

# Laguna Beach Nearshore Giant Kelp and Bryozoan Encrustation

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## SUMMARY

Kelp forests are highly productive marine ecosystems that provide habitat, food, and coastal protection, yet they are increasingly stressed by warming ocean conditions. This paper examines the scattered nearshore kelp beds in Laguna Beach subtidal shallow rock reef substrate between Brooks Street and Thalia Street, referred to as town. The nearshore kelp is approximately 200 meters from shore. This area has been protected since 2012 when it was considered a California Marine Protected Area (MPA) and classified as Laguna Beach State Marine Reserve (LBSMR). We observed a lack of historic nearshore kelp in town during the period from 2015 to 2023. Our observations were confirmed by reviewing images from KelpWatch.org, where data is processed from NASA's Landsat satellite program (1). We observed an increase in marine life in town from 2022 to 2024, and in spring 2024 we observed a resurgence of native giant kelp (*Macrocystis pyrifera*). Most of the giant kelp blades quickly succumbed to bryozoan (*Membranipora membranacea*) encrustation in less than two months, and by month three the kelp beds had been reduced by approximately 70%. Giant kelp fronds naturally senesce when they reach between three to twelve months (2). Although kelp has a natural growth cycle and warmer sea temperatures may expedite senescence, our observational data suggest that bryozoan encrustation may have delayed visible blade deterioration by providing physical structure to disintegrating blades, though this relationship remains correlative rather than causal. Nearshore kelp is once again growing in Laguna Beach, likely due to the biodiversity afforded by MPA protection; however, additional action may be needed to protect kelp in warming waters associated with the climate crisis, and further quantitative research is required to better understand the relationship between kelp and bryozoan.

## INTRODUCTION

The nearshore kelp studied is approximately 3.5 to 5 meters deep, and approximately 150–200 meters from the shore, just slightly beyond the surf break. There is a nearby, but distinct nearshore giant kelp bed at Third Reef and farther out on Anita Reef approximately 7 to 8 meters deep and approximately 300 meters from shore, which are not the main focus of this paper—this paper examines the nearshore kelp beds scattered closer to shore (Figure 1). The study area is located between approximately 33.53170° N, 117.78009° W and 33.53384° N, 117.78197° W and is within the boundaries of LBSMR. California Department of Fish and Wildlife (CDFW) stated the goal of LBSMR “is to protect the tidepool, surfgrass, sandy seafloor, kelp forest, and rocky reef habitat found there” (3).

Giant kelp may look like a plant, but it is actually brown algae (4). Giant kelp has historically been present in Laguna Beach substrate and is an integral part of marine life in the Gulf of Santa Catalina. Adult sporophytes can survive in water 8–23 °C (46.4–73.4 °F) and juveniles in 0–20 °C (32.0–68.0 °F); however, giant kelp living in lower latitudes have adaptations that allow them to cope with warmer temperatures (2). The kelp forests progress through seasons as the amounts of sunlight and nutrients naturally change (5).

Giant kelp provides food and protection to numerous marine species. We observed kelp bass (*Paralabrax clathratus*), California sheephead (*Semicossyphus pulcher*), garibaldi (*Hypsypops rubicundus*), zebra perch (*Kyphosus azureus*), and opal eye (*Girella nigricans*) in the lower mid-level kelp habitat, and kelp crabs (*Pugettia producta*) on the kelp canopy. Some of these animals feed directly on the kelp and are capable of considerable damage. Predatory fish such as kelp bass and various rockfish often prey on the smaller fish and keep kelp consumption in check, and kelp crabs and snails that feed in the frond canopy often fall prey to seabirds (5). The MPA provides biodiversity, though it will take time to fully reestablish the area. Sea otters (*Enhydra lutris nereis*) had not been spotted in Laguna Beach for thirty years until 2011 and again in 2016 (6). Sea otters are predators of kelp-grazing sea urchins (*Strongylocentrotus franciscanus* and *Strongylocentrotus purpuratus*). Unfortunately, there has not yet been a resurgence in the sea otter population in Laguna Beach. Sea stars (*Pisaster ochraceus*) also feed on urchins but have succumbed to sea star wasting disease en masse, likely exacerbated by the 2014–2016 marine heat wave (7), and are now hard to find in Laguna Beach. We observed California spiny lobster (*Panulirus interruptus*) and California sheephead, both predators of sea urchins.

