionda kelp bed reached its maximum size in 2013 then decreased in size in 2014 and 2015; this kelp bed has been absent from 2016 through 2024 (Figure 6).

Encina Power Plant. This kelp bed was absent in 2022 and continued to be absent in 2023 and 2024 (Table 5, Appendix A.26, and A.72). The canopy area in 2024 was 0% of the maximum recorded in 2013 (Table 6).

The Encina Power Plant kelp bed was present most years from 1976 to 2018, However, this kelp bed disappeared in 2019 and has been absent since (Figure 7).

Carlsbad State Beach. This kelp bed was absent in 2022 and continued to be absent in 2023 and 2024 (Table 5, Appendix A.27, and A.73). The canopy area in 2024 was 0% of the maximum recorded in 2013 (Table 6).

The Carlsbad State Beach (Carlsbad State Park) kelp bed was present nearly every year from 1967 to 2017 but disappeared in 2018 and has been absent since (Figure 7).

III.2.F - LEUCADIA TO TORREY PINES

Leucadia. This kelp bed reappeared in 2023 (0.002 km^2) but disappeared once again in 2024 (Table 5). The canopy area in 2024 was 0% of the maximum recorded in 2013 (Table 6).

The Leucadia kelp bed comprises the North, Central, and South Leucadia kelp beds, which are surveyed as three separate beds because of distinct breaks in the beds (Appendices A.28, A.29, A.74, and A.75). Surface canopy was observed in this kelp bed nearly every year from 1967 to 2020 (except in 1998), but it has been absent three of the past four years (Figure 7).

Encinitas. This kelp bed reappeared in 2023 (0.010 km^2), then decreased by 50% (to 0.005 km^2) in 2024 (Table 5, Appendix A.30, and A.76). The canopy area in 2024 was 1% of the maximum recorded in 2008 (Table 6).

Surface canopy has been observed in this kelp bed most years from 1967 to 2020. Although Encinitas kelp bed disappeared for two years (2021 and 2022), surface canopy was present in 2023 and 2024 (Figure 7).

Cardiff. This kelp bed was absent in 2022 but reappeared in 2023 (0.026 km^2) then decreased by 65% (to 0.009 km^2) in 2024 (Table 5, Appendix A.30, and A.76). The canopy area in 2024 was 3% of the maximum recorded in 2013 (Table 6).

The Cardiff kelp bed was present nearly every year from 1983 to 2018 (except in 2005) but.disappeared in 2019 and was absent through 2022 (Figure 8).

Solana Beach. This kelp bed reappeared in 2023 (0.006 km^2), then increased by 250% in 2024 (to 0.021 km^2) (Table 5, Appendix A.31, and A.77). The canopy area in 2024 was 2% of the maximum recorded in 2008 (Table 6).

The Solana Beach kelp bed was present every year from 1984 to 2018 but has been absent in three of the past six years since (Figure 8).

Del Mar. This kelp bed was absent in 2022 and continued to be absent in 2023 and 2024 (Table 5, Appendix A.32, and A.78). The canopy area in 2024 was 0% of the maximum recorded in 1989 (Table 6).

The Del Mar kelp bed is typically one of the smallest beds in Region Nine. Surface canopy was present each year from 2007 to 2015 but has been absent for the last nine years (Figure 8).

Torrey Pines. This kelp bed was not observed in 2022 and continued to be absent in 2023 and 2024 (Table 5, Appendix A.33, A.34, A.79, and A.80). The canopy area in 2024 was 0% of the maximum recorded in 2012 (Table 6).

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 disappeared in 2014 and has been absent since.

III.2.G - LA JOLLA

La Jolla. This kelp bed decreased in size by 85%, from 0.446 km^2 in 2022 to 0.067 km^2 in 2023; it decreased by another 21% to 0.053 km^2 in 2024, representing an overall decrease of 88% from 2022 to 2024 (Table 5, Appendix A.34, A.35, A.80, and A.81). The canopy area in 2023 and 2024 was only approximately 1% of the maximum recorded in 1989 (Table 6, Figure 3).

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. The La Jolla kelp bed has decreased in size each year since 2018 (Figure 9). The size of this kelp bed in 2024 was the smallest observed since 1996.

III.2.H - POINT LOMA TO CORONADO BEACH

Point Loma. This kelp bed decreased in size by 77%, from 1.417 km^2 in 2022 to 0.324 km^2 in 2023; it decreased by another 52% to 0.157 km^2 in 2024, representing an overall decrease of 89% from 2022 to 2024 (Table 5, Appendix A.37, A.38, A.83, and A.84). The canopy area in 2023 was 4% of the maximum recorded in 2018 and in 2024 was 2% of the maximum (Figure 3).

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. 1967). It is usually the largest bed in Region Nine. The maximum canopy area ever recorded since 1967 was observed in 2018 (7.9 km^2), but this kelp bed has decreased in size every year since, reaching the smallest size in 2024 (approximately 0.2 km^2) that has been recorded since 1984 (Figure 9).

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

No kelp was observed at Coronado Beach (Appendix A.42 and A.88) or Silver Strand (Appendix A.43 and A.89) in 2023 or 2024; neither are designated kelp beds.

Imperial Beach. This kelp bed was not observed in 2023 and continued to be absent in 2023 and 2024 (Table 5, Appendix 45, and A.91). The canopy area in 2024 was 0% of the maximum recorded in 2008 (Table 6).

The Imperial Beach kelp bed was present nearly every year from 1985 to 2016 (exception in 1998) but disappeared in 2017 and has been absent since (Figure 8).

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 0.8 km^2 in 2023 and 0.6 km^2 in 2024.

2. What is the variability of the coastal kelp bed canopy over time?

- The total kelp canopy decreased in size in 2023 by 58% (from 1.9 km^2 to 0.8 km^2) and by an additional 25% in 2024 (from 0.8 km^2 to 0.6 km^2), representing an overall decrease in size of 68% from 2022 to 2024;
- Four kelp beds with visible surface canopy in 2022 increased in size in 2023 and three kelp beds with visible surface canopy in 2023 increased in size in 2024;
- Two kelp beds with visible surface canopy present in 2022 decreased in size in 2023 and seven kelp beds with visible surface canopy in 2023 decreased in size in 2024.

3. Are coastal kelp beds disappearing? If yes, what are the factors that could contribute to the disappearance?

- No kelp beds disappeared in 2023 and one kelp bed disappeared in 2024;
- Eleven kelp beds that displayed no surface canopy in 2022 were still absent in 2023 and 2024.
- Above average sea surface temperatures and low nutrient availability may have contributed to the absence of surface canopy at these kelp beds.

4. Are new kelp beds forming?

- Six kelp beds reappeared in 2023 and one additional kelp bed reappeared in 2024.

The total kelp canopy in Region Nine covered approximately 0.8 km^2 in 2023 and 0.6 km^2 in 2024. In 2018, total canopy size was well above the long-term average (Figure 10). Total canopy size was below the long-term average and has decreased substantially each of the past six years. The total canopy sizes observed in 2023 and 2024 represented the lowest levels recorded since 1998. The two largest kelp beds in Region Nine each year usually are the Point Loma and La Jolla kelp beds (these two kelp beds accounted for 69 to 99% of the total kelp canopy in the region from 2015 to 2022) (Table 7). Although the Point Loma kelp bed was the largest bed in 2023, the La Jolla kelp bed was only the fourth largest, and these two kelp beds only accounted for 47% of the total kelp canopy. In 2024, the North Laguna Beach kelp bed was the largest in the region, while the Point Loma kelp bed was the second largest, and the La Jolla kelp bed was the fourth largest; Point Loma and La Jolla combined only represented 34% of the total canopy. In 2023 and 2024, most beds were very small or absent, with only four beds exceeding 5% of their historical maximum levels.

Giant kelp off San Diego is at the lowest density ever recorded, despite supportive ocean climate conditions over the last three years (Parnell 2024). Algae that grow close to the bottom have gained a foothold over the past several years at many of the shallower sites off San Diego and this understory can prevent giant kelp from recruiting through competition for space. Deeper areas of the kelp forest (>16 m) appear to have been affected by low light levels at the sea bottom due to recent extensive phytoplankton blooms. Giant kelp requires adequate light to germinate and produce young plants, but light levels were reduced from 2020 through 2022 and only recently have supported some giant kelp recruitment at sites off San Diego. An alternation between periods of moderate giant kelp recruitment and recovery followed by collapse has been observed at some sites off San Diego at mostly intermediate depths, probably at least partly due to the substantial surface warming that has occurred over the last several summers. At sites off North La Jolla and North County, except for Solana Beach, where most algae is now absent, these areas are becoming dominated by suspension feeding invertebrates including bryozoans and suspension feeders that have negative effects on kelp recruitment.

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 are 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).

IV.2.A - WATER TEMPERATURE

Sea surface temperature (SST) data are discussed below and have been used as a proxy 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 proxy, 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 Mean Lower Low Water (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 (refer to 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 (refer to www.ndbc.noaa.gov). Temperature data were not available for the Point Loma South Station (46232) in late 2023, so data from the Mission Bay West Station (46258, 32.749 N 117.502 W (32°44'58" N 117°30'6" W) were utilized.

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 for 2023 (City of San Diego 2025). Sensors recorded water temperature at four-meter intervals from near the sea surface to a depth of 54 meters MLLW. This thermistor string was not operated during 2024.

- 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 (Orange County Sanitation District, 2025). Sensors recorded water temperature at five-meter intervals from the sea surface to near the bottom (a depth of 75 meters MLLW).

SSTs for 2023 and 2024 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 2023, SST values were warmer than average during January, much of July and August, and most of September through December. SST values were below average in February through April, as well as for most of May and June (Figure 11). In 2024, SST values were warmer than average throughout most of the year, with occasional cooler temperatures below average from April through December.

Nutrient availability for kelp forest growth is generally favorable when daily sea SST values fall below 14 ºC (Leichter et al., 2023), In 2023, SST values at Newport Pier, Oceanside, Scripps Pier, and La Jolla fell below this threshold relatively often during February, March and April, ranging from 8 to 25 days per month at each location. In contrast, SST values rarely fell below this threshold in January and consistently remained above the threshold from July through December (Figures 11 and 14). In 2024, daily SST values were rarely or never below 14ºC from January through November at any of the four locations. However, 21 days with SST values below this threshold were recorded at Scripps Pier in December 2024.

Temperature monitoring was accomplished via a thermistor string deployed off Point Loma in 2023 (data were missing from mid-July through December). No data were collected in 2024. In 2023, temperatures warmer than 14ºC were observed at depths from the surface to below depths of 40 meters for most of January. Temperatures cooler than 14ºC were observed at depths below 20 meters from February through June (Figure 12).

In 2023, water temperatures offshore of the Orange County coastline at Station 2106 were usually cooler than 14ºC at most depths below 40 meters throughout the year Figure 13). Water temperatures at all depths were also usually below 14ºC from January through April of 2023. However, water temperatures in the upper 20 meters of the water column were usually warmer than 14ºC from May through December in 2023 and were usually warmer than 14ºC from 25 to 35 meters from September to December. In 2024, water temperatures were usually cooler than 14ºC throughout the year at depths from 35 meters to the bottom. Water temperatures were usually warmer than 14ºC in the upper 15 meters of the water column throughout the year.

In 2023, the number of days with daily SST values less than 14ºC was relatively high at Newport Pier and Scripps Pier (50 and 59 days, respectively) in comparison to the levels observed from 2015 to

2022 (12 days or less at each location per year) (Figures 14 and 15). This is the first time since the three-year period from 2011 to 2013 that the number of days with daily SST values below 14ºC has exceeded 50 per year at either location. In 2024, fewer days with daily SST values less than 14ºC were observed at Newport Pier and Scripps Pier (8 and 29 days, respectively); while the number of days below 14ºC at Newport Pier was only slightly above the range recorded from 2015 to 2022 (6 days or less each year), the Scripps Pier level exceeded the range from 2015 to 2022 (2 to 12 days per year). At Newport Pier and Scripps Pier, the numbers of days with daily SST values in 2023 and 2024 greater than 16ºC, greater than 18ºC, and greater than 20ºC (38 and 58 days respectively) were similar to the values observed from 2019 to 2022 (Figures 14 and 15)

In 2023, the mean annual SST value at Newport Pier (16.9ºC) was higher than the long-term average (16.6ºC), as has been the case since 2015 (Table 8), but equal to the long-term average in 2024. The mean annual SST values in 2023 and 2024 at Scripps Pier (16.9ºC and 17.2ºC, respectively) were lower than the long-term average (17.7ºC), which was also the case in 2021.

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 2023 NQ Index values shown on Figure 15 correspond to the period from July 1, 2023 to June 30, 2024, while the 2024 NQ Index values correspond to the period from July 1, 2024 to June 20, 2025). 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.

The NQ calculations for four locations in Region Nine in 2023/2024 and in 2024/2025 are shown in Tables 9 and 10. The 2023/2024 NQ Index was calculated to be 9 for Newport Pier, 8 for Oceanside, 11 for Scripps Pier, and 6 for Point Loma (Table 9). These values were all below their long-term averages, as has usually been the case since 2013 (Figure 15). The 2024/2025 NQ Index was calculated to be 26 for Newport Pier, 16 for Oceanside, 31 for Scripps Pier, and 17 for Point Loma (Table 10). These values were all above their long-term averages and similar to the values recorded in 2022/2023 (Figure 16). However, these high index values for 2024/2025 were primarily due to the low surface water temperatures recorded from January through April of 2025, which would have no influence on kelp canopies in calendar year 2024 (Table 10).

Historically, nutrient availability 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 calculated for the Newport Pier and Scripps Pier locations were 11 and 4, respectively. In contrast, during 1988/1989, a year in which kelp beds reached their maximum extents in several decades, NQ values calculated for the Newport Pier and Scripps Pier locations were 36 and 27, respectively (Figure 16). 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. The low NQ index values observed in 2023/24 fall within the range identified by Parnell et al.(2010) that has led to a bad year for kelp beds in the past. The high index values observed in 2024/25 fall within the range for a very good year for kelp beds in the past, at least at the Newport Pier and Scripps Pier locations.

IV.2.C - UPWELLING

The frictional stress of equatorward wind on the ocean's surface, combined with the effect of the earth's rotation, causes water in the surface layer to move away from the western coast of continental land masses. This offshore moving water is replaced by water which upwells, or 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 2023 (at a location approximately 161 km west of Solana Beach) was near the long-term monthly mean from January through July, and in September and October (Figure 17). Upwelling was below the long-term monthly mean in August and extremely low in November and December. Upwelling was strongest in 2023 from April through July (Figures 17 and 18). In 2024, upwelling was near the long-term monthly mean from January through April, greater than the long-term mean from May through August, and near the monthly mean once again from September through December. Upwelling was strongest in 2024 from May through July. Nearly all of the months in 2023 and 2024 with strong upwelling corresponded to periods with generally warmer surface water temperatures; April 2023 was the only month with a high number of days with surface water temperatures below 14^{o}C (Figure 11).

IV.2.D - ENVIRONMENTAL INDICES

The El Nino/Southern Oscillation (ENSO) is the most important coupled ocean-atmosphere phenomenon affecting interannual climate variability. ENSO can be monitored via the Multivariate ENSO Index (MEI Index v2), 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) (refer to www.psl.noaa.gov). Negative values of the MEI Index v2 represent the cold ENSO phase (i.e., La Niña), while positive MEI values represent the warm ENSO phase (El Niño) (Figure 19).

The North Pacific Gyre Oscillation (NPGO) is a climate pattern that is based on sea surface height variability in the Northeast Pacific Ocean (Figure 20). 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. When the NPGO is positive, conditions favorable to upwelling are usually recorded in the California Current and Alaskan Gyre regions. 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 (refer to www.o3d.org/npgo).

The Pacific Decadal Oscillation (PDO) is a long-lived El Niño-like pattern of Pacific climate variability. The PDO and ENSO 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 (negative values) persisted from 1890 through 1924 and again from 1947 through 1976, while a “warm” PDO regime (positive values) dominated from 1923 through 1946 and from 1977 through the mid-1990s (Figure 21). Warm eras correlate with enhanced coastal ocean biological productivity in Alaska and inhibited productivity off the west coast of the United States, while the cold PDO eras typically produce the opposite effect in those areas (refer to www.ncdc.noaa.gov.teleconnections/pdo). Causes for PDO fluctuations are not currently known.

The MEI Index transitioned from negative (cold phase, or La Niña condition) to positive (warm phase, or El Niño condition) in April 2014, then back to negative in September 2016 (Figure 19). The MEI Index shifted to positive once again in May 2018 and throughout 2019, before transitioning back to negative in early 2020. The MEI Index remained negative through most of 2023 but returned to positive throughout most of 2024. The PDO became positive in early 2014 (Figure 21; Mantua 2017; and NOAA-ESRL 2018) and remained mostly positive through the middle of 2017 but has been mostly negative since then through 2024. The NPGO changed from positive to negative in October 2013 and has stayed negative for most of the time since then through 2024 (although it was positive for five months in 2016) (Figure 20; Di Lorenzo 2017).

The negative MEI Index and PDO values since 2018 could indicate a return to cold water conditions. But the strongly negative NPGO values since 2018 may be indicative of lower productivity along the Pacific coast during that period (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 (refer to http://www.cdip.ucsd.edu). The Oceanside buoy is located at 33 10.765’ N and 117 28.277’ W, approximately 4 nautical miles west-southwest of Oceanside Harbor. The Point Loma buoy is located at 32 31.002’ N and 117 25.512’ W, approximately 15.5 nautical miles west of Imperial Beach Pier.

The direction of swells off Oceanside in 2023 was predominately from the south-southwest (202.5^{o}), approximately 36% of the time in 2023 and approximately 43% of the time in 2024 (Table 11), compared to 48% of the time in 2021 and 40% in 2022. High-energy waves that negatively affect kelp beds usually are low-frequency, high-amplitude waves approaching from the west (180^{o}). Off Oceanside, waves approached from the west approximately 19% of the time in 2023 and approximately 18% of the time in 2024, compared to 17% of the time in 2021 and 16% of the time in 2022.

The direction of swells offshore of Point Loma was predominately from the west (270^{o}), approximately 32% of the time in 2023 and approximately 31% of the time in 2024 (Table 11), compared to 28% of the time in 2021 and 37% in 2022. The direction of swells was from the south (180^{o}) approximately 22% of the time in 2023 and 16% of the time in 2025, and from the south-southwest (202.5^{o}) approximately 19% of the time in 2023 and 25% of the time in 2024.

The occurrence of large waves (defined as 3 meters or more) off Oceanside and Point Loma in 2023 and 2024 are shown in Table 13. Many storms in 2023 and 2024 produced wave heights greater than 6 meters off Point Loma, while wave heights off Oceanside were usually less than 5 meters. The largest wave off Oceanside in 2023 was recorded on April 3rd at a height of 5.0 meters; no other waves larger than 5.0 meters were recorded in 2023. Waves exceeding 3 meters were only recorded from

January through April, and in August, September, and December. The largest waves (5 meters or more) offshore of Point Loma in 2023 were recorded in January (on 9 days, with the largest wave of 6.6 meters on the 2nd), February (on 5 days, with the largest wave of 8.0 meters on the 22nd), March (on 5 days, with the largest wave of 7.2 meters on the 2nd), April (on 2 days, with largest wave of 6.6 meters occurring on the 4th), and December (on 4 days, with the largest wave of 7.3 meters on the 29th). Waves exceeding three meters were recorded every month in 2023 except for July.

The California coastal wave monitoring and prediction system predicts average swell heights each day within offshore and nearshore areas of the Southern California Bight based on buoy observations. Wave and swell heights produced by major storms in 2023 and 2024 are presented below (Table 13 and Figures 22 through 44):

- The storms that occurred on January 1 and 2, 2023, produced wave heights off Oceanside of 4.8 meters maximum on January 1 (data not available for January 2) and off Point Loma of 6.3 and 6.6 meters maximum (Table 12). These storms produced maximum swells up to 2 to 6 feet in kelp areas (Figure 22).
- A prolonged storm event from January 10-17, 2023, produced significant wave activity along the Region Nine coastline. Maximum wave heights reached 3.2 to 4.9 meters off Oceanside and 4.9 to 6.4 meters off Point Loma (Table 13). Predicted swell heights were generally up to 6 feet throughout the region, with peaks up to 9 feet near San Diego on January 11 and south of Oceanside on January 14. Offshore swell heights ranged from 4 to 6 feet in the northern portion of the region and up to 8 feet in the south (Figure 23).
- The storms that occurred on February 6 and 7, 2023, produced maximum wave heights off Oceanside from 3.0 to 4.6 meters and off Point Loma from 4.9 to 5.6 meters (Table 13). These storms produced maximum swells up to 2 to 6 feet in kelp areas (Figure 24).
- The storm on February 15, 2023, produced wave heights off Point Loma up to 6.6 meters maximum (no data available for Oceanside) (Table 13). Maximum swells recorded in kelp areas ranged up to 3 to 6 feet (Figure 25).
- A series of storms from February 22-25, 2023, produced maximum wave heights off Oceanside from 2.2 to 4.9 meters and off Point Loma from 3.7 to 8.0 meters (Table 13). Maximum swells in kelp areas ranged from 0 to 6 feet (Figure 26).
- The storms that occurred on March 1 and 2, 2023, produced maximum wave heights off Oceanside from 2.4 to 3.0 meters and off Point Loma from 5.6 to 7.2 meters (Table 13). Maximum swells in kelp areas ranged from 0 to 6 feet (Figure 27).
- A series of storms from March 21-23, 2023, produced maximum wave heights off Oceanside from 2.9 to 4.5 meters and off Point Loma from 5.3 to 6.0 meters (Table 13). Maximum swells in kelp areas up to 1 to 10 feet (no data available for March 22) (Figure 28).
- The storms that occurred on April 3 and 4, 2023, produced maximum wave heights off Oceanside up to 5.0 meters and off Point Loma from 5.1 to 6.6 meters (Table 13). Maximum swells in kelp areas ranged from only 0 to 2 feet (Figure 29).
- A series of storms from December 28-31, 2023, produced maximum wave heights off Oceanside from 4.2 to 4.8 meters and off Point Loma from 5.9 to 6.3 meters (Table 13). Maximum swells in kelp areas ranged from 2 to 12 feet (Figure 30).
- A series of storms from January 4-8, 2024, produced maximum wave heights off Oceanside from 1.3 to 4.4 meters and off Point Loma from 4.2 to 7.1 meters (Table 13). Maximum swells in kelp areas ranged from 3 to 6 feet (Figure 31).

- The storm on January 11, 2024, produced wave heights off Point Loma up to 6.1 meters maximum (no data available for Oceanside) (Table 13). Maximum swells recorded in kelp areas ranged from 0 to 6 feet (Figure 32).
- The storm on January 21, 2024, produced wave heights off Oceanside up to 3.1 meters maximum and off Point Loma up to 5.2 meters maximum (Table 13). Maximum swells recorded in kelp areas ranged from 2 to 6 feet (Figure 33).
- The storms that occurred on February 1 and 2, 2024, produced maximum wave heights off Oceanside from 3.9 to 4.8 meters and off Point Loma from 5.8 to 6.1 meters (Table 13). Maximum swells in kelp areas ranged from 2 to 8 feet (Figure 34).
- The storm on February 5, 2024, produced wave heights off Oceanside up to 5.4 meters maximum and off Point Loma up to 7.1 meters maximum (Table 13). Maximum swells recorded in kelp areas ranged from 4 to 6 feet (Figure 35).
- The storms that occurred on February 20 and 21, 2024, produced maximum wave heights off Oceanside from 4.1 to 5.2 meters and off Point Loma from 5.4 to 7.3 meters (Table 13). Maximum swells in kelp areas ranged from 3 to 12 feet (no data available for February 21) (Figure 36).
- The storm on March 8, 2024, produced wave heights off Oceanside up to 3.1 meters maximum and off Point Loma up to 5.8 meters maximum (Table 13). Maximum swells recorded in kelp areas ranged from 0 to 6 feet (Figure 37).
- The storms that occurred on March 20 and 25, 2024, produced maximum wave heights off Oceanside from 4.7 to 5.1 meters and off Point Loma from 6.1 to 8.2 meters (Table 13). Maximum swells in kelp areas ranged from 0 to 6 feet (Figure 38).
- The storm on April 6, 2024, produced wave heights off Oceanside up to 3.8 meters maximum and off Point Loma up to 5.1 meters maximum (Table 13). Maximum swells recorded in kelp areas ranged from 0 to 6 feet (Figure 39).
- The storm on April 27, 2024, produced wave heights off Oceanside up to 4.7 meters maximum and off Point Loma up to 5.5 meters maximum (Table 13). Maximum swells recorded in kelp areas ranged from 1 to 3 feet (Figure 40).
- The storm on October 29, 2024, produced wave heights off Oceanside up to 3.6 meters maximum and off Point Loma up to 6.3 meters maximum (Table 13). Maximum swells recorded in kelp areas ranged from 2 to 6 feet (Figure 41).
- The storms that occurred on November 15 and 16, 2024, produced maximum wave heights off Oceanside from 3.6 to 4.8 meters and off Point Loma from 5.4 to 5.7 meters (Table 13). Maximum swells in kelp areas ranged from 0 to 6 feet (Figure 42).
- A series of storms from December 22-26, 2024, produced maximum wave heights off Oceanside from 2.5 to 3.1 meters and off Point Loma from 5.1 to 6.6 meters (Table 13). Maximum swells in kelp areas ranged from 2 to 12 feet (Figure 43).
- The storm on December 29, 2024, produced wave heights off Oceanside up to 2.4 meters maximum and off Point Loma up to 5. meters maximum (Table 13). Maximum swells recorded in kelp areas ranged from 0 to 9 feet (Figure 44).

Large waves generated by major storm events can cause mortality to giant kelp individuals, particularly during strong El Niño events, through destruction of the holdfast anchoring individuals to the bottom. (Edwards 2019; Edwards & Estes 2006; Seymour et al 1989). Very few large waves (5 meters or more) were recorded off Oceanside in 2023 or 2024 (only on 1 date in 2023 and 3 dates in 2024). However, large waves (5 meters or more) were more frequently recorded off Point Loma in 2023 and 2024 than in each year from 2018 through 2022 (Table 14). In 2023, large waves were recorded on eight days in January, five days in February, 5 days in March, and 2 days in April (a total of 20 days with maximum wave heights of 5 meters or more in 2023). In 2024, large waves were recorded on six days in January, six days in February, three days in March, 2 days in April, one day in October, two days in November, and six days in December (a total of 26 days with maximum wave heights of 5 meters or more in 2024). In comparison, from 2018 to 2022 the total number of days with maximum wave heights of 5 meters or more ranged from 0 to 10 days per year. It appears likely that the frequency of storms with large waves in 2023 and 2024 could have caused mortality to giant kelp within the Point Loma kelp bed (although no data was found to confirm this).

IV.2.F - RAINFALL

Rainfall data for 2023 and 2024 for Costa Mesa and San Diego are shown in Figure 45.

The total amount of rainfall in 2023 was only slightly higher than average for Costa Mesa (14.8 inches compared to an average of 13.3 inches), but higher than usual rainfall in San Diego (14.4 inches compared to an average of 10.3 inches). Costa Mesa and San Diego both experienced higher than normal amounts of rainfall during the months of January and March, and close to average rainfall in February. In 2023, rainfall for Costa Mesa was relatively low in April and from June through November but slightly above average in May and approximately half the normal amount in December. Rainfall for San Diego in 2023 was relatively low from April through July and in September and October but well above average in August and approximately half to two-thirds normal in November and December.

Total rainfall in 2024 was lower than in 2023 in both Costa Mesa and San Diego. Rainfall was slightly below average for Costa Mesa (11.2 inches compared to average rainfall of 13.3 inches per year), but slightly above average for San Diego (11.2 inches compared to average rainfall of 10.3 inches per year). Rainfall was lower than average for Costa Mesa in 2024 during the month of January (approximately half to two-thirds lower than normal), but higher than average in February and March. However, rainfall was higher than average for San Diego from January through March. Little to no rainfall was recorded for Costa Mesa or San Diego from April through December in 2024.

Heavy rainfall runoff in southern California may increase sedimentation that may negatively impact kelp understory growth due to sand scour. Increased freshwater input to the nearshore environment may lead to higher resuspension of sediment resulting in increased turbidity and light attenuation, which could compromise kelp growth (Seymour et al. 1989). Rainfall was higher than normal in January and March of 2023 for Costa Mesa and San Diego and from January through March of 2024 for one or both locations. It is possible that high runoff during these periods produced increased turbidity in nearshore areas, but no data could be found to evaluate potential adverse impacts to kelp beds in the region.

IV.2.G - PHYTOPLANKTON

Harmful Algal Bloom (HAB) data were available in real time for certain locations via the SCCOOS website (refer to www.sccoos.org). 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). The phytoplankton concentrations recorded at Newport Pier and Scripps Pier in 2023 and 2024 appear unlikely to have impacted kelp beds.

At Newport Pier, extremely high concentrations of the *Pseudonitzschia seriata* and *P. delicatissima* groups were recorded in February, March, and April 2023. High concentrations of the *P. seriata* group were also recorded in January and June 2023 and January, May, July, August, and October 2024 (Figure 46). High concentrations of the *P. delicatissima* group were recorded most months in 2023 and 2024 (except August, November, and December 2023 and December 2024).

At Scripps Pier, extremely high concentrations of the *P. seriata* group were recorded in March and April 2023, as well as in December 2024 (Figure 47). High concentrations were also recorded in February and June 2023, as well as in January, March, May, and July 2024. High concentrations of the *P. delicatissima* group were recorded from February through October 2023, as well as in January, March, April, and May 2024. Extremely high concentrations of the *P. delicatissima* group were recorded in June, July, October, and December 2024.

Domoic acid was extremely high (2.4 ng/mL) at Newport Pier in March 2023; low levels were recorded in February and April 2023, but domoic acid was not recorded from May 2023 through December 2024 (Figure 47). Domoic acid concentrations at Scripps Pier were low in February, March, April, and November 2023, as well as in August 2024 (Figure 48). An extremely high concentration (2.5 ng/mL) was recorded at Scripps Pier in December 2024.

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 (Eger et al. 2020). 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 organizations, 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).

The protection and restoration of California's kelp forests has emerged as a top priority for the California Ocean Protection Council (OPC) and the California Department of Fish and Wildlife (CDFW). Efforts initiated in 2019 and 2020 are providing resource managers with critical monitoring data, an enhanced understanding of the drivers of kelp loss and persistence, and science-based evaluations of potential kelp restoration approaches. However, significant knowledge gaps remain. In support of OPC's Strategic Plan to Protect California's Coast and Ocean 2020--2025, an Interim Action Plan was developed to summarize current state-supported kelp research and restoration initiatives, as well as other relevant efforts in California; highlight key knowledge gaps; and outline priorities for action in kelp research and monitoring, policy development, restoration, and community engagement (California Ocean Protection Council, 2021). Those priorities include: completing pilot efforts; developing science-based metrics for tracking kelp forest ecosystem health; implementing statewide kelp forest monitoring based on those metrics; initiating the development of a kelp restoration and management plan, which will include a restoration "toolkit"; and engaging with California's coastal communities and Native American Tribes. The OPC has developed this interim Action Plan in partnership with CDFW to serve as a starting point for discussion between resource managers, the academic community, California Native American Tribes, coastal stakeholders (including the diving and fishing communities), and members of the public. The final Kelp Restoration and Management Plan remains under development.

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 (MBC Aquatic Sciences, 2023). One factor that may be impeding recovery of the kelp beds is the abundance of an invasive species known as devil weed (*Sargassum horneri*) (Marks, Reed, and Holbrook 2020). This species forms dense beds and may crowd out giant kelp. Nancy Caruso (Get Inspired, Inc) 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 (required to support 28 tons of fish and 150 acres of kelp forest annually for 32 years). Monitoring results indicated that the reef was not on a trajectory to meet the mitigation goal for kelp area (although this was met from 2010 through 2015, it was not met in 2009 or 2016) and fish standing stock (was not met from 2009 through 2016).

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. The reef now encompasses 376 acres, stretching from Seal Rock to Dana Point. According to scientists from the University of California, Santa Barbara, Marine Science Institute, monitoring data collected in 2021 for the Wheeler North Reef indicated that it was meeting most performance expectations (food chain support, resident fish density, young-of-year density, fish species richness, fish reproductive rates, fish production, sessile invertebrate percent cover, mobile invertebrate density, and total invertebrate species richness), but did not meet the standards for algal percent cover or algal species richness (California Coastal Commission 2021).

A revised method for calculating mitigation credits was adopted in 2019. The annual standing stock of fish and acreage of giant kelp at Wheeler North Reef are measured each year and will be summed over time until they reach a cumulative total equivalent to the annual target x the number of years of San Onofre Nuclear Generating Station (SONGS) operations (32 years). The reef produced 34 acres of kelp in 2019, 4 acres in 2020, and 47 acres in 2021, as well as 18 tons of fish standing stock in 2019, 22 tons in 2020, and 28 tons in 2021. In total, 4,800 acres of giant kelp area credit will be required for mitigation plus 896 tons of fish standing stock credit (California Coastal Commission 2021).

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*), 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 15). 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).

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). In 2020, 32 licenses were issued in California (13 for giant kelp). The license must specify the intent to participate in specified seaweed harvesting categories. The categories differ in the intended use. Historically (prior to 2011), the categories were edible seaweed, kelp, and agar. Algae harvested as edible seaweed must be used for human consumption, while algae harvested as kelp can be used for purposes other than human consumption, such as feed for cultivated abalone. Algae harvested as agar historically were harvested for agar extraction, although this is not a current use. In 2011, the Department split the kelp category on the licenses into giant kelp and bull kelp and added "bull kelp human consumption" as an option for edible seaweed to better understand kelp targets and intended uses.

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.

The California Fish and Game Commission adopted regulation amendments and new regulations for commercial harvest of kelp and other marine algae that became effective on January 1, 2023 (California Code of Regulations, 2023). The revised regulations include California Code of Regulations Title 14, sections 165 and 165.5, Appendix A, and the new Section 705.1. These regulations include temporary changes that expire on Jan. 1, 2026. The changes aim to reduce harvest pressure on bull kelp, which is in decline in Sonoma and Mendocino counties.

The new regulations pertain to all commercial harvest of marine algae. The more substantive changes pertaining to licensing and reporting requirements include:

- The harvesting license is now known as the Kelp Harvesting License and Drying Application and will include a drying option for those who dry their harvest.
- Monthly harvest reports will require reporting the number of individuals harvesting for the business during the reporting period, and central latitude/longitude coordinates of bull kelp harvest locations.
- The Commercial Kelp Harvester's Monthly Report will require separating reporting weights for bull kelp and giant kelp harvest.

In the future, CDFW also plans to review its Royalty Rates and License Fees schedule for commercial harvesters. The royalty rates for kelp were established roughly 25 years ago at $1.71 per wet ton, and the rates for edible seaweed and agar were established roughly 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 under review (Rebecca Flores-Miller, personal communication). Recreational harvesters are prohibited from harvesting or disturbing eelgrass (*Zostera* spp.), surfgrass (*Phyllospadix* spp.), and sea palm (*Postelsia palmaeformis*). Marine aquatic plants may not be cut or harvested in state marine reserves. Regulations may prohibit cutting or harvesting of marine aquatic plants within state marine conservation areas and state marine parks (California Code of Regulations, Title 14, Section 632b). The extent of recreational kelp harvest is unknown as recreational marine alga harvesters are not required to report harvest data and the Department does not monitor the number of recreational harvesters or the amount of their harvest. Department staff estimated that prior to 2000, less than 25 tons were harvested annually by recreational and Tribal users (refer to wildlife.ca.gov/Conservation/Marine/Kelp/Commercial-Harvest).

Commercial marine algae harvest data are shown in Figure 49 for the period from 1931 to 2020 (refer to marinespecies.wildlife.ca.gov/kelp/the-fishery/). 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 Region Nine.

Table 16 illustrates 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.

V - CONCLUSIONS

The total kelp canopy declined by 58% in 2023 (to 0.8 km^2) and by an additional 25% in 2024 (to 0.6 km^2), resulting in an overall decrease of 68 % from 2022 to 2024. Total canopy size was well below the long-term average and the 2023 and 2024 values represented the lowest levels recorded since 1998, and these two kelp beds only accounted for 47% of the total kelp canopy. In 2024, the Point Loma kelp bed was the second largest in the region and the La Jolla kelp bed was the fourth largest; these two kelp beds only represented 34% of the total canopy. In 2023 and 2024, most beds were very small or absent, with only four beds exceeding 5% of their historical maximum levels.

SST values were warmer than average during January, much of July and August, and most of September through December 2023, as well as most of 2024. SST values were below average for much of February, March, and April 2023, with surface water temperatures below 14°C (when nutrient availability is generally favorable for kelp forest growth) often during this period. However, surface temperatures were rarely below 14°C during the remainder of 2023 or most of 2024 (January through November). The very low Nutrient Index values during 2023/24 indicate low nutrient availability, which probably created conditions unfavorable for kelp growth, contributing to the decrease in total kelp canopy observed in 2023. Although Nutrient Index values were high for the 2024/25 period, this was primarily due to low temperatures recorded from January through April 2025; nutrient availability during calendar year 2024 therefore was relatively low.

VI – LITERATURE CITED

California Coastal Commission. 2021. Monitoring plan for the SONGS' Reef Mitigation Project. 44 p.

California Code of Regulations. Title 14, Section 165. 2023. Commercial Harvesting of kelp and Other Aquatic Plants.

California Ocean Protection Council. 2021. Interim Action Plan for Protecting and Restoring California's Kelp Forests.

City of San Diego. 2025. Thermistor data from offshore Point Loma.

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

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

Edwards, M.S. 2019. Comparing the impacts of four ENSO events on giant kelp (*Macrocystis pyrifera*) in the northeast Pacific Ocean. Algae 34(2):141-151.

Edwards, M.S. and J.A. Estes. 2006. Catastrophe, recovery and range limitation in NE Pacific kelp forests: a large-scale perspective. Mar. Ecol. Prog. Ser. 320:79-87.

Eger, A.M., A. Verges, C.G. Choi, H. Christie, M.A. Coleman, C.W. Fagerli, D. Fujita, M. Hasegawa, J.H. Kim, M. Mayer-Pinto, D.C. Reed, P.D. Steinberg, and E.M. Marzinelli. 2020. Financial and institutional support are important for large-scale kelp forest restoration. Front. Mar. Sci. 25:1-15.

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

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

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

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

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

Leichter, J.L., L.B. Ludah, P.E. Parnell, M.D. Stokes, M.T. Costa, J. Fumo, and P.K. Dayton. 2023. Persistence of southern California giant kelp beds and alongshore variation in nutrient exposure driven by seasonal upwelling and internal waves. Front. Mar. Sci. 10:1-15.

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

Lynn, R.J. and J.J. Simpson. 1987. The California Current system: the seasonal variability of its physical characteristics. J. Geophys. Res. 92:12,947-12,966.

MBC Aquatic Sciences. 2019. Status of the Kelp Beds in 2018: Ventura, Los Angeles, Orange, and San Diego Counties. Prepared for the Region Nine Kelp Survey Consortium

MBC Aquatic Sciences. 2020. Status of the Kelp Beds in 2019: Orange and San Diego Counties. Prepared for the Region Nine Kelp Survey Consortium

MBC Aquatic Sciences. 2023. Status of the Kelp Beds in 2021 and 2022: Orange County and San Diego Counties. Prepared for the Region Nine Kelp Survey Consortium

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

Marks, L.M., D.C. Reed, and S.J. Holbrook. 2020. Niche complementarity and resistance to grazing promote the invasion success of *Sargassum horneri* in North America. Diversity 12, 54:1-17.

National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory (ESRL). 2024. Multivariate ENSO Index. Web site: http://www.esrl.noaa.gov/psd/enso/mei/index.html

National Oceanic and Atmospheric Administration (NOAA) National Data Buoy Center (NDBC). 2024. Data Buoys. Web site: http://www.ndbc.noaa.gov

National Oceanic and Atmospheric Administration (NOAA) Pacific Fisheries Env. Lab. (PFEG). 2024. Web site: http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/upwelling/NA

National Oceanic and Atmospheric Administration (NOAA) Southwest Fisheries Sci. Center (SWFSC) Env. Res. Div. (ERD). 2024. Web site: https://swfsc.noaa.gov/erd/

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

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

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

Orange County Sanitation District. 2025. Thermistor data from offshore Orange County.

Parnell, E. 2024. Evaluation of anthropogenic impacts on the San Diego coastal kelp forest ecosystem - Final Project Report: 2019 to 2024.

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

SCCOOS (Southern California Coastal Ocean Observing System). 2024. HAB and ROMS data. Web site: http://www.sccoos.org.

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

Seymor, R.J., M.J. Tegner, P.K. Dayton and P.E. Parnell. 1989. Storm wave induced mortality of giant kelp, *Macrocystis pyrifera*, in southern California. Estuarine, Coastal & Shelf Science 28:277-292.

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

Turner, C.H., E.E. Ebert, and R.R. Given. 1967. The marine environment offshore from Point Loma, San Diego County. Fish Bulletin 140.

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

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

FIGURES

1 through 49

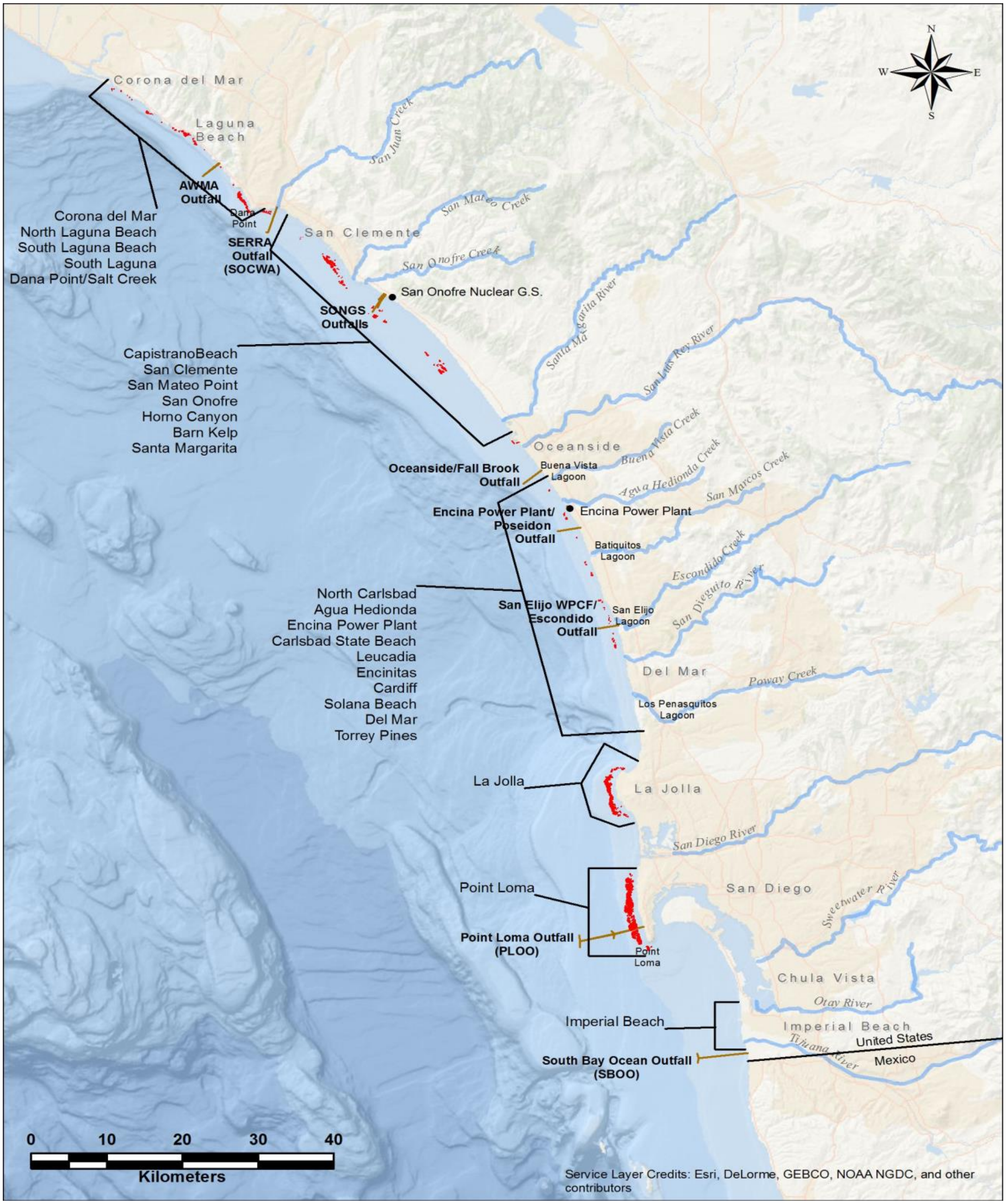
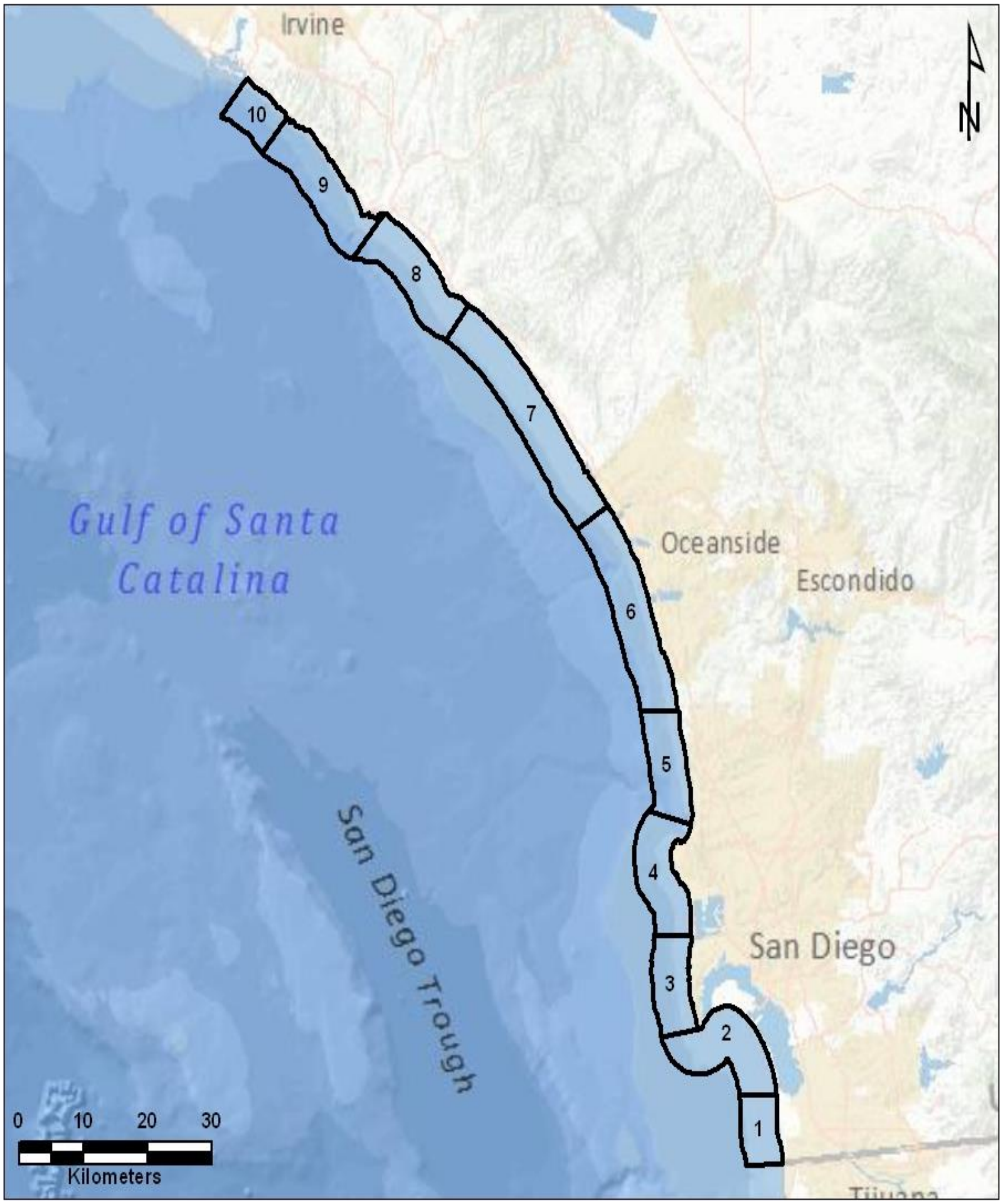


Figure 1. Location of ocean outfalls and designated kelp beds within the Region Nine survey area (red illustrates the approximate areas where surface canopy may occur in a given year within each kelp bed).



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.

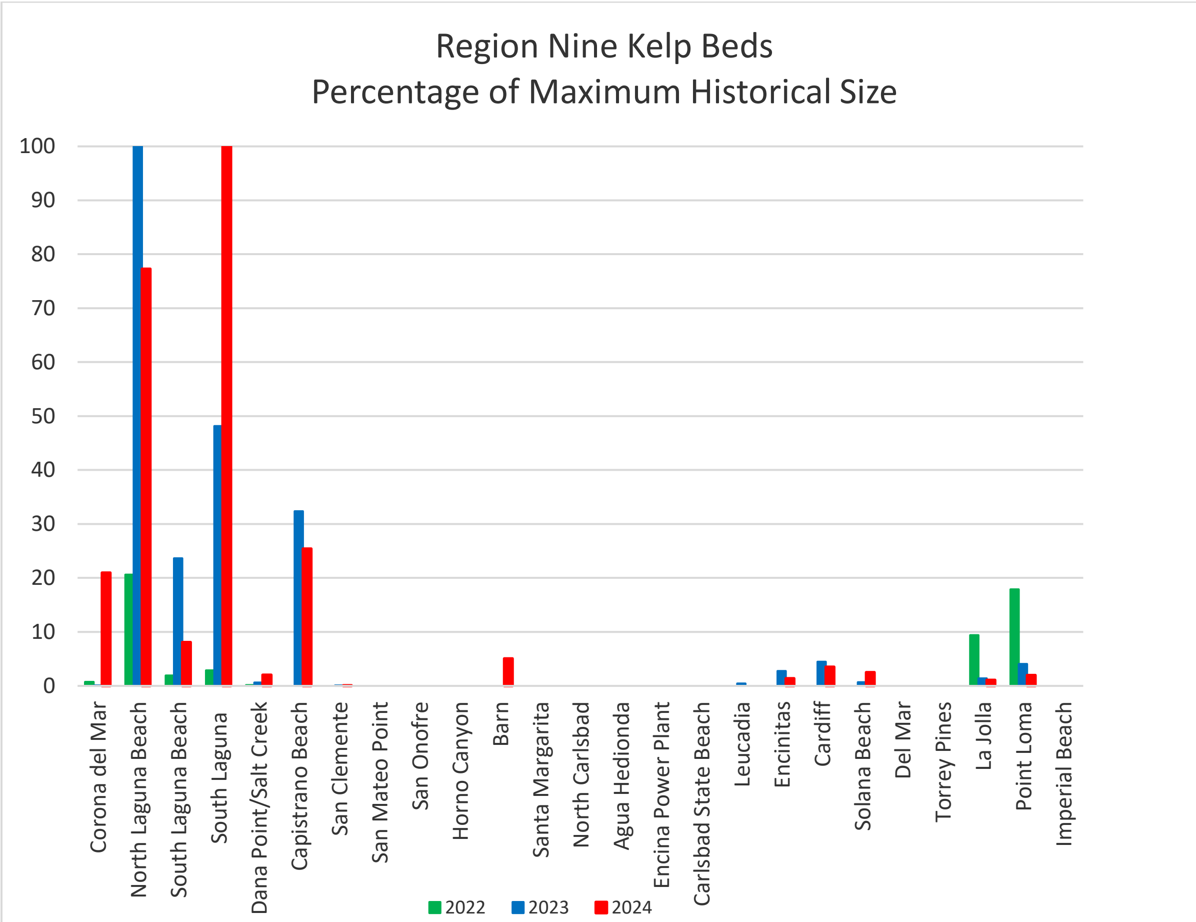


Figure 3. Region Nine kelp canopy coverage in 2022, 2023, and 2024 compared to historical maximum size of each kelp bed.

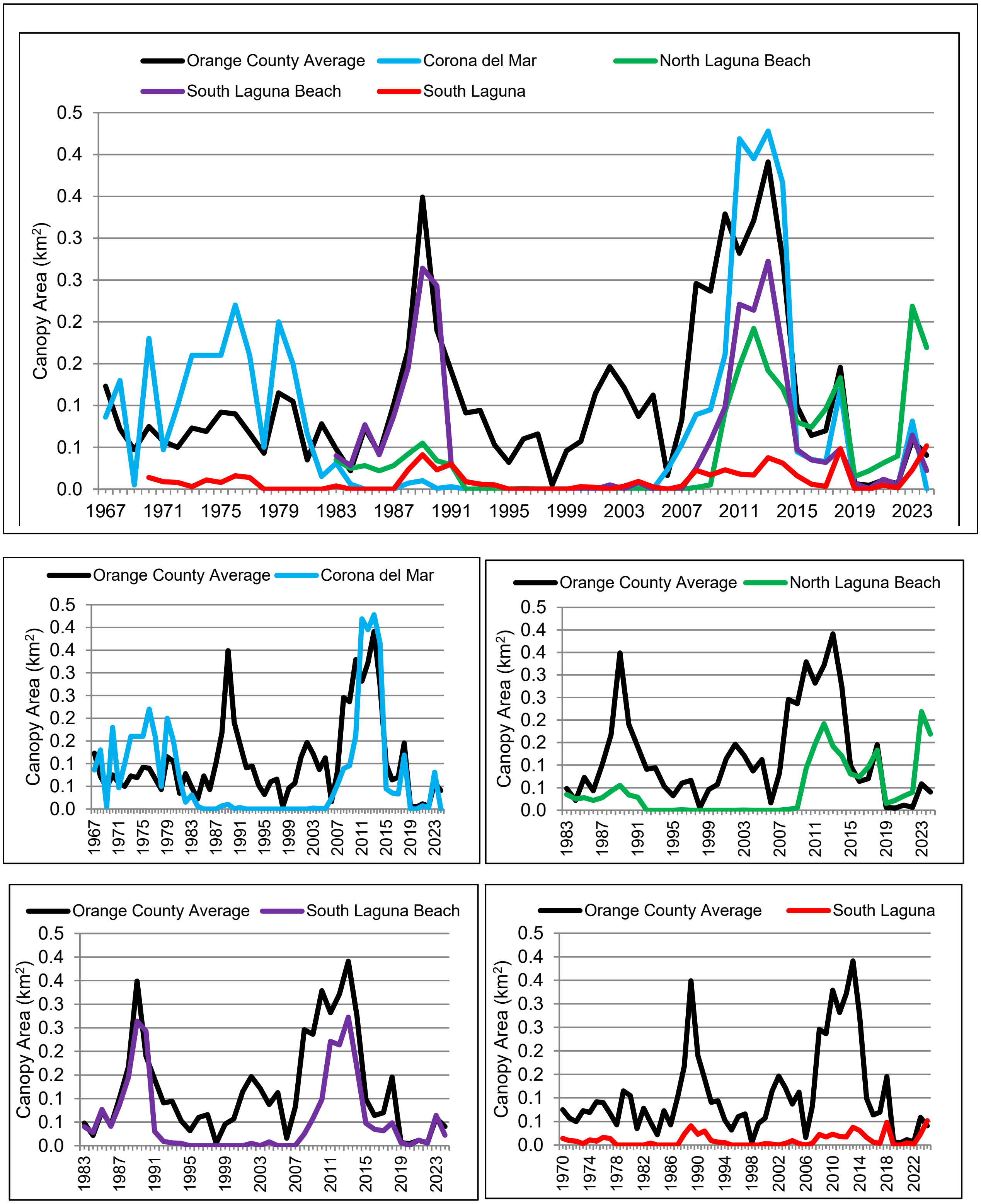


Figure 4. Average Orange County ABAPY compared to canopy coverage of the kelp beds from Corona del Mar to South Laguna from 1967 through 2024 (upper graph), and comparison of ABAPY to canopy coverage of each individual kelp bed (lower four graphs).

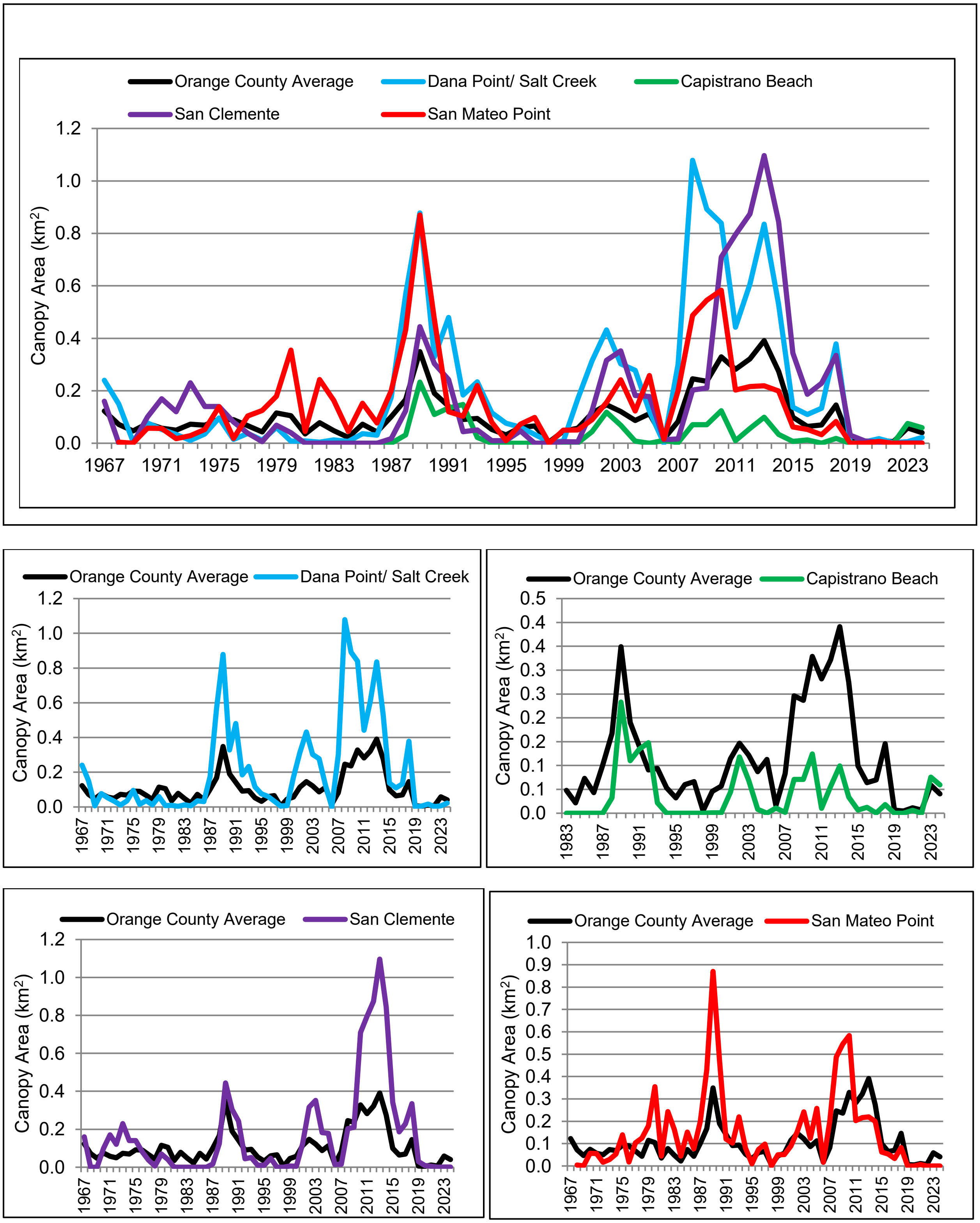


Figure 5. Average Orange County ABAPY compared to the canopy coverage of the kelp beds from Dana Point/Salt Creek to San Mateo Point from 1967 through 2024 (upper graph), and comparison of ABAPY to canopy coverage of each individual kelp bed (lower four graphs).

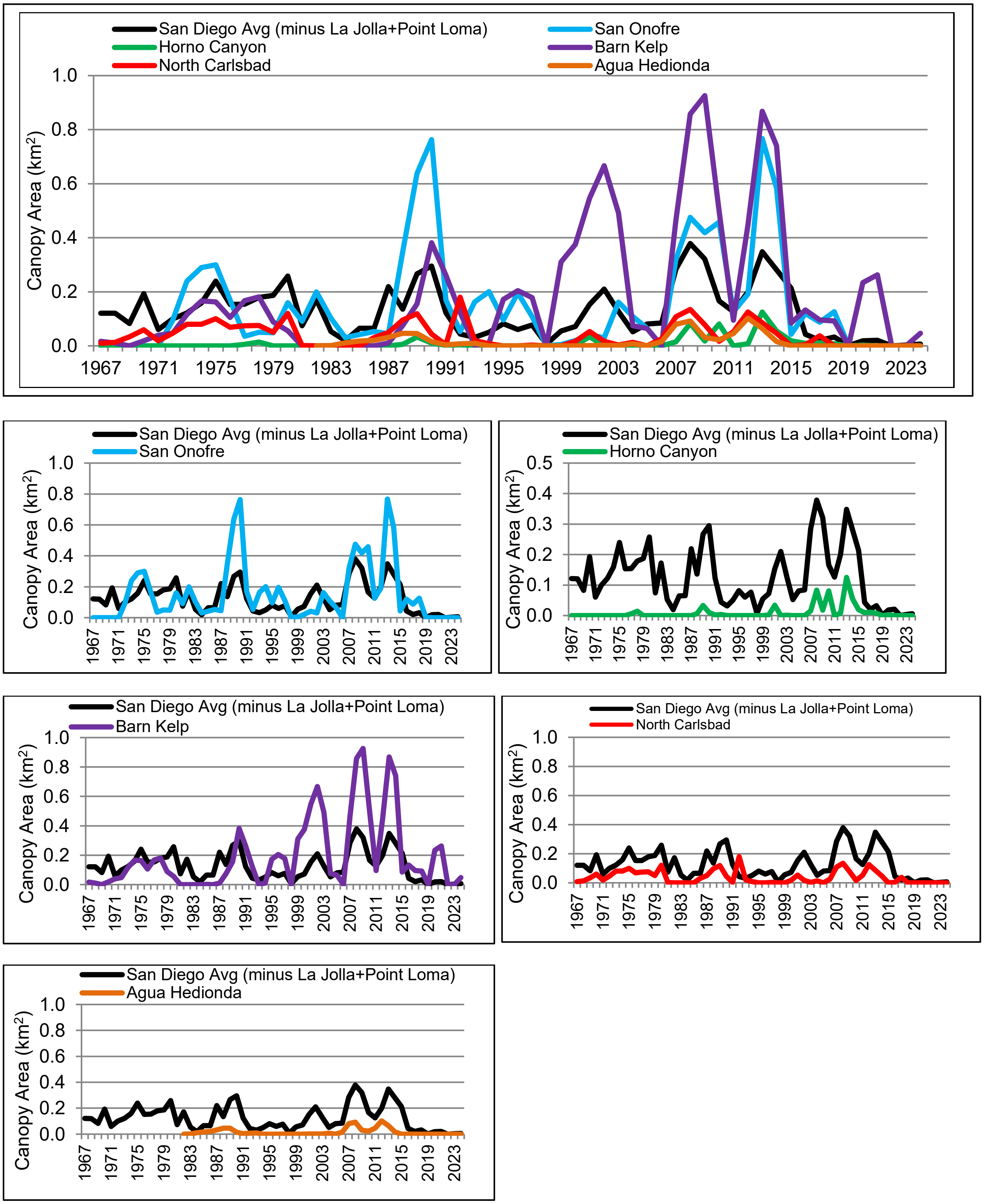


Figure 6. Average San Diego ABAPY compared to canopy coverage of the kelp beds from San Onofre to Agua Hedionda from 1967 to 2024 (upper graph), and comparison of ABAPY to canopy coverage of each individual kelp bed (lower five graphs).

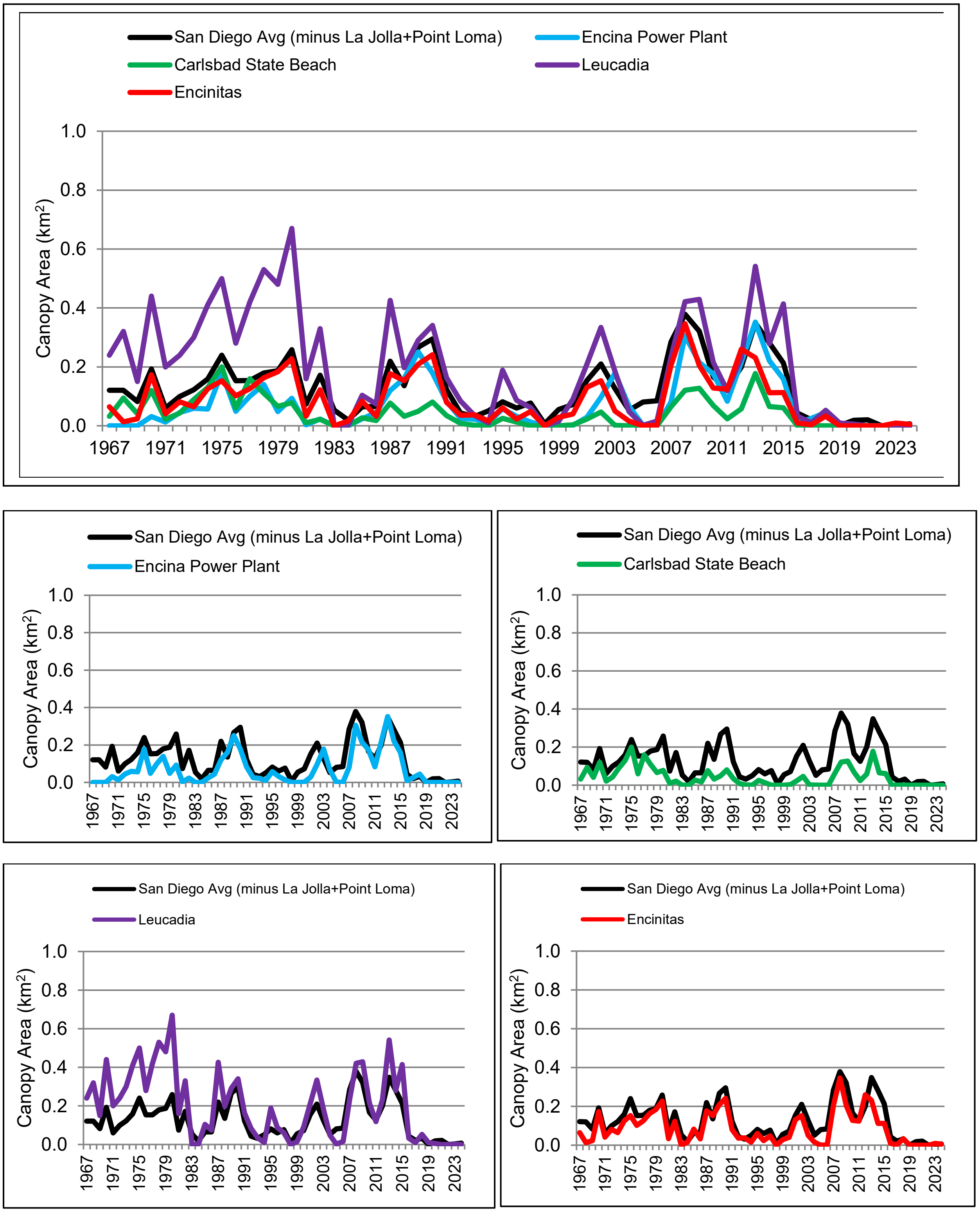


Figure 7. Average San Diego ABAPY compared to canopy coverage of the kelp beds from Encina Power Plant to Encinitas from 1967 to 2024 (upper graph), and comparison of ABAPY to canopy coverage of each individual kelp bed (lower four graphs).

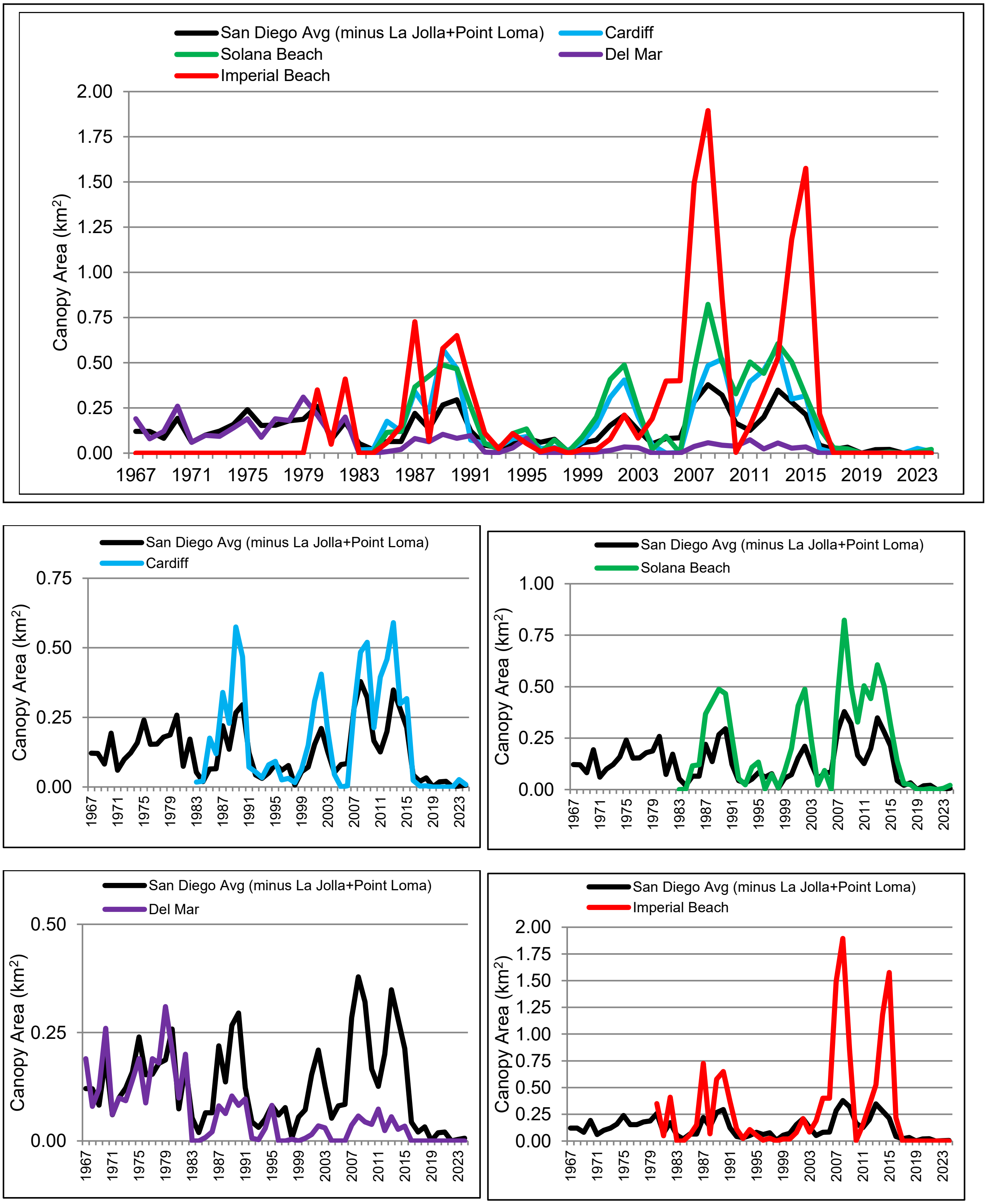


Figure 8. Average San Diego ABAPY compared to canopy coverage of the kelp beds from Cardiff to Imperial Beach from 1967 to 2024 (upper graph), and comparison of ABAPY to canopy coverage of each individual kelp bed (lower four graphs).

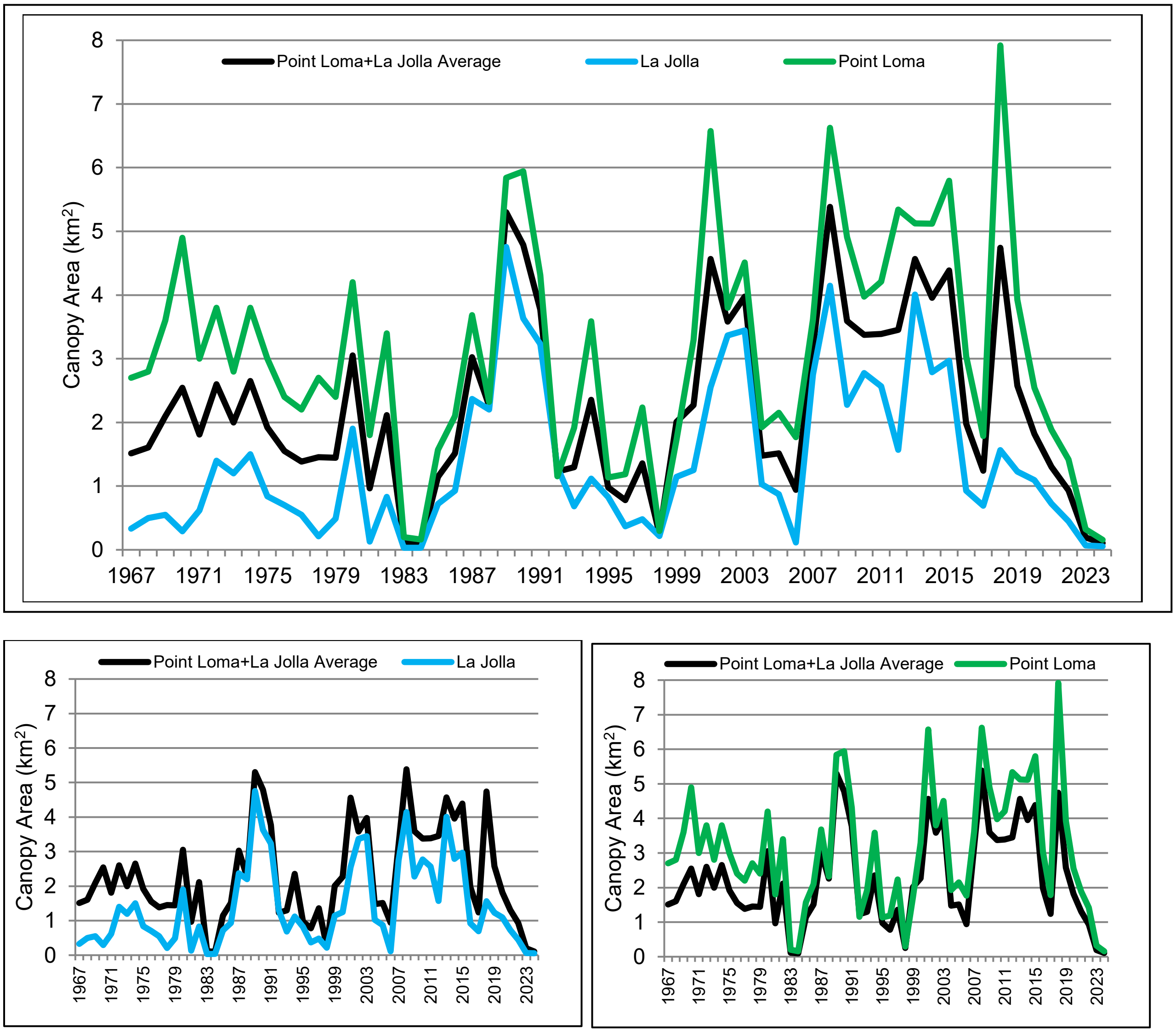


Figure 9. Average Point Loma/La Jolla ABAPY compared to canopy coverage of the La Jolla and Point Loma kelp beds from 1967 to 2024 (upper graph), and comparison of ABAPY to canopy coverage of each individual kelp bed (lower two graphs).

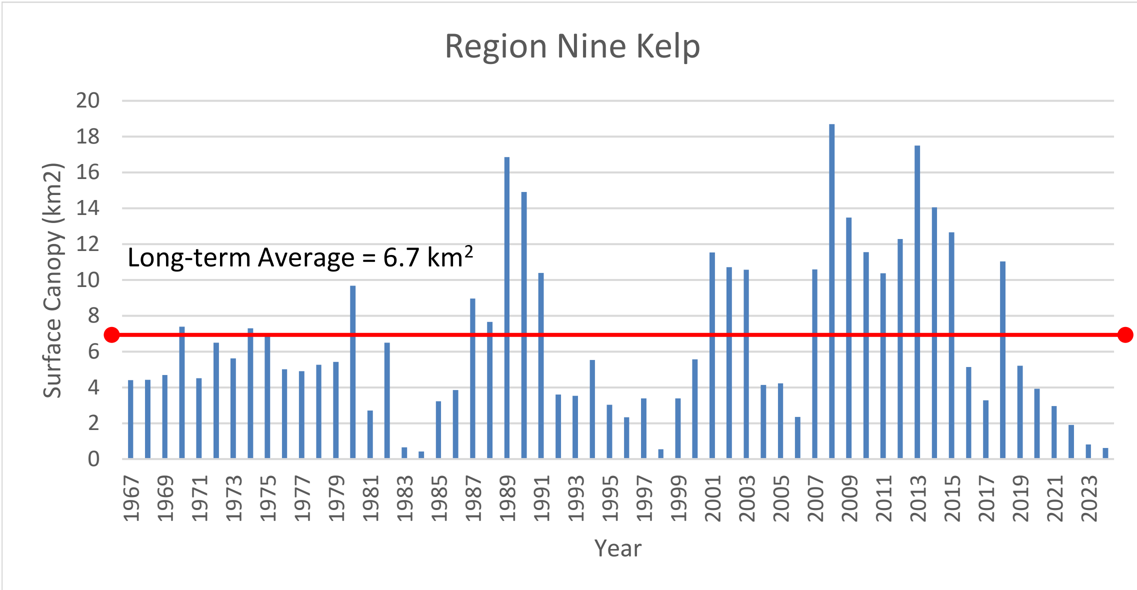


Figure 10. Combined canopy coverage of all kelp beds off Orange and San Diego Counties from 1967 through 2024.

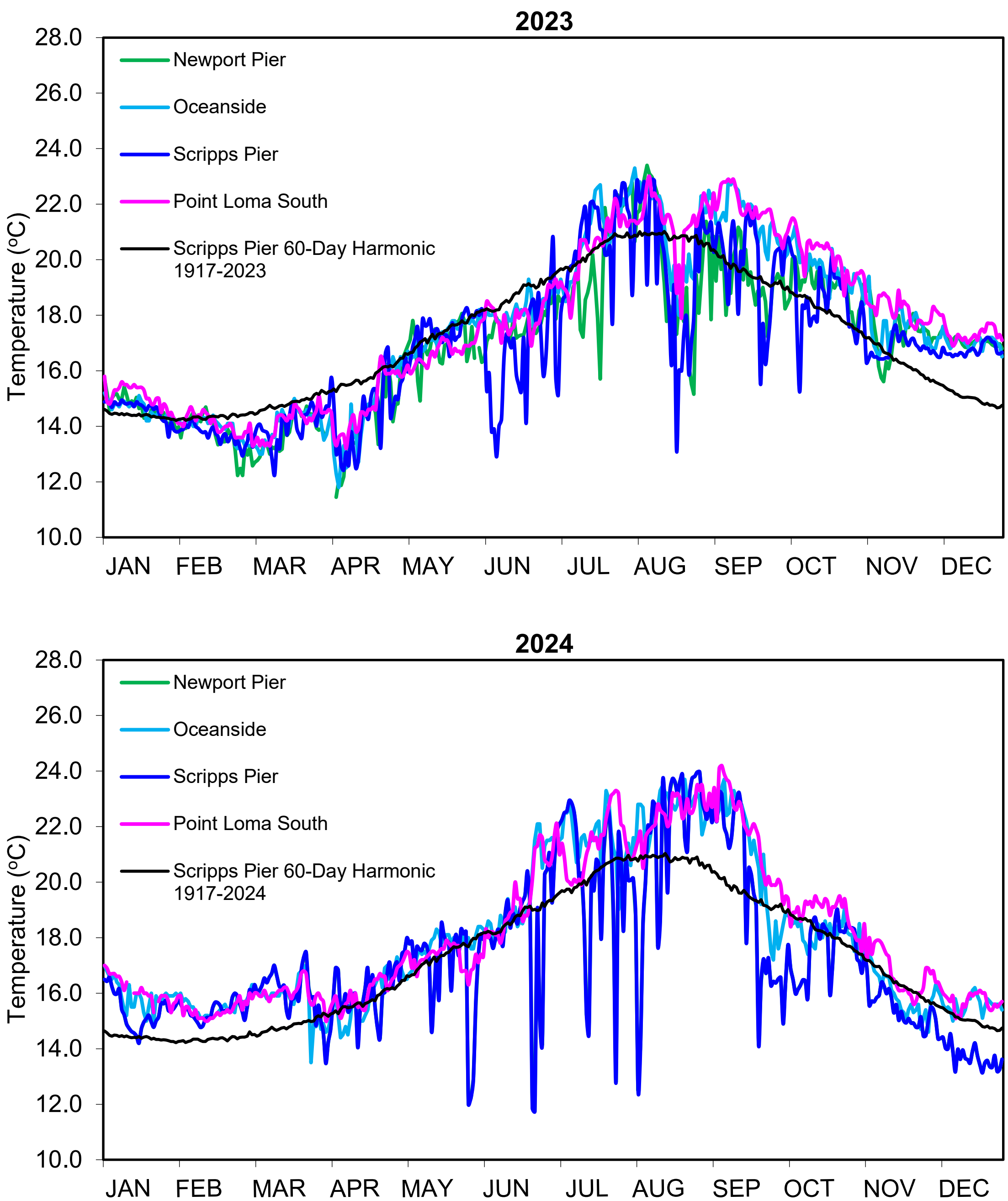


Figure 11. Daily sea surface temperatures (SSTs) at Newport Pier, Oceanside, Scripps Pier, and Point Loma South for 2023 with the long-term harmonic mean for Scripps Pier SIO 60-Day Harmonic calculated from 1917 through 2023, and for 2024 with the long-term harmonic mean for Scripps Pier 60-day harmonic calculated from 1917 through 2024.

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

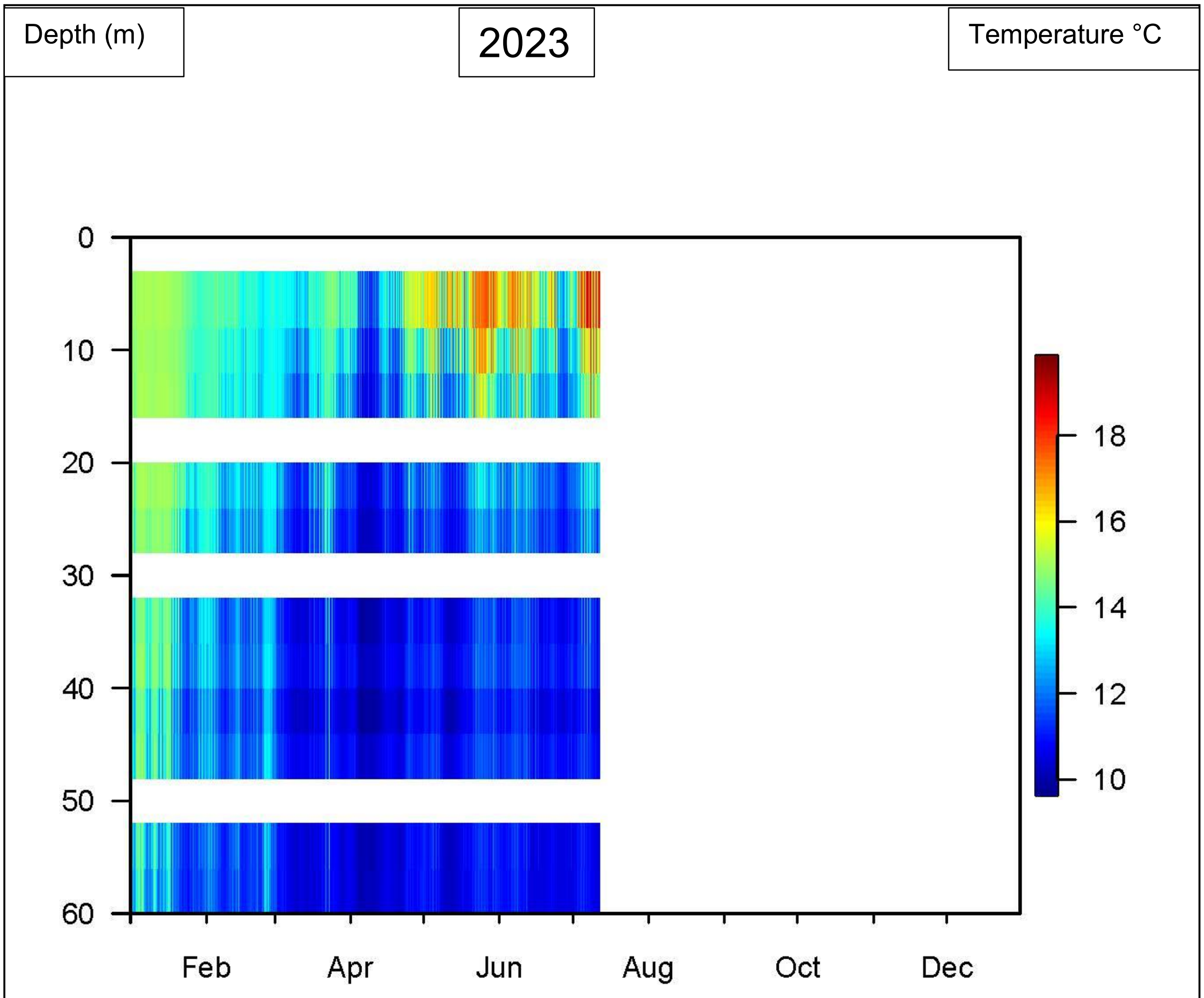


Figure 12. Temperatures (°C) throughout the water column (near surface to a depth of 60 m) off Point Loma during 2023 (no data recorded in 2024).

Note: white areas = no data recorded.

Source: City of San Diego, 2025.

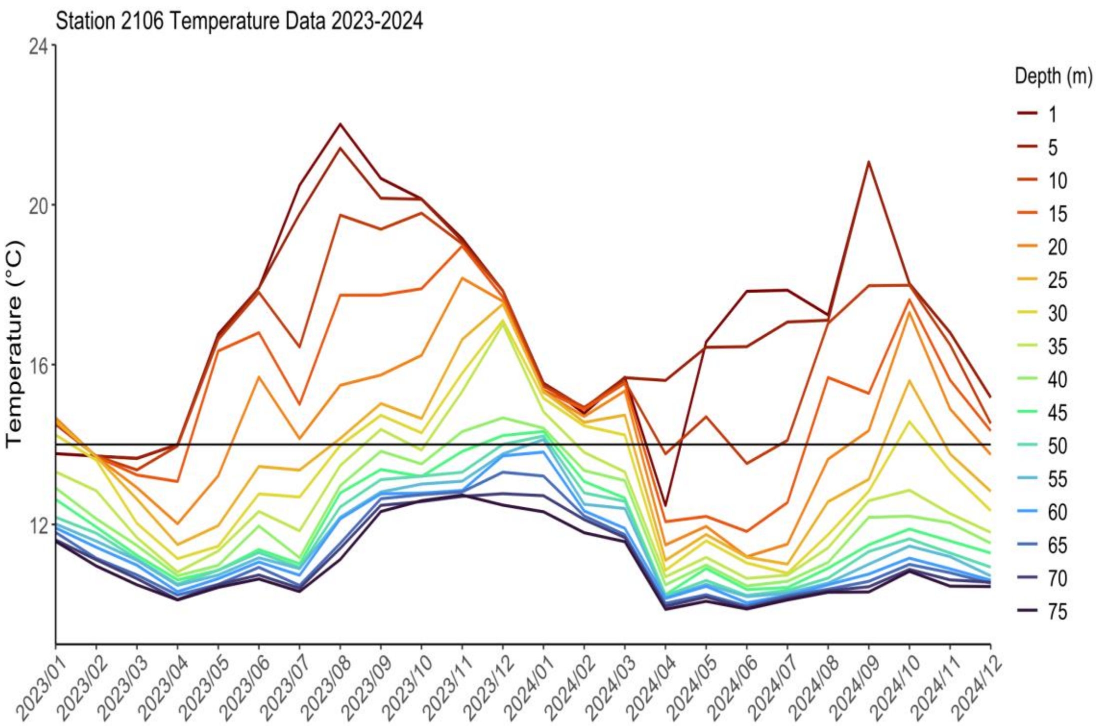


Figure 13. Temperatures (°C) throughout the water column (near surface to a depth of 75 m) off Orange County at Station 2106 during 2023 and 2024.

Horizontal line indicates temperature of 14°C.

Source: Orange County Sanitation District, 2025.

