Satellite SSTs along the west coast of the US during the 2014-2016 northeast Pacific marine heat wave

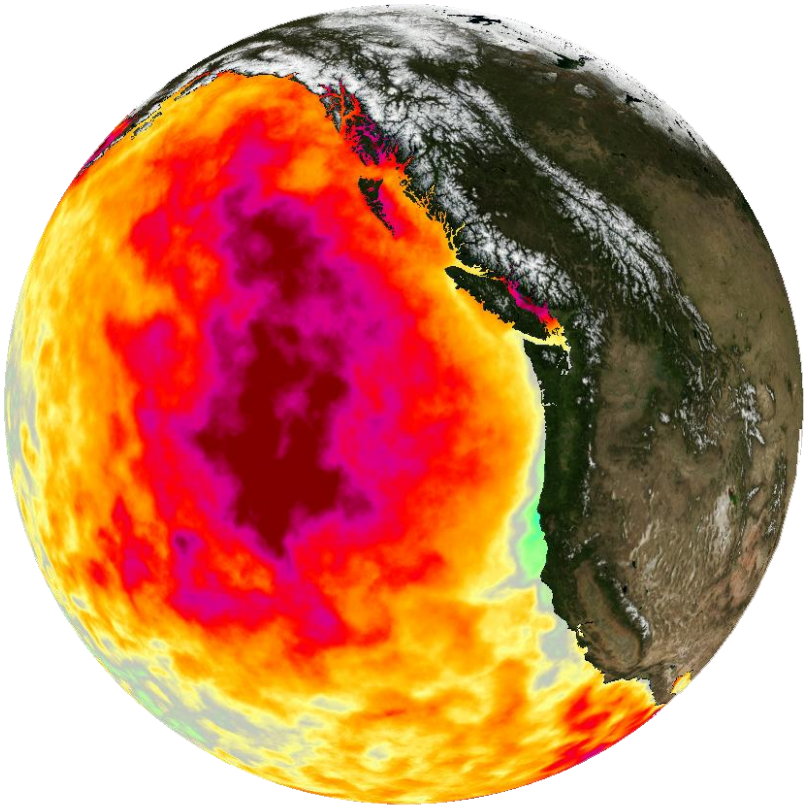

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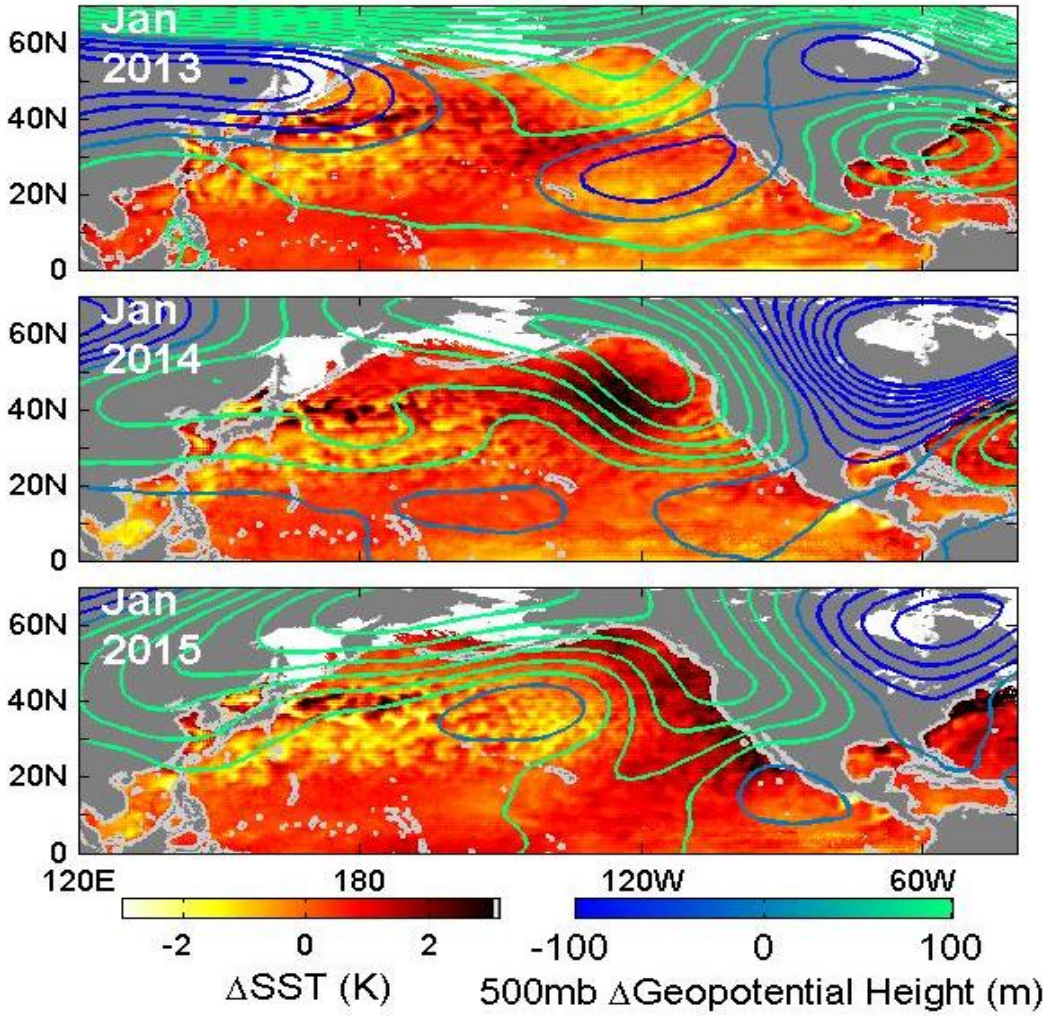
Image Credit: NASA JPL: C. Thompson & J. Hall