El Niño Southern Oscillation (ENSO) is a natural climate pattern that strongly influences weather and oceanographic conditions along the Southern California coast. During El Niño events, warm water builds up across the equatorial Pacific Ocean and spreads east toward the western coasts of North and South America, deepening thermoclines and blocking the upwelling processes that deliver essential nutrients to coastal ecosystems (9). Higher water temperatures during El Niño may also lead to increased Pacific storms that can uproot kelp and disrupt marine ecosystems.

Although warming and cooling ocean temperatures are cyclical and natural, climate change has contributed to a long-term increase in both marine and terrestrial temperatures. Gavin Schmidt, director of NASA's Goddard Institute for Space Studies, noted a clear trend of “more heat and warmer sea surface temperatures across much of the globe” (10). The ocean absorbs approximately 93% of the excess heat trapped by greenhouse gases, primarily in the form of increased thermal energy (11). As a result, marine heat has been increasing since modern record-keeping began in the mid-1950s (12).

The nearshore scattered kelp beds in town were not recovered as kelp surface canopy cover was not detectable in the Region Nine Kelp Survey Consortium (RNKSC) survey in 2021. In fact, the total regional kelp canopy recorded in 2021 was the lowest since 2006 (13). Changing climate and weather patterns influence seasonal water temperatures, which regulate giant kelp life cycles. Understanding how kelp responds to increasingly warm summer conditions requires further investigation. This study was motivated by our observation of extensive bryozoan encrustation on the longest-lasting giant kelp blades in Laguna Beach during summer 2024.

The invasive seaweed *Sargassum horneri* has been spreading throughout Southern California and Mexico since 2003 and may outcompete giant kelp populations due to its higher tolerance of warm water and grazing (2). The negative effects of invasive seaweed on native kelp appear to result from shading, which reduces light availability for photosynthesis (14). Scientists correlated warm water during the 2015–2016 El Niño with reduced native canopy-forming algae and enhanced recruitment and survival of *Sargassum* (15). We did not observe *Sargassum* hindering giant kelp in our study area.

The encrusting bryozoan and the foraging snail (*Lacuna vincta*) are responsible for increased breakage of algal fronds during large wave events and can significantly reduce canopy cover and biomass (16). We did not observe snails on the kelp, but we observed extensive bryozoan encrustation. Bryozoan encrustation causes degradation of the outer blade cell layers, reducing blade flexibility and structural integrity (16).

## **RESULTS**

This study investigated whether bryozoan encrustation was associated with differences in kelp blade tearing and persistence under warm summer conditions. Giant kelp blades were quickly covered in bryozoan encrustation, and observationally, heavily encrusted blades appeared to persist longer than blades with little or no encrustation (Table 1.0).

Giant kelp returned to the nearshore area of Laguna Beach between Brooks Street Beach and Thalia Street Beach in noticeable quantities last observed a decade ago (17). No kelp predators were observed in high abundance during surveys, and there was an ample supply of nutrition in the water due to the presence of phytoplankton overbloom in June and July (Table 1.0). June, July, and August had warmer-than-average water temperatures (Graph 2.0). From June to September there were nine Day Record High temperatures (18). Warmer waters likely expedite kelp senescence as well as provide conducive conditions for bryozoan abundance (19).