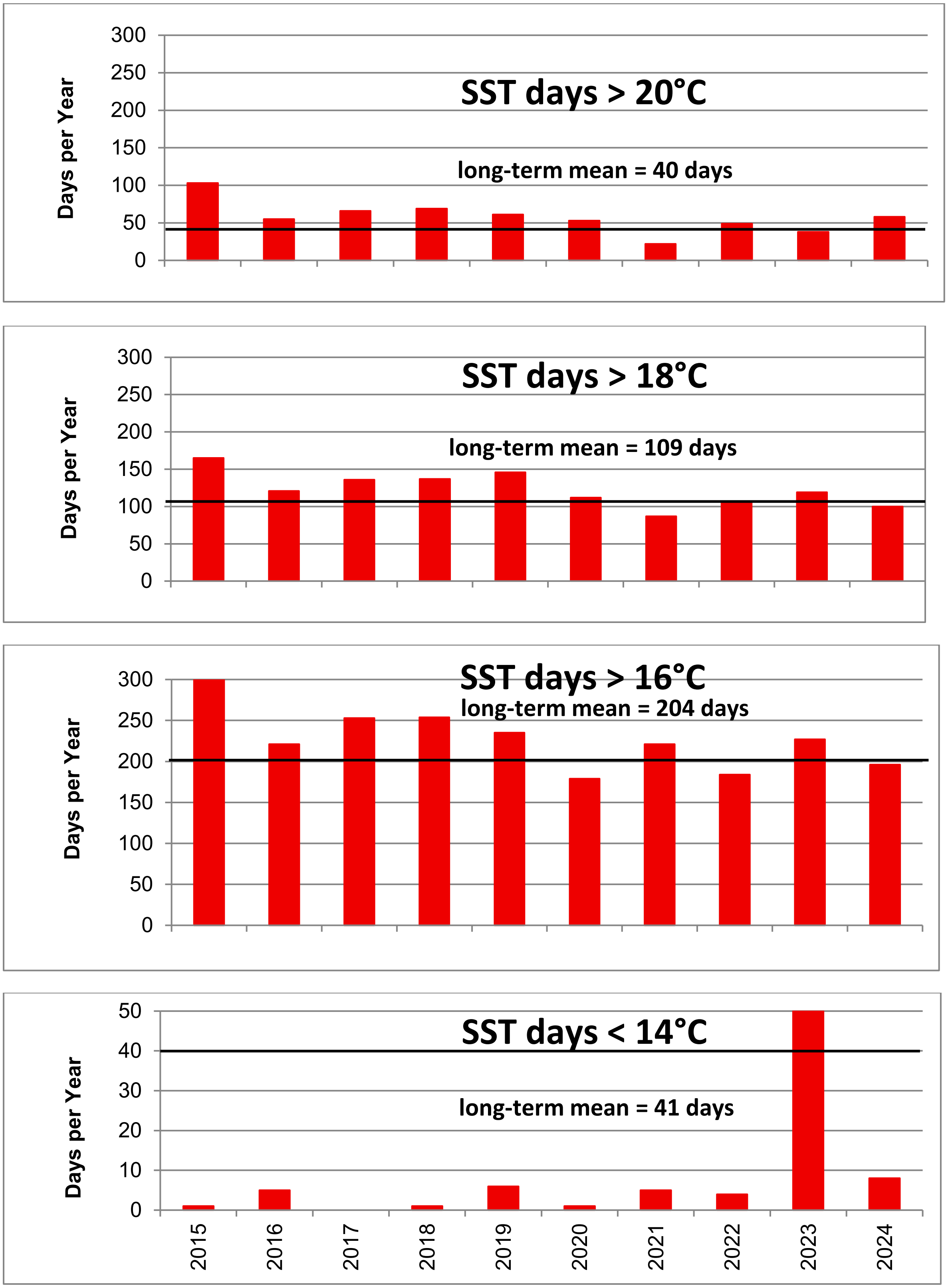


Figure 14. Number of days with SSTs >20ºC, >18ºC, >16ºC, and <14ºC at Newport Pier from 2015 to 2024, and the means from 1994 to 2024.

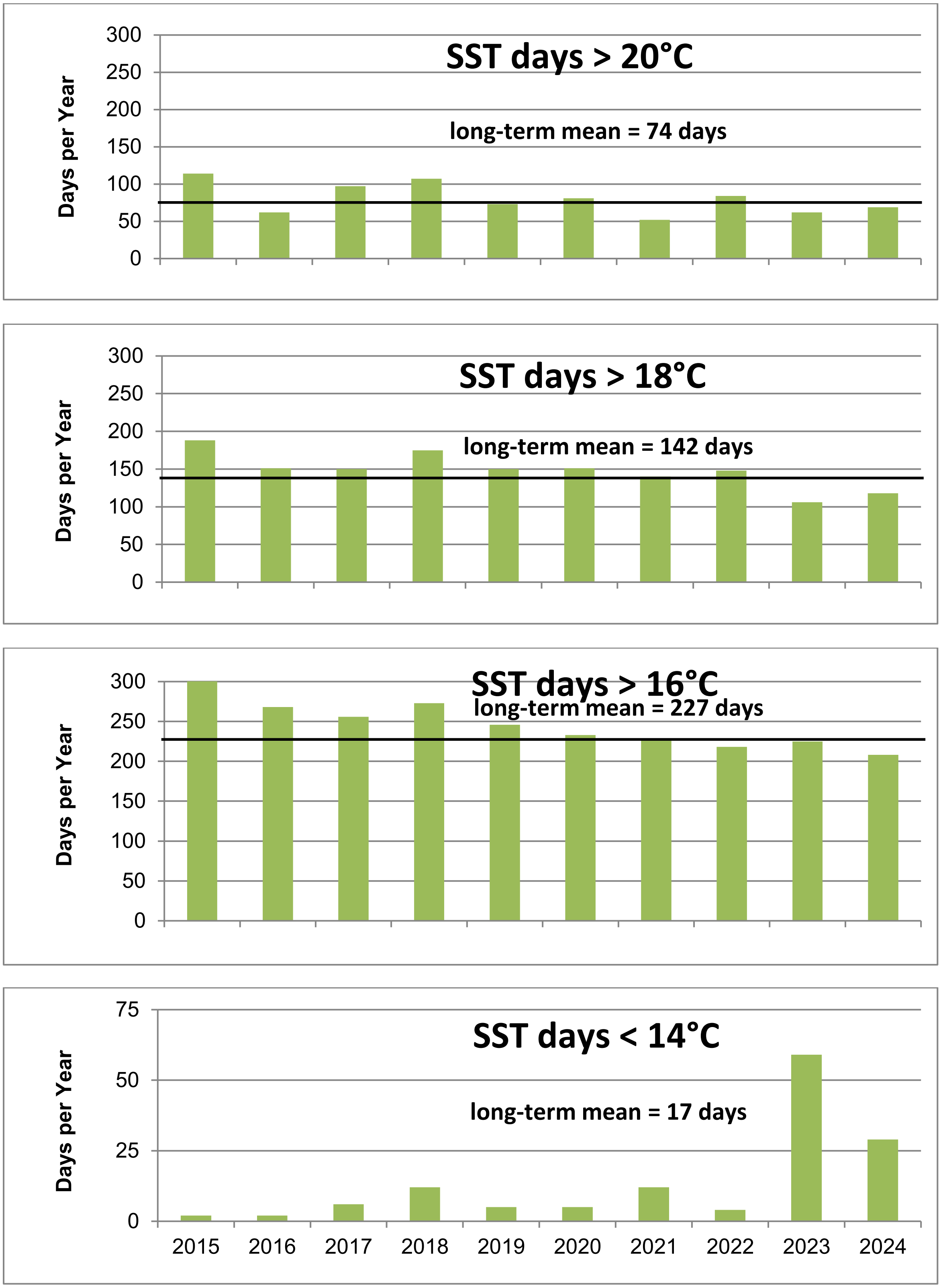


Figure 15. Number of days with SSTs >20ºC, >18ºC, >16ºC, and <14ºC at Scripps Pier from 2015 to 2024, and the means from 1994 to 2024.

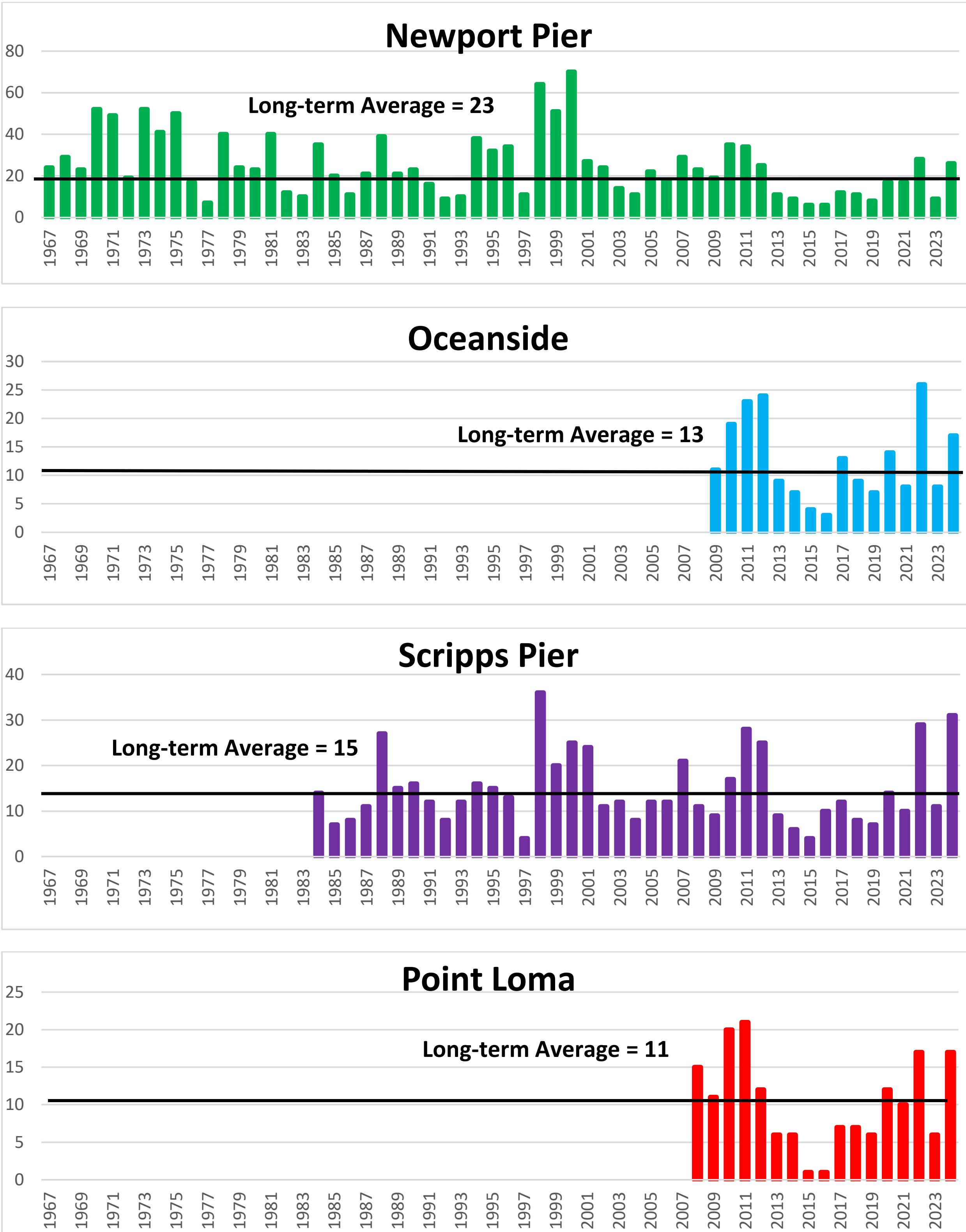


Figure 16. Nutrient Quotient (NQ) values in Region Nine, 1967 to 2024 (black line = long-term mean for site).

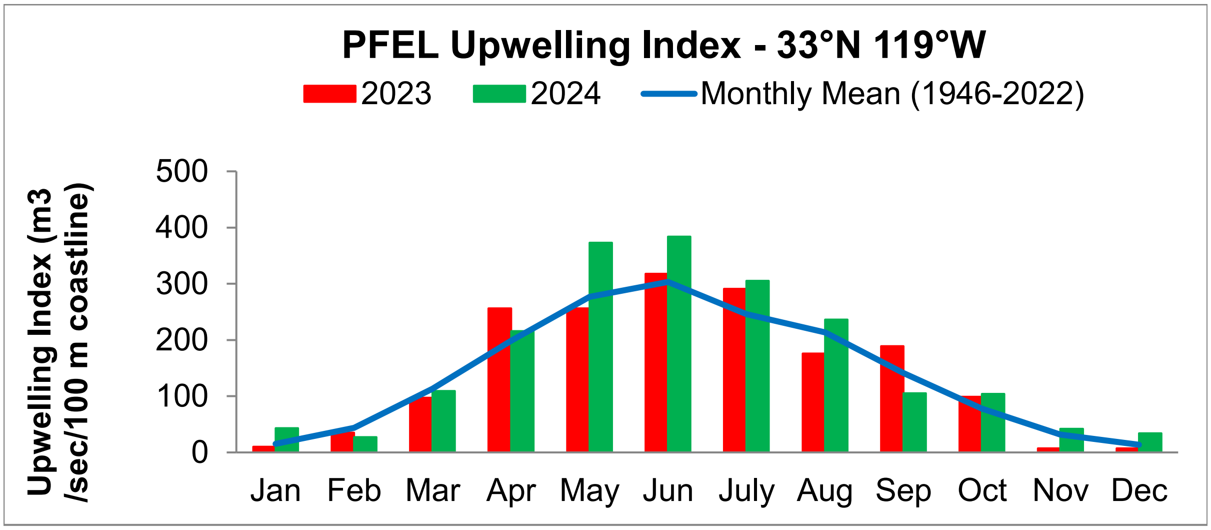


Figure 17. Monthly PFEL upwelling index at 33ºN 119ºW for 2023 and 2024 (compared to 75-year monthly mean from 1946 through 2024).

Source: https://coastwatch.pfeg.noaa.gov/erddap/griddap/erdUI33mo.html.

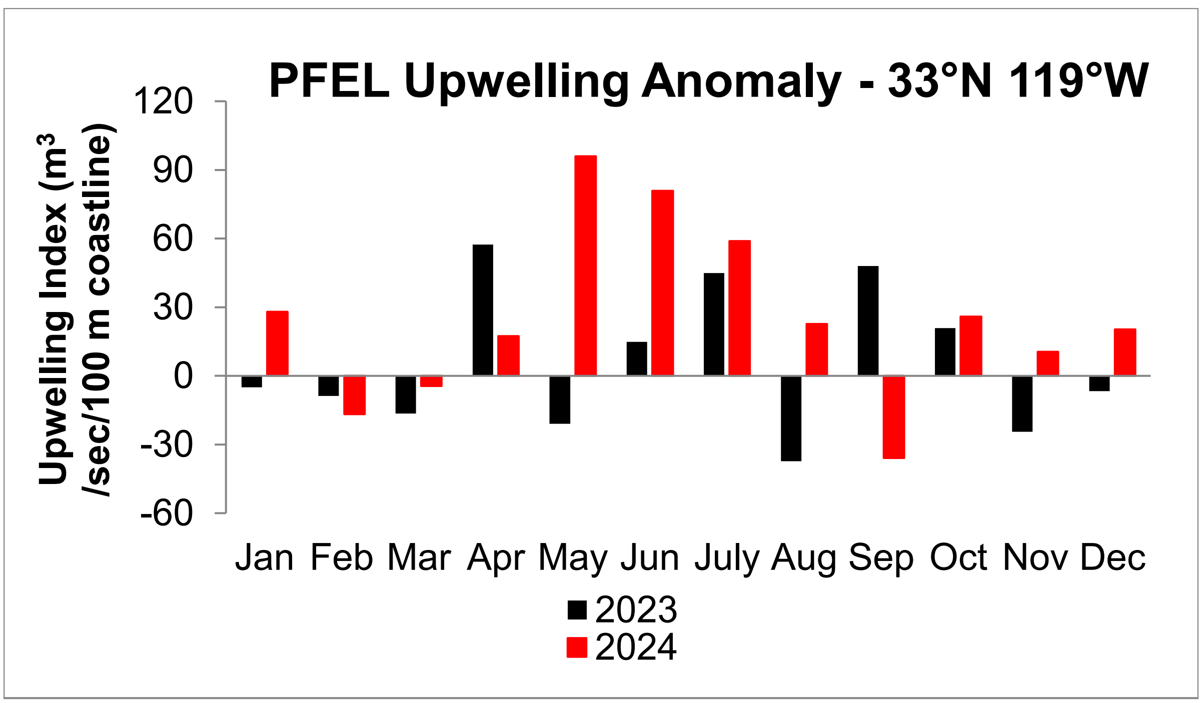


Figure 18. Daily Upwelling Index anomalies at 33°N 119°W for 2023 and 2024 (positive values indicate upwelling greater than the long-term mean from 1946 through 2022; negative values indicate upwelling less than long-term mean).

Source: https://coastwatch.pfeg.noaa.gov/erddap/griddap/erdUI33mo.html.

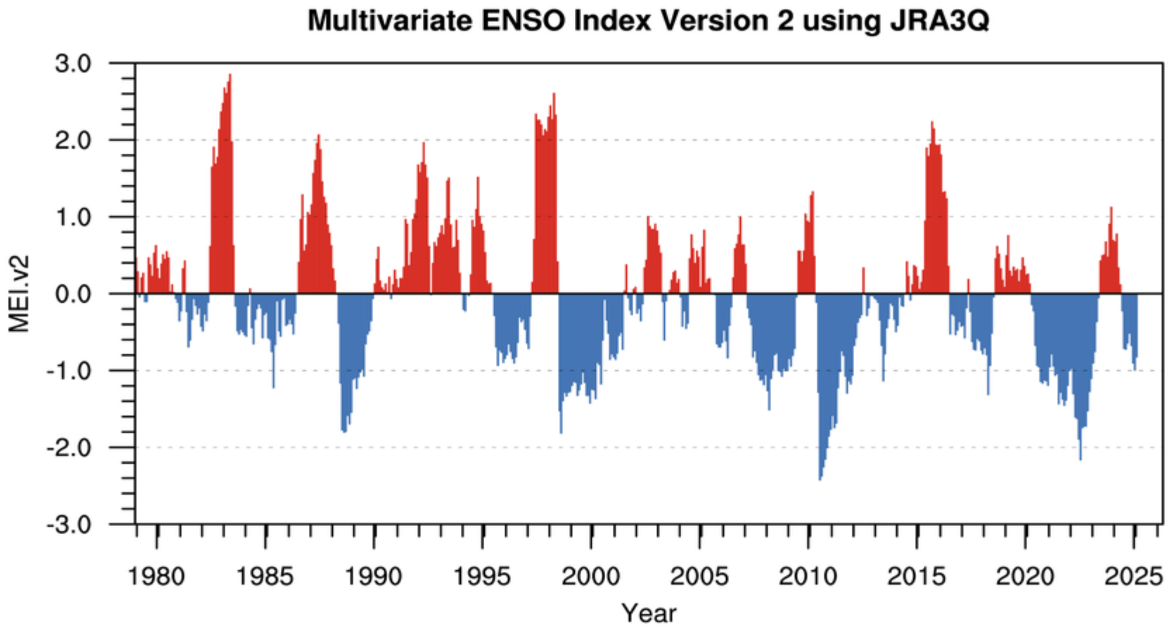


Figure 19. The Multivariate Enso Index (MEI) from 1979 through 2024.

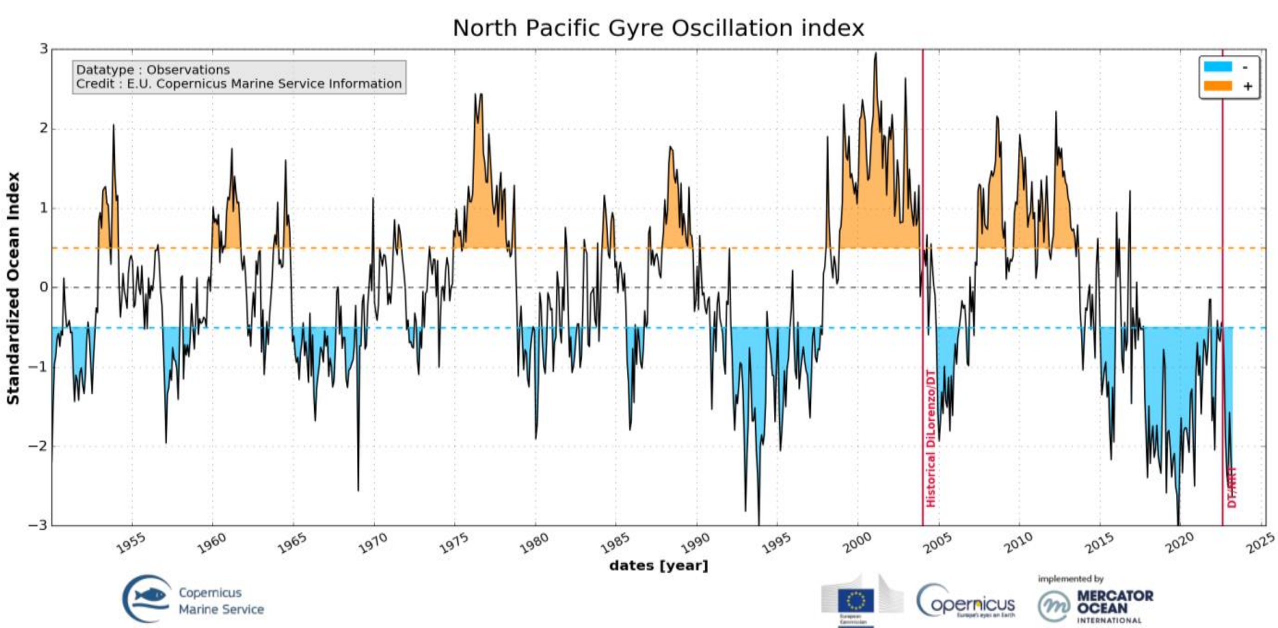


Figure 20. The North Pacific Gyre Oscillation Index (NPGO) from 1950 through 2024.

Source:https:/marine.copernicus.eu/access-data/ocean-monitoring-indicators/north-pacific-gyre-observations-reprocessing

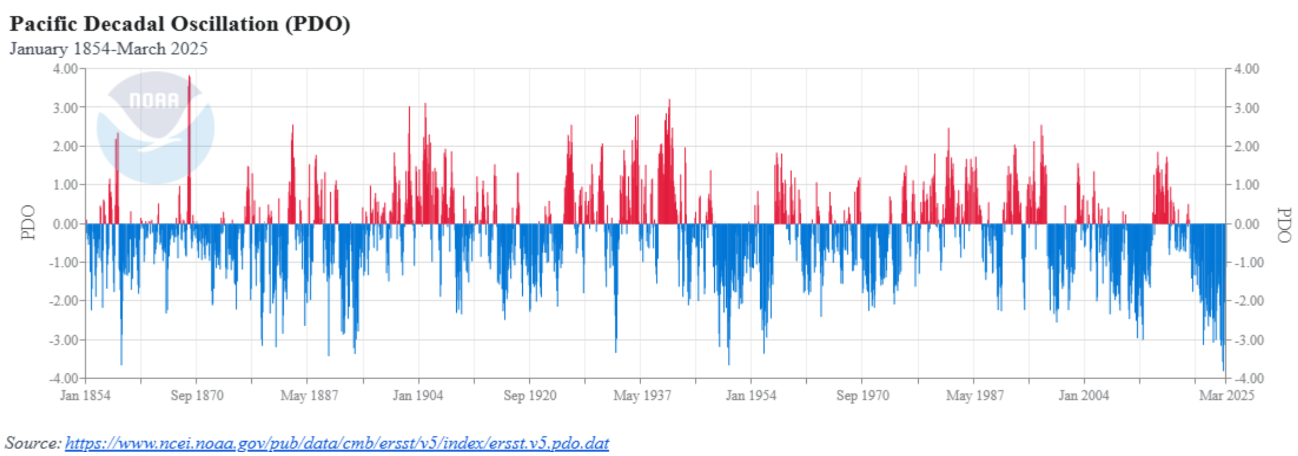


Figure 21. The Pacific Decadal Oscillation Index (PDO) from 1854 through 2024.

Source: https:://www.ncei.noaa.gov/pub/data/cmb/ersst/v5/index/ersst.v5.pdo.dat

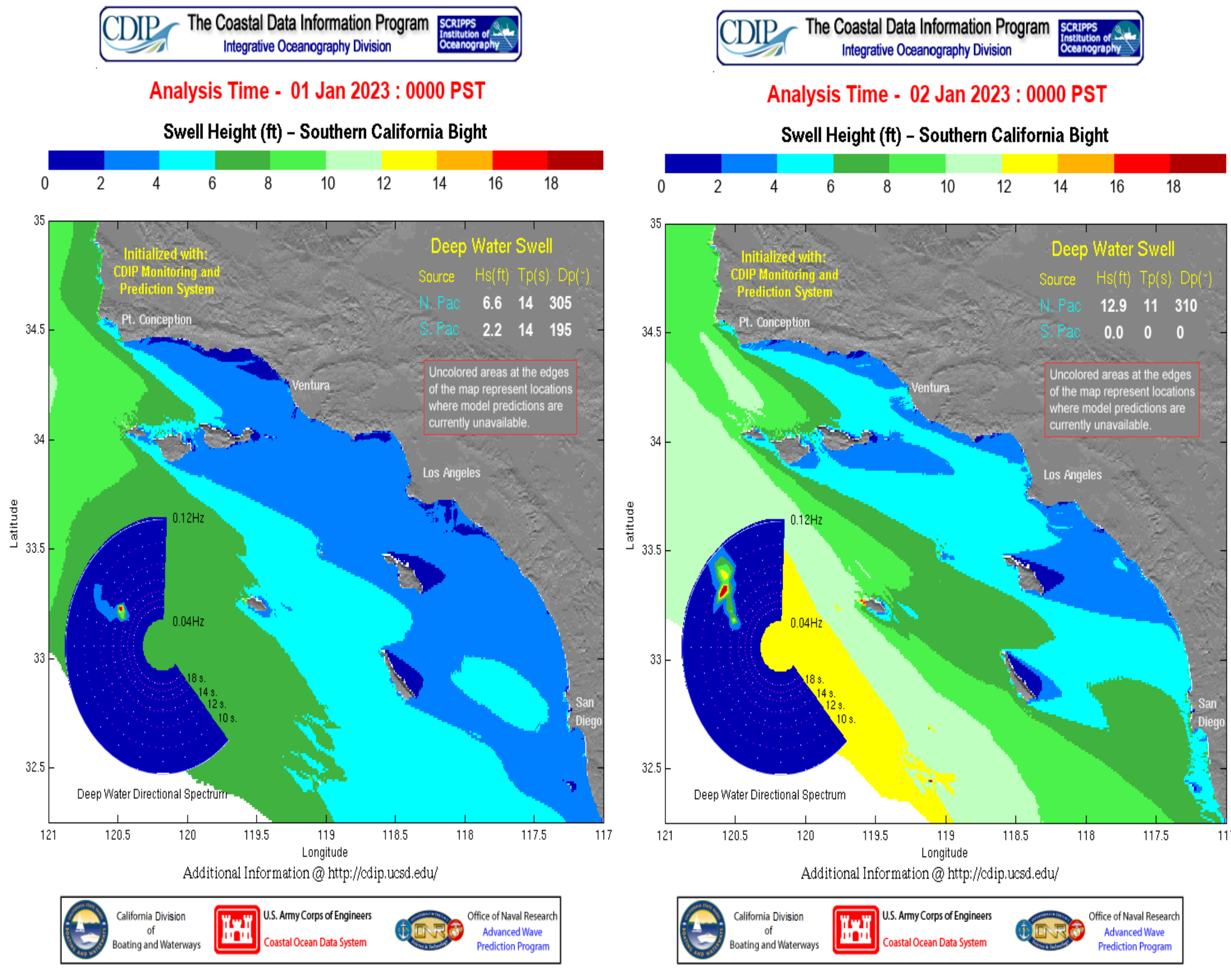
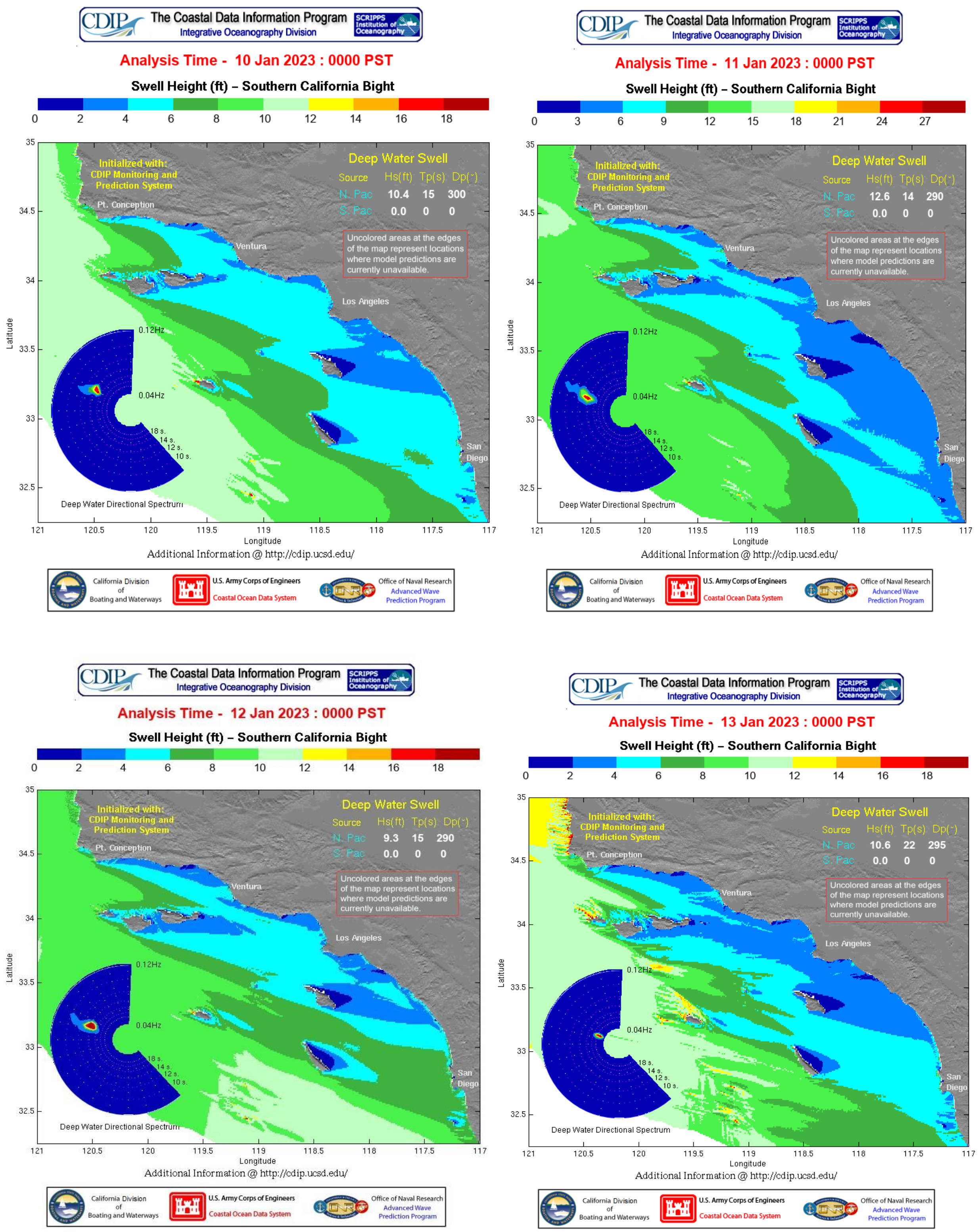


Figure 22. Swell height and direction in the Southern California Bight on January 1 and 2, 2023. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.



(Figure 23 continues on next page)

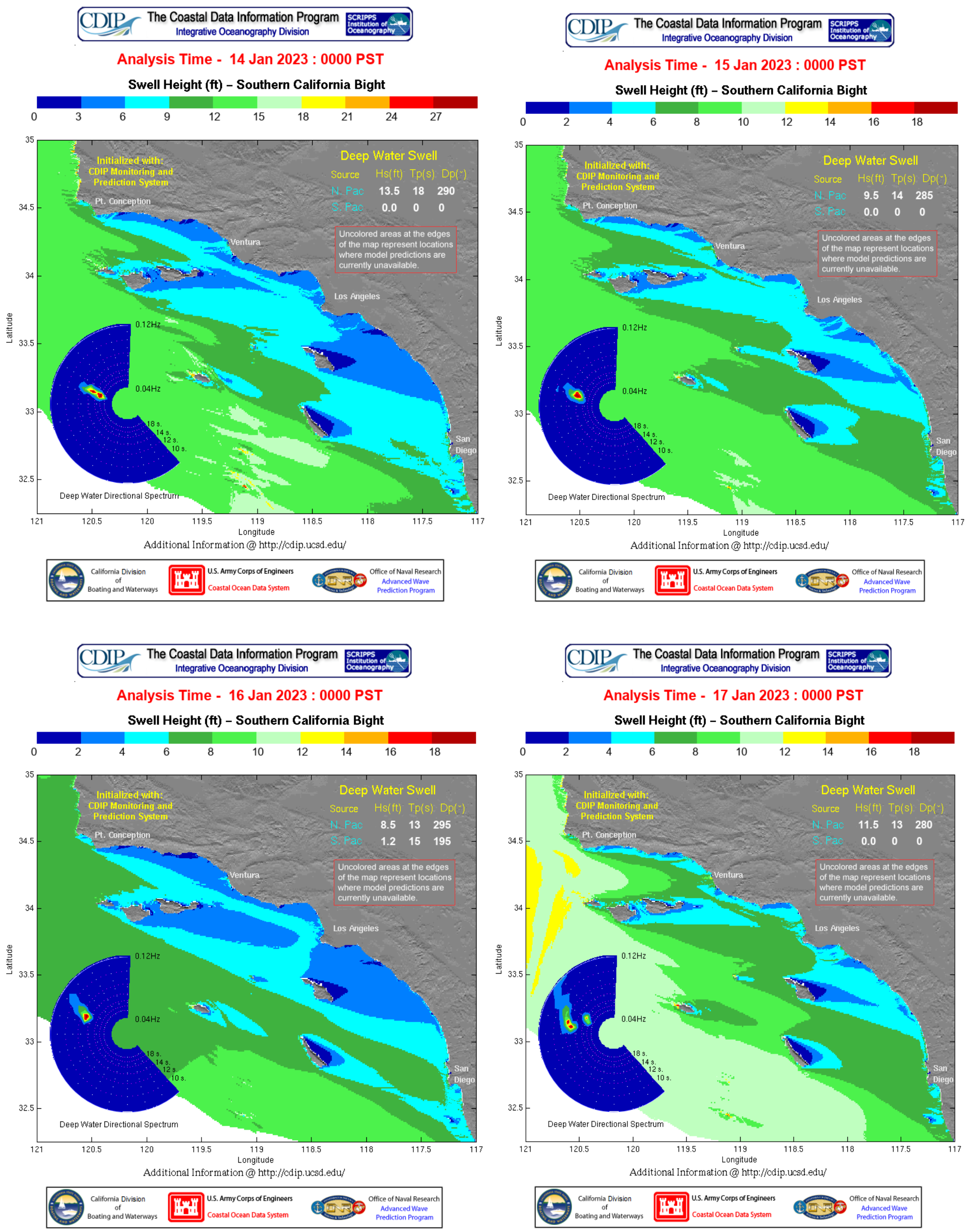


Figure 23. Swell height and direction in the Southern California Bight from January 10 through 17, 2023. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

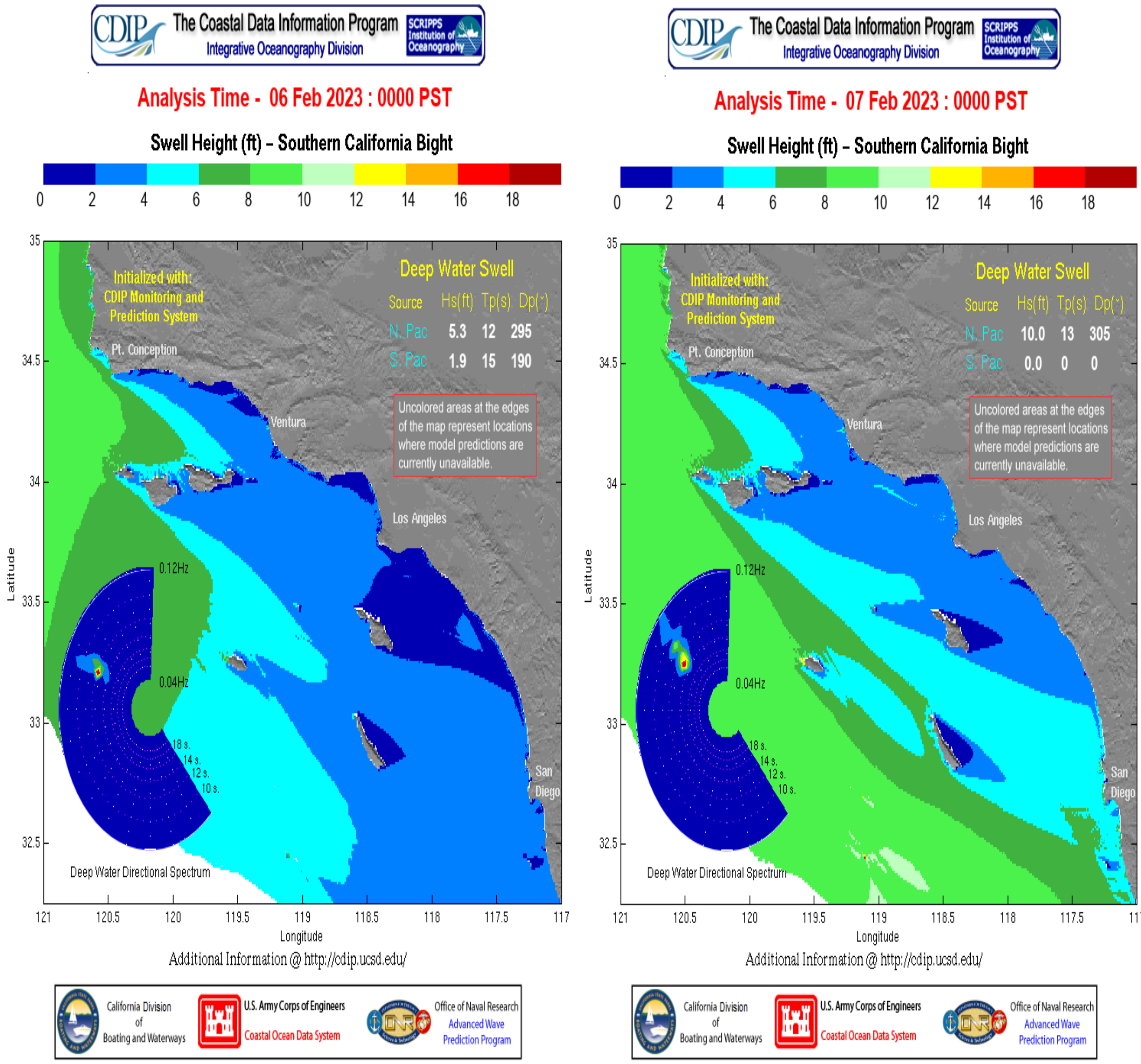


Figure 24. Swell height and direction in the Southern California Bight on February 6 and 7, 2023. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

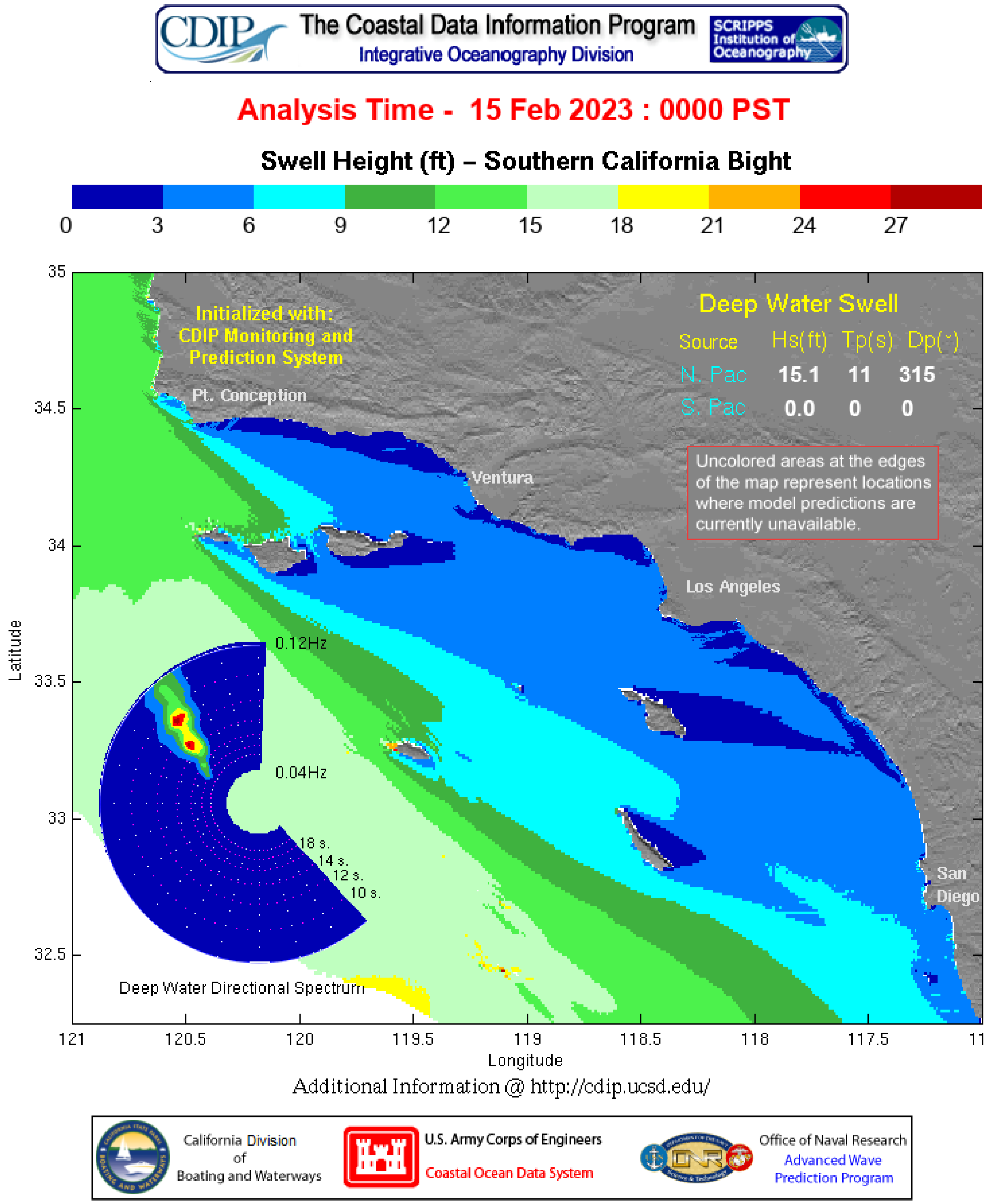


Figure 25. Swell height and direction in the Southern California Bight on February 15, 2023. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

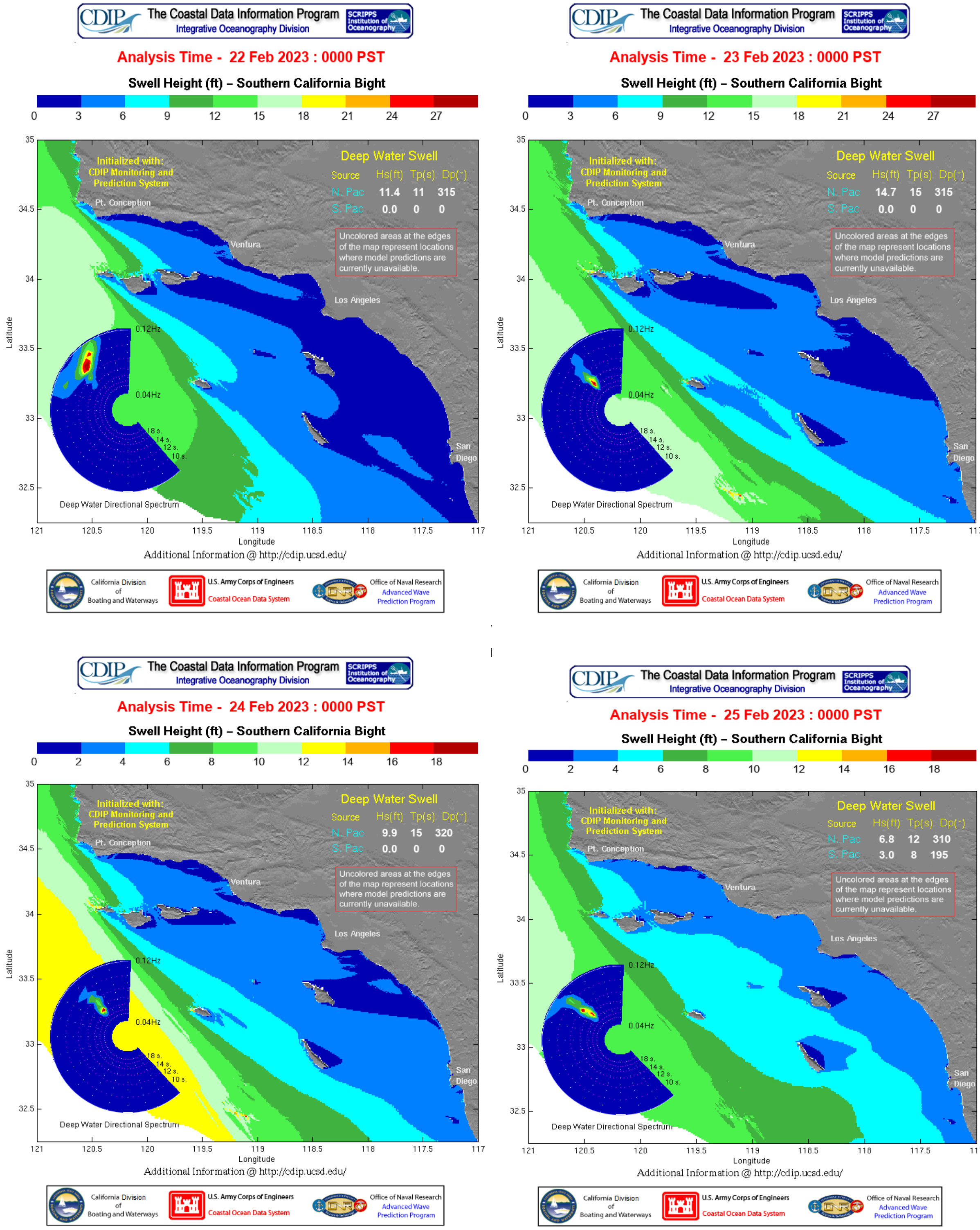


Figure 26. Swell height and direction in the Southern California Bight on February 22, 23, 24, and 25, 2023. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

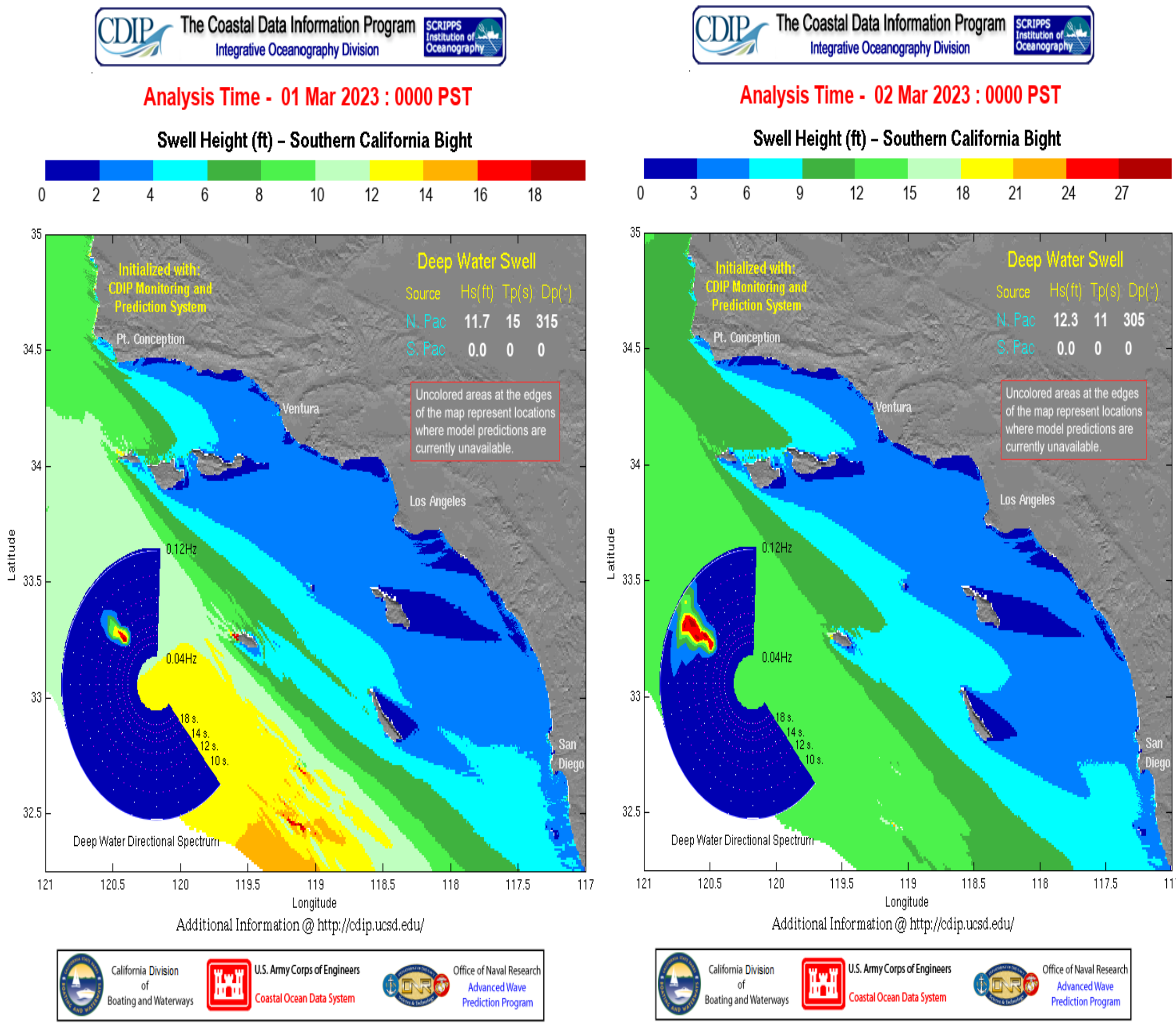


Figure 27. Swell height and direction in the Southern California Bight on March 1 and 2, 2023. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

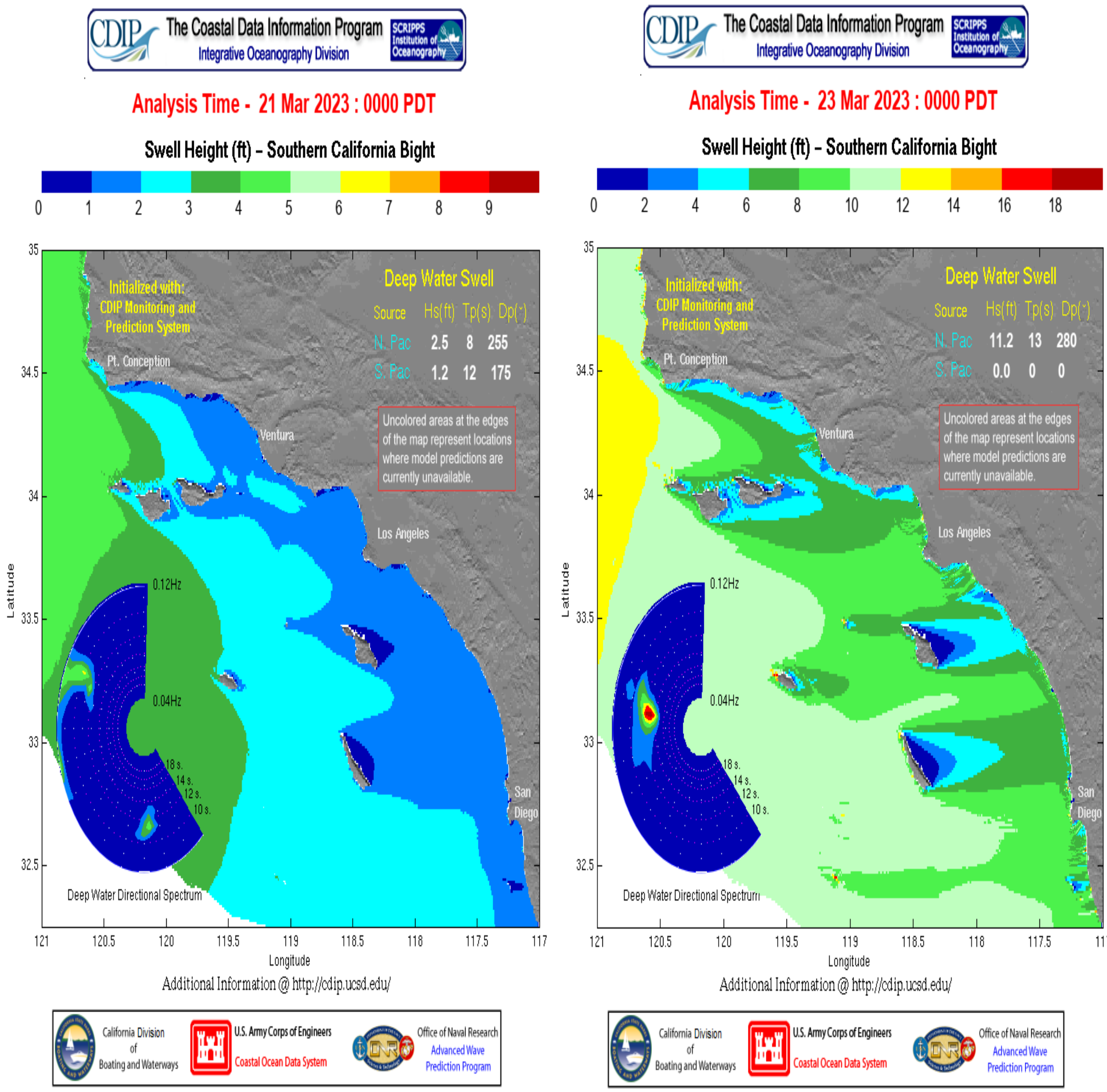


Figure 28. Swell height and direction in the Southern California Bight on March 21 and 23, 2023 (data not available for March 22, 2023. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

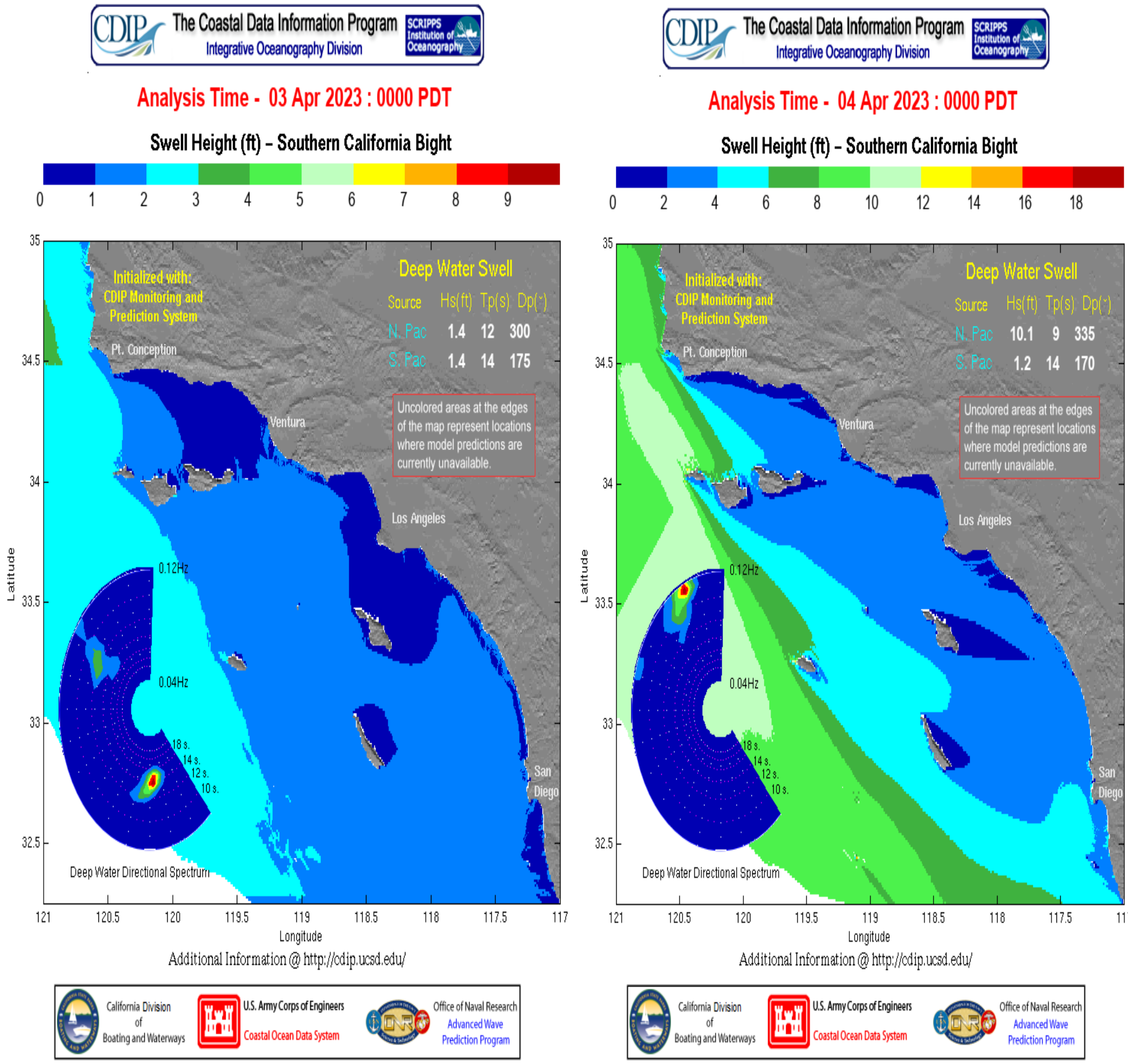


Figure 29. Swell height and direction in the Southern California Bight on April 3 and 4, 2023. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

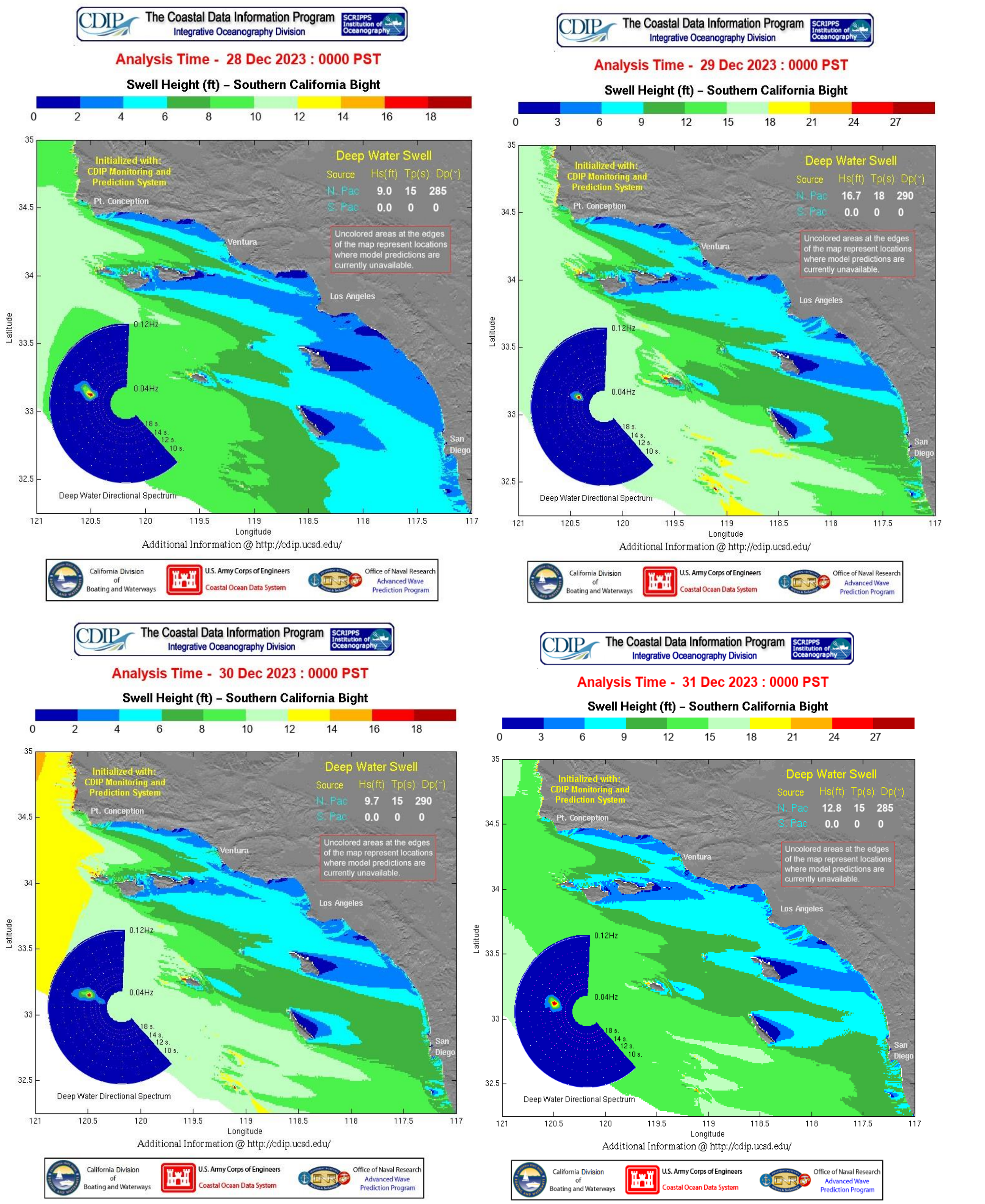
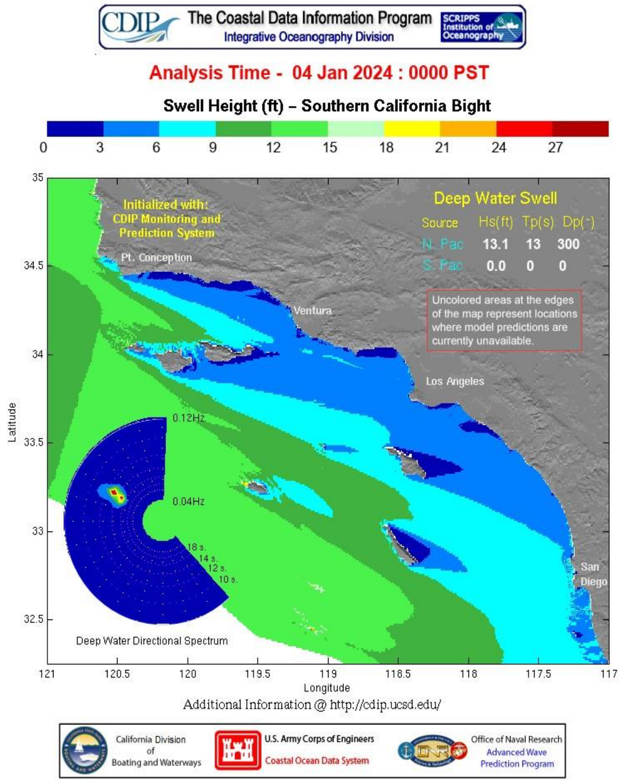
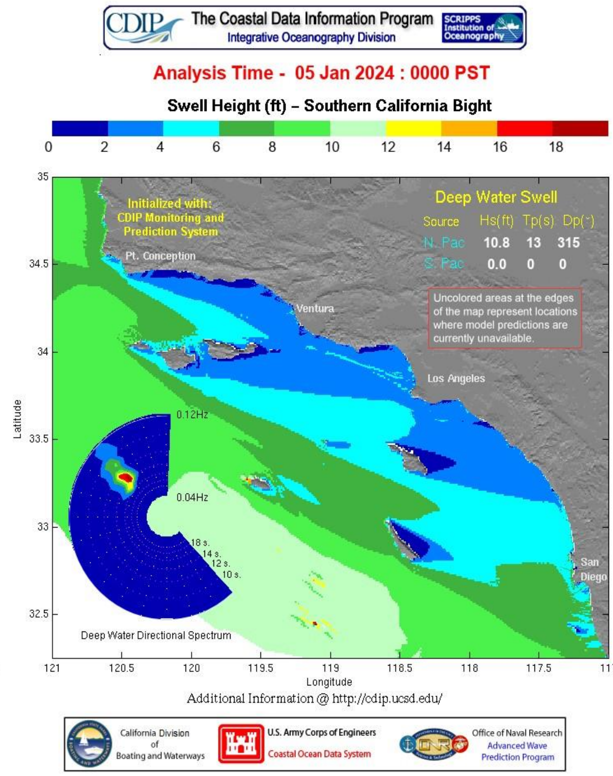
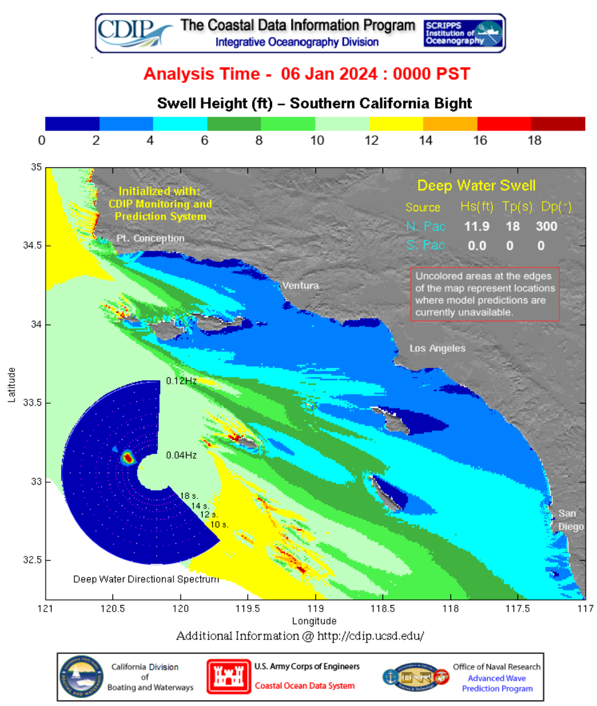


Figure 30. Swell height and direction in the Southern California Bight on December 28, 29, 30 and 31, 2023. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.







(Figure 31 continues on next page)

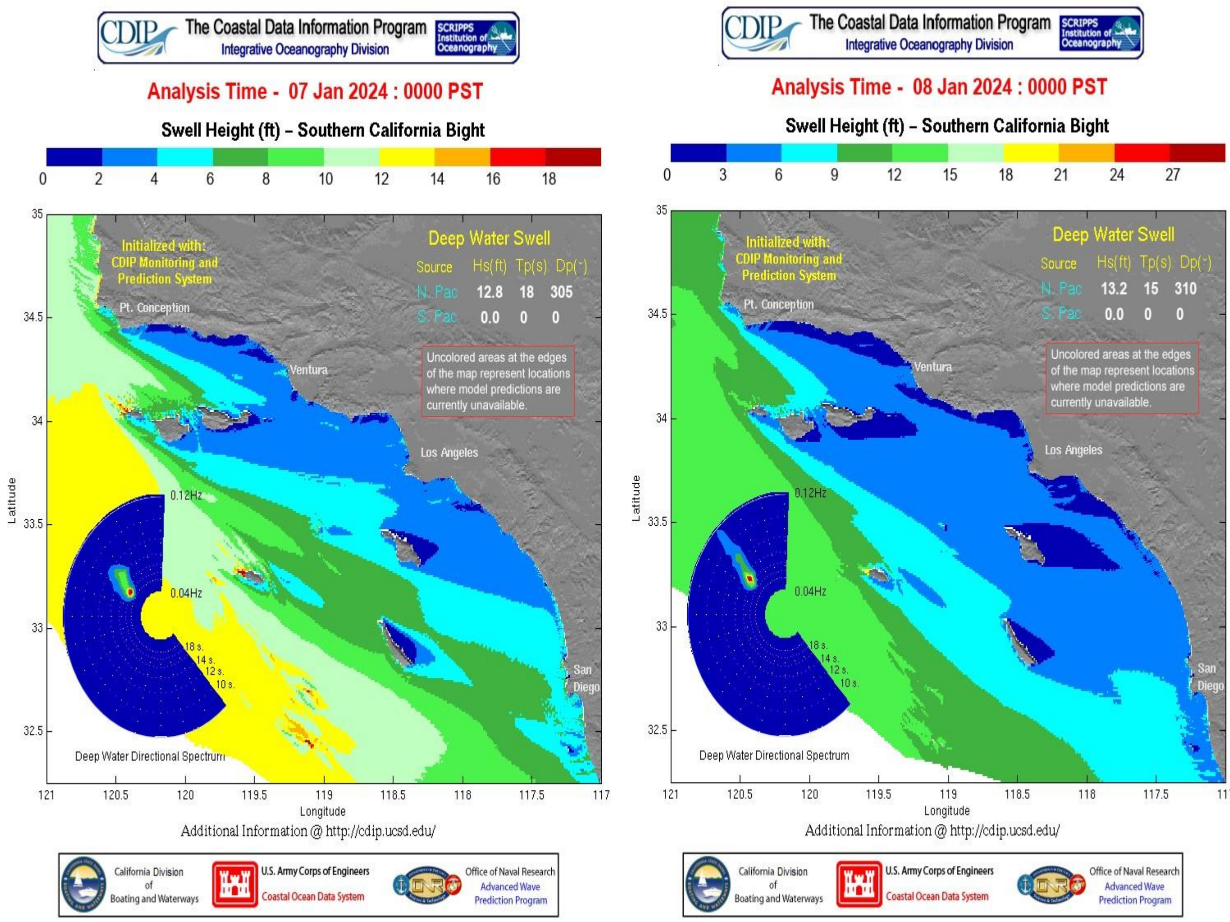


Figure 31. Swell height and direction in the Southern California Bight from January 4 to 8, 2024. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

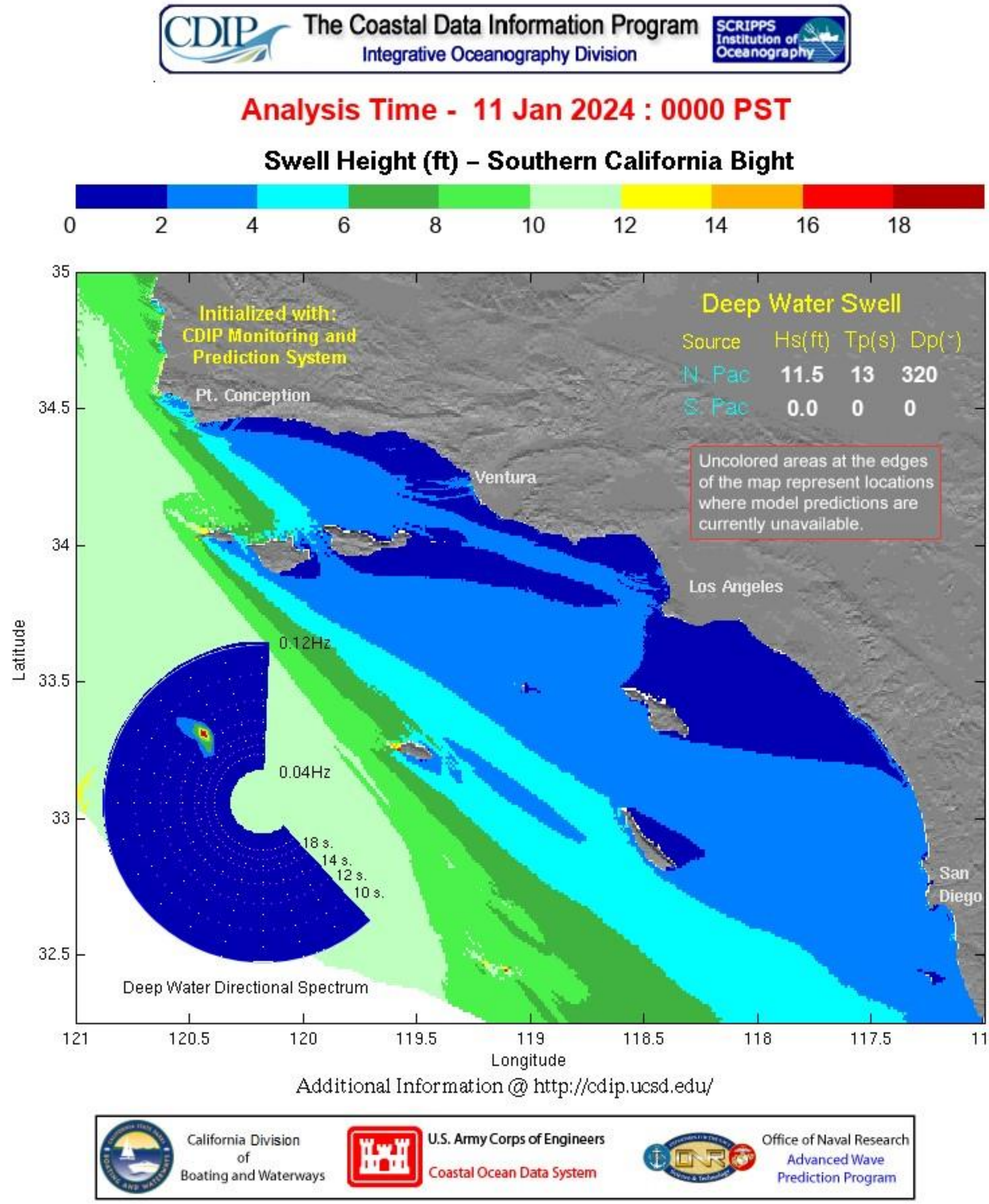


Figure 32. Swell height and direction in the Southern California Bight on January 11, 2024. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

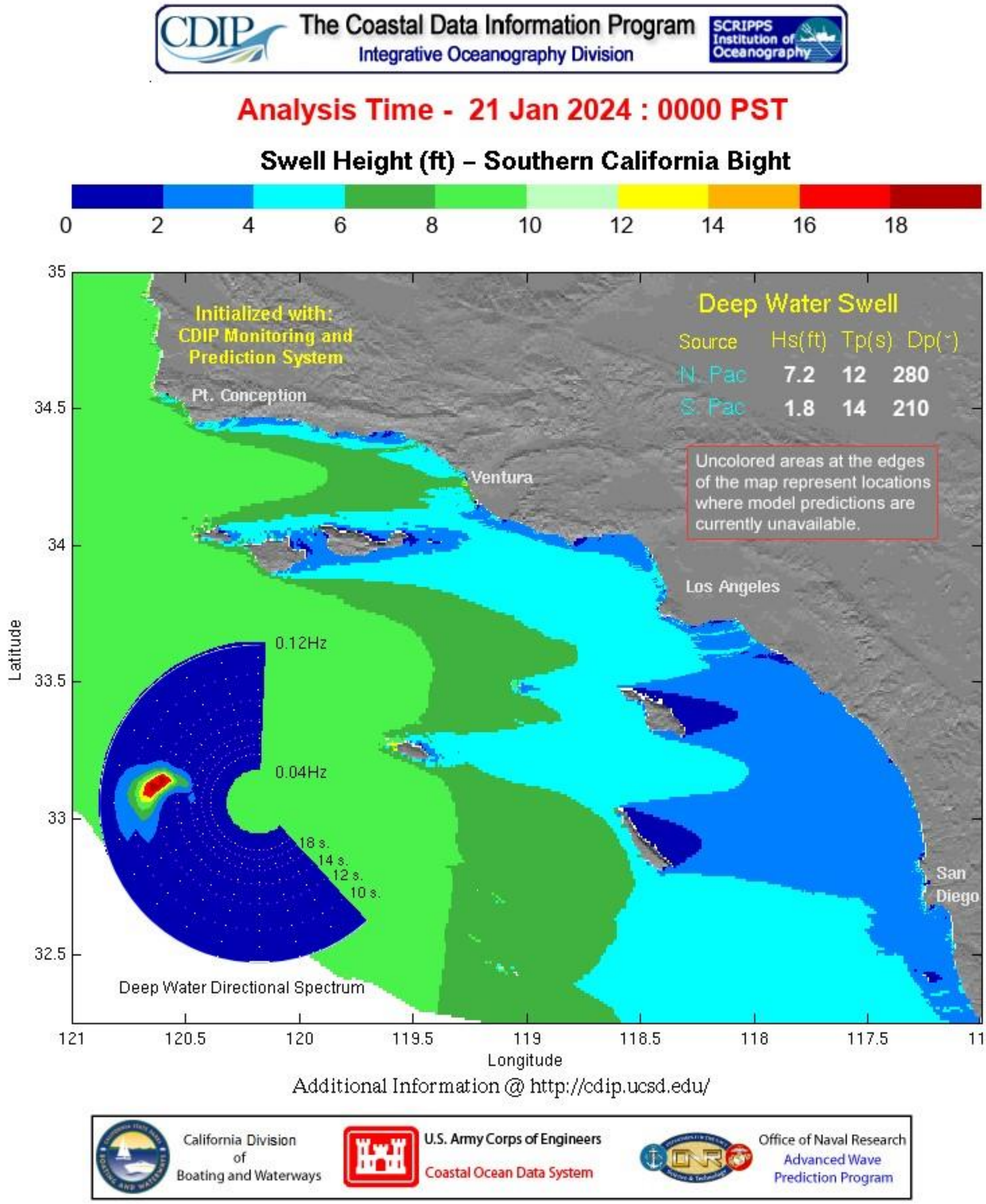


Figure 33. Swell height and direction in the Southern California Bight on January 21, 2024. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

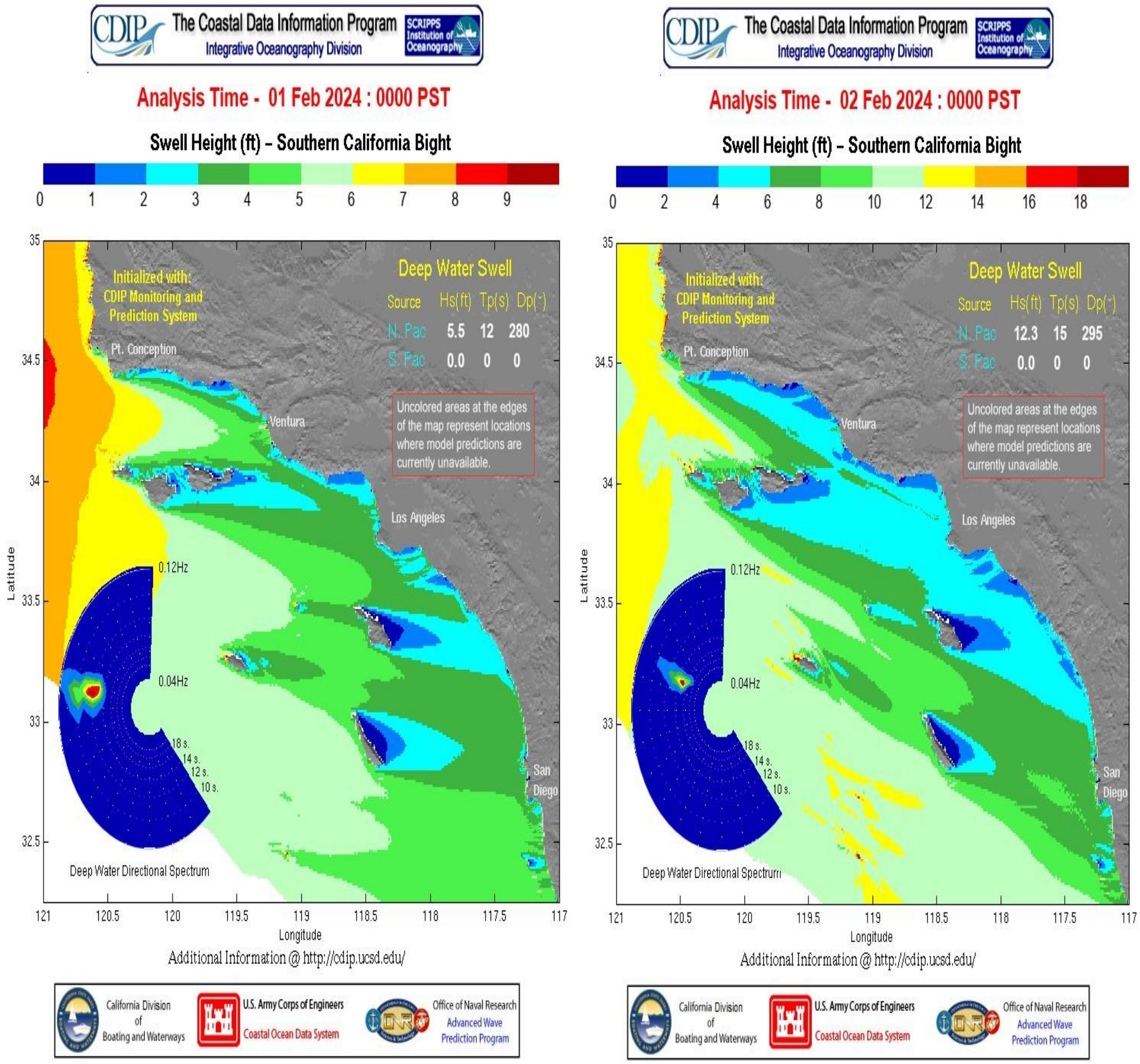


Figure 34. Swell height and direction in the Southern California Bight on February 1 and 2, 2024. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

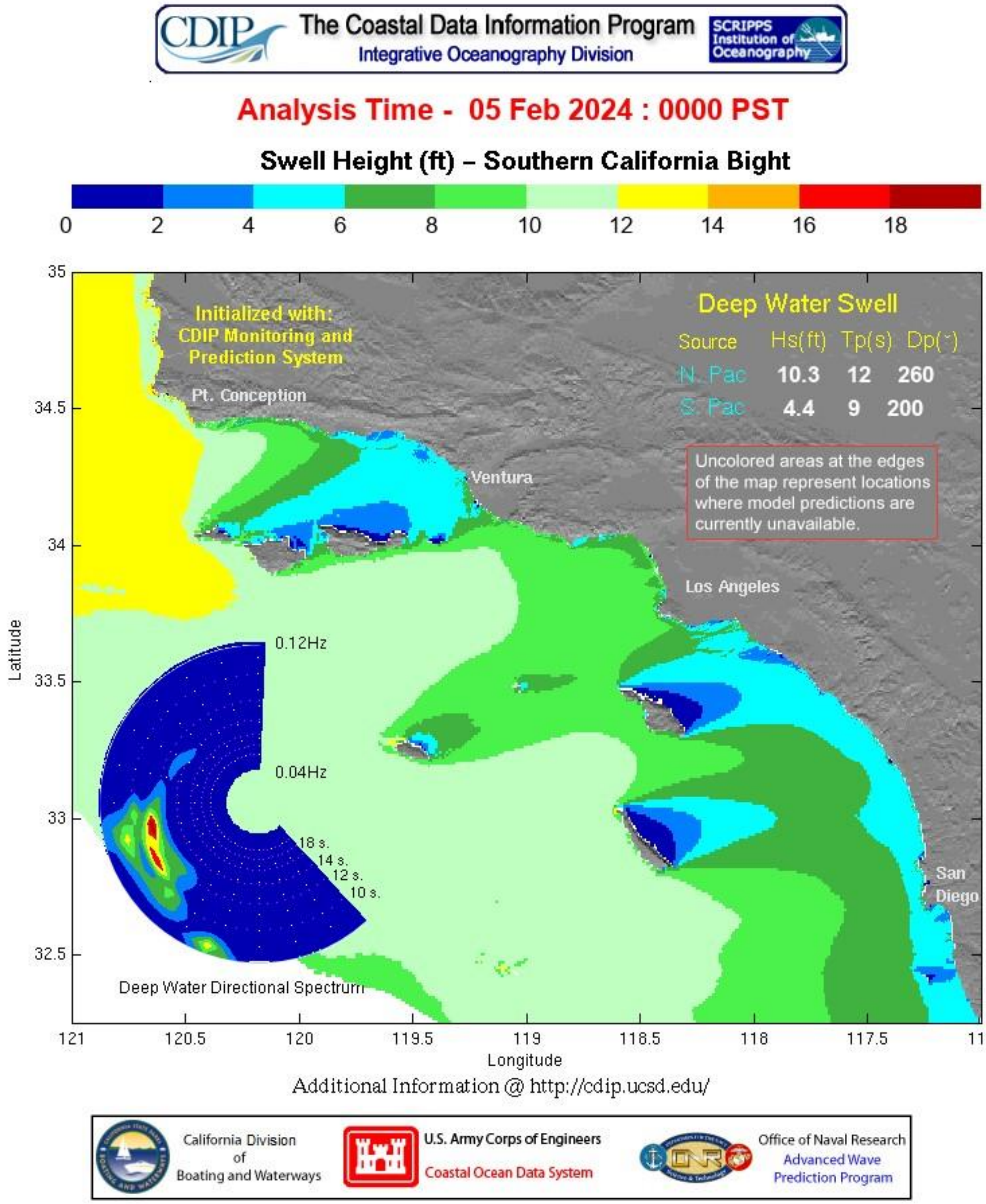


Figure 35. Swell height and direction in the Southern California Bight on February 5, 2024. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

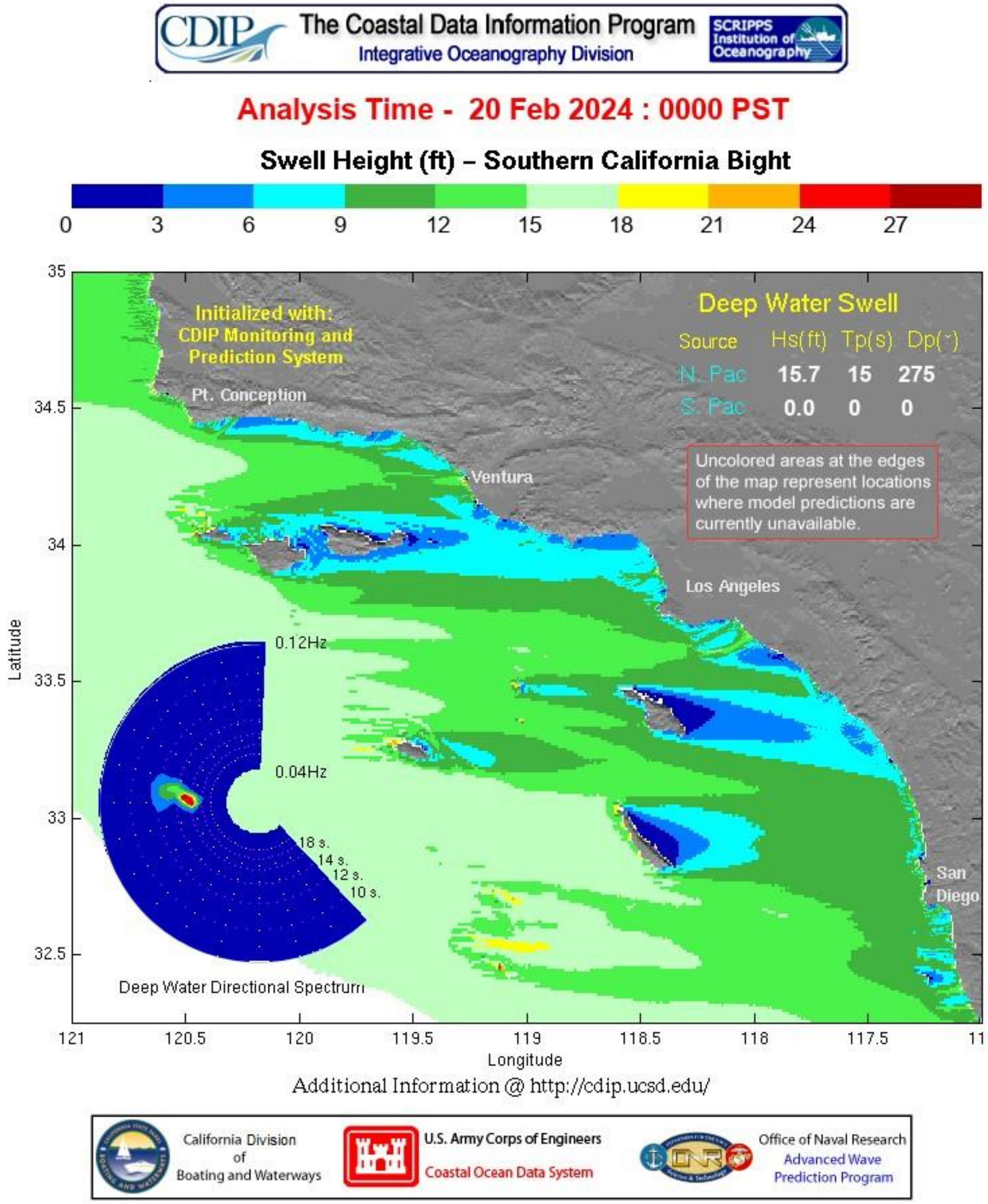


Figure 36. Swell height and direction in the Southern California Bight on February 20, 2024 (no data available on February 21, 2024). Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

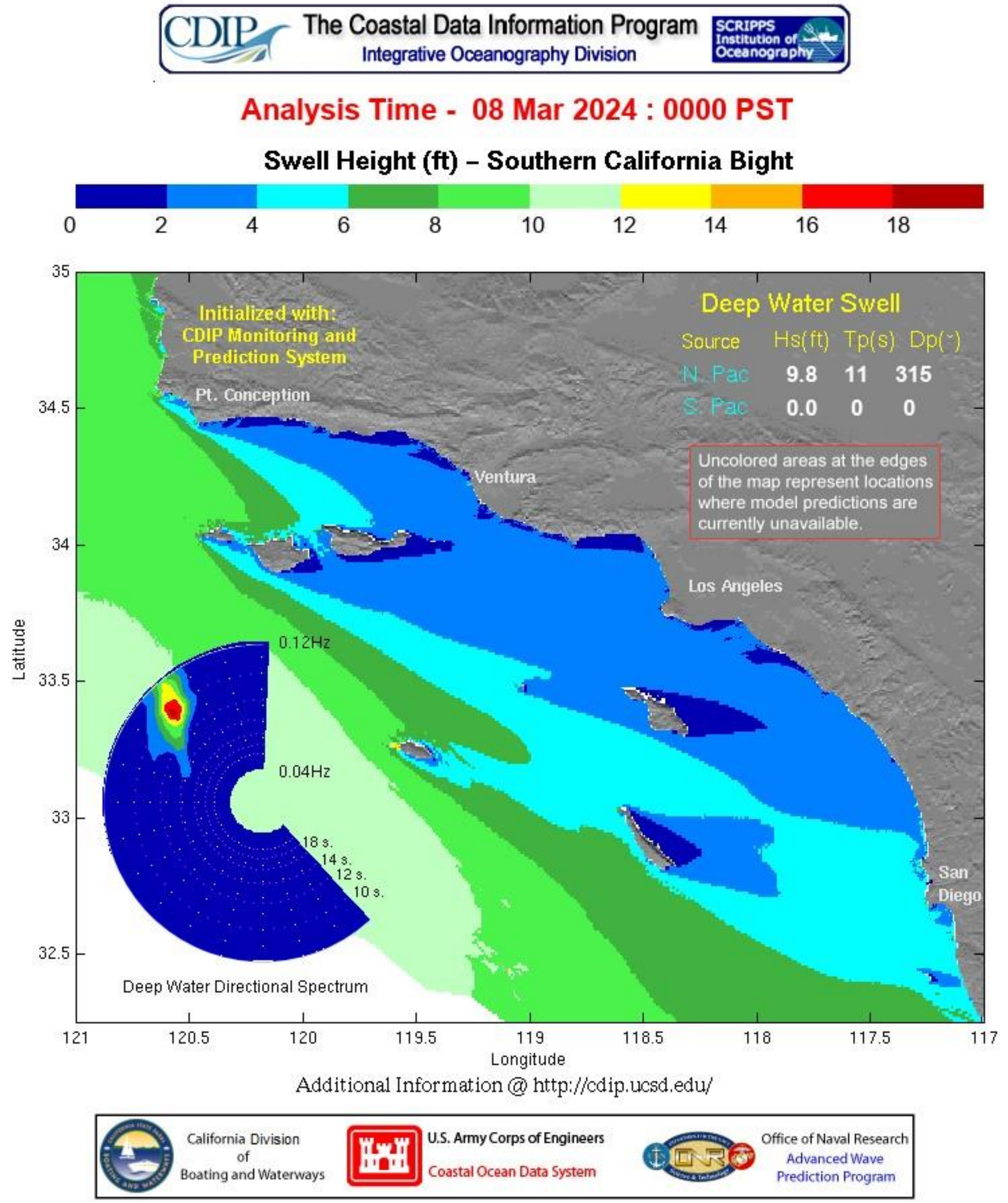


Figure 37. Swell height and direction in the Southern California Bight on March 8, 2024. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

