Baseline Highlights from Atmospheric and Oceanographic Monitoring in California's South Coast

Assessing Physical Conditions of South Coast MPAs

ABOUT THIS SNAPSHOT REPORT

This report highlights some key scientific findings from long-term monitoring of physical conditions in California's South Coast region over the past 120 years, including during the time of marine protected area (MPA) implementation. Information and figures are derived from the full report on physical conditions in the South Coast, available at OceanSpaces.org.

Guest Snapshot Report

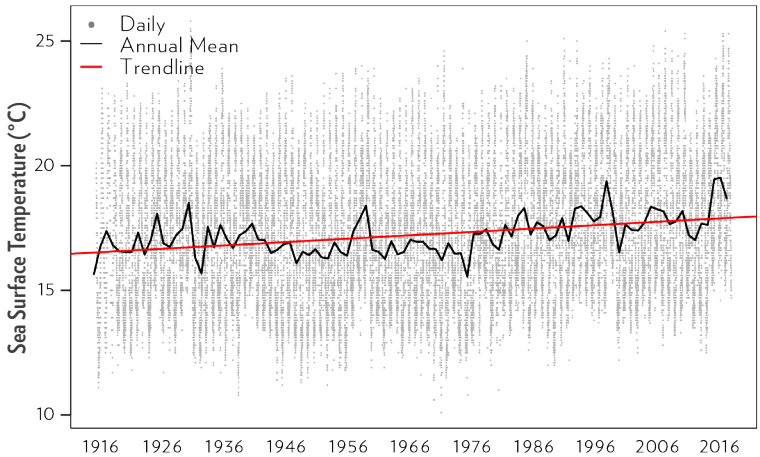
What are Physical Conditions?

Physical conditions refer to atmospheric and oceanographic conditions in the coast and ocean that act as drivers of change on both short and long timescales. They describe non-biological aspects of the ocean (e.g., temperature, salinity, currents, waves, sea level, upwelling) and characteristics of the atmosphere (e.g., precipitation, air temperature, cloudiness). The interaction of the ocean and atmosphere can influence physical conditions through El Niño Southern Oscillation (ENSO) events, climate change, and ocean acidification (i.e., lowering of ocean pH).

Typical and Anomalous Physical Conditions During 2012-2016

SEA SURFACE TEMPERATURE

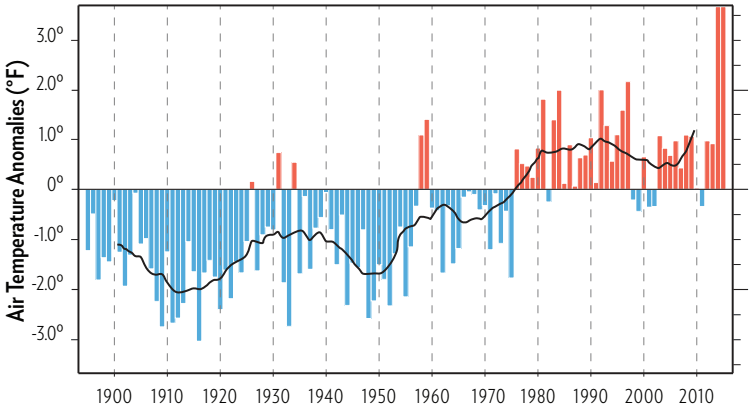
Sea surface temperature (SST) at the Scripps Institution of Oceanography (SIO) pier in La Jolla is a good representation of temperature throughout the South Coast. For the past 100 years, SST has ranged from 11.8-23.6°C, with an average of 17.1°C. During this timeframe, average SST at the SIO pier has increased by approximately 1.8°C, which is twice the global rate. Anomalously warm water conditions in the North Pacific basin, nicknamed 'The Blob,' were detected in 2012 and have persisted into 2016. SST in the South Coast was abnormally warm from spring of 2014 through 2016, with temperatures warmer by 3°C in some areas. These warm water conditions in the South Coast were initially associated with the arrival of a unique warm water anomaly termed, the Southern California Warm Anomaly (SCWA) and continued with the onset of an El Niño event in 2015-2016. The degree of warming was similar to that of the strong El Niño events of 1957-1958, 1982-1983, and 1997-1998.