Air-Sea & Sea-Air



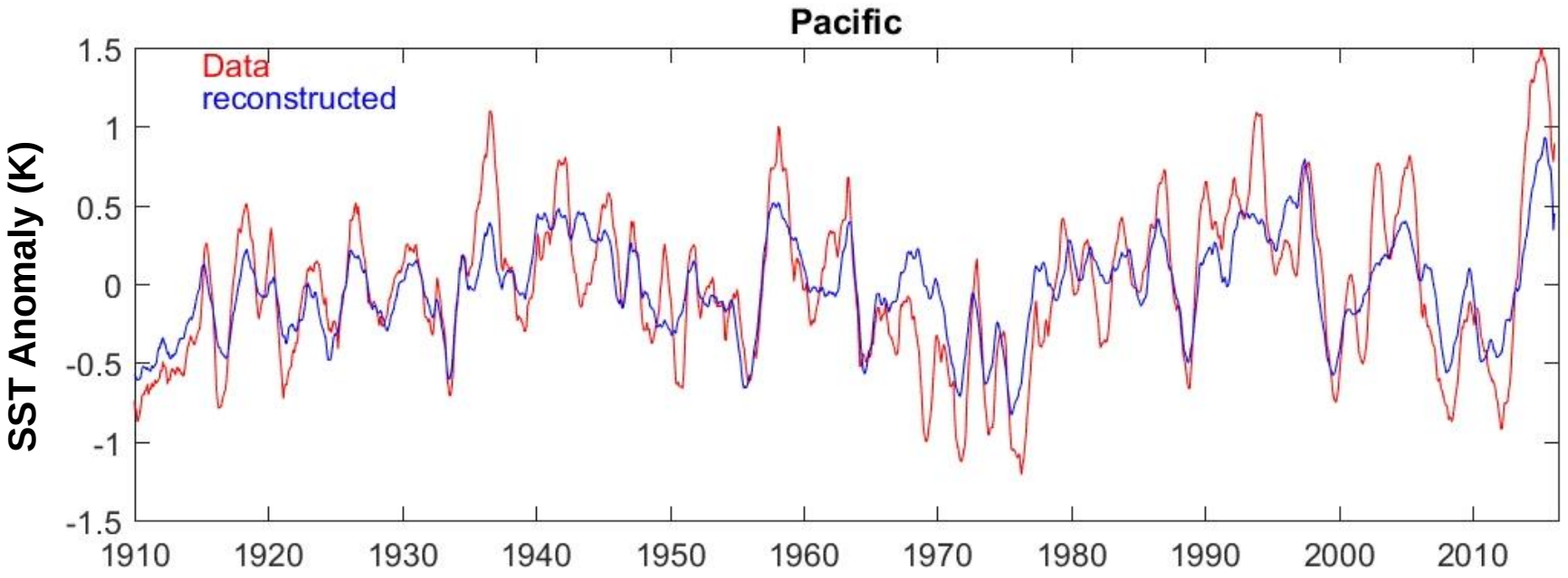
- Stationary high pressure ridge
- Winds 2nd lowest on record

(Bond, 2015)

Reduced mixing

Reduced Ekman transport

Timeseries of SST



Timeseries shown for Blob region, including all monthly data and EOF reconstruction. Data is smoothed.

HadiSST v2 data does not use EOF in it's construction
Recent data uses AVHRR SSTs, prior to satellite data all in situ obs
More info: http://www.metoffice.gov.uk/hadobs/hadisst/