The tear test was designed to expose the ease of kelp frond breakage in sections of kelp that were not encrusted compared with sections of kelp with heavy bryozoan encrustation. The tester used two hands 0.5 cm apart with the blade held between the thumb and index finger of each hand, then the tester attempted to tear the kelp blades. Testing within the LBSMR, we only tested kelp that had been left on the beach during low tide and had no chance of surviving. The tested fronds were returned to the exact location they were found, allowing the frond to decompose on the beach or return to the ocean during high tide and decompose in the ocean as kelp naturally does.

For our tear test examination of kelp fronds, we chose blades that had both sections without significant encrustations and sections with significant encrustation. We found the tear in the section without significant encrustation (A) was easy to make and the tear quickly extended, or kept tearing (Figure 5). In contrast, the tear in the significantly encrusted section (B) was difficult to make as the tester was met with resistance and had to apply more force to make the tear,

and the tear was prohibited from extending farther down the blade by the bryozoan colonies (Figure 5, Table 2.0). On the beach, examination of washed-up kelp revealed that many encrusted or minimally encrusted blades remained intact, whereas most torn blades failed the tear test in regions with little or no encrustation (Figure 6).

## **DISCUSSION**

This study documented a nearshore resurgence of giant kelp in Laguna Beach and an observed association between bryozoan encrustation and kelp blade tearing behavior during summer 2024. The MPA likely contributed to increased biodiversity and kelp recovery after nearly a decade of reduced nearshore canopy presence. While bryozoan encrustation is often considered detrimental to kelp, our observations suggest that encrusted blades may resist tearing under low-wave conditions, though this relationship remains observational.

We did not observe sea urchins in significant numbers, but we observed California sheephead, a known predator of sea urchins. A well-documented trophic cascade along the Pacific coast involves California sheephead, sea urchins, and kelp (20). By consuming sea urchins, California sheephead can indirectly promote kelp persistence.

Warm water temperatures, invasive species, bryozoan encrustation, and storm activity are all stressors for kelp forests. Unfavorable environmental conditions such as warm water, low nutrients, and high wave energy are major causes of mortality in macroscopic kelp life stages (20). Nutrient availability in spring 2024 likely supported kelp growth and a phytoplankton bloom. Summer swell activity appeared lower than typical; thus, warmer-than-average water temperatures may have been a primary stressor during the observation period (Graph 2.0). Nearshore waters in Southern California have warmed over the past century, as documented by shore station measurements and satellite records (21). Marine heat waves have contributed to rapid kelp forest losses in California (21).

Though kelp is cyclical and bryozoan encrustation in the long run degrades the kelp by blocking sunlight which kelp requires for photosynthesis, bryozoan encrustation in the short term may actually help extend the life of kelp blades by providing a physical structure akin to an exoskeleton (Figure 11). The lifespan of an entire frond is about six months depending on environmental conditions in the surrounding water (23). A study found bryozoan encrustation on the surface of kelp blades, increased blade breakage and led to significant canopy loss during heavy waves (24). However, we observed the kelp blades that remained in July were 80-90%

encrusted by bryozoan (Table 1.0), which seems to indicate that encrustation may have offered some protection to those blades, delaying senescence. These observations highlight the complexity of kelp–bryozoan interactions and underscore the need for controlled quantitative experiments to test causation.

Giant kelp is a critical component of Laguna Beach’s marine ecosystem and plays a role in coastal carbon cycling by assimilating CO<sub>2</sub> through high productivity (25). Changes in kelp abundance and environmental stressors may influence atmospheric carbon levels and climate change. Marine heatwaves are driving pronounced shifts in species distributions across marine ecosystems; therefore, understanding how ecological communities resist, recover from or are transformed by climate perturbations, such as marine heatwaves, represents one of the most pressing challenges for building ecosystem resilience capacity (22). The MPA status of nearshore waters in Laguna Beach may have supported ecological recovery, yet warming ocean temperatures associated with climate change may challenge future kelp persistence. Shallow nearshore waters may experience higher thermal stress than offshore areas. Despite these challenges, the resurgence of kelp observed in 2024 is a hopeful indicator of ecosystem resilience. Continued research is needed to clarify how bryozoan encrustation interacts with warming waters to influence kelp survival and blade integrity.

