Laguna Beach Nearshore Giant Kelp and Bryozoan

Keanu Mir-Scaer*, Zen Mir-Scaer*
Laguna Beach, California
*Both authors contributed equally

keanu.mirscaer@lbusd.org, https://orcid.org/0009-0008-0162-6095
zen.mirscaer@lbusd.org, https://orcid.org/0009-0009-8229-5028

Abstract

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 the 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 last decade, from 2015 to 2023. Our observations were confirmed by reviewing images from KelpWatch.org, where data is processed from NASA's Landsat satellite program, the largest map of kelp forest canopy from 1984 to 2021 (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 senescence when they reach between three to twelve months (2). Although kelp has a natural growth cycle and warmer sea temperatures may expedite senescence, bryozoan encrustation possibly delayed senescence by providing physical structure to the disintegrating blades. Nearshore kelp is once again growing in Laguna Beach, likely due to the biodiversity afforded by MPA protection, however, additional action is required to protect kelp in warming waters due to climate crisis and we see a need for additional research into the relationship between kelp and bryozoan.

Keywords

Keywords: giant kelp, bryozoan, climate crisis, global warming, Marine Protected Area (MPA).

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 (Image A). Study area is approximately 33.53170° N, 117.78009° W to 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).”

Image A, Approximate study area

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 degrees Celsius (°C; 46.4−73.4 °F) and juveniles in 0–20 °C (32.0 to 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 change with natural cycles (5).

Predators:
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 nig*ricans*) 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 a predator of kelp ravaging 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.

Climate:

Weather in Southern California is affected by the natural climate pattern known as El Niño Southern Oscillation (ENSO) and is driven by interactions of oceanic and atmospheric forces in the Pacific (8). During El Niño, warm water builds up across the equatorial Pacific Ocean and spreads east toward the western coasts of North and South America, and as the warm water floats over denser, cooler water, ocean thermoclines deepen and effectively block the upwelling processes that deliver essential nutrients to coastal ecosystems (9). The higher water temperatures during El Nino may lead to increased Pacific storms that uproot kelp, and the warmer water may impact marine ecosystems.

Although warming and cooling ocean temperatures are cyclical and natural, the human-made climate crisis warming the earth and sea temperatures is unequivocal and has a detrimental impact on marine life. Gavin Schmidt, the director of NASA's Goddard Institute for Space Studies has noted that over much of the last century, there is a clear trend of "more heat and warmer sea surface temperatures pretty much everywhere (10)." The ocean takes up about 93% of the global warming heat entering Earth's climate system (11). As a result, marine heat has been increasing since modern record-keeping began in the mid 1950's (12). Beyond deniability, marine temperatures are overall warmer.

The nearshore scattered kelp beds in town were clearly not recovered as the 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 bring seasonal changes to water temperatures, which keep giant kelp life cyclical. How long will kelp be able to withstand the perils of warmer waters? The answer lies in critically needed research, as we observed an interesting presence of bryozoan encrustation on the longest lasting giant kelp blades in Laguna Beach this summer.

Invasive Species:
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 be a result of shading (14). Scientists have correlated warm water during the 2015–2016 El Niño that reduced native canopy-forming algae and enhanced recruitment and survival of sargassum (15). We, however, did not observe any sargassum hindering the giant kelp in our area of study.

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

Methods

Visual surveys were conducted by our team and a volunteer swimmer. Observations were made almost daily and noted monthly (Table 1). Images were recorded with gopro camera footage approximately every four to five weeks for four months (Images 1-12). Footage was obtained on June 19th, July 16th, August 26th and October 9th. Control data were collected during winter, February 10th.

A tear test was conducted on kelp partially encrusted with bryozoan. We only tested kelp that had washed ashore.

Results

Images taken between February 10th and October 19th, 2024.