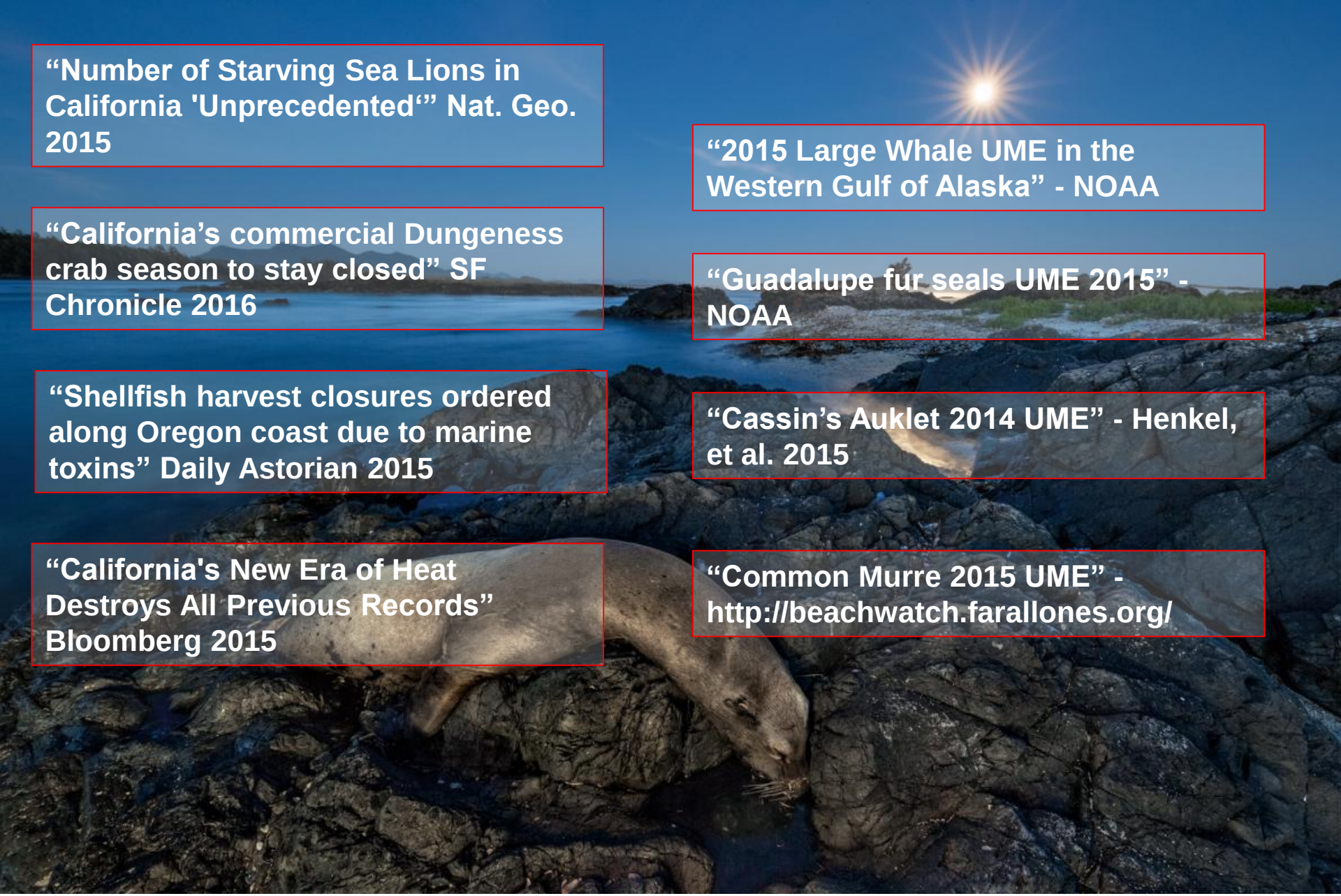
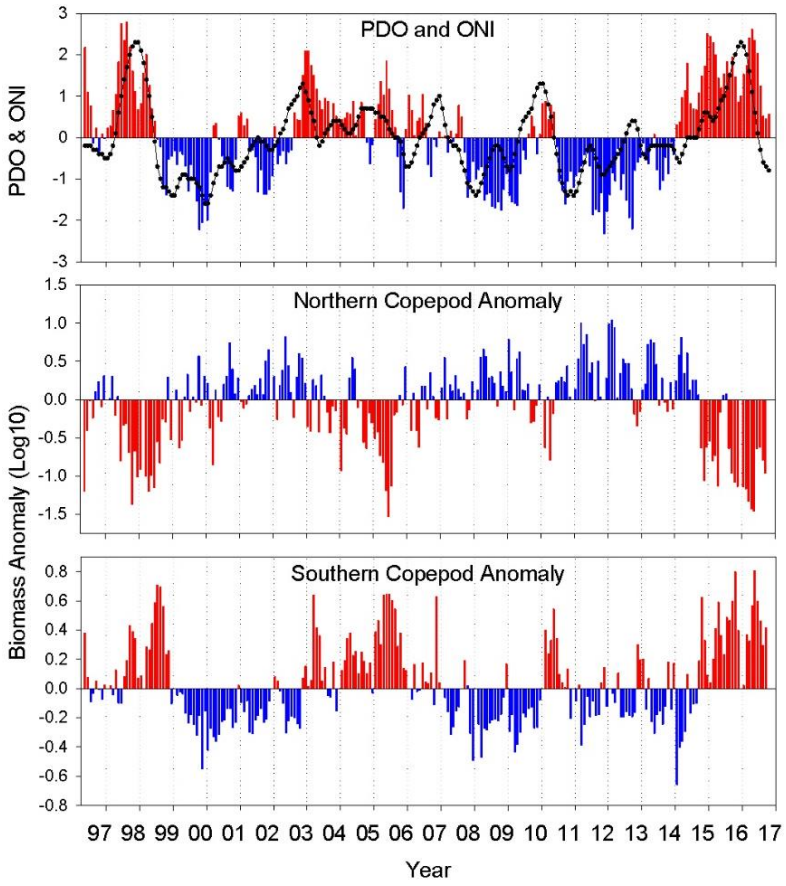


Photo by Paul Nicklen from the National Geographic, “The Blob that cooked the Pacific” full article at http://www.nationalgeographic.com/magazine/2016/09/warm-water-pacific-coast-algae-nino/

SST and fuel for fishes

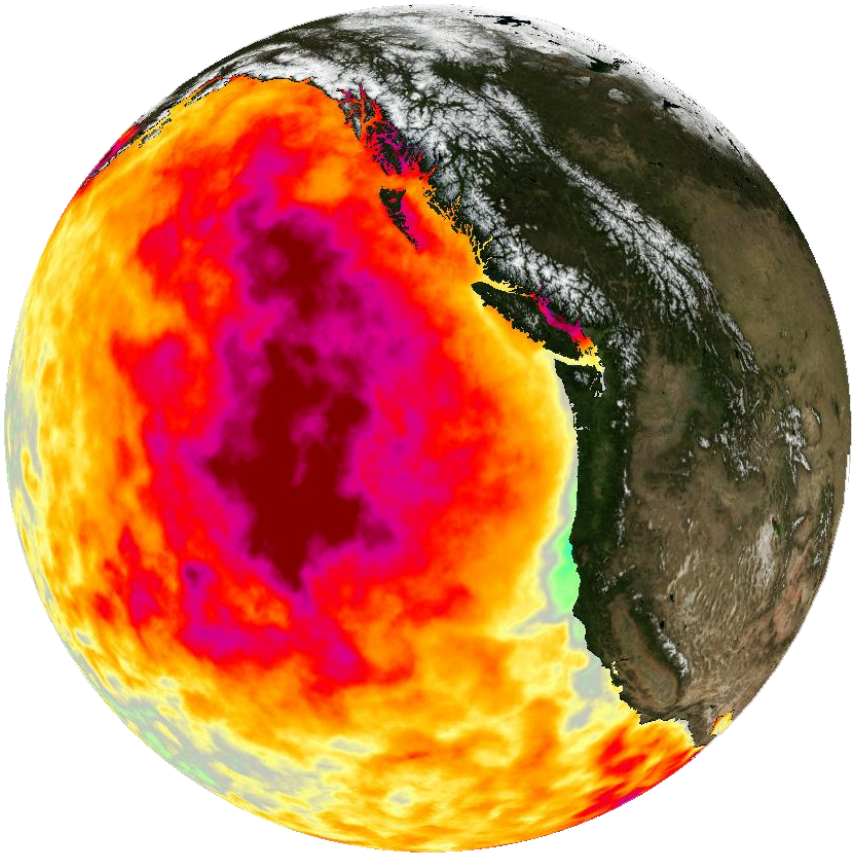


The Pacific Decadal Oscillation (upper), and northern copepod biomass anomalies (lower), from 1969 to present. Biomass values are log base-10 in units of mg carbon m^{-3}.