Sea surface temperature at the SIO pier for 1916-2015. Shown are daily data (gray dots), annual mean (black line), and linear trend (red line). Source: SIO.

AIR TEMPERATURE

Average air temperature in the South Coast relative to a 1949-2005 baseline period is 62.1°F. A 120-year record of air temperature in the South Coast revealed that 2014 and 2015 were the warmest years on record, with 2015 air temperature exceeding the mean by 3.9°F. Warming in the South Coast is occurring at a rate of 2.65 ± 0.49°F per 100 years. The trend of warming air temperature also contributes to the warming of the surface ocean.



Mean monthly temperature anomalies in the South Coast from 1895 to 2015. Shown are mean monthly temperatures that are cooler (blue bars) and warmer (red bars) than the historical mean, and 11-year running mean (black line). Anomalies are relative to the 1949-2006 base period. Source: Western Regional Climate Center.

The Importance of Long-Term Monitoring

Monitoring is key to documenting and learning about the dynamic conditions of the ocean. Long-term monitoring allows scientists to assess whether what is happening today differs from long-term patterns, to determine the scale of variability, and to make projections about the impacts of future climate change. Physical conditions in the South Coast are well-monitored through sampling stations, gliders (i.e., autonomous underwater vehicles), moorings (i.e., buoys), and satellites.

Scripps Institution of Oceanography pier where measurements of physical conditions are made daily by researchers and scientists. Photo: Sara Shen.