Image 1 Healthy giant kelp in Laguna

Image 2 Healthy giant kelp canopy

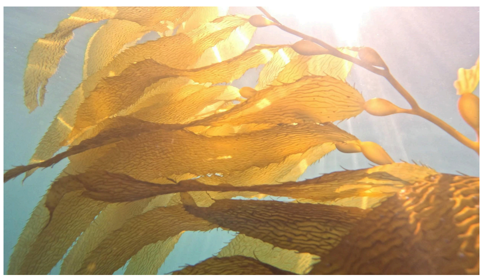


Image 3 Healthy giant kelp in clear water

Image 4 Healthy kelp blade

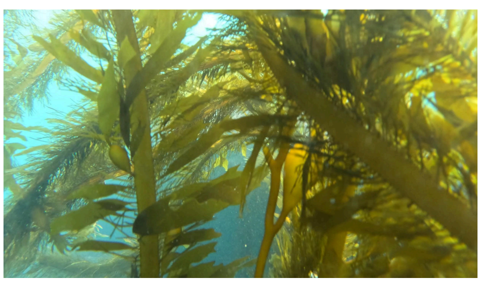


Image 5: Giant kelp and feather boa
feather boa

Image 6: Encrusted giant kelp and

Image 7: bryozoan encrustation

Image 8: disintegrating kelp

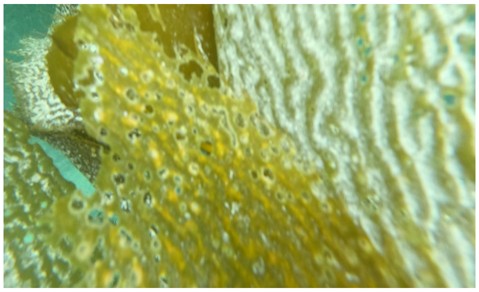


Image 9: loss of biomass
encrustation

Image 10: close up bryozoan

Image 11: bryozoan zoomed in

Image 12: stranded kelp after a swell

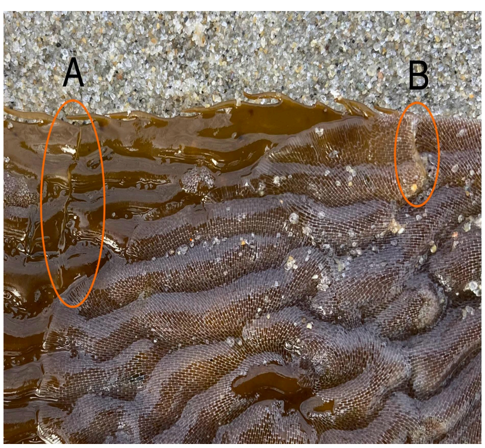
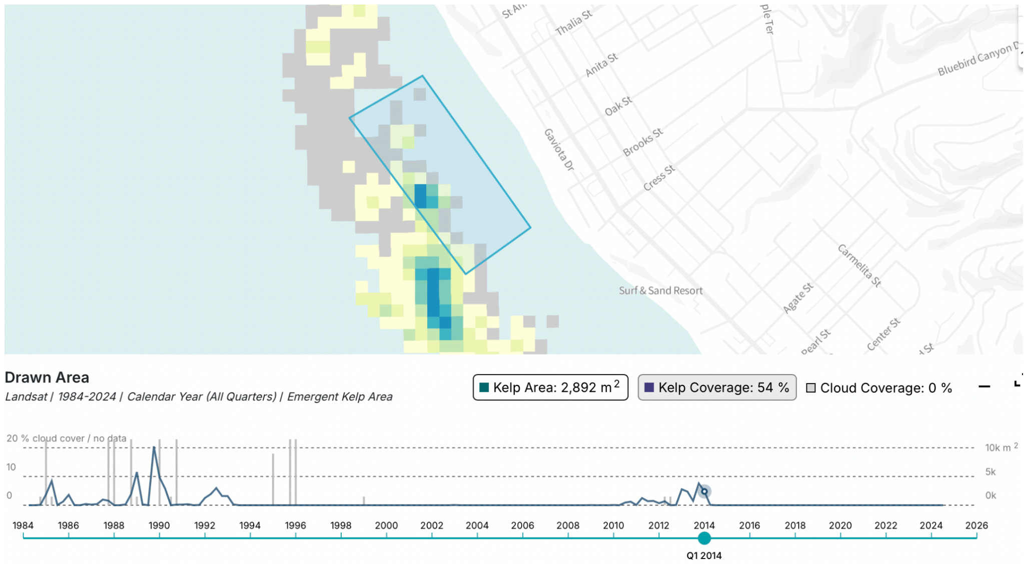


