Assessing the abundance of canopy-forming kelps in the Northeast Pacific
INTRODUCTION

About this document

The Kelp Report Card is an annual, data-driven evaluation of kelp canopy dynamics in the Northeast Pacific relative to historical trends. This analysis spans the West Coast of the United States through Baja California, Mexico and mobilizes nearly 40 years of Landsat satellite-derived kelp canopy data (Bell et al. 2024) to provide a summary of 2022 trends in kelp canopy to inform strategic conservation, restoration, management, and research of this important natural resource and ecosystem. The data underlying this report card are publicly available in interactive format on Kelpwatch.org.

Background

The Kelp Report Card summarizes the annual status of the floating canopies of the two dominant canopy-forming kelp species in the Northeastern Pacific (bull kelp and giant kelp, Nereocystis luetkeana and Macrocystis pyrifera respectively) in 2022 relative to historical trends. Both species in the Northeastern Pacific were impacted by multiple stressors during the 2014–2016 marine heatwave and El Niño events, a time frame defined by several prolonged high seawater temperature periods, reduced upwelling of ocean nutrients, an increase in herbivorous native purple sea urchins (Strongylocentrotis purpuratus), and the near-complete loss of an important sea urchin predator, the sunflower sea star (Pycnopodia helianthoides). Since 2014, many regions experienced large losses of kelp forests and recovery has been variable by region. Additionally, interannual variability in oceanographic conditions and changes in purple sea urchin abundance and grazing behavior have contributed to varied regional kelp canopy dynamics. The Kelp Report Card shows the kelp canopy status for 2022 by mapping the annual maximum kelp canopy area and displaying these as a percentage of the historical mean of annual maximum kelp canopy area from 1984 to 2013 (the period before the multiple stressor events that began in 2014).

Methods

The methods used to calculate the annual maximum bull kelp and giant kelp canopy area are built on Bell et al., 2023, a peer-reviewed paper that described regional kelp loss and recovery using Kelpwatch.org. The kelp canopy detections are not distinguishable at the species level from the Landsat imagery. In this analysis, kelp canopy data for each year was included if at least 50% of the historical kelp habitat within each region contained a valid observation in at least three seasons of a given year. In addition to replicating published methods, the Kelp Report Card analysis required that one of these valid seasonal observations occurred during summer. The inset maps of the featured reefs on the regional pages of the report card use the same methodology to show maximum annual kelp canopy area for 2022 across selected areas within each region at 30 meter spatial resolution. We also include figures showing the historical dynamics of kelp canopy area within each region and sea surface temperature compared to the mean and standard deviation from all previous years starting in 1985 from the NOAA Coral Reef Watch 5 km sea surface temperature (SST) product. Landsat data are not available for some years, which appears as gaps on the graph.
How the regions are established

The Kelp Report Card summarizes kelp canopy area trends in the Northeast Pacific in 2022 at a regional and sub-regional level. Regions follow state and national boundaries across the west coast of the United States and Mexico: Washington (WA), Oregon (OR), California, Baja California Norte (BN), and Baja California Sur (BS). The state of California is categorized into three sub-regions: Northern (NC), Central (CC), and Southern California (SC) that represent areas defined by the dominant canopy-forming kelp species and physical ocean conditions: the Northern California region includes kelp canopy north of San Francisco to the Oregon border; Central California includes kelp canopy south of San Francisco to Point Conception; and the Southern California region includes kelp south of Point Conception to the Mexico border including the offshore Channel Islands (Carr and Reed, 2016).

Sea surface temperature

Ocean temperatures are one of the strongest correlates to both seasonal and interannual kelp dynamics. Cool, nutrient-rich seawater is typically associated with strong kelp recruitment and rapid growth, leading to high kelp canopy area. Warm seawater is typically associated with poor kelp recruitment and growth. The Kelp Report Card summarizes the mean daily sea surface temperature for the current year in each region and shows seawater temperature compared to previous years. Sea surface temperature data are acquired from areas that have or have historically contained kelp canopy.