The northern copepod biomass is an index of the amount of energy transferred up the food chain. These fatty compounds appear to be essential for many pelagic fishes if they are to grow and survive through the winter successfully

Figure from: https://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/eb-copepod-anomalies.cfm#NSC-01

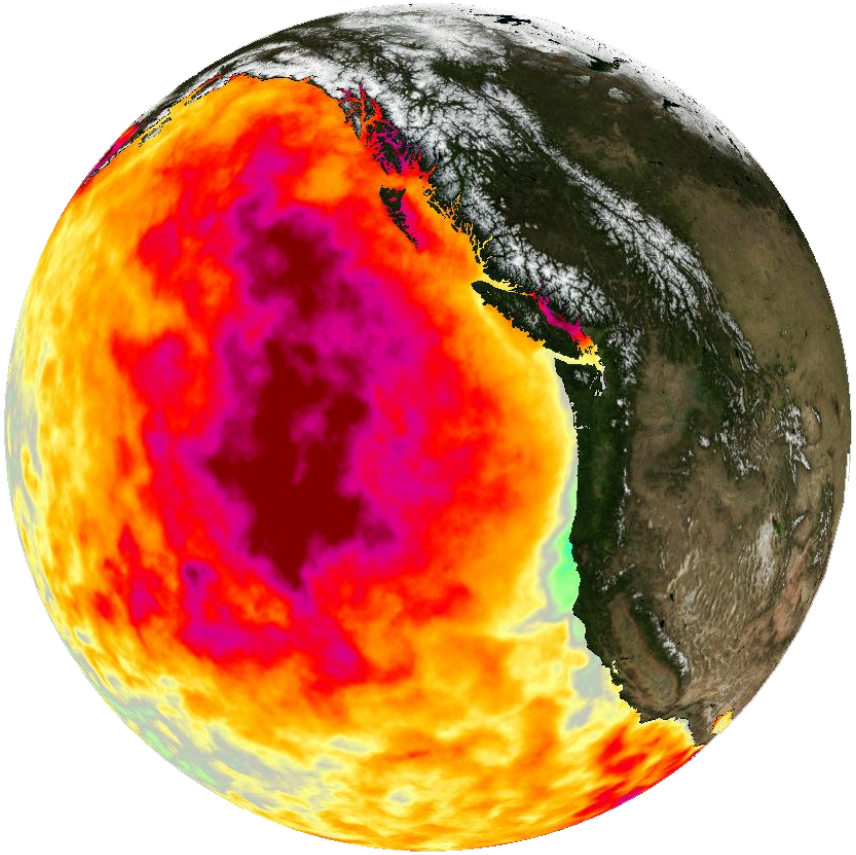
High Resolution SSTs



- High temporal and spatial resolution SST data allow investigations in to high resolution spatial/temporal changes in ocean conditions in regions along the coast which are crucial for fisheries

Image Credit: NASA JPL: C. Thompson & J. Hall

High temporal/spatial



- Allow for more accurate investigations into drivers/responses
- Upwelling not uniform
- How did SSTs along the west coast change during this event?

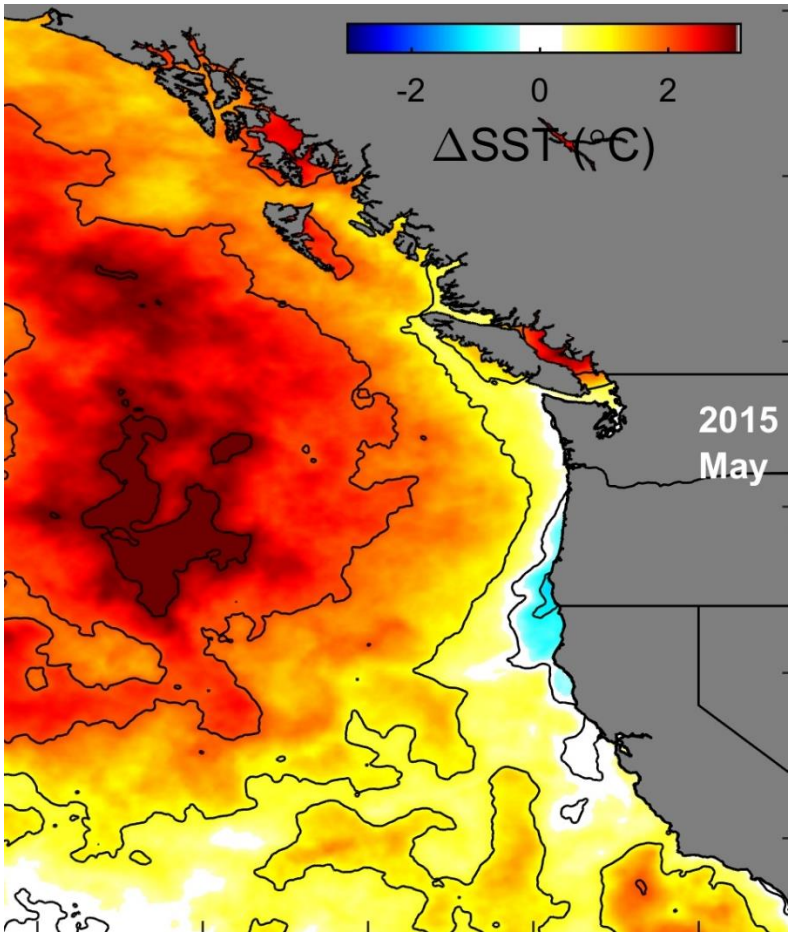
Image Credit: NASA JPL: C. Thompson & J. Hall