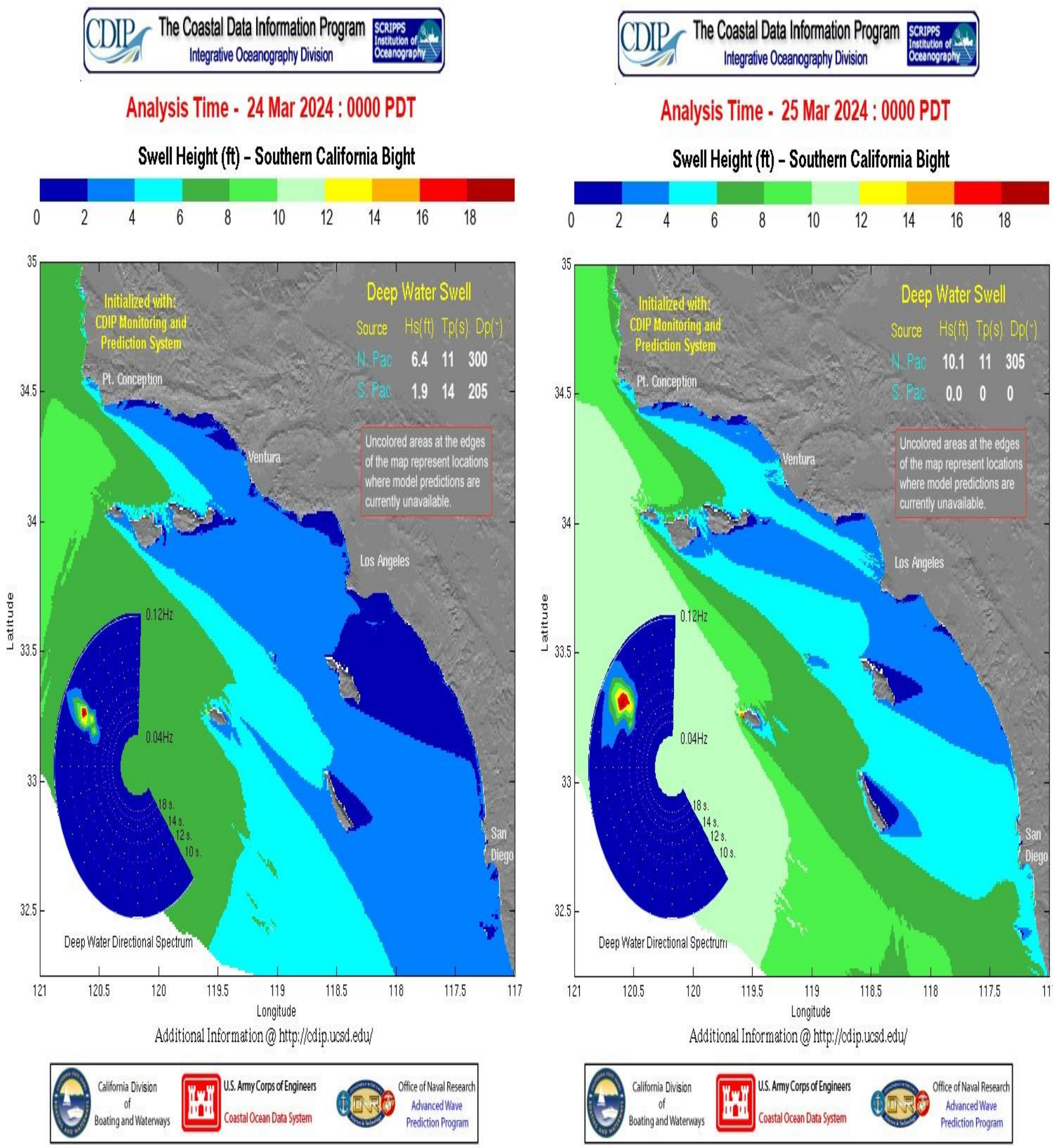


Figure 38. Swell height and direction in the Southern California Bight on March 24 and 25, 2024. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

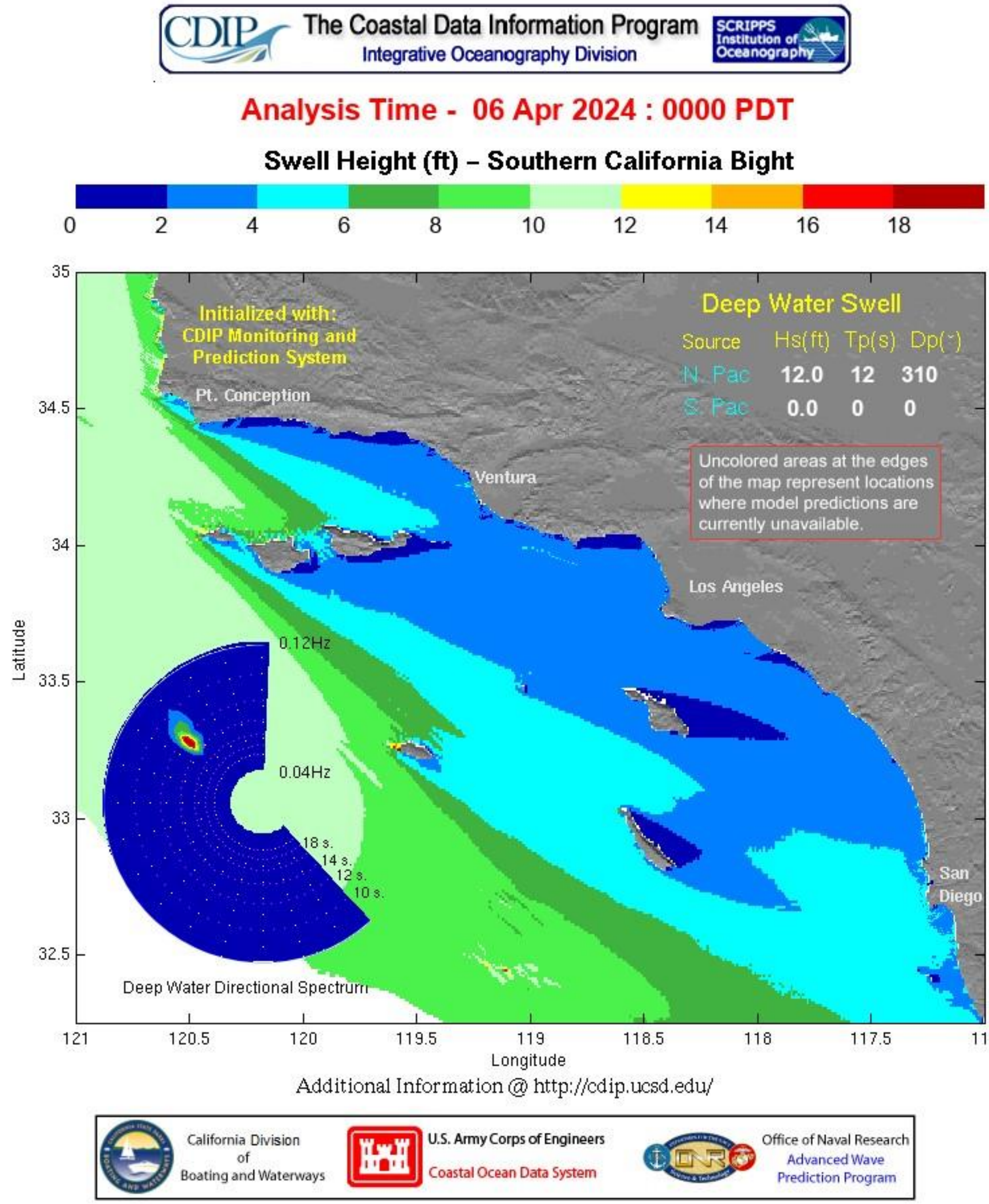


Figure 39. Swell height and direction in the Southern California Bight on April 6, 2024. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

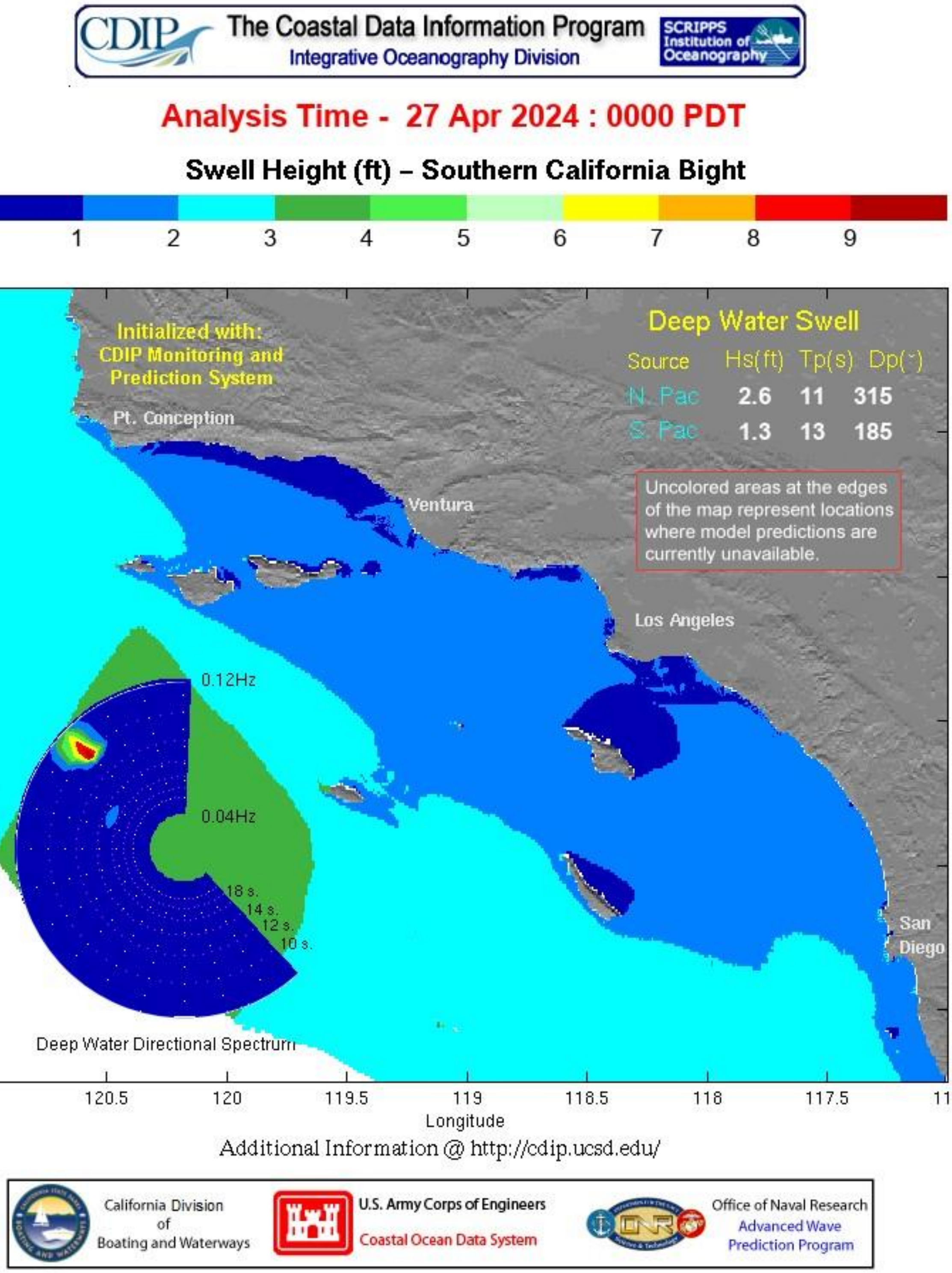


Figure 40. Swell height and direction in the Southern California Bight on April 27, 2024. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

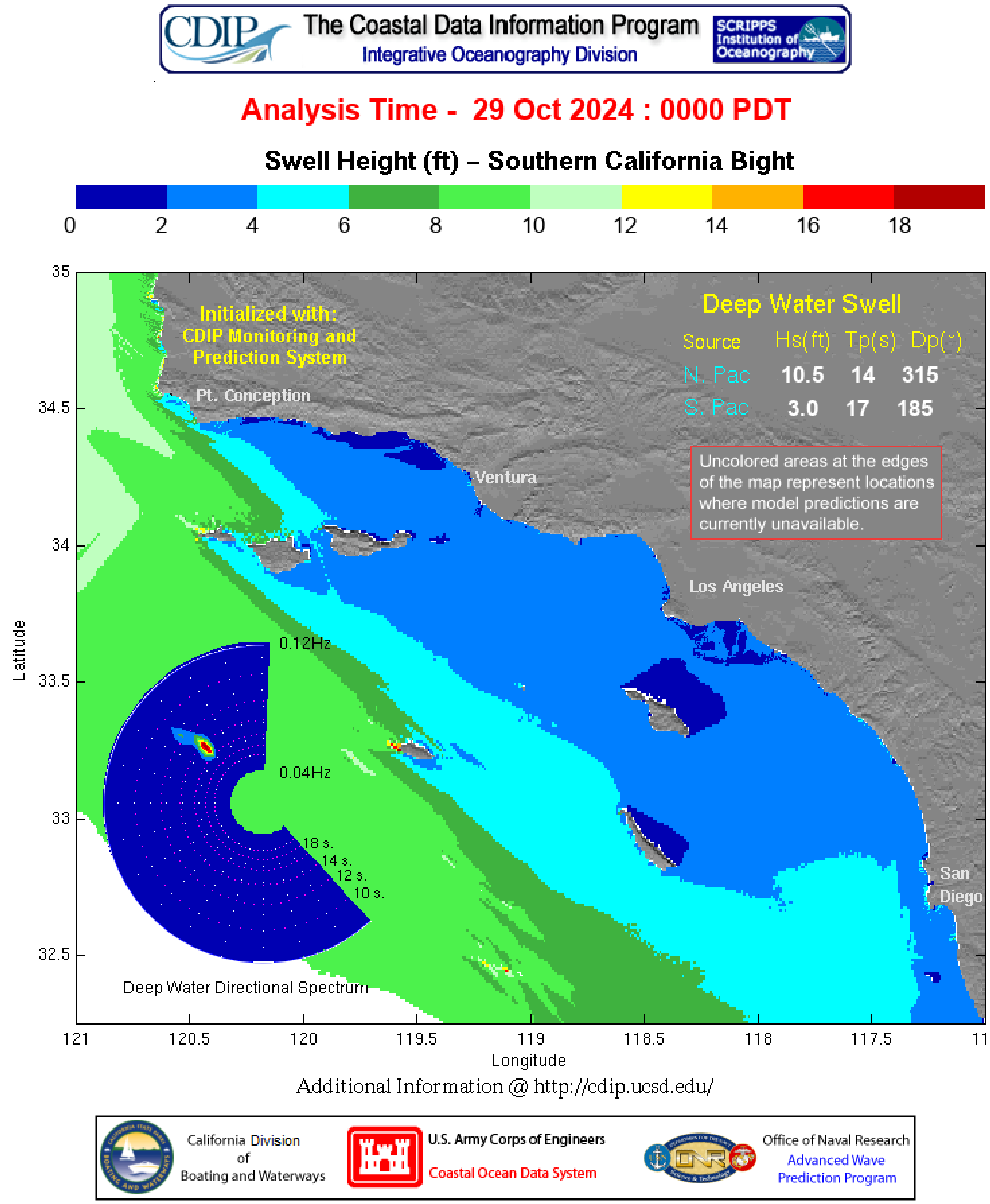


Figure 41. Swell height and direction in the Southern California Bight on October 29, 2024. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

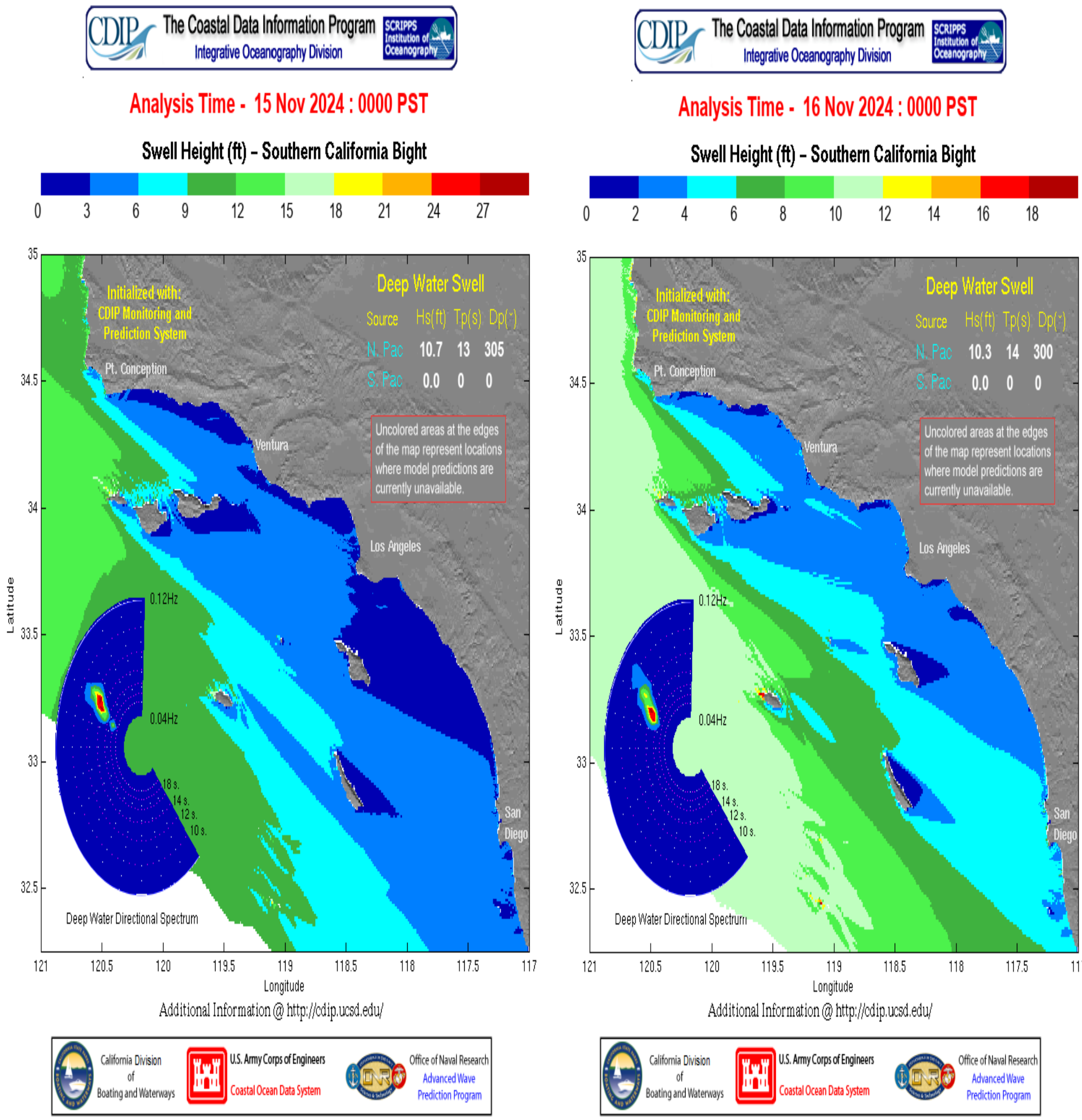
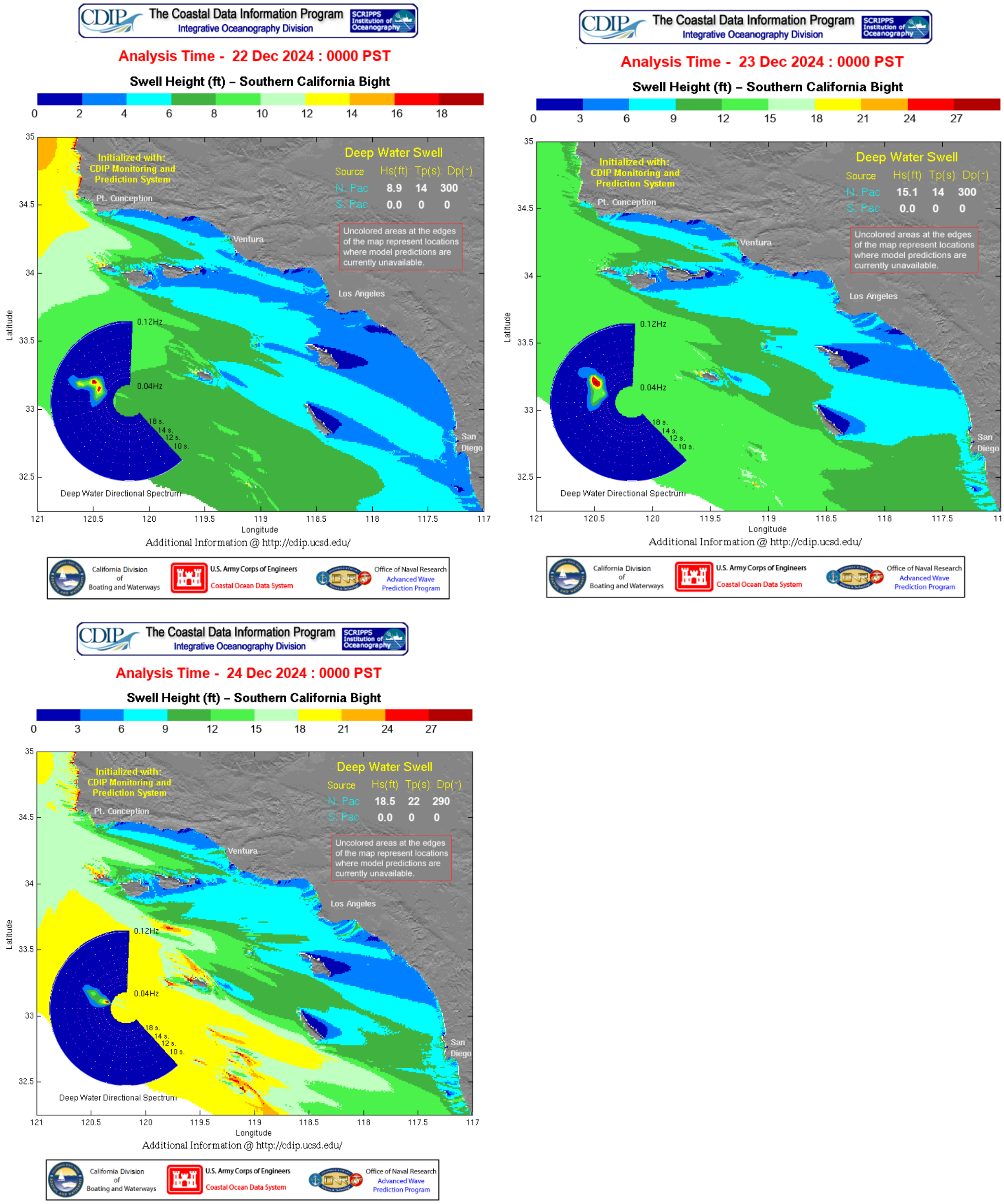


Figure 42. Swell height and direction in the Southern California Bight on November 15 and 16, 2024. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.



(Figure 43 continues on next page)

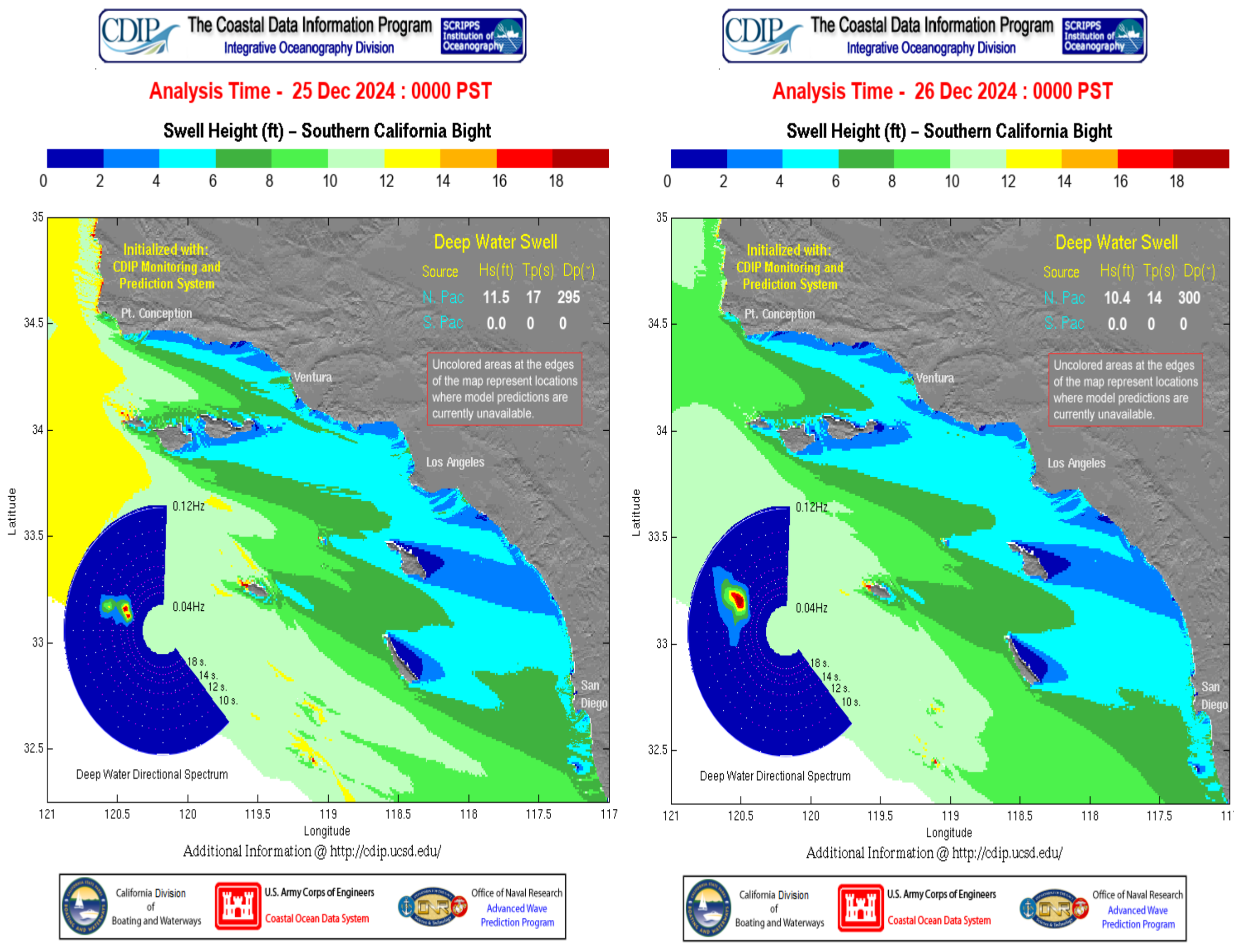


Figure 43. Swell height and direction in the Southern California Bight from December 22 to 26, 2024. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

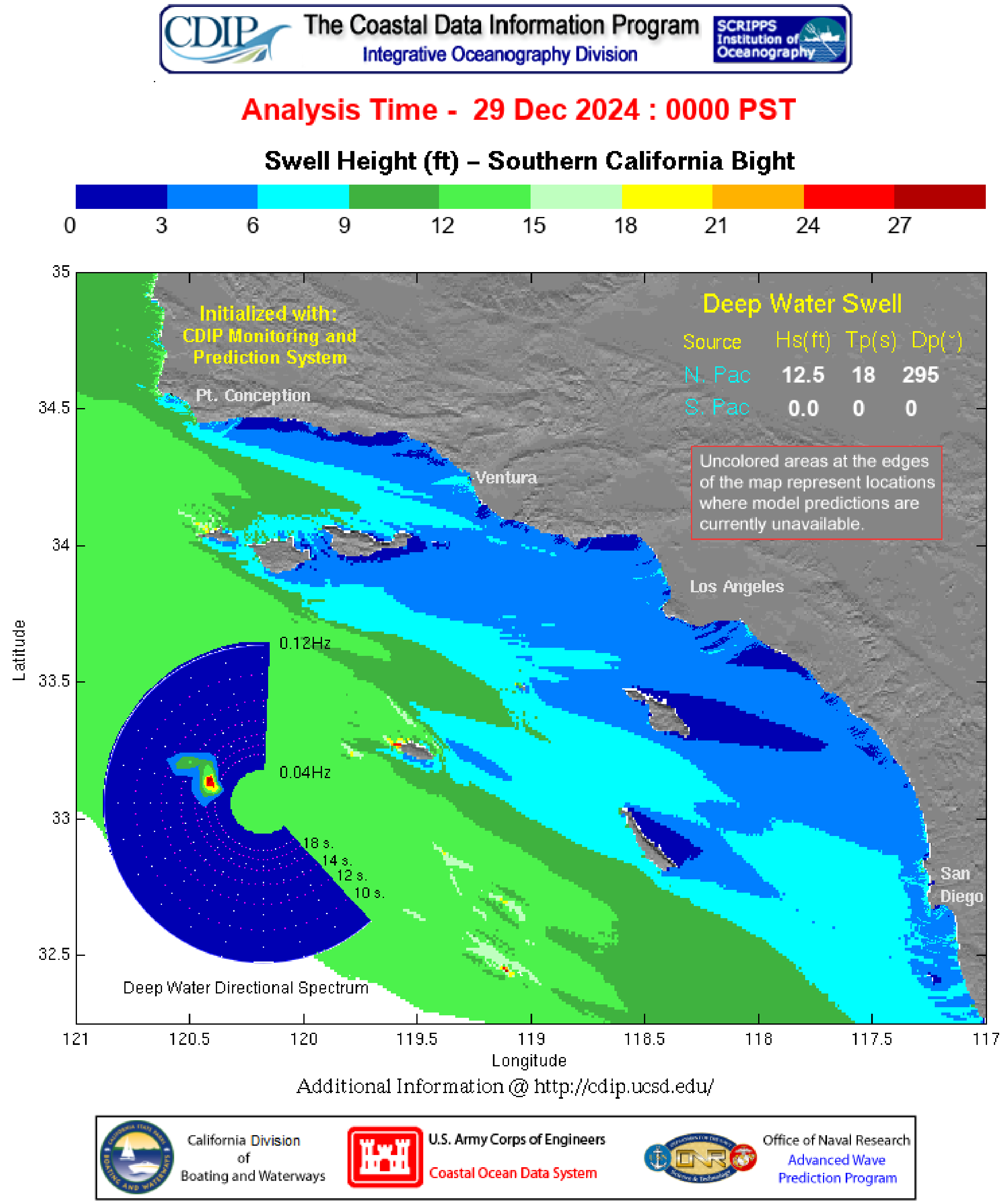


Figure 44. Swell height and direction in the Southern California Bight on December 29, 2024. Source: Coastal Data Information Program (CDIP); refer to cdip.ucsd.edu/.

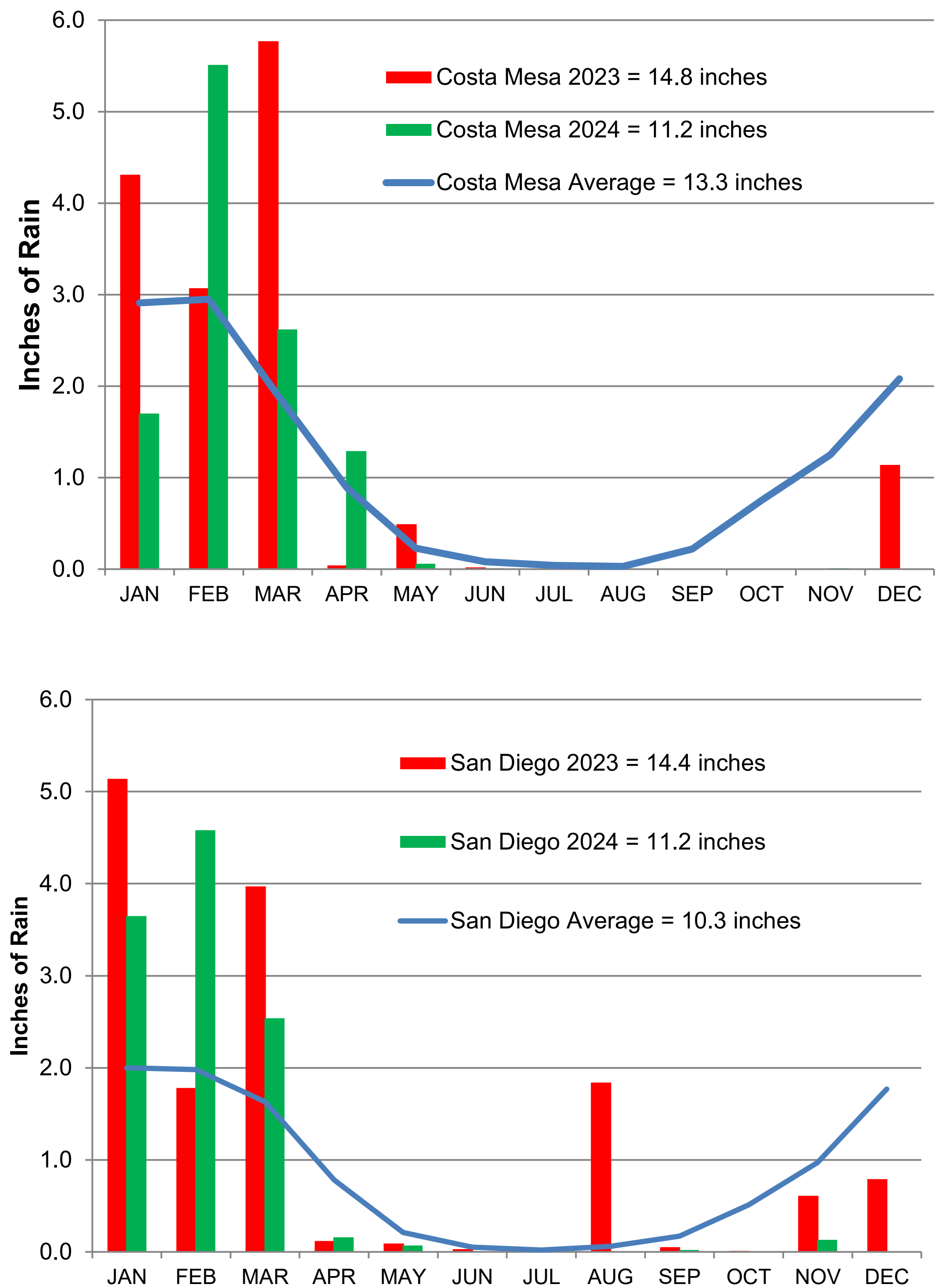


Figure 45. Monthly rainfall for 2023 and 2024 and historical average monthly rainfall recorded for Costa Mesa (John Wayne Airport and San Diego (Lindbergh Field).

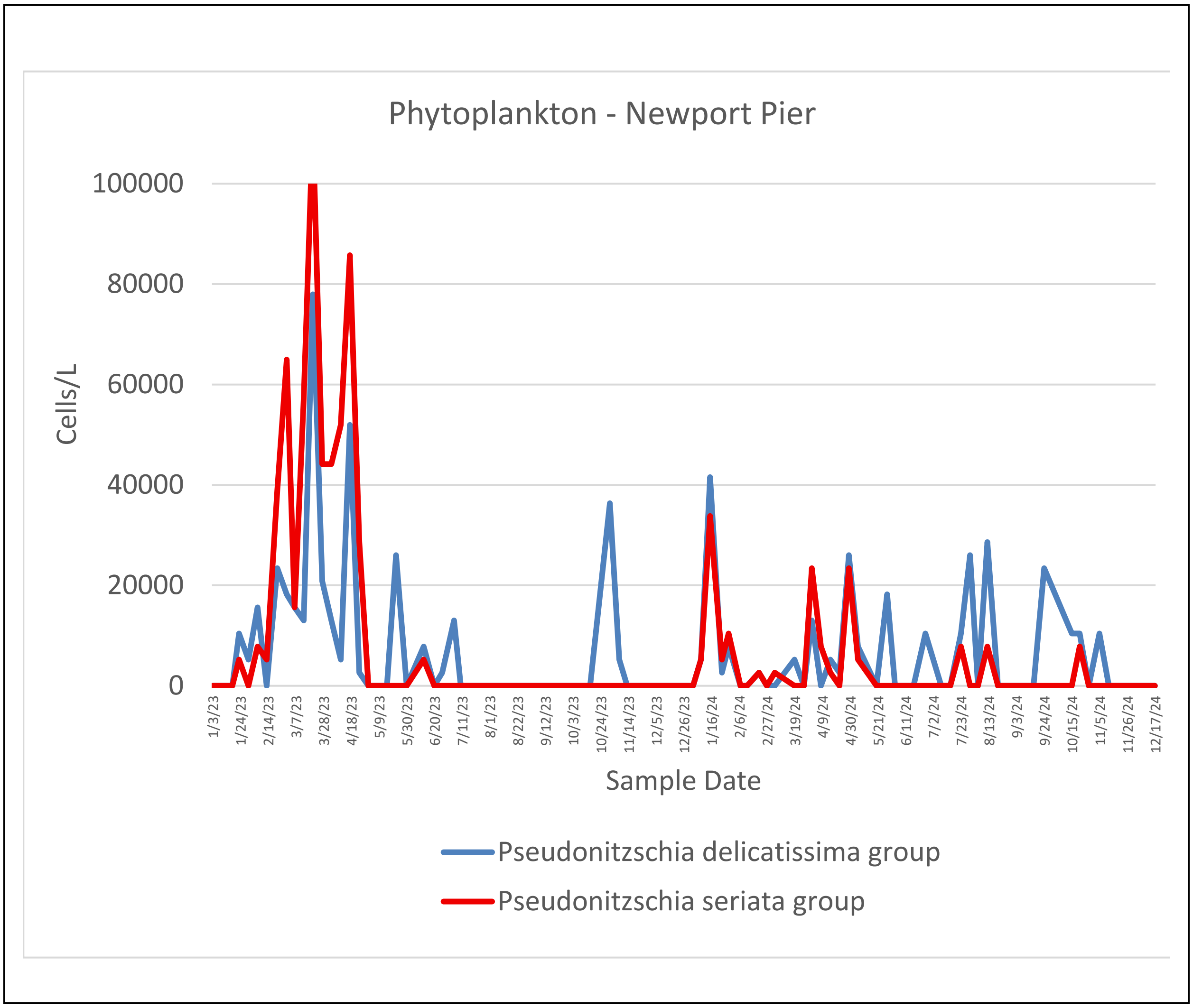


Figure 46. Phytoplankton Concentrations at Newport Pier in 2023 and 2024.

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

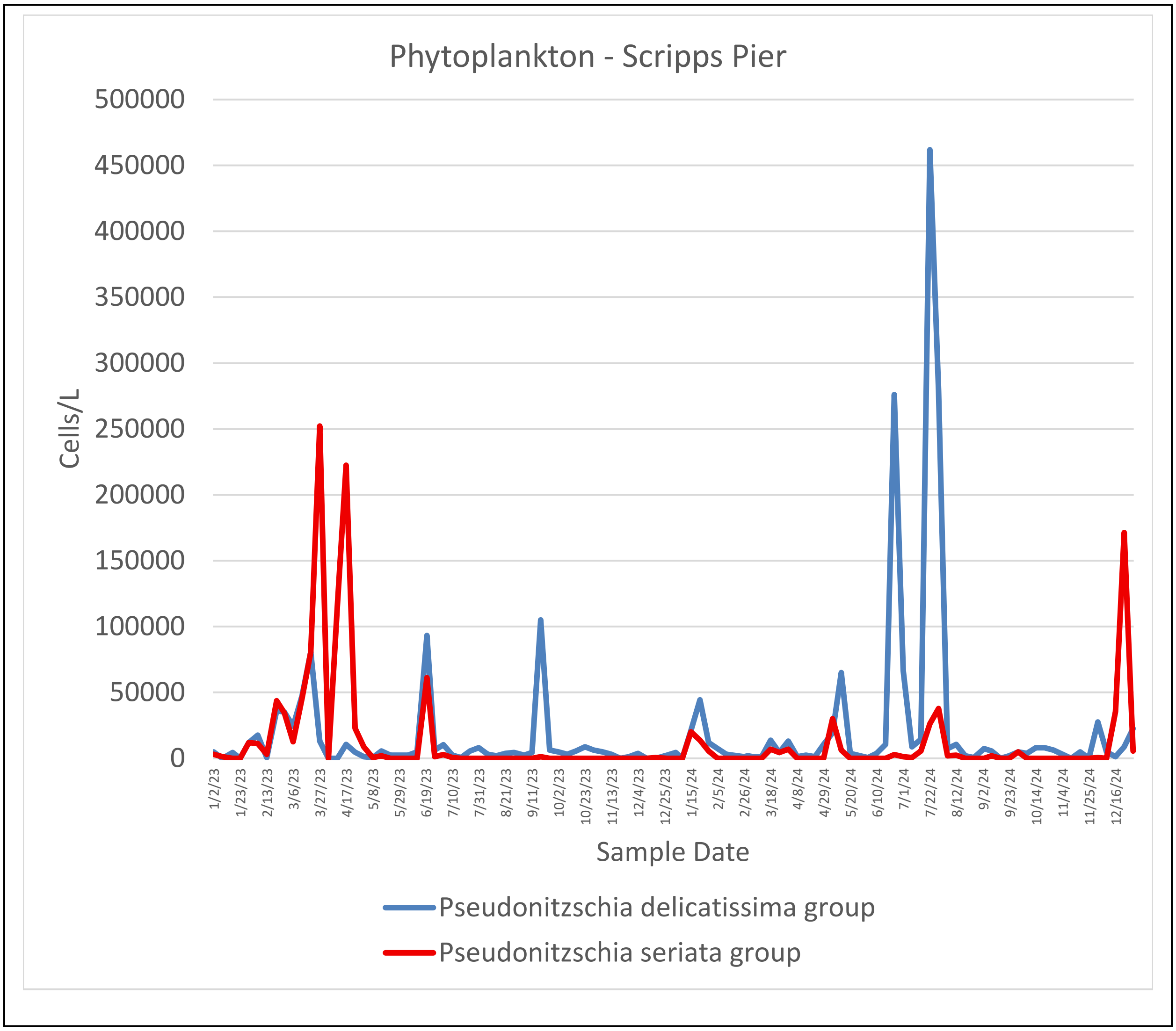


Figure 47. Phytoplankton Concentrations at Scripps Pier in 2023 and 2024.

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

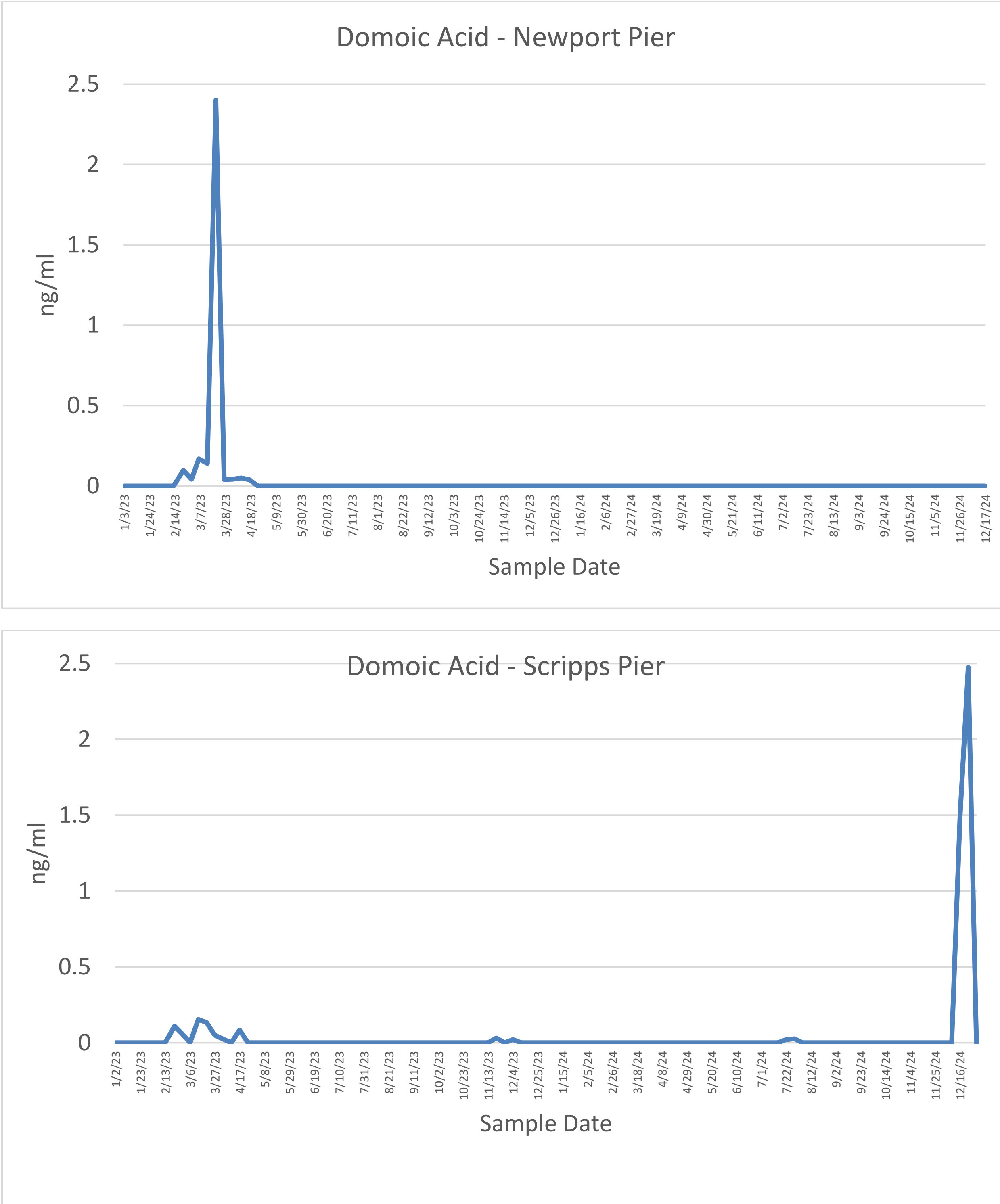


Figure 48. Domoic Acid Concentrations at Newport Pier and Scripps Pier in 2023 and 2024.

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

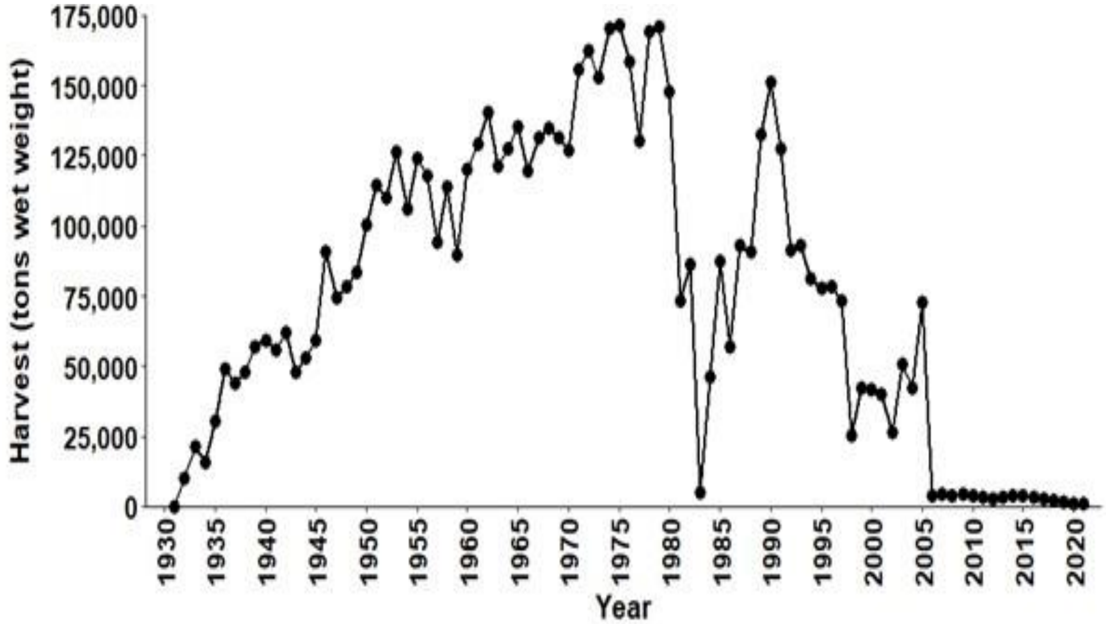


Figure 49. Commercial kelp harvest landings for giant and bull kelp from 1931 through 2021 (most is giant kelp).

Source: https://wildlife.ca.gov/Conservation/Marine/Kelp/Commercial-Harvest.

TABLES

1 through 16

Table 1. Kelp bed overflights in 2023.

Quarter	Target Date	Actual Date	Comments
1st Quarter 2023	**January to March 2023**	April 20, 2023	Excellent conditions for photos and observations during overflight (survey delayed from March due to bad weather)
2nd Quarter 2023	**April to June 2023**	June 20, 2023	Excellent conditions for photos and observations during overflight
3rd Quarter 2023	**July to September 2023**	October 12, 2023	Good conditions for photos and observations during overflight (survey delayed from September due to foggy conditions; scattered to significant fog from Carlsbad to Mission Bay in October)
4th Quarter 2023	**October to December 2023**	December 26, 2023	Excellent conditions for photos and observations during overflight

Table 2. Kelp bed overflights in 2024.

Quarter	Target Date	Actual Date	Comments
1st Quarter 2024	**January to March 2024**	March 8, 2024	Excellent conditions for photos and observations during overflight
2nd Quarter 2024	**April to June 2024**	July 24, 2024	Excellent conditions for photos and observations during overflight (survey delayed due to foggy conditions during month of June)
3rd Quarter 2024	**July to September 2024**	October 30, 2024	Excellent conditions for photos and observations during overflight (survey delayed due to foggy conditions during month of September)
4th Quarter 2024	**October to December 2024**	January 2 & 15, 2025	Excellent conditions for photos and observations during overflight (survey delayed due foggy conditions during month of December; partial survey completed on January 2nd due to fog, remainder completed on January 15th)

Table 3. Rankings assigned to kelp beds from aerial photographs from 2023 Region Nine surveys between Newport Harbor and Imperial Beach.

	2023 Surveys			
Kelp Beds	April 20, 2023	June 20, 2023	October 12, 2023	December 23, 2023
Newport Harbor*	—	—	—	—
Corona del Mar	0.5	1.5	—	0.5
North Laguna Beach	1.5	3.0	2.5	4.0
South Laguna Beach	0.5	1.0	0.5	0.5
South Laguna	—	1.0	0.5	3.0
Salt Creek-Dana Point	—	0.5	—	1.0
Dana Marina*	—	—	—	—
Capistrano Beach	—	3.0	1.5	2.5
San Clemente	—	—	—	0.5
San Mateo Point	—	—	—	—
San Onofre	—	—	—	—
Pendleton Reefs*	—	—	—	—
Horno Canyon	—	—	—	—
Barn Kelp	—	—	—	—
Santa Margarita	—	—	—	—
Oceanside Harbor*	—	—	—	—
North Carlsbad	—	—	—	—
Agua Hedionda	—	—	—	—
Encina Power Plant	—	—	—	—
Carlsbad State Beach	—	—	—	—
Leucadia (North, Central, South)	—	—	—	0.5
Encinitas	—	—	—	1.0
Cardiff	—	0.5	3.0	3.0
Solana Beach	—	—	—	0.5
Del Mar	—	—	—	—
Torrey Pines	—	—	cloudy	—
La Jolla Upper	—	—	cloudy	0.5
La Jolla Lower	—	—	cloudy	0.5
Point Loma Upper	—	0.5	1.5	1.5
Point Loma Lower	—	0.5	1.5	1.5
Imperial Beach	—	—	—	—

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

Table 4. Rankings assigned to kelp beds from aerial photographs from 2024 Region Nine surveys between Newport Harbor and Imperial Beach.

	2024 Surveys			
Kelp Beds	**March 8 8, 2024**	**July 24, 2024**	**October 30, 2024**	**January 2 & 15, 2025**
Newport Harbor*	—	—	—	—
Corona del Mar	1.5	1.0	—	—
North Laguna Beach	3.5	1.0	0.5	1.5
South Laguna Beach	0.5	1.0	1.0	1.5
South Laguna	3.0	0.5	—	2.0
Salt Creek-Dana Point	1.0	—	0.5	0.5
Dana Marina*	—	—	—	—
Capistrano Beach	3.5	—	—	—
San Clemente	0.5	—	0.5	—
San Mateo Point	—	—	—	—
San Onofre	—	—	—	—
Pendleton Reefs*	—	—	—	—
Horno Canyon	—	—	—	—
Barn Kelp	—	—	—	2.5
Santa Margarita	—	—	—	—
Oceanside Harbor*	—	—	—	—
North Carlsbad	—	—	—	—
Agua Hedionda	—	—	—	—
Encina Power Plant	—	—	—	—
Carlsbad State Beach	—	—	—	—
Leucadia (North, Central, South)	—	—	—	—
Encinitas	1.0	0.5	0.5	1.0
Cardiff	1.5	—	0.5	—
Solana Beach	1.0	—	0.5	0.5
Del Mar	—	—	—	—
Torrey Pines	—	—	—	—
La Jolla Upper	0.5	1.0	1.0	0.5
La Jolla Lower	1.0	1.0	1.0	1.0
Point Loma Upper	1.0	1.5	1.5	0.5
Point Loma Lower	1.0	1.5	1.5	1.0
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

Table 5. Comparison of the canopy coverage of the Region Nine kelp beds from Corona del Mar to Imperial Beach (kelp beds listed north to south) during 2022. 2023, and 2024

Kelp Bed	2022 (km^2)	2023 (km^2)	Percent Difference (2022 to 2023)	2024 (km^2)	Percent Difference (2023 to 2024)	Overall Percentage Difference (2022 to 2024)
Corona Del Mar*	**0.003**	**0.081**	**+2,600%**	**0.088**	**+9%**	**+2,833%**
North Laguna Beach	**0.040**	**0.219**	**+488%**	**0.169**	**-23%**	**+322%**
South Laguna Beach	**0.005**	**0.064**	**+1,180%**	**0.022**	**-66%**	**+340%**
South Laguna	**0.001**	**0.023**	**+2,200%**	**0.052**	**+126%**	**+5,100%**
Dana Point/Salt Creek	**0.002**	**0.006**	**+200%**	**0.022**	**+267%**	**+1,000%**
Capistrano Beach	**0**	**0.075**	**Reappeared**	**0.059**	**-21%**	**Reappeared**
San Clemente	**0**	**0.001**	**Reappeared**	**0.001**	**No change**	**Reappeared**
San Mateo Point	**0**	**0**	**No change**	**0**	**No change**	**No change**
San Onofre	**0**	**0**	**No change**	**0**	**No change**	**No change**
Horno Canyon	**0**	**0**	**No change**	**0**	**No change**	**No change**
Barn Kelp	**0**	**0**	**No change**	**0.047**	**Reappeared**	**Reappeared**
Santa Margarita	**0**	**0**	**No change**	**0**	**No change**	**No change**

Table 5 (continued)

Kelp Bed	2022 (km^2)	2023 (km^2)	Percent Difference (2022 to 2023)	2024 (km^2)	Percent Difference (2023 to 2024)	Overall Percentage Difference (2022 to 2024)
North Carlsbad	0	0	No change	0	No change	No change
Agua Hedionda	0	0	No change	0	No change	No change
Encina Power Plant	0	0	No change	0	No change	No change
Carlsbad State Beach	0	0	No change	0	No change	No change
Leucadia	0	0.002	Reappeared	0	Disappeared	No change
Encinitas	0	0.010	Reappeared	0.005	-50%	Reappeared
Cardiff	0	0.026	Reappeared	0.009	-65%	Reappeared
Solana Beach	0	0.006	Reappeared	0.021	+250%	Reappeared
Del Mar	0	0	No change	0	No change	No change
Torrey Pines	0	0	No change	0	No change	No change
La Jolla	0.446	0.067	-85%	0.053	-21%	-88%
Point Loma	1.417	0.324	-77%	0.157	-52%	-89%
Imperial Beach	0	0	No change	0	No change	No change
TOTAL	1.911	0.824	-58%	0.619	-25%	-68%

*Although Corona Del Mar is a designated kelp bed within the Central Region, it is included here for informational purposes.

Table 6. Percentage of Historical Maximum Size of the Region Nine kelp beds from Corona del Mar to Imperial Beach during 2022, 2023, and 2024.

Kelp Bed	Historical Maximum Size (km^2)	2022 (% of Maximum)	2023 (% of Maximum)	2024 (% of Maximum)
Corona del Mar*	0.419	0.8	19.4	21.0
North Laguna Beach	0.219	20.6	100.0	77.3
South Laguna Beach	0.272	1.9	23.6	8.1
South Laguna	0.052	2.9	45.0	100.0
Dana Point/Salt Creek	1.068	0.2	0.6	2.0
Capistrano Beach	0.233	0.0	32.4	25.5
San Clemente	1.097	0.0	0.1	0.1
San Mateo Point	0.870	0.0	0.0	0.0
San Onofre	0.767	0.0	0.0	0.0
Horno Canyon	0.125	0.0	0.0	0.0
Barn Kelp	0.926	0.0	0.0	5.0
Santa Margarita	0.080	0.0	0.0	0.0
North Carlsbad	0.180	0.0	0.0	0.0
Agua Hedionda	0.102	0.0	0.0	0.0
Encina Power Plant	0.352	0.0	0.0	0.0
Carlsbad State Beach	0.178	0.0	0.0	0.0
Leucadia	0.541	0.0	0.4	0.0
Encinitas	0.346	0.0	2.8	1.4

Table 6 (continued)

Kelp Bed	Historical Maximum Size (km^2)	2022 (% of Maximum)	2023 (% of Maximum)	2024 (% of Maximum
Cardiff	0.590	0.0	4.5	3.5
Solana Beach	0.823	0.0	0.7	2.5
Del Mar	0.104	0.0	0.0	0.0
Torrey Pines	0.034	0.0	0.0	0.0
La Jolla	4.755	9.4	1.4	1.1
Point Loma	7.920	17.9	4.1	2.0
Imperial Beach	1.895	0.0	0.0	0.0

*Although Corona Del Mar is a designated kelp bed within the Central Region, it is included here for information purposes.

Table 7. Canopy coverage (km^2) of the kelp beds from North Laguna Beach to Imperial Beach (kelp beds listed from north to south) from 2015 through 2024.

Kelp Bed	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
N Laguna Beach	0.080	0.074	0.096	0.133	0.015	0.022	0.031	0.040	0.219	0.169
S Laguna Beach	0.048	0.035	0.032	0.131	0.007	0.001	0.012	0.005	0.064	0.022
South Laguna	0.016	0.006	0.003	0.048	-	-	0.005	0.001	0.023	0.052
Dana Pt/Salt Creek	0.137	0.110	0.133	0.379	-	0.005	0.017	0.002	0.006	0.022
Capistrano Beach	0.007	0.012	0.0004	0.018	-	-	0.006	-	0.075	0.059
Total F&W 9	0.287	0.237	0.264	0.709	0.022	0.028	0.071	0.048	0.388	0.324
San Clemente	0.343	0.187	0.229	0.335	0.031	0.009	0.004	-	0.001	0.001
San Mateo Point	0.062	0.053	0.033	0.083	0.0001	-	0.007	-	0.0	-
San Onofre	0.043	0.120	0.087	0.127	0.001	-	-	-	-	-
Total F&W 8	0.449	0.359	0.349	0.545	0.032	0.009	0.011	0.000	0.001	0.01
Horno Canyon	0.019	0.010	0.011	0.008	-	0.003	-	-	-	-
Barn Kelp	0.085	0.133	0.096	0.092	-	0.234	0.262	-	-	0.047
Santa Margarita	-	-	-	-	-	-	-	-	-	-
Total F&W 7	0.104	0.143	0.107	0.100	0.000	0.237	0.262	0.000	0.000	0.047
North Carlsbad	0.047	-	0.004	0.038	-	-	-	-	-	-
Agua Hedionda	0.016	-	-	-	-	-	-	-	-	-
Encina Power Plant	0.159	0.009	0.025	0.045	-	-	-	-	-	-
Carlsbad State Bch	0.061	-	0.001	-	-	-	-	-	-	-
Total F&W 6	0.282	0.009	0.031	0.083	0.000	0.000	0.000	0.000	0.000	0.000
Leucadia	0.414	0.033	0.010	0.053	0.009	0.006	-	-	0.002	-
Encinitas	0.113	0.009	0.003	0.033	-	0.0003	-	-	0.010	0.005
Cardiff	0.318	0.024	0.003	0.005	-	-	-	-	0.026	0.009
Solana Beach	0.316	0.138	0.029	0.024	-	-	0.006	-	0.006	0.021
Del Mar	0.034	-	-	-	-	-	-	-	-	-
Torrey Pines	-	-	-	-	-	-	-	-	-	-
Total F&W 5	1.195	0.204	0.045	0.114	0.009	0.006	0.006	0.000	0.044	0.035
La Jolla F&W 4	2.968	0.927	0.694	1.566	1.227	1.094	0.725	0.446	0.067	0.053
Point Loma F&W 3&2	5.806	3.037	1.787	7.920	3.924	2.545	1.882	1.417	0.324	0.157
Imperial Beach F&W 1	1.576	0.217	-	-	-	-	-	-	-	-
TOTAL	12.667	5.134	3.277	11.037	5.213	3.919	2.964	1.911	0.824	0.619

Red denotes warm-water years

"-" = no canopy area

Table 8. Comparison of mean sea surface temperature from 1994 through 2024 versus annual mean temperature from 2015 through 2024 at Newport Pier and Scripps Pier.

		Annual Mean SST (°C)									
	Mean SST (°C) (1994–2024)	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Newport Pier	**16.6**	**18.4**	**17.8**	**17.8**	**17.9**	**17.6**	**17.4**	**16.9**	**17.2**	**16.9**	**16.6**
Scripps Pier	**17.7**	**18.9**	**17.7**	**17.9**	**18.6**	**17.8**	**18.8**	**17.3**	**17.7**	**16.9**	**17.2**

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

Table 9. Nutrient Quotient calculations for period from July 2023 to June 2024.

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 2024 Feb 2024 Mar 2024 Apr 2024	May 2024	**9** (2 pts x 4) + (1 pt x 1)
Oceanside				Jan 2024 Feb 2024 Mar 2024 Apr 2024		**8** (2 pts x 4)
Scripps Pier				Jan 2024 Feb 2024 Mar 2024 Apr 2024	Nov 2023 Dec 2023 May 2024	**11** (2 pts x 4) + (1 pt x 3)
Point Loma				Feb 2024 Mar 2024 Apr 2024		**6** (2 pts x 3)

Table 10. Nutrient Quotient calculations for period from July 2024 to June 2025.

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		Mar 2025	Dec 2024 Jan 2025 Feb 2025 Apr 2025	Nov 2024		**26** (8 pts x 1) + (4 pts x 4) + (2 pts x 1) + (1 pt x 0)
Oceanside			Jan 2025 Feb 2025 Mar 2025	Dec 2024 Apr 2025	Nov 2025	**17** (4 pts x 3) + (2 pts x 2) + (1 pt x 1)
Scripps Pier		Dec 2024 Jan 2025	Feb 2025 Mar 2025 Apr 2025	Nov 2024		**31** (8 pts x 2) + (4 pts x 3) + (2 pts x 1) + (1 pt x 0)
Point Loma			Jan 2025 Feb 2025 Mar 2025	Dec 2024 Apr 2025	Nov 2024	**17** (4 pts x 3) + (2 pts x 2) + (1 pt x 1)

Table 11. Direction of swells in 2023 and 2024. Source : http://cdip.ucsd.edu.

Direction	Oceanside		Pont Loma South	
	2023	2024	2023	2024
West-northwest (292.5°)	2%	2%	12%	11%
West (270°)	19%	18%	32%	31%
West-southwest (247.5°)	11%	10%	6%	7%
Southwest (225°)	10%	12%	7%	10%
South-southwest (202.5°)	36%	43%	19%	25%
South (180°)	22%	15%	22%	16%

Table 12. Large waves (≥3 meters) in 2023 and 2024.

Dates and Locations in 2023			Dates and Locations in 2024		
	Oceanside (meters)	Point Loma South (meters)		Oceanside (meters)	Point Loma South (meters)
1/1/23	4.8	6.3	**1/1/24**		4.5
1/2/23		6.6	**1/2/24**		3.3
1/3/23		3.3	**1/3/24**		3.3
1/8/23		4.2	**1/4/24**	4.4	6.3
1/9/23		4.6	**1/5/24**		5.8
1/10/23	3.7	4.9	**1/6/24**		4.2
1/11/23		5.5	**1/7/24**		7.1
1/12/23		5.3	**1/8/24**	3.5	6.7
1/13/23		4.9	**1/9/24**		3.3
1/14/23	3.2	6.4	**1/10/24**		3.3
1/15/23	3.6	5.8	**1/11/24**		6.1
1/16/23	4.3	5.7	**1/12/23**		4.1
1/17/23	4.9	6.2	**1/19/24**		3.1
1/18/23		4.7	**1/21/24**	3.1	5.2
1/19/23		3.5	**1/22/24**	3.2	4.3
1/20/23		3.7	**1/23/24**	3.1	3.8
1/23/23		3.2	**1/24/24**		3.8
1/25/23		3.3	**1/25/24**		3.5
2/6/23	4.6	5.6	**1/26/24**		3.9
2/7/23	3.0	4.9	**1/27/24**		3.4
2/11/23	3.3	4.3	**1/31/24**		3.0

Table 12 (continued). Large waves (≥3 meters) in 2023 and 2024.

Dates and Locations in 2023			Dates and Locations in 2024		
	Oceanside (meters)	Point Loma South (meters)		Oceanside (meters)	Point Loma South (meters)
2/12/23	3.2	4.1	**2/1/24**	4.8	6.1
2/13/23		3.3	**2/2/24**	3.9	5.8
2/14/23		4.3	**2/3/24**	3.4	4.3
2/15/23		6.6	**2/4/24**		3.5
2/16/23		4.1	**2/5/24**	5.4	7.1
2/22/23		8.0	**2/6/24**	3.4	4.6
2/23/23		5.2	**2/7/24**	3.1	4.0
2/24/23	3.4	3.7	**2/8/24**	4.6	4.6
2/25/23	4.9	6.1	**2/9/24**	3.6	4.2
2/26/23	3.3	4.2	**2/10/24**		3.7
3/1/23		5.6	**2/18/24**	3.9	5.2
3/2/23	3.0	7.2	**2/19/24**	3.9	4.8
3/14/23		3.1	**2/20/24**	5.2	7.3
3/15/23	3.2	3.1	**2/21/24**	4.1	5.4
3/16/23		3.3	**2/22/24**		3.5
3/21/23		5.3	**3/3/24**		3.6
3/22/23	4.5	5.3	**3/4/24**	3.3	4.1
3/23/23		6.0	**3/7/24**		4.3
3/24/23	3.2	4.6	**3/8/24**	3.1	5.8
3/25/23		3.9	**3/12/24**		3.5
3/26/23		3.8	**3/13/24**		3.5

Table 12 (continued). Large waves (≥3 meters) in 2023 and 2024.

Dates and Locations in 2023			Dates and Locations in 2024		
	Oceanside (meters)	Point Loma South (meters)		Oceanside (meters)	Point Loma South (meters)
3/27/23		3.3	**3/14/24**		3.4
3/30/23		3.5	**3/15/23**		3.1
3/31/23		3.2	**3/24/24**	5.1	6.1
4/3/23	5.0	5.1	**3/25/24**	4.7	8.2
4/4/23		6.6	**3/26/24**		4.3
4/5/23		4.2	**3/30/24**	3.7	4.9
4/12/23		3.1	**3/31/24**	3.5	4.9
4/13/23		3.6	**4/1/24**		4.5
4/14/23		3.0	**4/5/24**	3.1	4.3
4/19/23		3.4	**4/6/24**	3.8	5.1
5/1/23		3.4	**4/8/24**		3.4
5/2/23		3.1	**4/14/24**		3.2
5/10/23		3.2	**4/15/24**		3.6
5/17/23		3.4	**4/26/24**		3.7
5/18/23		3.6	**4/27/24**	4.7	5.5
6/22/23		3.3	**4/30/24**		3.1
6/27/23		3.4	**5/1/24**		3.1
8/20/23		3.7	**5/2/24**		3.1
8/21/23	3.7	3.2	**5/5/24**		4.5
9/9/23		3.1	**5/6/24**	3.6	4.9
9/10/23	3.3	3.4	**5/8/24**		3.0

Table 12 (continued). Large waves (≥3 meters) in 2023 and 2024.

Dates and Locations in 2023			Dates and Locations in 2024		
	Oceanside (meters)	Point Loma South (meters)		Oceanside (meters)	Point Loma South (meters)
9/28/23		3.2	**6/2/24**		3.3
9/28/23		3.2	**6/16/24**		4.6
10/12/23		3.4	**6/17/24**		3.3
10/20/23		4.2	**7/5/24**		3.2
10/21/23		3.8	**8/9/24**		3.3
10/22/23		3.7	**10/13/24**		3.2
10/23/23		3.1	**10/18/24**		3.3
10/29/23		3.3	**10/28/24**		3.5
11/8/23		3.7	**10/29/24**	3.6	6.3
11/16/23		4.1	**10/30/24**		3.5
11/20/23		4.0	**11/3/24**		4.2
11/26/23		3.1	**11/4/24**		3.6
12/1/23	3.3	4.3	**11/13/24**		4.0
12/2/23		4.4	**11/14/24**		3.3
12/7/23		3.6	**11/15/24**	3.6	5.4
12/8/23		4.0	**11/16/24**	4.8	5.7
12/9/23		3.7	**11/17/24**		4.4
12/19/23		3.2	**11/19/24**		3.3
12/21/23		3.3	**11/22/24**		3.1
12/22/23		3.7	**12/10/24**		3.0
12/23/23		3.0	**12/13/24**		3.8

Table 12 (continued). Large waves (≥3 meters) in 2023 and 2024.

Dates and Locations in 2023			Dates and Locations in 2024		
	Oceanside (meters)	Point Loma South (meters)		Oceanside (meters)	Point Loma South (meters)
12/26/23		3.7	**12/14/24**		3.5
12/27/23		3.6	**12/15/24**		3.6
12/28/23	4.6	5.9	**12/16/24**		4.1
12/29/23	4.8	7.3	**12/18/24**		4.1
12/30/23		7.1	**12/22/24**		5.2
12/31/23	4.2	6.0	**12/23/24**	3.1	6.6
			12/24/24		6.1
			12/25/24		6.0
			12/26/24		5.1
			12/27/24		4.2
			12/28/24		4.0
			12/29/24		5.2
			12/30/24		4.2
			12/31/24		3.7

Table 13. Storms Producing Largest Swells in Kelp Areas of Region Nine in 2023 and 2024.

Year	Month	Dates of Storm	Wave Heights off Oceanside (m)	Wave Heights off Point Loma (m)	Maximum Swells in Kelp Areas (ft)
2023	January	1 & 2	4.8	6.3–6.6	≤2–6
		10–17	2.2–4.9	4.9–6.4	≤2–8
	February	6 & 7	3.0–4.6	4.9–5.6	≤2–6
		15	No data	6.6	≤3–6
		22–25	2.2–4.9	3.7–8.0	0–6
	March	1 & 2	2.4–3.0	5.6–7.2	0–6
		21–23	2.9–4.5	5.3–6.0	≤1–10
	April	3 & 4	5.0	5.1–6.6	0–2
	December	28–31	4.2–4.8	5.9–6.3	≤2–12
2024	January	4–8	1.3–4.4	4.2–7.1	≤3–6
		11	No data	6.1	0–6
		21	3.1	5.2	≤2–6
	February	1 & 2	3.9–4.8	5.8–6.1	≤2–8
		5	5.4	7.1	≤4–6
		20 & 21	4.1–5.2	5.4–7.3	≤3–12
	March	8	3.1	5.8	0–6
		24 & 25	4.7–5.1	6.1–8.2	0–6
	April	6	3.8	5.1	0–6
		27	4.7	5.5	≤1–3
	October	29	3.6	6.3	≤2–6
	November	15 & 16	3.6–4.8	5.4–5.7	0–6
	December	22–26	2.5–3.1	5.1–6.6	≤2–12
		29	2.4	5.2	0–9

Table 14. Frequency of Occurrence of Large Waves from 2018 through 2024 off Point Loma.

	Number of days with maximum wave heights ≥ 5 meters					
Month	2019	2020	2021	2022	2023	2024
January			1		8	6
February			2		2	6
March				4	5	3
April	1			1	2	2
May	1			1		
October						1
November	1			1		2
December	1					6

Source: MBC 2019, 2020, 2023

Table 15. Administrative management categories for California kelp beds.

Designation	Harvesting Status	Number
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 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

Table 16. Region Nine kelp bed designations compared to California Department of Fish and Wildlife kelp bed designations.

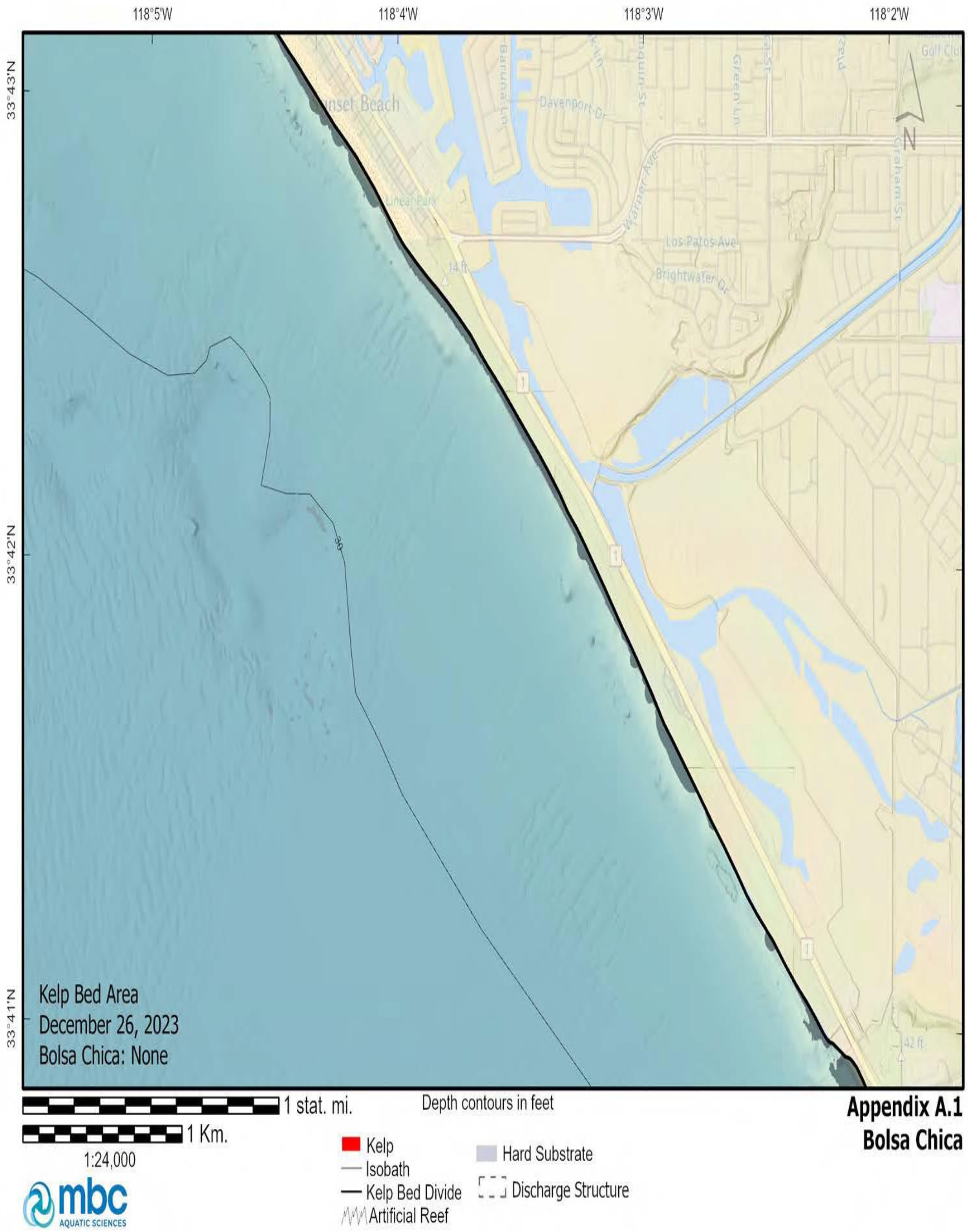
F & W Lease Area	Region Nine Kelp Bed Designations
Bed 1	Imperial Beach
Beds 2 and 3	Point Loma
Bed 4	La Jolla
Bed 5	Leucadia, Encinitas, Cardiff, Solana Beach, Del Mar, Torrey Pines
Bed 6	North Carlsbad, Agua Hedionda, Encina Power Plant, Carlsbad State Beach
Bed 7	Horno Canyon, Barn Kelp, Santa Margarita
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

APPENDIX A

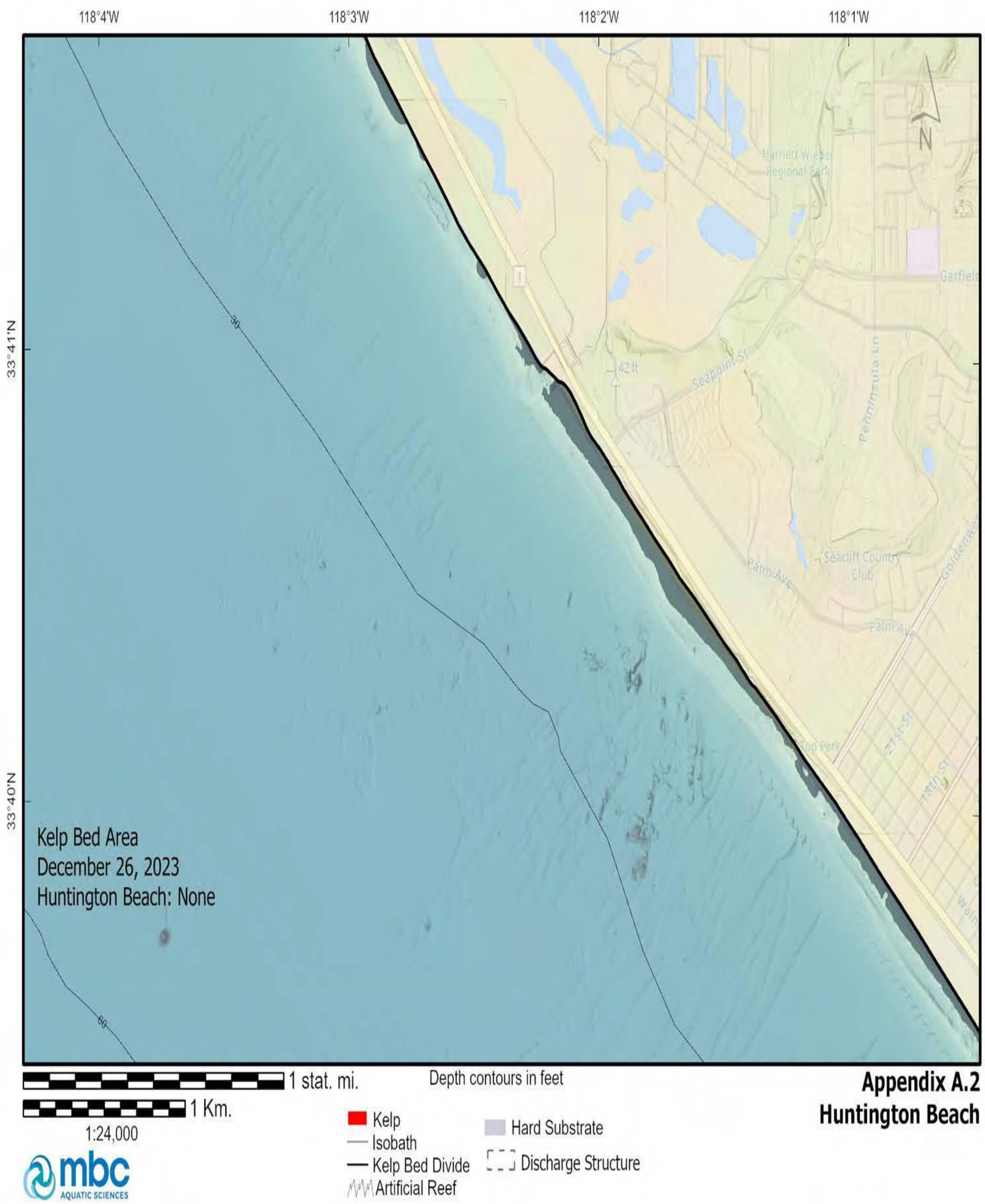
KELP CANOPY MAPS

2023 (A.1 TO A.46)

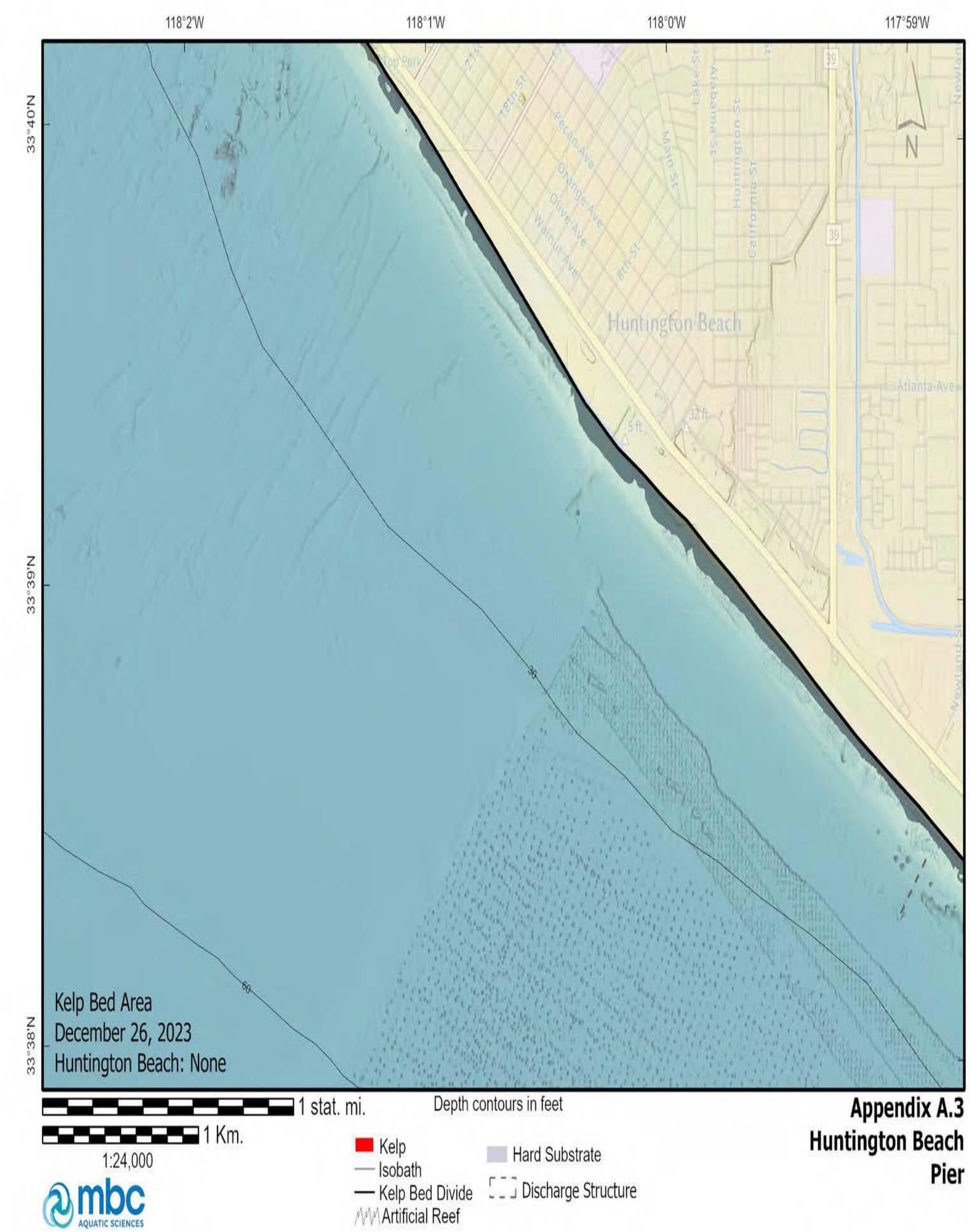
2024 (A.47 TO A.92)


118°5'W
118°4'W
118°3'W
118°2'W
33°43'N
33°42'N
33°41'N
Sunset Beach
Davenport Dr
Warner Ave
Los Patos Ave
Brightwater Dr
Graham St
Green Ln
14 ft
42 ft
30
N
Kelp Bed Area
December 26, 2023
Bolsa Chica: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
mbc AQUATIC SCIENCES
Appendix A.1
Bolsa Chica

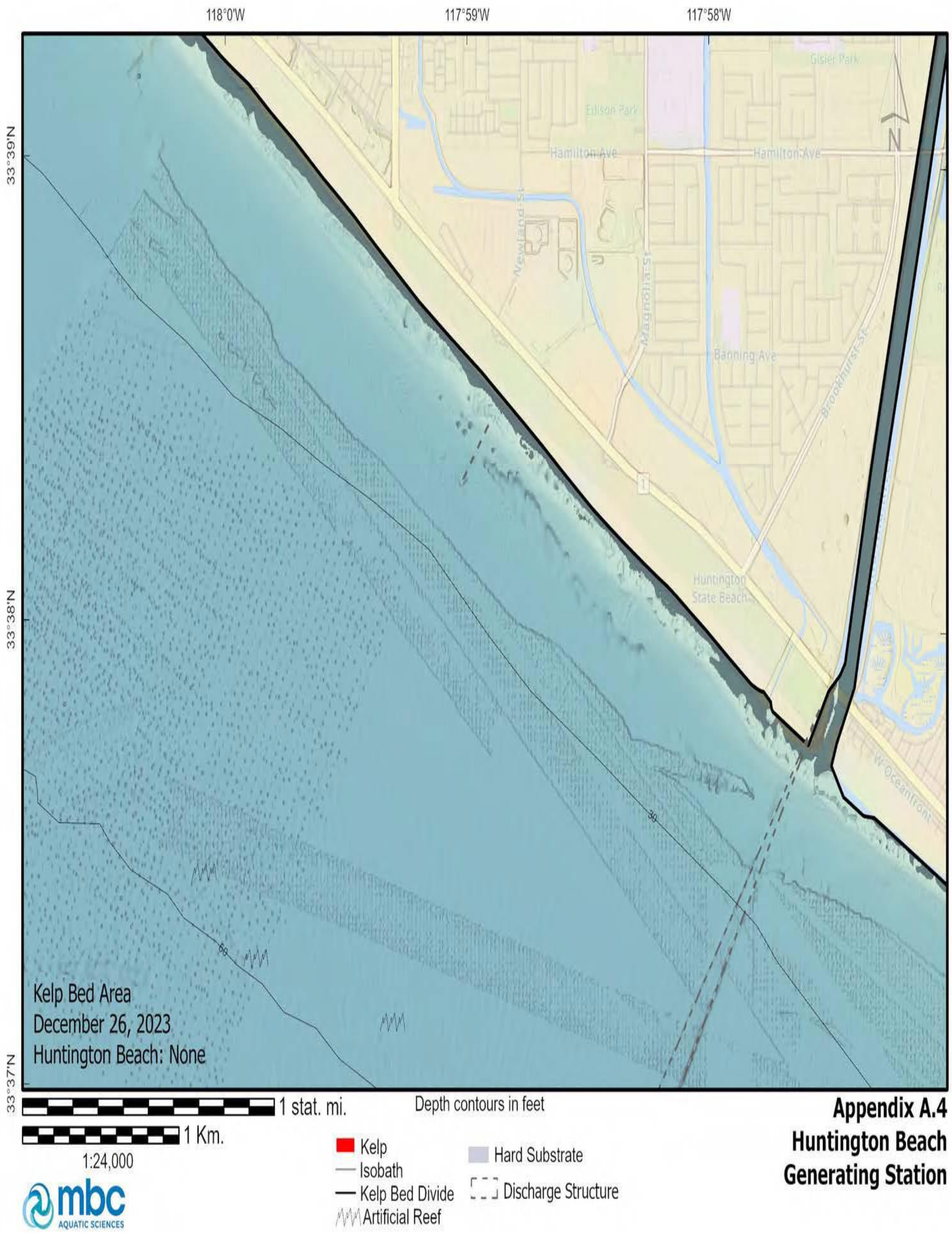
Page A-01


118°4'W
118°3'W
118°2'W
118°1'W
33°41'N
33°40'N
N
Harriett Wieder Regional Park
Garfield
Seapoint St
Peninsula Ln
Seacliff Country Club
Palm Ave
Goldenwest
21st St
18th St
Kelp Bed Area
December 26, 2023
Huntington Beach: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.2
Huntington Beach

