Anomalous warming in nearshore waters of the Southern California Bight as observed by the SCCOOS Automated Shore Station (SASS) network

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Since 2005 the Southern California Coastal Ocean Observing System (SCCOOS) has operated the SCCOOS Automated Shore Station (SASS) network to record water properties in shallow, nearshore waters of the Southern California Bight.

The SASS network comprises instrument packages mounted on the Scripps Institution of Oceanography (SIO) Pier, Newport Beach Pier, Santa Monica Pier, and Stearns Wharf in Santa Barbara.

Preliminary analysis of the SASS temperature time series reveals multiple marine heatwaves (MHWs) such as the “Warm Blob” of 2014-15 and the following El Niño in 2015-16.

A more subtle change was a ~1 °C temperature increase in 2014 that has persisted with some variability. The temperature increase was recorded across all 4 pier sites and in the long record of glider transects of the California Underwater Glider Network (CUGN).

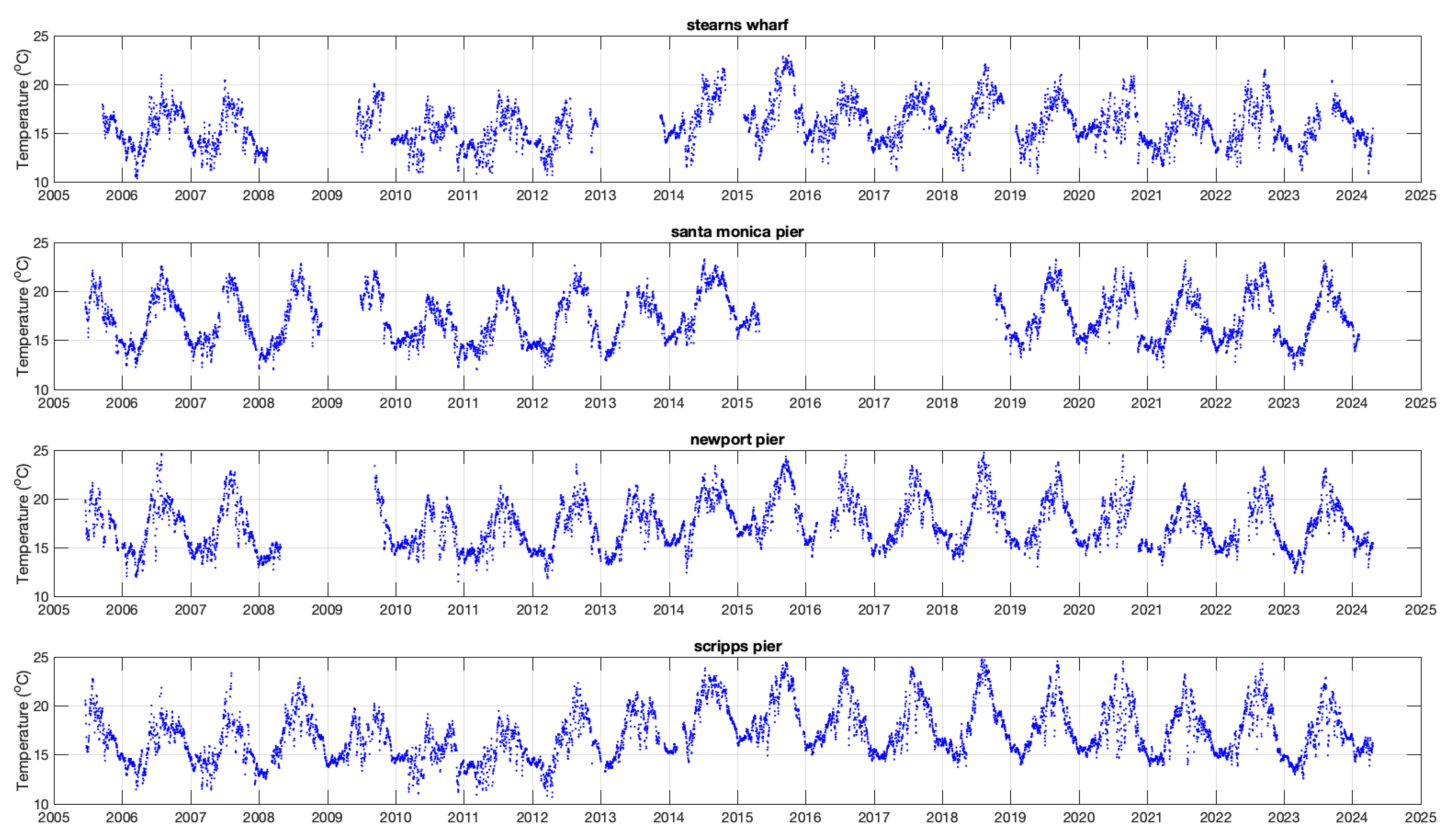


Figure 1. Daily-averaged temperatures since 2005 at the 4 SCCOOS Automated Shore Stations shown in the map of Figure 3.

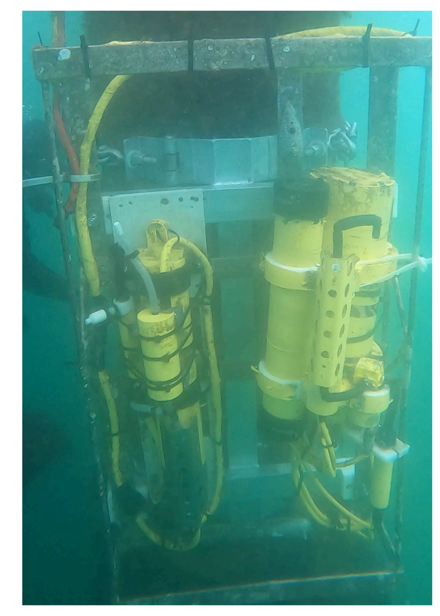
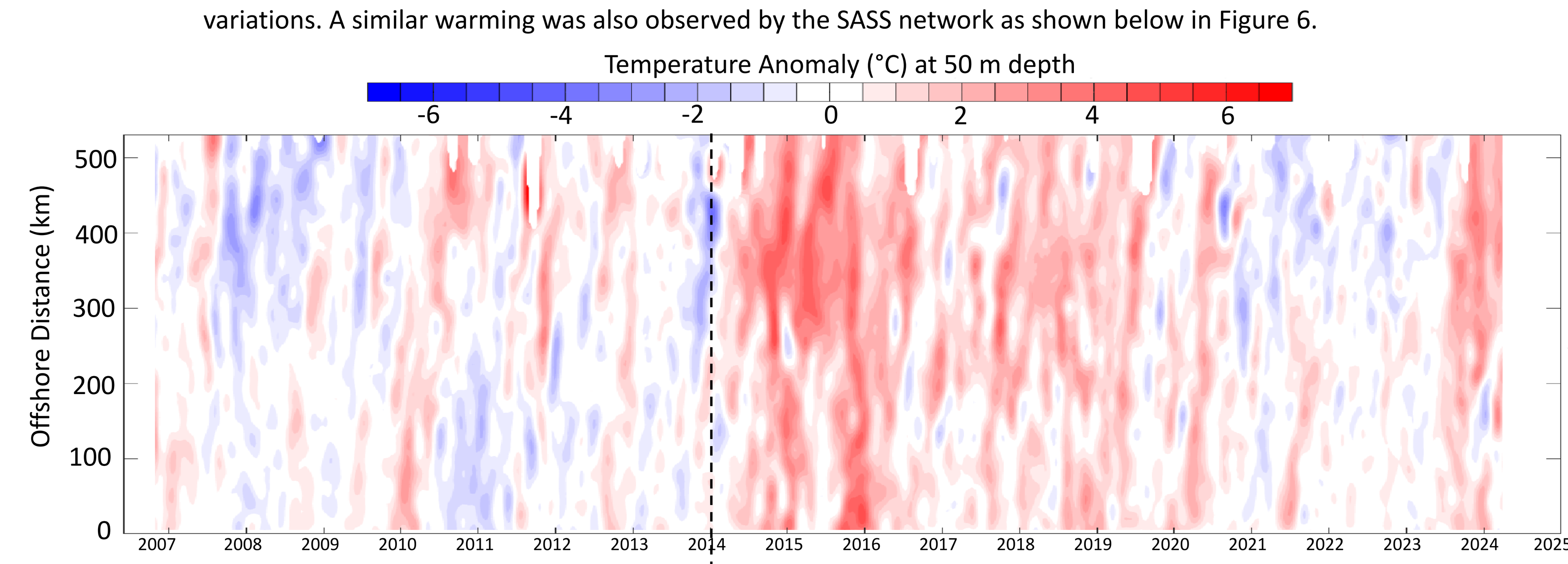