Results

- Satellite SST and wind stress show the phenology and extent of the recent record-breaking marine heat wave along the U.S. West Coast
- Warm SSTs occurred January 2014 to August 2016, but abated briefly along the coast during the upwelling season
- The largest SST anomalies occurred off central and southern California in late 2015 during decreased upwelling-favorable winds

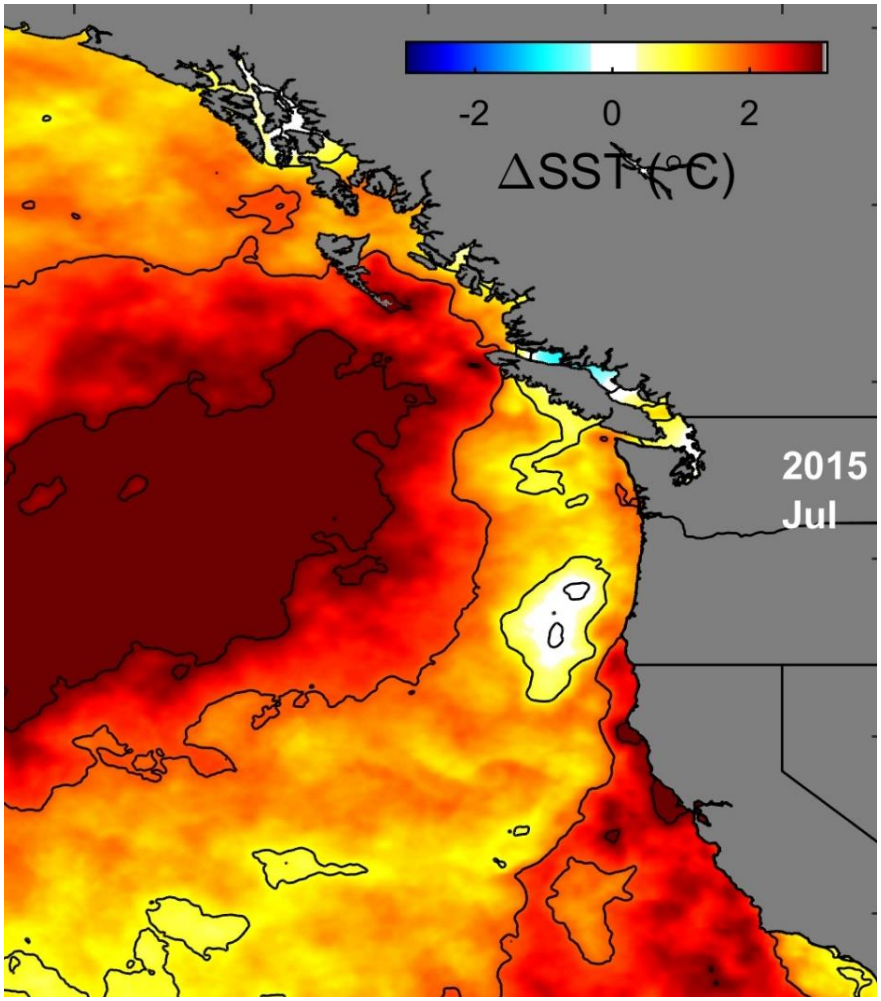
Brief periods of ‘normal’ SSTs

- From 2014 – 2016, onshore warm anomalies only weakened for short periods in May-June of each year



Alongshore warming

- Onshore anomalies were generally stronger and more persistent in California than further north, with a peak of 6.2 C on 14 September 2015, just south of Point Conception