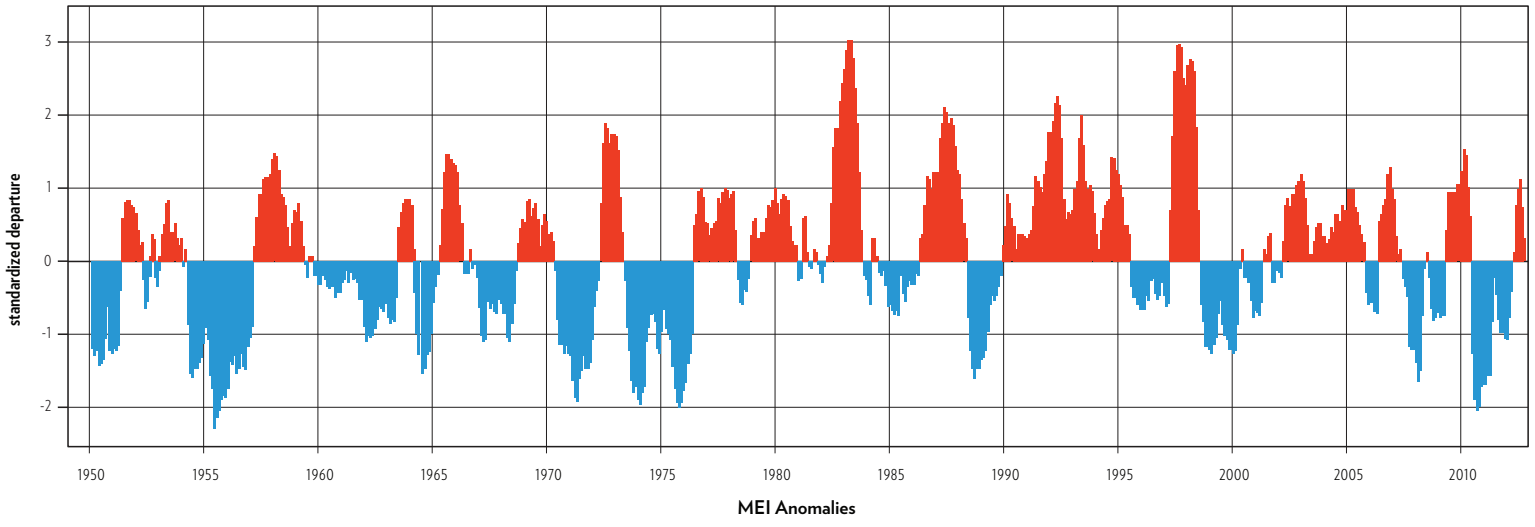
PRECIPITATION

California has been in various states of drought since 2011. In the South Coast, 2012-2015 were the driest consecutive years since 1895. 2013 was the driest year of the 120-year record, with the South Coast only receiving 31% of its average rainfall. Changes in atmospheric circulation during the 2015-2016 El Niño event meant that the South Coast did not receive the large amount of rainfall that was predicted, and actually experienced a drier than normal winter.

EL NIÑO SOUTHERN OSCILLATION

The ENSO is a global ocean-atmosphere phenomenon that occurs approximately every 2-7 years. El Niño is the warm phase of ENSO, and the South Coast experiences warm water, weak winds, large waves, and higher than normal sea level and rainfall. The cool phase of ENSO is La Niña and is characterized by cool temperature, strong upwelling, and high productivity. The Multivariate ENSO Index (MEI) is positive during El Niño events and negative during La Niña events.

The California Current System experienced La Niña from 2010-2012, a return to normal conditions in 2013, and a transition to a strong El Niño in 2014 that peaked in the summer of 2015 and persisted into 2016. The 2015-2016 El Niño was the third strongest El Niño since 1949 after the 1982-1983 and 1998-1998 events, with a peak MEI value of 2.53 in August-September.



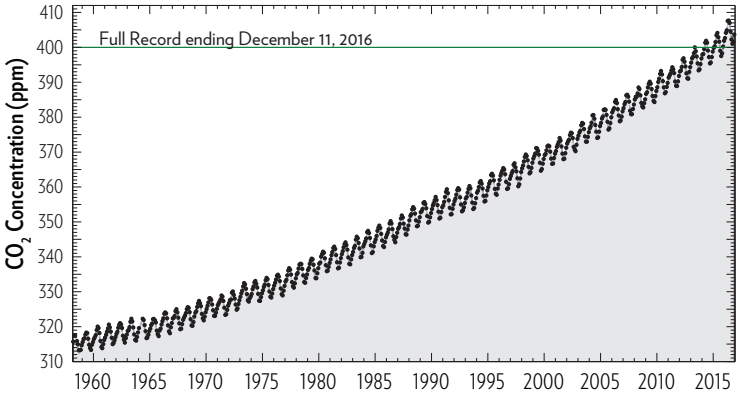
Multivariate ENSO Index (MEI) for 1949-2016. Shown are warmer (red) and cooler (blue) anomalies from the mean . Source: CNAP.

A research vessel departing from Point Loma. Photo: Sara Shen.

CLIMATE CHANGE AND OCEAN ACIDIFICATION

Climate change is occurring round the world due to the addition of carbon dioxide (CO_2) to the atmosphere from the burning of fossil fuels to power cars and factories. The rapid increase in atmospheric CO_2 from 317 to 405 parts per million (ppm) since 1960 is changing the climate and ocean in unprecedented ways. As a result, the temperature of the air and ocean has increased, sea level has risen, glaciers and ice sheets have melted, and ocean pH has declined. The increase in CO_2 in the ocean and subsequent decline in pH is referred to as ocean acidification.

The California Current System is especially vulnerable to ocean acidification because the cool, nutrient-rich water that is brought to the surface during upwelling and that supports a productive ecosystem is also low in oxygen and pH, and high in CO_2. Therefore, ocean acidification may happen more quickly in the California Current System because waters are already naturally enriched in CO_2. In the South Coast, CO_2 ranged from approximately 200-800 ppm and pH ranged from 7.6-8.3 off Santa Barbara from 2011 to 2016. Due to the long time scales of transfer between the atmosphere and the ocean, and within the ocean (from the surface to depth), ocean warming and acidification will continue for centuries whether or not CO_2 emissions are curbed.