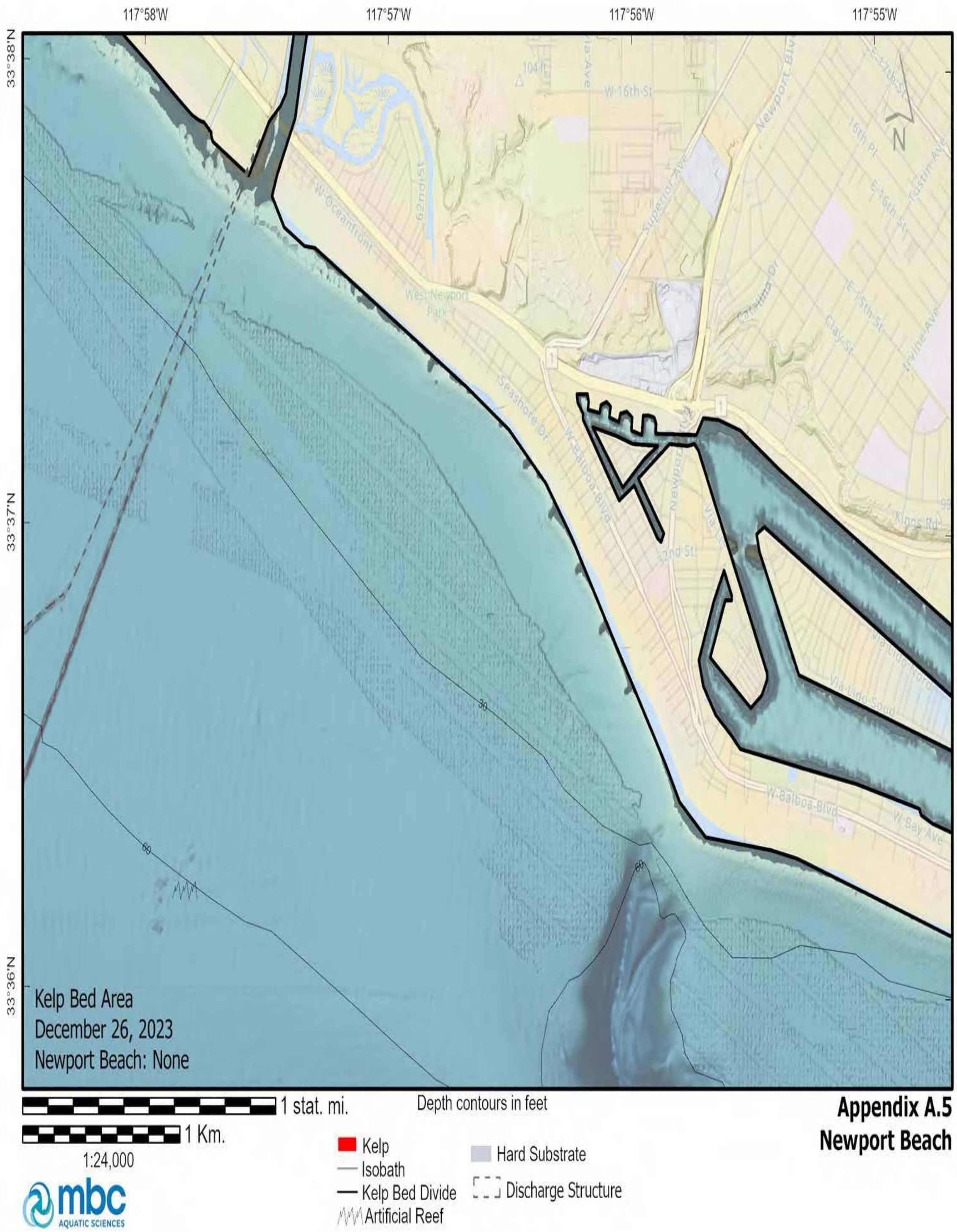
Page A-02


118°2'W
118°1'W
118°0'W
117°59'W
33°40'N
33°39'N
33°38'N
N
Huntington Beach
Atlanta Ave
Main St
Huntington St
California St
Lake St
Alabama St
Pecan Ave
Orange Ave
Olive Ave
Walnut Ave
8th St
18th St
Newland St
39
30
60
Kelp Bed Area
December 26, 2023
Huntington Beach: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
mbc
AQUATIC SCIENCES
Appendix A.3
Huntington Beach
Pier

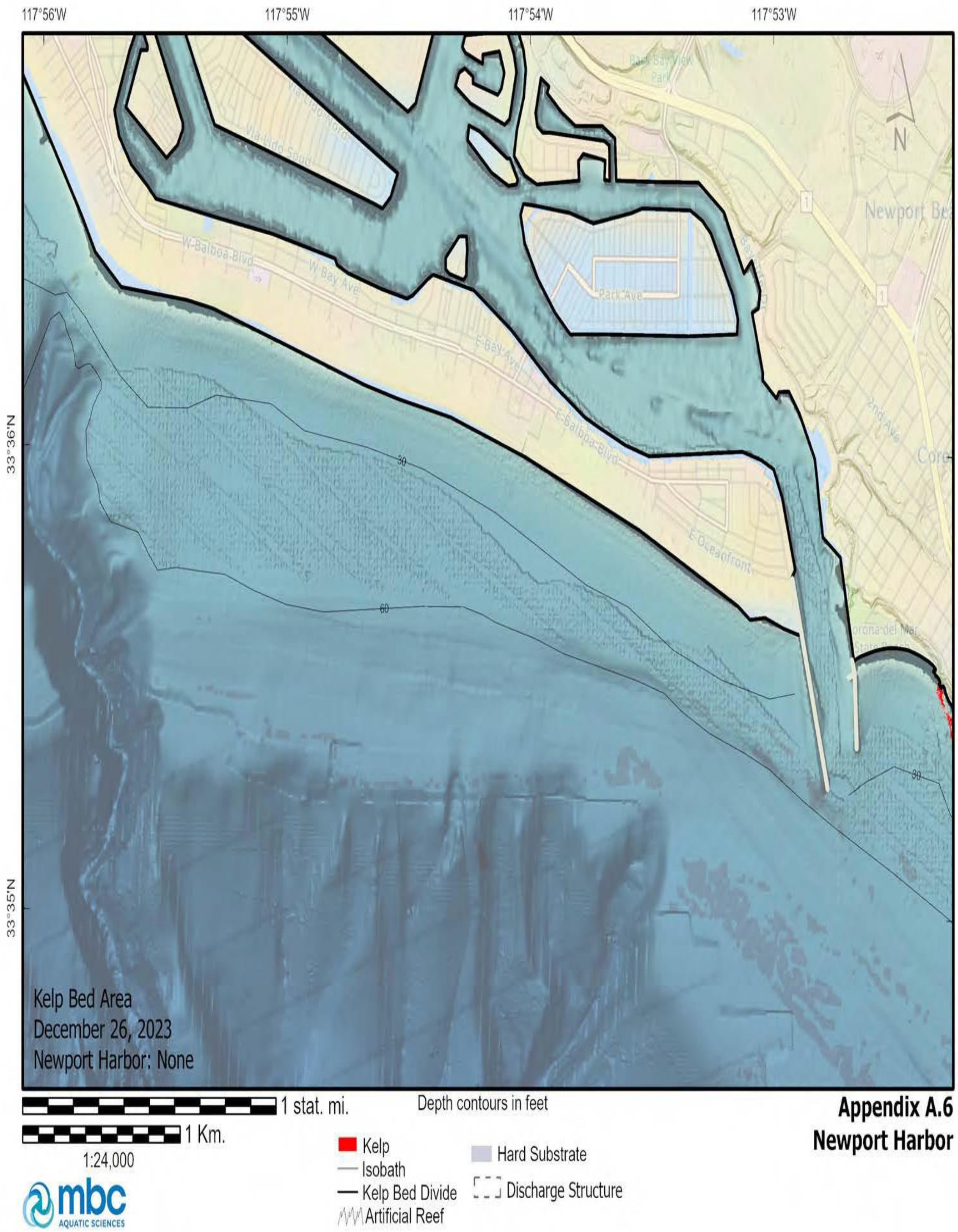
Page A-03


118°0'W
117°59'W
117°58'W
33°39'N
33°38'N
33°37'N
Edison Park
Hamilton Ave
Newland St
Magnolia St
Banning Ave
Brookhurst St
Huntington State Beach
W Oceanfront
N
Kelp Bed Area
December 26, 2023
Huntington Beach: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.4
Huntington Beach
Generating Station

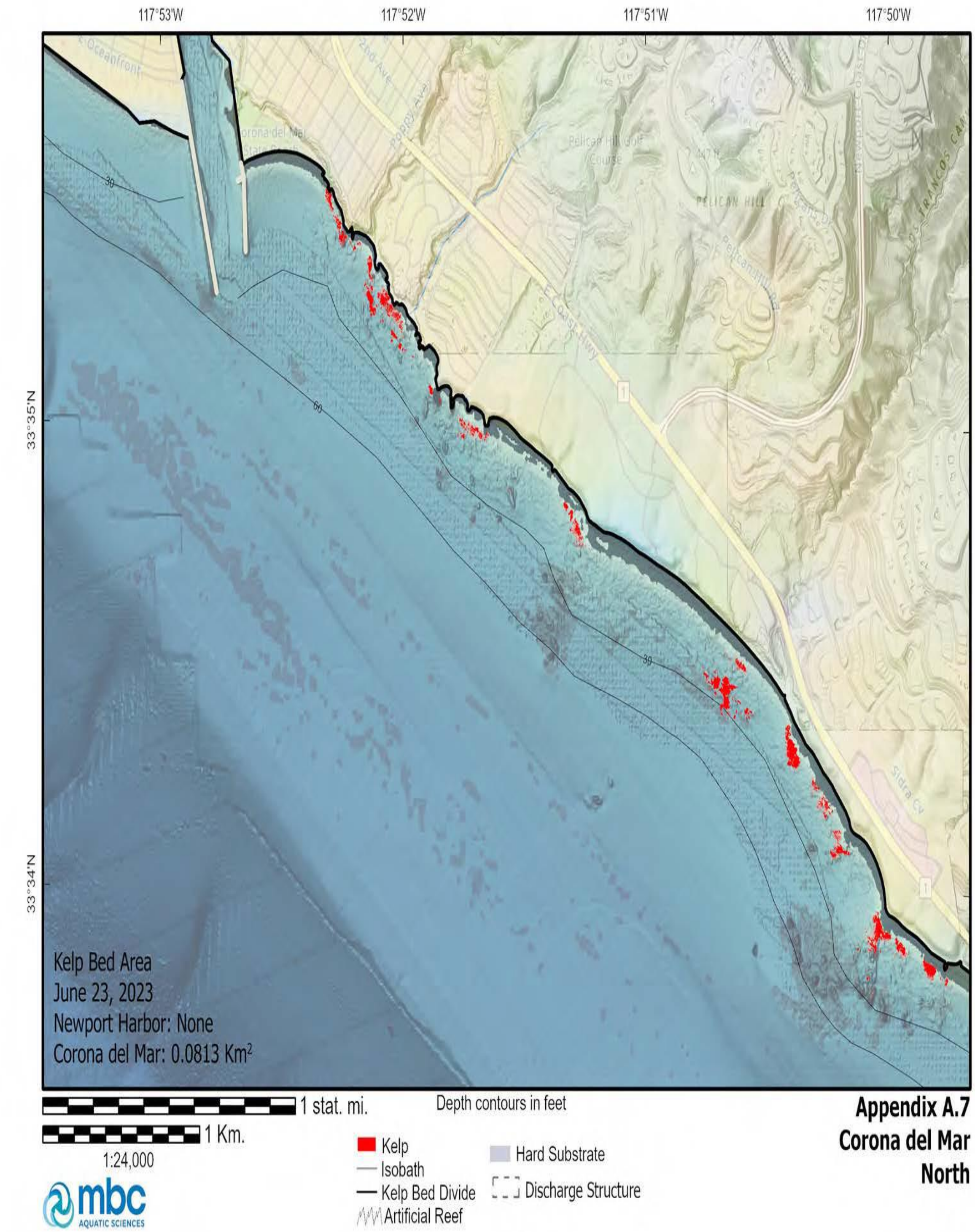
Page A-04


117°58'W
117°57'W
117°56'W
117°55'W
33°38'N
33°37'N
33°36'N
N
Kelp Bed Area
December 26, 2023
Newport Beach: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.5
Newport Beach

Page A-05

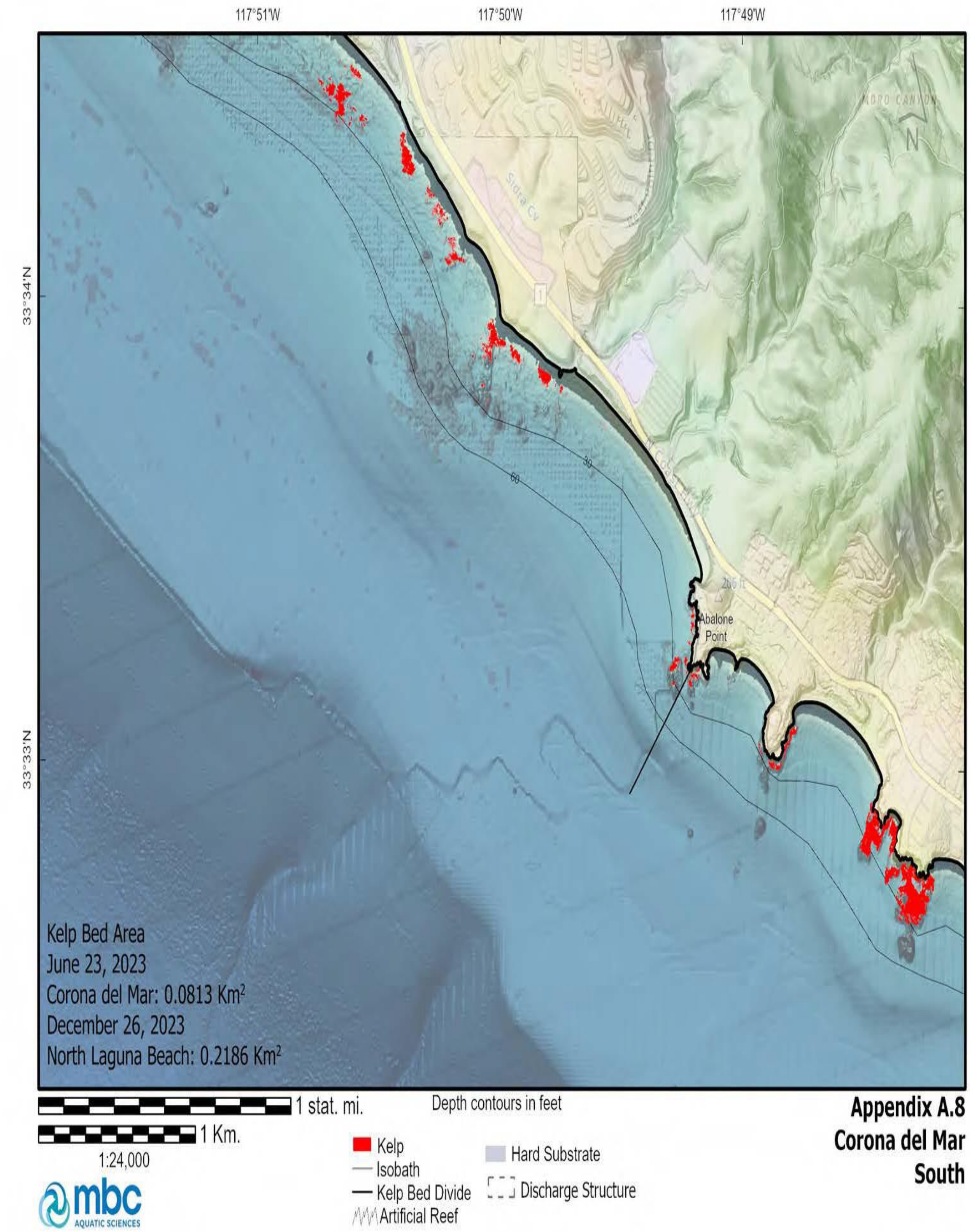

117°56'W
117°55'W
117°54'W
117°53'W
33°36'N
33°35'N
N
Newport Be
Corona del Mar
W Balboa Blvd
W Bay Ave
E Bay Ave
E Balboa Blvd
E Oceanfront
Park Ave
Via Lido Soud
30
60
Kelp Bed Area
December 26, 2023
Newport Harbor: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.6
Newport Harbor
mbc
AQUATIC SCIENCES

Page A-06

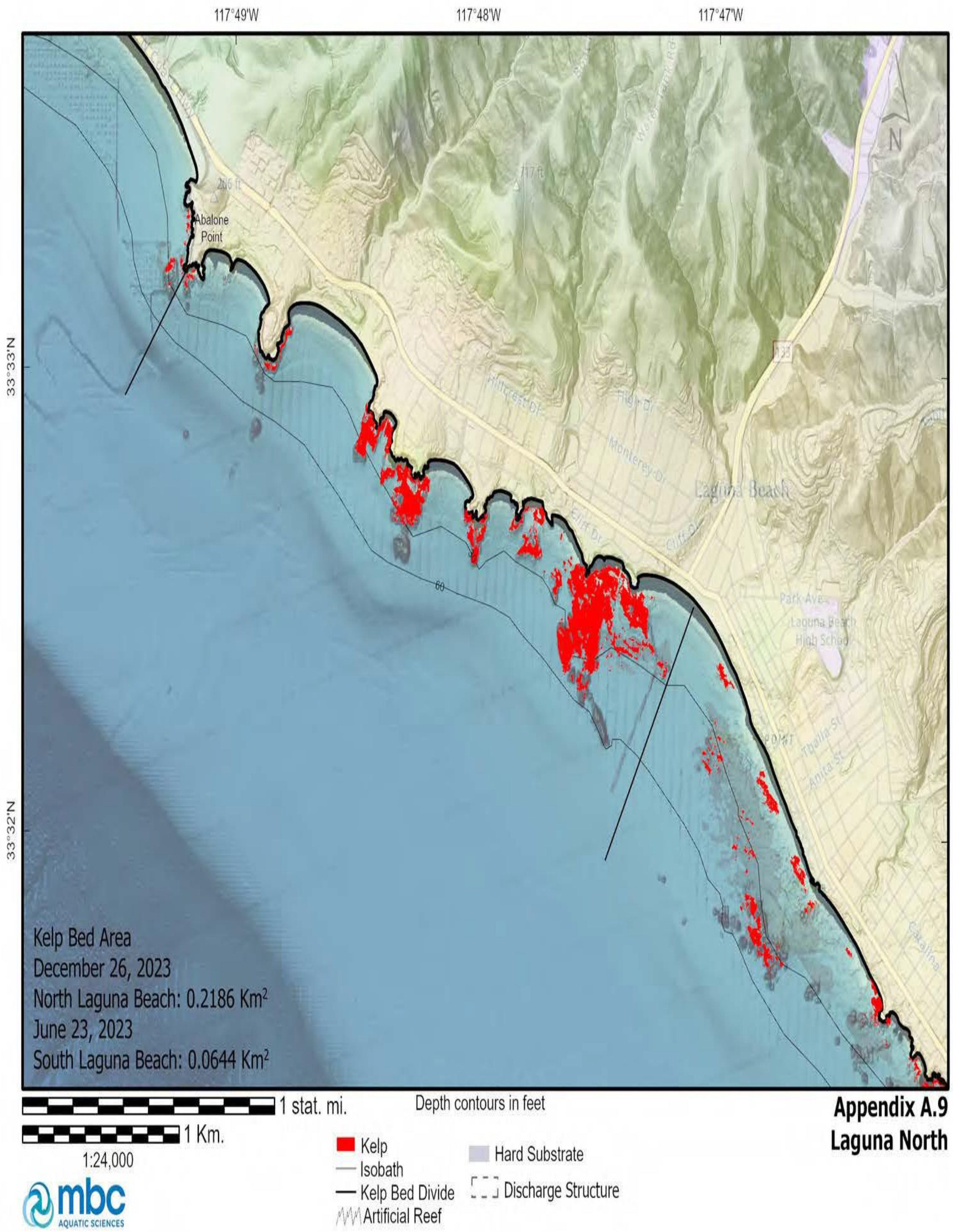


117°53'W
117°52'W
117°51'W
117°50'W
33°35'N
33°34'N
Kelp Bed Area
June 23, 2023
Newport Harbor: None
Corona del Mar: 0.0813 Km²
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.7
Corona del Mar
North

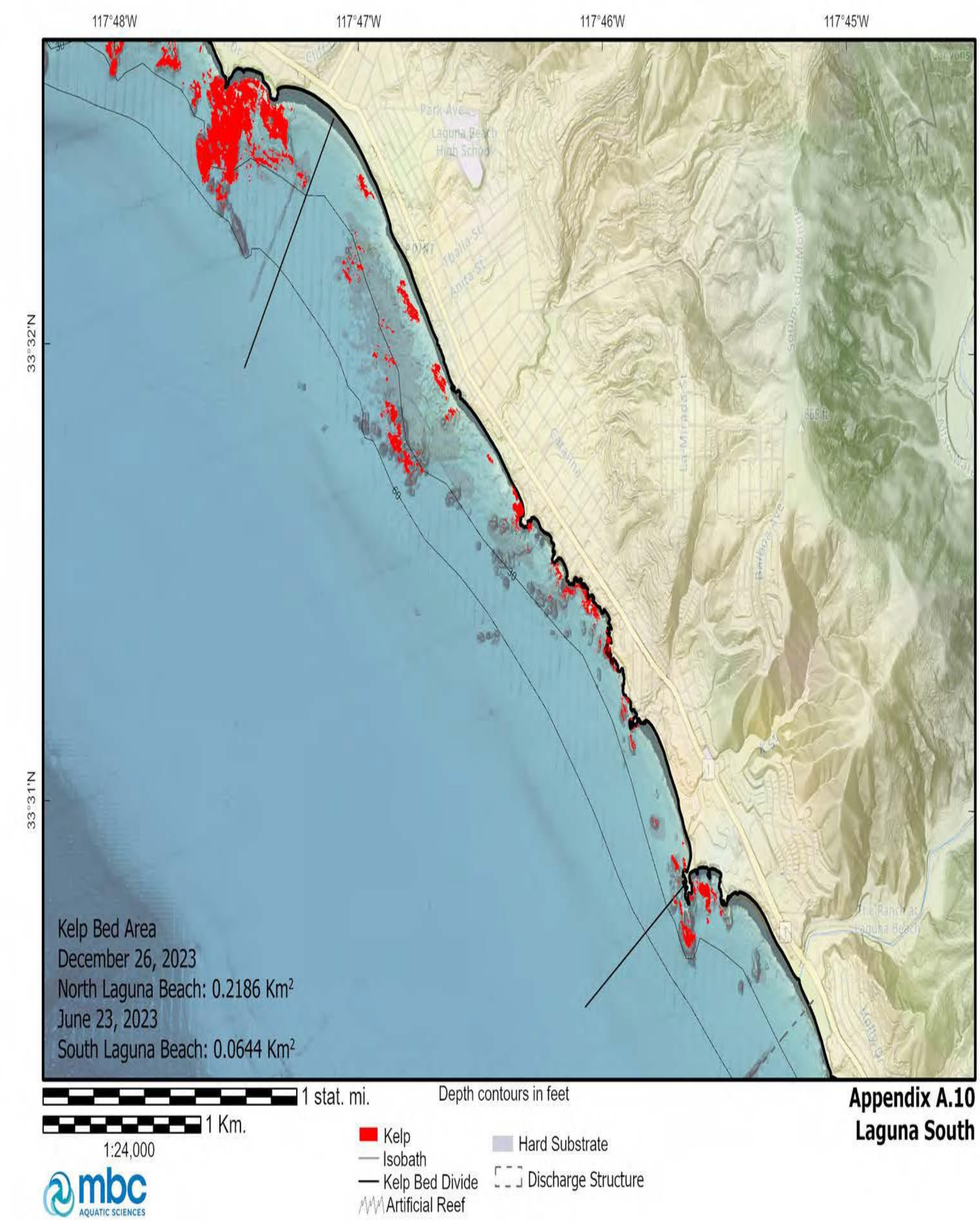
Page A-07


117°51'W
117°50'W
117°49'W
33°34'N
33°33'N
Sidra Cv
Abalone Point
Kelp Bed Area
June 23, 2023
Corona del Mar: 0.0813 Km²
December 26, 2023
North Laguna Beach: 0.2186 Km²
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.8
Corona del Mar
South

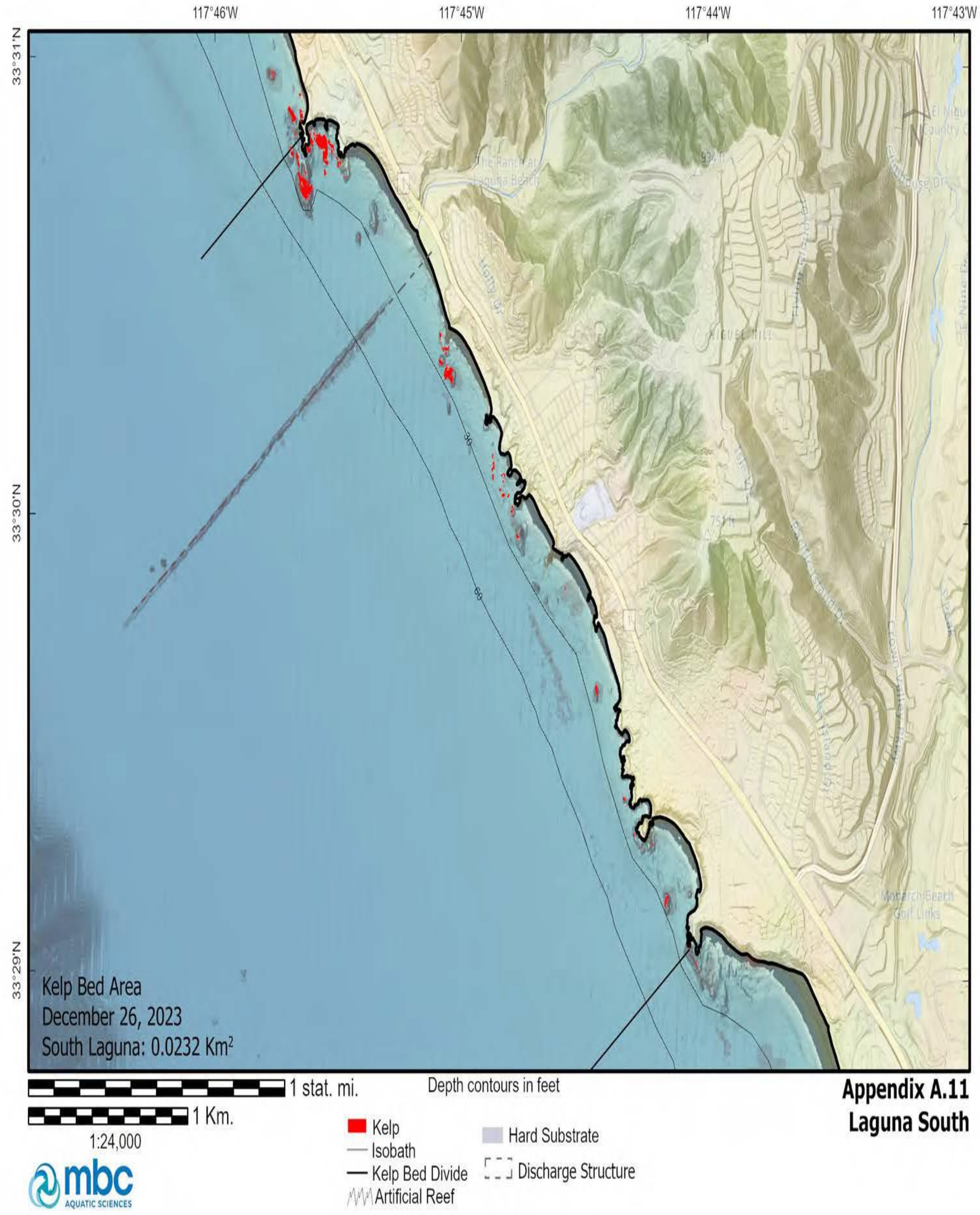
Page A-08


117°49'W
117°48'W
117°47'W
33°33'N
33°32'N
Abalone Point
Laguna Beach
Kelp Bed Area
December 26, 2023
North Laguna Beach: 0.2186 Km²
June 23, 2023
South Laguna Beach: 0.0644 Km²
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.9
Laguna North
mbc
AQUATIC SCIENCES

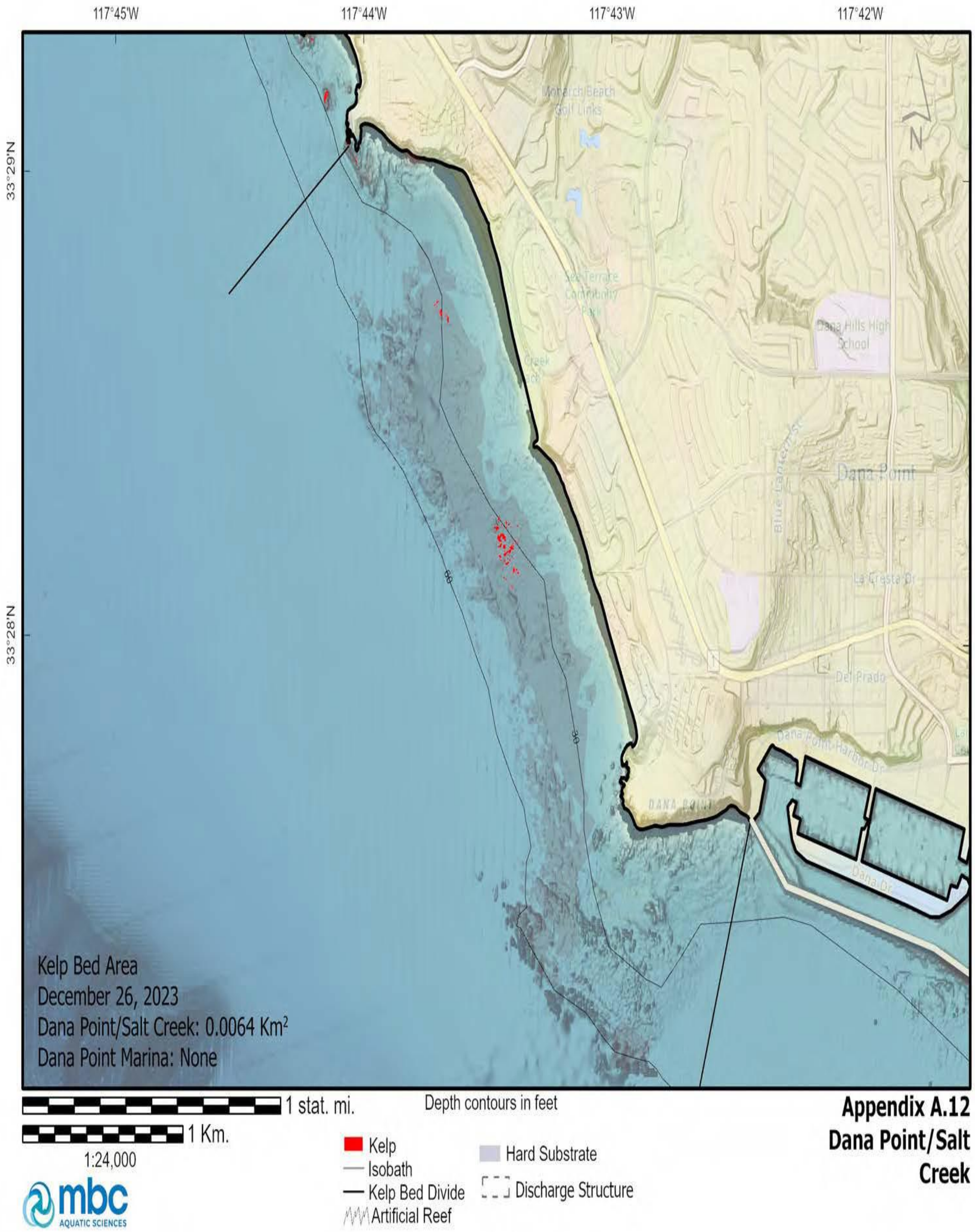
Page A-09


117°48'W
117°47'W
117°46'W
117°45'W
33°32'N
33°31'N
Kelp Bed Area
December 26, 2023
North Laguna Beach: 0.2186 Km²
June 23, 2023
South Laguna Beach: 0.0644 Km²
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
mbc
AQUATIC SCIENCES
Appendix A.10
Laguna South

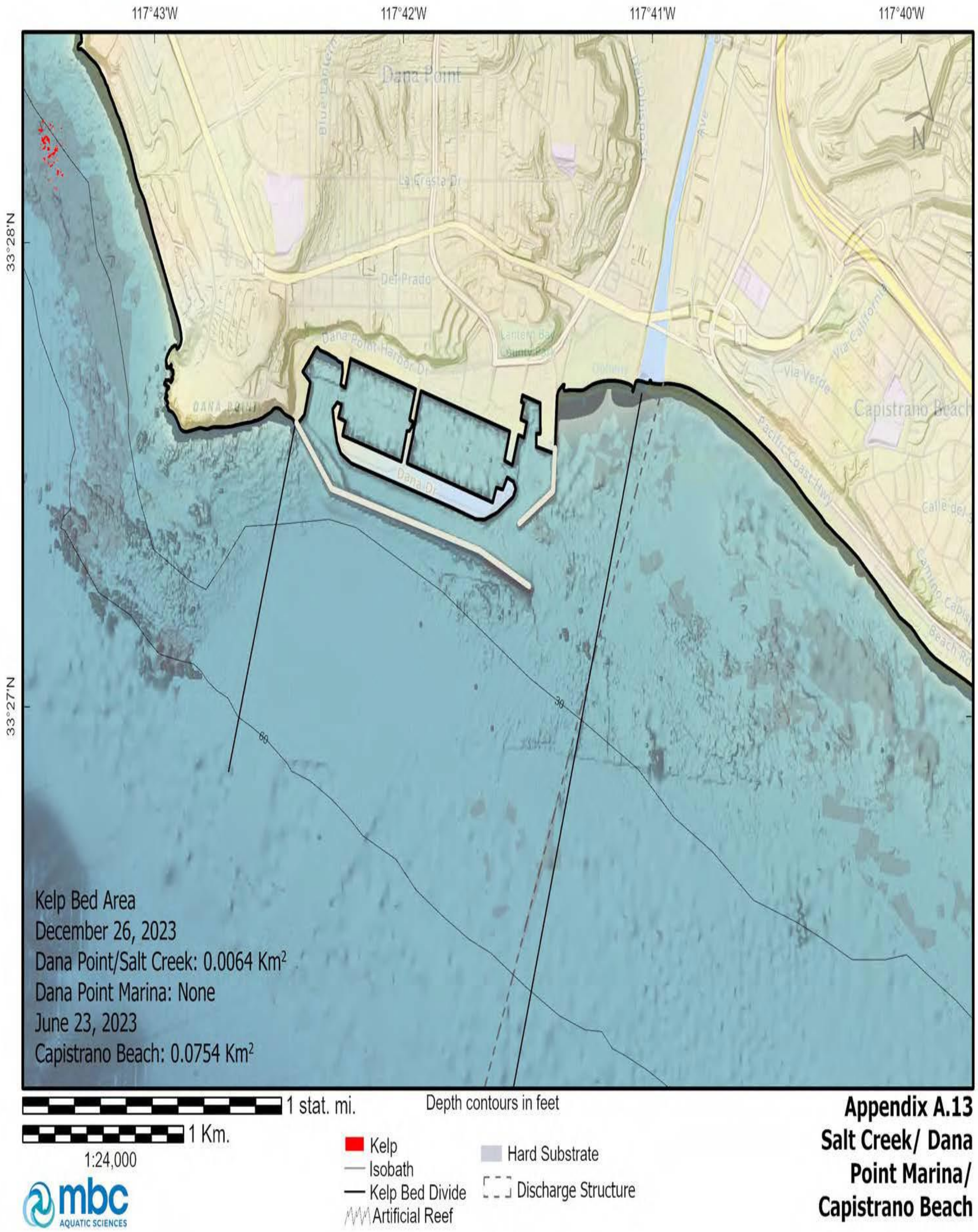
Page A-10


117°46'W
117°45'W
117°44'W
117°43'W
33°31'N
33°30'N
33°29'N
Kelp Bed Area
December 26, 2023
South Laguna: 0.0232 Km²
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.11
Laguna South
mbc
AQUATIC SCIENCES

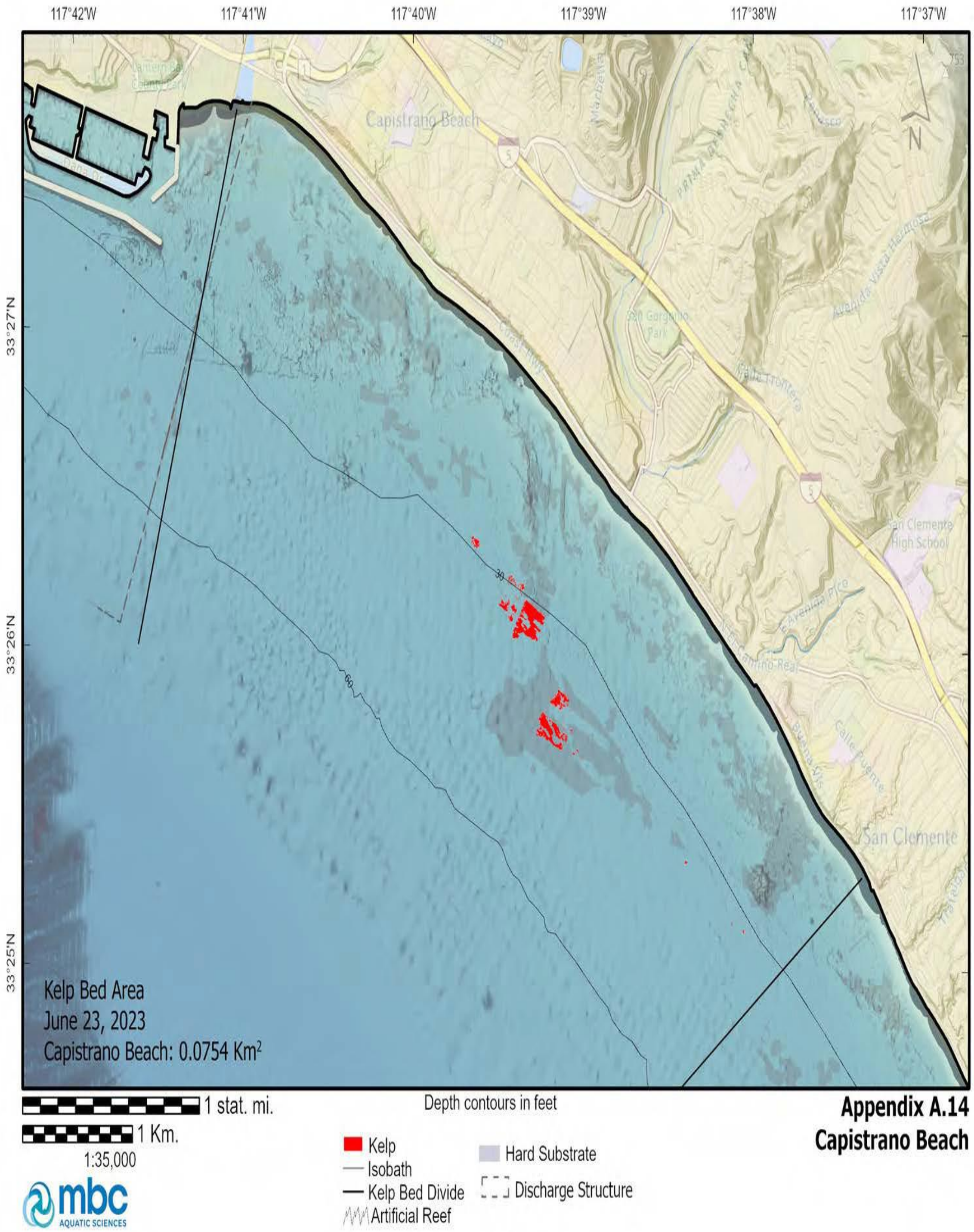
Page A-11


117°45'W
117°44'W
117°43'W
117°42'W
33°29'N
33°28'N
N
Monarch Beach Golf Links
Sea Terrace Community Park
Dana Hills High School
Dana Point
Blue Lantern St
La Cresta Dr
Del Prado
Dana Point Harbor Dr
Dana Dr
Kelp Bed Area
December 26, 2023
Dana Point/Salt Creek: 0.0064 Km²
Dana Point Marina: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.12
Dana Point/Salt Creek
mbc AQUATIC SCIENCES

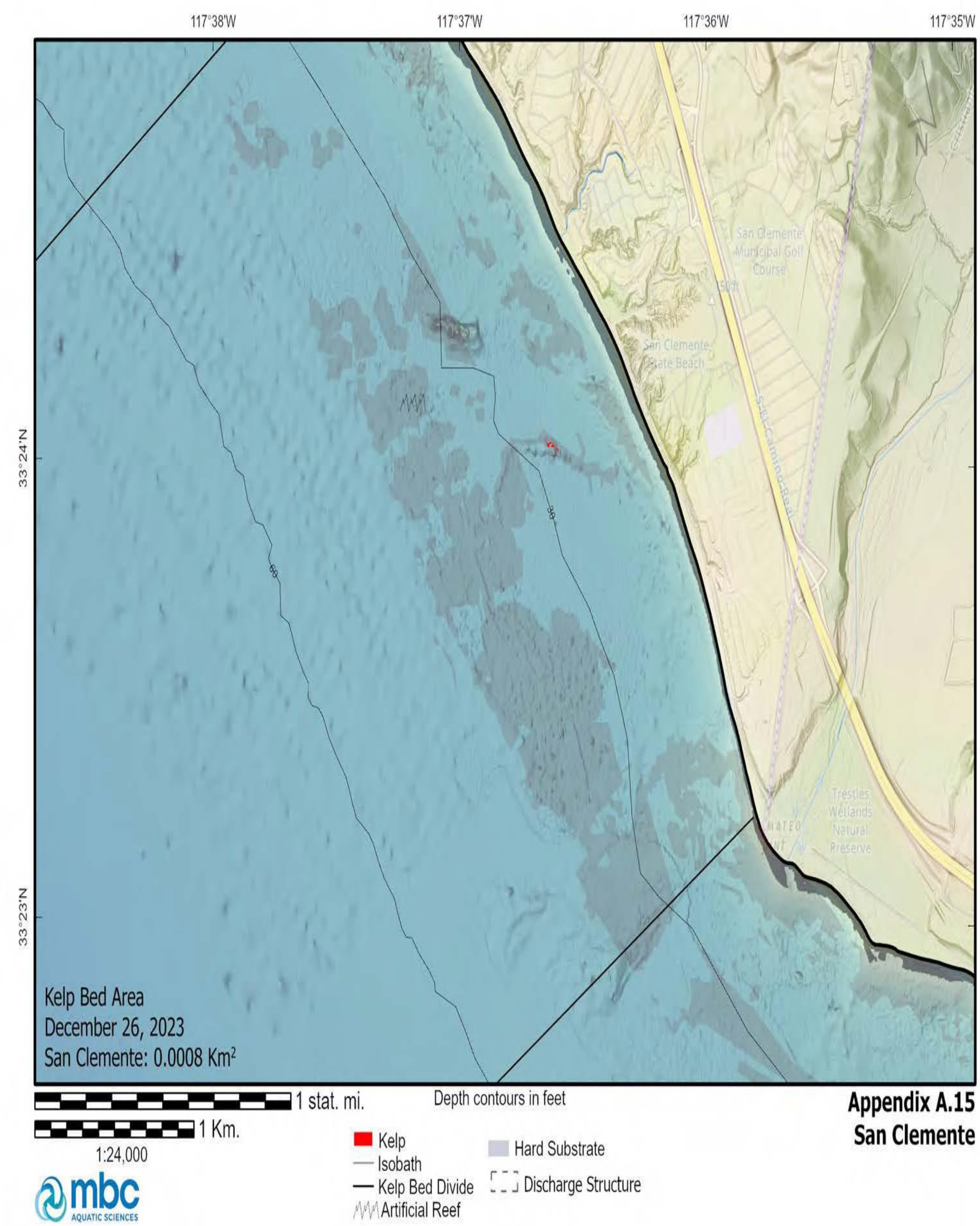
Page A-12


117°43'W
117°42'W
117°41'W
117°40'W
33°28'N
33°27'N
N
Dana Point
La Cresta Dr
Del Prado
Dana Point Harbor Dr
DANA POINT
Dana Dr
Via Verde
Capistrano Beach
Pacific Coast Hwy
30
60
Kelp Bed Area
December 26, 2023
Dana Point/Salt Creek: 0.0064 Km²
Dana Point Marina: None
June 23, 2023
Capistrano Beach: 0.0754 Km²
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.13
Salt Creek/ Dana Point Marina/ Capistrano Beach

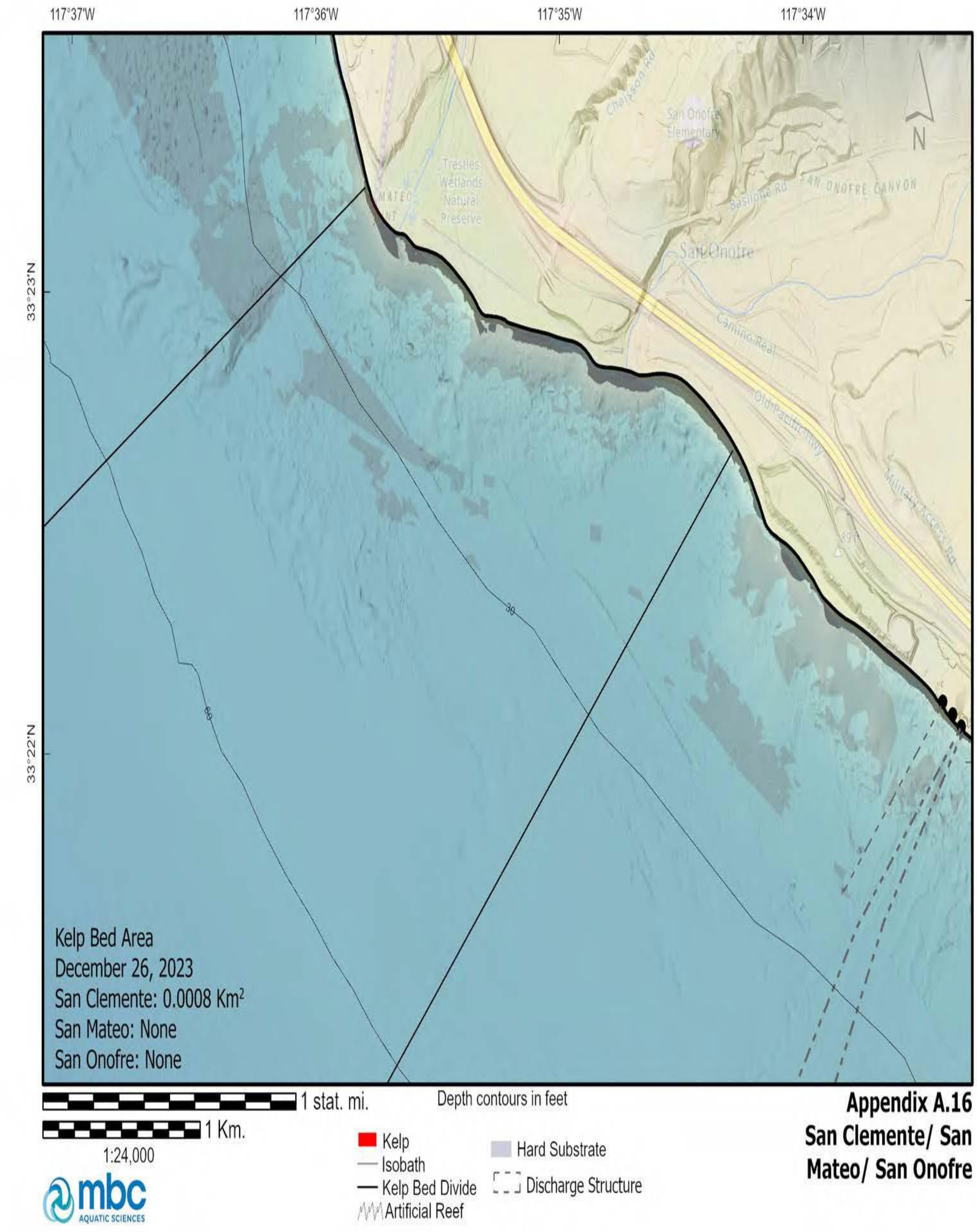
Page A-13


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
N
Capistrano Beach
San Clemente
San Clemente High School
30
60
Kelp Bed Area
June 23, 2023
Capistrano Beach: 0.0754 Km²
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.14
Capistrano Beach

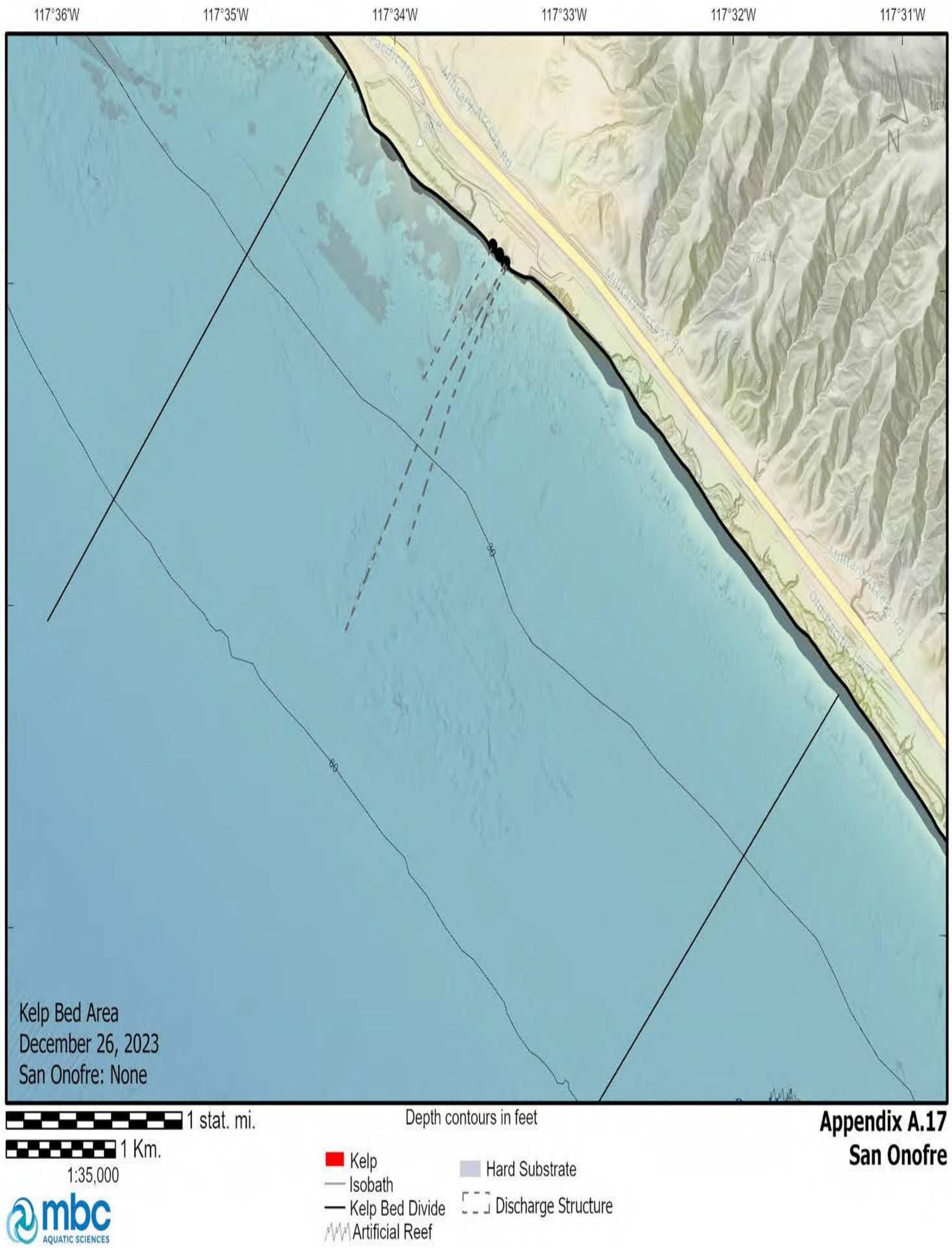
Page A-14


117°38'W
117°37'W
117°36'W
117°35'W
33°24'N
33°23'N
San Clemente Municipal Golf Course
San Clemente State Beach
Trestles Wetlands Natural Preserve
Kelp Bed Area
December 26, 2023
San Clemente: 0.0008 Km²
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.15
San Clemente

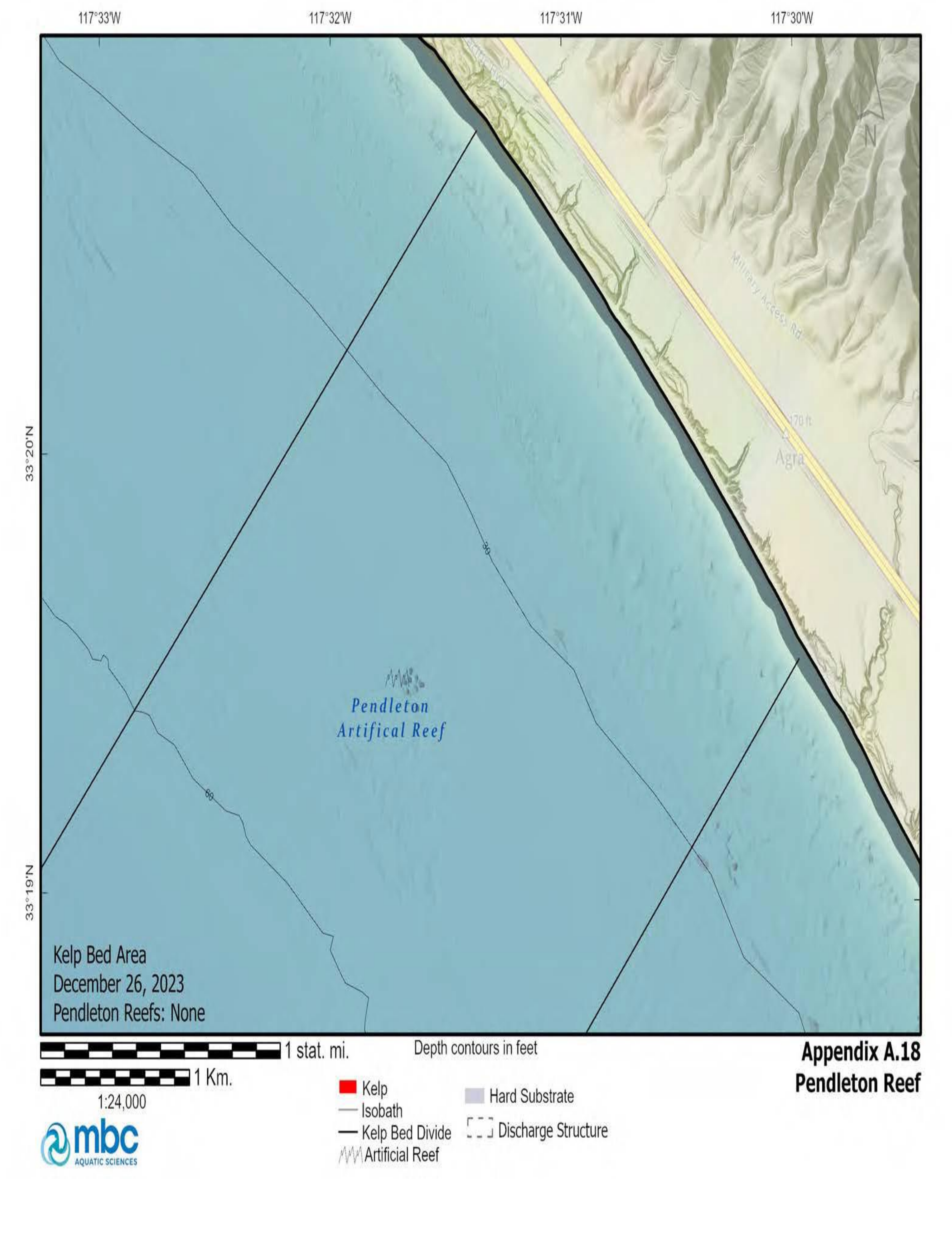
Page A-15


117°37'W
117°36'W
117°35'W
117°34'W
33°23'N
33°22'N
San Onofre
Trestles Wetlands Natural Preserve
Basilone Rd
SAN ONOFRE CANYON
Camino Real
Old Pacific Hwy
Military Access Rd
N
30
60
Kelp Bed Area
December 26, 2023
San Clemente: 0.0008 Km²
San Mateo: None
San Onofre: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.16
San Clemente/ San Mateo/ San Onofre

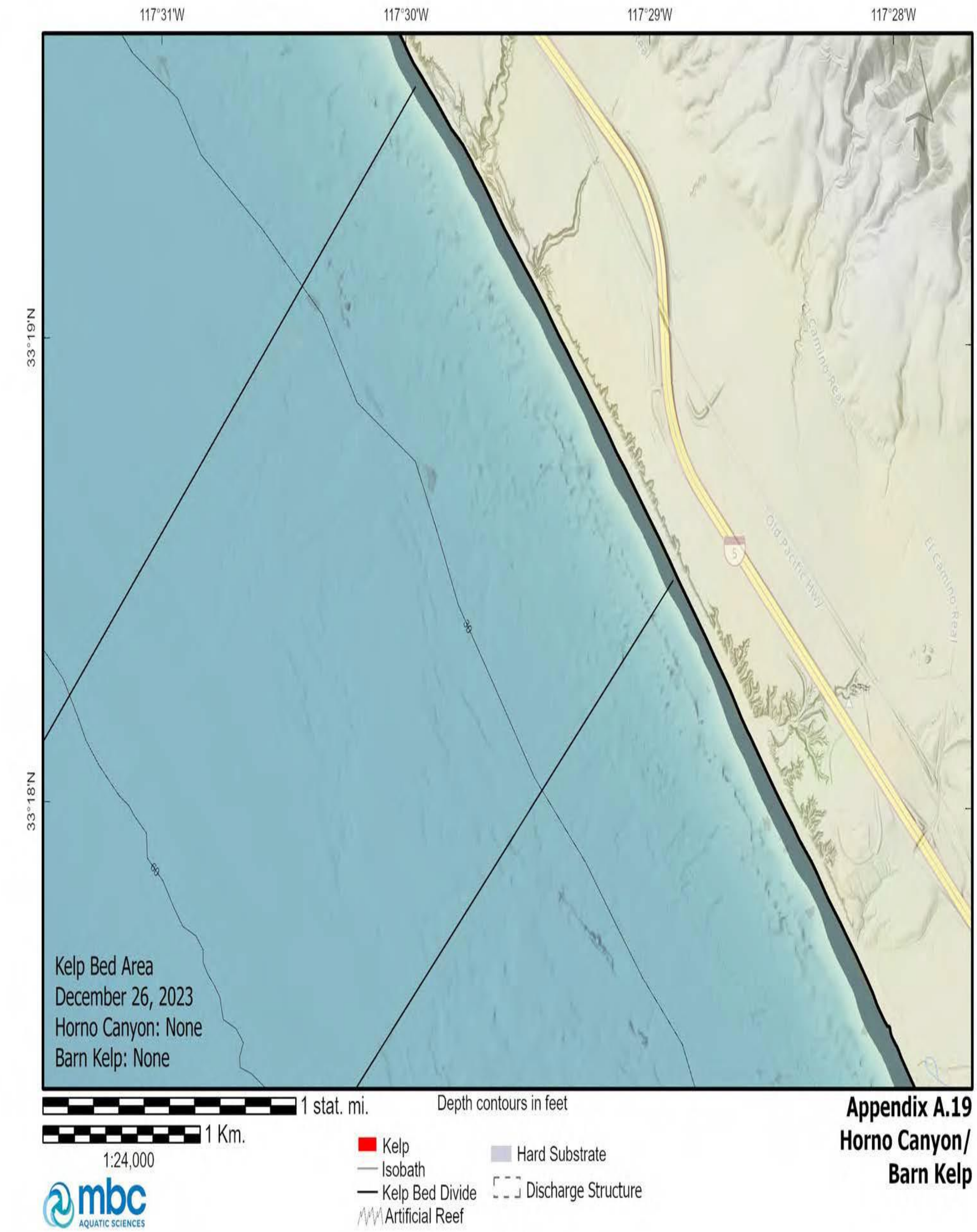
Page A-16


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
Kelp Bed Area
December 26, 2023
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.17
San Onofre
mbc
AQUATIC SCIENCES

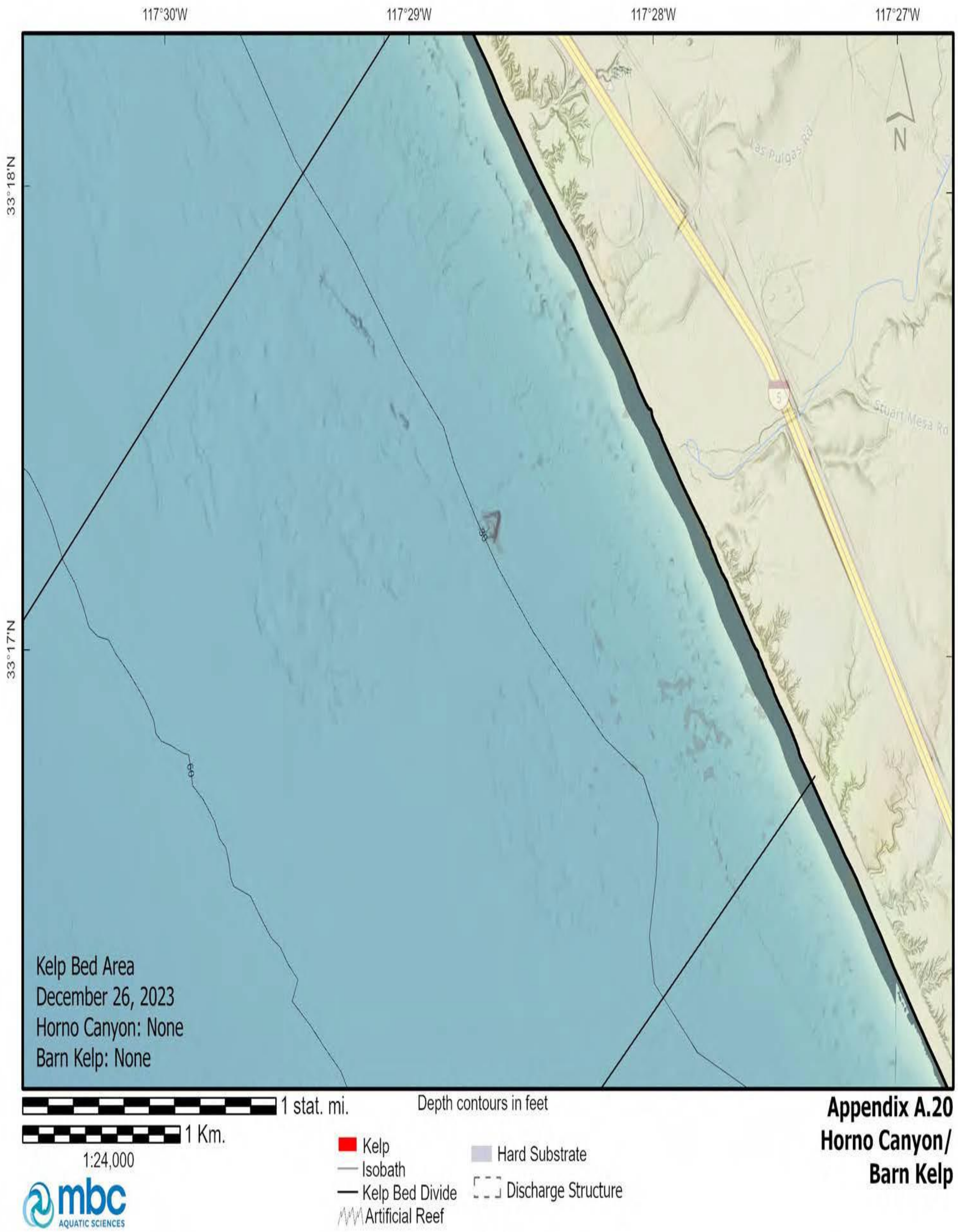
Page A-17


117°33'W
117°32'W
117°31'W
117°30'W
33°20'N
33°19'N
N
Military Access Rd
Pendleton Artifical Reef
30
60
Kelp Bed Area
December 26, 2023
Pendleton Reefs: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.18
Pendleton Reef
mbc
AQUATIC SCIENCES

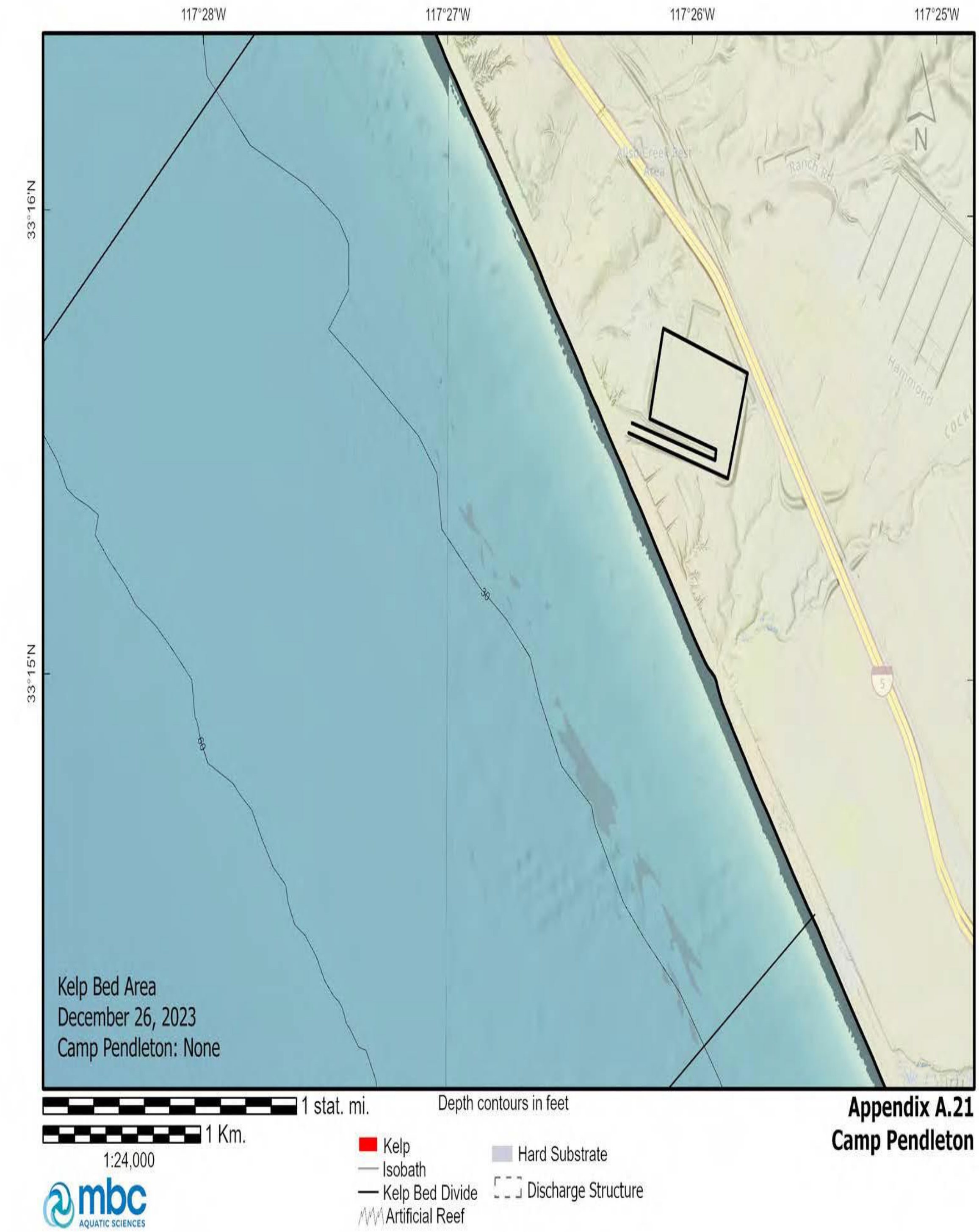
Page A-18


117°31'W
117°30'W
117°29'W
117°28'W
33°19'N
33°18'N
Camino Real
Old Pacific Hwy
El Camino Real
5
Kelp Bed Area
December 26, 2023
Horno Canyon: None
Barn Kelp: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.19
Horno Canyon/
Barn Kelp
mbc
AQUATIC SCIENCES

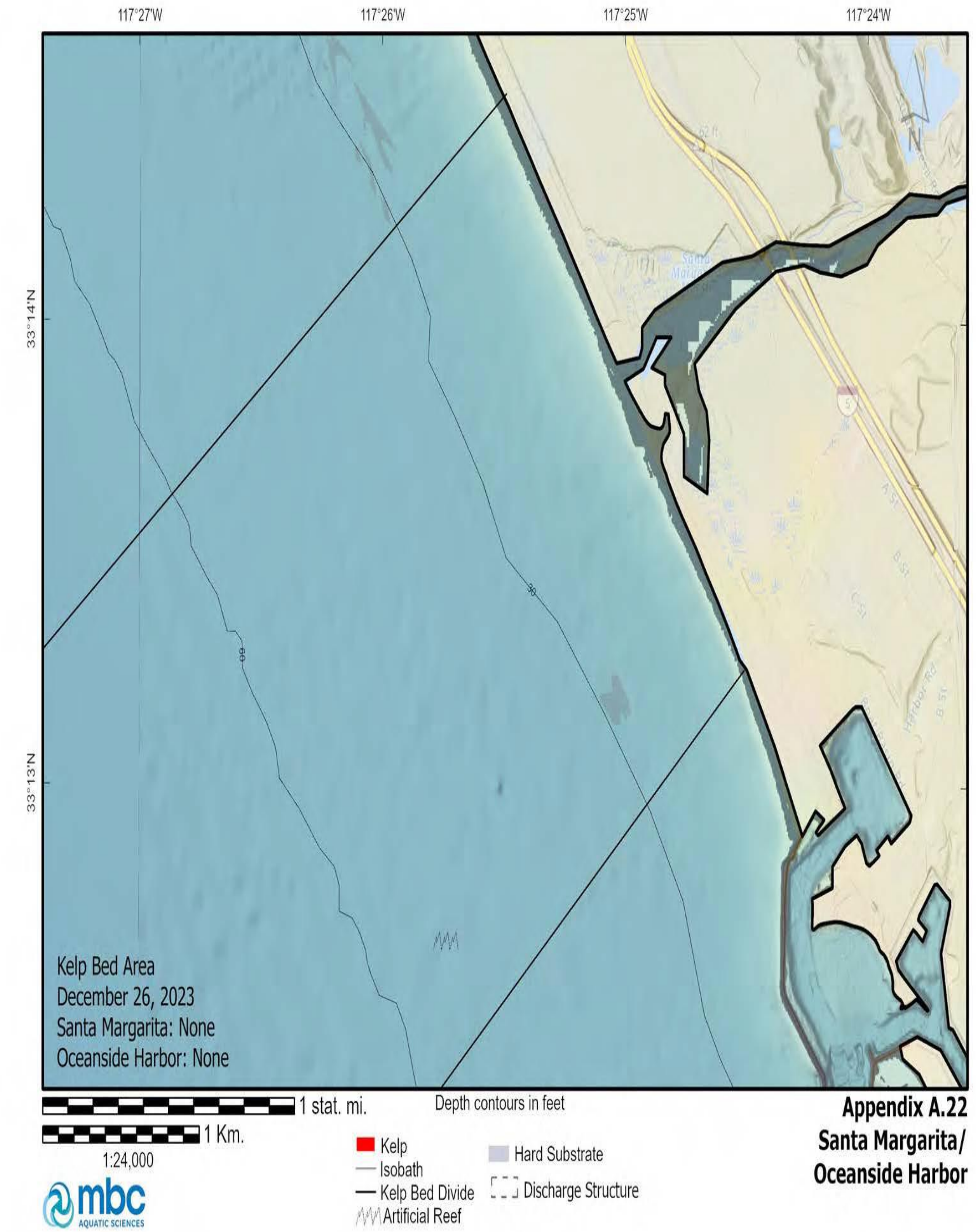
Page A-19


117°30'W
117°29'W
117°28'W
117°27'W
33°18'N
33°17'N
N
Las Pulgas Rd
Stuart Mesa Rd
5
60
Kelp Bed Area
December 26, 2023
Horno Canyon: None
Barn Kelp: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.20
Horno Canyon/
Barn Kelp

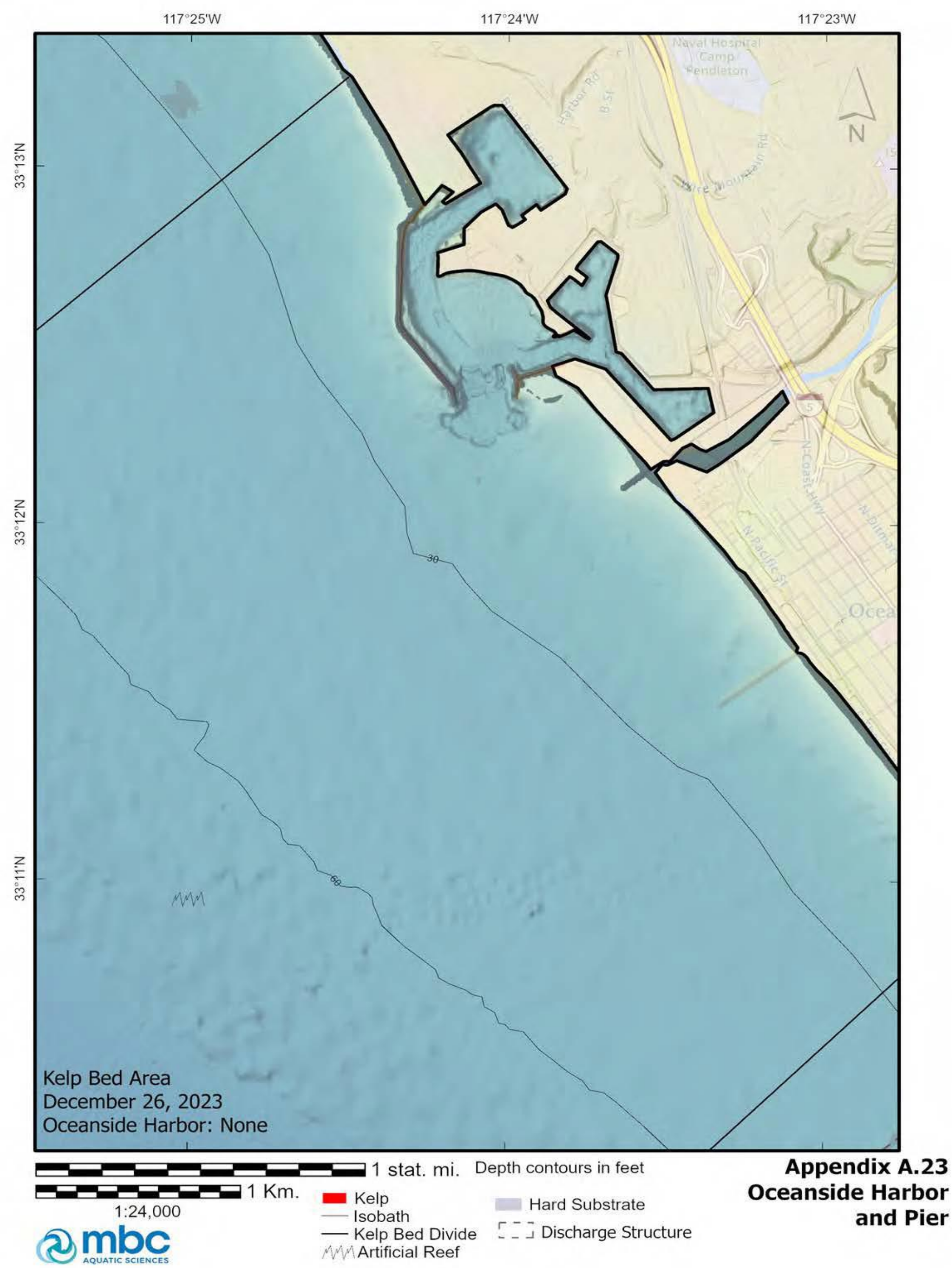
Page A-20


117°28'W
117°27'W
117°26'W
117°25'W
33°16'N
33°15'N
N
Kelp Bed Area
December 26, 2023
Camp Pendleton: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.21
Camp Pendleton
mbc
AQUATIC SCIENCES

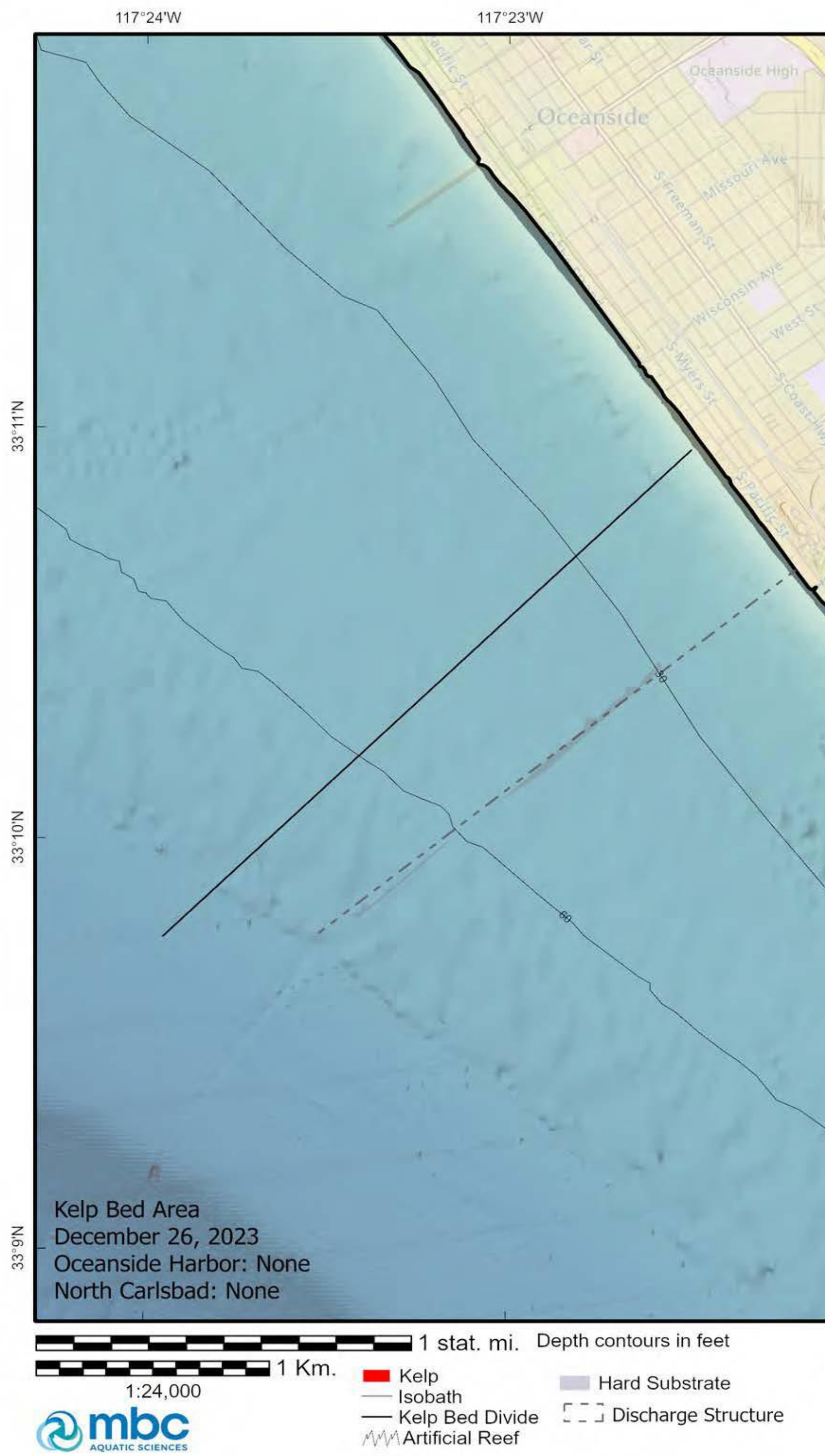
Page A-21


117°27'W
117°26'W
117°25'W
117°24'W
33°14'N
33°13'N
60
30
Kelp Bed Area
December 26, 2023
Santa Margarita: None
Oceanside Harbor: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.22
Santa Margarita/
Oceanside Harbor
mbc
AQUATIC SCIENCES

Page A-22

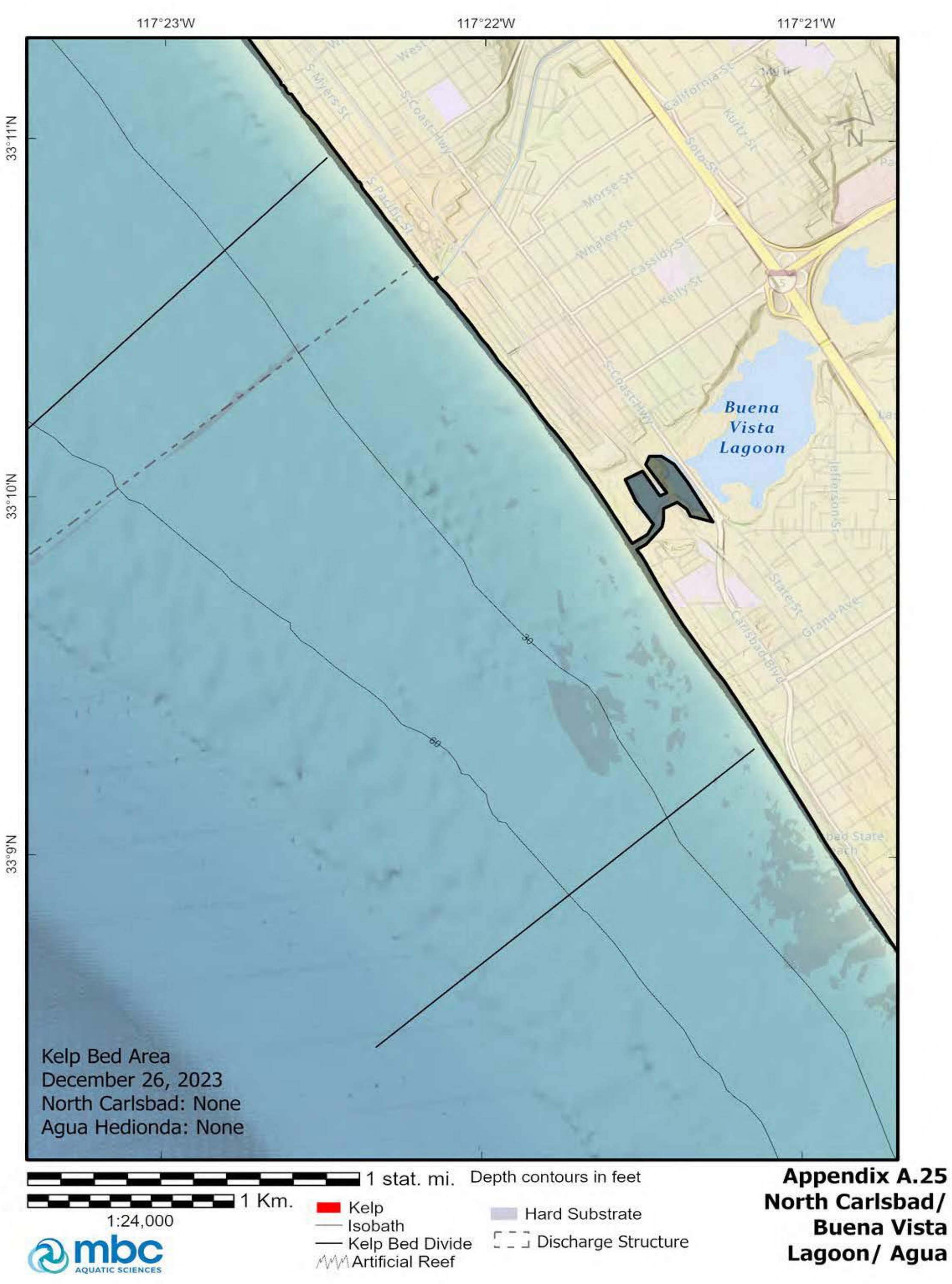

117°25'W
117°24'W
117°23'W
33°13'N
33°12'N
33°11'N
N
Naval Hospital Camp Pendleton
Harbor Rd
B St
Vandegrift Blvd
Fire Mountain Rd
N Coast Hwy
N Pacific St
Ocea
30
60
Kelp Bed Area
December 26, 2023
Oceanside Harbor: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.23
Oceanside Harbor
and Pier
mbc
AQUATIC SCIENCES

Page A-23

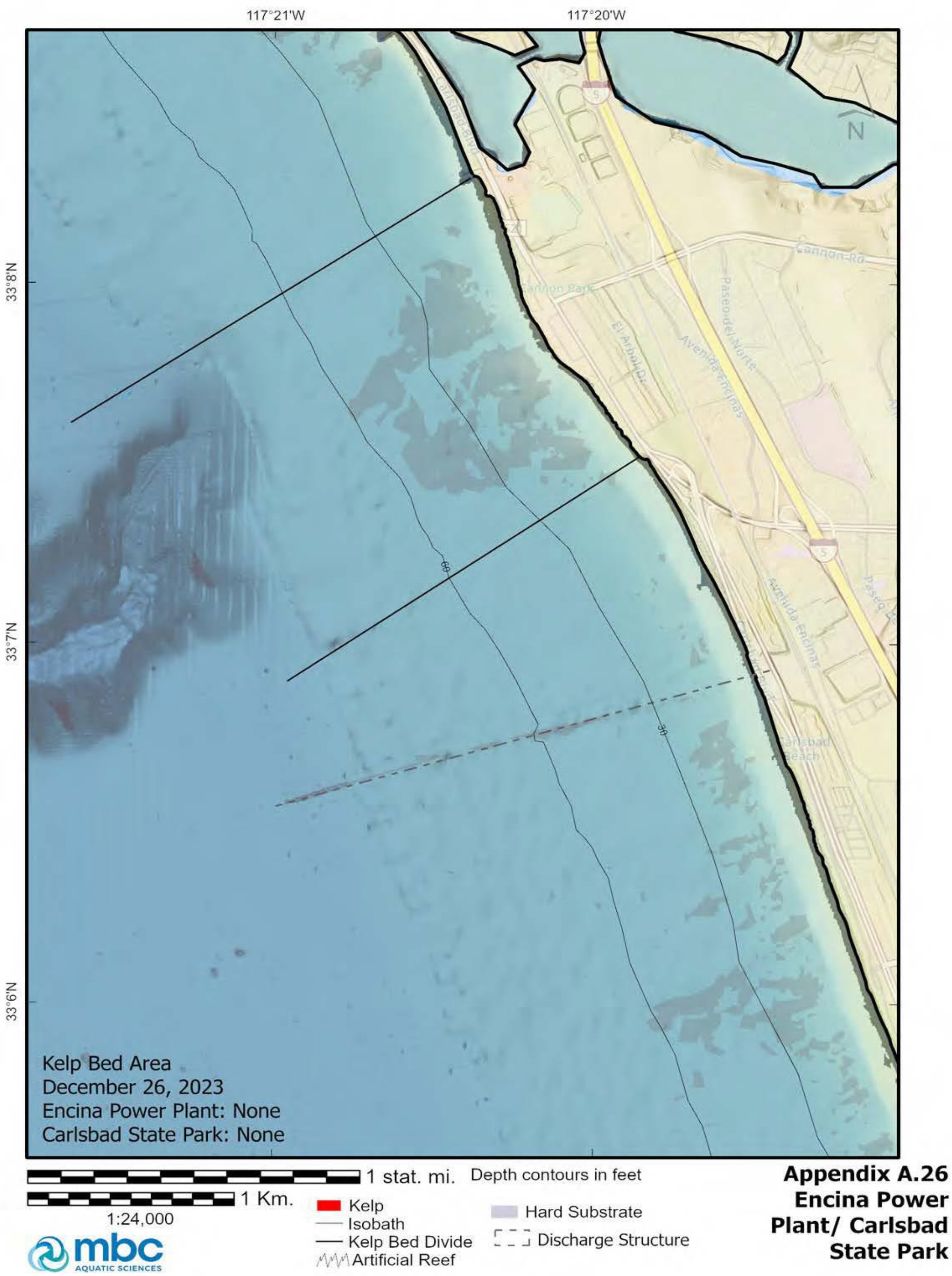


Appendix A.24 Oceanside Harbor/ Pier/ North Carlsbad

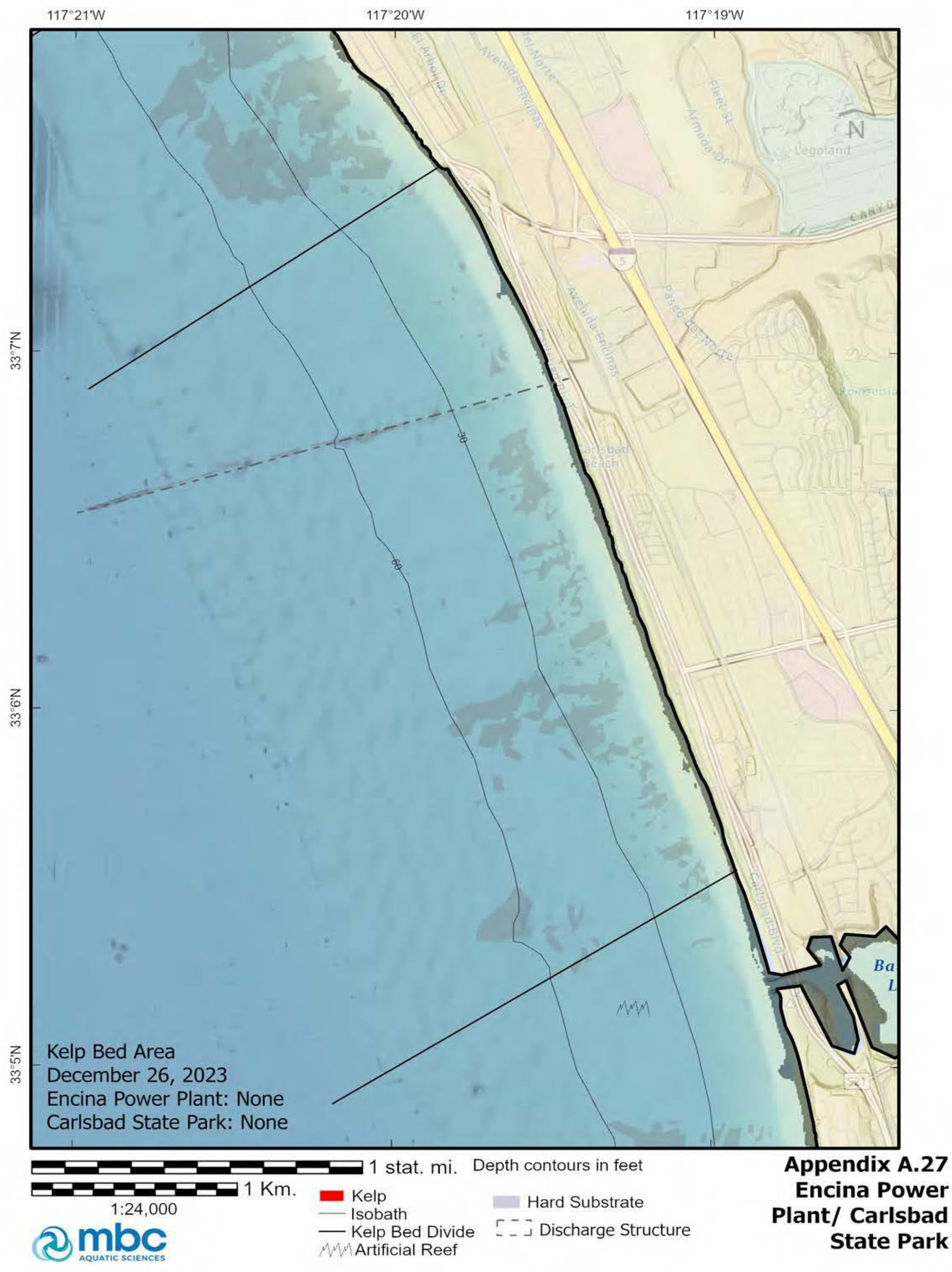
Page A-24


117°23'W
117°22'W
117°21'W
33°11'N
33°10'N
33°9'N
Buena Vista Lagoon
30
60
Kelp Bed Area
December 26, 2023
North Carlsbad: None
Agua Hedionda: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.25
North Carlsbad/
Buena Vista
Lagoon/ Agua