Figure 2. Instrument package on pier of the Scripps Institution of Oceanography.

Figure 3. Southern California Bight and locations of SCCOOS Automated Shore Stations (SASS). Red line shows nominal track of Spray ocean gliders along CalCOFI line 90, part of the California Underwater Glider Network (CUGN). The glider network and a climatology of the California Current System are described by Rudnick et al. (2017).

Figure 4. Temperature anomalies measured by the CUGN along line 90 at 50 m depth. An increase in temperature anomalies began in 2014 (vertical dashed line) and has persisted since with some variations. A similar warming was also observed by the SASS network as shown below in Figure 6.



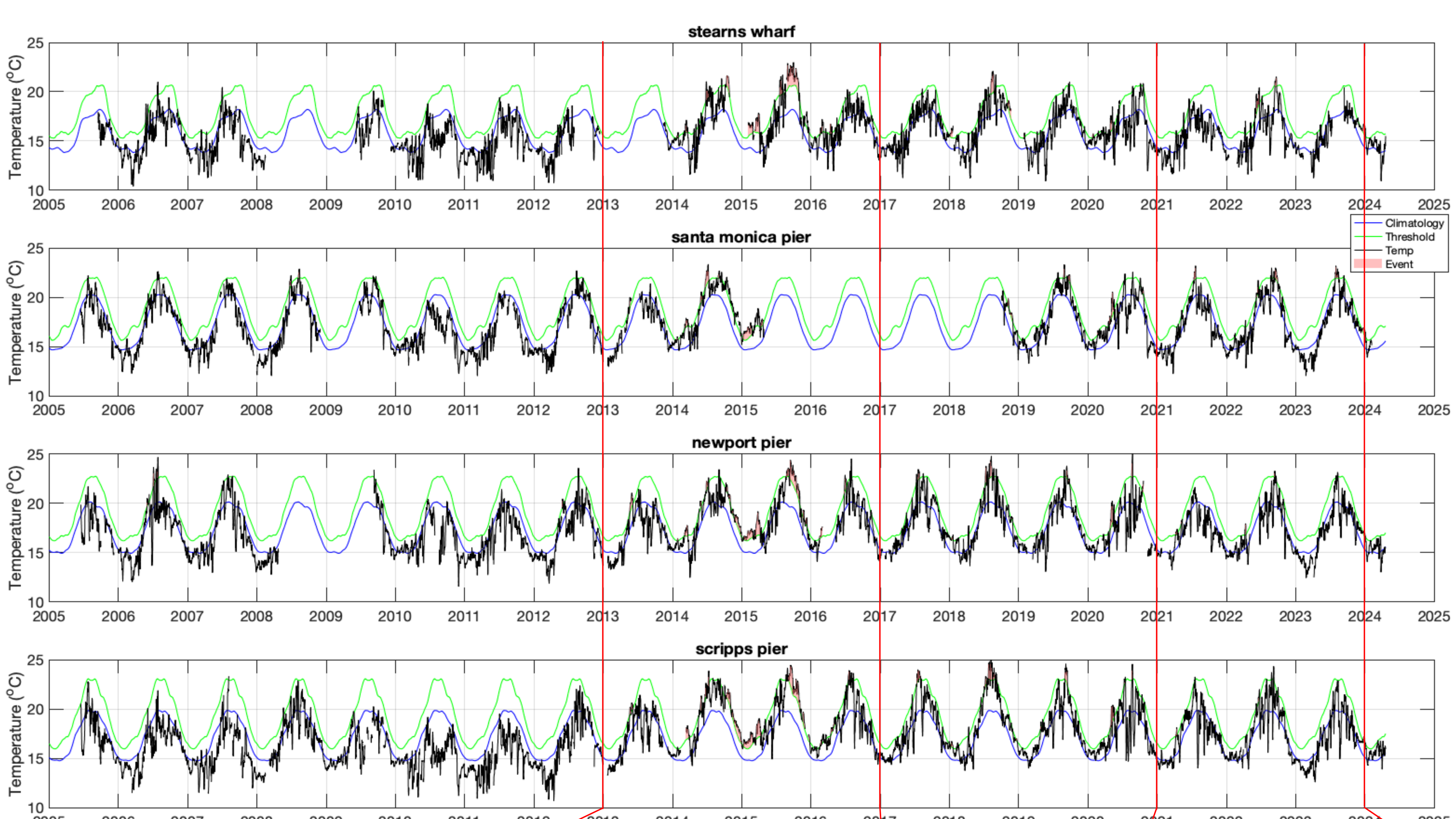


Figure 5. Daily averaged temperatures (black lines) are superimposed on climatological values (blue lines; climatology based on all years is shown in Figure 9) and 90% thresholds for MHW detection (green lines) from Hobday et al. (2016). MHWs were prominent during the “Warm Blob” of 2014-15 and the following El Niño in 2015-16. Expanded views of these are shown in Figure 7. Shaded areas between green and black lines are MHWs.