SSTs 2014-2016

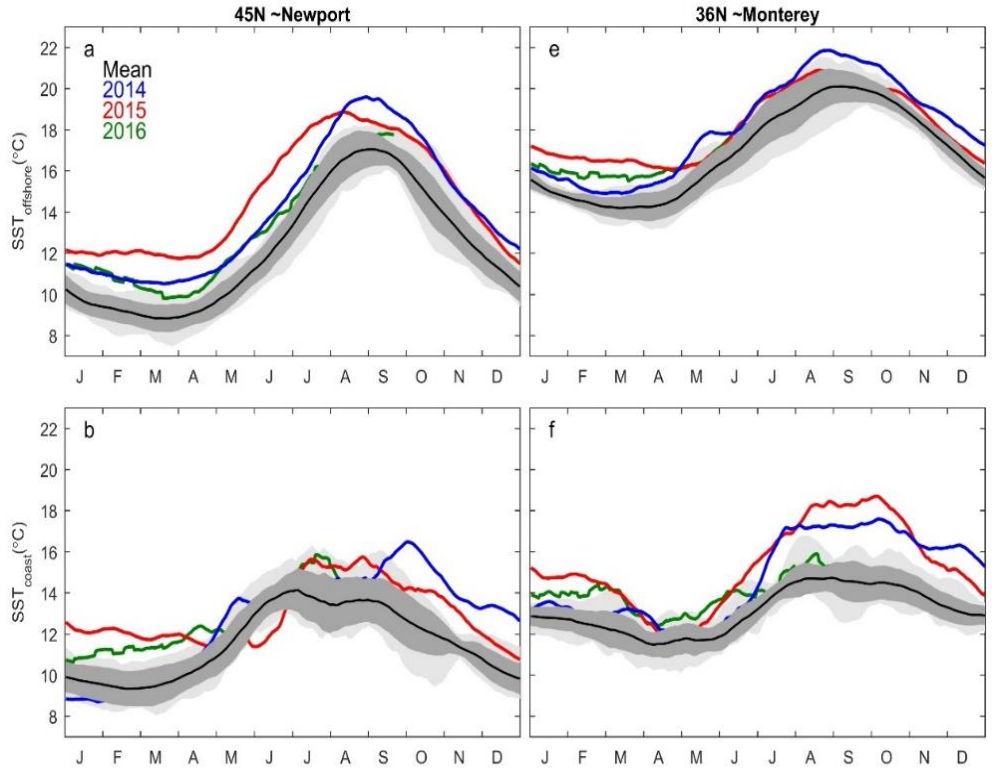
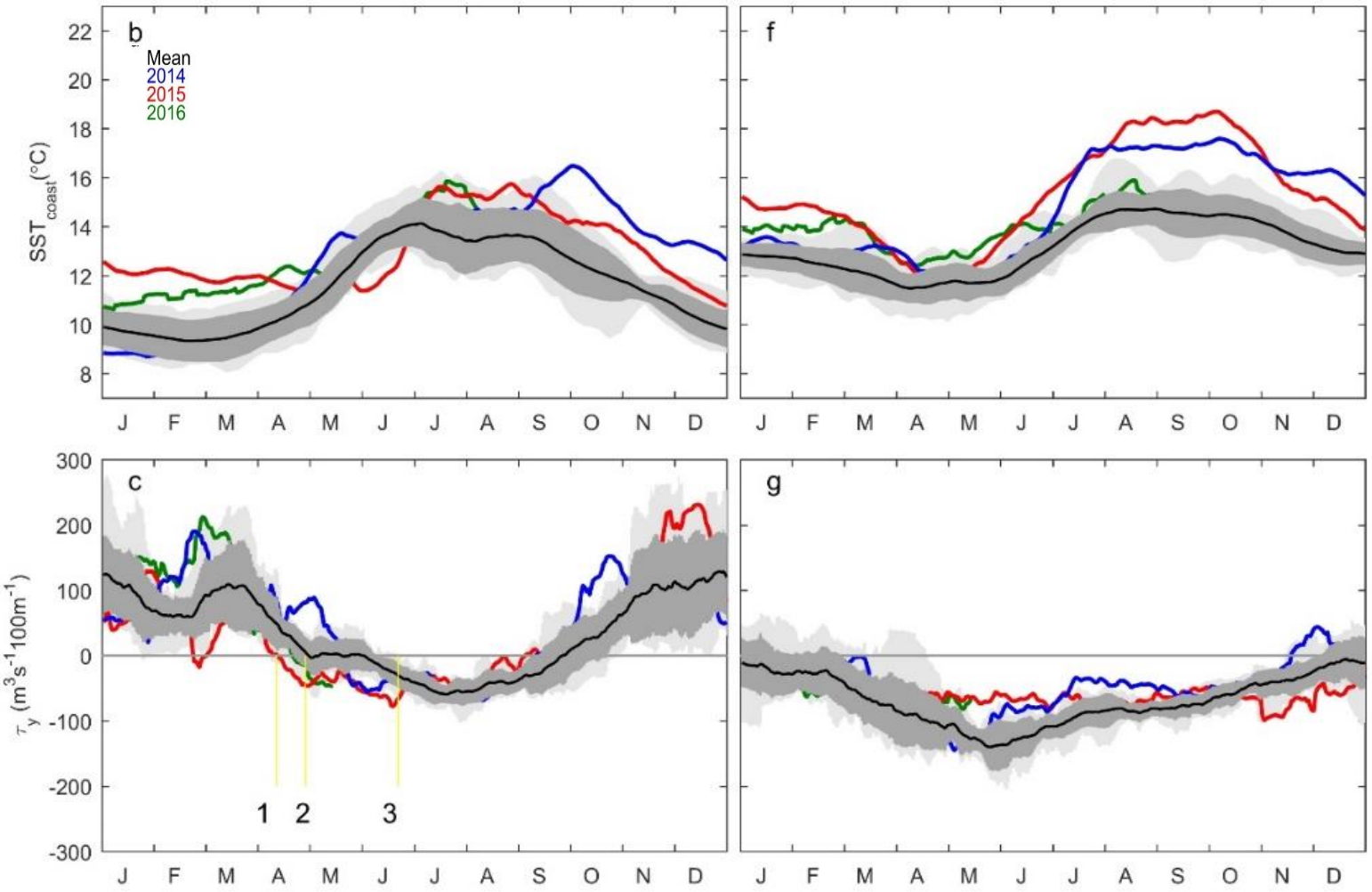


Figure 3. Time series of daily SSTs, smoothed with a 30-day running mean, in the northern (left column) and southern (right column) parts of the CCUS. (a, e) SST 1000 km offshore. (b, f) SST 1 km. In each panel, light grey indicates the envelope of maximum and minimum values during 2002-2013; dark grey indicates the envelope of +/- 1 SD around the mean during 2002-2013; and the black, blue, red, and green lines indicate the mean during 2002–2013 and the values during 2014, 2015, and 2016, respectively. To emphasize anomalies >1 SD from the mean, the data are plotted so that the yearly lines are obscured when within 1 SD of the mean.

Coastal SSTs / winds



Results

- The presence or absence of upwelling-favorable winds is not sufficient to judge ecosystem health
- 2014-2016: A combination of persistent warm SSTs and weaker/shifted upwelling season were associated with substantial ecosystem disturbances
- A better understanding of how changes in the ocean impact ecosystem health is needed to understand how forecasted changes in winds may impact future ecosystems

Gentemann, C. L., M. R. Fewings, and M. García-Reyes (2016), Satellite sea surface temperatures along the West Coast of the United States during the 2014–2016 northeast Pacific marine heat wave, Geophys. Res. Lett., 43, doi:10.1002/2016GL071039.