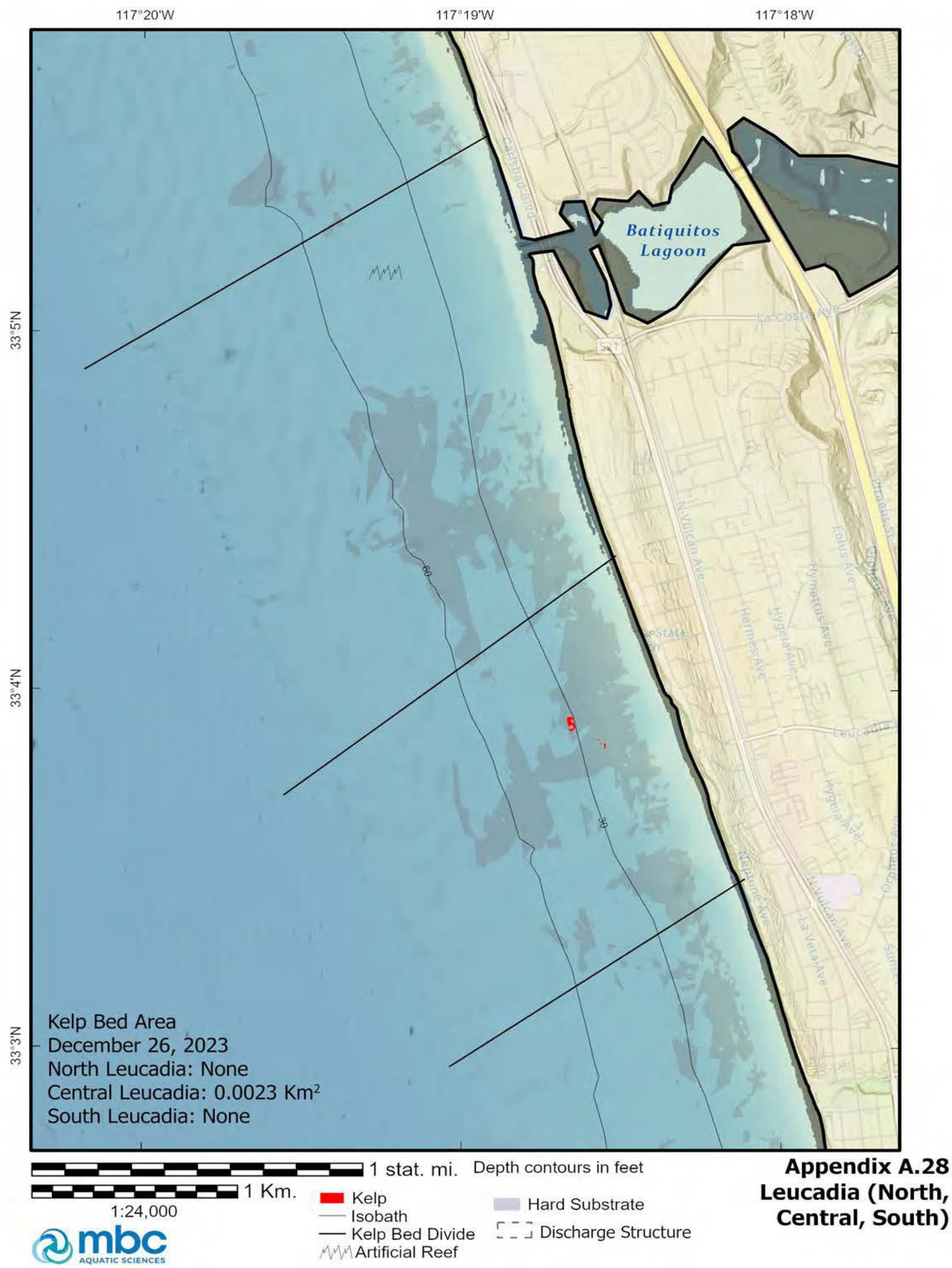
Page A-25


117°21'W
117°20'W
33°8'N
33°7'N
33°6'N
N
Cannon Rd
Paseo del Norte
Avenida Encinas
El Arbol Dr
Carlsbad Beach
60
30
Kelp Bed Area
December 26, 2023
Encina Power Plant: None
Carlsbad State Park: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.26
Encina Power Plant/ Carlsbad State Park

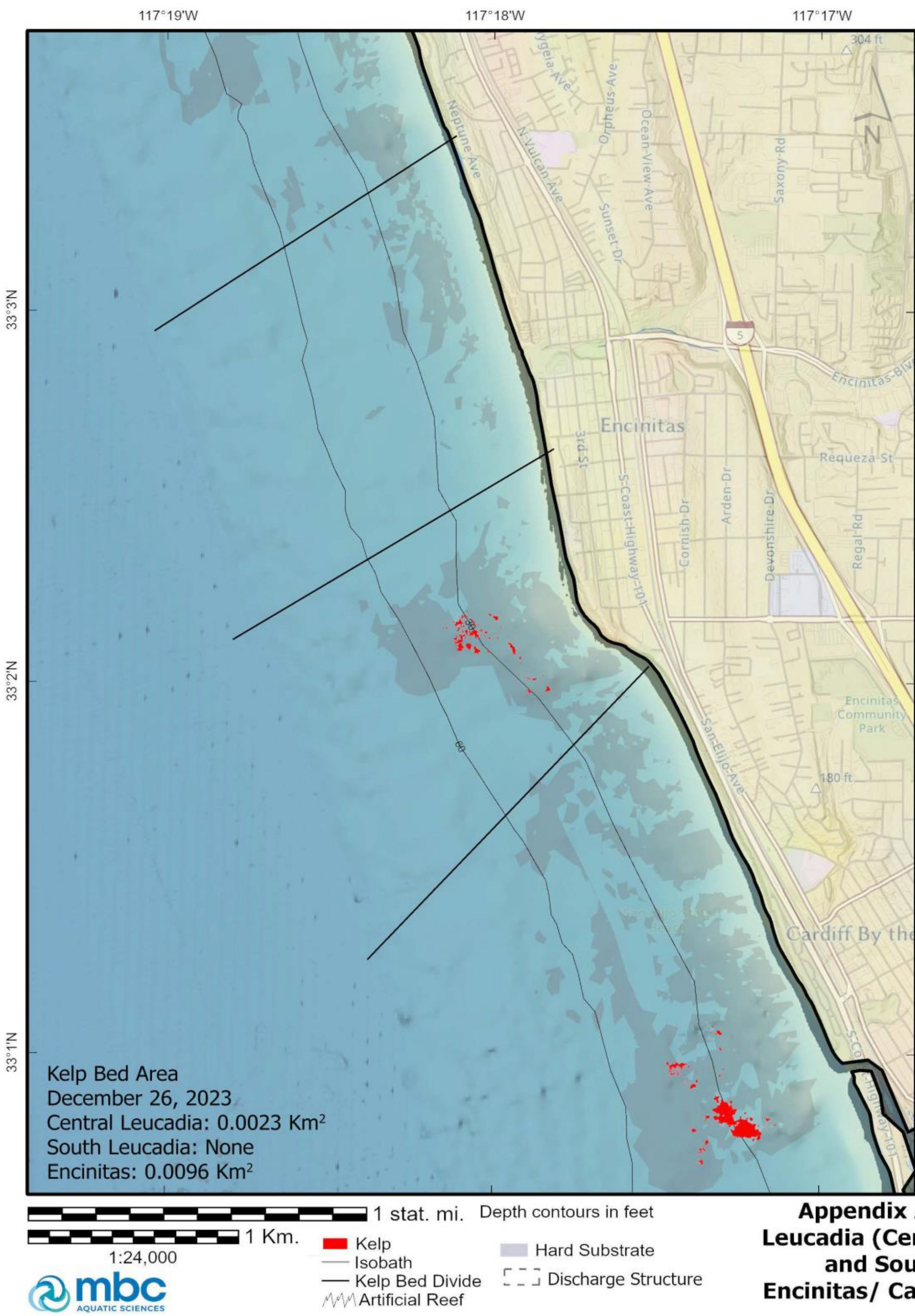
Page A-26


117°21'W
117°20'W
117°19'W
33°7'N
33°6'N
33°5'N
Kelp Bed Area
December 26, 2023
Encina Power Plant: None
Carlsbad State Park: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.27
Encina Power Plant/ Carlsbad State Park

Page A-27

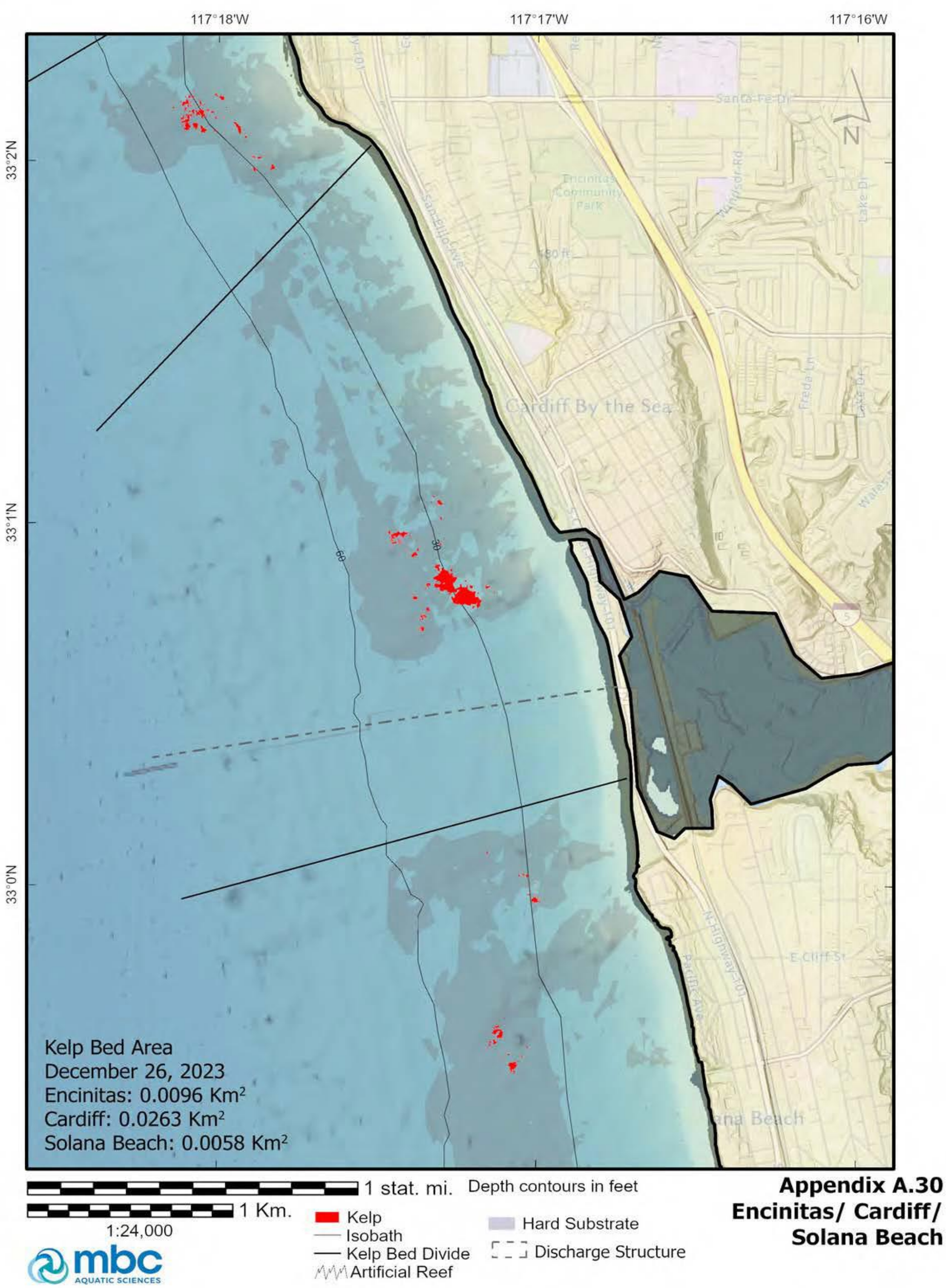

117°20'W
117°19'W
117°18'W
33°5'N
33°4'N
33°3'N
Batiquitos Lagoon
Carlsbad Blvd
La Costa Ave
N Vulcan Ave
Neptune Ave
Hermes Ave
Hygeia Ave
Hymettus Ave
Eolus Ave
Leucadia
La Veta Ave
60
30
Kelp Bed Area
December 26, 2023
North Leucadia: None
Central Leucadia: 0.0023 Km²
South Leucadia: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
mbc AQUATIC SCIENCES
Appendix A.28
Leucadia (North, Central, South)

Page A-28

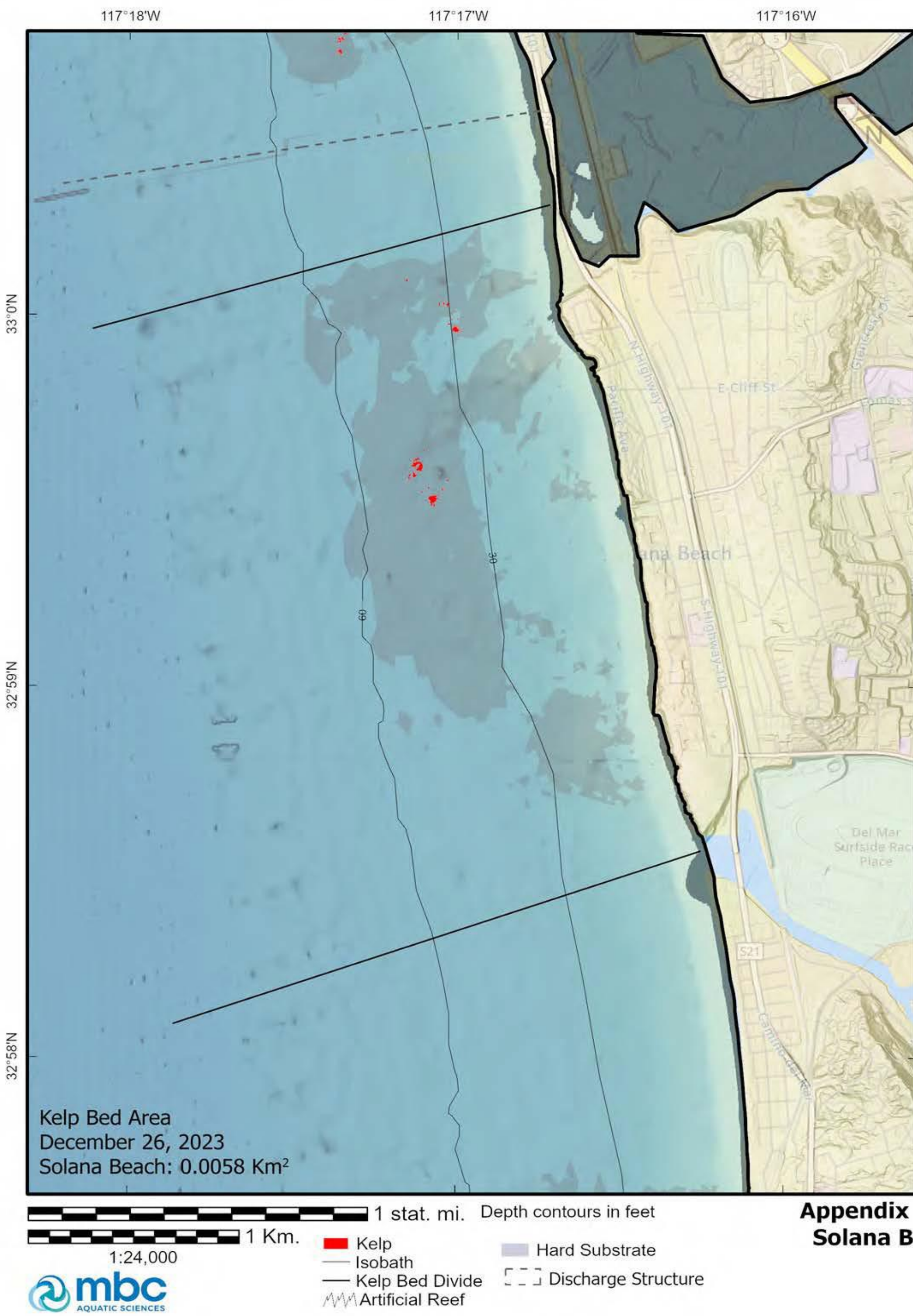


Appendix A.29 Leucadia (Central and South)/ Encinitas/ Cardiff

Page A-29

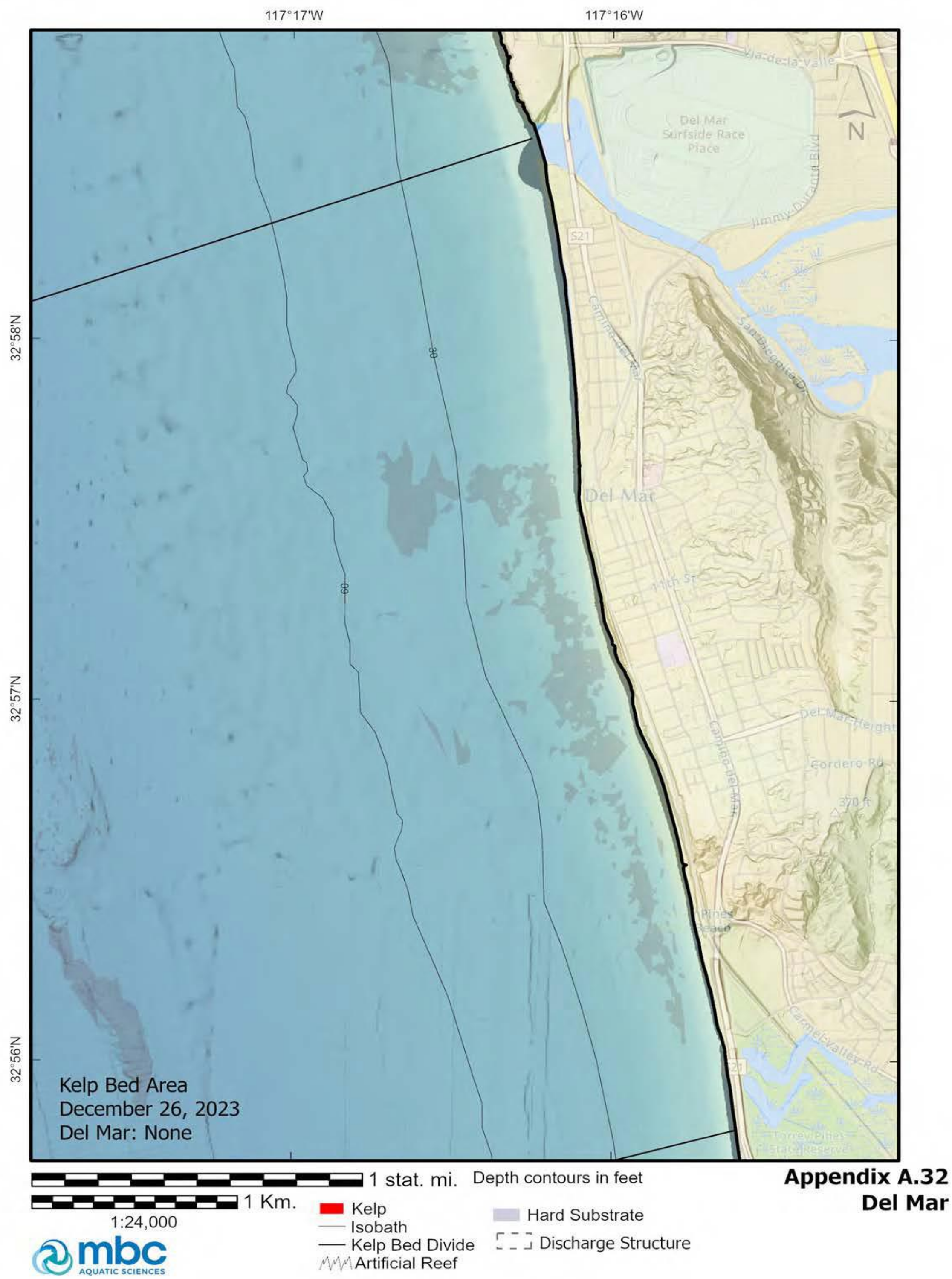

117°18'W
117°17'W
117°16'W
33°2'N
33°1'N
33°0'N
Cardiff By the Sea
Kelp Bed Area
December 26, 2023
Encinitas: 0.0096 Km²
Cardiff: 0.0263 Km²
Solana Beach: 0.0058 Km²
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
mbc
AQUATIC SCIENCES
Appendix A.30
Encinitas/ Cardiff/
Solana Beach

Page A-30

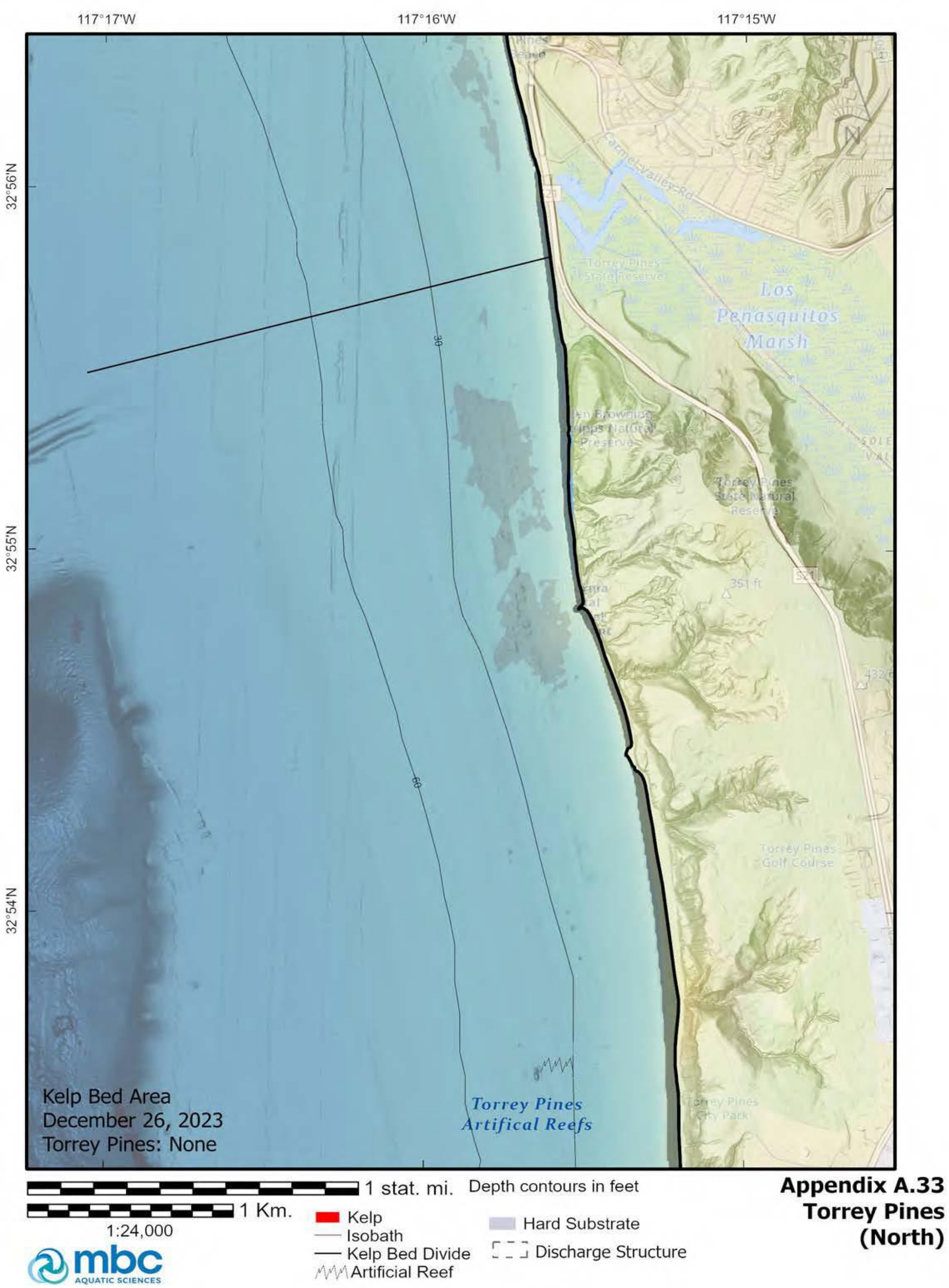


Appendix A.31
Solana Beach

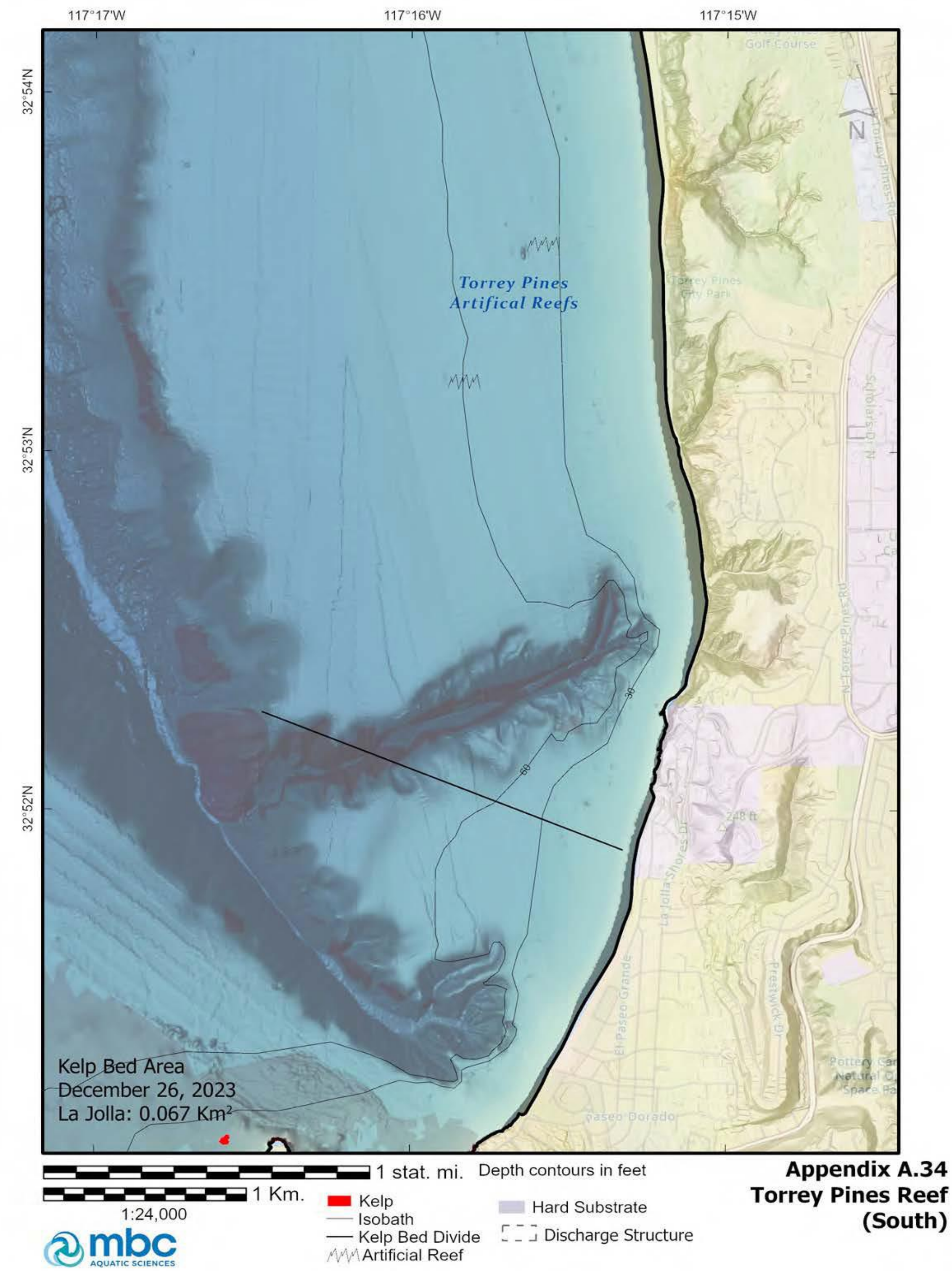
Page A-31


117°17'W
117°16'W
32°58'N
32°57'N
32°56'N
Via-de-la-Valle
Del Mar Surfside Race Place
Jimmy Durante Blvd
N
S21
Camino-del-Mar
San Dieguito Dr
Del Mar
30
60
Del Mar Heights
Cordero Rd
Carmel-Valley-Rd
Torrey Pines State Reserve
Kelp Bed Area
December 26, 2023
Del Mar: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.32
Del Mar

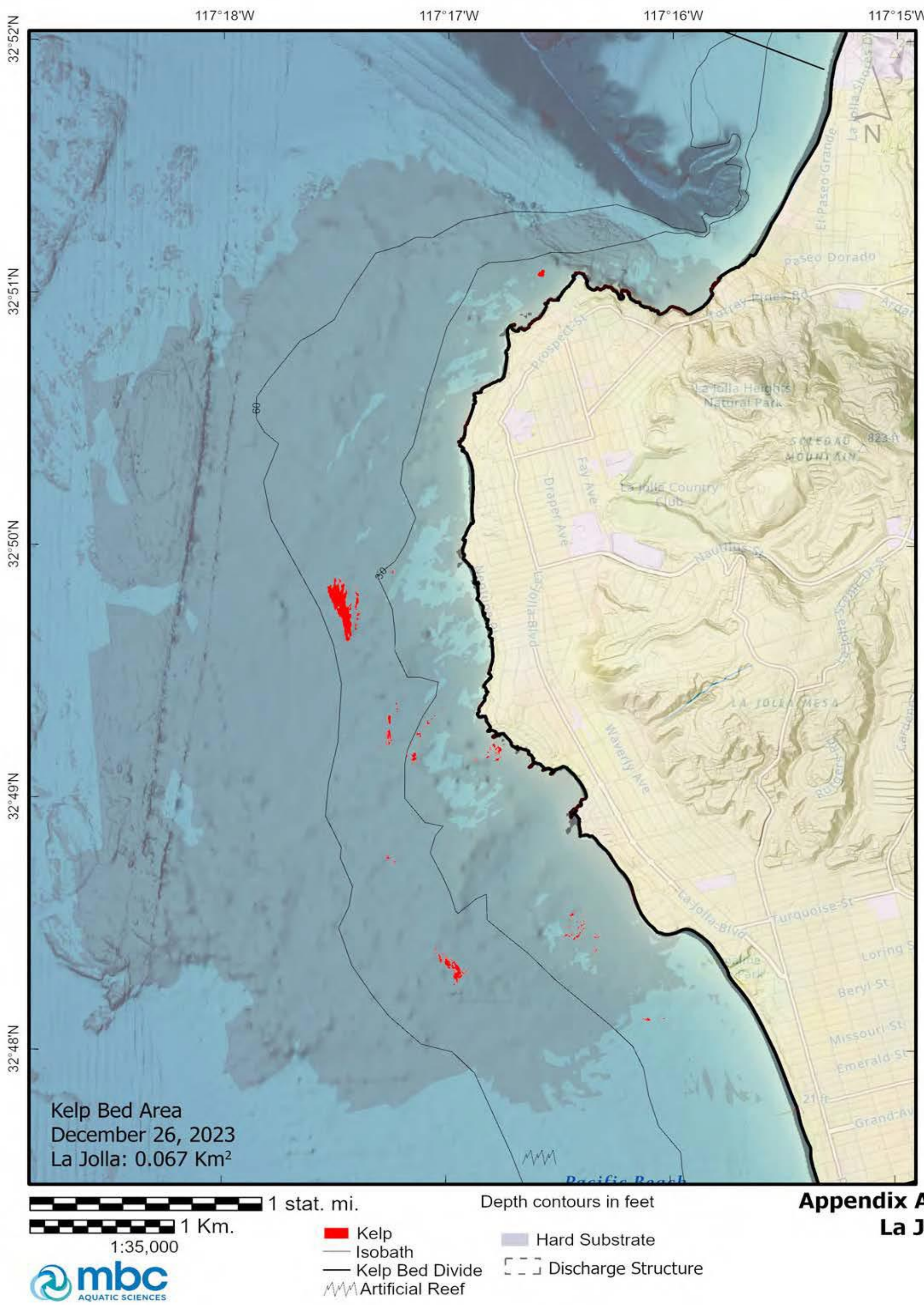
Page A-32


117°17'W
117°16'W
117°15'W
32°56'N
32°55'N
32°54'N
Los Penasquitos Marsh
Torrey Pines State Reserve
Torrey Pines State Natural Reserve
Torrey Pines Golf Course
30
60
Torrey Pines Artifical Reefs
Kelp Bed Area
December 26, 2023
Torrey Pines: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.33
Torrey Pines
(North)

Page A-33

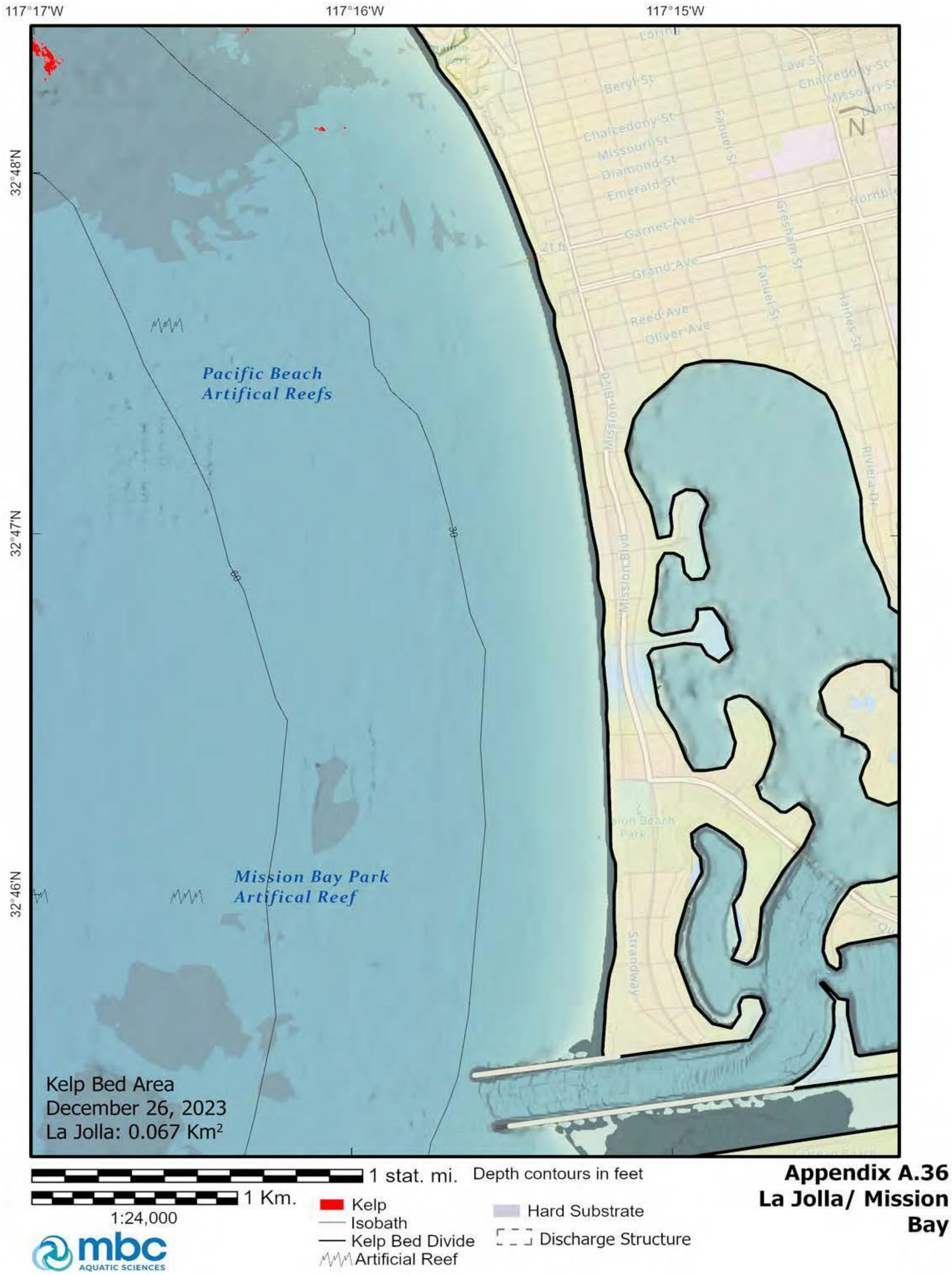

117°17'W
117°16'W
117°15'W
32°54'N
32°53'N
32°52'N
Torrey Pines
Artifical Reefs
Kelp Bed Area
December 26, 2023
La Jolla: 0.067 Km²
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.34
Torrey Pines Reef
(South)

Page A-34



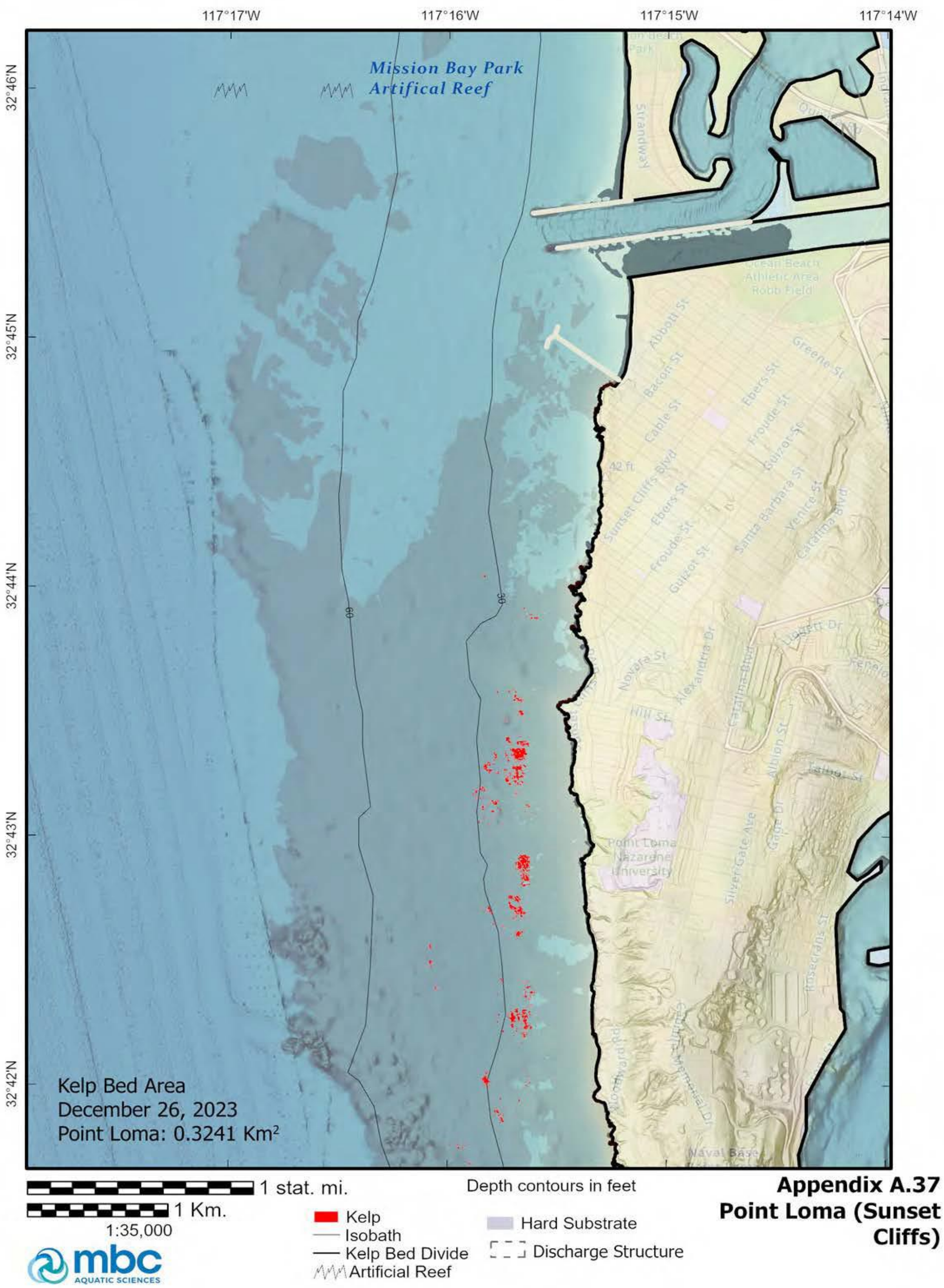
Appendix A.35
La Jolla

Page A-35

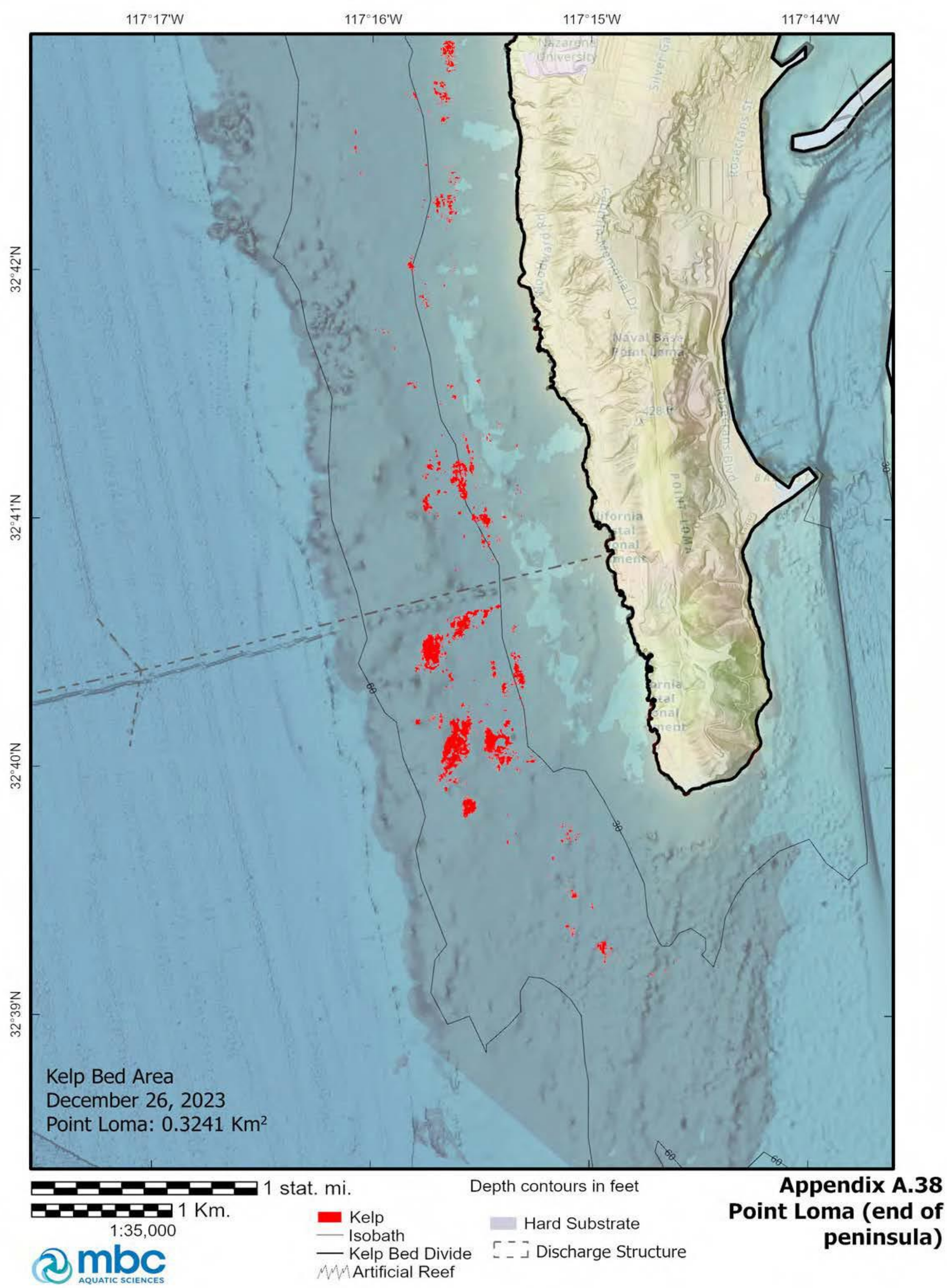


Appendix A.36
La Jolla/ Mission Bay

Page A-36

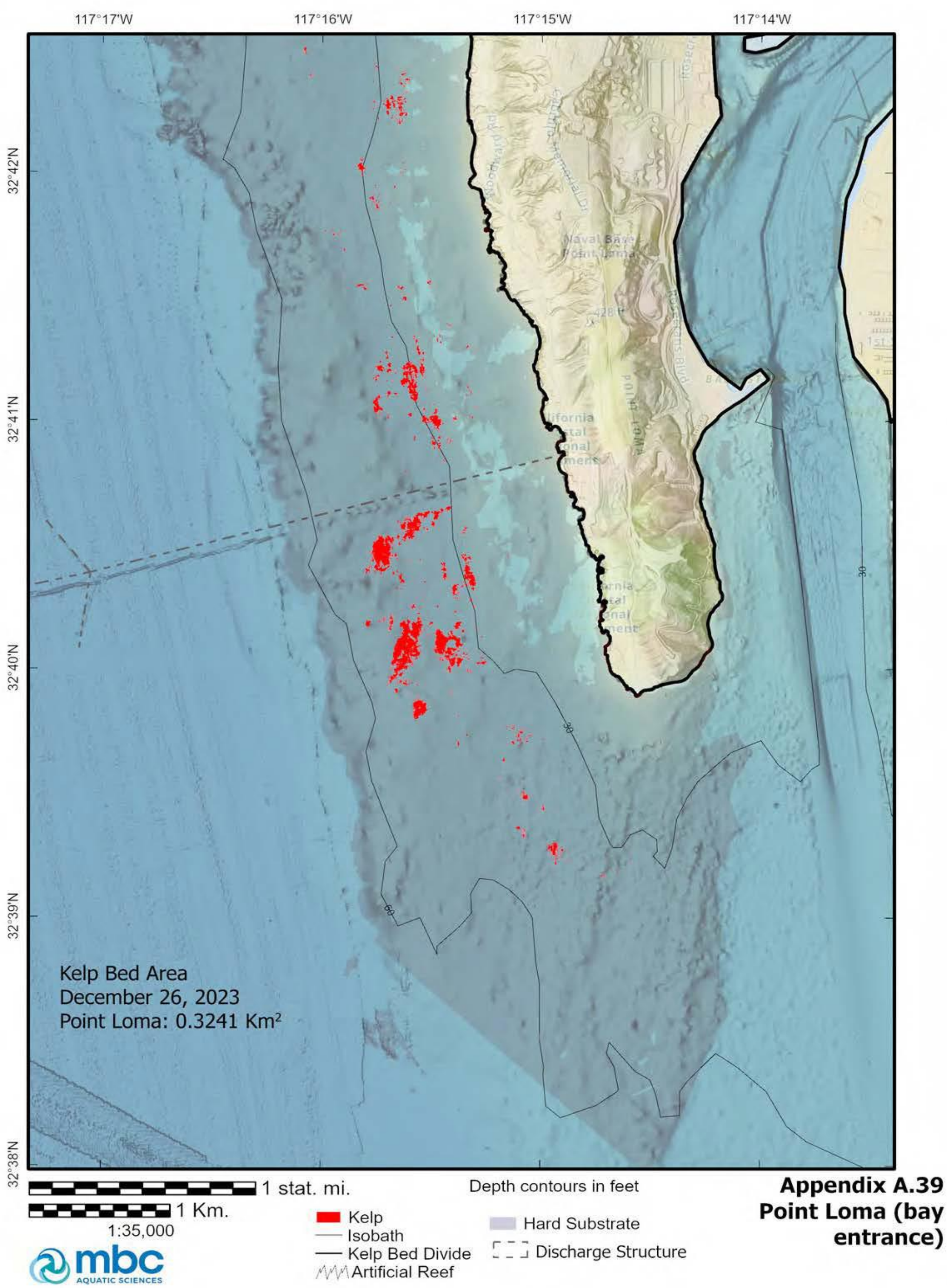

117°17'W
117°16'W
117°15'W
117°14'W
32°46'N
32°45'N
32°44'N
32°43'N
32°42'N
Mission Bay Park
Artifical Reef
Kelp Bed Area
December 26, 2023
Point Loma: 0.3241 Km²
1 stat. mi.
1 Km.
1:35,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.37
Point Loma (Sunset Cliffs)

Page A-37



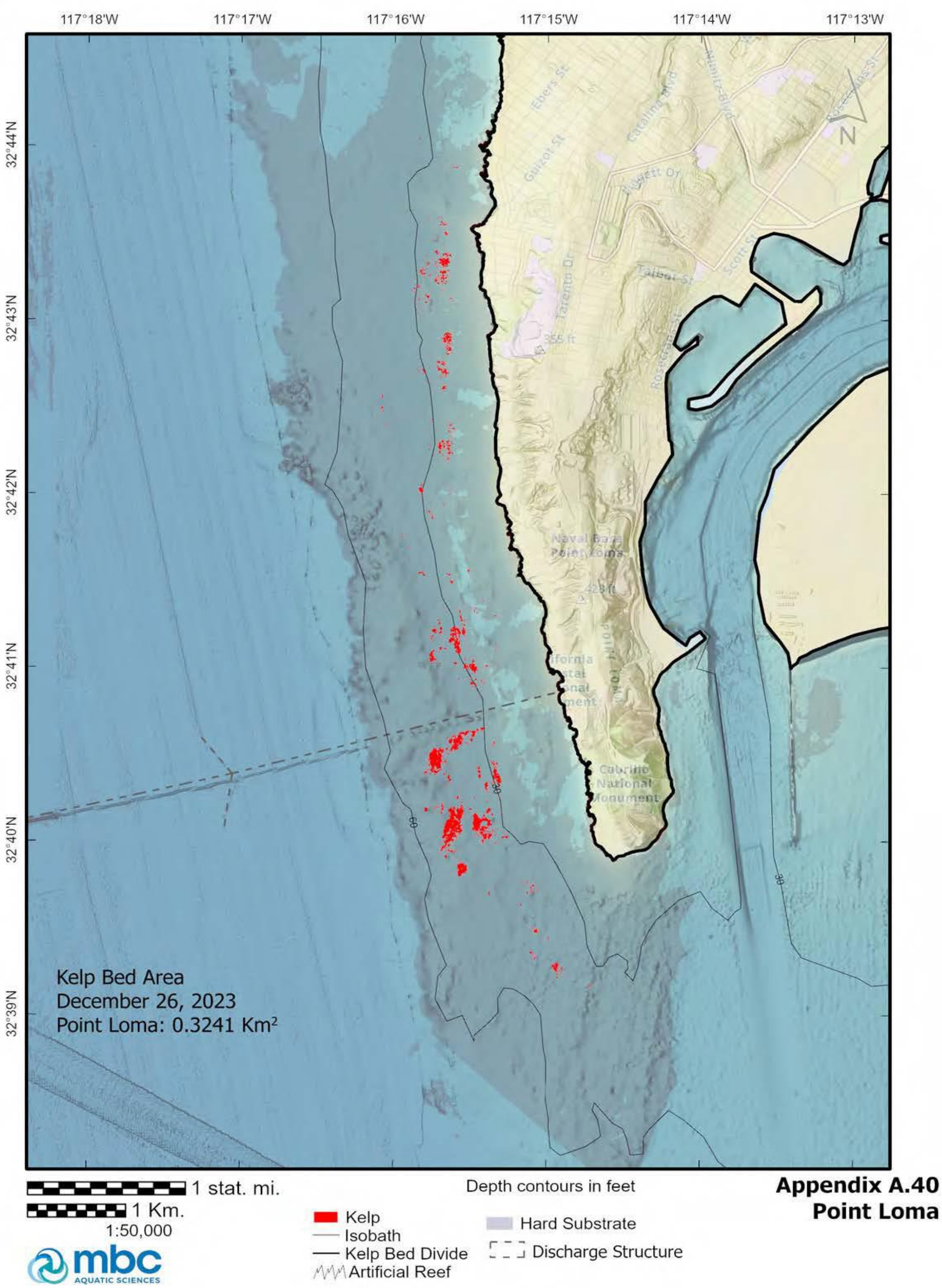
Appendix A.38
Point Loma (end of peninsula)

Page A-38

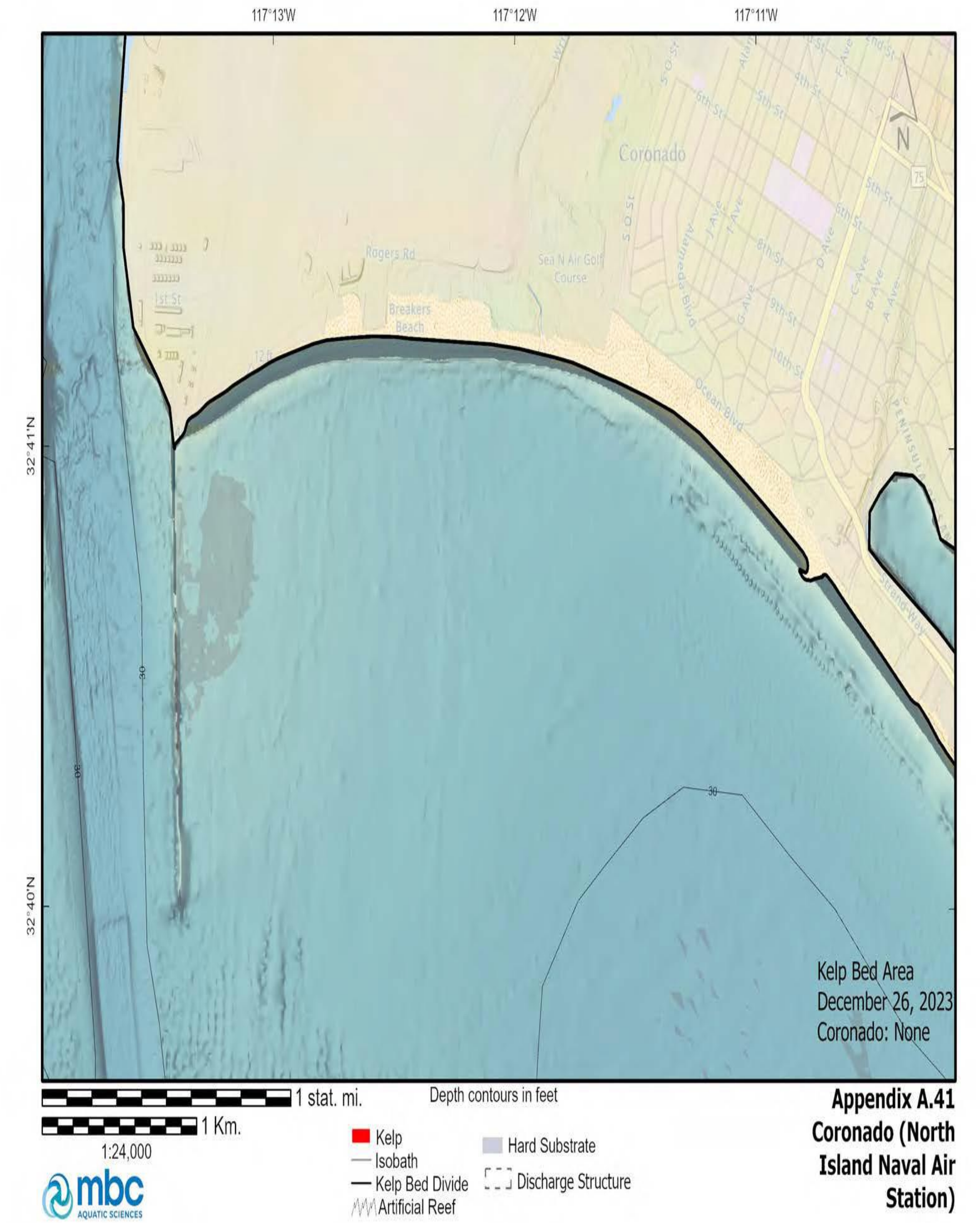


Appendix A.39 Point Loma (bay entrance)

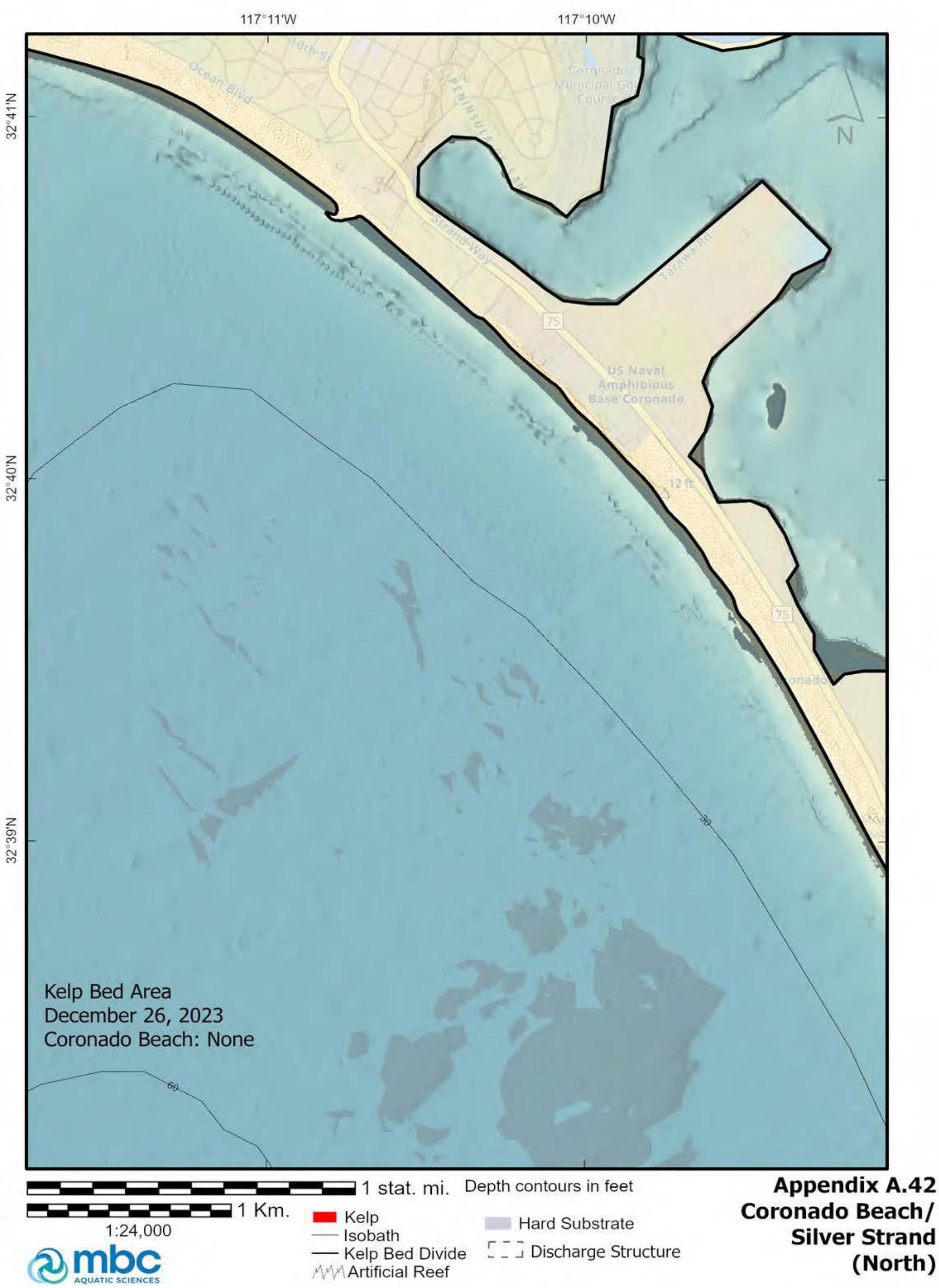
Page A-39


117°18'W
117°17'W
117°16'W
117°15'W
117°14'W
117°13'W
32°44'N
32°43'N
32°42'N
32°41'N
32°40'N
32°39'N
Kelp Bed Area
December 26, 2023
Point Loma: 0.3241 Km²
1 stat. mi.
1 Km.
1:50,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.40
Point Loma

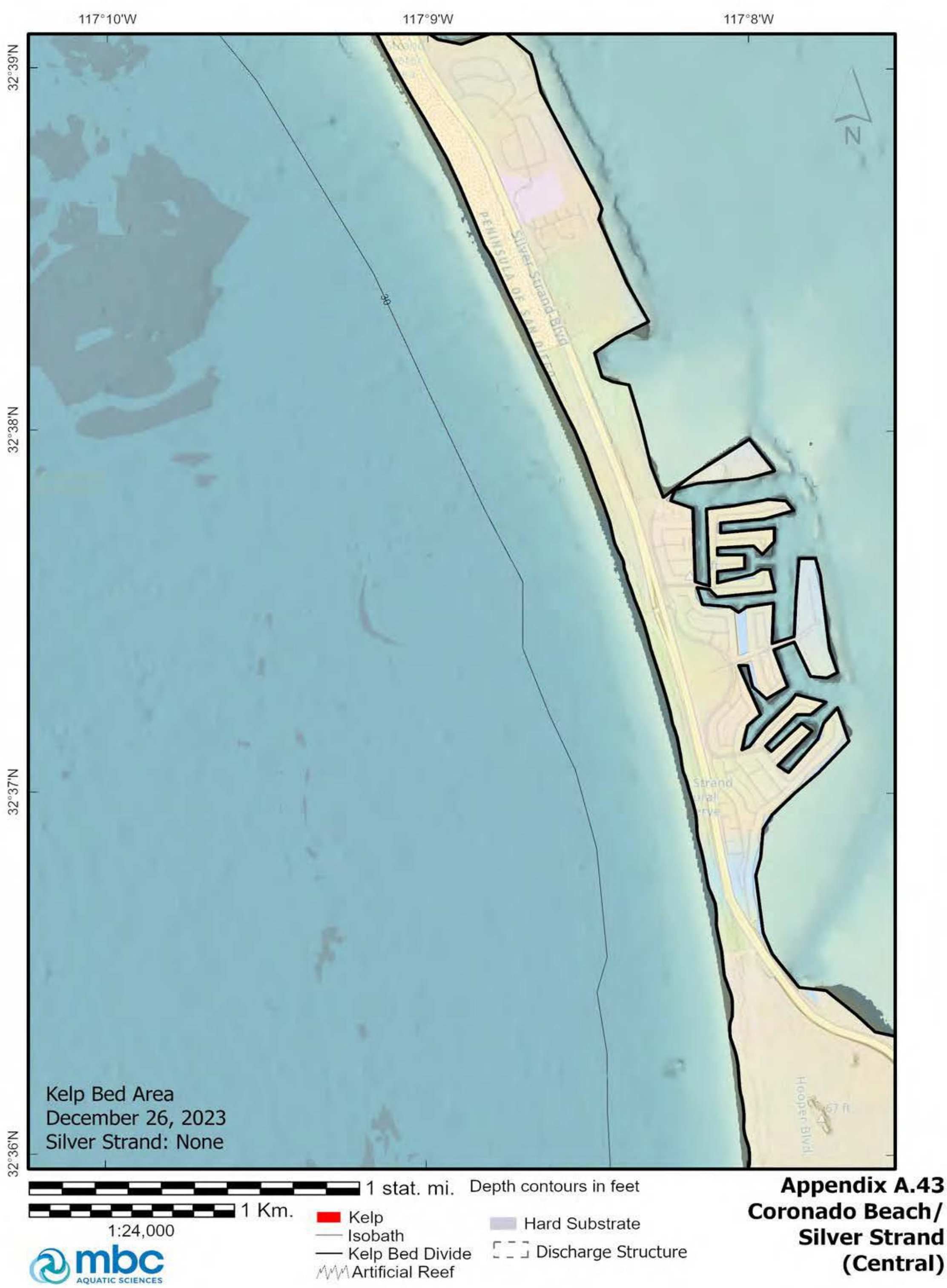
Page A-40


117°13'W
117°12'W
117°11'W
32°41'N
32°40'N
Coronado
Rogers Rd
Sea N Air Golf Course
Breakers Beach
Ocean Blvd
Kelp Bed Area
December 26, 2023
Coronado: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.41
Coronado (North Island Naval Air Station)

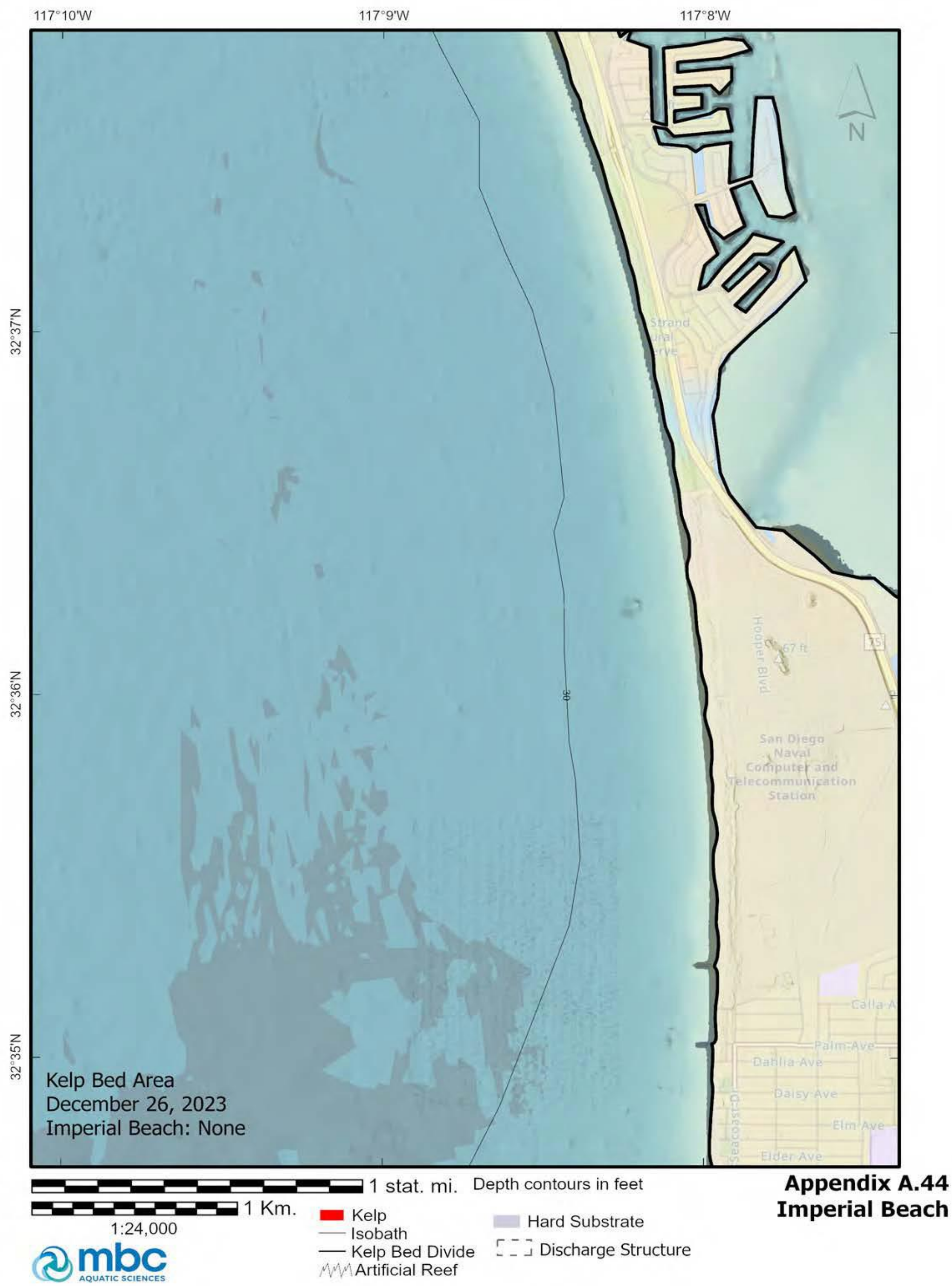
Page A-41


117°11'W
117°10'W
32°41'N
32°40'N
32°39'N
Ocean Blvd
Strand Way
US Naval Amphibious Base Coronado
Coronado Municipal Golf Course
N
Kelp Bed Area
December 26, 2023
Coronado Beach: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.42
Coronado Beach/
Silver Strand
(North)

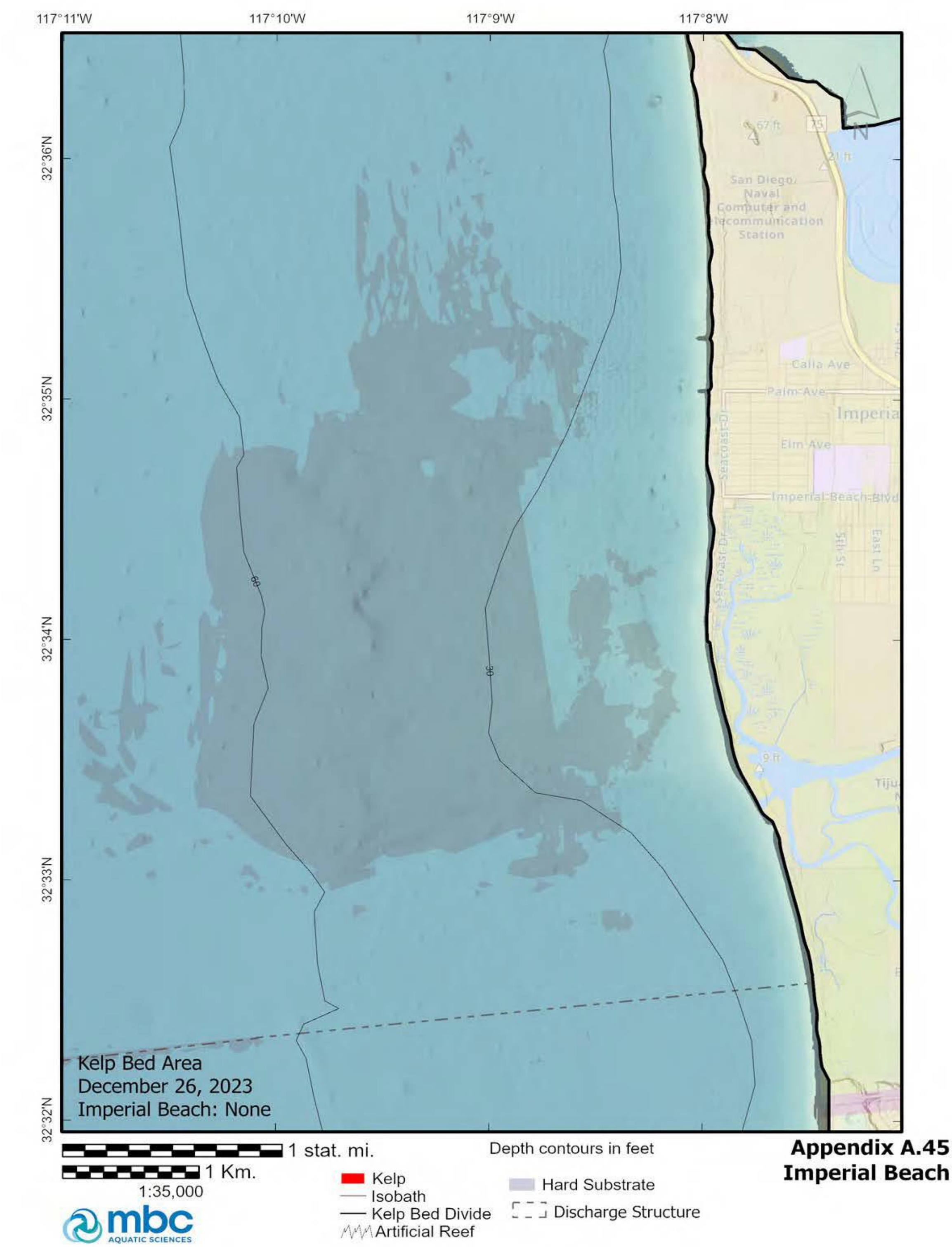
Page A-42


117°10'W
117°9'W
117°8'W
32°39'N
32°38'N
32°37'N
32°36'N
N
Silver Strand Blvd
PENINSULA OF SAN DIEGO
30
Hooper Blvd
Kelp Bed Area
December 26, 2023
Silver Strand: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
mbc
AQUATIC SCIENCES
Appendix A.43
Coronado Beach/
Silver Strand
(Central)

Page A-43

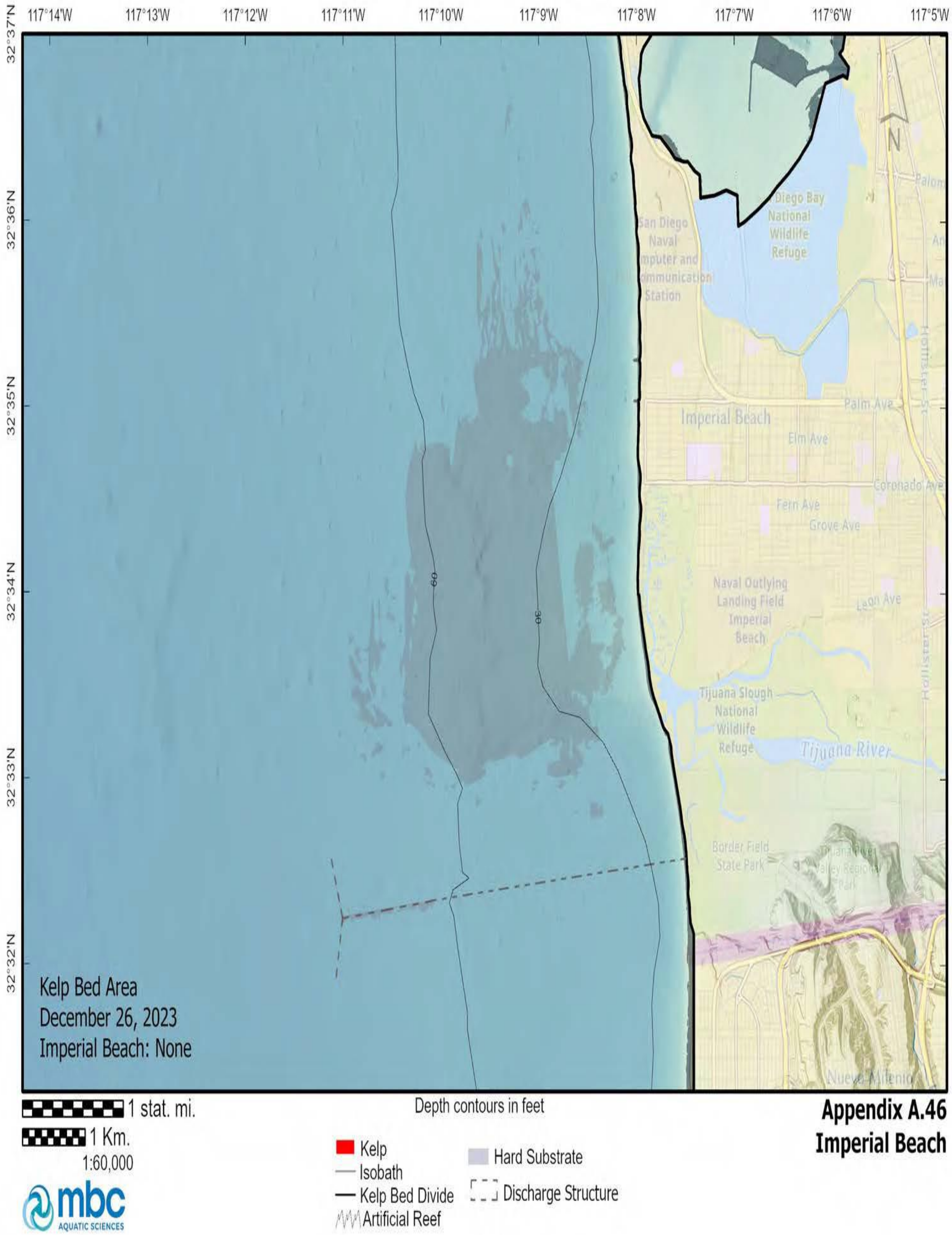

117°10'W
117°9'W
117°8'W
32°37'N
32°36'N
32°35'N
N
Kelp Bed Area
December 26, 2023
Imperial Beach: None
30
Hooper Blvd
67 ft
75
San Diego Naval Computer and Telecommunication Station
Calla Ave
Palm Ave
Dahlia Ave
Daisy Ave
Elm Ave
Elder Ave
Seacoast Dr
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.44
Imperial Beach

Page A-44



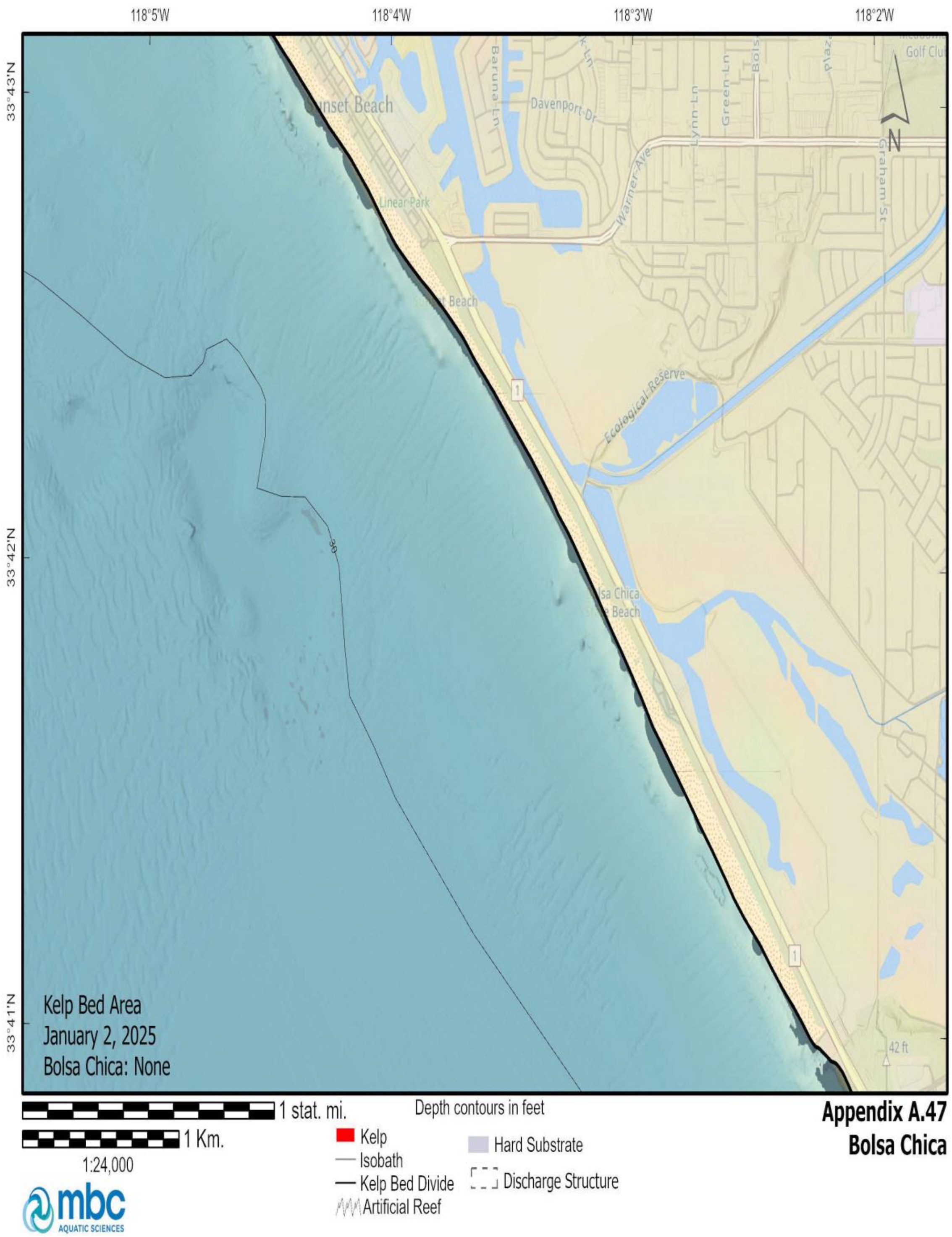
117°11'W
117°10'W
117°9'W
117°8'W
32°36'N
32°35'N
32°34'N
32°33'N
32°32'N
San Diego Naval Computer and Telecommunication Station
Calla Ave
Palm Ave
Elm Ave
Imperial Beach Blvd
Seacoast Dr
60
30
Kelp Bed Area
December 26, 2023
Imperial Beach: None
1 stat. mi.
1 Km.
1:35,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.45
Imperial Beach

Page A-45

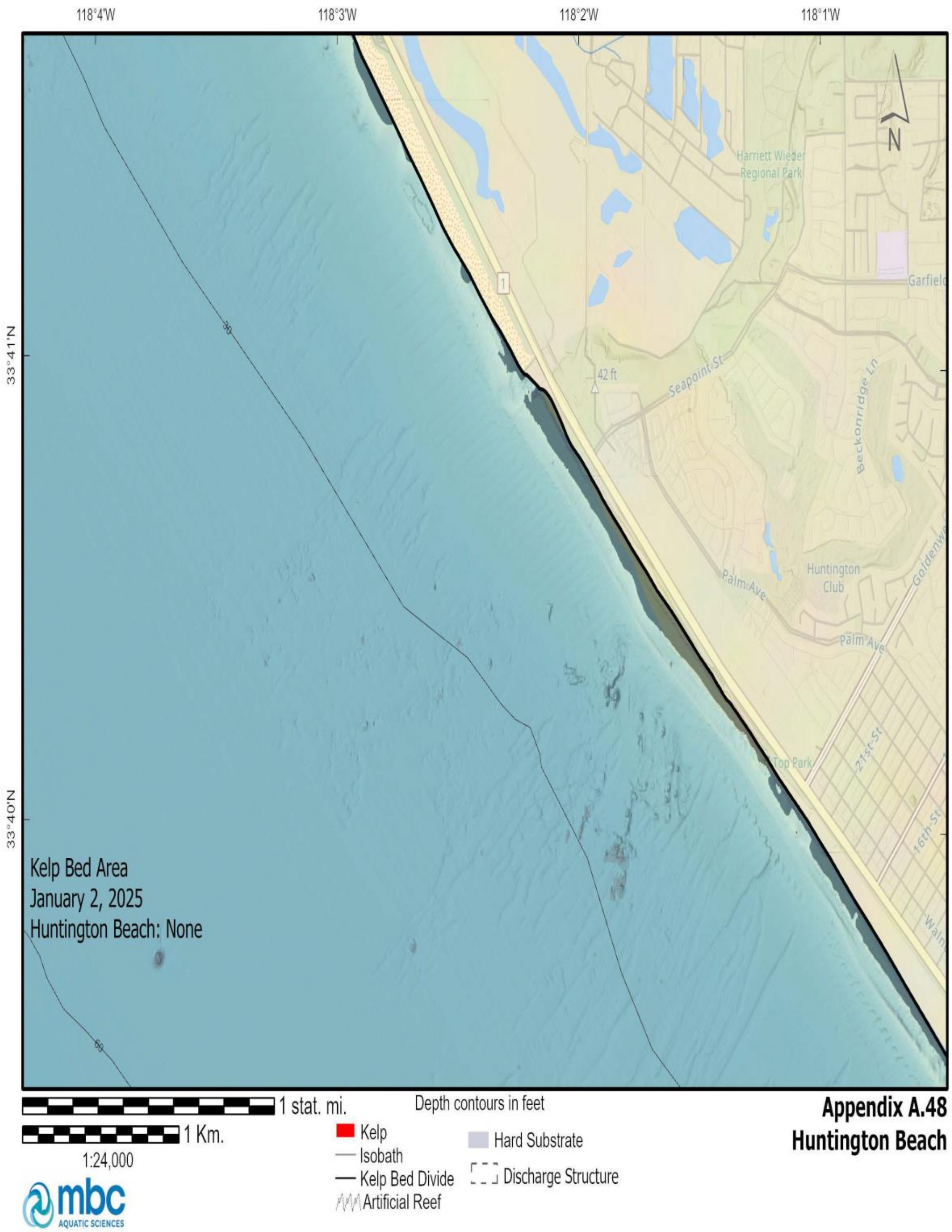


117°14'W
117°13'W
117°12'W
117°11'W
117°10'W
117°9'W
117°8'W
117°7'W
117°6'W
117°5'W
32°37'N
32°36'N
32°35'N
32°34'N
32°33'N
32°32'N
San Diego Naval Computer and Communication Station
San Diego Bay National Wildlife Refuge
Imperial Beach
Palm Ave
Elm Ave
Coronado Ave
Fern Ave
Grove Ave
Naval Outlying Landing Field Imperial Beach
Leon Ave
Hollister St
Tijuana Slough National Wildlife Refuge
Tijuana River
Border Field State Park
60
30
N
Kelp Bed Area
December 26, 2023
Imperial Beach: None
1 stat. mi.
1 Km.
1:60,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.46
Imperial Beach

Page A-46

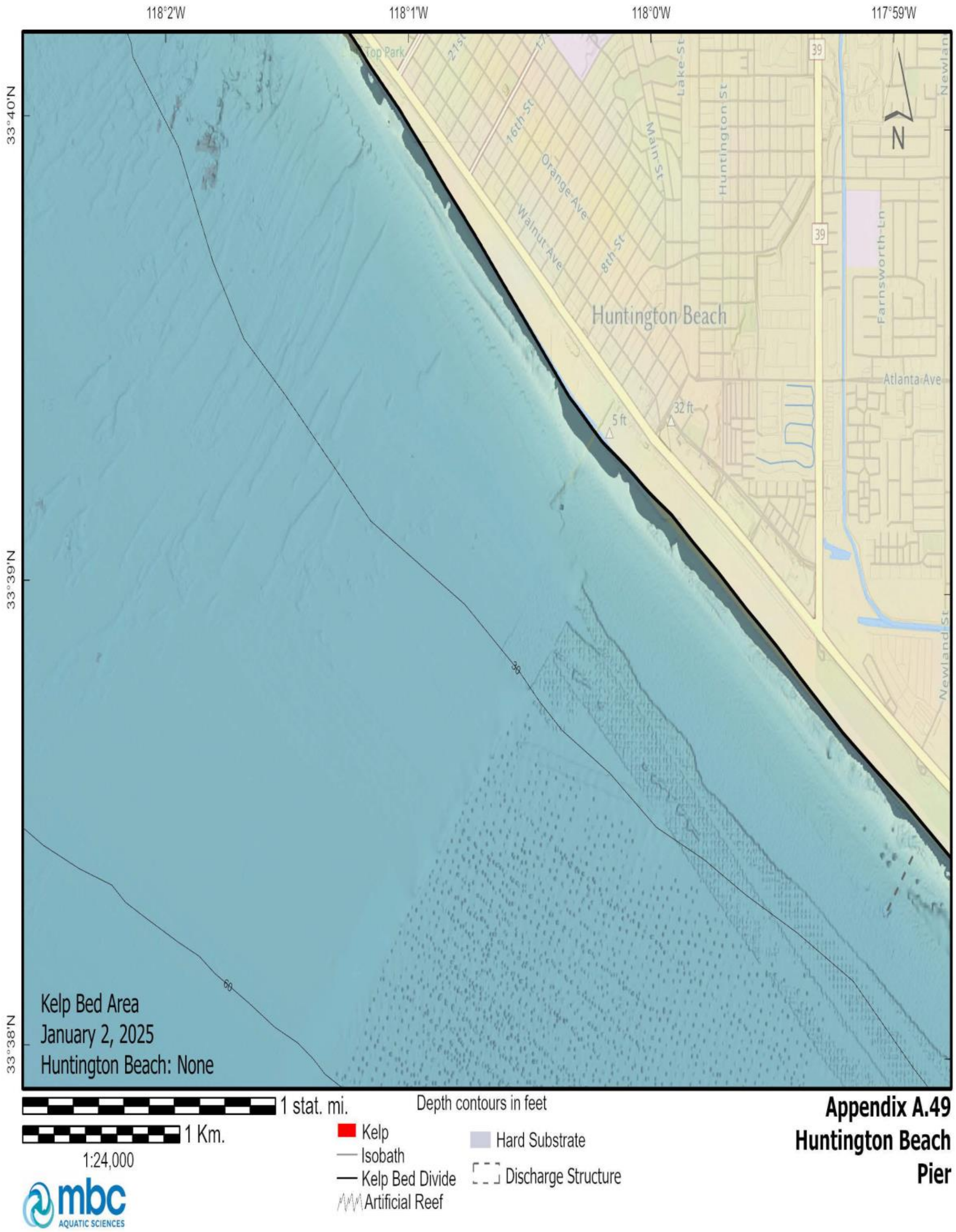

118°5'W
118°4'W
118°3'W
118°2'W
33°43'N
33°42'N
33°41'N
Sunset Beach
Linear Park
Davenport Dr
Warner Ave
Lynn Ln
Green Ln
Graham St
Baruna Ln
Ecological Reserve
Bolsa Chica State Beach
N
Kelp Bed Area
January 2, 2025
Bolsa Chica: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.47
Bolsa Chica
mbc AQUATIC SCIENCES