Image 13: kelp blade tore easily at site A without bryozoan encrustation. At site B with bryozoan encrustation, there was more resistance.

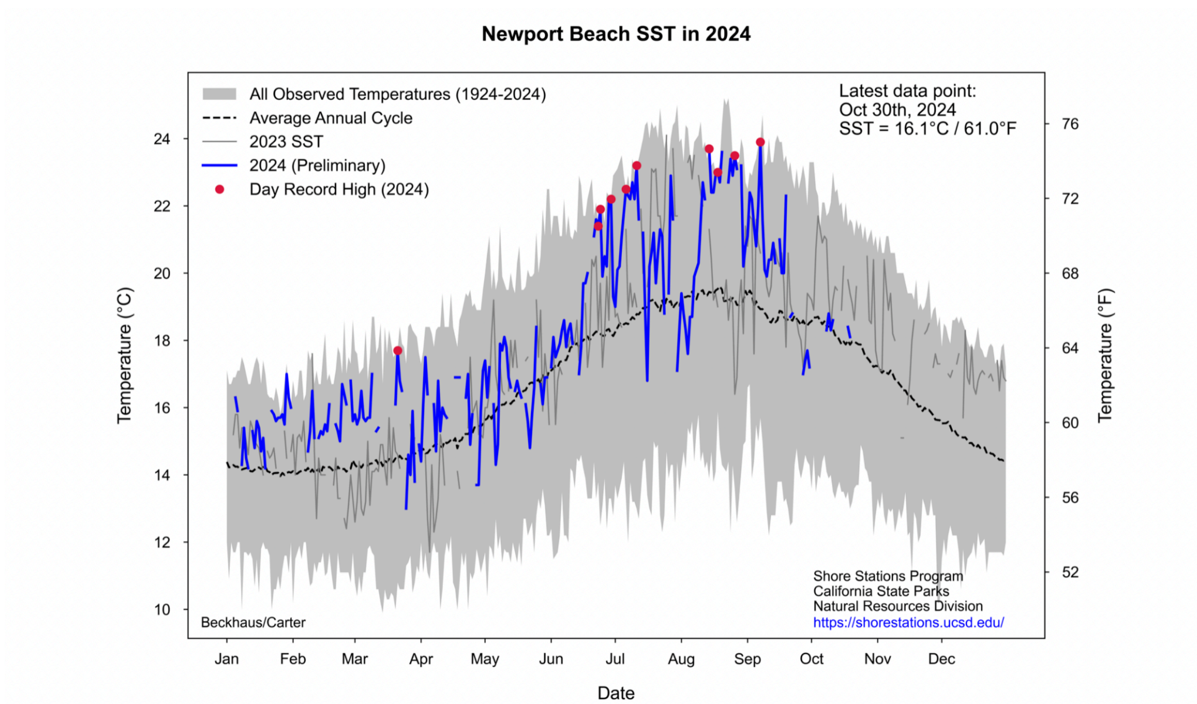
Image 14 beached kelp blade with encrusted area of the blade intact