Thanks to:

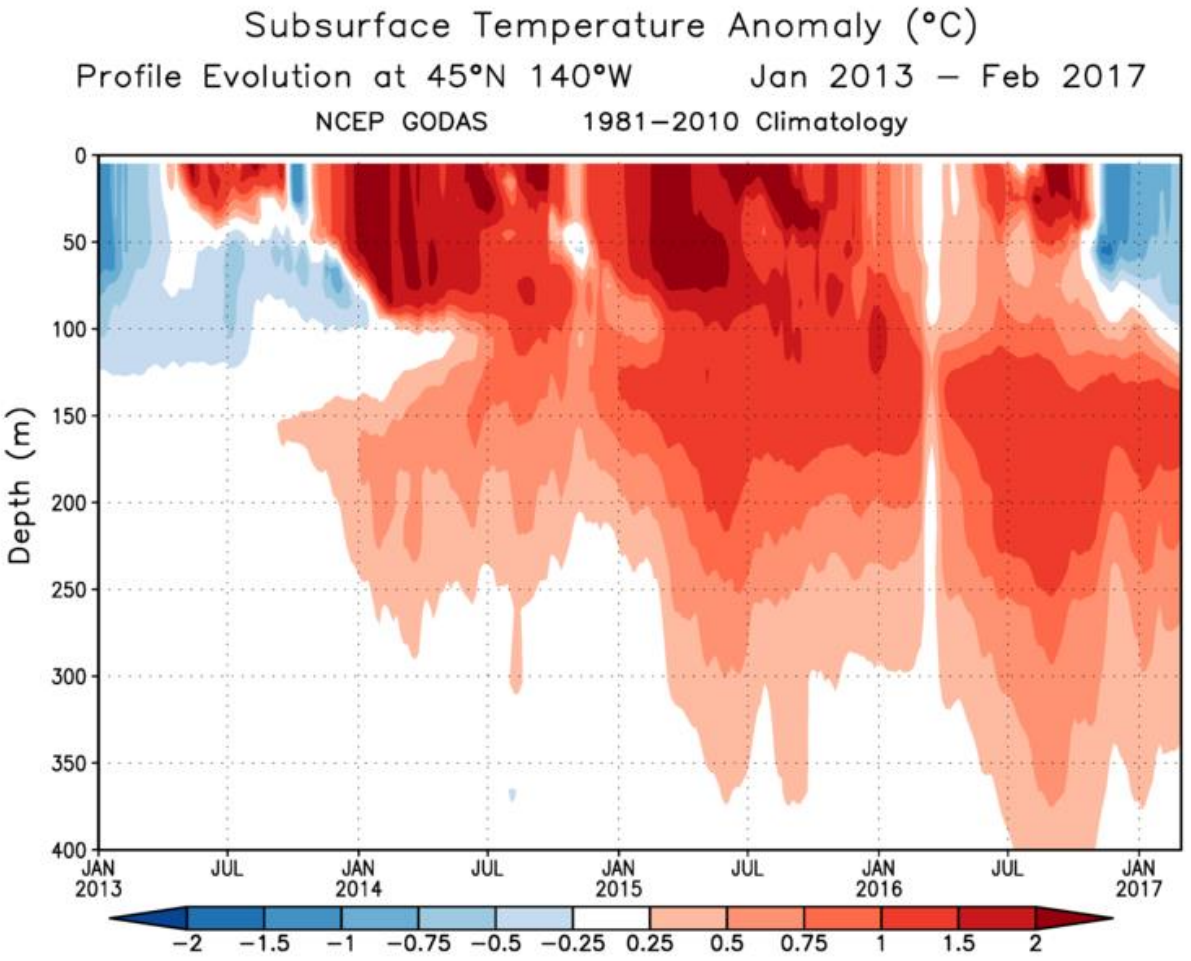
Data: JPL MUR v4 global, daily, 1km multi-scale ultra-high resolution motion-compensated analysis; PMEL Bakun upwelling index, ECMWF ERA-interim 10 m wind

Jim Edson provided his MATLAB code for the COARE 3.5 drag coefficient

Funding: NASA Physical Oceanography, Ocean Vector Winds Science Team, JPL

Charles Thompson, JPL, provided Blue Marble SST image for May 2015

So, where are we now?