## **MATERIALS AND METHODS**

Visual surveys were conducted by our team and a volunteer swimmer. We entered the water at Oak Street Beach and went south to Brooks Street Beach, examining the southern section of the study area. We then went north from Oak to Anita Street Beach and onto Thalia Street Beach, examining the northern section of the study area. Since we were studying subtidal kelp, we made most of our observations while swimming. Specifically, the amount of bryozoan encrustation was observed via swimming and free diving. Observations of the amount of kelp in the study area were supplemented by observations from the Oak Street Beach lookout deck, the Thalia Street lookout landing and via surfboard, which allowed us to quickly cover the entire area.

Observations were made almost daily and noted monthly (Table 1.0). Images were recorded with GoPro camera footage approximately every four to five weeks for four months (Figures 2-5). Footage was obtained on June 19th, July 16th, August 26th, and October 9th. Control data were collected during winter, on February 10th, from existing GoPro footage used to capture

Laguna Beach marine life. In addition to capturing images of the kelp and bryozoan encrustation, we observed and noted kelp abundance, kelp health (including percentage of bryozoan encrustation estimates), water clarity, wave height and water temperature. We estimated sea temperature to be warmer than normal during our data collection swims, but noted actual sea temperature with data obtained from [seatemperature.info](http://seatemperature.info) (Table 1.0).

A tear test was conducted on beached kelp during low tide. We only tested kelp that was naturally uprooted and certain to begin decomposition, and it was left on the beach where it was found. We chose blades that had both sections without significant encrustations and sections with significant encrustation. The tear test was designed to compare kelp frond breakage in sections of kelp that were void of encrustation with sections of kelp with heavy encrustation. The tester used two hands 0.5 cm apart with the blade held between the thumb and index finger of each hand, then the tester attempted to tear the kelp blades.

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## Figures



**Figure 1: Study Area Indicating Nearshore Kelp**

The estimated area of our study nearer to the shore (inner nearshore), distinct from the outer nearshore kelp area which is not part of our study.



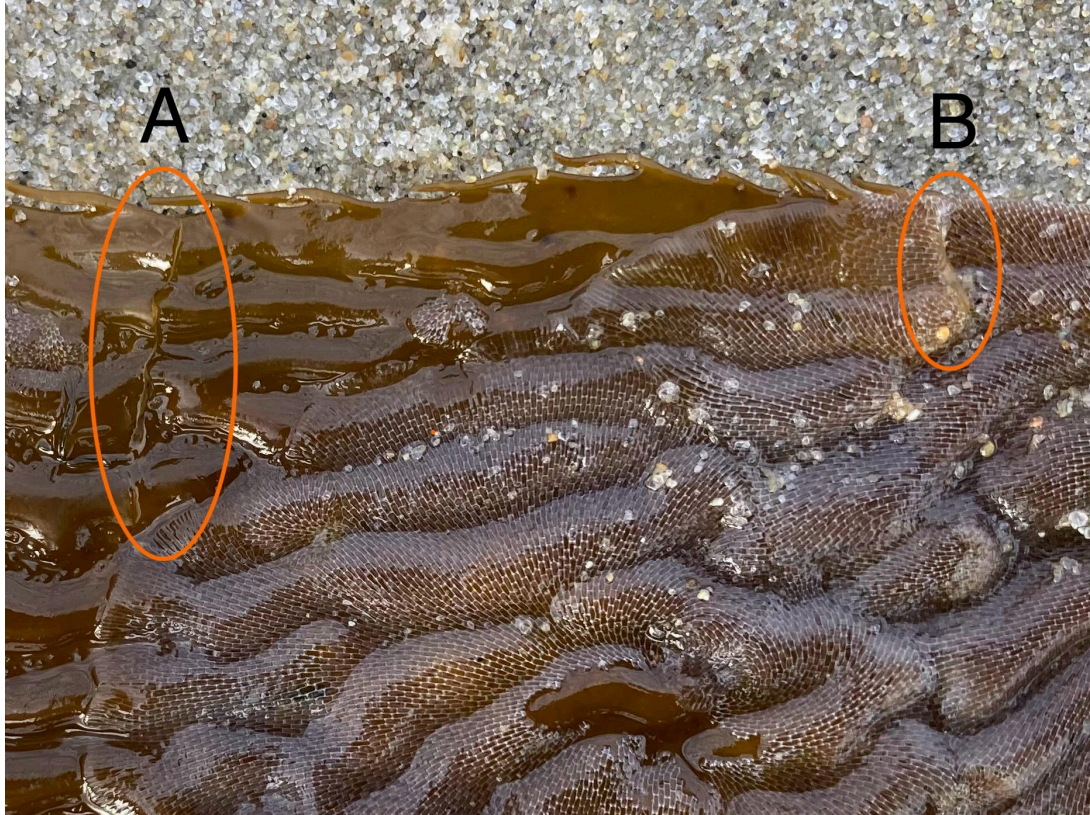
**Figure 2: Healthy Kelp** Nearshore kelp in town reemerged in the spring of 2024. We documented healthy kelp, with no bryozoan encrustation.