	Control: February	**Month 1 June**	**Month 2 July**	**Month 3 August**	**Month 4 Sept (early Oct)**
Giant kelp	sparse	abundant in entire surveyed area	abundant in entire surveyed area	very sparse off Brooks and Oak, moderate kelp off Anita and Thalia, severely damaged blades	sparse, missing blades
Kelp health	very healthy, minimal bryozoans	healthy, 10-20% of kelp covered in bryozoans encrustation	75% of kelp 80-90% covered by bryozoans	disintegrated blades, missing blades, missing kelp	some stalks left with missing leaves, new growth 10-20% covered by bryozoans
Other observations	Clear water	Greenish, bitter water with impaired visibility; foul smell--all indicating phytoplankton bloom.	Mildly greenish with impaired, but improved visibility, improved smell	Clear water	Clear water
Swell	3-4 ft	2-3 ft	1-2 ft	2-3 ft	2-3 ft
Water temp*	16.8 C	20.22 C	23.89 C	23.78 C	22.72 C

Table 1.0 Table of Observations



Graph 1.0 from Kelpwatch.org - Satellite image nearshore kelp in town Q1 2014 (17)



Data provided by the Shore Stations Program sponsored at Scripps Institution of Oceanography by California Department of Parks and Recreation, Natural Resources Division, Award# C1670003.

Graph 2.0 from UCSD Shore Stations Program - Warmer SST in 2024 (18)

Discussion

The MPA conserves biodiversity and has very likely enabled the visible resurgence in marine life, including the return of giant kelp in town after almost a decade. While we were unable to observe a kelp predator, the sea urchin; we did observe a sea urchin predator, the California sheephead. A well-known trophic cascade on the Pacific coast is the relationship between the California sheephead, sea urchins, and kelp. Population explosions of two species of sea urchins and the accompanying degradation of kelp forests were recorded along the coasts of southern California (19). Urchins feed voraciously on kelp, sometimes cutting the seaweed at its base, and can fell entire kelp forests (19). The California sheephead plays a key role in the kelp forest because of its ability to consume large quantities of sea urchins and other invertebrate prey (19).

In addition to sea urchins, there are many threats to kelp including historically warm water temperatures, invasive sargassum, destructive bryozoans, and powerful storm swells. Unfavorable environmental conditions such as warm water, low nutrients, and high wave energy are a major cause of mortality in macroscopic kelp life stages (20). Abundant nutrient levels must have existed in Laguna Beach nearshore waters in the spring of 2024 because there was a resurgence of giant kelp in town as well as a phytoplankton bloom in early summer. We also observed an odd lack of significant summer swell, typically an active season of south swell surf. Thus, the only unfavorable environmental condition was warmer than average water (See graph 2.0).

Measurements at California's shore stations show that nearshore coastal waters have warmed over the past century, particularly in Southern California. Similarly, satellite-based records over the past four decades show warming ocean waters off Southern California (21). The Office of Environmental Health Hazard Assessment (OEHHA) in California has calculated that waters in nearby San Clemente increased by 0.37 degrees Farenheit from 1965 to 2020 (21). Marine Heat Waves contributed to the rapid and extensive loss of kelp forests in Northern and Southern California (21).

Although global warming and warming oceans are undeniable, the impact of warming oceans needs to be studied in a search for solutions to warming marine habitat. Seasonal water temperature changes dictate the life cycle of giant kelp, but how well kelp can survive the increasingly warmer summer cycles in Southern California is not clear. Warmer waters cause a multitude of changes, often problematic for native marine life. During the summer of 2024 we observed that warmer waters created an environment where bryozoans overwhelmed giant kelp in the nearshore subtidal waters of Laguna Beach. 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).

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 (Image 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. We examined a partially encrusted blade and made two small tears, one tear (A) where there was no bryozoan encrustation and another tear (B) where the kelp was heavily encrusted (Image 13). We found the tear in the section without encrustation was easy to make and it quickly extended. In contrast, the tear in the encrusted section was met with more resistance and the tear was prohibited from extending farther down the blade by the bryozoan. On the beach examining washed up kelp, we also observed most encrusted or minimally encrusted kelp blades were intact. Most of the torn blades were mostly encrusted (Image 14) suggesting that while bryozoan provide physical structure that protects the kelp blade, perhaps under pressure of rougher water during significant swells (a 4-5 ft swell had uprooted the kelp we observed) the contrasting strength and rigidity of bryozoan colonies on only partially encrusted blades leads to blade breakage on the relatively weaker areas without encrustation.