Winners and Losers: biological impacts

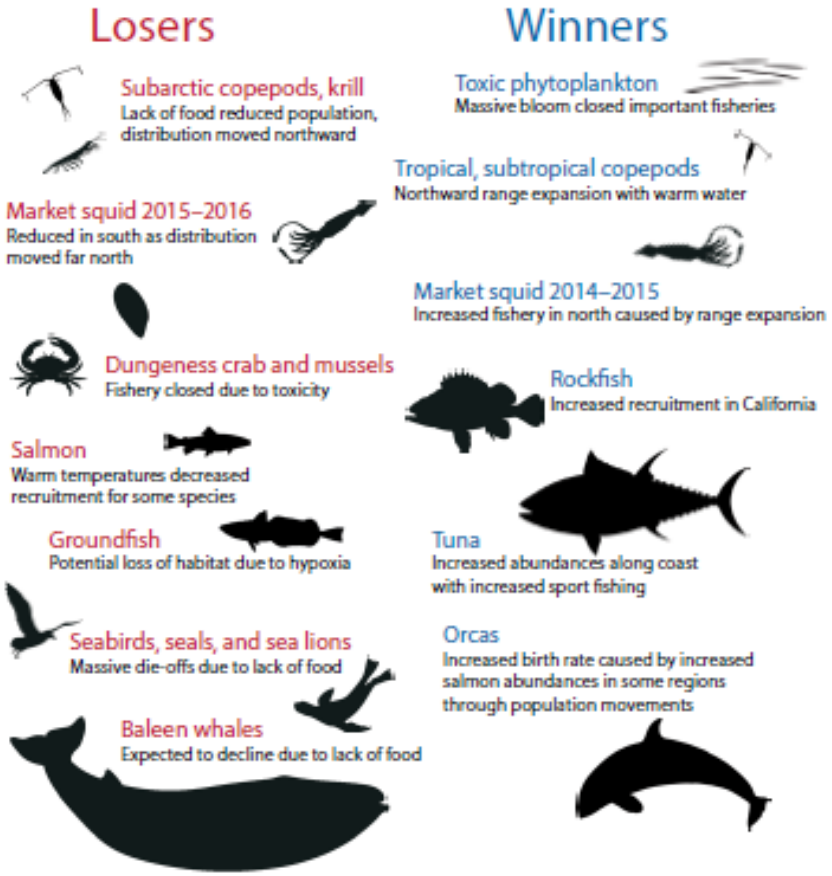


FIGURE 5. Organisms observed to be positively and negatively impacted by the WWA. Negatively affected organisms are labeled as "Losers" (left column), while organisms positively affected are labeled as "Winners" (right column). Organisms are presented in both columns from lower (top of the column) to higher (bottom of the column) trophic levels.

What is the future?
Climate change predicts overall increase in stratification and warming of the Pacific…

Increase in HABs
Changes to species distributions

Figure from Cavole, L. M., et al. (2016). "Biological Impacts of the 2013–2015 Warm-Water Anomaly in the Northeast Pacific: Winners, Losers, and the Future." Oceanography 29.

Work still to be done…

- Detailed analysis of how ocean color (primary productivity) changed along coast
- Detailed analysis of changes to wind speed / curl
- Did eddy dynamics / ocean mixing change during this period?
- Mixed layer changes?
- Energy budget
- Ocean currents?
- Ocean Salinity?
- Connect variability to ecosystem impacts

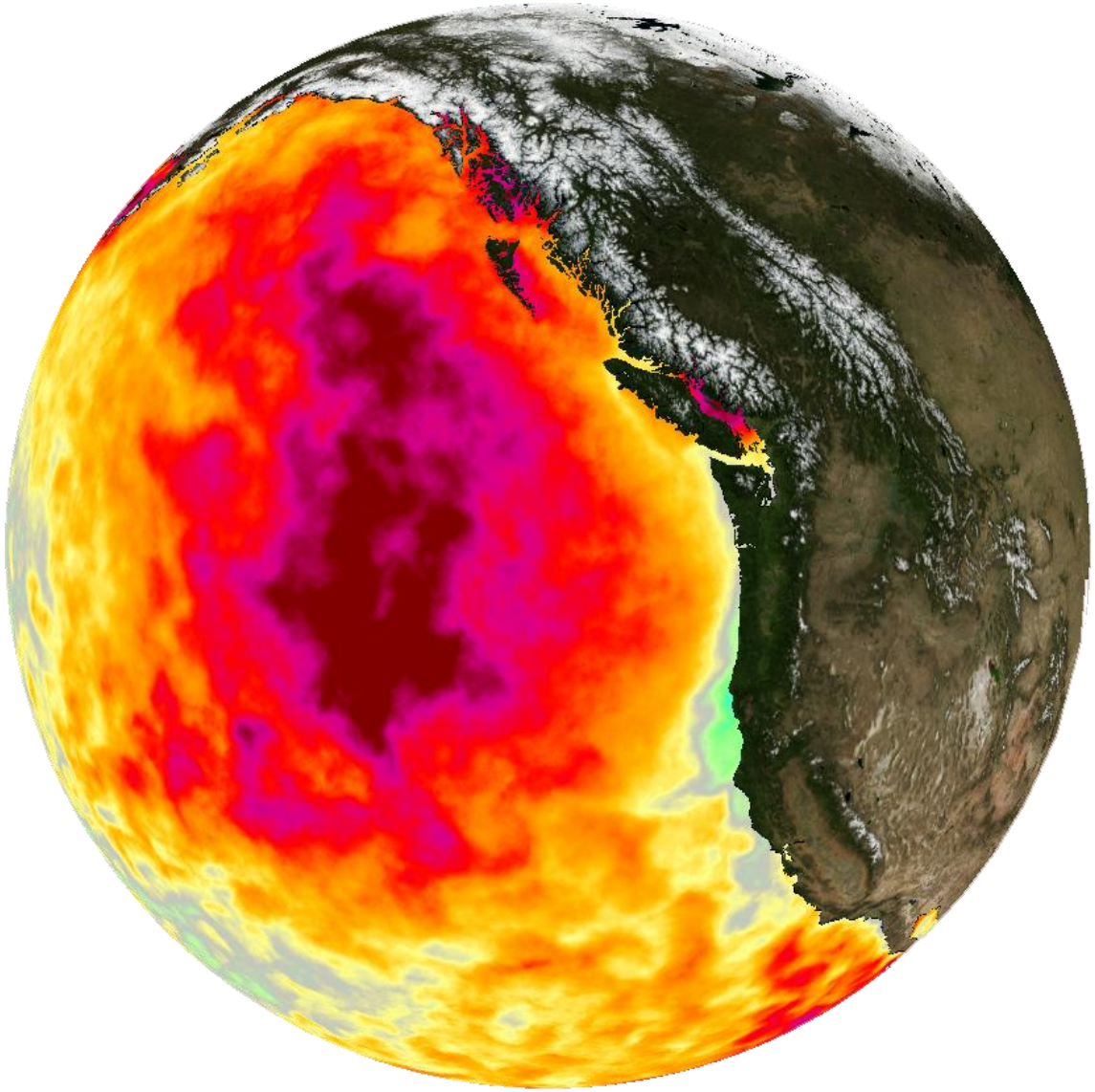


Image Credit: NASA JPL: C. Thompson & J. Hall