**Figure 3: Bryozoan Encrustation** Heavy bryozoan encrustation on the reemerged nearshore kelp in our study.



**Figure 4: Bryozoan Colony Up-Close** Enlarged to show the mesh-like structure of the bryozoan colony on a kelp blade



**Figure 5: Tear Test: Not Encrusted Area Compared to Encrusted Area**

The tear test was conducted by tearing a partially encrusted kelp blade in two distinct areas: tearing the kelp where it was not encrusted by bryozoan (A) and tearing the kelp where it was heavily encrusted (B). The kelp tore much more easily at site A and the tear was longer than at site B.

**Tables and Graphs:**

	<b>Control: February</b>	<b>Month 1 June</b>	<b>Month 2 July</b>	<b>Month 3 August</b>	<b>Month 4 Sept (early Oct)</b>
<b>Giant kelp</b>	sparse	abundant in entire surveyed area	abundant in entire surveyed area	very sparse off Brooks and Oak, moderate kelp off Anita and Thalia	sparse, missing blades

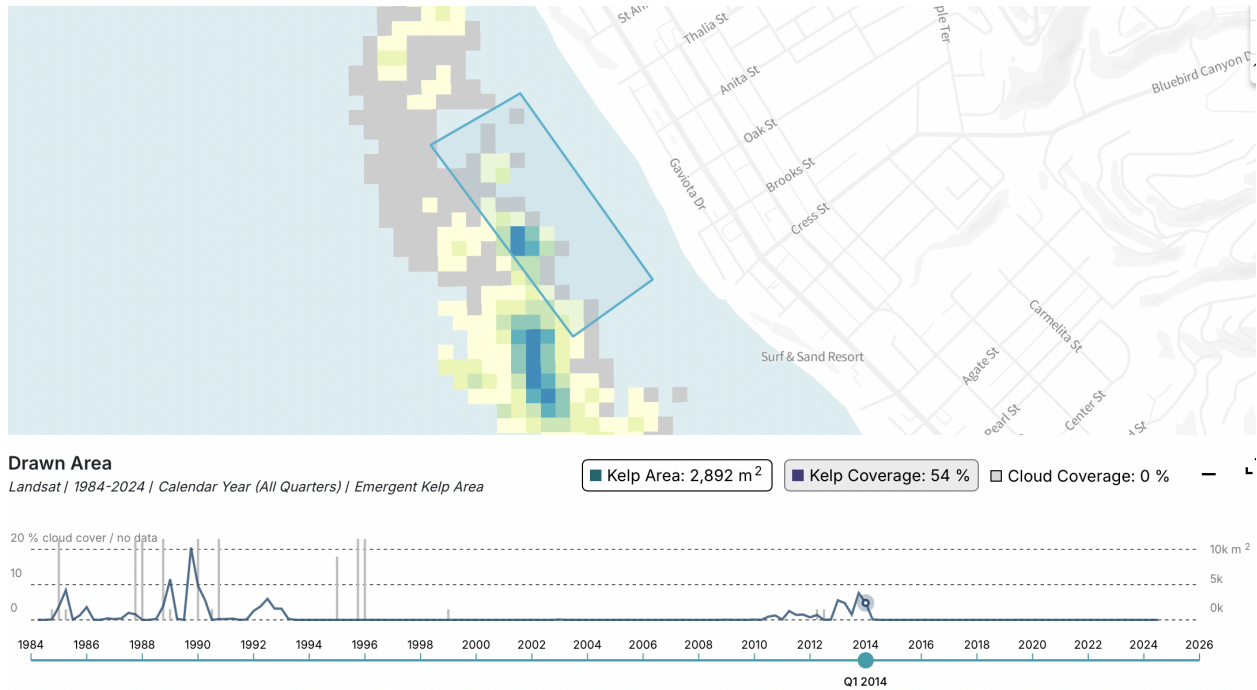
<b>Kelp health</b>	very healthy, minimal bryozoan	healthy, 10-20% of kelp covered in bryozoan encrustation	75% of kelp 80-90% covered by bryozoan encrustation	disintegrated blades, missing blades, 90% of kelp 80-90% covered by bryozoan	some stalks left with missing leaves, new growth 10-20% covered by bryozoan encrustation
<b>Water clarity</b>	Clear water	Greenish, bitter water with impaired visibility, foul smell: phytoplankton bloom	Mildly greenish with impaired, but improved visibility, improved smell	Clear water	Clear water
<b>Swell</b>	3-4 ft	2-3 ft	1-2 ft	2-3 ft	2-3 ft
<b>Water temp*</b>	16.8 C	20.22 C	23.89 C	23.78 C	22.72 C