Page A-47



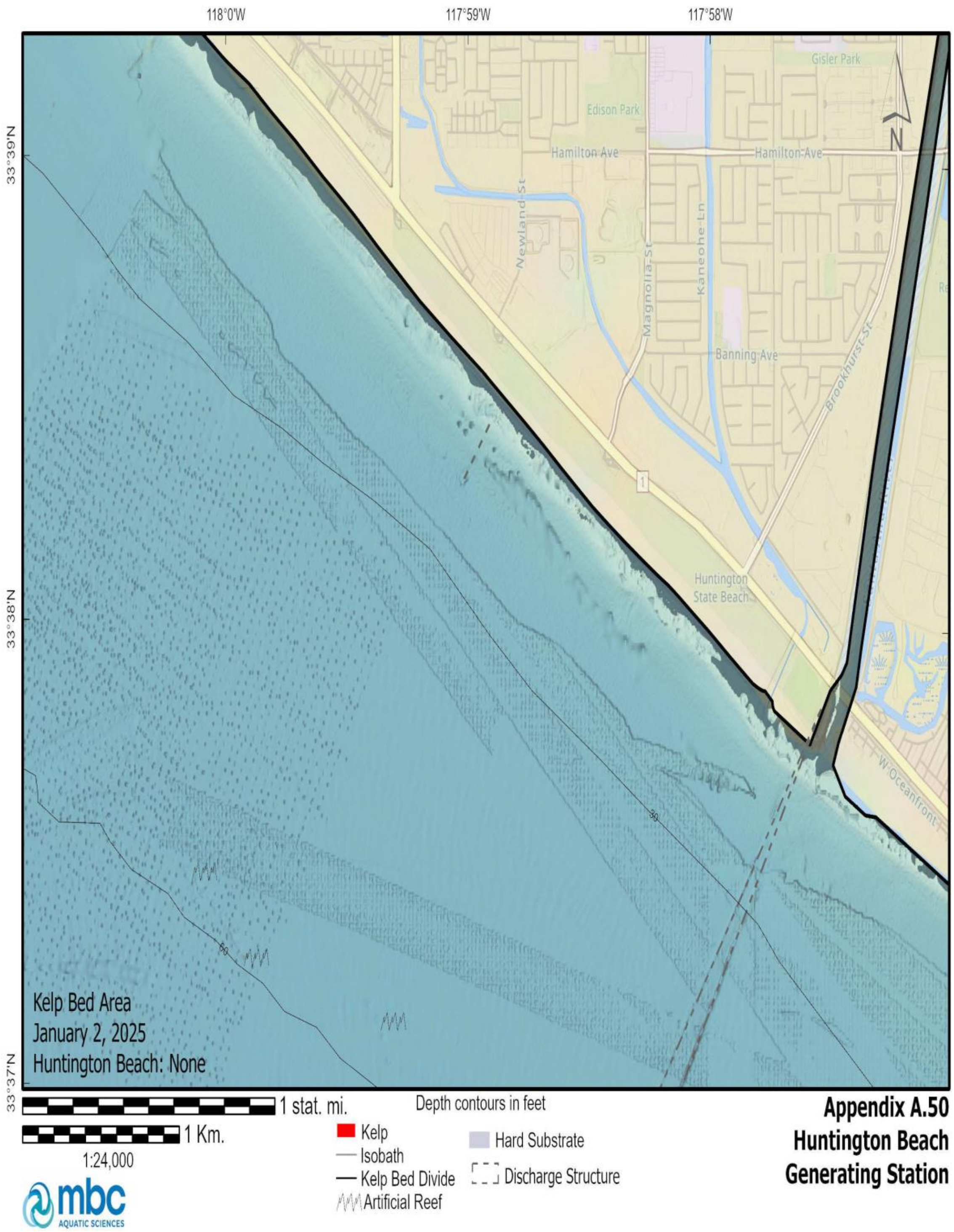
118°4'W
118°3'W
118°2'W
118°1'W
33°41'N
33°40'N
N
Harriett Wieder Regional Park
Garfield
Seapoint St
42 ft
Beckonridge Ln
Huntington Club
Palm Ave
Goldenwest
21st St
16th St
Top Park
Kelp Bed Area
January 2, 2025
Huntington Beach: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.48
Huntington Beach

Page A-48



118°2'W
118°1'W
118°0'W
117°59'W
33°40'N
33°39'N
33°38'N
Huntington Beach
Atlanta Ave
Kelp Bed Area
January 2, 2025
Huntington Beach: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.49
Huntington Beach
Pier

Page A-49

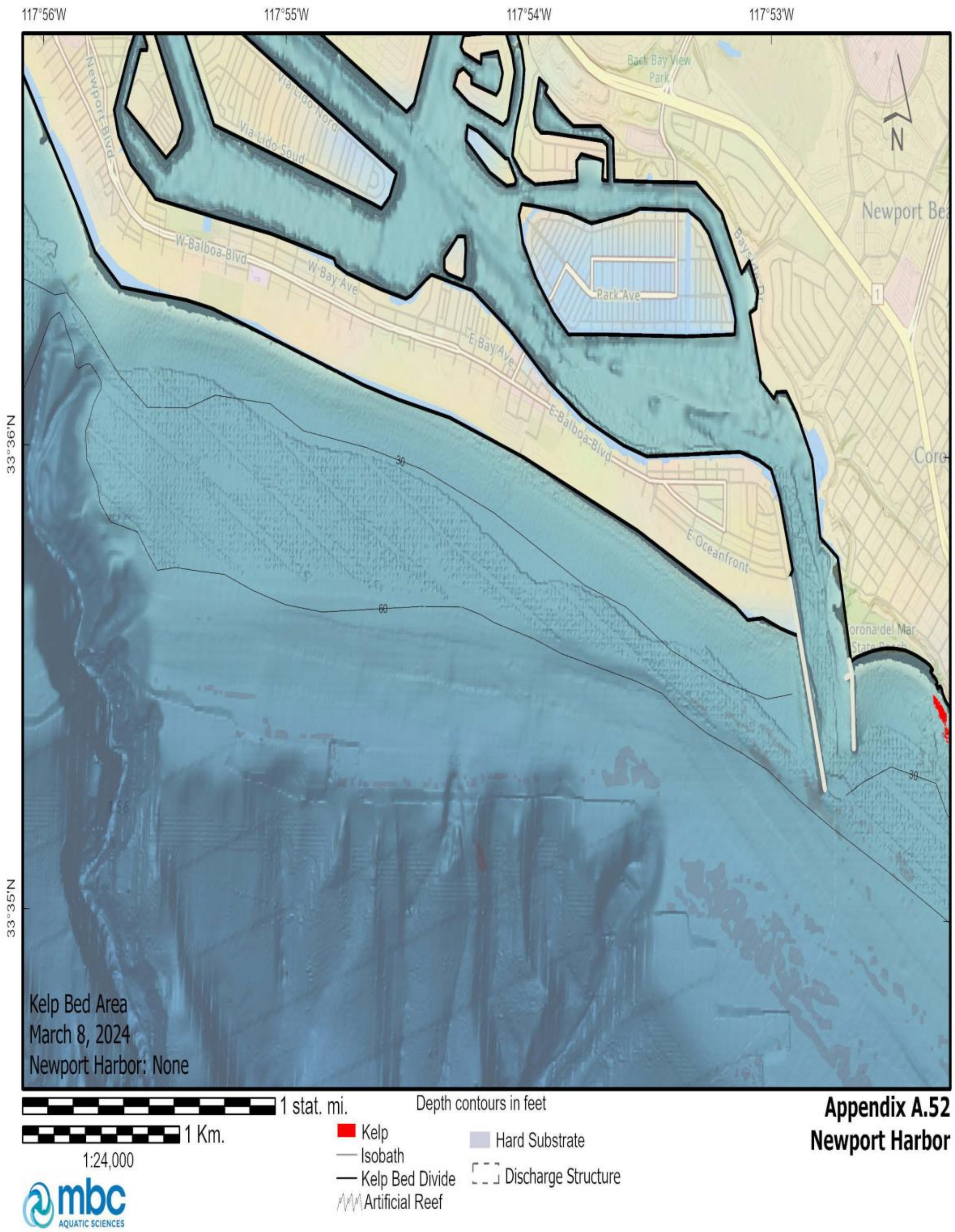


118°0'W
117°59'W
117°58'W
33°39'N
33°38'N
33°37'N
Gisler Park
Edison Park
Hamilton Ave
Newland St
Magnolia St
Kaneohe Ln
Banning Ave
Brookhurst St
Huntington State Beach
W Oceanfront
N
Kelp Bed Area
January 2, 2025
Huntington Beach: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.50
Huntington Beach
Generating Station
mbc
AQUATIC SCIENCES

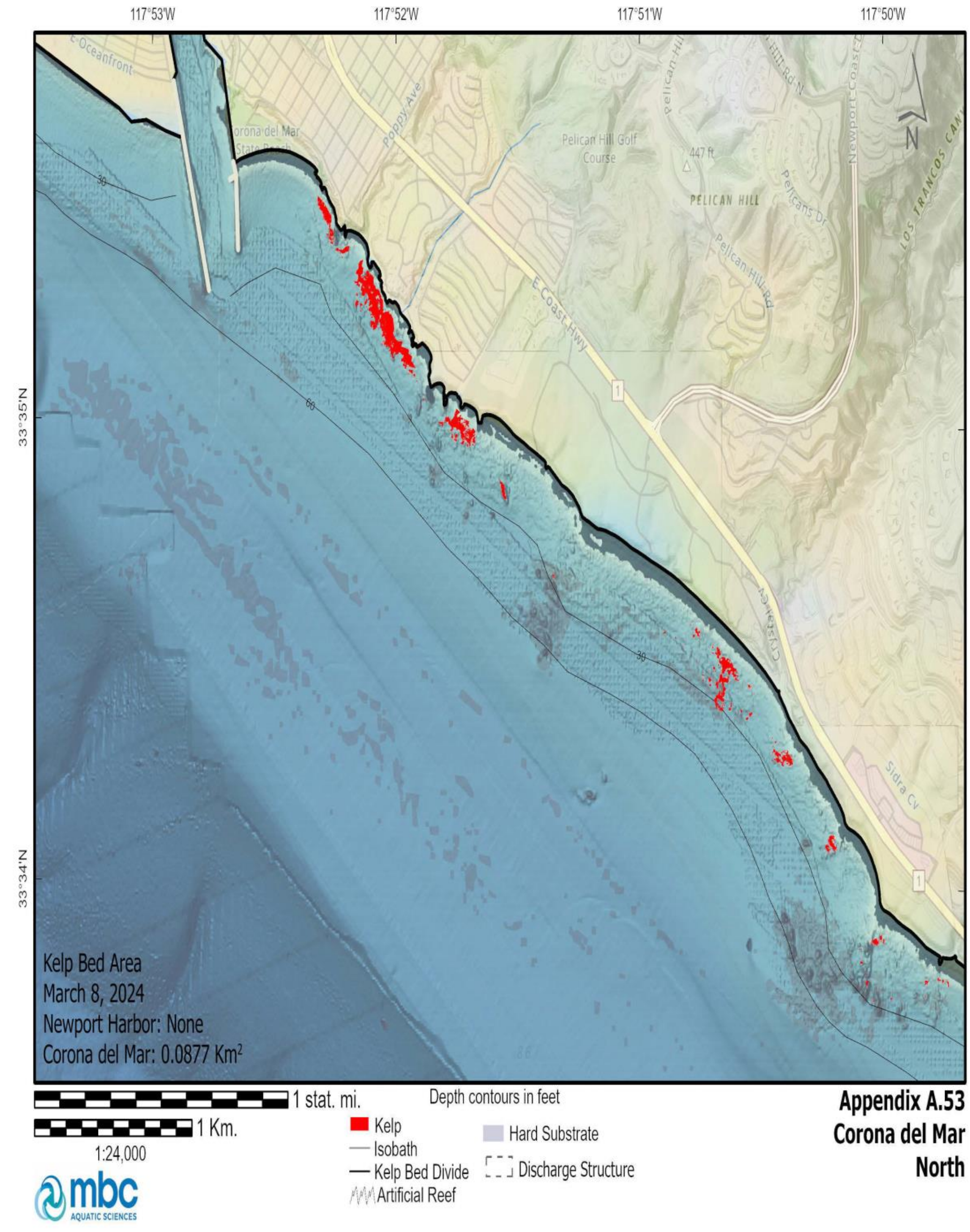
Page A-50

Appendix A.51
Newport Beach

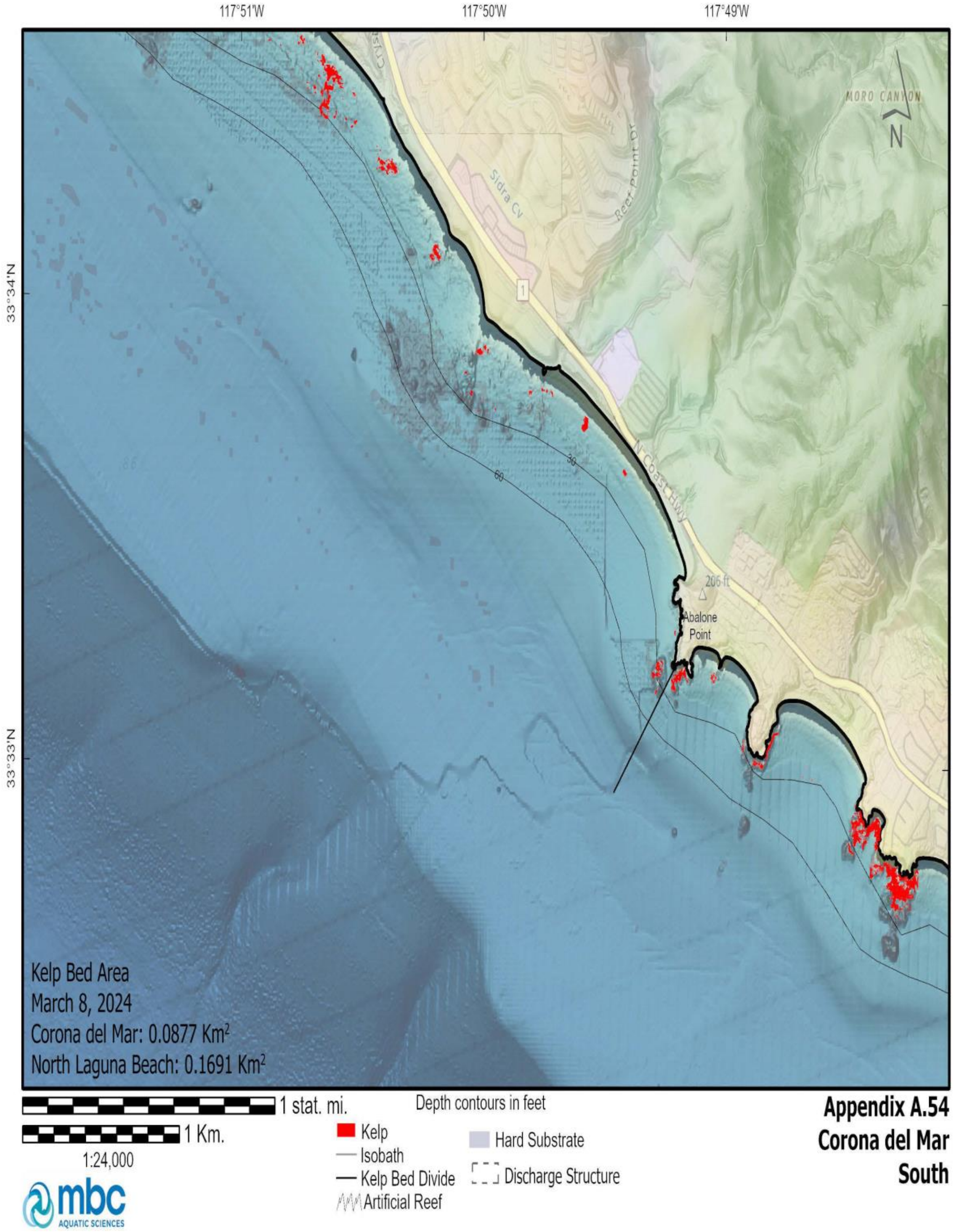
Page A-51


117°56'W
117°55'W
117°54'W
117°53'W
33°36'N
33°35'N
N
Newport Blvd
Via Lido Nord
Via Lido Soud
W Balboa Blvd
W Bay Ave
E Bay Ave
E Balboa Blvd
E Oceanfront
Park Ave
Back Bay View Park
Newport Bea
Coro
Corona del Mar State Beach
30
60
Kelp Bed Area
March 8, 2024
Newport Harbor: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.52
Newport Harbor

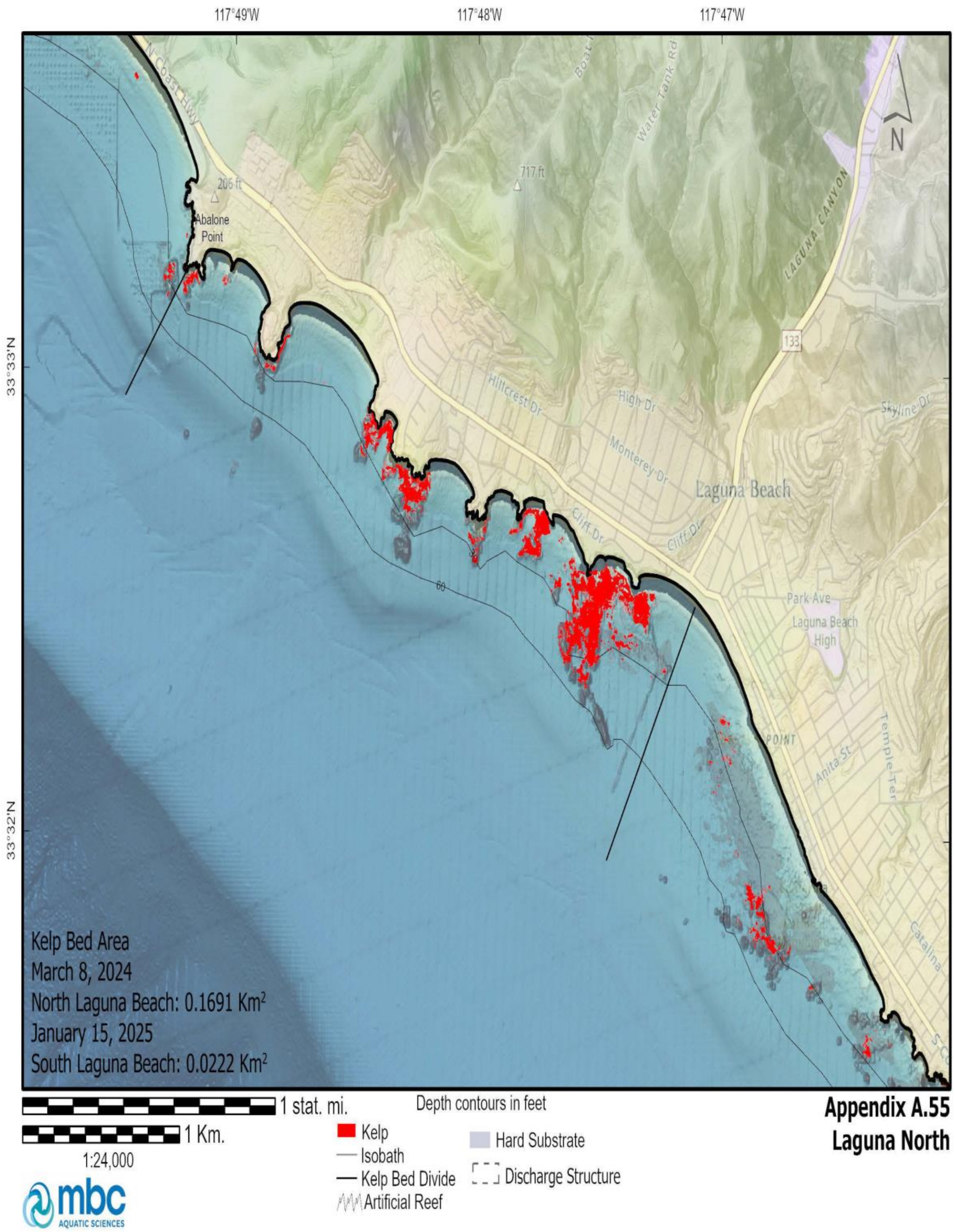
Page A-52


117°53'W
117°52'W
117°51'W
117°50'W
33°35'N
33°34'N
Kelp Bed Area
March 8, 2024
Newport Harbor: None
Corona del Mar: 0.0877 Km²
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.53
Corona del Mar
North

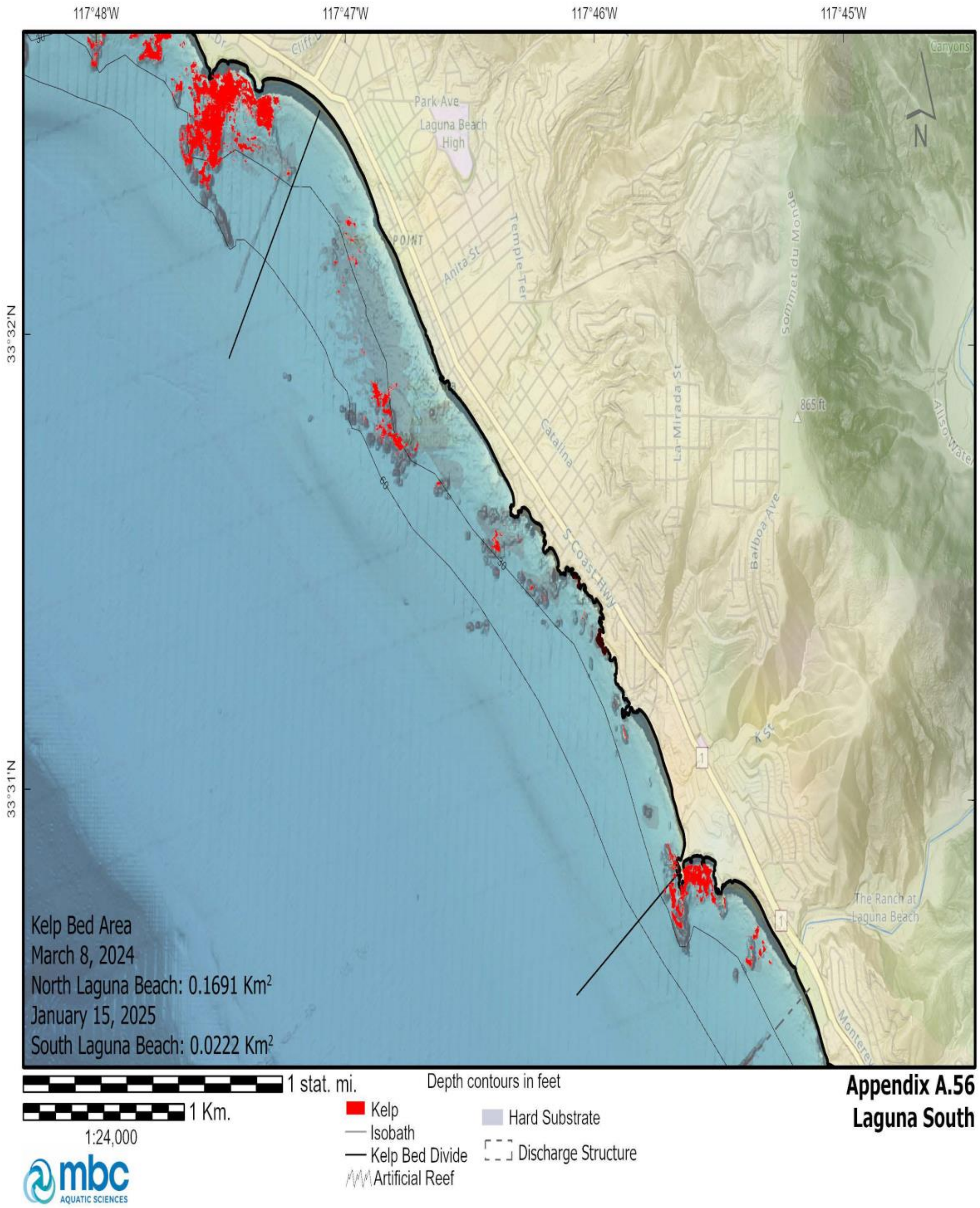
Page A-53


117°51'W
117°50'W
117°49'W
33°34'N
33°33'N
Sidra Cv
Reef Point Dr
N Coast Hwy
MORO CANYON
N
206 ft
Abalone Point
Kelp Bed Area
March 8, 2024
Corona del Mar: 0.0877 Km²
North Laguna Beach: 0.1691 Km²
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.54
Corona del Mar
South

Page A-54

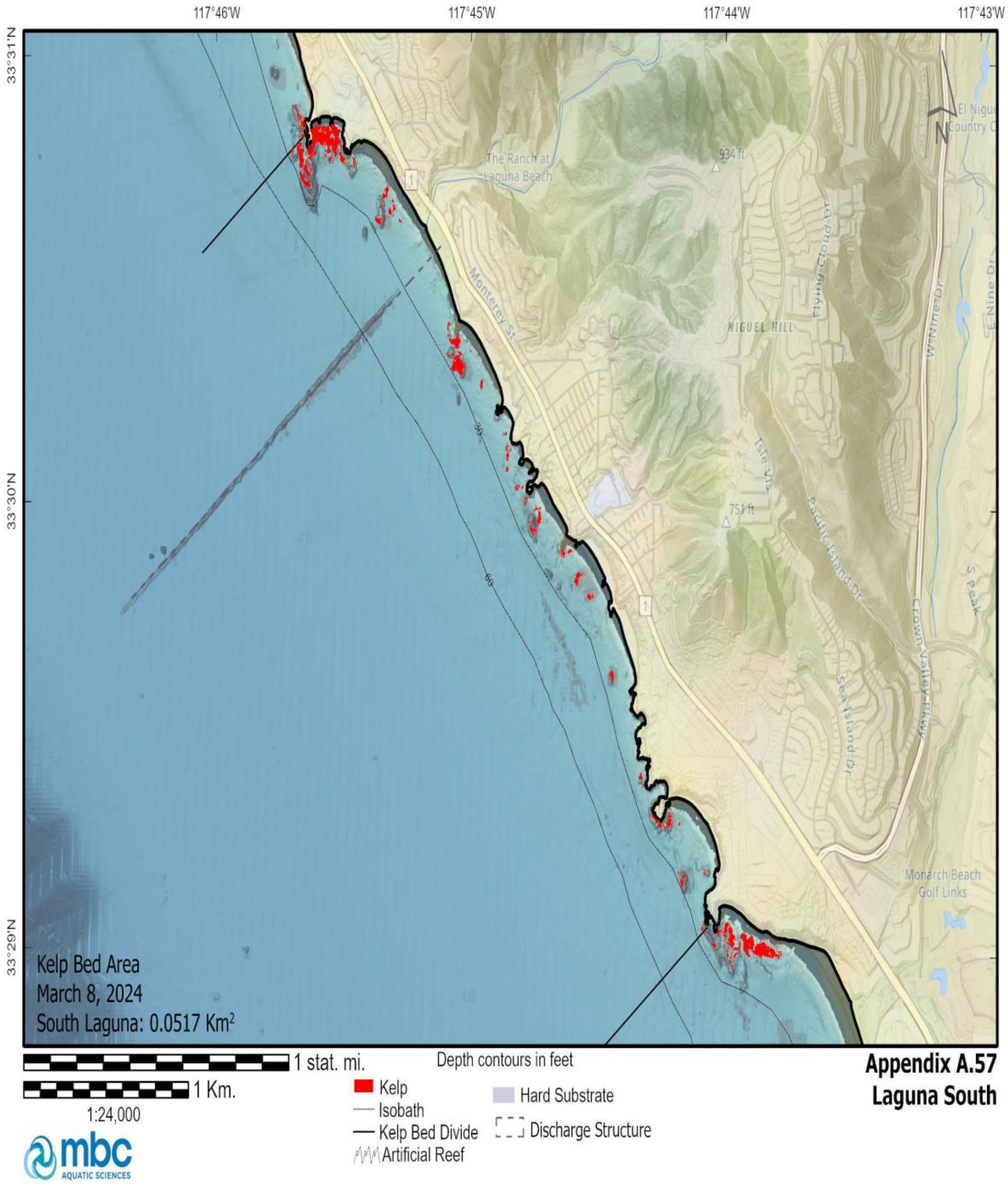

117°49'W
117°48'W
117°47'W
33°33'N
33°32'N
N
Abalone Point
206 ft
717 ft
N Coast Hwy
Laguna Canyon
133
Hillcrest Dr
High Dr
Skyline Dr
Monterey Dr
Laguna Beach
Cliff Dr
Park Ave
Laguna Beach High
Anita St
Temple Ter
60
Kelp Bed Area
March 8, 2024
North Laguna Beach: 0.1691 Km²
January 15, 2025
South Laguna Beach: 0.0222 Km²
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.55
Laguna North
mbc
AQUATIC SCIENCES

Page A-55

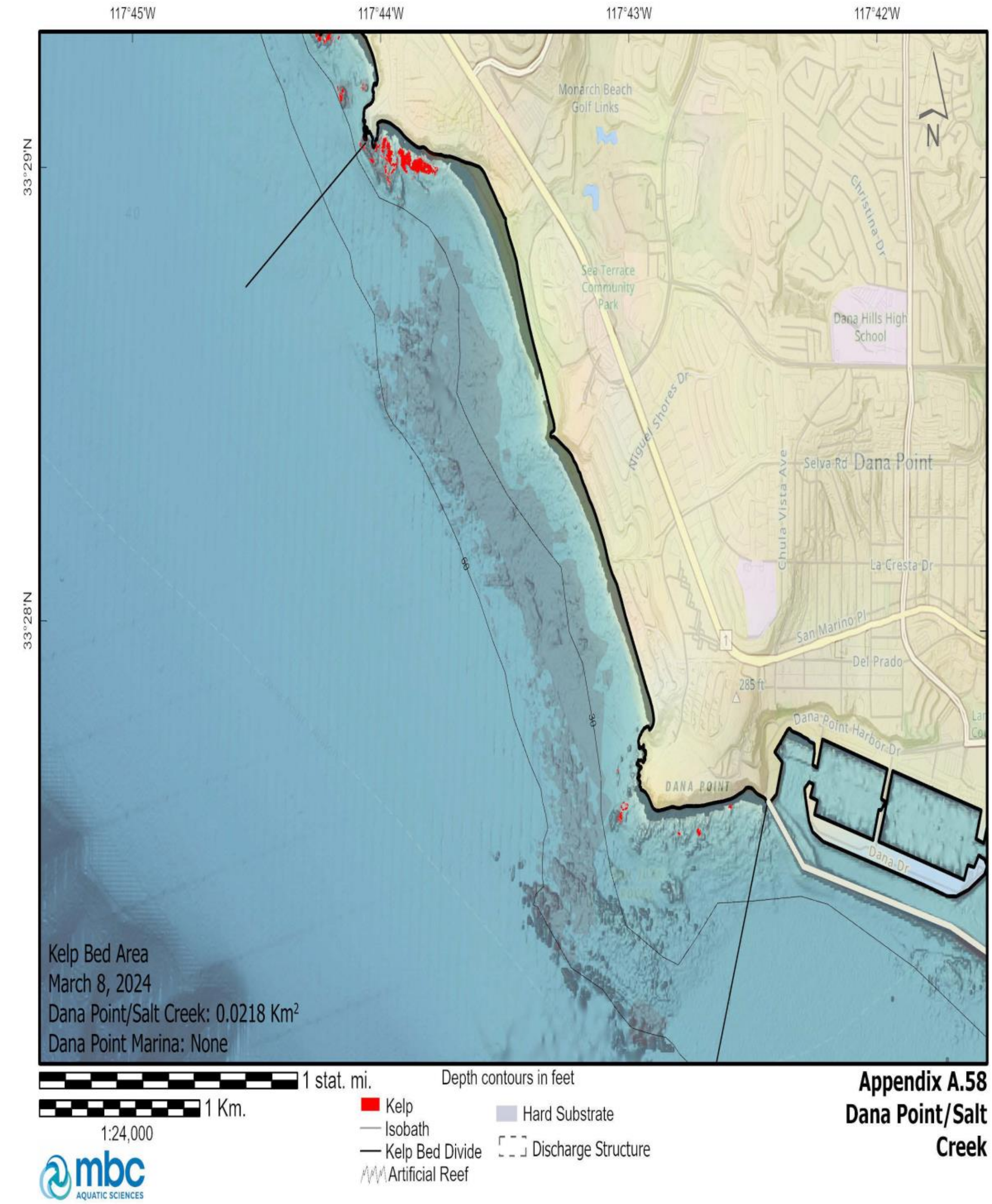


117°48'W
117°47'W
117°46'W
117°45'W
33°32'N
33°31'N
N
Park Ave
Laguna Beach High
Temple Ter
Anita St
Sommet du Monde
865 ft
La Mirada St
Catalina
S Coast Hwy
Balboa Ave
Aliso Water
The Ranch at Laguna Beach
Canyons
Kelp Bed Area
March 8, 2024
North Laguna Beach: 0.1691 Km²
January 15, 2025
South Laguna Beach: 0.0222 Km²
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.56
Laguna South
mbc
AQUATIC SCIENCES

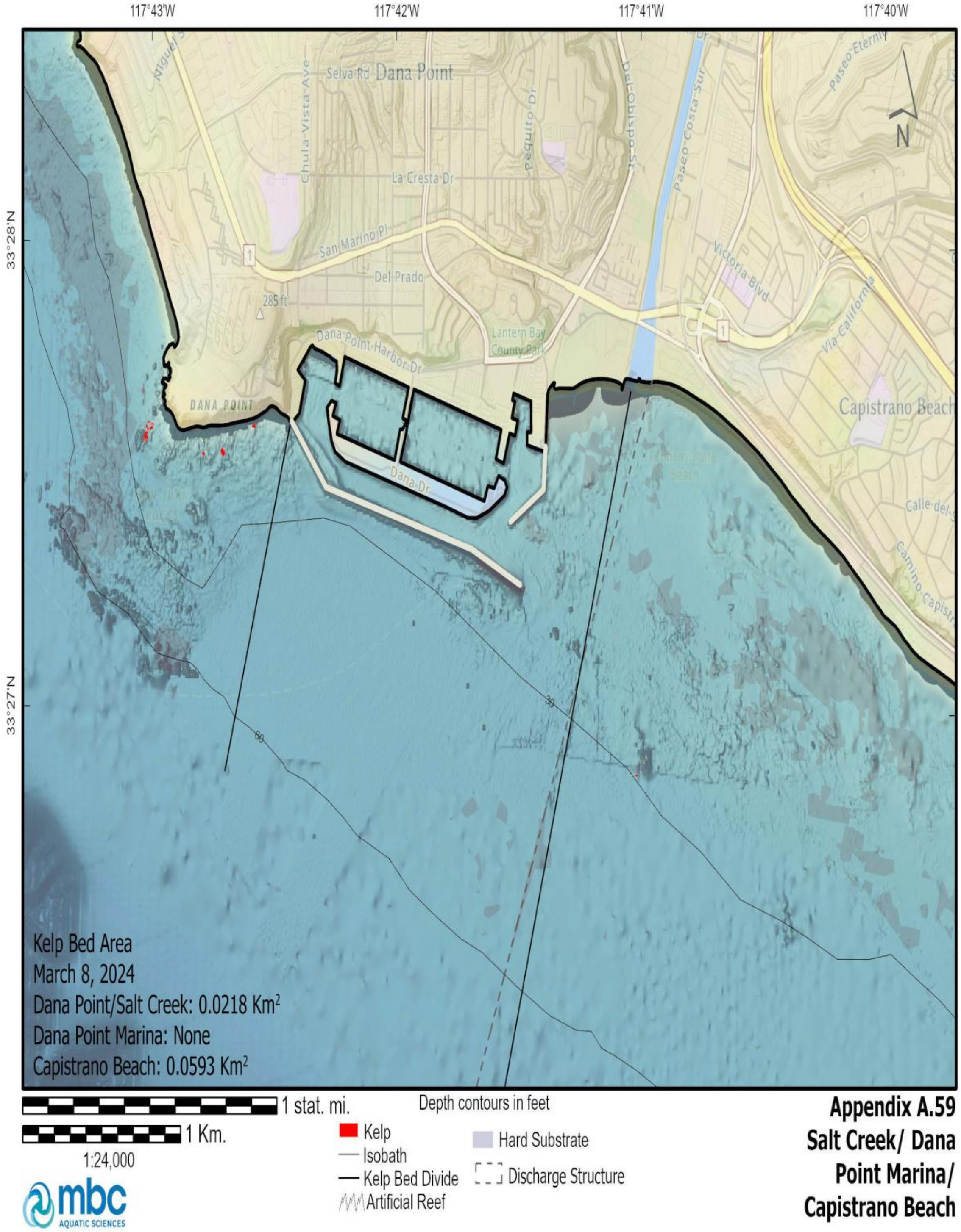
Page A-56


117°46'W
117°45'W
117°44'W
117°43'W
33°31'N
33°30'N
33°29'N
The Ranch at Laguna Beach
934 ft
Monterey St
NIGUEL HILL
751 ft
Kelp Bed Area
March 8, 2024
South Laguna: 0.0517 Km²
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.57
Laguna South

Page A-57

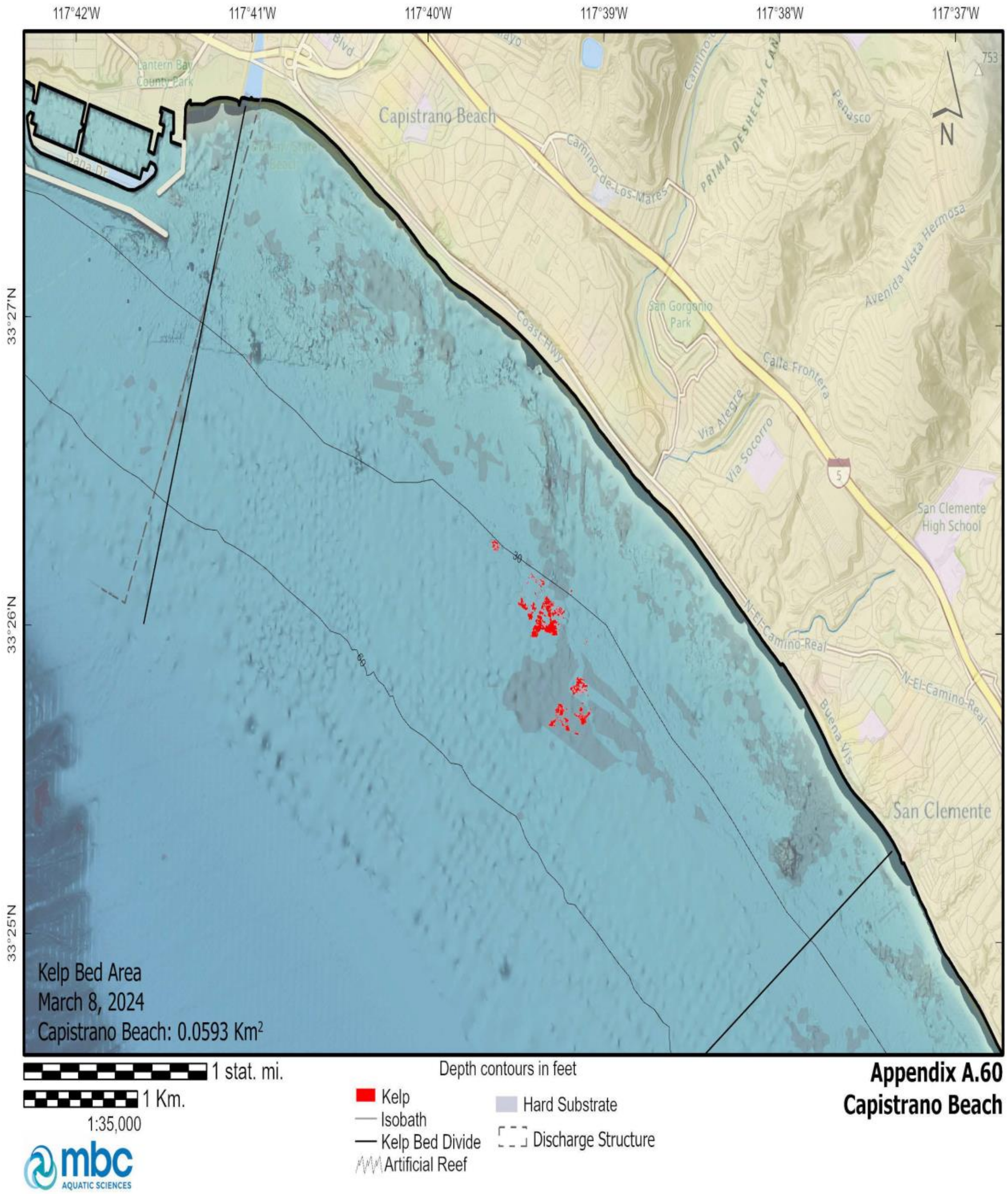

117°45'W
117°44'W
117°43'W
117°42'W
33°29'N
33°28'N
N
Monarch Beach Golf Links
Sea Terrace Community Park
Dana Hills High School
Christina Dr
Niguel Shores Dr
Selva Rd
Dana Point
Chula Vista Ave
La Cresta Dr
San Marino Pl
Del Prado
285 ft
Dana Point Harbor Dr
DANA POINT
Dana Dr
Kelp Bed Area
March 8, 2024
Dana Point/Salt Creek: 0.0218 Km²
Dana Point Marina: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.58
Dana Point/Salt Creek
mbc
AQUATIC SCIENCES

Page A-58

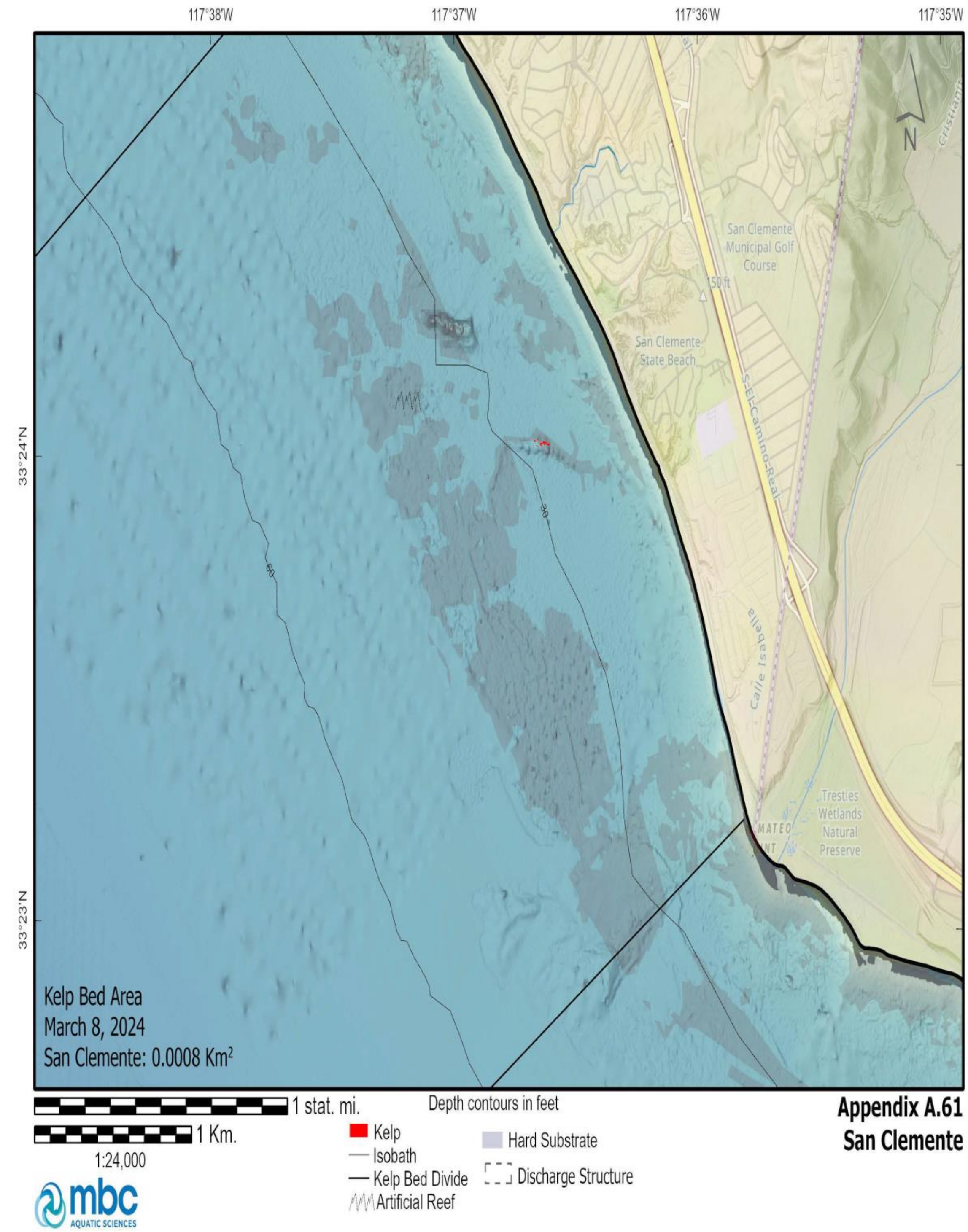


Appendix A.59
Salt Creek/ Dana Point Marina/ Capistrano Beach

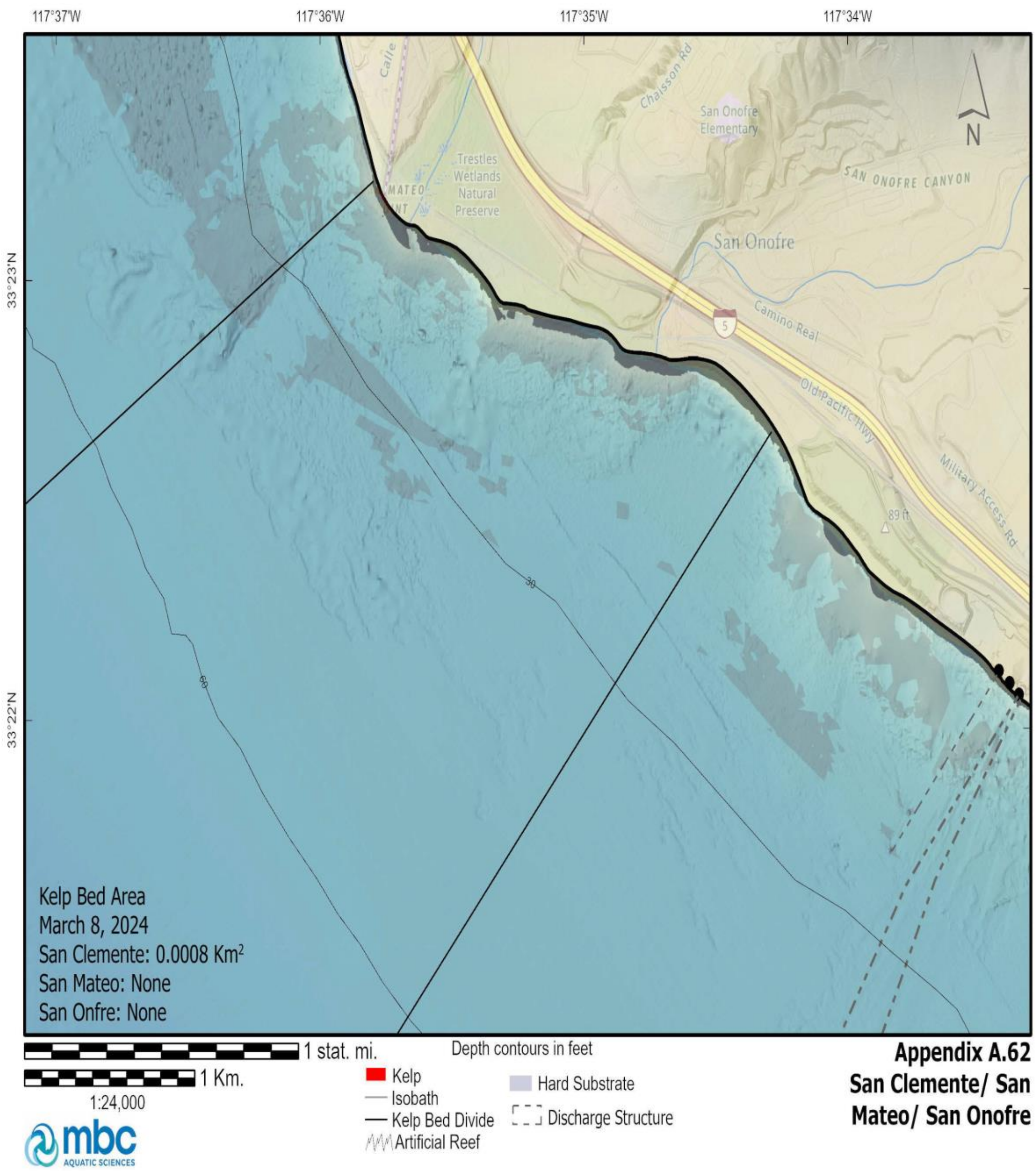
Page A-59


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
Capistrano Beach
San Clemente
San Clemente High School
San Gorgonio Park
Lantern Bay County Park
Dana Dr
Coast Hwy
Camino-de-Los-Mares
Calle Frontera
Via Alegre
Via Socorro
N-El-Camino-Real
Buena Vis
Avenida Vista Hermosa
Penasco
PRIMA DESHECHA CAN
5
30
60
N
Kelp Bed Area
March 8, 2024
Capistrano Beach: 0.0593 Km²
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.60
Capistrano Beach
mbc
AQUATIC SCIENCES

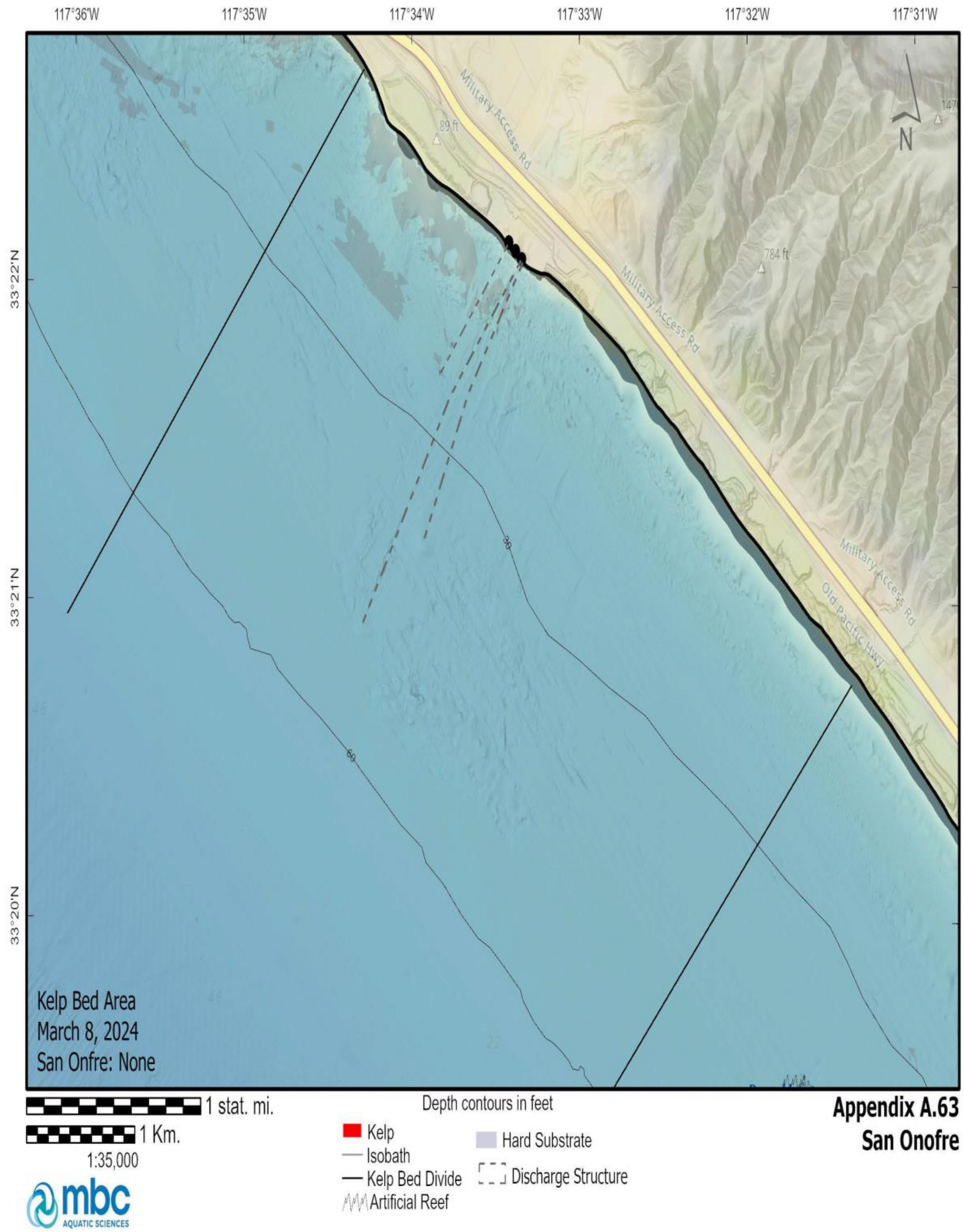
Page A-60


117°38'W
117°37'W
117°36'W
117°35'W
33°24'N
33°23'N
N
San Clemente Municipal Golf Course
150 ft
San Clemente State Beach
S-El-Camino-Real
Calle Isabella
Trestles Wetlands Natural Preserve
MATEO
30
60
Kelp Bed Area
March 8, 2024
San Clemente: 0.0008 Km²
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.61
San Clemente

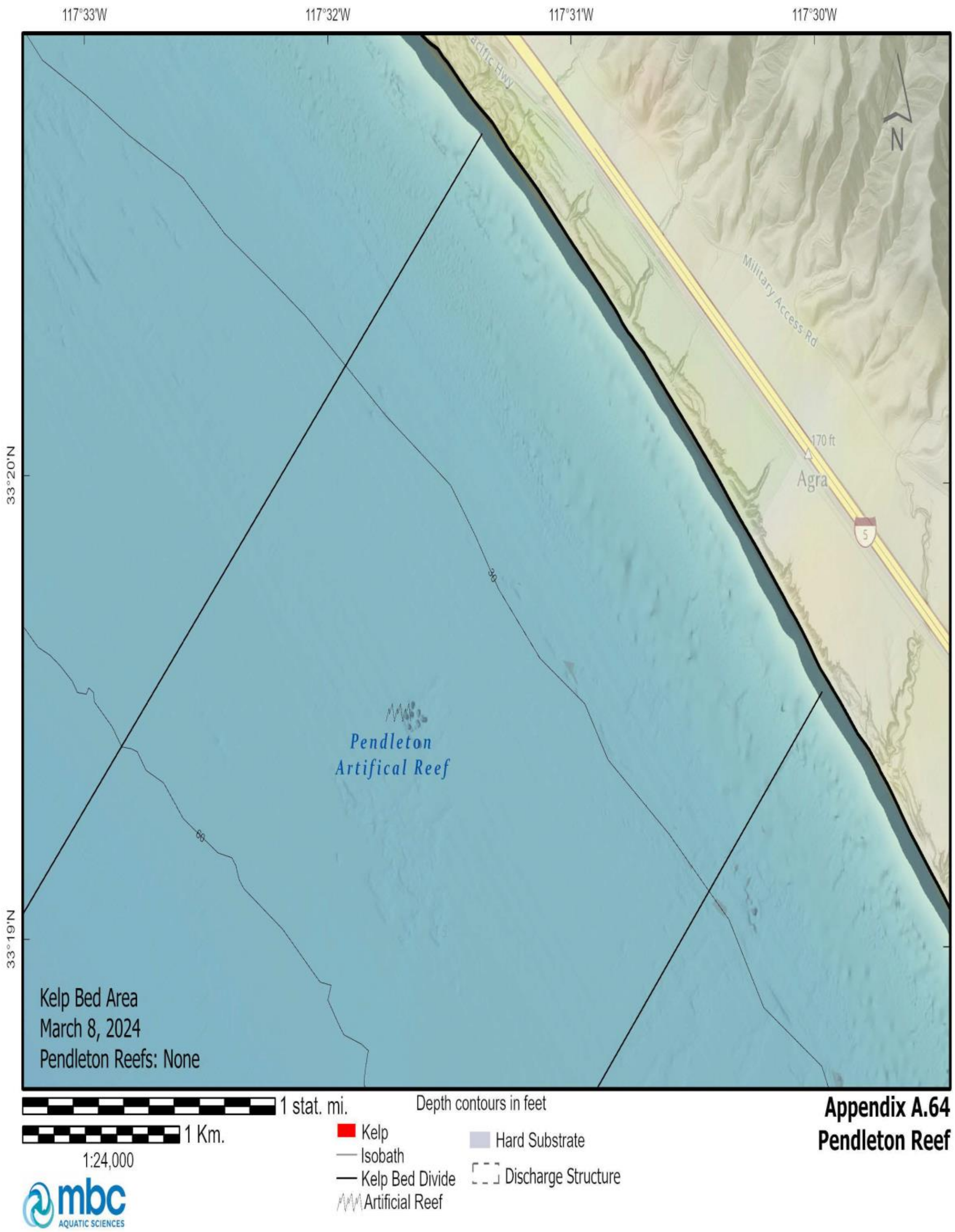
Page A-61


117°37'W
117°36'W
117°35'W
117°34'W
33°23'N
33°22'N
N
San Onofre Elementary
SAN ONOFRE CANYON
San Onofre
Trestles Wetlands Natural Preserve
Camino Real
Old Pacific Hwy
Military Access Rd
Chaisson Rd
89 ft
30
60
Kelp Bed Area
March 8, 2024
San Clemente: 0.0008 Km²
San Mateo: None
San Onfre: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.62
San Clemente/ San Mateo/ San Onofre

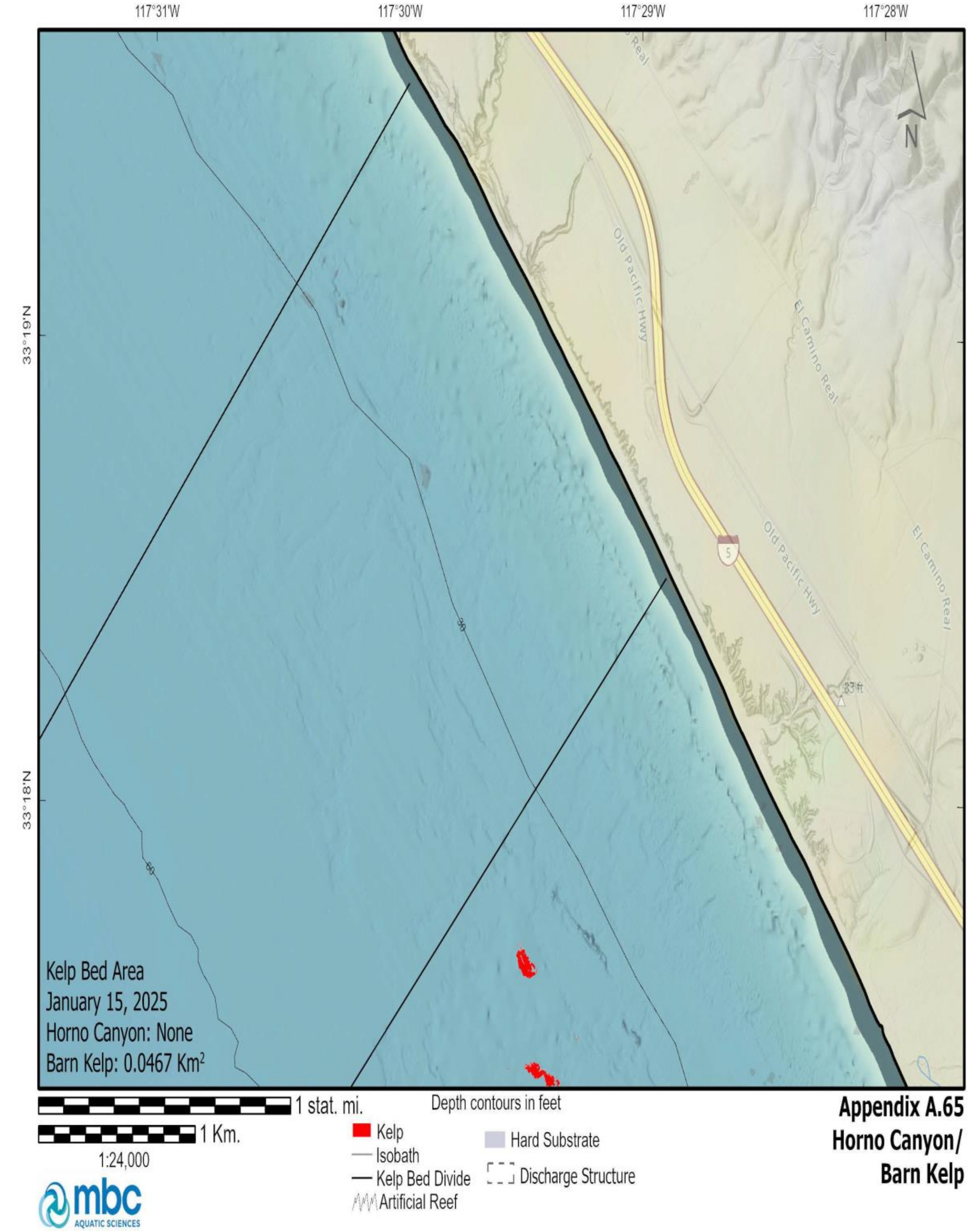
Page A-62


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
Military Access Rd
Old Pacific Hwy
89 ft
784 ft
N
Kelp Bed Area
March 8, 2024
San Onfre: 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.63
San Onofre

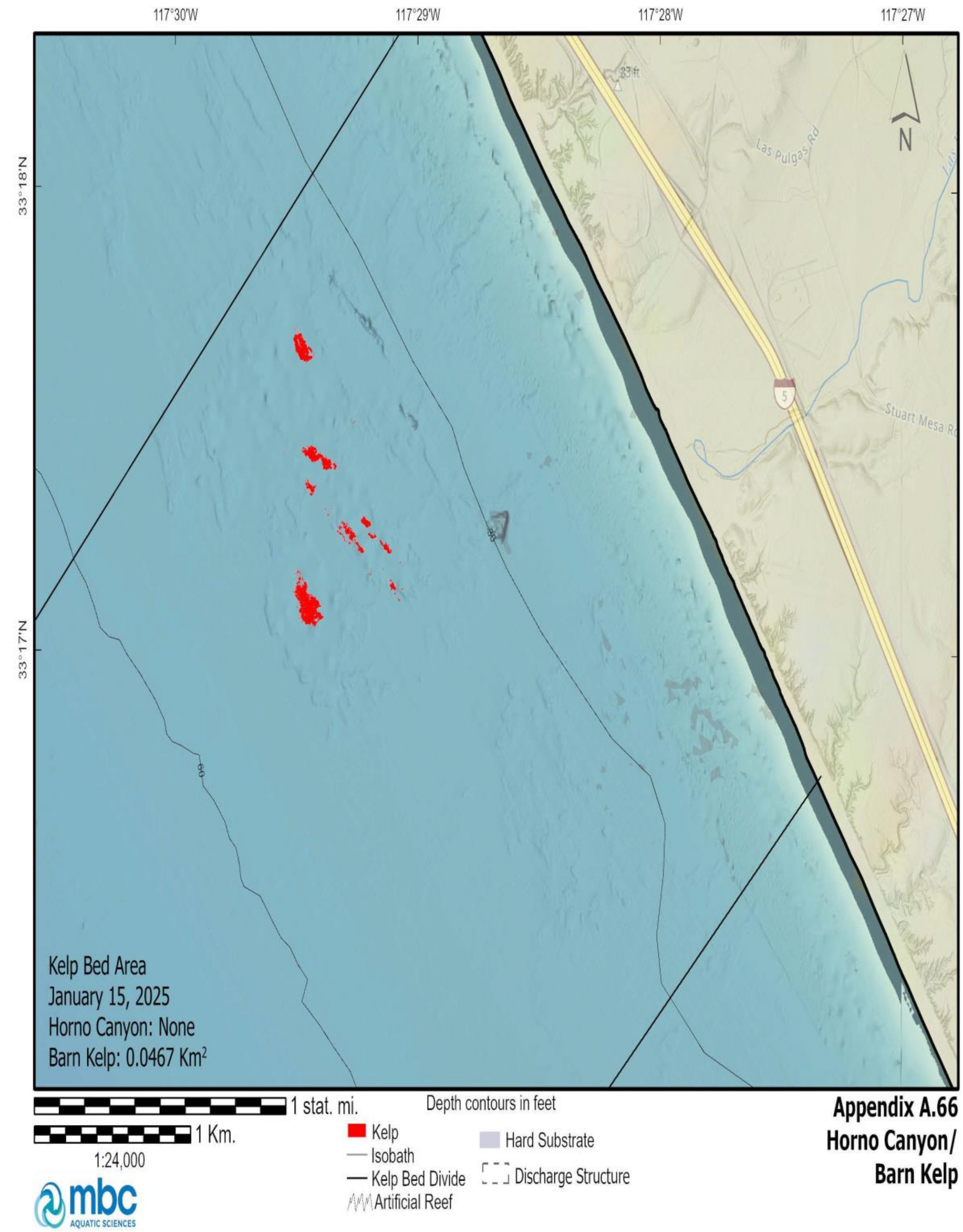
Page A-63


117°33'W
117°32'W
117°31'W
117°30'W
33°20'N
33°19'N
N
Pacific Hwy
Military Access Rd
170 ft
Agra
5
80
80
Pendleton
Artifical Reef
Kelp Bed Area
March 8, 2024
Pendleton Reefs: None
1 stat. mi.
1 Km.
1:24,000
mbc
AQUATIC SCIENCES
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.64
Pendleton Reef

Page A-64

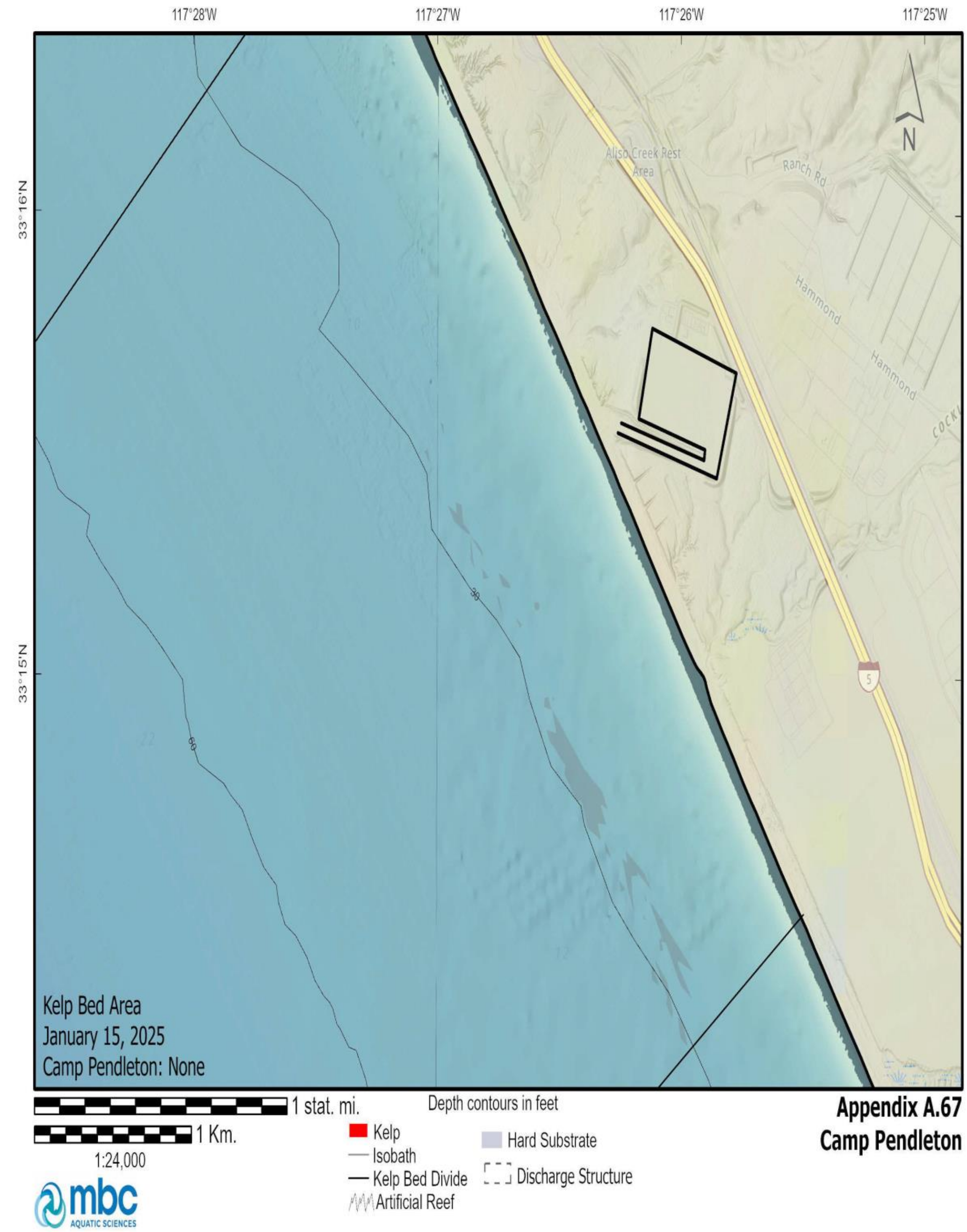

117°31'W
117°30'W
117°29'W
117°28'W
33°19'N
33°18'N
N
Old Pacific Hwy
El Camino Real
5
83 ft
Kelp Bed Area
January 15, 2025
Horno Canyon: None
Barn Kelp: 0.0467 Km²
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.65
Horno Canyon/
Barn Kelp
mbc AQUATIC SCIENCES

Page A-65



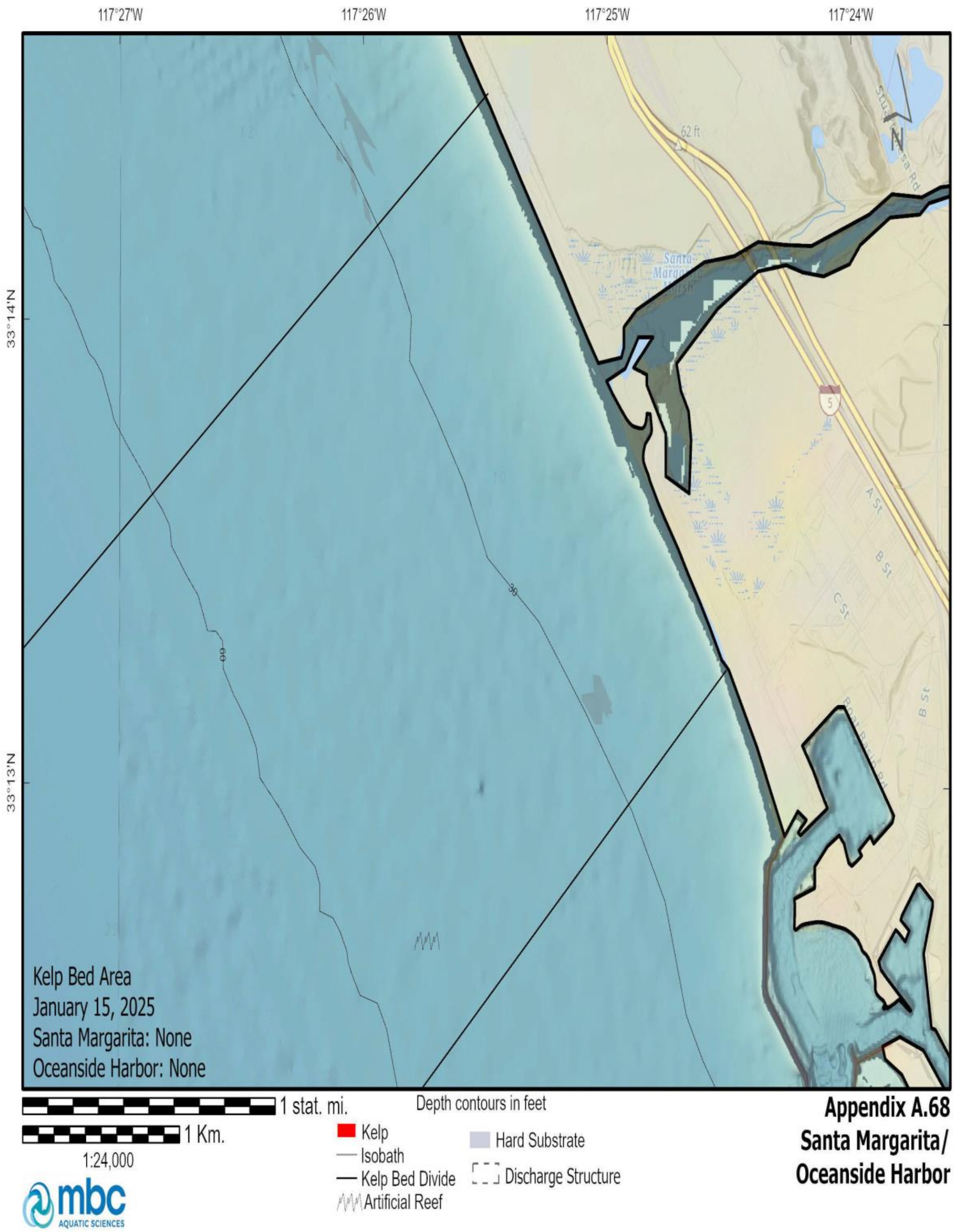
Appendix A.66
Horno Canyon/
Barn Kelp

Page A-66



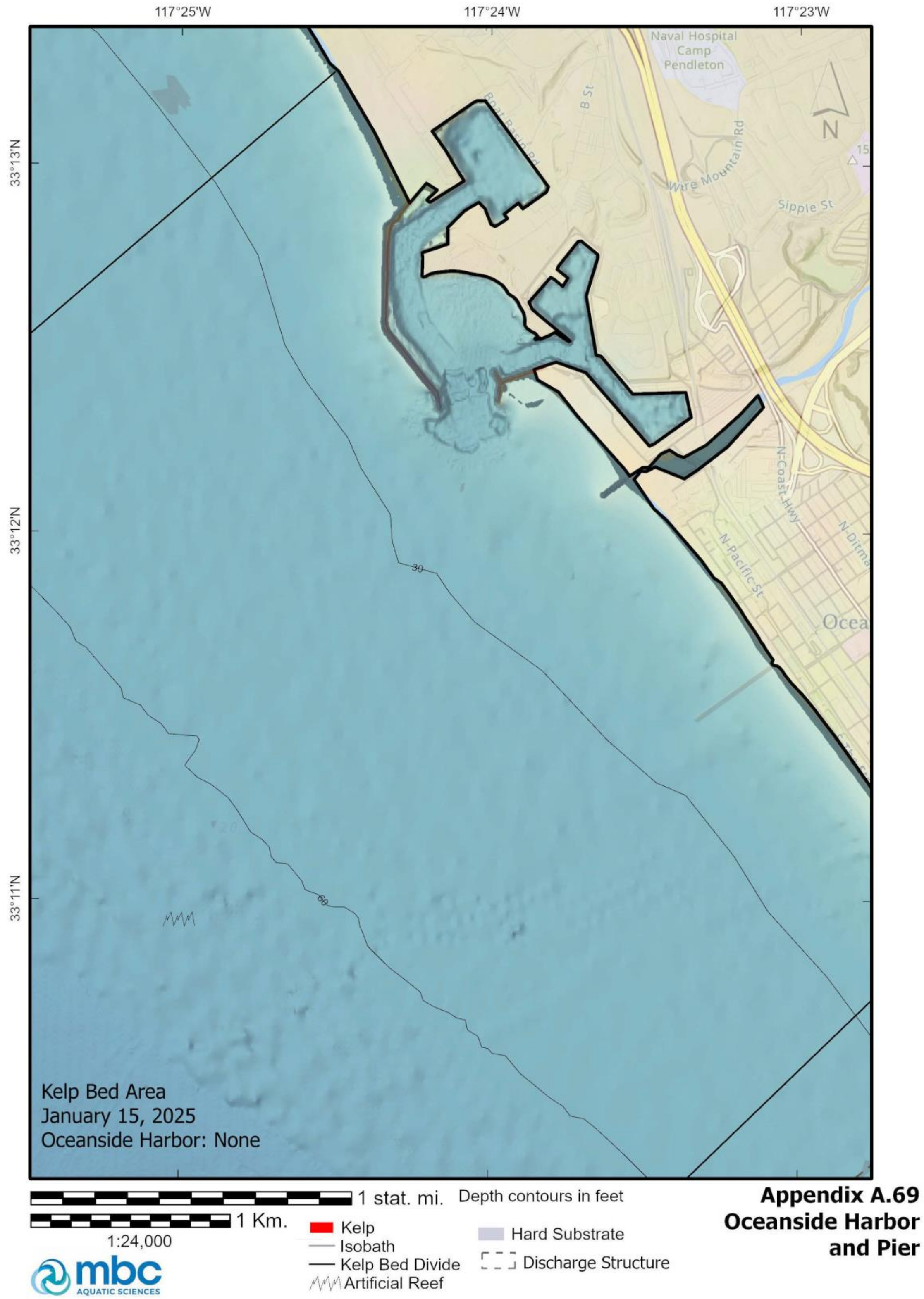
Appendix A.67
Camp Pendleton

Page A-67



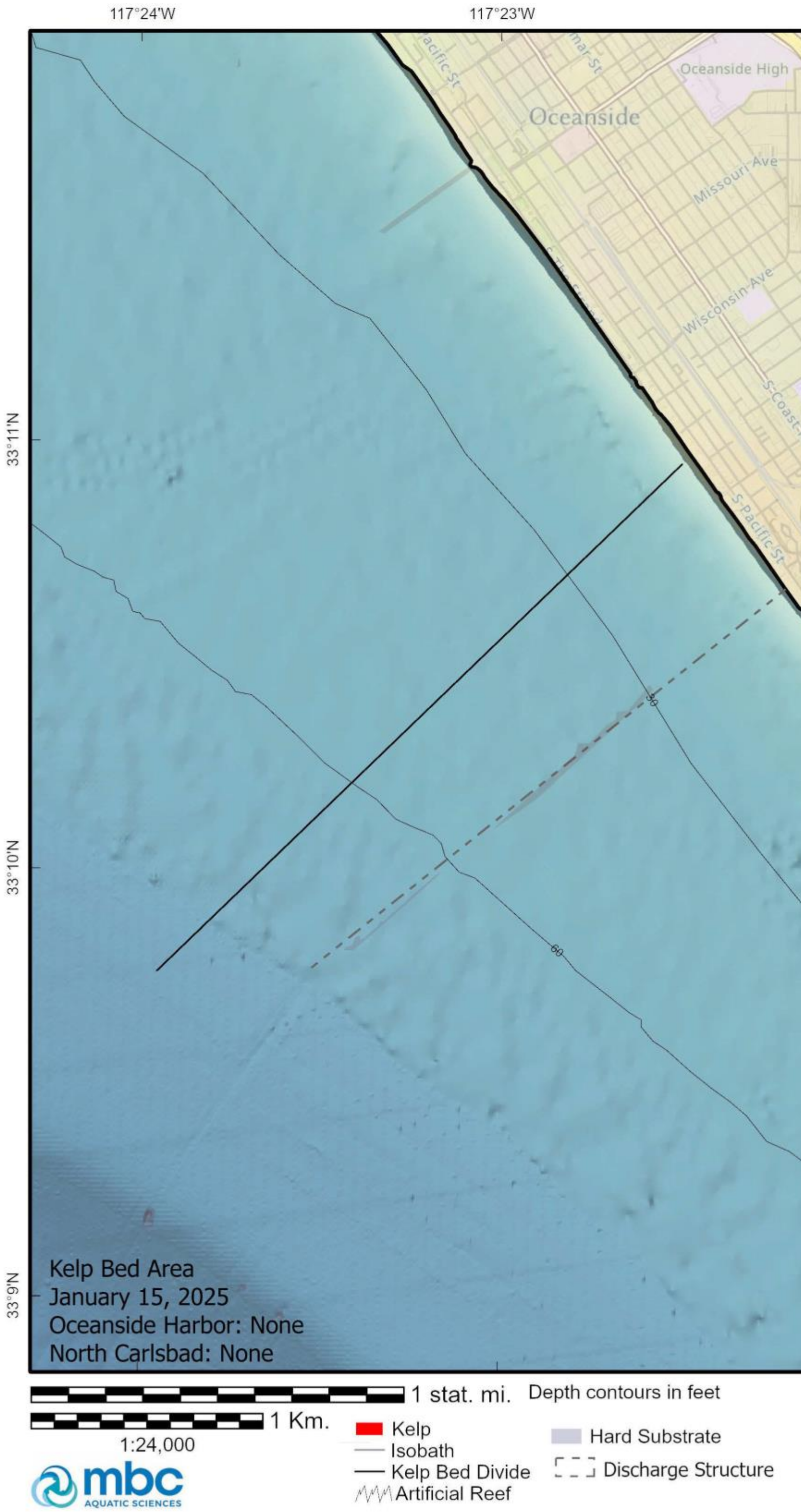
117°27'W
117°26'W
117°25'W
117°24'W
33°14'N
33°13'N
Kelp Bed Area
January 15, 2025
Santa Margarita: None
Oceanside Harbor: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.68
Santa Margarita/
Oceanside Harbor

Page A-68



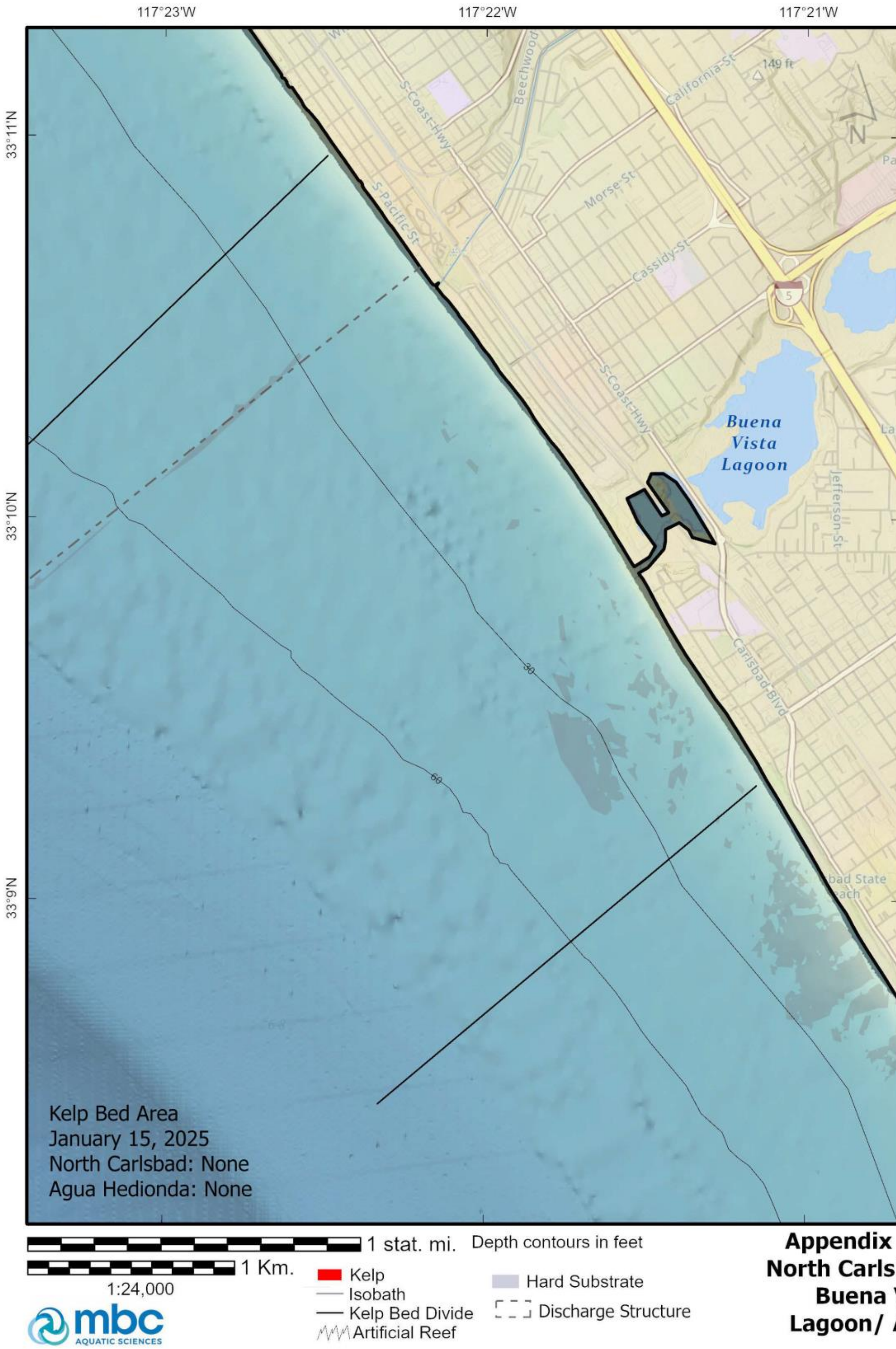
Appendix A.69
Oceanside Harbor and Pier

Page A-69



Appendix A.70 Oceanside Harbor/ Pier/ North Carlsbad

Page A-70



Appendix A.71
North Carlsbad/
Buena Vista
Lagoon/ Agua

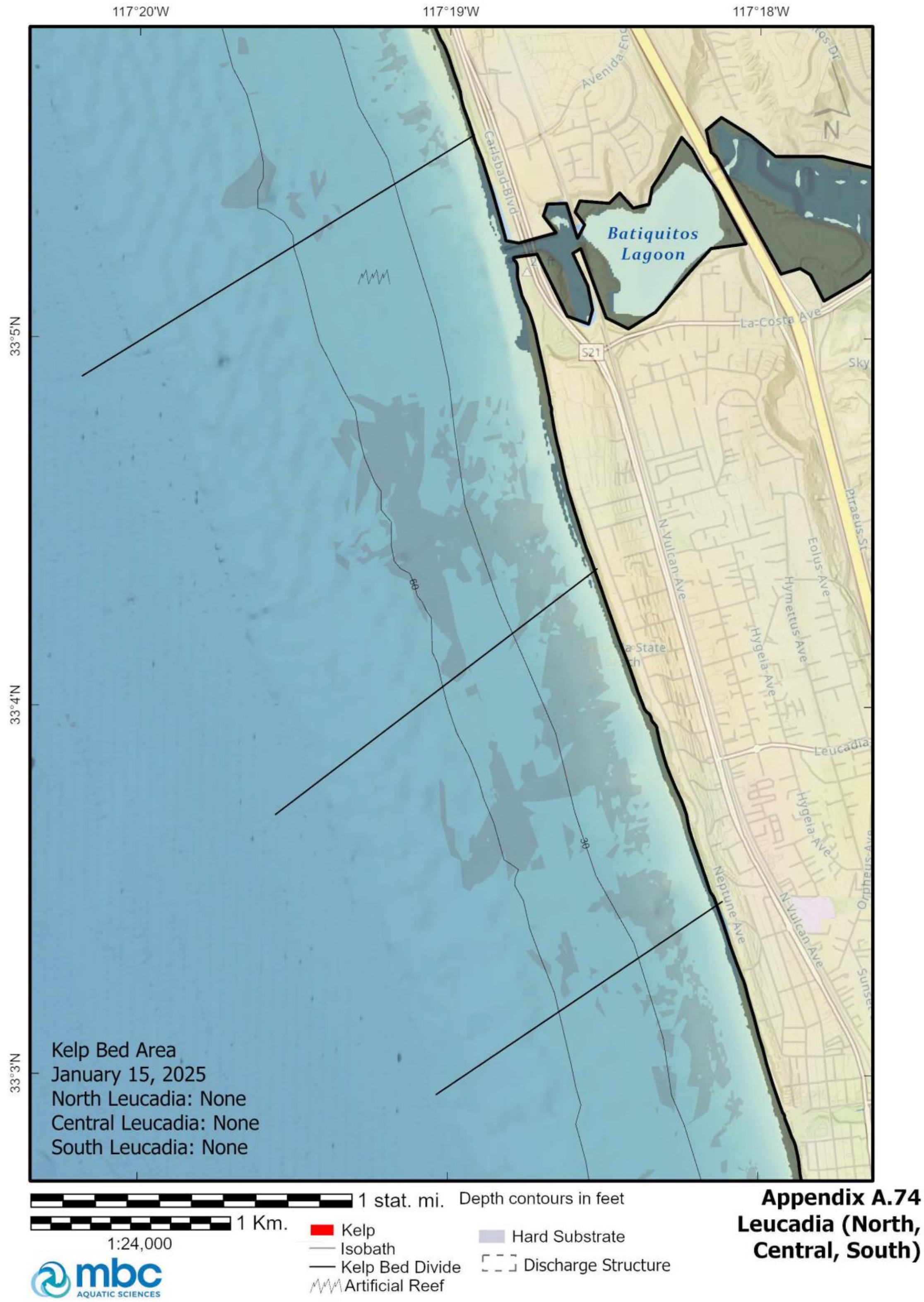
Page A-71

Appendix A.72
Encina Power Plant/ Carlsbad State Park

Page A-72

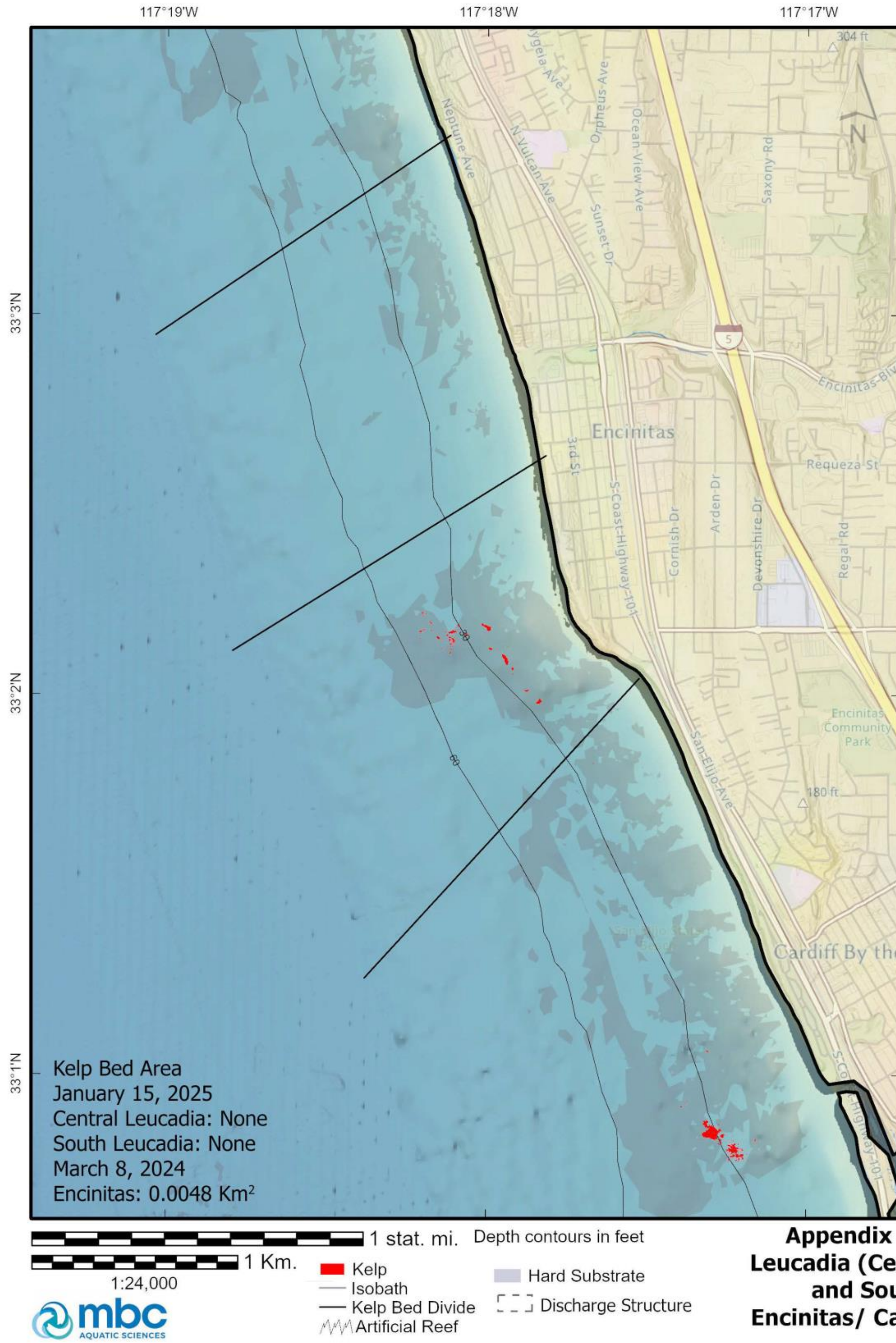

117°21'W
117°20'W
117°19'W
33°7'N
33°6'N
33°5'N
Los Robles Dr
Avenida Encinas
Armada Dr
Legoland California
Paseo del Norte
Poinsettia
South Carlsbad State Beach
Carlsbad Blvd
Avenida Encinas
S21
30
60
N
Kelp Bed Area
January 15, 2025
Encina Power Plant: None
Carlsbad State Park: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.73
Encina Power Plant/ Carlsbad State Park