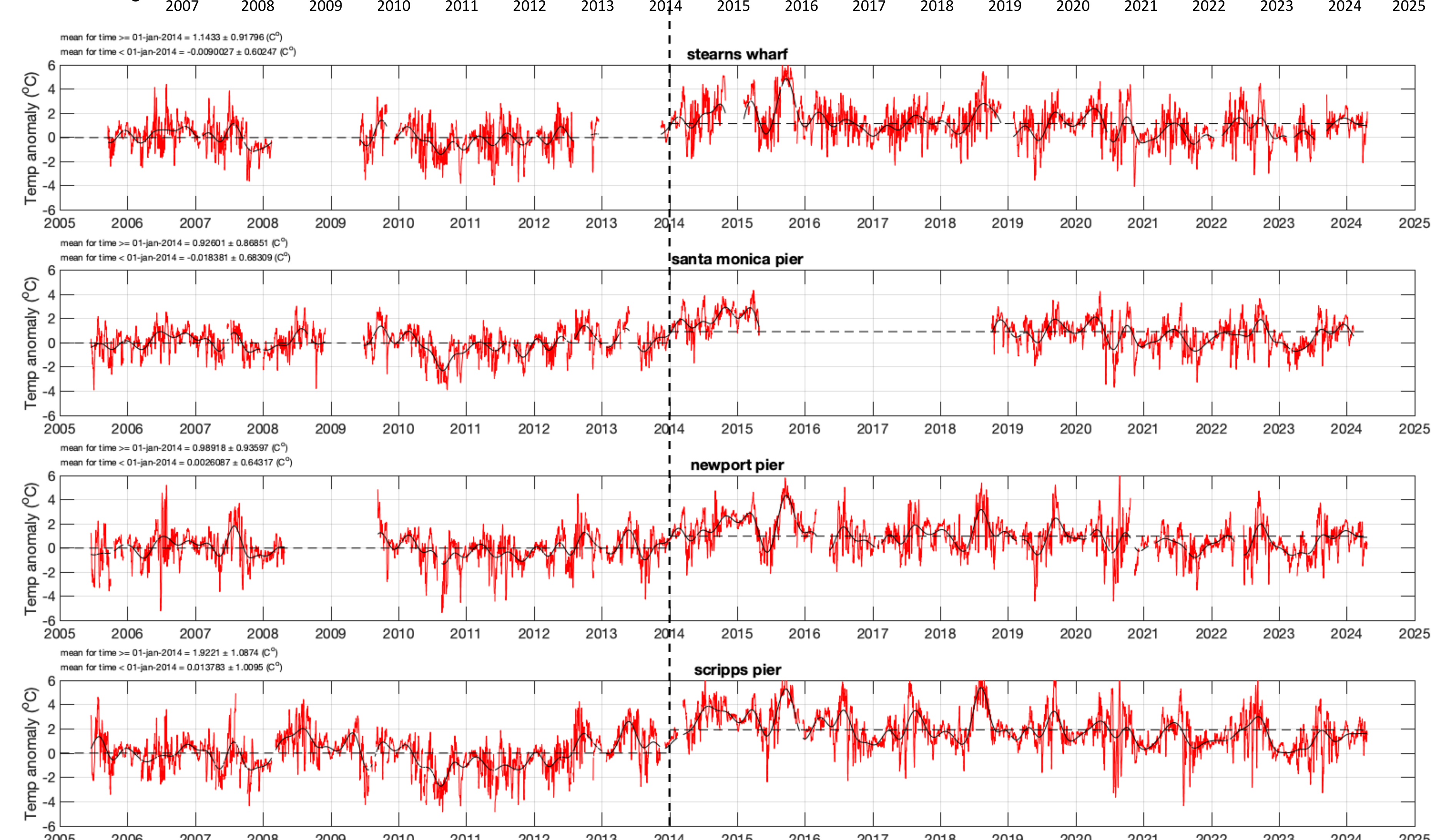


Figure 6. Daily averaged temperatures anomalies (red lines) increased by about 1 °C beginning in 2014 (vertical dashed line). Four-month, low-passed filtered anomalies (black lines) were more consistently positive after 1 January 2014 compared with before. Higher temperature anomalies were also observed by the CUGN beginning in 2014 as shown in Figure 4 above. The reference climatology is shown below in Figure 9 (blue line). Horizontal dashed lines show mean temperatures before and after 1 Jan 2014.