**Table 1.0 Laguna Beach Nearshore Kelp and Water Conditions** \*sea temperature data from seatemperature.info. Since we were studying subtidal kelp, most of our observations were obtained via swimming and free diving. We also paddled on a surfboard, which allowed us to quickly cover the entire area. In addition to observations, images were recorded with GoPro camera footage approximately every four to five weeks for four months. We observed and noted kelp abundance, kelp health (including percentage of bryozoan encrustation estimates), water clarity, wave height and water temperature. We estimated sea temperature to be warmer than normal during our data collection swims, but noted actual sea temperature with data obtained from seatemperature.info

	<b>Tear Test 1</b>	<b>Tear Test 2</b>	<b>Tear Test 3</b>	<b>Tear Test 4</b>	<b>Tear Test 5</b>
<b>Tear A (not encrusted)</b>	easy, long tear	mild resistance to start (at the edge), long easy tear	easy, long tear	mild resistance to start (at the edge), long easy tear	easy, long tear
<b>Tear B (encrusted)</b>	harder to tear, stopped tearing	harder to tear, tear did not extend	harder to tear initially, but then "gave" as we applied force	harder to tear, tear did not extend	harder to tear, tear did not extend

**Table 2.0 Tear Test Results** We devised a tear test to examine kelp frond breakage in sections of kelp that were void of encrustation with sections of kelp with heavy encrustation. A tear test

was conducted on beached kelp during low tide. We only tested kelp that was naturally uprooted and certain to begin decomposition, and it was left on the beach where it was found. The tester used two hands 0.5 cm apart with the blade held between the thumb and index finger of each hand, then the tester attempted to tear the kelp blades. We found the encrusted sections to be stronger than the sections that were not encrusted.



**Figure 6 Satellite Confirmation of Nearshore Kelp** Prior to 2024, nearshore kelp beds were last significantly noticeable in the study area back in Q1 2014, as confirmed by data from Kelpwatch.org. (17)