2022 AT A GLANCE

Kelp canopy area was variable across the Northeast Pacific in 2022 with some regions near historical averages including Central California and Baja California Sur. Northern California showed little recovery since the multiple stressor events that began in 2014, while Oregon and Baja California Norte remained well below historical averages. Washington and Southern California were at about half the historical average but within the annual fluctuations present before 2014.

LATEST TRENDS (kelp canopy area as a % of historical mean*)

<table>
<thead>
<tr>
<th>Region</th>
<th>Average Marine Heatwave (2014–16)</th>
<th>Average Last 5 Years (2018–22)</th>
<th>2022</th>
</tr>
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<tbody>
<tr>
<td>Washington (WA)</td>
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<td>98</td>
<td>51</td>
</tr>
<tr>
<td>Oregon (OR)</td>
<td>54</td>
<td>43</td>
<td>21</td>
</tr>
<tr>
<td>Northern California (NC)</td>
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<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Central California (CC)</td>
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<td>82</td>
<td>94</td>
</tr>
<tr>
<td>Southern California (SC)</td>
<td>53</td>
<td>69</td>
<td>50</td>
</tr>
<tr>
<td>Baja Norte (BN)</td>
<td>81</td>
<td>66</td>
<td>35</td>
</tr>
<tr>
<td>Baja Sur (BS)</td>
<td>105</td>
<td>118</td>
<td>82</td>
</tr>
</tbody>
</table>

* Kelp canopy area was measured against the historical mean of the annual maximum canopy area for the period before the multiple disturbance events that began in 2014 (1984–2013). The map on the right shows the maximum annual kelp canopy area for 2022 as a percentage of the historical mean for 20 x 20 km cells across the range included in this report card. A 20 x 20 km cell was only included if it contained at least 0.45 km² of kelp habitat (Bell et al. 2023).
Overall, the area of the giant and bull kelp canopies along the open coast and Strait of Juan de Fuca in Washington (WA) was lower in 2022 relative to the historical mean but was within historical annual fluctuations around the historical average. Neah Bay and the northwest coastline of the Olympic Peninsula (shown on the right) showed a mixture of high and low canopy cover.

**Washington sea surface temperature for 2022**

- Sea surface temperatures in 2022 (blue line) generally followed the historical pattern. Historical mean is the black line and light blue shaded area is the standard deviation.

**Washington annual maximum kelp canopy area for 2022**

- The blue line shows the annual maximum kelp canopy area as a percentage of the historical mean. Green shaded area shows the multiple disturbance events that began in 2014. Landsat data are not available for some years, which appear as gaps on the graph.
Oregon (OR) kelp canopy area remained low in 2022 relative to the historical mean, especially around Orford Reef, one of the historically largest kelp-supporting rocky reefs in the region. Rogue Reef (shown on the right) continued to show high kelp canopy cover relative to the historical mean.

Sea surface temperatures in 2022 (blue line) generally followed the historical pattern with a few cold water events during summer. Historical mean is the black line and light blue shaded area is the standard deviation.

The blue line shows the annual maximum kelp canopy area as a percentage of the historical mean. Green shaded area shows the multiple disturbance events that began in 2014.
Northern California (NC) kelp canopy area continued to be much lower than the historical mean throughout the region. Point Arena (shown on the right), one of the most extensive and persistent bull kelp reef systems in the region, has experienced multiple years of low canopy area following the slight increases observed from 2020-2021.

**Northern California sea surface temperature for 2022**

- Sea surface temperatures in 2022 (blue line) generally followed the historical pattern with one warm water event in summer. Historical mean is the black line and light blue shaded area is the standard deviation.