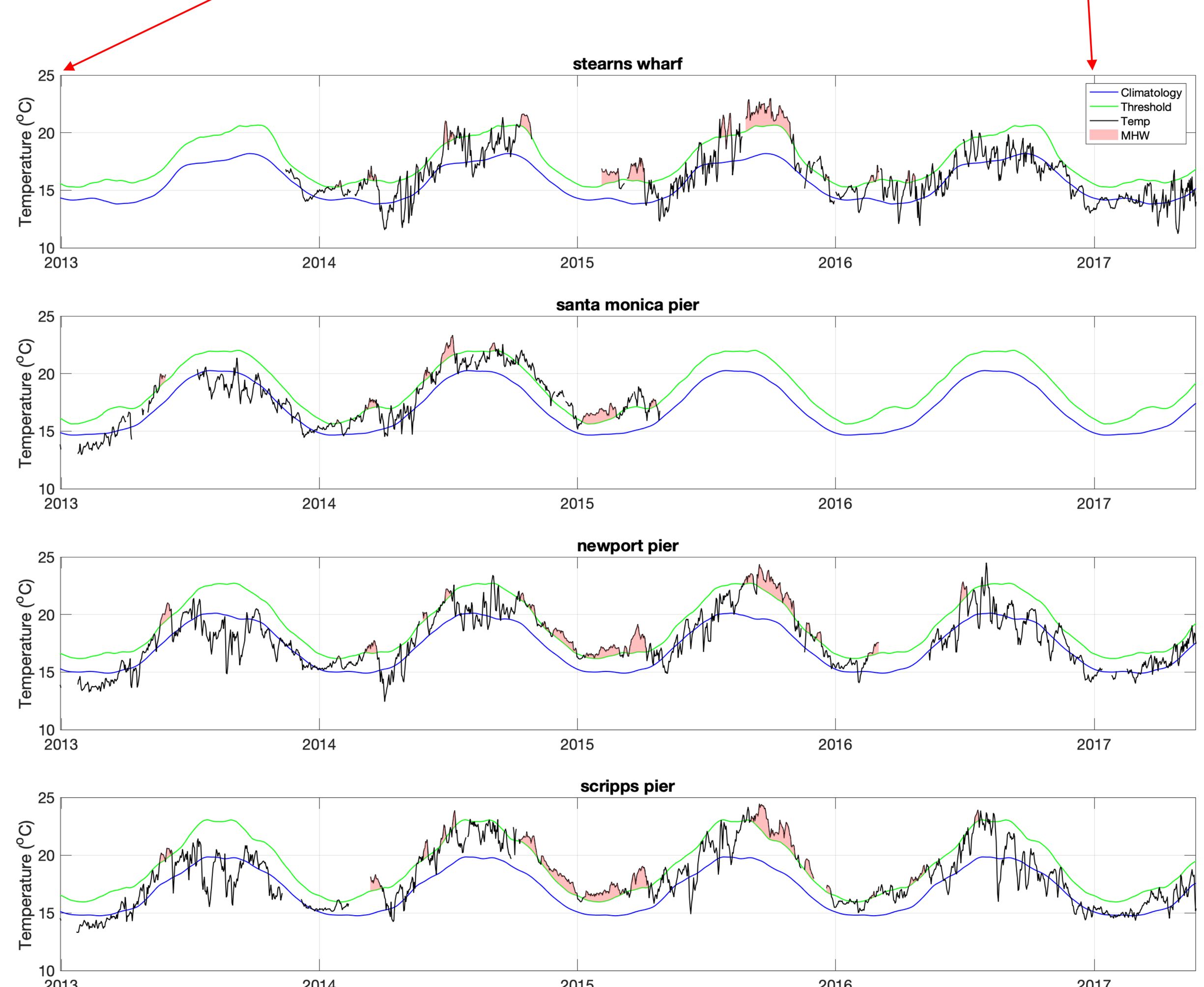


Figure 7. Marine heat waves (shaded areas between green and black lines) during the “Warm Blob” of 2014-15 and the El Niño in 2015-16.