Keeling Curve showing daily atmospheric CO_2 at the Mauna Loa Observatory, Hawaii for 1958-2016. CO_2 reading from December 11, 2016 was 404.47 ppm. Source: SIO.

Researchers deploy a conductivity-temperature-depth (CTD) rosette. Photo: Sara Shen.

Impacts of Ocean Acidification on Organisms

Ocean acidification is already starting to negatively affect marine ecosystems around the world. Calcifying organisms, such as corals, oysters, clams, sea urchins, and some species of plankton, are having difficulty growing calcium carbonate shells and skeletal structures. Elevated CO_2 concentrations are also disrupting the development and behavior of many species of fish, making it more difficult for them to find food and suitable habitat, and avoid predators.

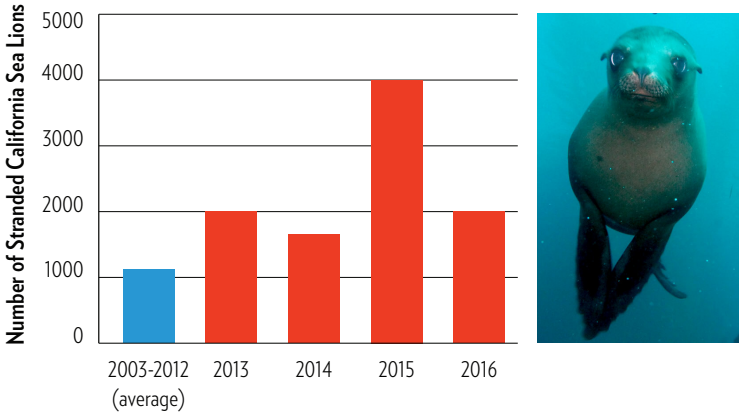
Ocean acidification may affect the ability of the corals, sea urchin, and snails in this image to grow shells and skeletal structures. Photo: Chad King.

Biological and Ecological Responses to Physical Conditions

Short-term and longer-term changes in the physical conditions of the South Coast from 2012-2015 related to the SCWA, El Niño, and climate change, affected the biology and ecology of the region, from the appearance of harmful algal blooms (HABs) to changes in the community composition of plankton to marine mammals.

Biological and ecological responses to physical conditions include:

- Decreased phytoplankton abundance and overall primary productivity;
- A HAB that extended from Santa Barbara to southeastern Alaska and poisoned Dungeness crab, rock crab, razor clams, mussels, and anchovies in 2015-2016;
- Changes to the distribution and abundance of zooplankton, fishes, and whales, including red crabs, market squid, anchovy, sardine, tuna, and Bryde's whale; and
- A drastic increase in the number of starving, stranded, and dying sea lions that led to the declaration of an Unusual Mortality Event (UME) for sea lions in 2013.



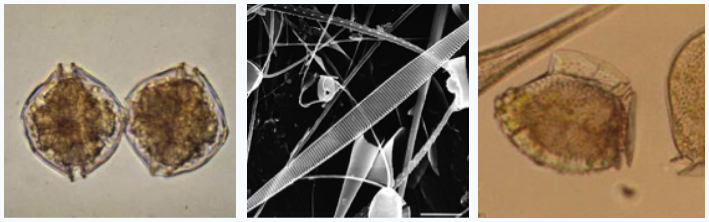
Number of stranded California sea lions during January-June for 2013-2016 (red bars) compared to the average based on data from 2003-2012 (blue bar). Source: NOAA. Photo: Ken Kurtis.

Important Definitions

Phytoplankton: Single-celled photosynthetic organisms.

Zooplankton: Heterotrophic organisms that feed on phytoplankton.