Page A-73



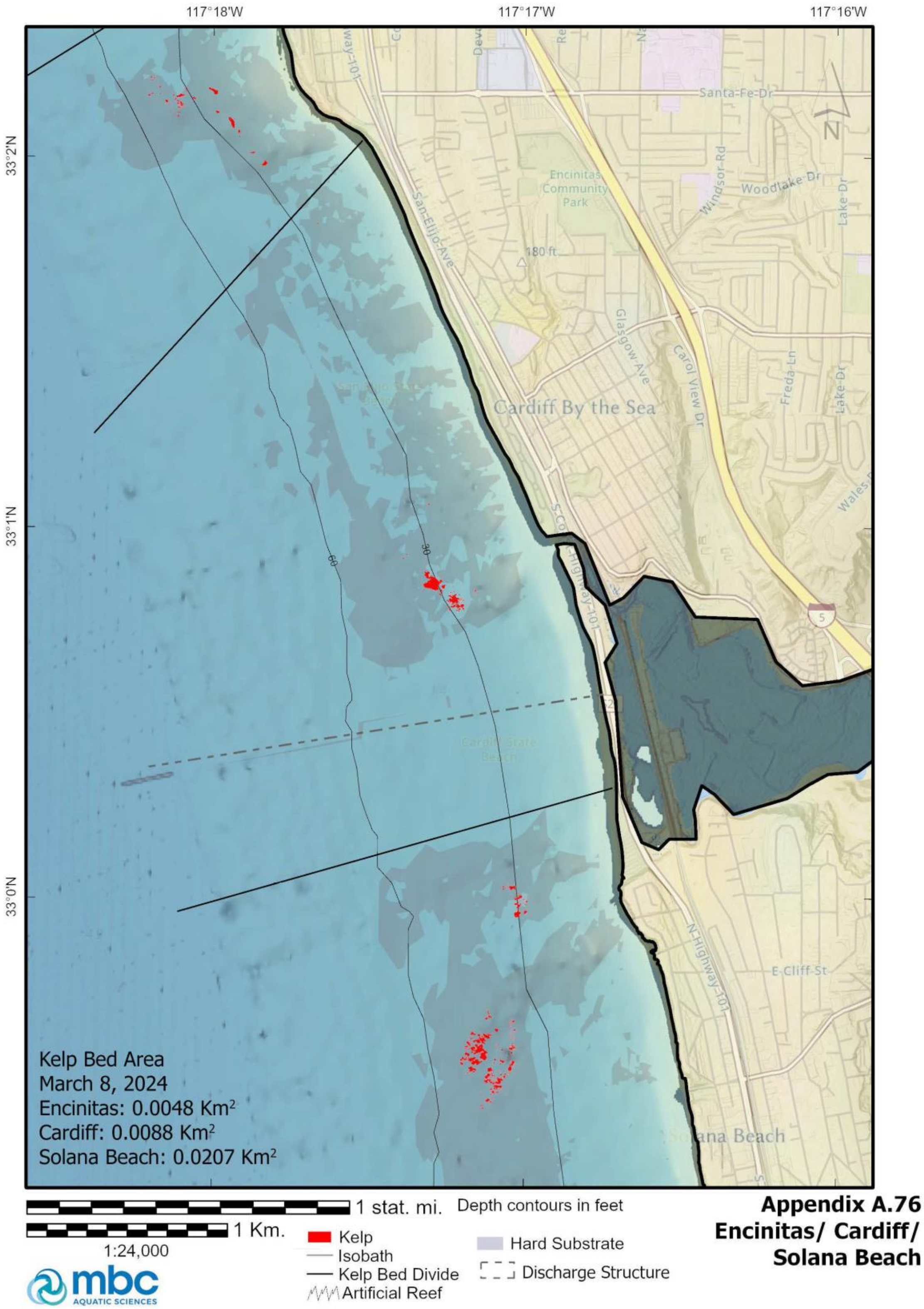
Appendix A.74
Leucadia (North, Central, South)

Page A-74



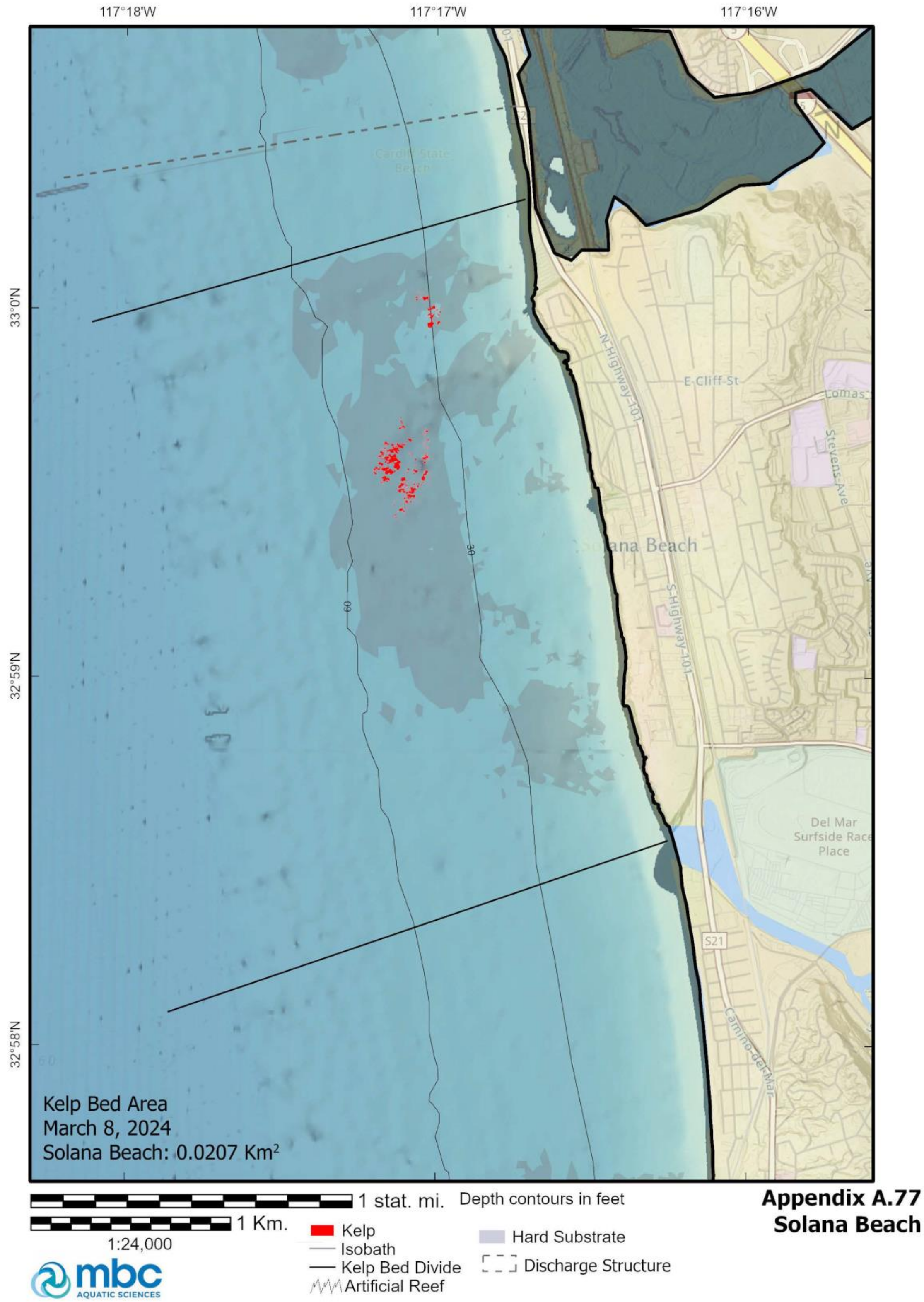
**Appendix A.75
Leucadia (Central and South)/ Encinitas/ Cardiff**

Page A-75



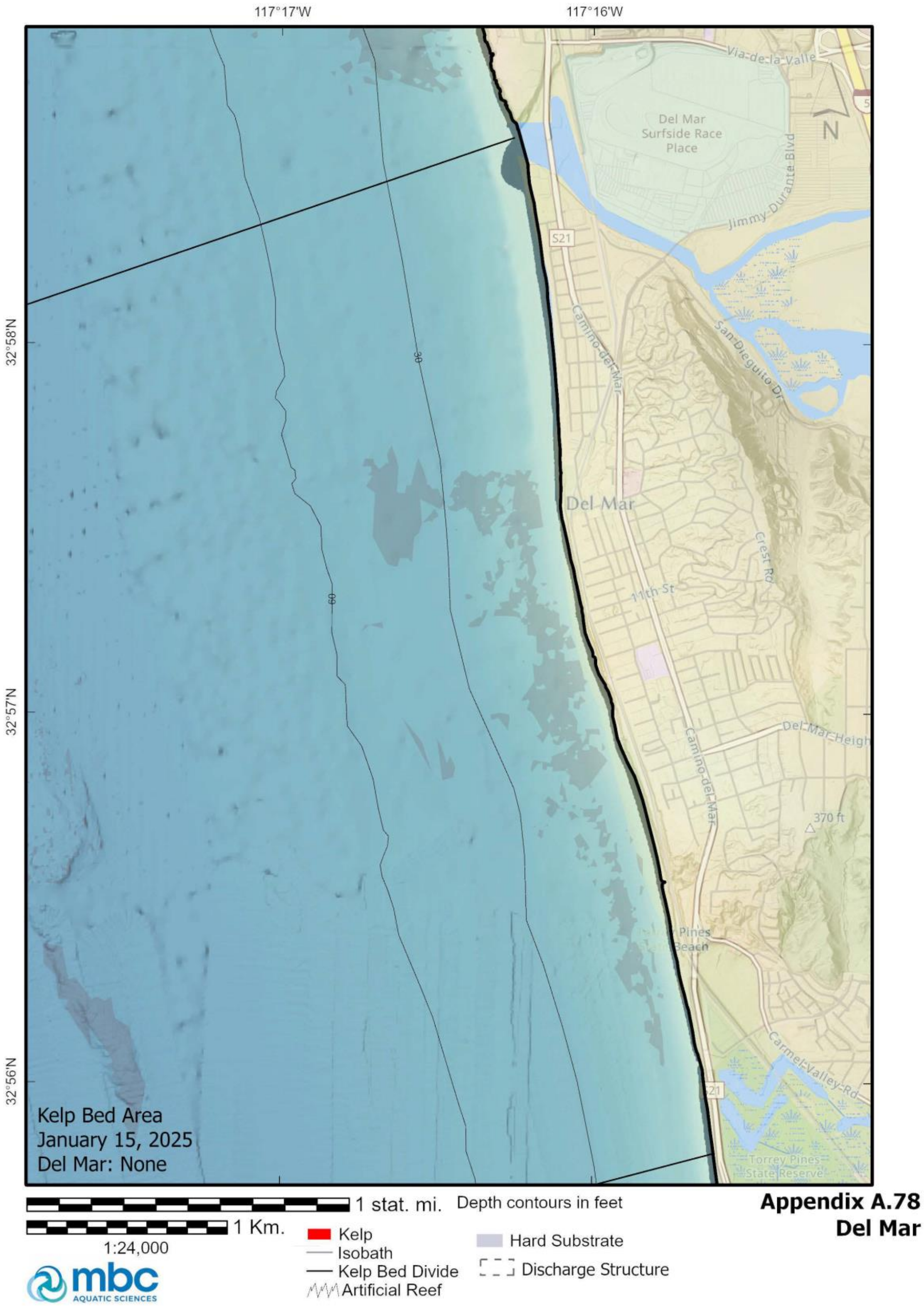
Appendix A.76
Encinitas/ Cardiff/ Solana Beach

Page A-76



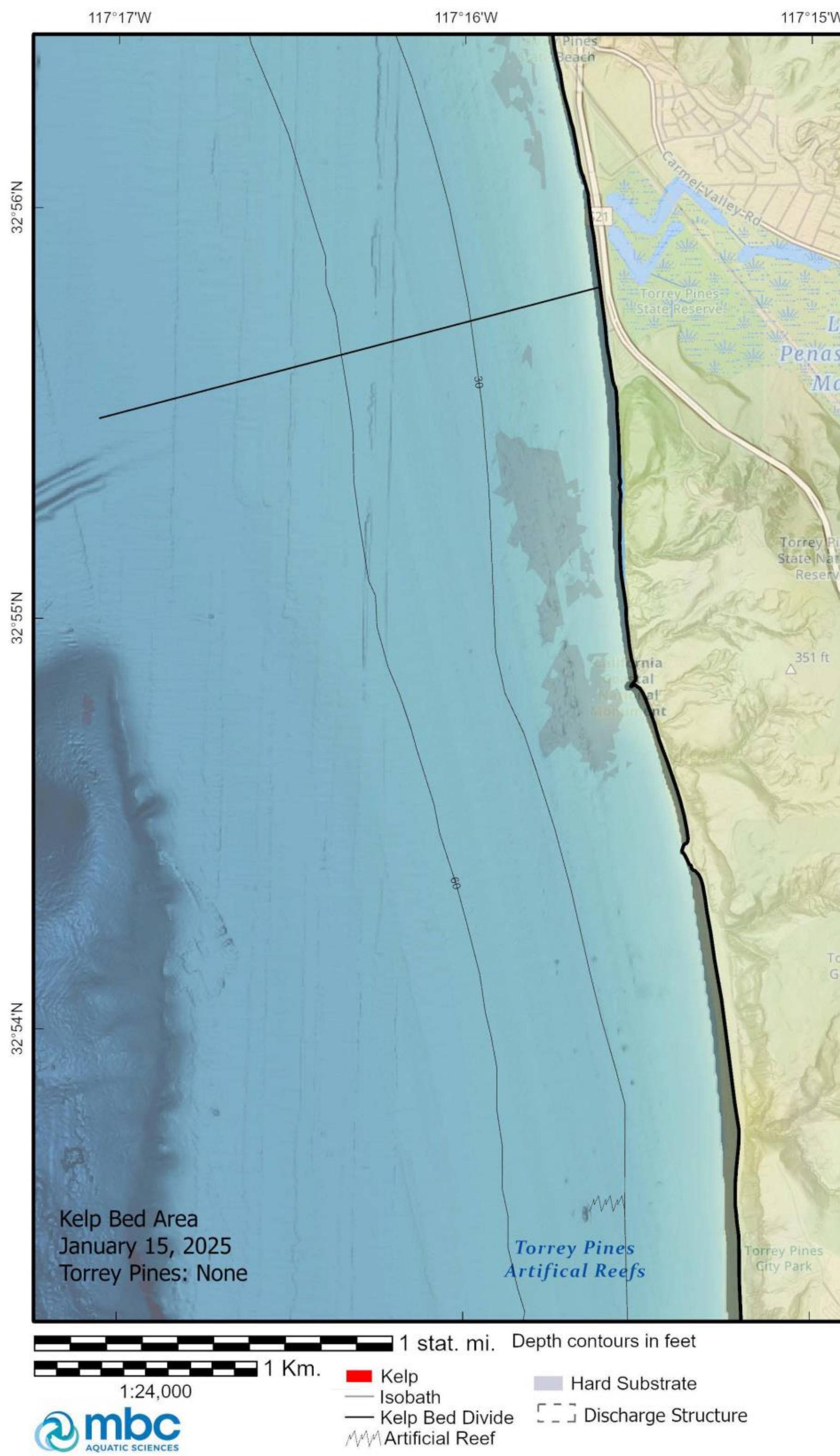
Appendix A.77
Solana Beach

Page A-77



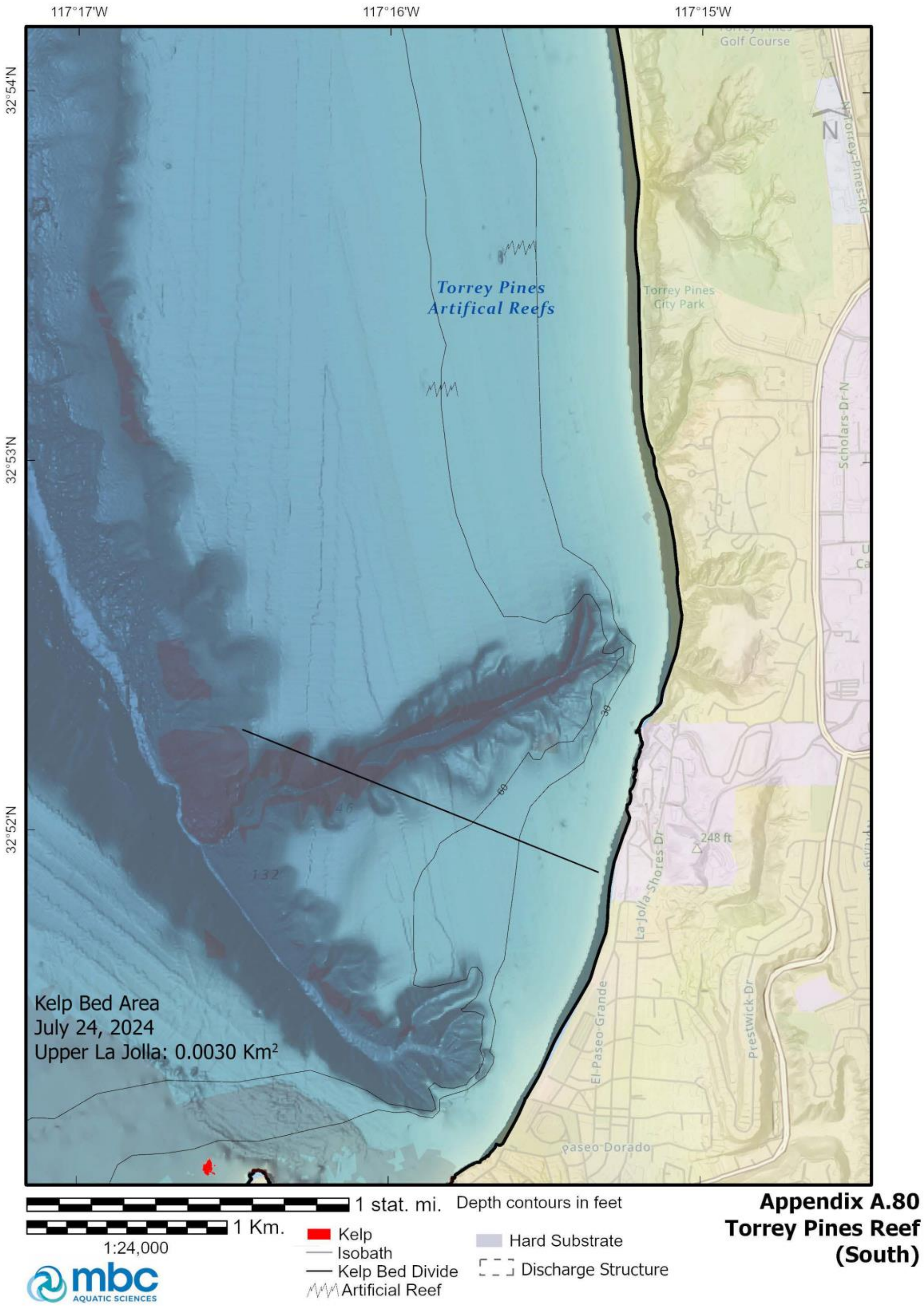
Appendix A.78
Del Mar

Page A-78



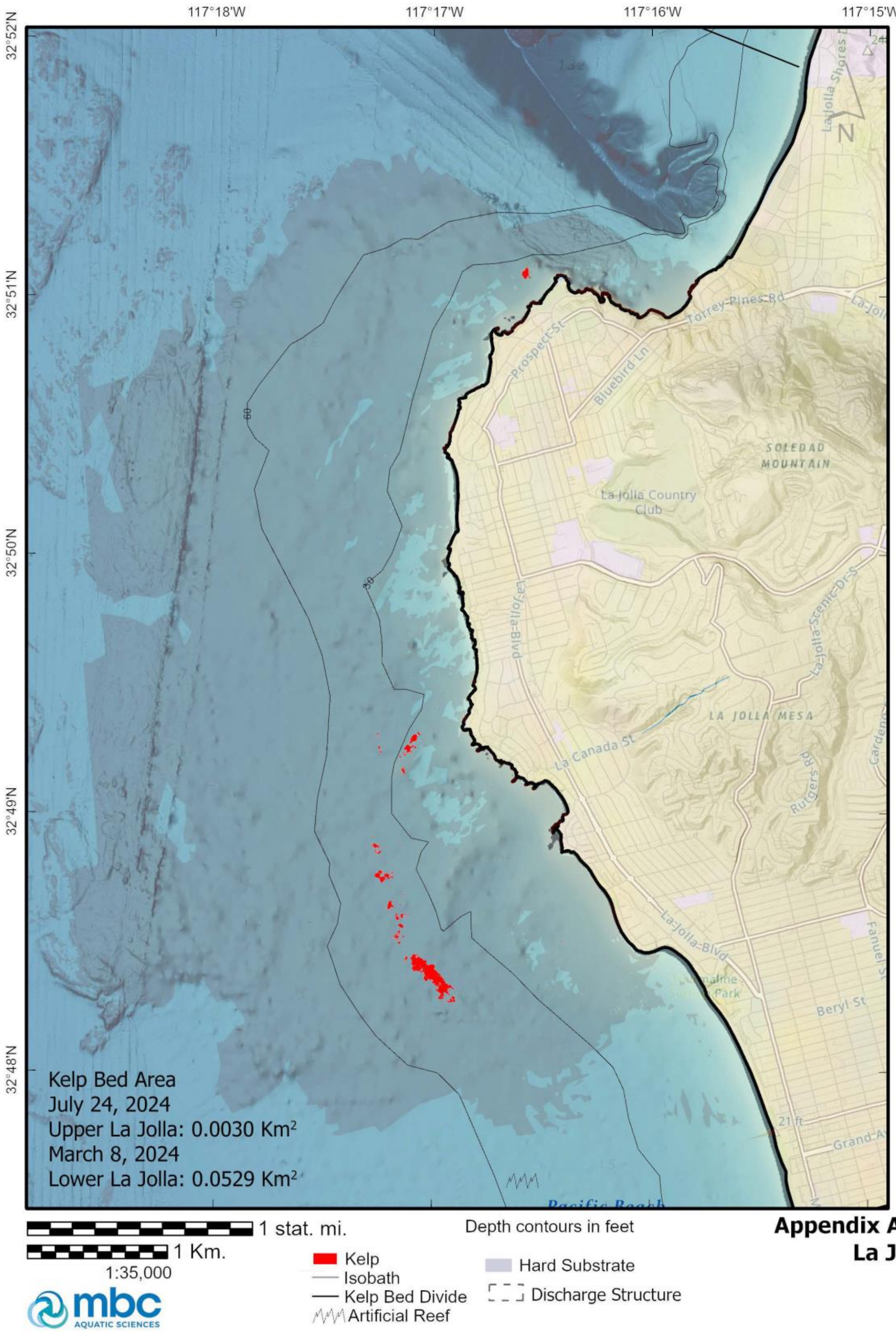
Appendix A.79
Torrey Pines
(North)

Page A-79



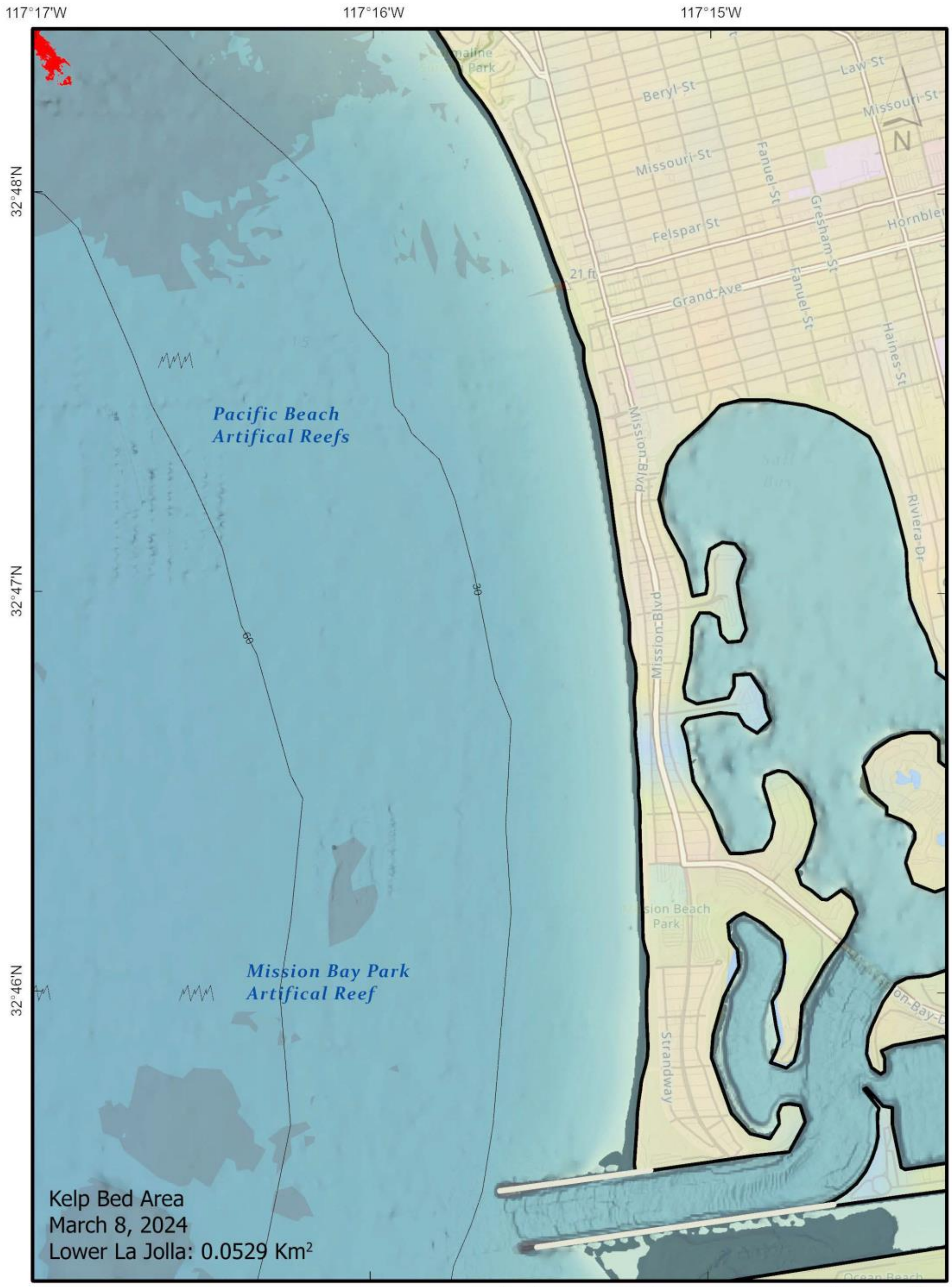
Appendix A.80
Torrey Pines Reef (South)

Page A-80



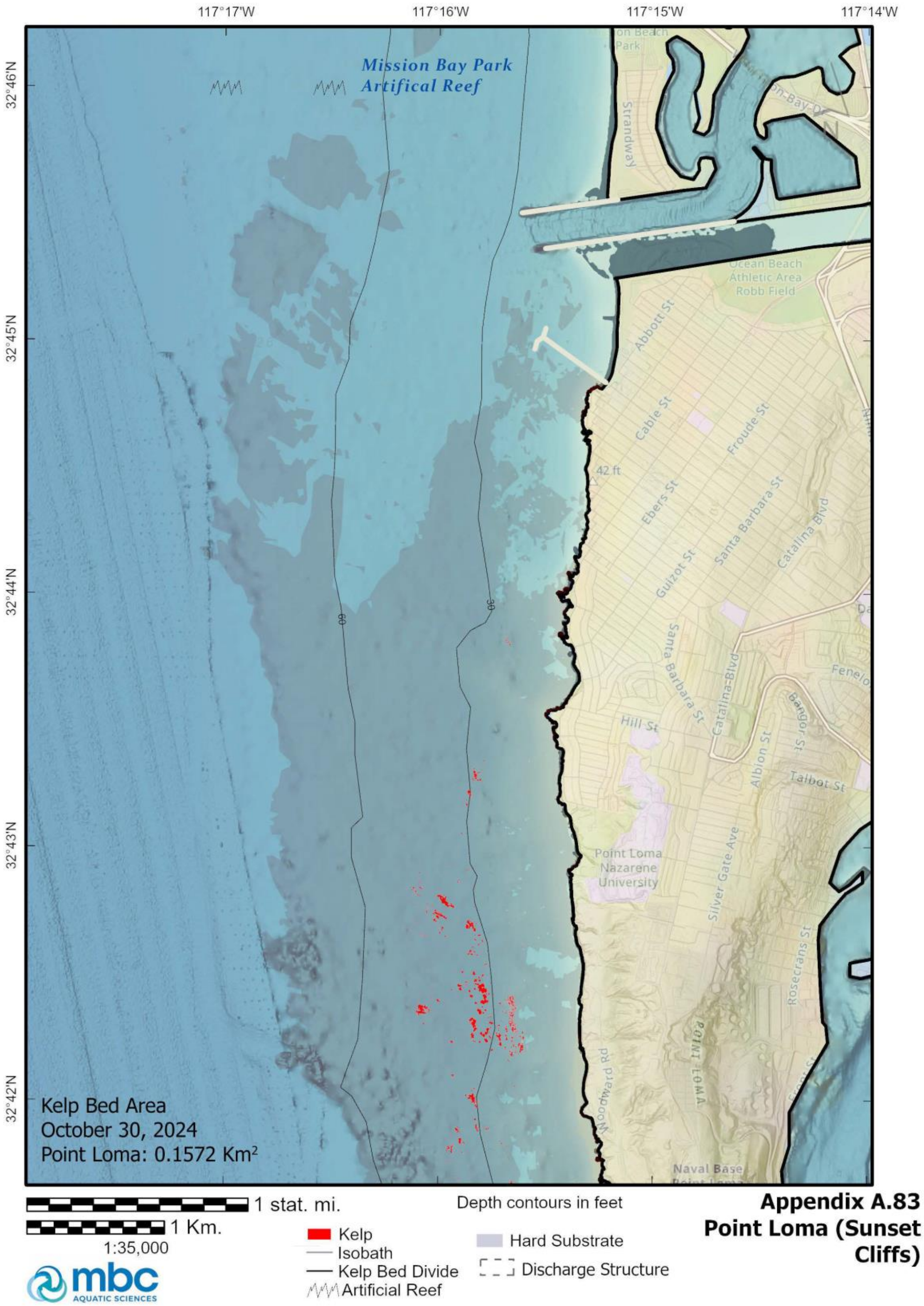
Appendix A.81
La Jolla

Page A-81



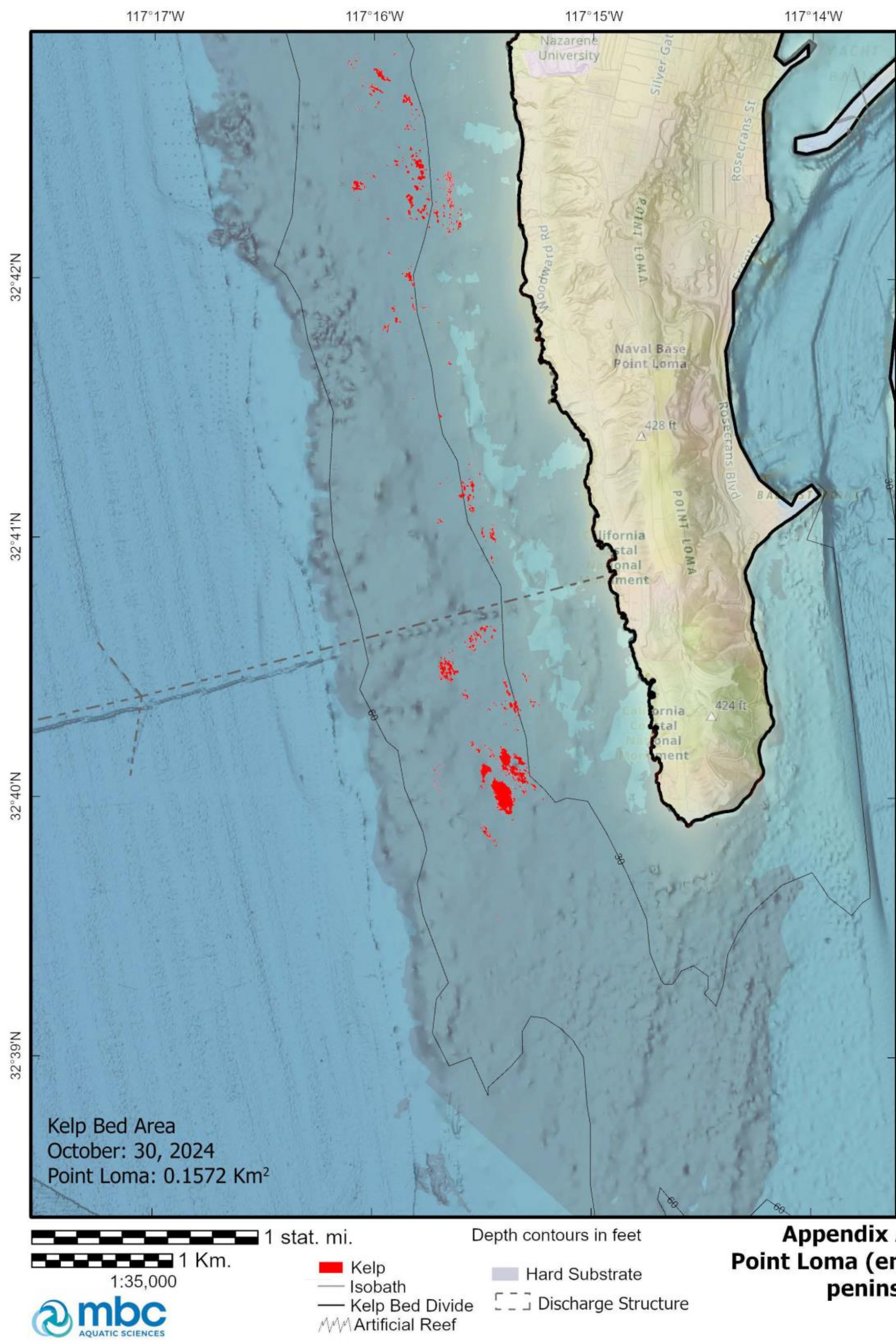
Appendix A.82
La Jolla/ Mission Bay

Page A-82



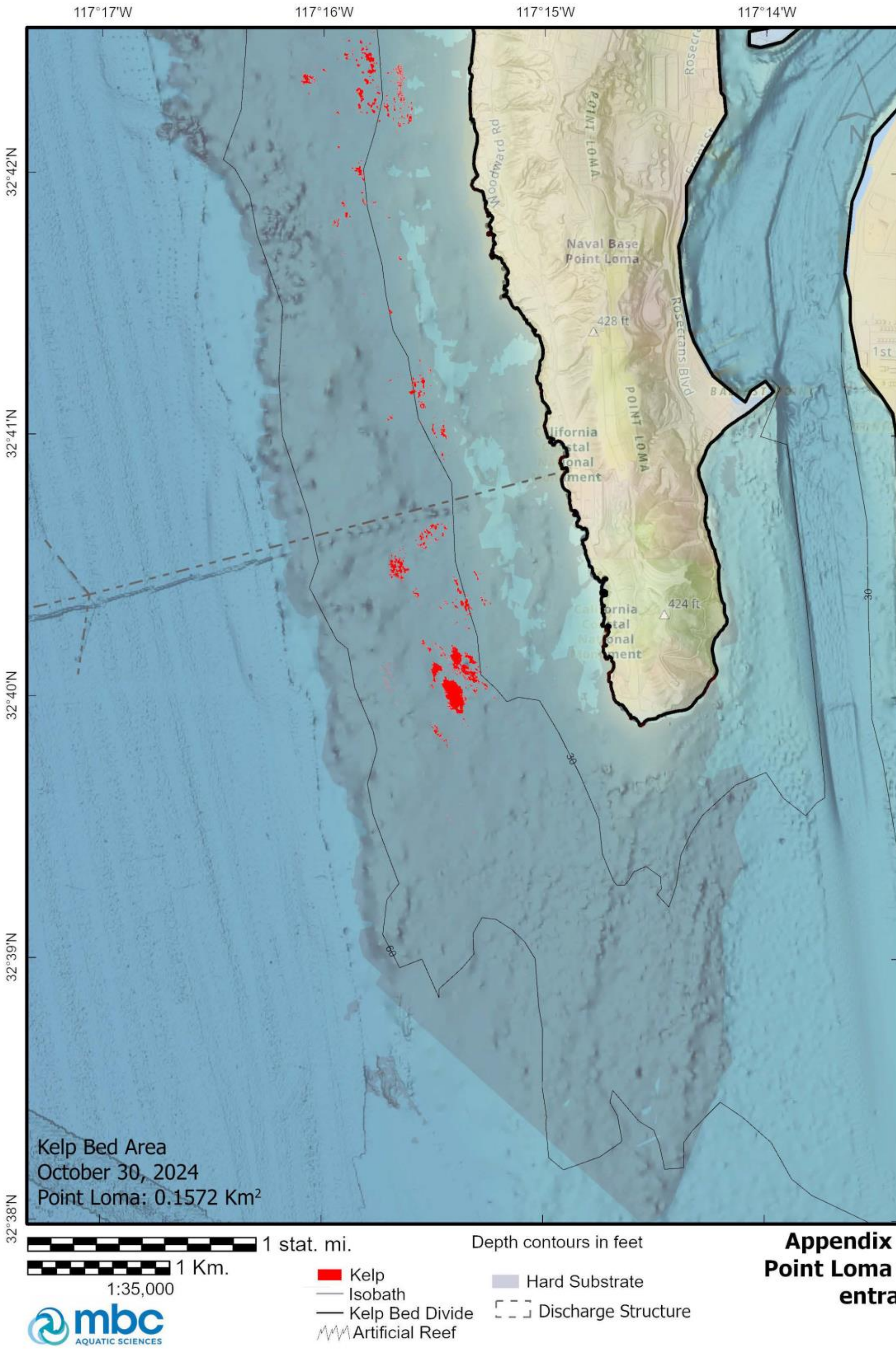
Appendix A.83
Point Loma (Sunset Cliffs)

Page A-83



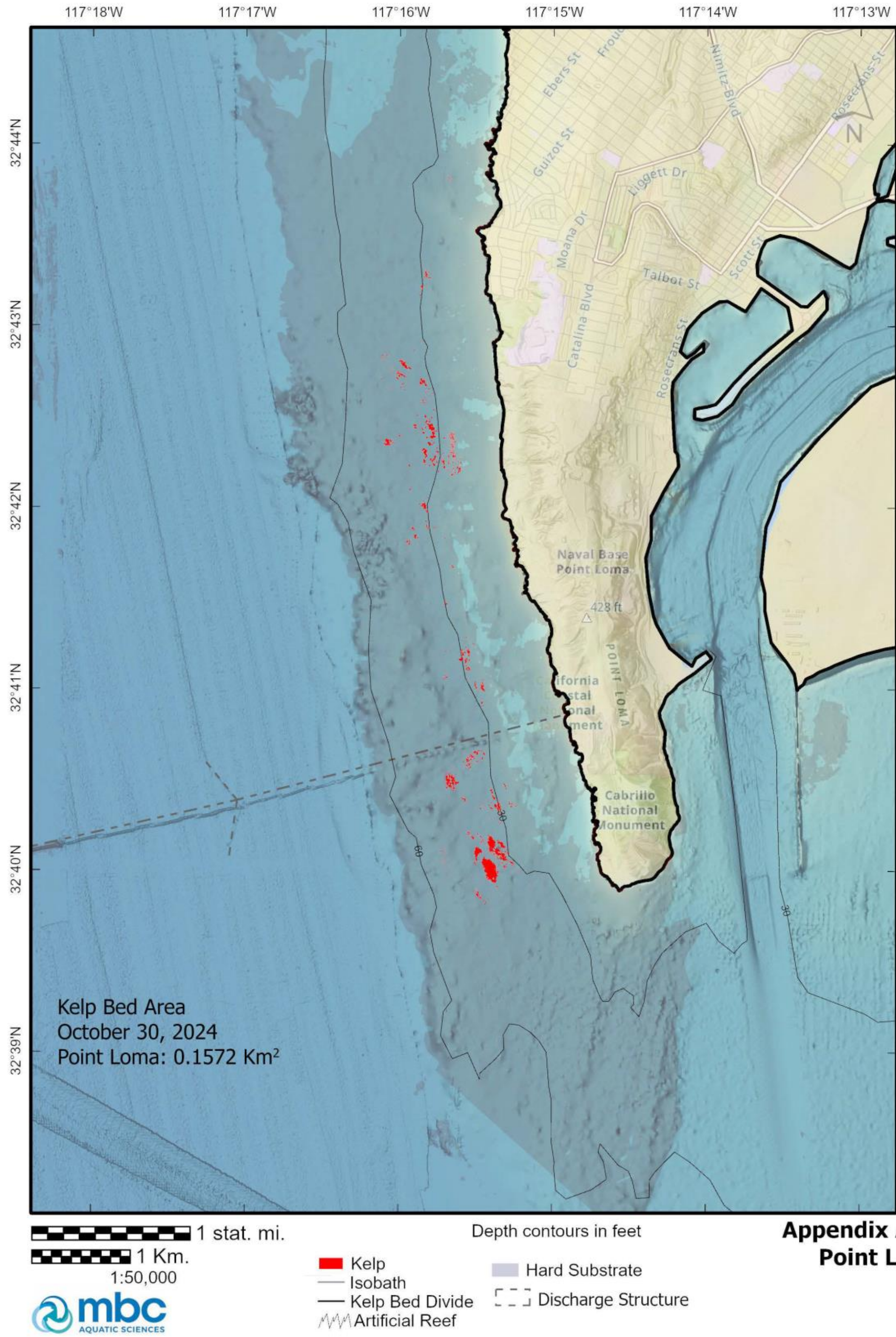
Appendix A.84
Point Loma (end of peninsula)

Page A-84



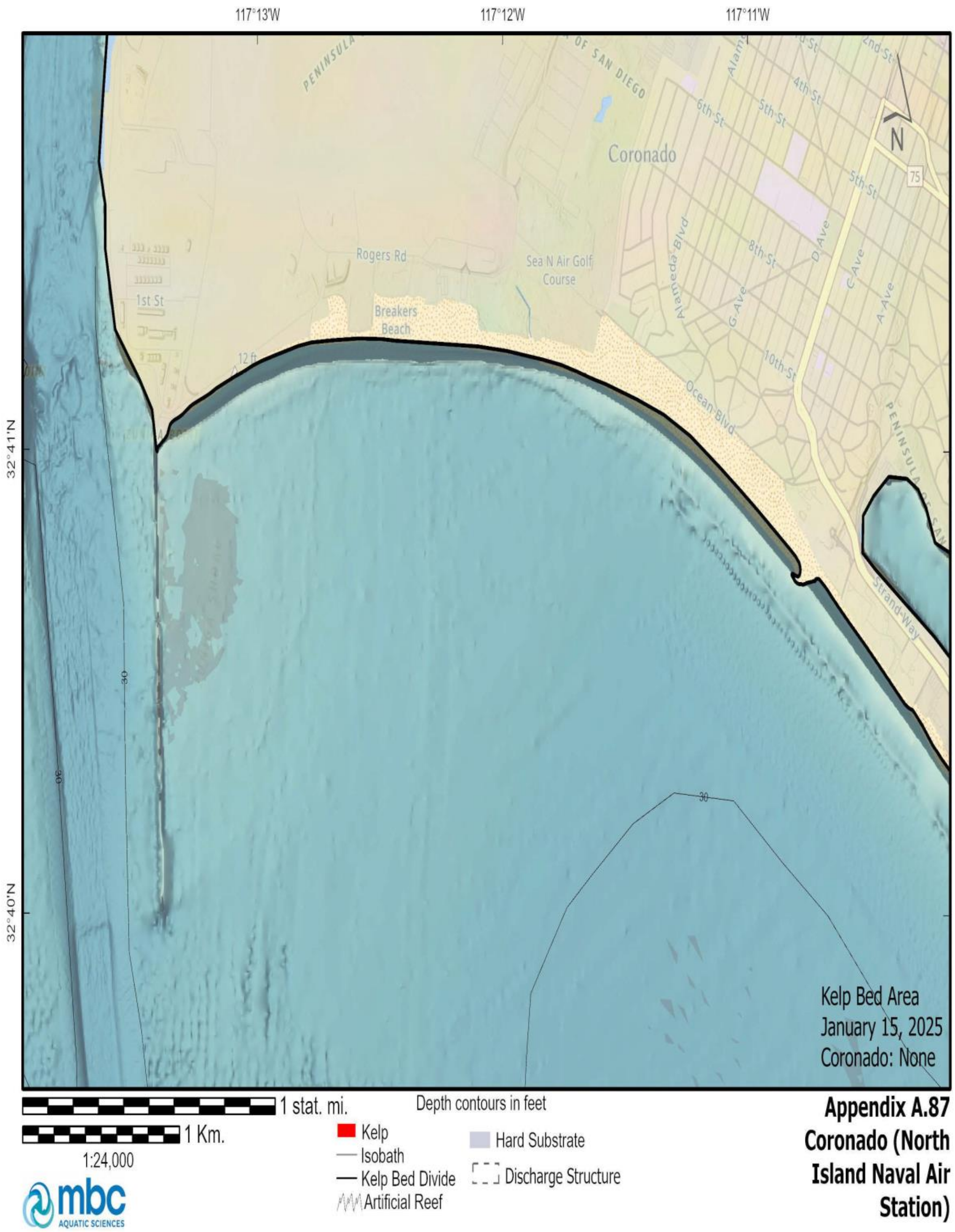
Appendix A.85
Point Loma (bay entrance)

Page A-85

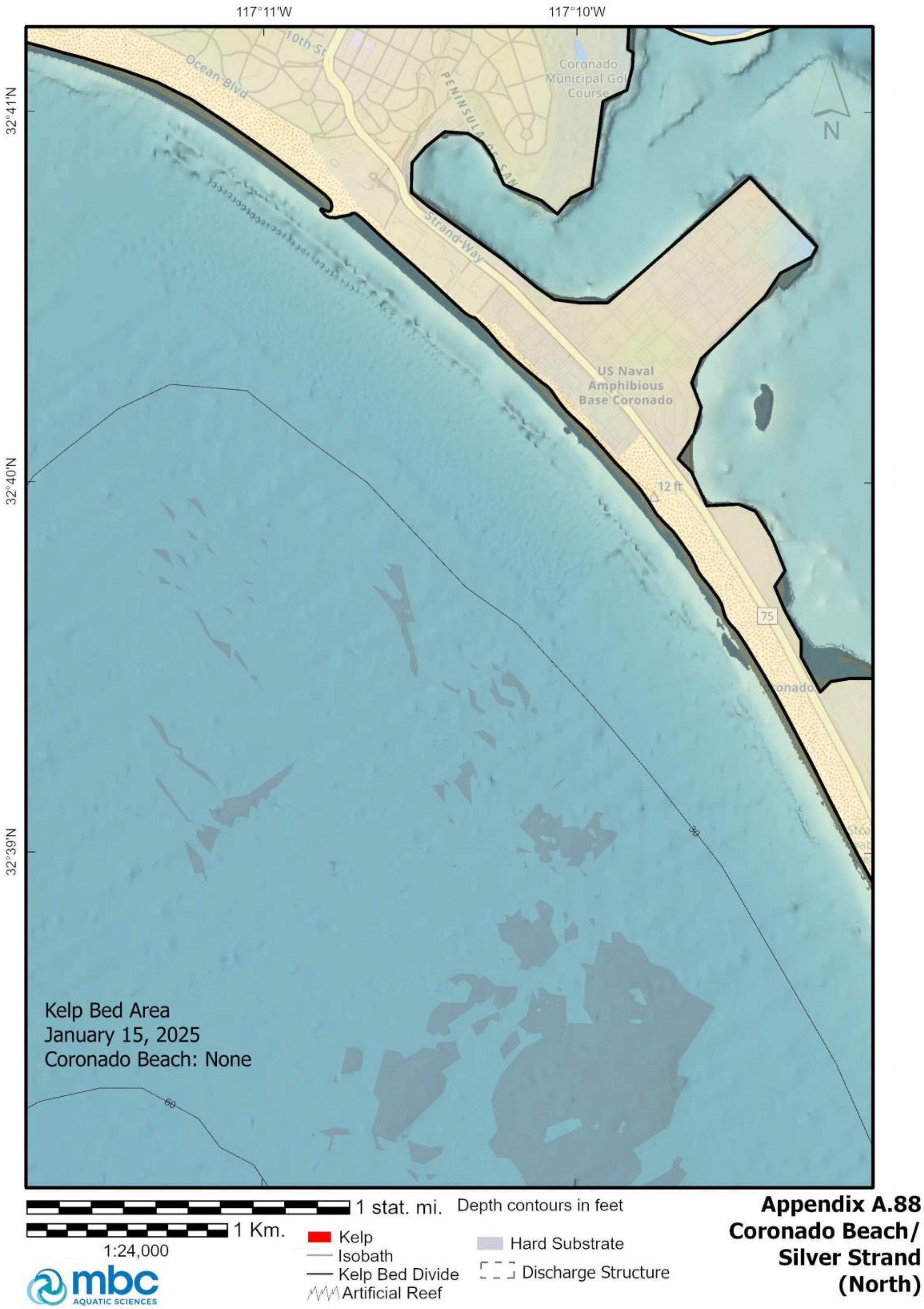


Appendix A.86
Point Loma

Page A-86


117°13'W
117°12'W
117°11'W
32°41'N
32°40'N
Coronado
Rogers Rd
Sea N Air Golf Course
Breakers Beach
1st St
Ocean Blvd
Strand Way
N
30
Kelp Bed Area
January 15, 2025
Coronado: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.87
Coronado (North Island Naval Air Station)

Page A-87

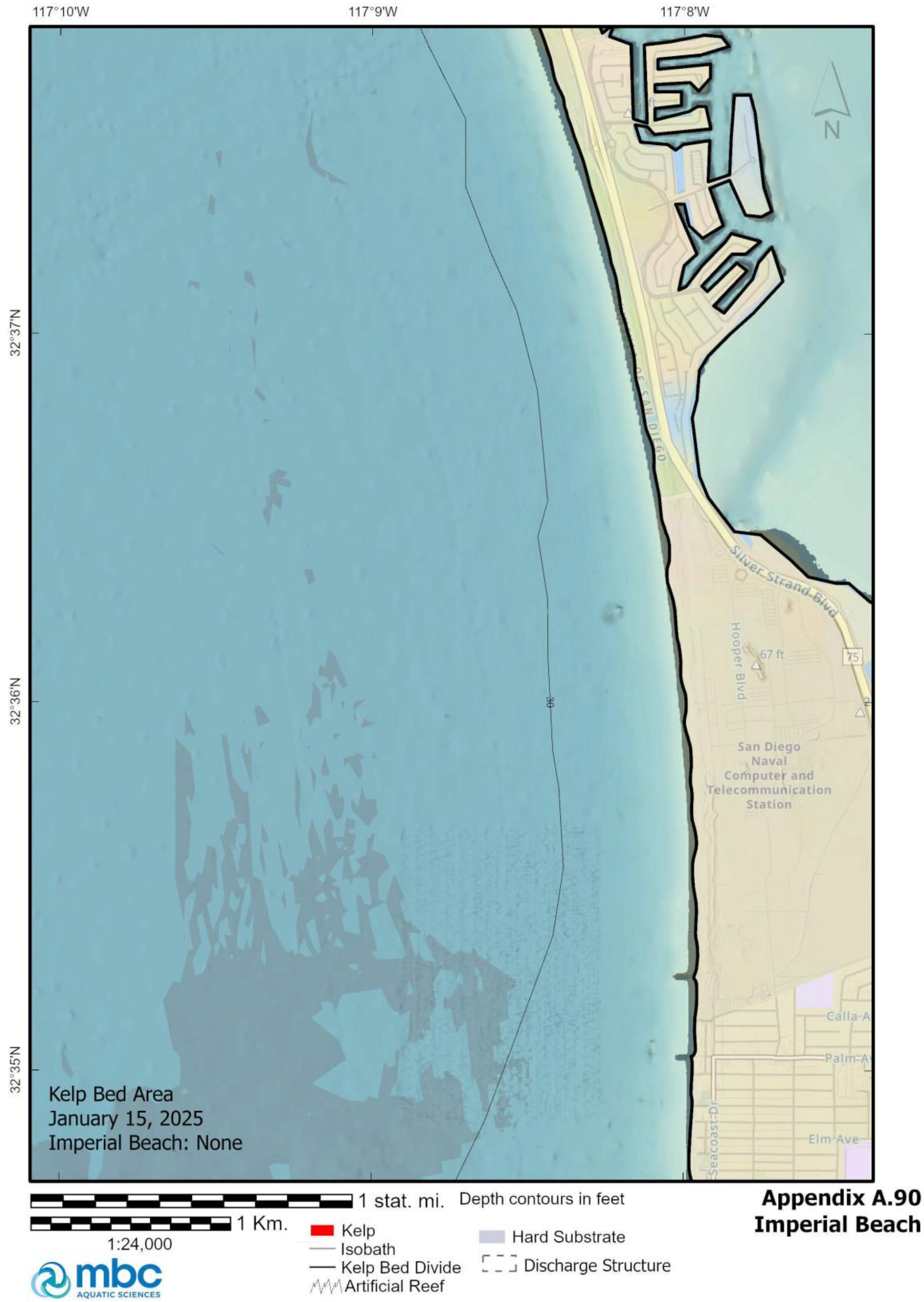


Appendix A.88 Coronado Beach/ Silver Strand (North)

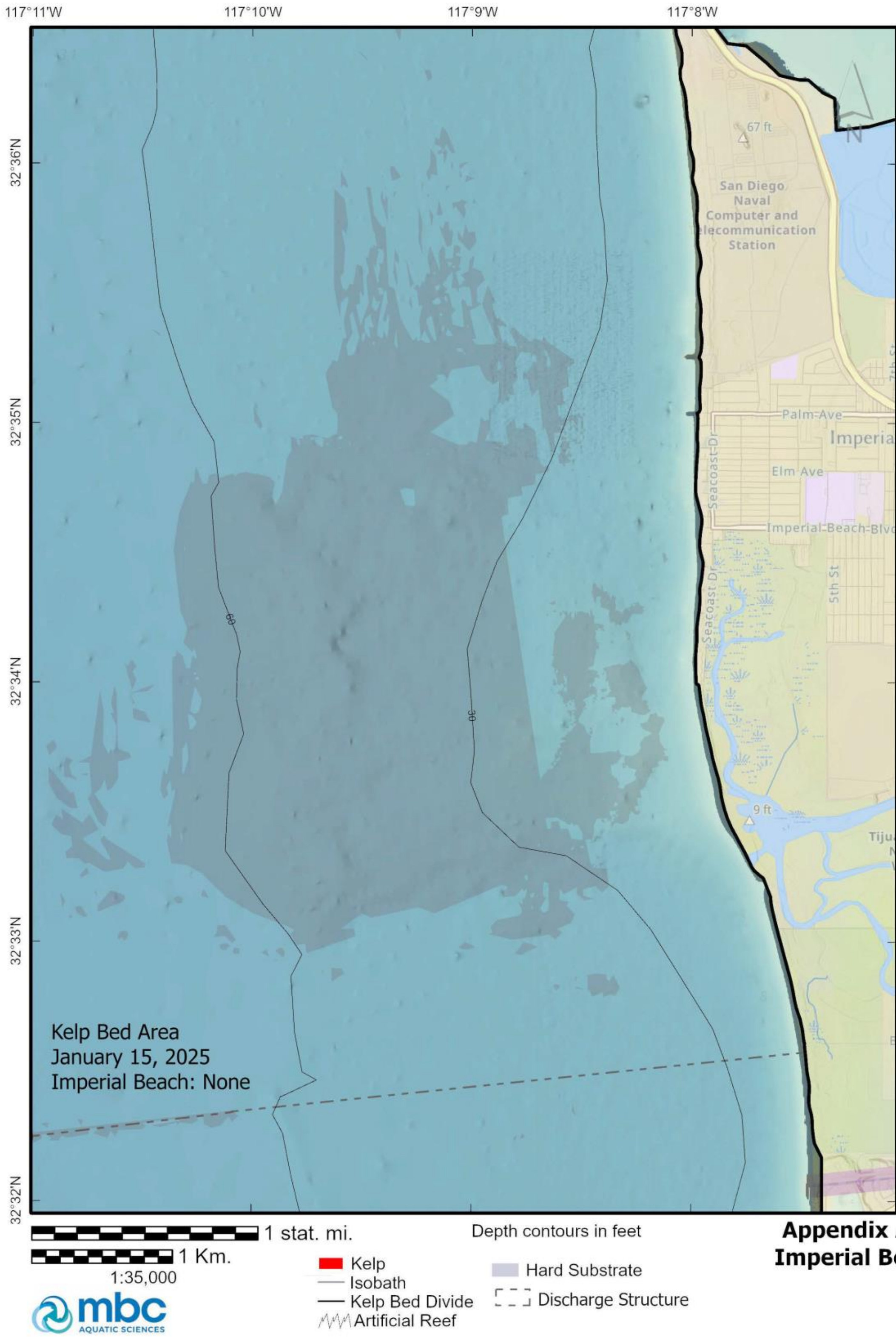
Page A-88

Appendix A.89
Coronado Beach/ Silver Strand (Central)

Page A-89

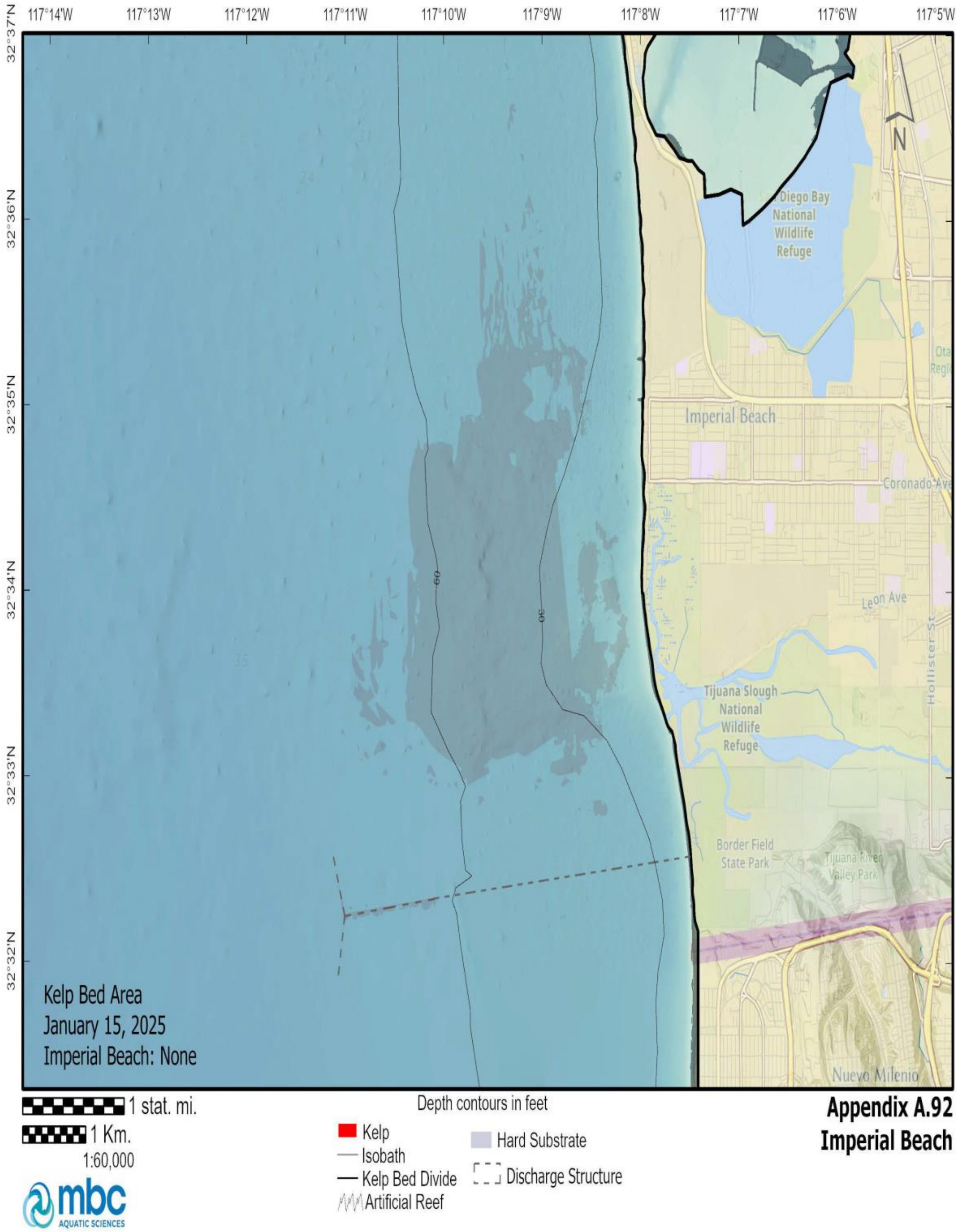

117°10'W
117°9'W
117°8'W
32°37'N
32°36'N
32°35'N
N
Silver Strand Blvd
Hooper Blvd
67 ft
75
San Diego Naval Computer and Telecommunication Station
Calla-A
Palm-A
Elm Ave
Seacoast-Dr
30
Kelp Bed Area
January 15, 2025
Imperial Beach: None
1 stat. mi.
1 Km.
1:24,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.90
Imperial Beach

Page A-90



Appendix A.91 Imperial Beach

Page A-91


117°14'W
117°13'W
117°12'W
117°11'W
117°10'W
117°9'W
117°8'W
117°7'W
117°6'W
117°5'W
32°37'N
32°36'N
32°35'N
32°34'N
32°33'N
32°32'N
Diego Bay National Wildlife Refuge
Imperial Beach
Coronado Ave
Leon Ave
Hollister St
Tijuana Slough National Wildlife Refuge
Border Field State Park
Tijuana River Valley Park
Nuevo Milenio
N
60
30
Kelp Bed Area
January 15, 2025
Imperial Beach: None
1 stat. mi.
1 Km.
1:60,000
Depth contours in feet
Kelp
Isobath
Kelp Bed Divide
Artificial Reef
Hard Substrate
Discharge Structure
Appendix A.92
Imperial Beach

Page A-92

APPENDIX B

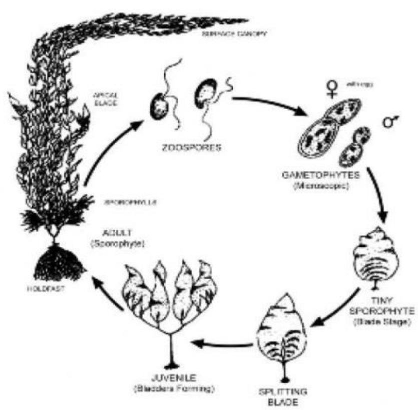
LIFE HISTORY OF GIANT KELP
HISTORICAL KELP SURVEYS
CRANDALL'S MAPS

Appendix B.1

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

Page B-1

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).

Page B-7

Appendix B.3 (Cont.).

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

Appendix B.3 (Cont.).

	Canopy Area (km²)											
Kelp Bed	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

Page B-9

Appendix B.3 (Cont.).

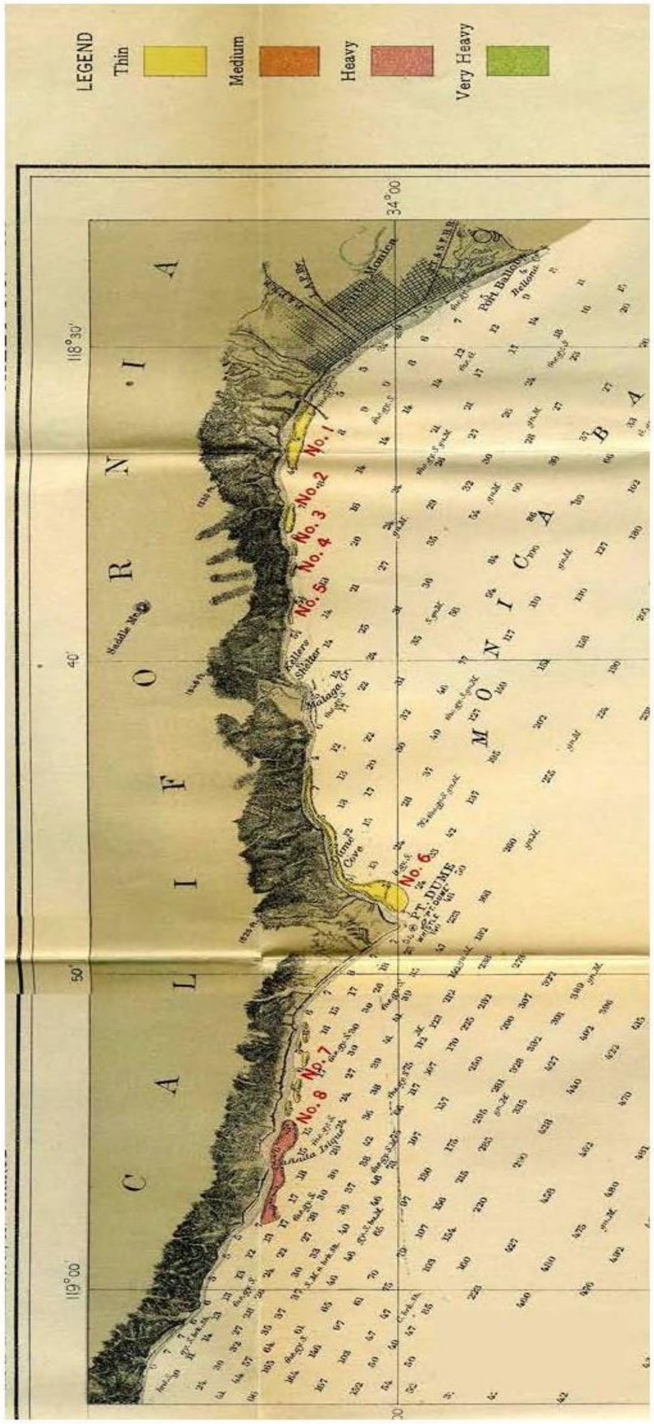
Kelp Bed	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
North Laguna Beach	0.005	0.093	0.147	0.192	0.142	0.120	0.080	0.074	0.096	0.133	0.015
South Laguna Beach	0.058	0.098	0.221	0.214	0.273	0.165	0.048	0.035	0.032	0.131	0.007
South Laguna	0.017	0.023	0.018	0.017	0.038	0.031	0.016	0.006	0.003	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

Page B-10

Appendix B.3 (Cont.)

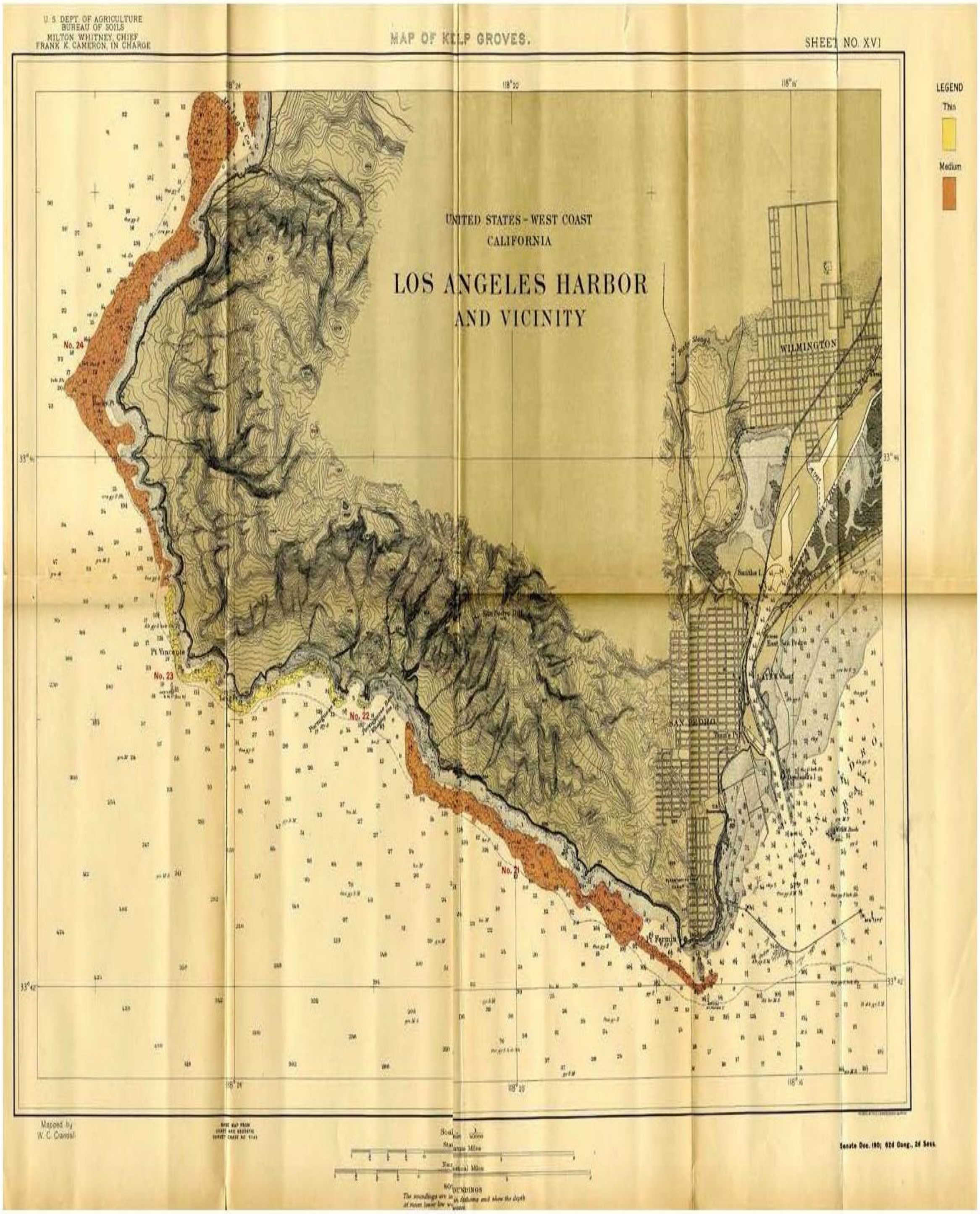
Kelp Bed	2020	2021	2022	2023	2024
North Laguna Beach	0.022	0.031	0.040	0.219	0.169
South Laguna Beach	0.001	0.012	0.005	0.064	0.022
South Laguna	-	0.005	0.001	0.023	0.052
Dana Point-Salt Creek	0.005	0.017	0.002	0.006	0.022
Capistrano Beach	-	0.006	-	0.075	0.059
Total F&W 9	0.028	0.071	0.048	0.388	0.324
San Clemente	0.009	0.004	-	0.001	0.001
San Mateo Point	-	0.007	-	0.0	-
San Onofre	-	-	-	-	-
Total F&W 8	0.009	0.011	0.000	0.001	0.01
Horno Canyon	0.003	-	-	-	-
Barn Kelp	0.234	0.262	-	-	0.047
Santa Margarita	-	-	-	-	-
Total F&W 7	0.237	0.262	0.000	0.000	0.047
North Carlsbad	-	-	-	-	-
Agua Hedionda	-	-	-	-	-
Encina Power Plant	-	-	-	-	-
Carlsbad State Beach	-	-	-	-	-
Total F&W 6	0.000	0.000	0.000	0.000	0.000
Leucadia	0.006	-	-	0.002	-
Encinitas	0.0003	-	-	0.010	0.005
Cardiff	-	-	-	0.026	0.009
Solana Beach	-	0.006	-	0.006	0.021
Del Mar	-	-	-	-	-
Torrey Pines	-	-	-	-	-
Total F&W 5	0.006	0.006	0.000	0.044	0.035
La Jolla F&W 4	1.094	0.725	0.446	0.067	0.053
Point Loma F&W 3&2	2.545	1.882	1.417	0.324	0.157
Imperial Beach F&W 1	-	-	-	-	-
TOTAL	3.919	2.964	1.911	0.824	

Page B-11



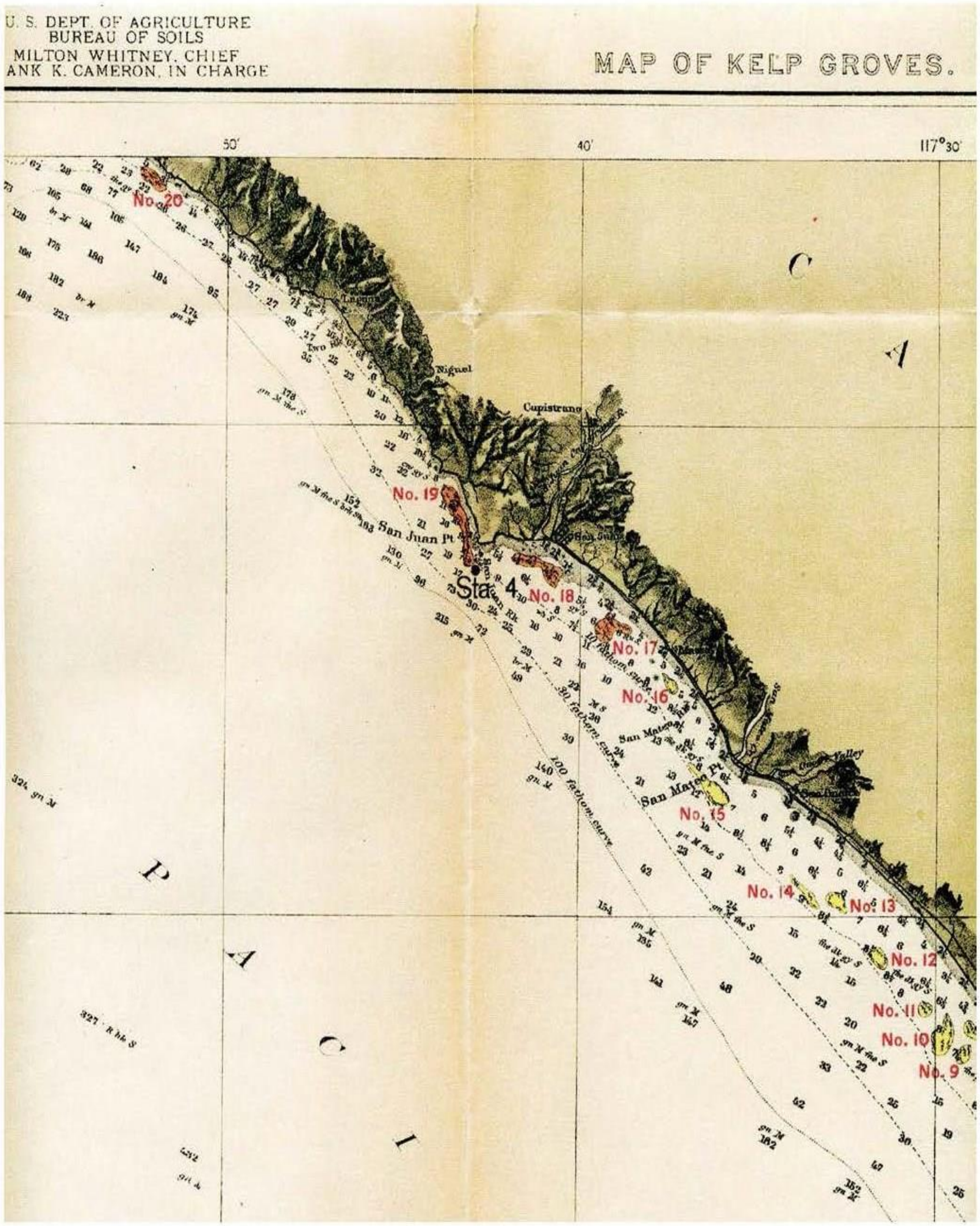
Appendix B.4 Crandall's 1911 kelp survey Deer Creek to Ballona Creek.

Page B-12



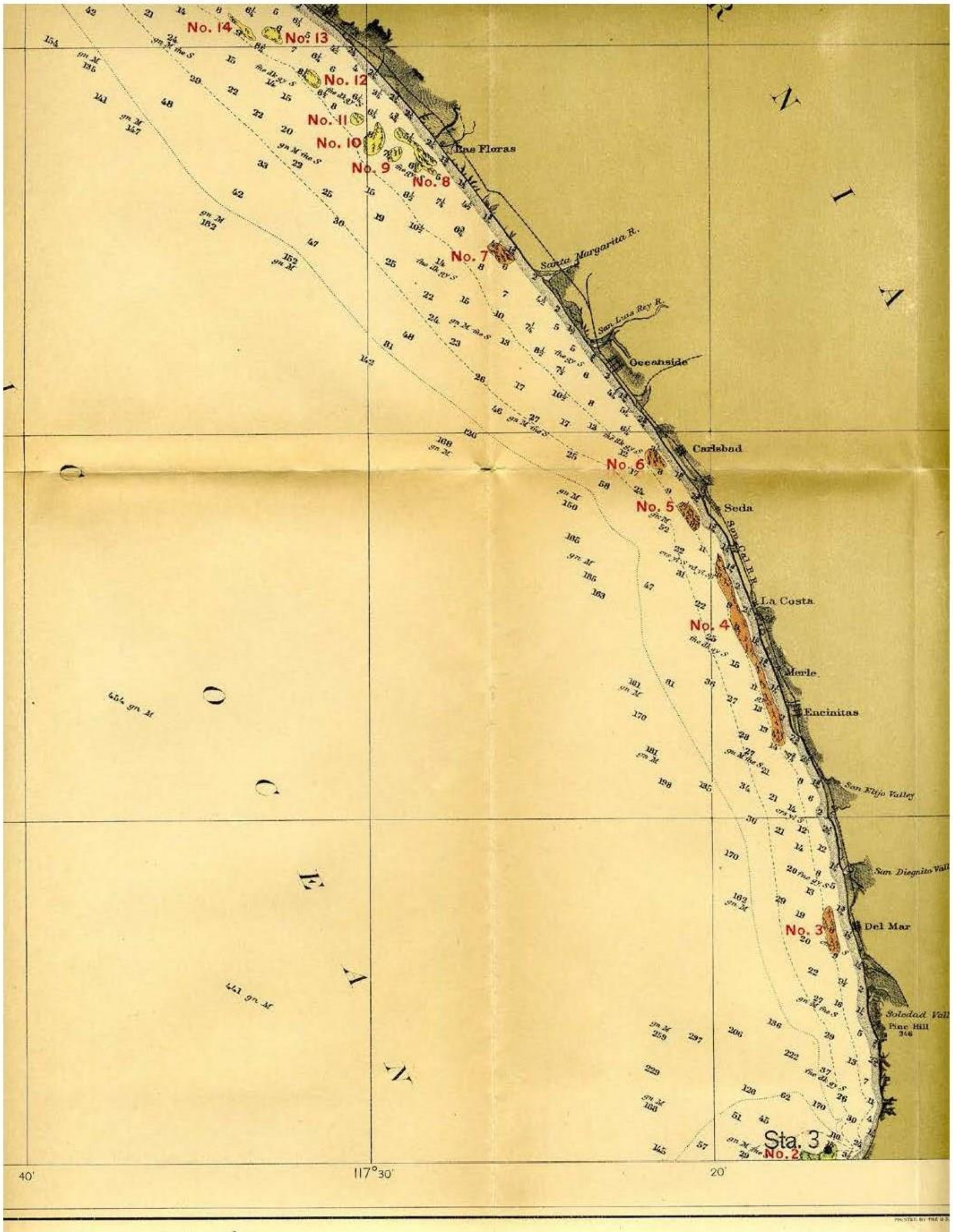
Appendix B.5 Crandall's 1911 kelp survey Palos Verdes to Los Angeles Harbor.

Page B-13



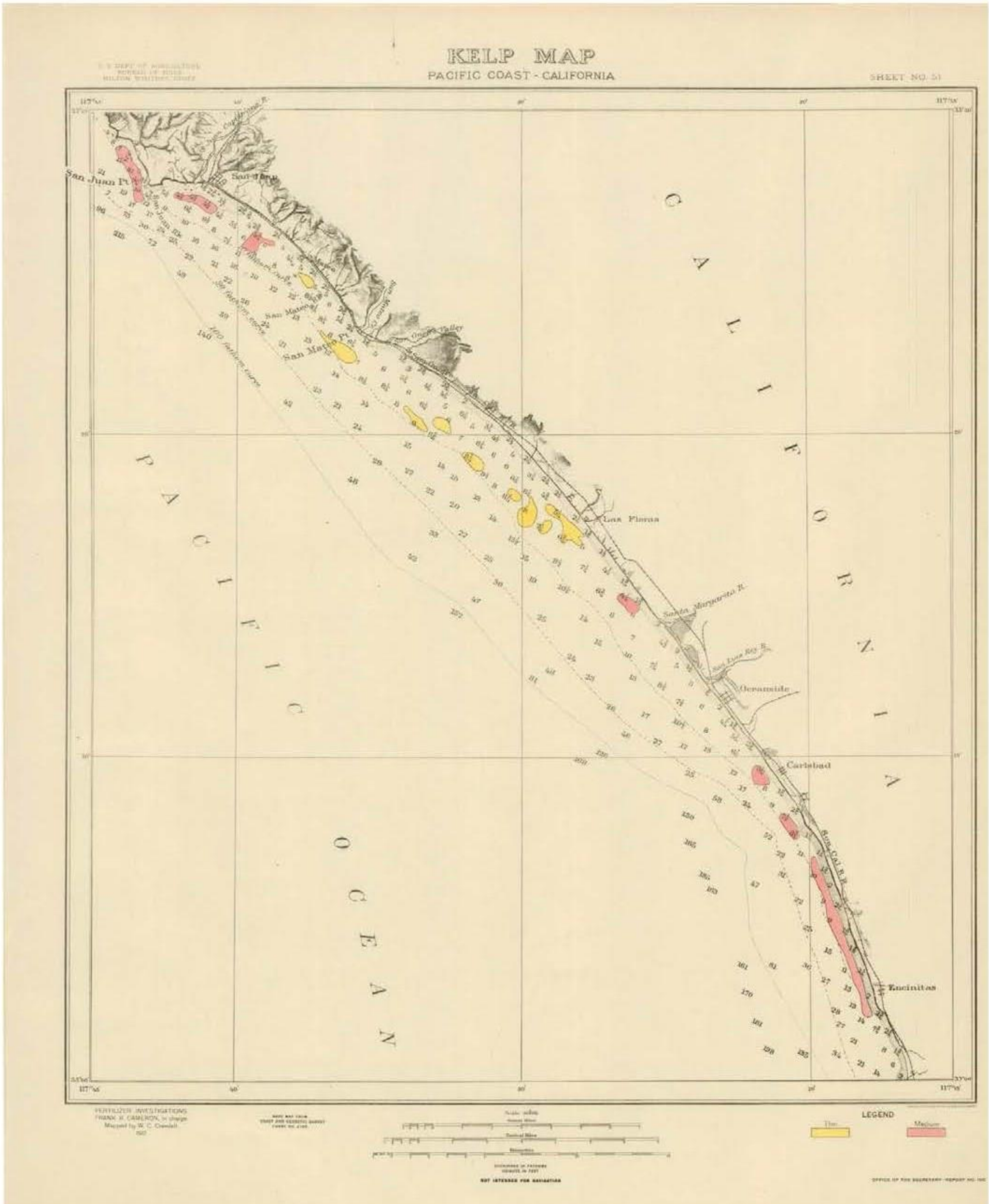
Appendix B.6 Crandall's 1911 kelp bed survey Newport to San Onofre.

Page B-14



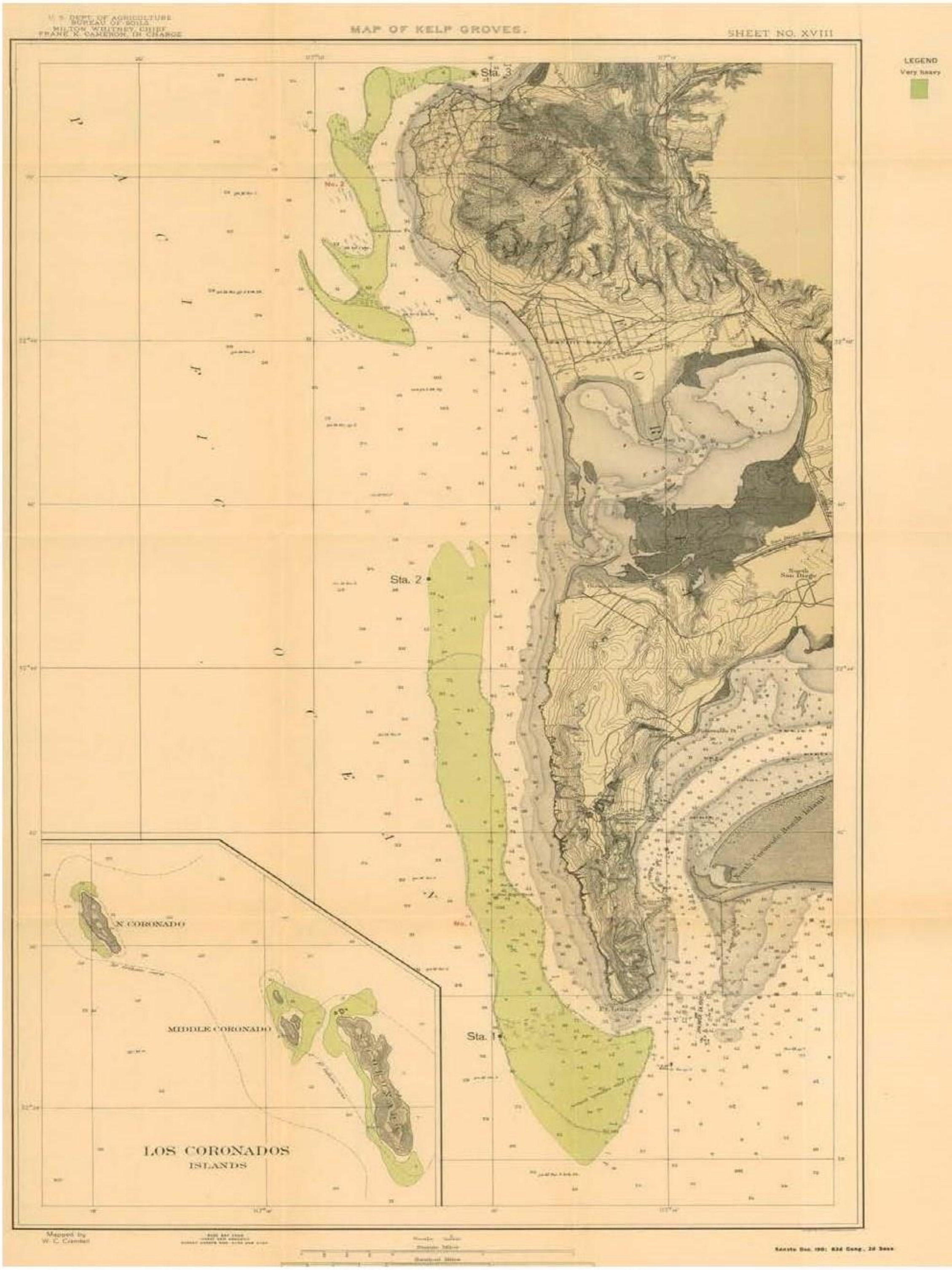
Appendix B.7 Crandall's 1911 kelp bed survey San Onofre to Del Mar.