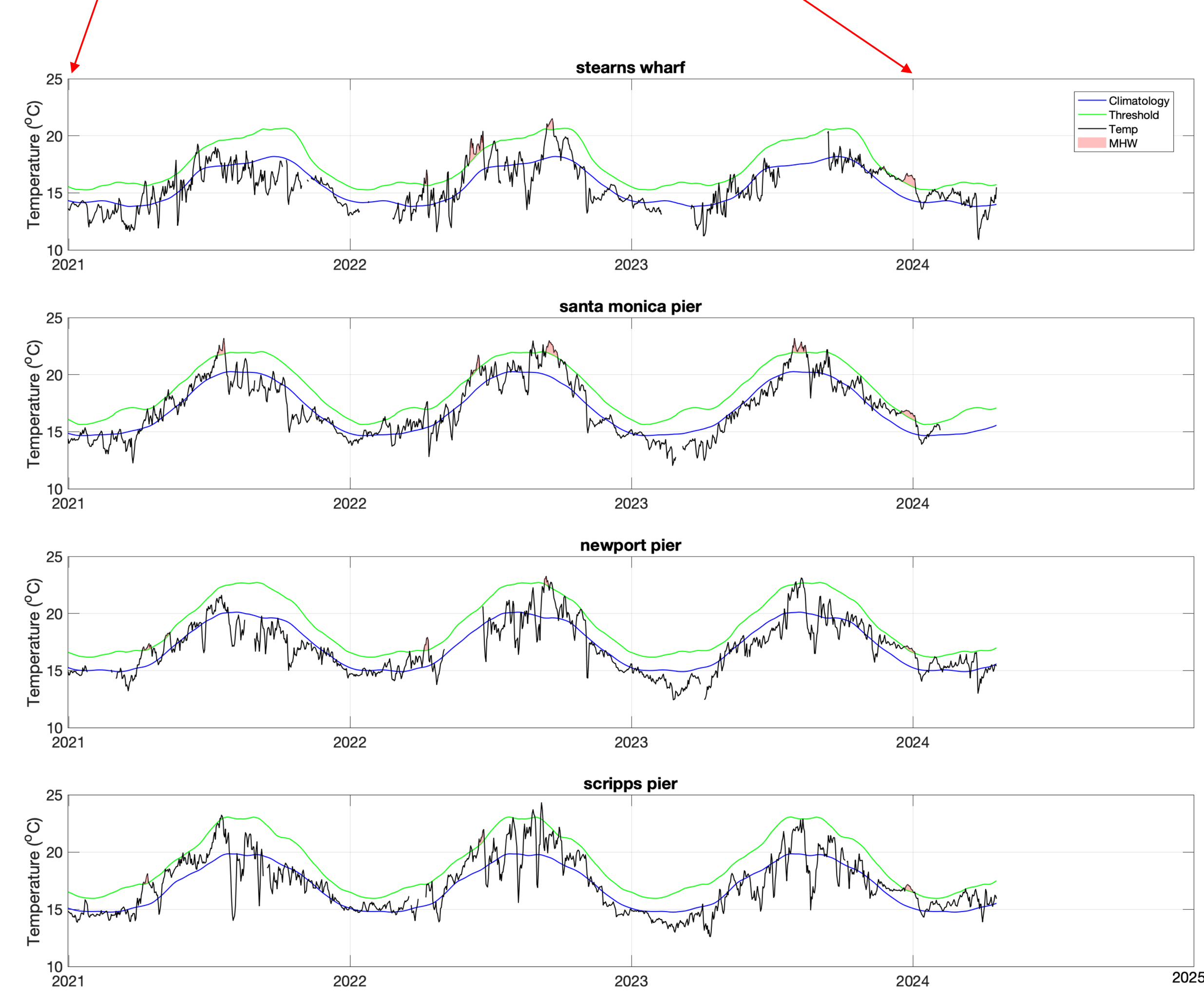


Figure 8. Weaker marine heat waves were observed during the 2023-24 El Niño compared with the 2015-16 El Niño.