Conclusion

Giant kelp is critical to Laguna Beach's marine habitat. Kelp forests assimilate substantial quantities of CO2 by virtue of their exceptional productivity and large spatial extent (25) Changes in the abundance of kelp, and the environmental conditions they experience, may have consequences for the global carbon cycle. More than 80% of kelp production enters the coastal ecosystem as detritus, where it eventually strands on beaches (Image 10), sinks to the seafloor, or is consumed or decomposed (25).

The MPA status of the nearshore waters in town likely allowed native marine life to recover, but the increasingly warm water temperatures due to the climate crisis are adversely affecting giant kelp recovery, whether directly due to warmer water temperatures or indirectly, due to extreme changes in weather that cause more powerful storms that may uproot kelp and irregular weather patterns that may cause excessive rain and runoff. It is also likely that the shallower waters of the nearshore reef in Laguna Beach were warmer than the recorded temperatures.

Ecosystem community shifts were associated with a pronounced decline in the relative proportion of cold water species and an increase in warm water species (22). Yet, the resurgence of kelp in the nearshore waters is a hopeful sign of a recovering ecosystem. Continued and more expansive research to identify the relationship between kelp and bryozoan is needed: bryozoan may actually provide kelp with a physical structure that, at least initially, fortifies kelp blades, countering an otherwise more rapid breakdown due to warmer waters. In addition to creating marine protected habitats, action must be taken to resolve the climate crisis and arrest rising sea temperatures, while investigating solutions such as the kelp-bryozoan relationship.

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Conflicts of Interest/Originality Statement

We have no conflict of interest. We are recreationally in these waters on an almost daily basis and want to better understand how to conserve the marine ecosystem.

References

1. “World’s Largest Dynamic Kelp Map Launched.” 4 April 2022. *NASA Landsat Science*, https://landsat.gsfc.nasa.gov/article/worlds-largest-dynamic-kelp-map-launched/. Accessed 19 Oct. 2024.
2. “Giant Kelp and Bull Kelp Enhanced Status Report.” *California Department of Fish and Wildlife Marine Species Portal*, marinespecies.wildlife.ca.gov/kelp/the-species/. Accessed 19 Oct. 2024.
3. “Laguna Beach State Marine Conservation Area.” *California Department of Fish and Wildlife*, nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=98220&inline. Accessed 19 Oct. 2024.

4. “Kelp Forest Habitat on the West Coast.” *NOAA Fisheries*, www.fisheries.noaa.gov/west-coast/habitat-conservation/kelp-forest-habitat-west-coast Accessed 19 Oct. 2024.
5. “Kelp Forests.” Spring 2020. *Project Oceanography*, www.marine.usf.edu/pjocean/packets/sp02/sp02u1p4.pdf. Accessed 19 Oct. 2024.
6. “Rare sea otter sighting offers sign of a resurgence, scientists hope.” 20 Mar. 2016. *The Guardian*, www.theguardian.com/us-news/2016/mar/20/rare-sea-otter-sighting-california#:~:text=Guardian-,Sea%20otters%2C%20which%20are%20hunted%20for%20food%20and%20clothing%20in,the%20first%20in%20three%20decades. Accessed 19 Oct. 2024.
7. Marine Multi-Agency Rocky Intertidal Network, *UC Santa Cruz*, 5 Sept. 2024, https://marine.ucsc.edu/data-products/sea-star-wasting/updates.html. Accessed 19 Oct. 2024.
8. “What is ENSO.” *National Weather Service*, www.weather.gov/mhx/ensowhat. Accessed 19 Oct. 2024.
9. “Extreme Weather El Nino.” *California Coastal Commission*, www.coastal.ca.gov/climate/extreme-weather/el-nino/. Accessed 19 Oct. 2024.
10. “The Ocean Has a Fever.” 21 Aug. 2023. *NASA Earth Observatory*, earthobservatory.nasa.gov/images/151743/the-ocean-has-a-fever. Accessed 19 Oct. 2024.
11. Johnson, Gregory and John M. Lyman. “Warming Trends Increasingly Dominate Global Ocean.” 13 July 2020. *Nature*. vol. 10, www.nature.com/articles/s41558-020-0822-0. Accessed 19 Oct. 2024.
12. “Ocean Warming.” *NASA*, climate.nasa.gov/vital-signs/ocean-warming/?intent=121. Accessed 19 Oct. 2024.
13. MBC Aquatic Sciences.“Status of the Kelp Beds in 2021: Orange and San Diego Counties.” 14 Sept. 2022. *Region Nine Kelp Survey Consortium*, www.sandiego.gov/sites/default/files/2021_rnksc_report.pdf. Accessed 19 Oct. 2024.
14. Britton-Simmons, Kevin H.”Direct and indirect effects of the introduced alga Sargassum muticum on benthic, subtidal communities of Washington State, USA” *Marine Ecology Progress Series*, vol. 277. Inter Research Science Publisher. 16 Aug. 2004, www.int-res.com/articles/meps2004/277/m277p061.pdf. Accessed 19 Oct. 2024.
15. Marks, Lindsay et al. “Sargassum Horneri In California, USA.” *National Oceanic and Atmospheric Administration Library*. ID# 33030. 2017, repository.library.noaa.gov/view/noaa/33030. Accessed 19 Oct. 2024.