Page B-15



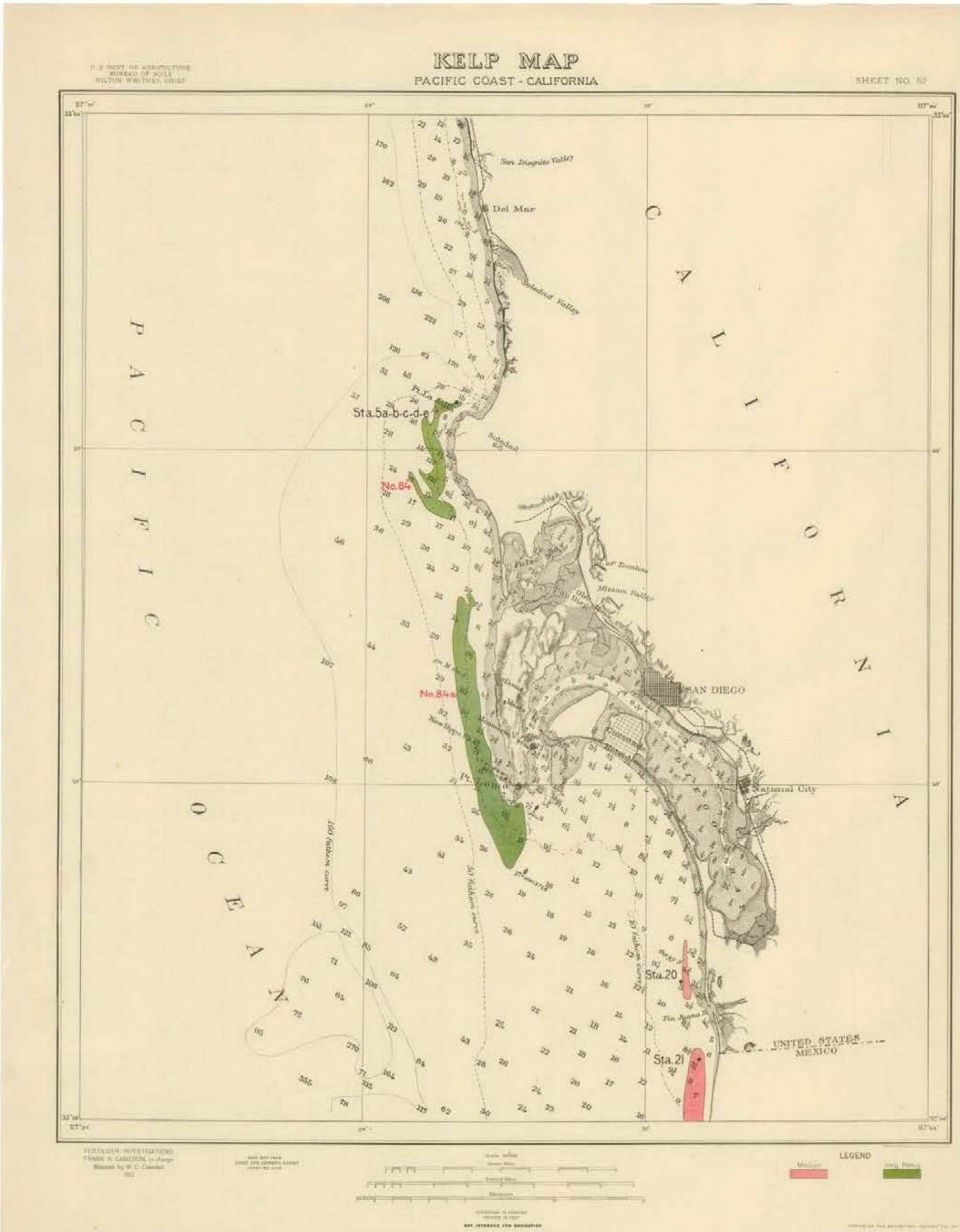
Appendix B.8 Crandall's 1911 kelp bed survey San Juan to Encinitas.

Page B-16



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

Page B-17

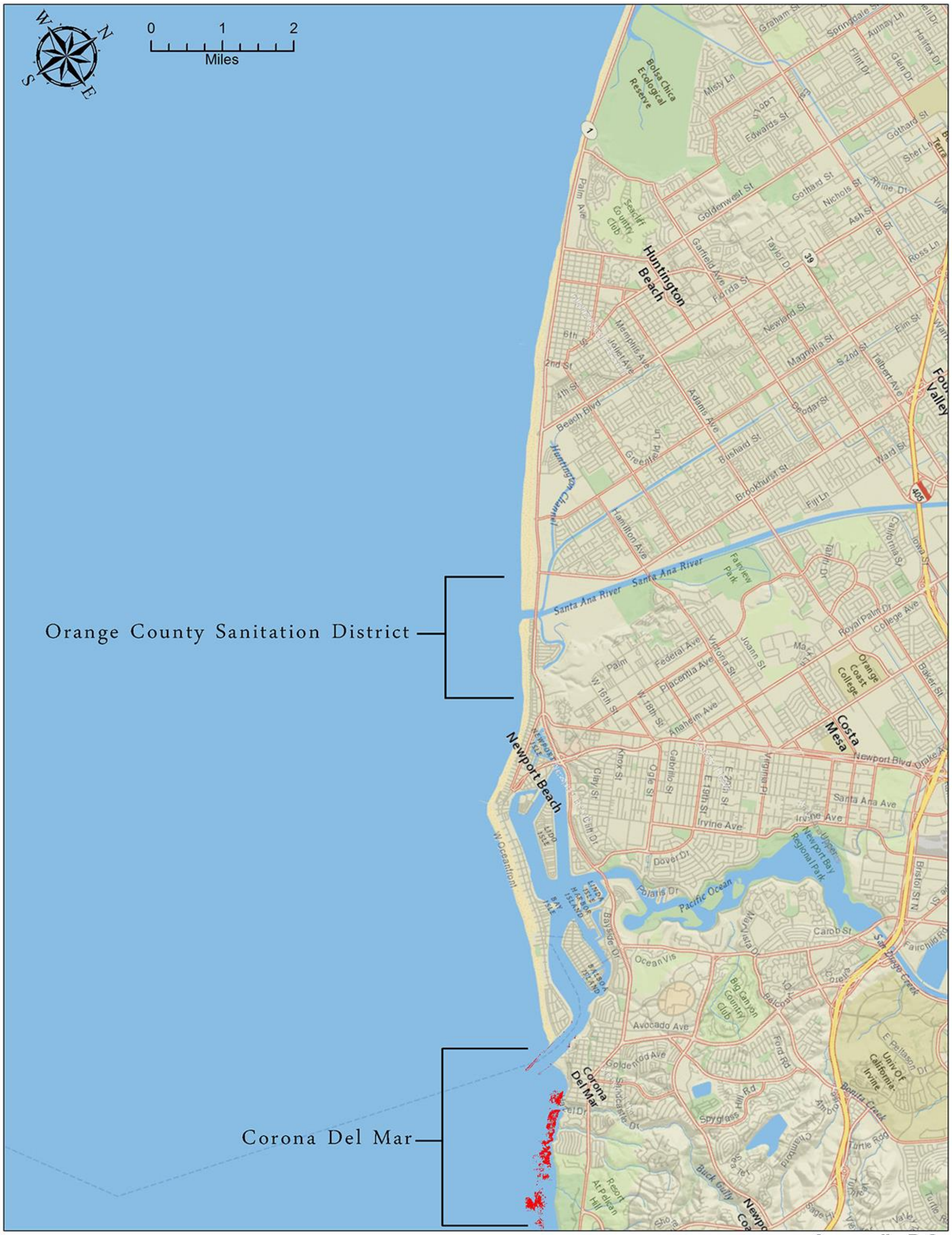


Appendix B.10 Crandall's 1911 kelp bed survey La Jolla to Imperial Beach.

Page B-18

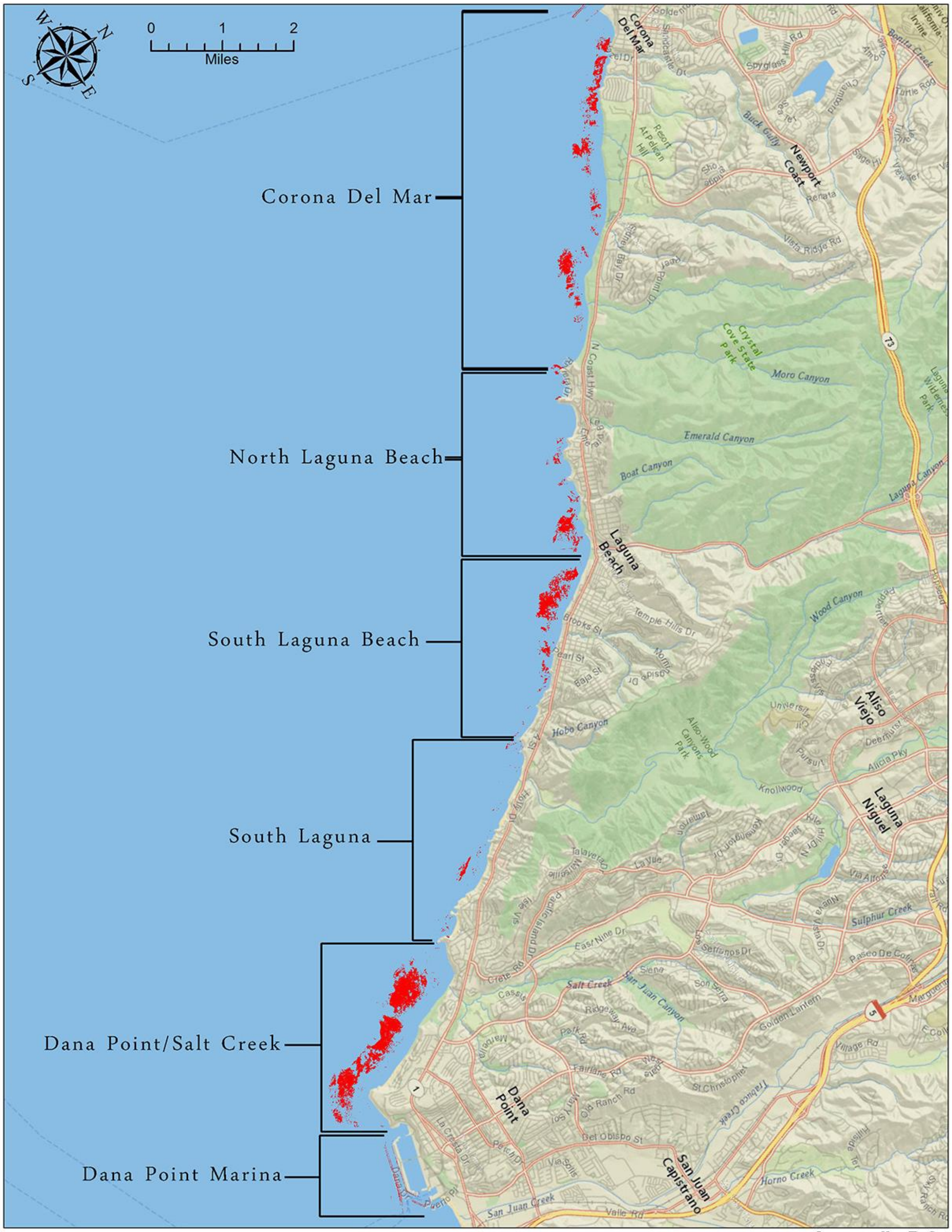
APPENDIX C

FLIGHT PATH
FLIGHT DATA REPORTS



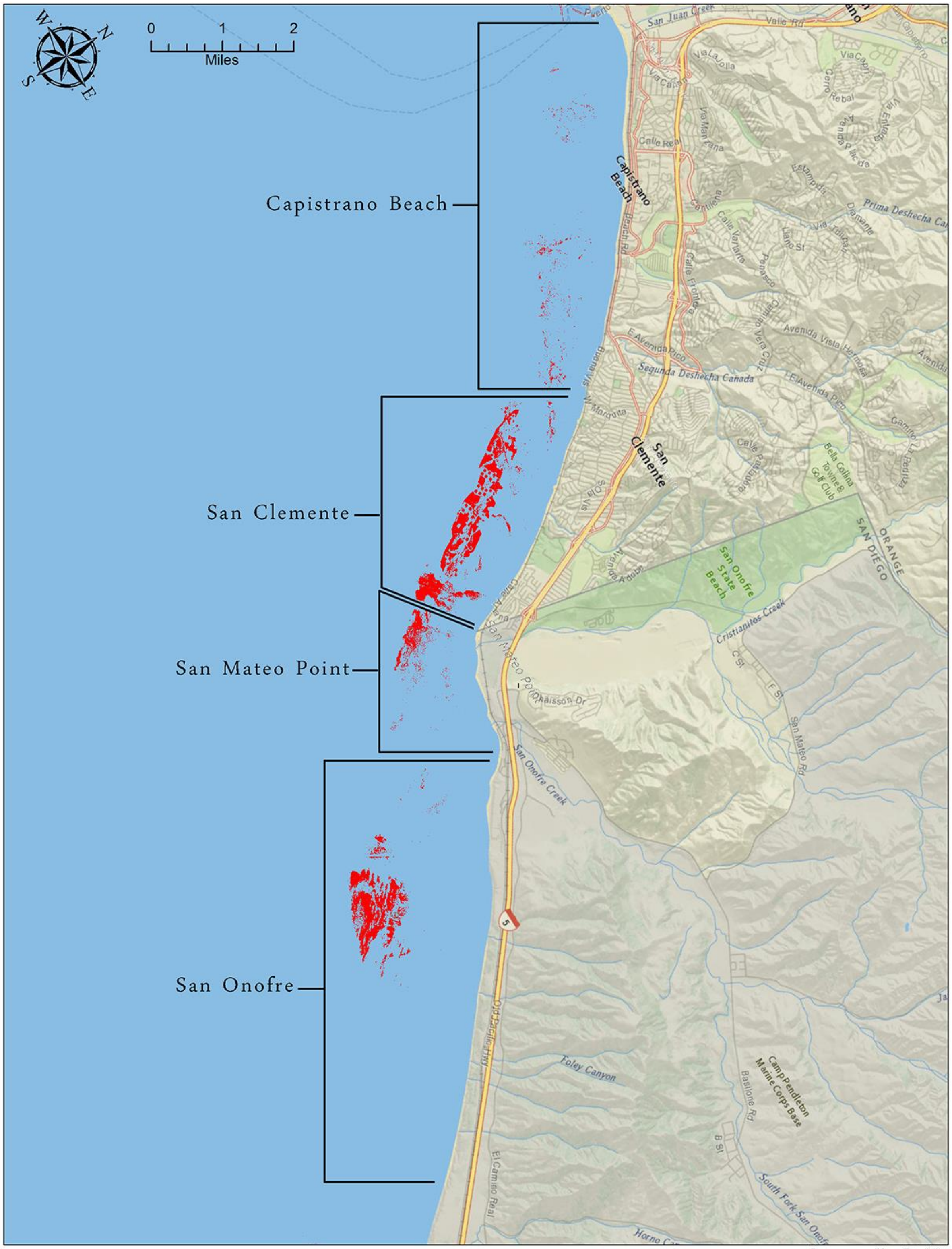
Appendix D.8

Page C-1



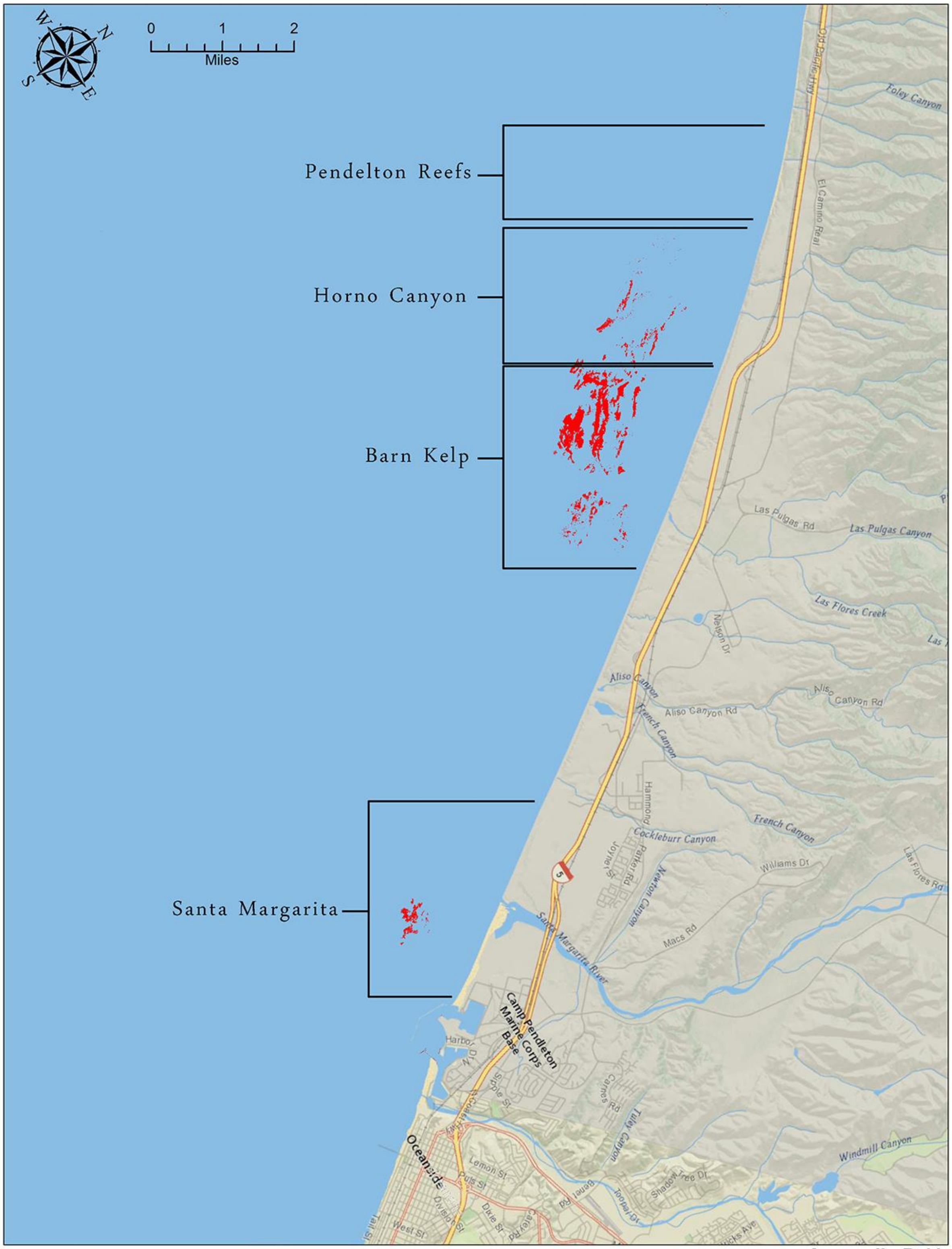
Appendix D.9

Page C-2



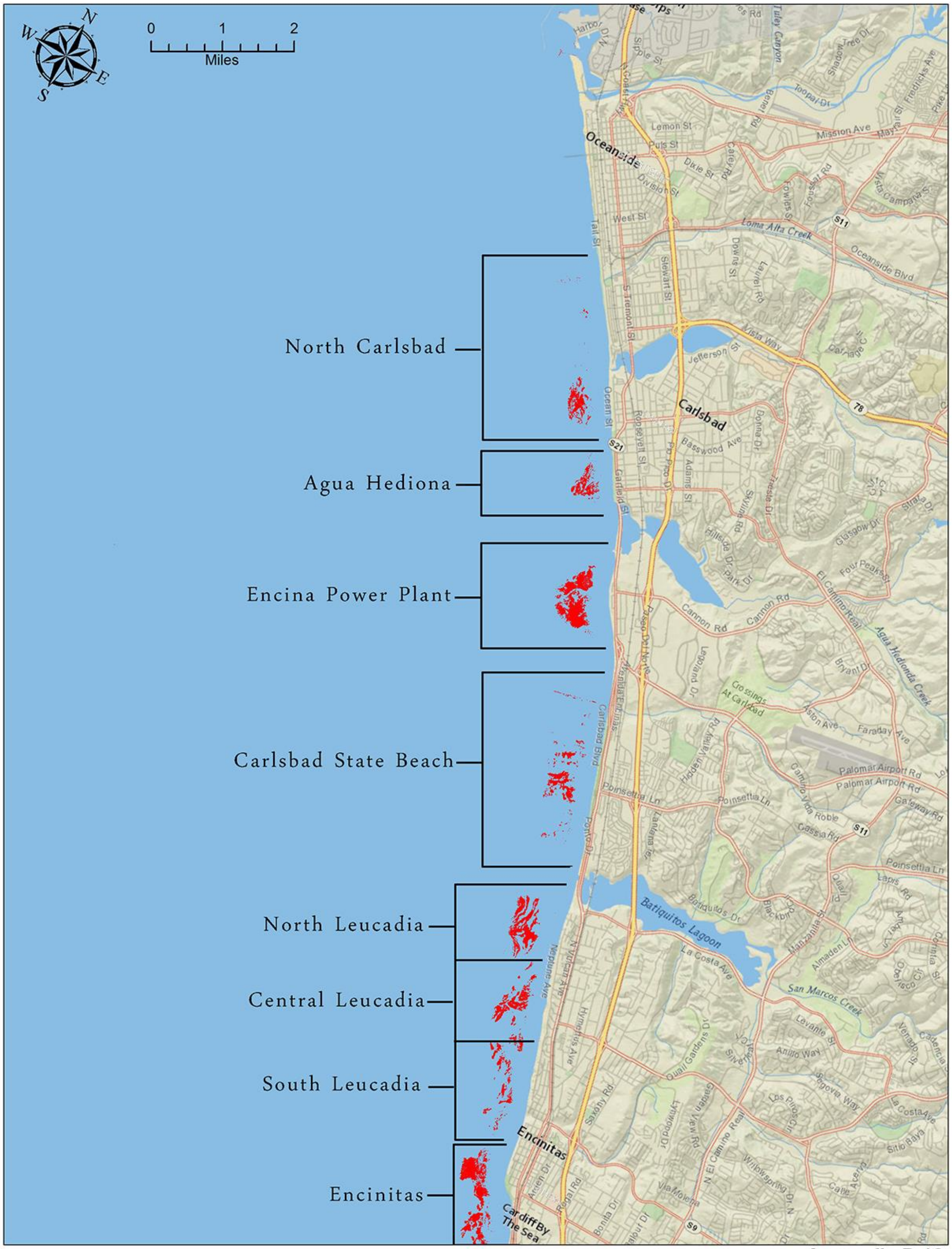
Appendix D.10

Page C-3



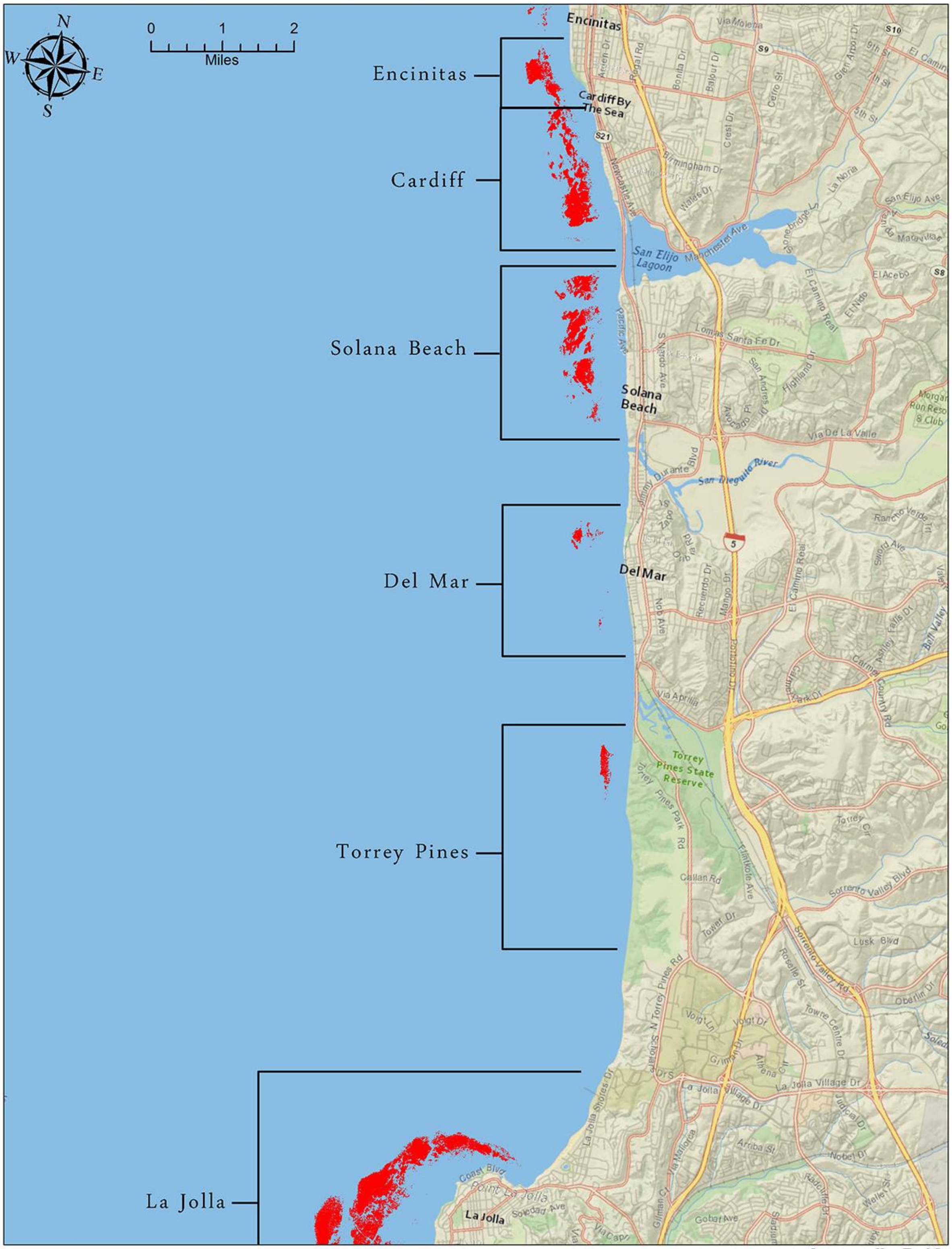
Appendix D.11

Page C-4



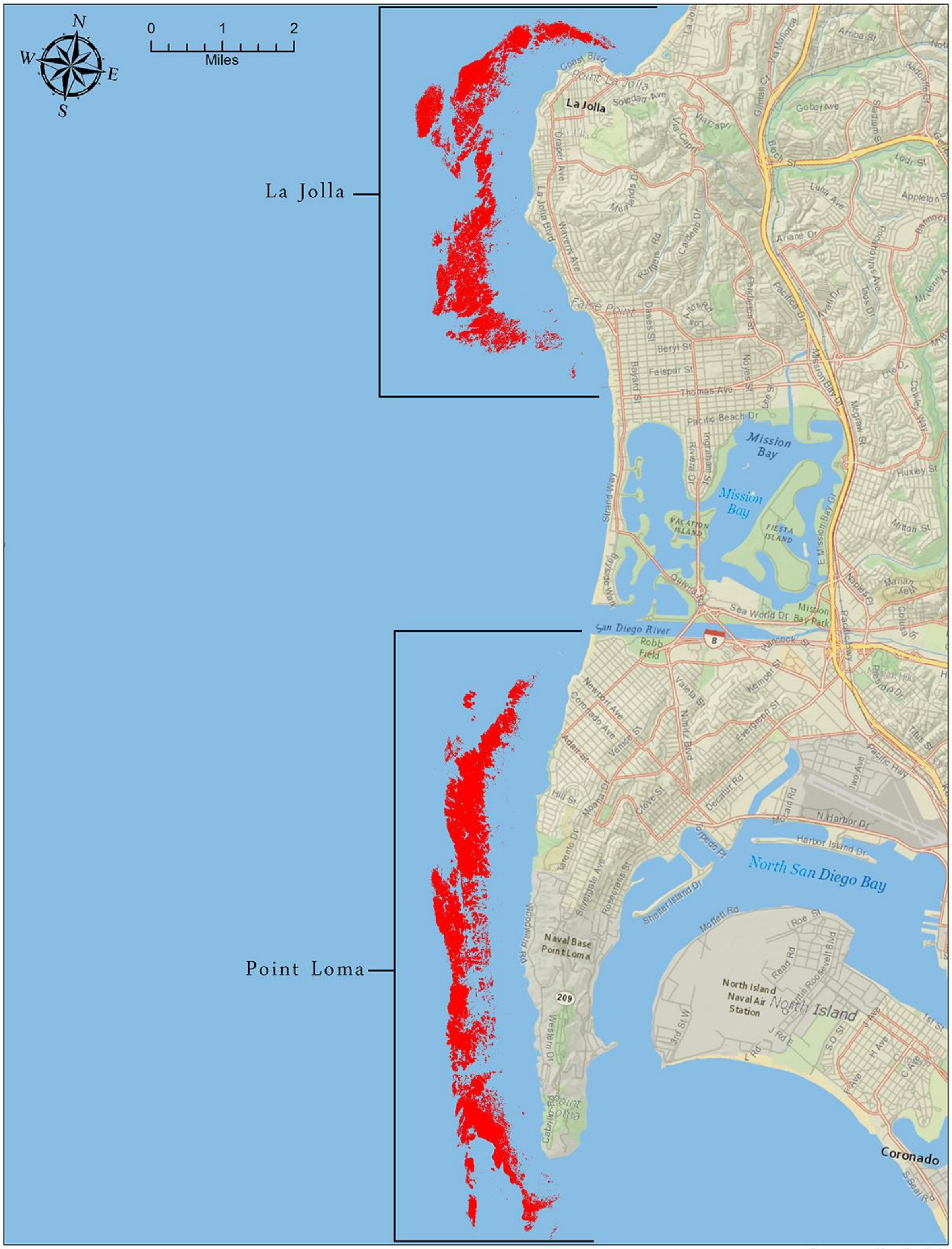
Appendix D.12

Page C-5



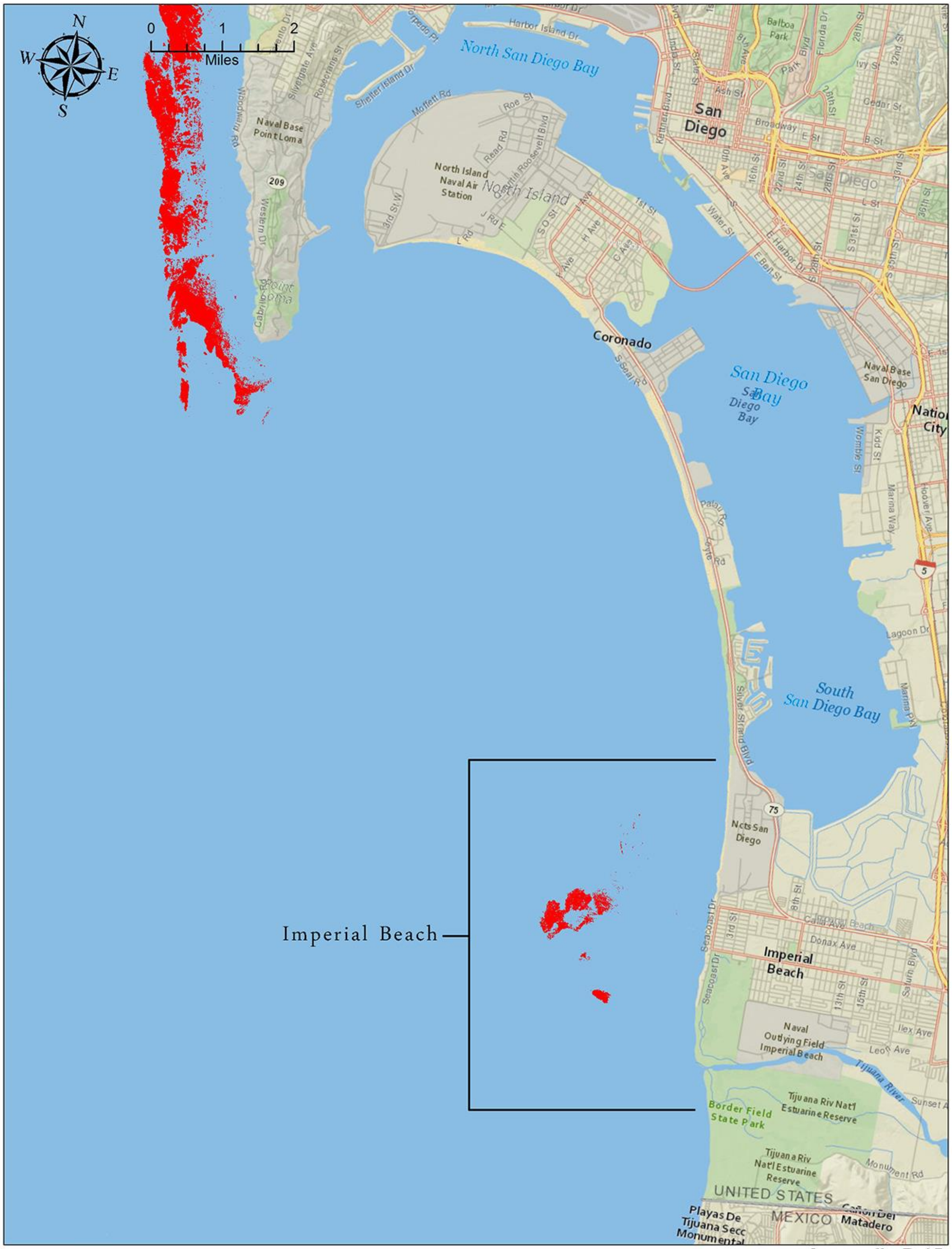
Appendix D.13

Page C-6



Appendix D.14

Page C-7



Appendix D.15

Page C-8

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:**	3/23
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	4/20/23
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	5/23

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

Project Title	**California Coastal Kelp Resources - Ventura to Imperial Beach - April 20, 2023**
Target Resource (s)/ Survey Range (s)	Coastal Kelp Canopies Newport Harbor to Imperial Beach (U.S./Mexican border)
Survey Data Flow — **Acquisition** Processing Analysis Presentation	Vertical color IR imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC in digital format for further processing and analysis

Aerial Resource Survey Flight Data for:		**April 20, 2023**			
	Survey Type	**Aircraft/Imagery Data**		**Associated Conditions**	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 30 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	E 15 kts.
	Videography	Lenses:	30mm	Sea/Swell:	1-2 feet
	Radio Telemetry	Film:	Digital	Time:	1420 -1550
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	1.4' (+) to 0.8' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Good Conditions

Range (s) Surveyed	Ventura to Imperial Beach	
Target Resource Observations	Kelp Canopies	The surface kelp canopies were absent throughout the survey range except for isolated plants on maps: 59, 60, 66, 67, and 71 (near Pt. Loma). A red tide was observed on maps: 62, 63, 64, 65, 66, 67, 70, 71, and 72. The red tide and surface kelp only co-occurred on map 67 on images 8-11. Othewise, the kelp was visually distinct from the red tide on other imagery.
Imagery Quality/ Comments	Excellent	All of the imagery was judged of excellent quality and was useable for the subsequent maping of the kelp resource.

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

Signed: ______________________ Bob Van Wagenen, Director

Copy To:

Page C-9

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:**	6/23
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	6/20/23
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	6/23

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - June 20, 2023**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Newport Harbor to Imperial Beach (U.S./Mexican border)
Survey Data Flow	**Acquisition** Processing Analysis Presentation	Vertical color IR imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC in digital format for further processing and analysis

Aerial Resource Survey Flight Data for:		**June 20, 2023**			
Survey Type		**Aircraft/Imagery Data**		**Associated Conditions**	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 30 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	W 5 kts.
	Videography	Lenses:	30mm	Sea/Swell:	1-2 feet
	Radio Telemetry	Film:	Digital	Time:	1515-1657
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	2.8' (+) to 2.7' (+) 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 to Imperial Beach	
Target Resource Observations	Kelp Canopies	The surface kelp canopies were largely absent throughout the survey range except for isolated canopies on maps: 59, 60, 63, 66, 67, and 71. The largest change from the previous survey (April 2023) were canopy extent increases on the Palos Verdes peninsula (map 63).
Imagery Quality/ Comments	Excellent	All of the imagery was judged of excellent quality and was useable for the subsequent maping of the kelp resource.

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

Signed: ______________________ Bob Van Wagenen, Director

Copy To:

Page C-10

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:**	9/23
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	10/12/23
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	11/23

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

Project Title		**California Coastal Kelp Resources - Newport to Imperial Beach - October 12, 2023**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Newport Harbor to Imperial Beach (U.S./Mexican border)
Survey Data Flow	**Acquisition** Processing Analysis Presentation	Vertical color IR imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC in digital format for further processing and analysis

Aerial Resource Survey Flight Data for:		**October 12, 2023**			
Survey Type		**Aircraft/Imagery Data**		**Associated Conditions**	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 30 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	W 5 kts.
	Videography	Lenses:	30mm	Sea/Swell:	1-2 feet
	Radio Telemetry	Film:	Digital	Time:	1543-1626
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	1.2' (+) to 1.8' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Good Conditions

Range (s) Surveyed	Newport to Imperial Beach. Scattered to significant coastal fog was present from Carlsbad (map 69) to Mission Bay (map 71). Several photographic passes were made of this range and the best imagey showing the nearshore habitat were included. No surface kelp canopies were observed beneath the fog within the survey range.	
Target Resource Observations	Kelp Canopies	The surface kelp canopies were largely absent throughout the survey range except for isolated canopies on maps: 66, 67, 70 and 71.
Imagery Quality/ Comments	Good/Excellent	All of the imagery was judged of good/excellent quality and was useable for the subsequent maping of the kelp resource.

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

Signed: ______________________ Bob Van Wagenen, Director

Copy To:

Page C-11

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:**	12/23
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	12/26/23
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	12/23

Project Title/Target Resource (s)- Survey Range (s)/Survey Data Flow		
Project Title		**California Coastal Kelp Resources - Newport to Imperial Beach - December 26, 2023**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura to Imperial Beach (U.S./Mexican border)
Survey Data Flow	**Acquisition** Processing Analysis Presentation	Vertical color IR imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC in digital format for further processing and analysis

Aerial Resource Survey Flight Data for:		**December 26, 2023**			
Survey Type		**Aircraft/Imagery Data**		**Associated Conditions**	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 30 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	W 5 kts.
	Videography	Lenses:	30mm	Sea/Swell:	1-2 feet
	Radio Telemetry	Film:	Digital	Time:	1351-1518
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	0.4' (-) to 1.1' (-) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

Range (s) Surveyed	Ventura to Imperial Beach.	
Target Resource Observations	Kelp Canopies	Kelp canopies are making a slow return within the survey range when compared with the October 2023 inventory.
Imagery Quality/ Comments	Excellent	All of the imagery was judged of excellent quality and was useable for the subsequent maping of the kelp resource.

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

Signed: ____________________ Bob Van Wagenen, Director

Copy To:

Page C-12

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:	3/24
City/State/Zip:	Costa Mesa, CA 92626	Data Acquisition Completed:	3/8/24
Phone 1/Phone 2:	(714) 850-4830	Draft Report Materials Due:	
Fax/E-Mail:	(714) 850-4840	Final Report Materials Due:	3/24

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

Project Title		**California Coastal Kelp Resources - Ventura to Imperial Beach - March 8, 2024**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Ventura to Imperial Beach (U.S./Mexican border)
Survey Data Flow	Acquisition Processing Analysis Presentation	Vertical color IR imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC in digital format for further processing and analysis

Aerial Resource Survey Flight Data for: March 8, 2024

	Survey Type	Aircraft/Imagery Data		Associated Conditions	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 30 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	W 5 kts.
	Videography	Lenses:	30mm	Sea/Swell:	1-2 feet
	Radio Telemetry	Film:	Digital	Time:	1538-1714
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	0.9' (-) to 1.6' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

Range (s) Surveyed	Ventura to Imperial Beach.	
Target Resource Observations	Kelp Canopies	Kelp canopies are making a slow return within the survey range when compared with the December 2023 inventory. Kelp plants/canopies were noted on map pages: 59, 60, 63, 65, 66, 67, 69, 70 and 71.
Imagery Quality/ Comments	Excellent	All of the imagery was judged of excellent quality and was useable for the subsequent maping of the kelp resource.

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

Signed: ______________________ Bob Van Wagenen, Director

Copy To:

Page C-13

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:**	6/24
City/State/Zip:	Costa Mesa, CA 92626	**Data Acquisition Completed:**	7/24/24
Phone 1/Phone 2:	(714) 850-4830	**Draft Report Materials Due:**	
Fax/E-Mail:	(714) 850-4840	**Final Report Materials Due:**	8/24

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

Project Title	**California Coastal Kelp Resources - Ventura to Imperial Beach - July 24, 2024**
Target Resource (s)/ Survey Range (s)	Coastal Kelp Canopies Ventura to Imperial Beach (U.S./Mexican border)
Survey Data Flow — **Acquisition** Processing Analysis Presentation	Vertical color IR imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC in digital format for further processing and analysis

Aerial Resource Survey Flight Data for:		**July 24, 2024**			
Survey Type		**Aircraft/Imagery Data**		**Associated Conditions**	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 30 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
√	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	W 5 kts.
	Videography	Lenses:	30mm	Sea/Swell:	1-2 feet
	Radio Telemetry	Film:	Digital	Time:	1511-1655
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	3.3' (+) to 2.1' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

Range (s) Surveyed	Ventura to Imperial Beach.	
Target Resource Observations	Kelp Canopies	Kelp canopies are making a slow return within the survey range when compared with the March 2024 inventory. Small/medium kelp canopies observed on map pages: 59, 60, 63, 66, 67 and 71.
Imagery Quality/ Comments	Excellent	All of the imagery was judged of excellent quality and was useable for the subsequent maping of the kelp resource.

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

Signed: ______________________ Bob Van Wagenen, Director

Copy To:

Page C-14

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:	9/24
City/State/Zip:	Costa Mesa, CA 92626	Data Acquisition Completed:	10/30/24
Phone 1/Phone 2:	(714) 850-4830	Draft Report Materials Due:	
Fax/E-Mail:	(714) 850-4840	Final Report Materials Due:	11/24

Project Title/Target Resource (s)- Survey Range (s)/Survey Data Flow		
Project Title		**California Coastal Kelp Resources - Newport to Imperial Beach - October 30, 2024**
Target Resource (s)/ Survey Range (s)		Coastal Kelp Canopies Newport to Imperial Beach (U.S./Mexican border)
Survey Data Flow	Acquisition Processing Analysis Presentation	Vertical color IR imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC in digital format for further processing and analysis

Aerial Resource Survey Flight Data for:		October 30, 2024			
Survey Type		Aircraft/Imagery Data		Associated Conditions	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 30 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility: 50+ miles	
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	W 5 kts.
	Videography	Lenses:	30mm	Sea/Swell:	3-4 feet
	Radio Telemetry	Film:	Digital	Time:	1340-1420
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	1.0' (+) to 0.5' (+) 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 to Imperial Beach.	
Target Resource Observations	Kelp Canopies	Kelp canopies are making a slow return within the survey range when compared with the July 2024 inventory. Small/medium kelp canopies observed on map pages: 70 and 71. Red tide was observed on map pages 65, 67, and 68.
Imagery Quality/ Comments	Excellent	All of the imagery was judged of excellent quality and was useable for the subsequent maping of the kelp resource.

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

Signed: ______________________ Bob Van Wagenen, Director

Copy To:

Page C-15

Ecoscan Resource Data
Data Acquisition
Flight Data Report

Contracting Agency/Contact		Contract/Order #/Agency File #	
Contracting Agency:	MBC Applied Environmental Sciences	Contract/Order #:	
Division:		Agency File #:	
Contact/Title:	Michael Lyons	**Calendar**	
Address:	3000 Redhill Ave.	Services Ordered:	12/24
City/State/Zip:	Costa Mesa, CA 92626	Data Acquisition Completed:	1/15/25
Phone 1/Phone 2:	(714) 850-4830	Draft Report Materials Due:	
Fax/E-Mail:	(714) 850-4840	Final Report Materials Due:	2/25

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

Project Title	**California Coastal Kelp Resources - Newport to Imperial Beach - January 2, 2025**
Target Resource (s)/ Survey Range (s)	Coastal Kelp Canopies Newport to Imperial Beach (U.S./Mexican border)
Survey Data Flow — Acquisition, Processing, Analysis, Presentation	Vertical color IR imagery of all coastal kelp canopies within the survey range Survey imagery indexed and delivered to MBC in digital format for further processing and analysis

Aerial Resource Survey Flight Data for: January 2, 2025

	Survey Type	Aircraft/Imagery Data		Associated Conditions	
	Aerial Transportation/Observation	Aircraft:	Cessna 182	Sky Conditions:	Clear
	Photographic Film Imagery - 35 mm	Altitude:	13,500' MSL	Sun Angle:	> 30 degrees from vertical
	Photographic Film Imagery - 70 mm	Speed:	100 kts.	Visibility:	50+ miles
✓	Digital Color/Color Infrared Imagery	Camera:	Nikon D200	Wind:	W 5 kts.
	Videography	Lenses:	30mm	Sea/Swell:	3-4 feet
	Radio Telemetry	Film:	Digital	Time:	1200-1435
	Radiometry/Geophysical Measurements	Angle:	Vertical	Tide:	4.7' (+) to 1.2' (+) MLLW
	Other 1:	Photo Scale:	As Displayed	Shadow:	None
	Other 2:	Pilot:	Unsicker	Other:	
	Other 3:	Photographer:	Van Wagenen	Comments:	Excellent Conditions

Range (s) Surveyed	Ventura to Pt. Mugu and Buena Vista Lagoon to the US/Mexican Border. Coastal fog was present from Pt. Mugu to Buena Vista Lagoon. A second aerial survey was conducted on January 15, 2025 to collect imagery of the range obsurred by fog (see subsequent data sheet).	
Target Resource Observations	Kelp Canopies	Kelp canopies are making a slow return within the survey range when compared with the October 2024 inventory. Small/medium kelp canopies observed on map pages: 59, 60, 63, 66, 68, 70 and 71. Red tide was observed on map pages: 71 and 72
Imagery Quality/ Comments	Excellent	All of the imagery was judged of excellent quality and was useable for the subsequent maping of the kelp resource.

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

Signed: ____________________ Bob Van Wagenen, Director

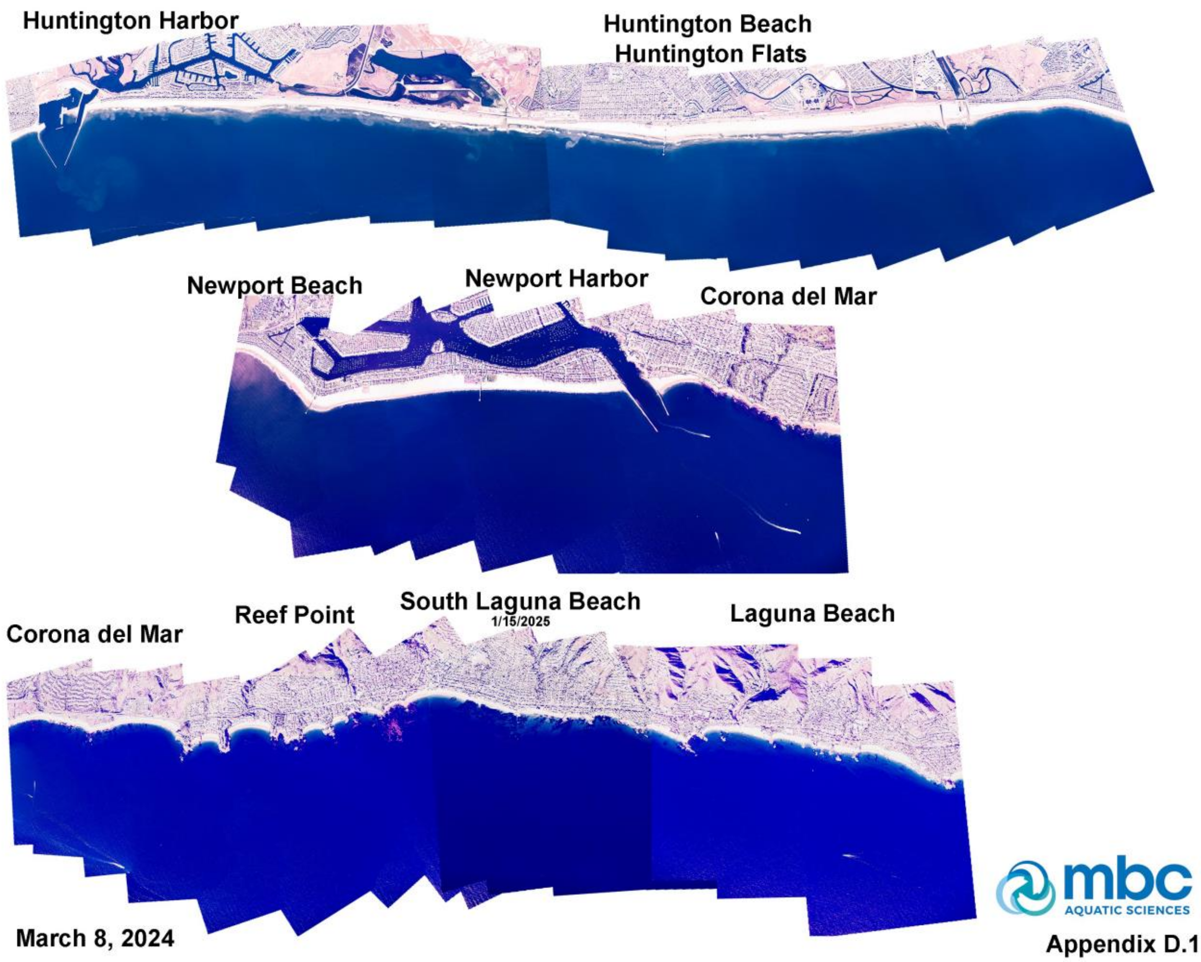
Copy To:

Page C-16

APPENDIX D

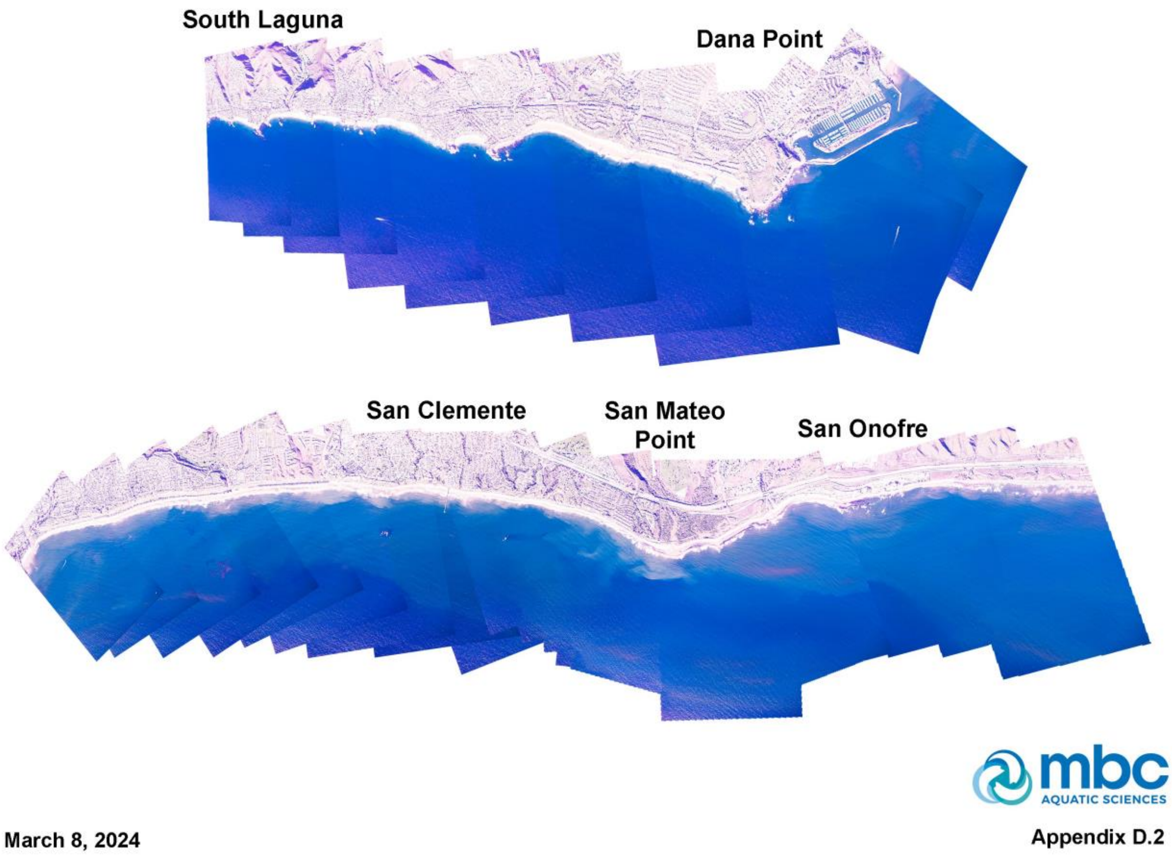
KELP CANOPY COMPOSITE AERIAL PHOTOGRAPHS

Photo D-1



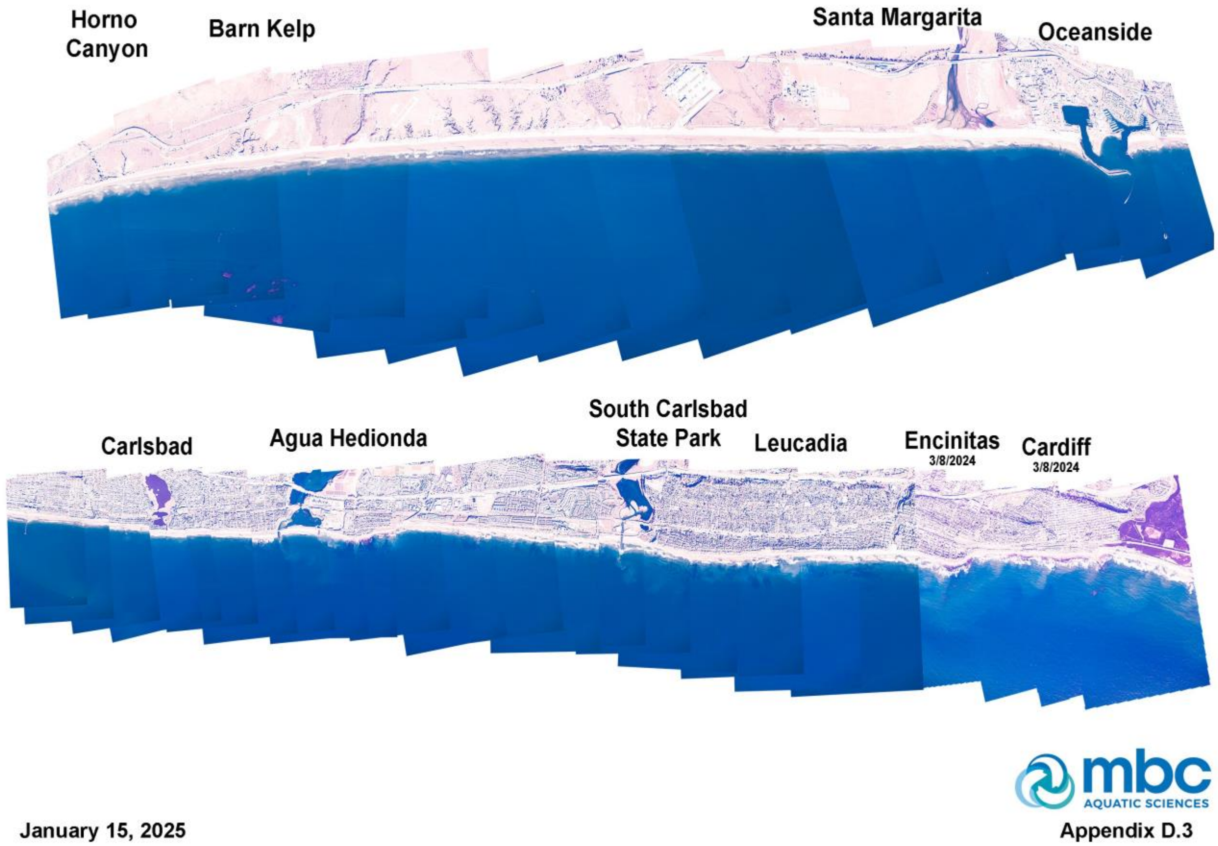
Page D-1

Photo D-2



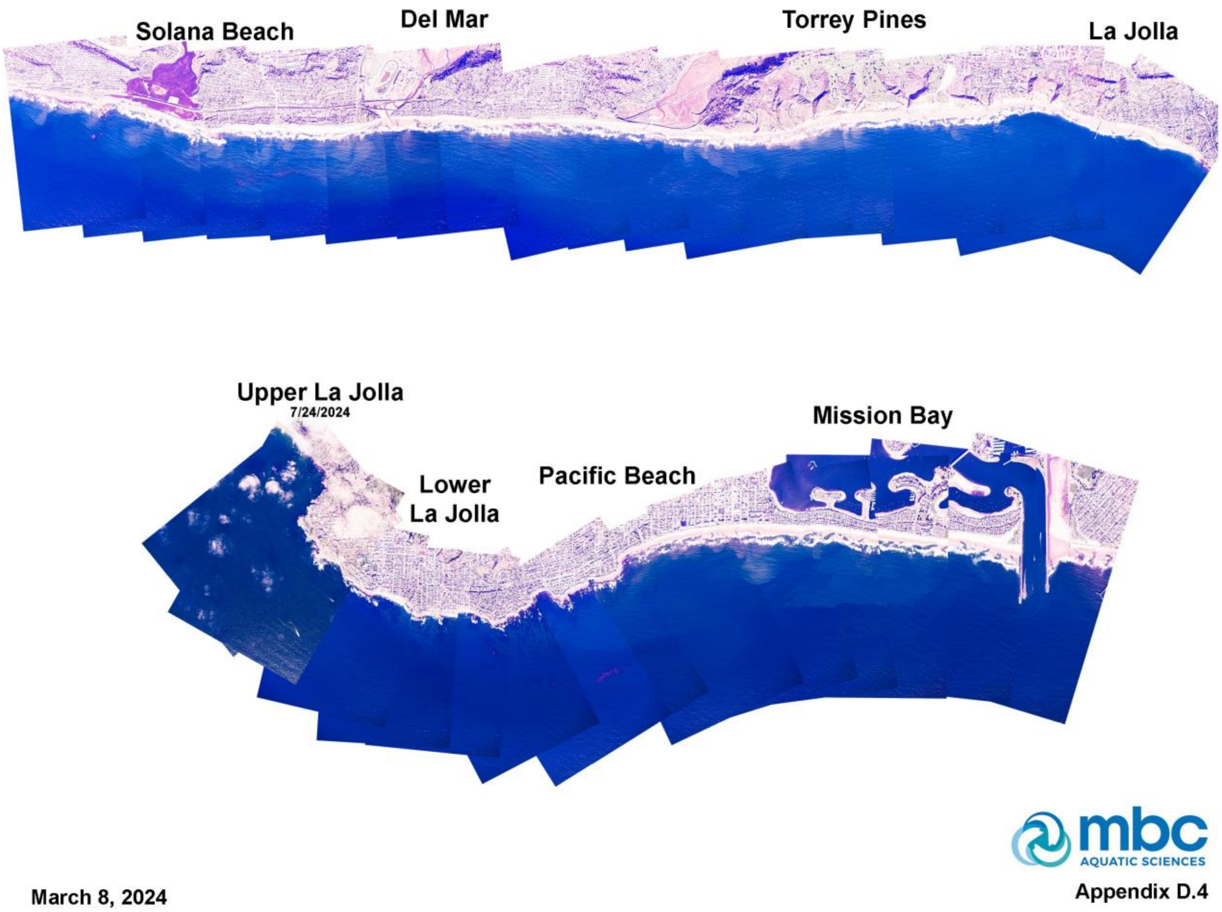
Page D-2

Photo D-3



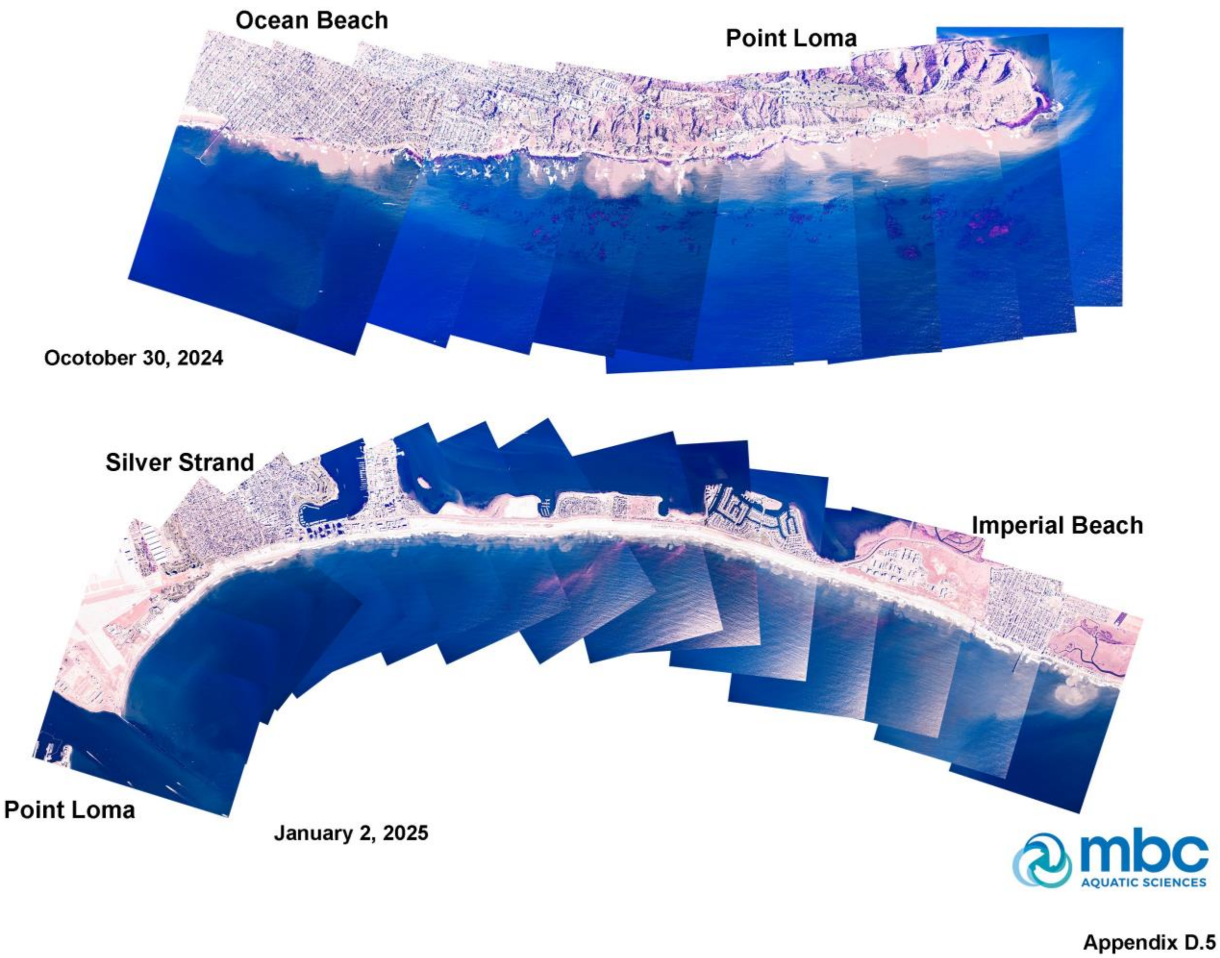
Page D-3

Photo D-4



Page D-4

Photo D-5

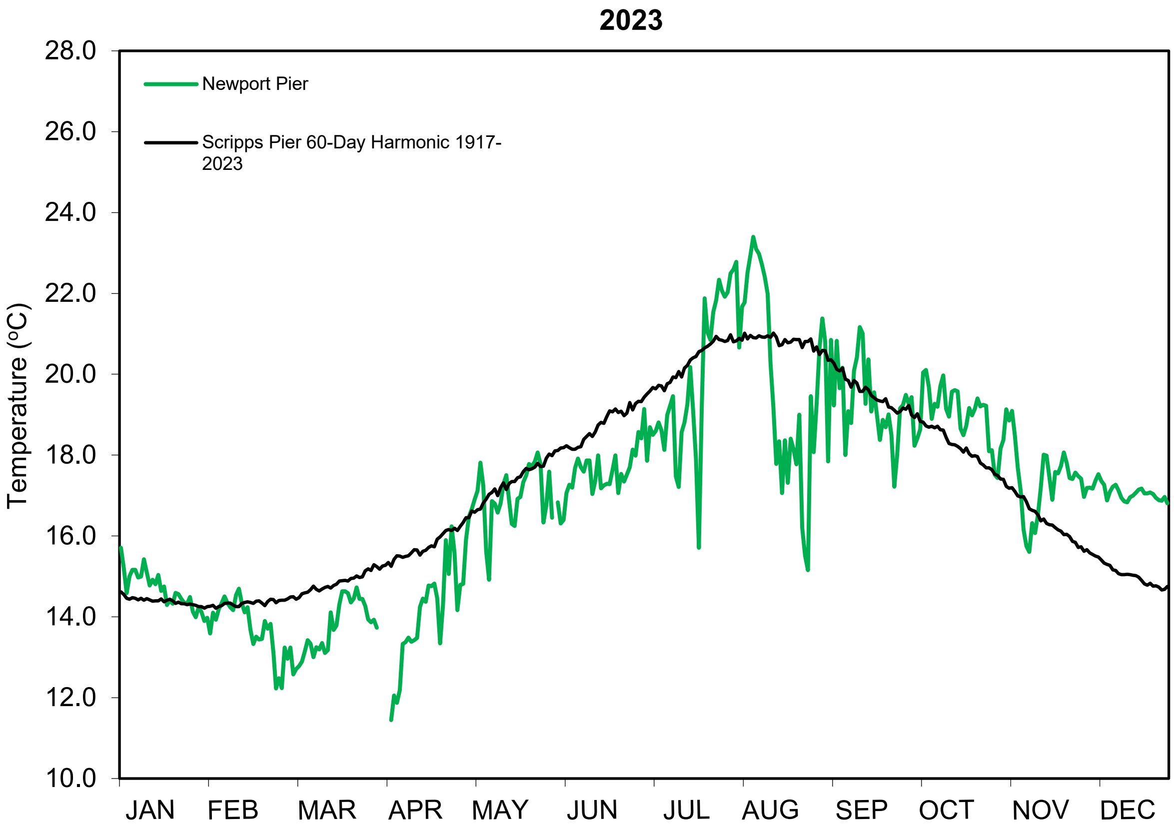


Page D-5

APPENDIX E

SEA SURFACE TEMPERATURES

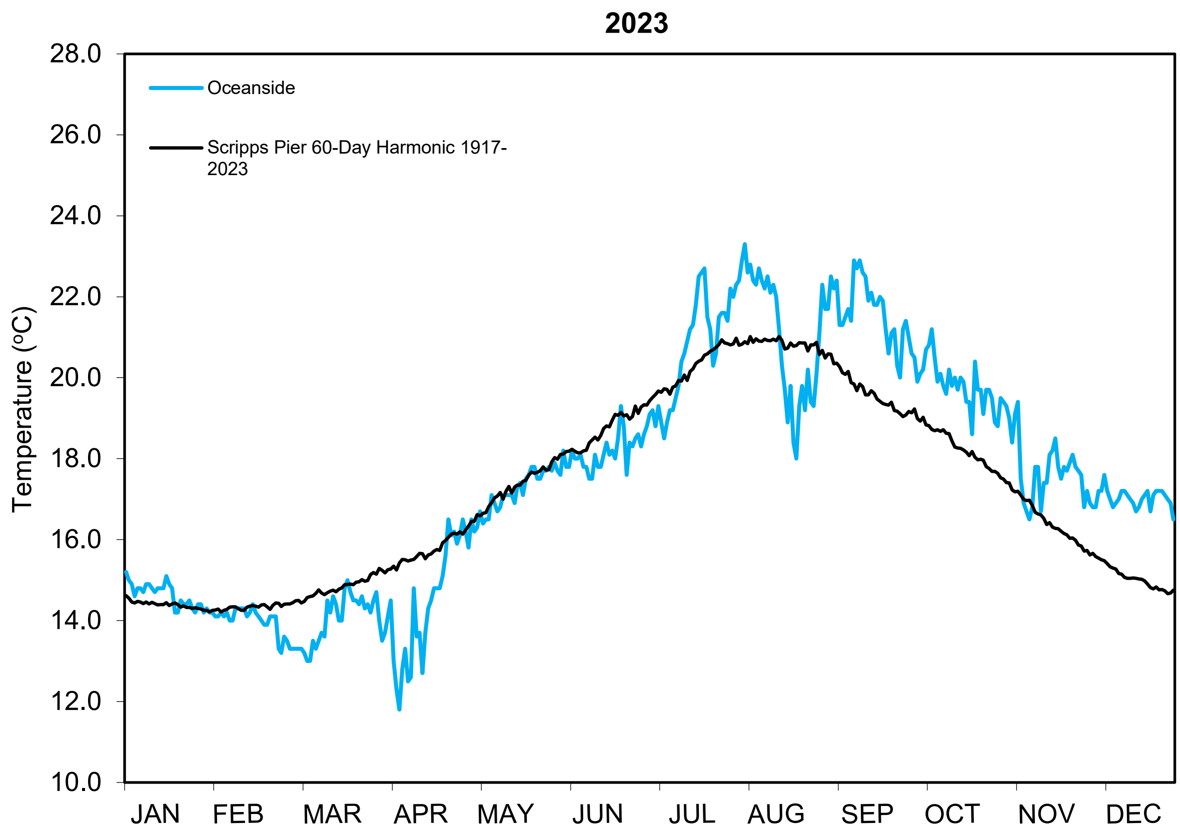
Appendix E.1 Newport Pier



Daily Sea Surface Temperatures (SST) at Newport Pier for 2023.

Page E-1

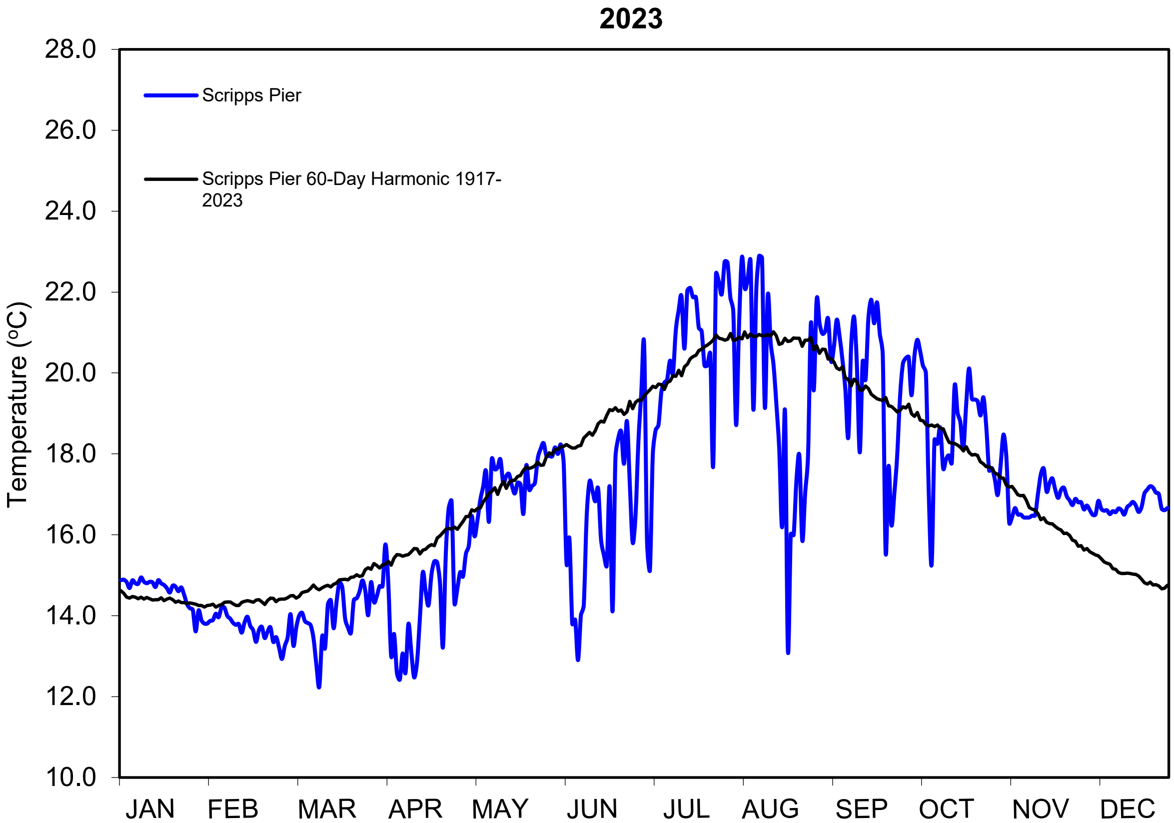
Appendix E.2 Oceanside



Daily Sea Surface Temperatures (SST) at Oceanside for 2023.

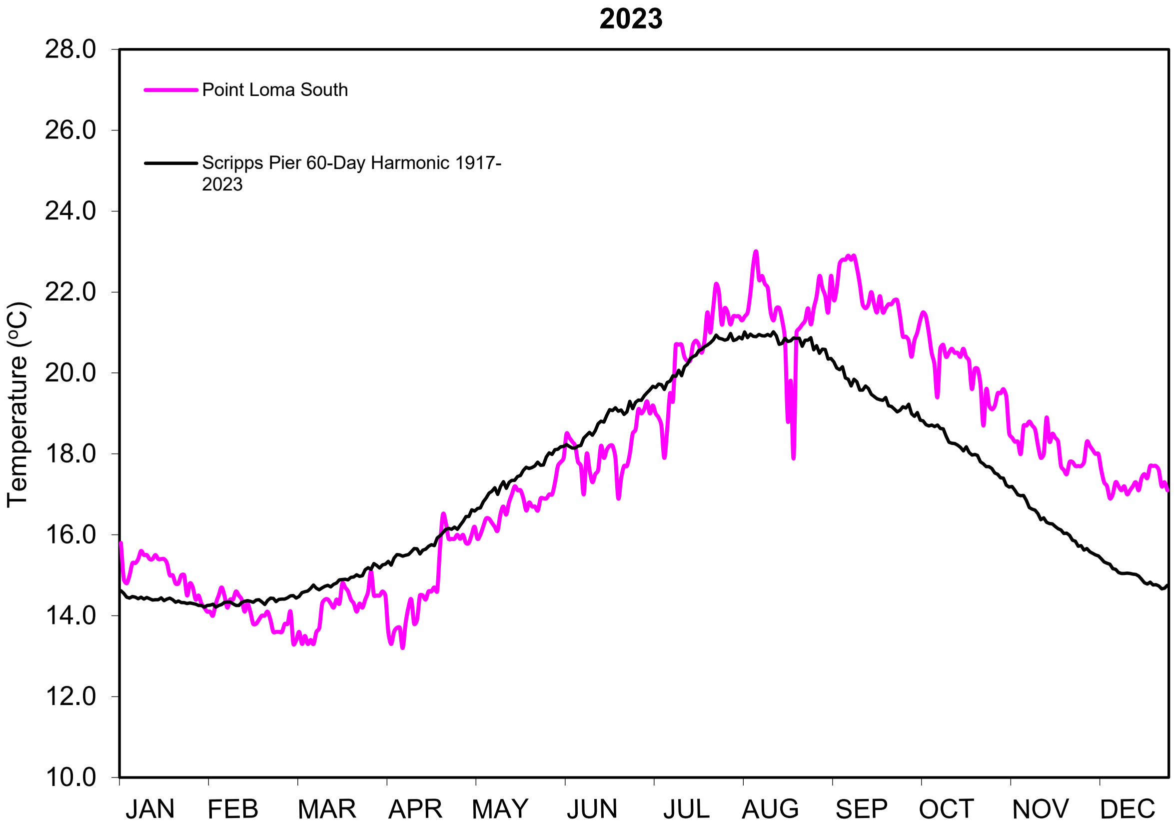
Page E-2

Appendix E.3 Scripps Pier



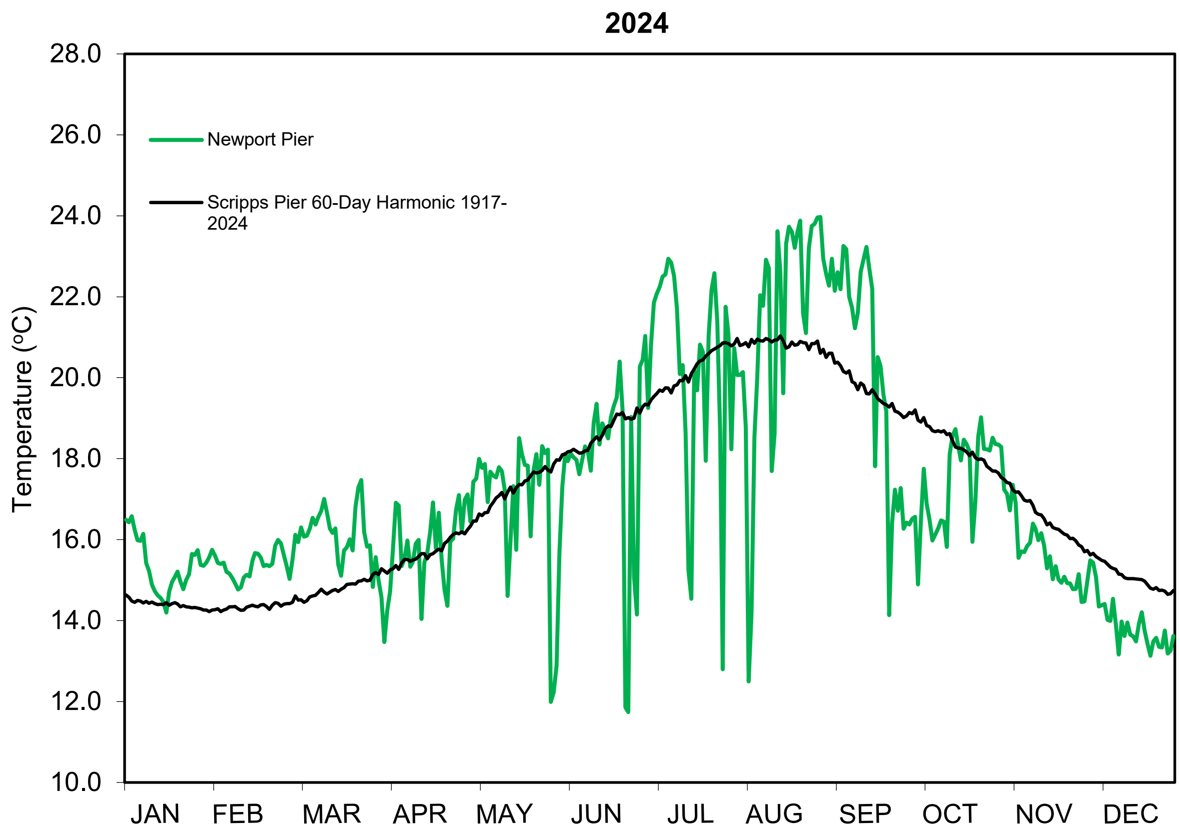
Daily Sea Surface Temperatures (SST) at Scripps Pier for 2023.

Appendix E.4 Point Loma



Daily Sea Surface Temperatures (SST) at Point Loma South for 2023.

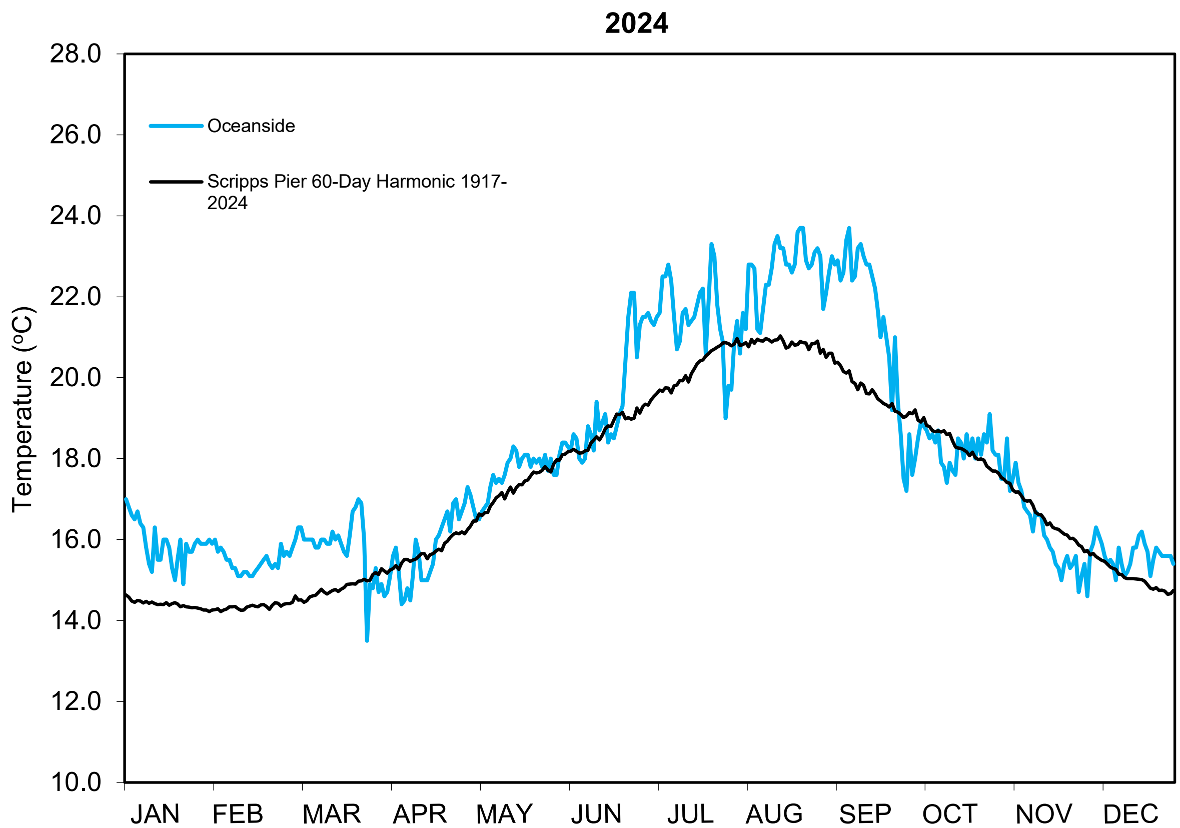
Appendix E.5 Newport Pier



Daily Sea Surface Temperatures (SST) at Newport Pier for 2024.

Page E-5

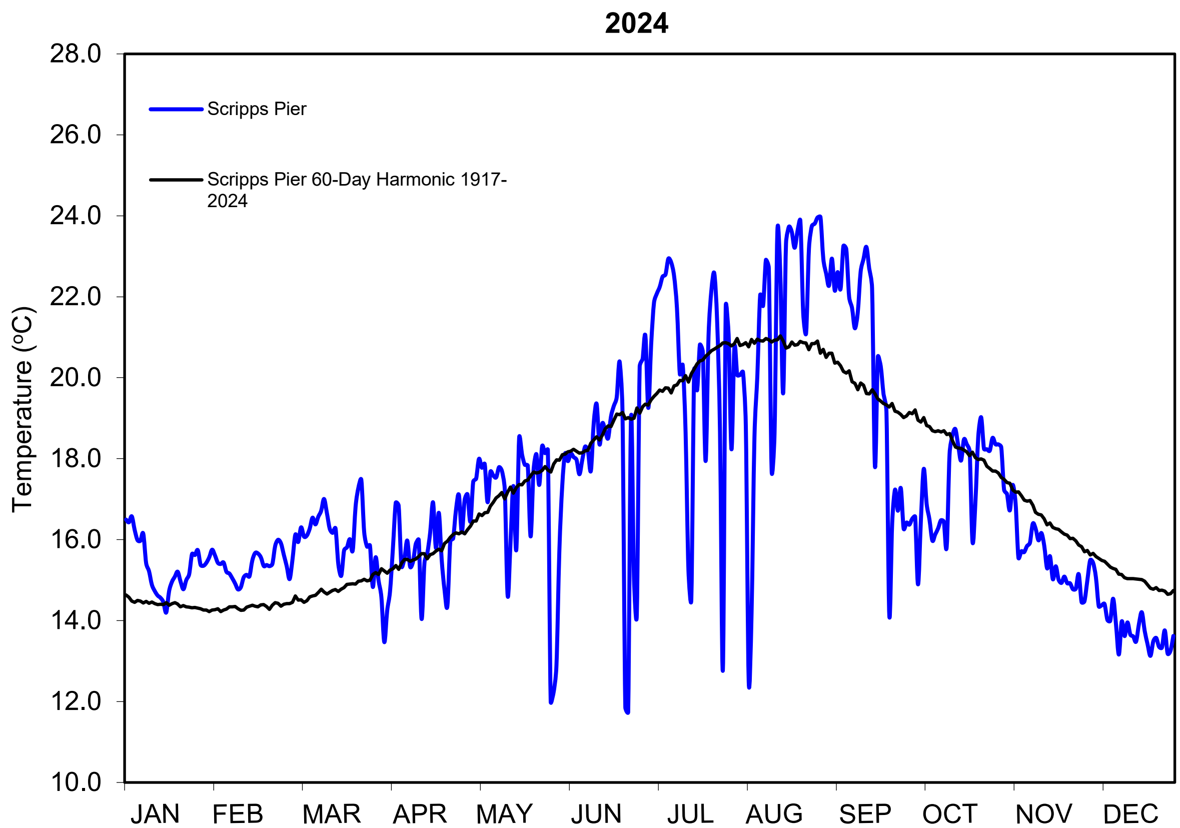
Appendix E.6 Oceanside



Daily Sea Surface Temperatures (SST) at Oceanside for 2024.

Page E-6

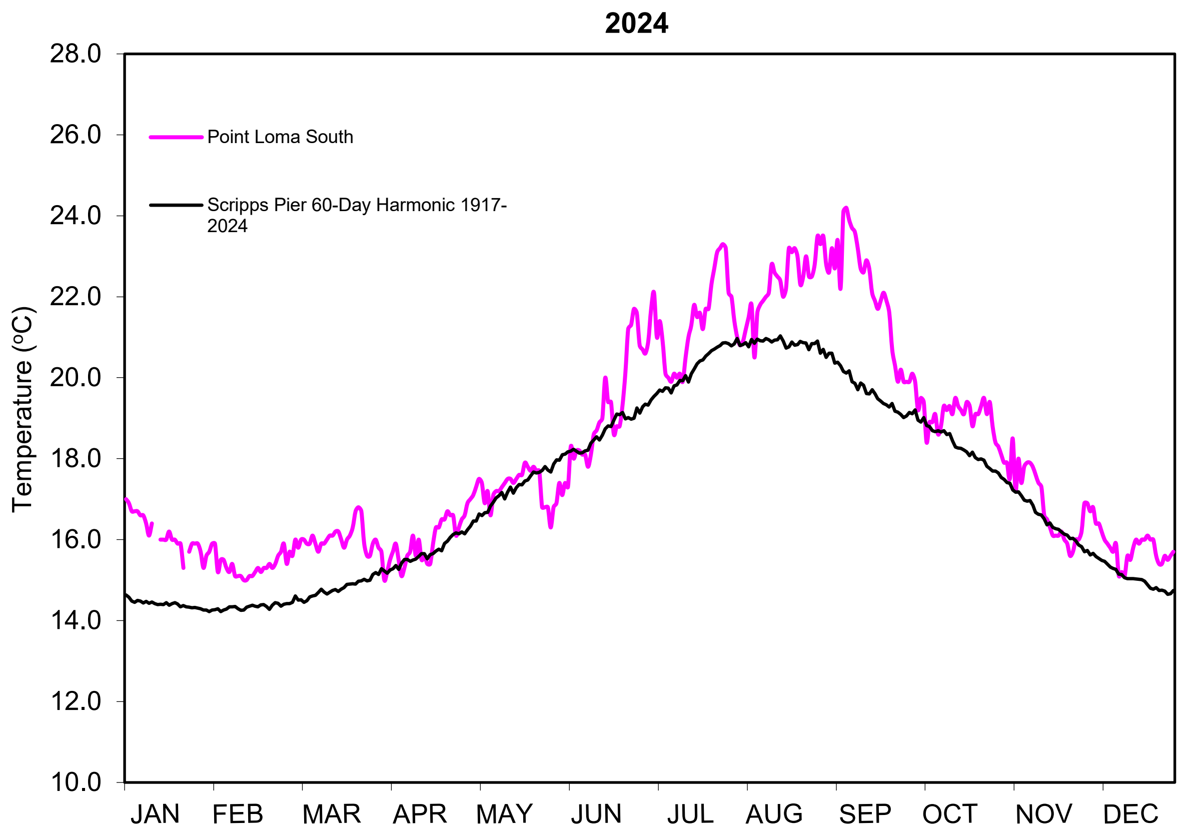
Appendix E.7 Scripps Pier



Daily Sea Surface Temperatures (SST) at Scripps Pier for 2024.

Page E-7

Appendix E.8 Point Loma



Daily Sea Surface Temperatures (SST) at Point Loma South for 2024.