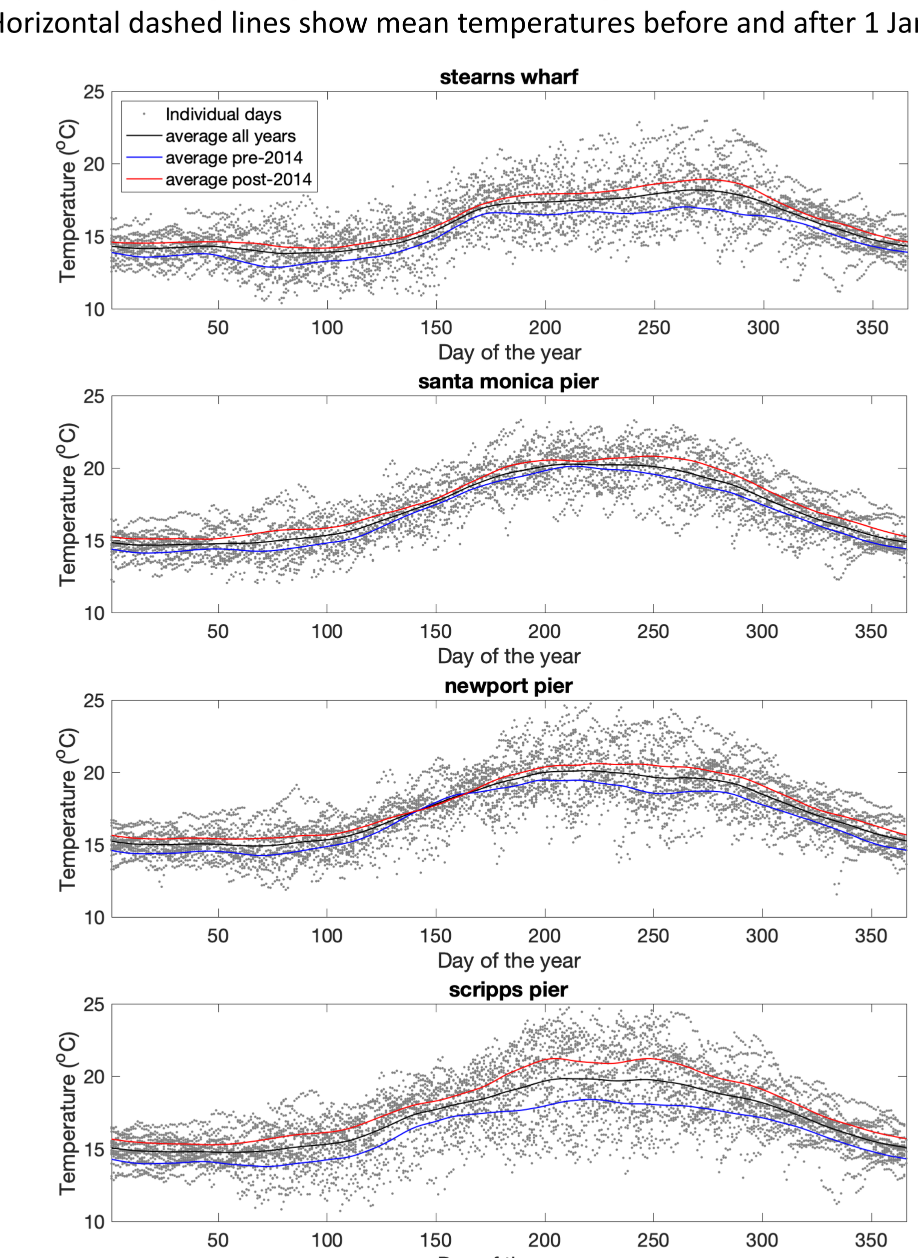


Figure 9. Temperature climatologies for computing anomalies. Climatologies are based on: 2005-2024 (black line), pre-1 Jan 2014 (blue line), and post-1 Jan 2014 (red line). Anomalies in Figure 6 are based on the pre-1 Jan 2014 climatology.

Ongoing and future directions:

1. Detect future marine heatwaves.
2. Evaluate the duration of events such as the 1 °C temperature anomaly.
3. Identify long-term changes in other water properties including salinity and chlorophyll a fluorescence.
4. Add additional real-time sensors to SASS network to measure pH, dissolved oxygen, and turbidity.

Acknowledgements

Funding for SASS development and operations came from SCCOOS. The Santa Barbara Coastal Long Term Ecological Research project (SBC LTER) provided technical support. The Bipartisan Infrastructure Bill and the Inflation Reduction Act will fund new SASS instrumentation for measuring pH, dissolved oxygen, fluorescent dissolved organic material, and turbidity.

References

Hobday et al. (2016), A hierarchical approach to defining marine heatwaves, Progress in Oceanography, 141, 227-238, https://doi.org/10.1016/j.pocean.2015.12.014.

Rudnick et al. (2017), A climatology of the California Current System from a network of underwater gliders, Progress in Oceanography, 154, 64-106, https://doi.org/10.1016/j.pocean.2017.03.002.

SOUTHERN CALIFORNIA COASTAL OCEAN OBSERVING SYSTEM

IOOS Integrated Ocean Observing System

Santa Barbara Coastal Long Term Ecological Research

CENTRAL & NORTHERN CALIFORNIA OCEAN OBSERVING SYSTEM