**Northern California annual maximum kelp canopy area for 2022**

- The blue line shows the annual maximum kelp canopy area as a percentage of the historical mean. Green shaded area shows the multiple disturbance events that began in 2014. Landsat data are not available for some years, which appear as gaps on the graph.
CENTRAL CALIFORNIA, USA

The California Central (CC) coast, a mix of both giant and bull kelp, continued to increase in kelp canopy area for the third year in a row (2020–2022) relative to the historical mean. However, the kelp canopies around the Monterey Peninsula (shown on the right) continued to decline to historical lows.

Central California sea surface temperature for 2022

Sea surface temperatures in 2022 (blue line) generally followed the historical pattern. Historical mean is the black line and light blue shaded area is the standard deviation.

Central California annual maximum kelp canopy area for 2022

The blue line shows the annual maximum kelp canopy area as a percentage of the historical mean. Green shaded area shows the multiple disturbance events that began in 2014.
Southern California sea surface temperature for 2022

- Sea surface temperatures in 2022 (blue line) generally followed the historical pattern with one warm water event in summer. Historical mean is the black line and light blue shaded area is the standard deviation.

Southern California annual maximum kelp canopy area for 2022

- The blue line shows the annual maximum kelp canopy area as a percentage of the historical mean. Green shaded area shows the multiple disturbance events that began in 2014.

Kelp canopy area in the Southern California (SC) Bight was variable in 2022 with areas such as Palos Verdes (mainland) and San Nicolas Island (Channel Islands) near historical averages. Giant kelp canopies in other areas have declined relative to the historical mean, such as San Miguel and Santa Rosa Islands (shown on the right). While kelp canopy area across these islands has been variable over the past four decades with periods of low kelp canopy in the 1990s and high canopy in the 2000s, few areas of canopy have been observed since 2018.
Baja California Norte (BN) kelp canopy area continued to remain low in 2022 relative to the historical mean, similar to 2020 and 2021. Several large giant kelp forest canopies were present in areas south of Punta Banda (shown to the right).

Baja California Norte sea surface temperature for 2022

Sea surface temperatures in 2022 (blue line) generally followed the historical pattern with one warm water event in summer. Historical mean is the black line and light blue shaded area is the standard deviation.

Baja California Norte annual maximum kelp canopy area for 2022

The blue line shows the annual maximum kelp canopy area as a percentage of the historical mean. Green shaded area shows the multiple disturbance events that began in 2014. Landsat data are not available for some years, which appear as gaps on the graph.
Baja California Sur (BS) kelp canopy area was near the historical regional mean in 2022. Several areas showed large, dense giant kelp canopies, especially around Isla Natividad and Punta Eugenia (shown on the right). This region remains one of the most resilient to the 2014–2016 marine heat waves.

Sea surface temperatures in 2022 (blue line) generally followed the historical pattern. Historical mean is the black line and light blue shaded area is the standard deviation.

The blue line shows the annual maximum kelp canopy area as a percentage of the historical mean. Green shaded area shows the multiple disturbance events that began in 2014. Landsat data are not available for some years, which appear as gaps on the graph.
CONCLUSION

Kelp canopy area was variable across the Northeast Pacific in 2022 with several regions near historical means or within normal variability around the historical mean, including Washington, Central California, Southern California, and Baja California Sur. Other regions such as Oregon and Baja California Norte were low relative to the historical mean and Northern California remained very low relative to the historical mean with little signs of recovery from the multiple disturbance events that began in 2014. Within regions, local areas such as the Monterey Peninsula in Central California and the western half of the Northern Channel Islands in Southern California showed little kelp canopy and are continued areas of concern. Overall, sea surface temperatures were near normal for most regions in 2022, with short periods of significant warming during the summer in Southern California and Baja California Norte.

Suggested citation


References


Bell, T, K. Cavanaugh, D. Siegel. 2024. SBC L TER: Time series of quarterly NetCDF files of kelp biomass in the canopy from Landsat 5, 7 and 8, since 1984 (ongoing) ver 23. Environmental Data Initiative. https://doi.org/10.6073/pasta/2c1218b7eb6967da52000ad0f0216a8b.

SST Data: https://coralreefwatch.noaa.gov/product/5km/index.php


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