Harmful Algal Bloom (HAB): Dense population or 'bloom' of a phytoplankton species that naturally produces toxins. Toxins can accumulate in the tissues and organs of shellfish and fish that eat the phytoplankton, resulting in in illness or death for fish, mammals, birds, and humans. The depletion of oxygen during HABs can also lead to massive die-offs of organisms.



Harmful algal species routinely monitored by California Department of Public Health. Photos: Woods Hole Oceanographic Institution.

Unusual Mortality Event (UME): A stranding that is unexpected, involves a significant number of deaths of marine mammals, and demands immediate response.

Summary

The South Coast experienced some unusual conditions from 2012-2016, including the SCWA and El Niño events, that changed ocean temperature, ecosystem productivity, and supported a HAB and UME for sea lions. The South Coast experienced some of the warmest and driest conditions in the past several decades. As CO_2 emissions rise with fossil fuel burning, climate change and ocean acidification will continue to affect the global atmosphere and ocean, including physical conditions and ecology of the South Coast. Long-term monitoring of atmospheric and ocean conditions and collaborative partnerships among various stakeholders will continue to inform and support the management of our coast and ocean during changing times.

References

1. P.D. Bromirski, R.E. Flick, and A.J. Miller. 2016. Storm surge along the Pacific Coast of North America. Journal of Geophysical Research, 122(1): 441-457.
2. S. Moser, J. Ekstrom, and G. Franco. 2012. Our Changing Climate 2012: vulnerability and adaptation to the increasing risks from climate change in California. California Climate Change Center. https://goo.gl/kxvQhi
3. T. Kadir et al. (Eds). 2013. Indicators of Climate Change in California. California Environmental Protection Agency and Office of Environmental health Hazard Assessment. https://goo.gl/BtnOcQ
4. CNAP. 2015. Drought in Southern California. https://goo.gl/J1L4gZ
5. CNAP. 2015. El Niño and Its Impact on California and Nevada. https://goo.gl/sQbnnF
6. California Ocean Science Trust, 2016. Frequently Asked Questions: Harmful Algal Blooms and California Fisheries, Developed in Response to the 2015-2016 Domoic Acid Event. https://goo.gl/TljLri
7. L.M. Cavole, et al. 2016. Biological impacts of the 2013–2015 warm-water anomaly in the Northeast Pacific: Winners, losers, and the future. Oceanography 29: 273-285.
8. Center for Environmental Visualization. NOAA, Pacific Marine Environmental Laboratory. https://goo.gl/7mfRxo
9. S.C. Doney et al. 2009. Ocean acidification: the other CO_2 problem. Annual Review of Marine Science, 1: 169-192.
10. A.W. Leising et al. 2014. State of the California Current 2013–14: El Niño looming. California Cooperative Oceanic Fisheries Investigations Reports, 55: 51-87. https://goo.gl/Cr8VKU
11. A.W. Leising et al. 2015. State of the California Current 2014-15: Impacts of the warm-water "blob." California Cooperative Oceanic Fisheries Investigations Reports, 56: 31-67. https://goo.gl/TLzr3m
12. R. Monroe. 2016. The Keeling Curve. Scripps Institution of Oceanography. https://goo.gl/jF8jnq
13. NOAA Fisheries. 2016. 2013-2016 California Sea Lion Unusual Mortality Event in California. https://goo.gl/bl9Scv
14. Scripps Institution of Oceanography. 2016. Shore Stations. https://goo.gl/xpF3X6
15. Southern California Coastal Ocean Observing System (SCCOOS). 2016. El Niño. https://goo.gl/YazDwa
16. Western Regional Climate Center. California Climate Tracker. https://goo.gl/QoBJ9q
17. K.D. Zaba and D.L. Rudnick. 2016. The 2014-2015 warming anomaly in the Southern California Current System observed by underwater gliders. Geophysical Research Letters, 43: 1241-1248.

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