16. “Monitoring the Collapse of Kelp Forests.” *NASA Earth Observatory*, earthobservatory.nasa.gov/images/148391/monitoring-the-collapse-of-kelp-forests. Accessed 19 Oct. 2024.
17. “Monitoring Kelp for Conservation.” *Kelpwatch.org*, kelpwatch.org/map?currentStep=2021.2&zoom=13.36477&center=-117.78380%2C33.52842. Accessed 19 Oct. 2024.
18. Shore Stations Program. Scripps Institution of Oceanography, UC San Diego, https://shorestations.ucsd.edu. Accessed 19 Oct. 2024.
19. “Sheephead, Sea Urchins & Kelp: A Dynamic Food Chain.” 28 May 2018. *Fish Bio*, fishbio.com/sheephead-sea-urchins-kelp-dynamic-food-chain/. Accessed 19 Oct. 2024.
20. “Giant Kelp and Bull Kelp Enhanced Status Report.” *California Department of Fish and Wildlife*, marinespecies.wildlife.ca.gov/kelp/the-species/. Accessed 19 Oct.. 2024.
21. “Indicators of Climate Change (2022).” 2022. *Coastal Ocean Temperature*, oehha.ca.gov/media/epic/downloads/03coastaloceantemps.pdf. Accessed 19 Oct. 2024.
22. Smith, Joshua G. et al. “A marine protected area network does not confer community structure resilience to a marine heatwave across coastal ecosystems” 13 July 2023. *Wiley Online Library*, onlinelibrary.wiley.com/doi/10.1111/gcb.16862. Accessed 19 Oct. 2024.
23. North, Wheeler J. “Biology of the Macrocystis resource in North America.“ California Institute of Technology. *Food and Agriculture Organization of the United Nations*, www.fao.org/4/x5819e/x5819e0a.htm. Accessed 19 Oct. 2024.
24. Krumhansl, Kira A et al. “Grazing Damage and Encrustation by an Invasive Bryozoan Reduce the Ability of Kelps to Withstand Breakage by Waves.” *Journal of Experimental Marine Biology and Ecology*, 15 October 2011, vol. 407. https://www.sciencedirect.com/science/article/abs/pii/S0022098111003054. Accessed 19 Oct. 20024.
25. Filbee-Dexter, Karen et al. ”Kelp Carbon Sink Potential Decreases with Warming Due to Accelerating Decomposition.” *National Library of Medicine*, 4 Aug. 2022, https://pmc.ncbi.nlm.nih.gov/articles/PMC9352061/. Accessed 19 Oct. 2024.