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EXTRAORDINARILY WARM NORTHEAST PACIFIC SURFACE WATERS: 2013-2015 OBSERVATIONS

RICHARD DEWEY[1], HOWARD FREELAND[2] AND STEVE MIHALY[1]

[1]OCEAN NETWORKS CANADA, UNIVERSITY OF VICTORIA, [2]INSTITUTE OF OCEAN SCIENCES, DEPARTMENT OF FISHERIES AND OCEANS

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Introduction

Starting in 2013, the surface marine conditions in the northeast Pacific (NEP) started warming, or perhaps more accurately, experienced a reduction in seasonal cooling. By January 2014, there appeared in all analyses of the sea surface temperature anomaly (SSTa) a large region of abnormally warm water (+2-3°C), extending over nearly $10^6 km^2$ and penetrating down to nearly 100m (Figure 1). Nicknamed the "Blob" by Nick Bond (UW), the warm anomalies have persisted for nearly two years. A result of reduced atmospheric winds, the Blob is one consequence of several variations in the large scale atmospheric conditions which have affect climates from California to Alaska. As of December 2015, the Blob remains nearly intact, having extended to depths over 200m in the central Gulf of Alaska. NEP winter storms are presently brewing.

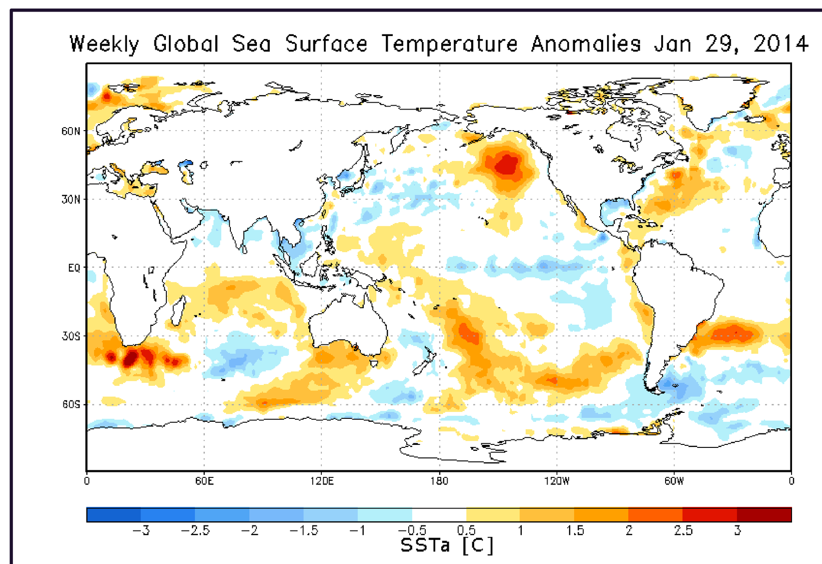


Figure 1. Sea Surface Temperature anomalies (SSTa) for the week ending January 29, 2014, showing was has been called the "Blob" occupying the Gulf of Alaska in the northeast Pacific. (NOAA-ESRL)

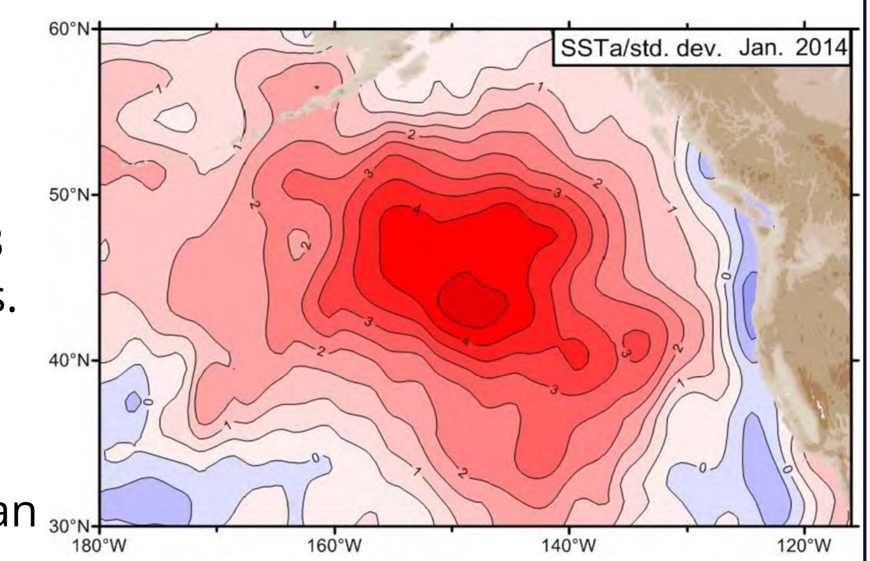
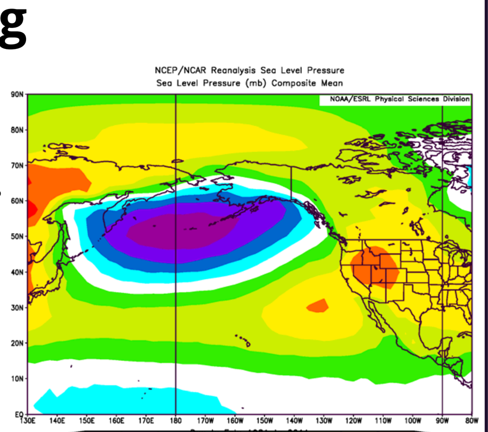
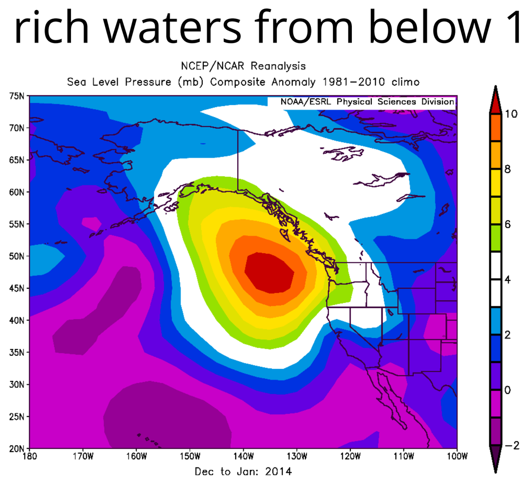


Figure 2. Sea Surface Temperature anomalies (SSTa) normalized by the standard deviation (std. dev.) based on 1981-2013 Reynolds NCEP reanalysis. If SSTa are Gaussian (unlikely), a 4 std. dev. monthly departure might not be expected more than once per millennium.

Cause: Reduced Atmospheric Forcing

Typical winter conditions in the NEP include the Aleutian Low (AL), a persistent large scale SLP depression (Figure 3, NOAA-ESRL). The wind stress curl over the Gulf of Alaska drives Ekman Pumping which thins the surface layer in the Gulf of Alaska, while frequent storms mix upwards cool, nutrient rich waters from below 120m.





The Aleutian Low in 2013-14 was particularly weak (Figure 4, SLPa NOAA-ESRL), with pressure gradients reduced by a factor of 2, wind stress (curl) by a factor of 4, and surface mixing by a factor of up to 8. The warm Blob of 2013-14 represents the result of an absence of winter cooling by a combination of reduced Ekman transport and wind mixing.

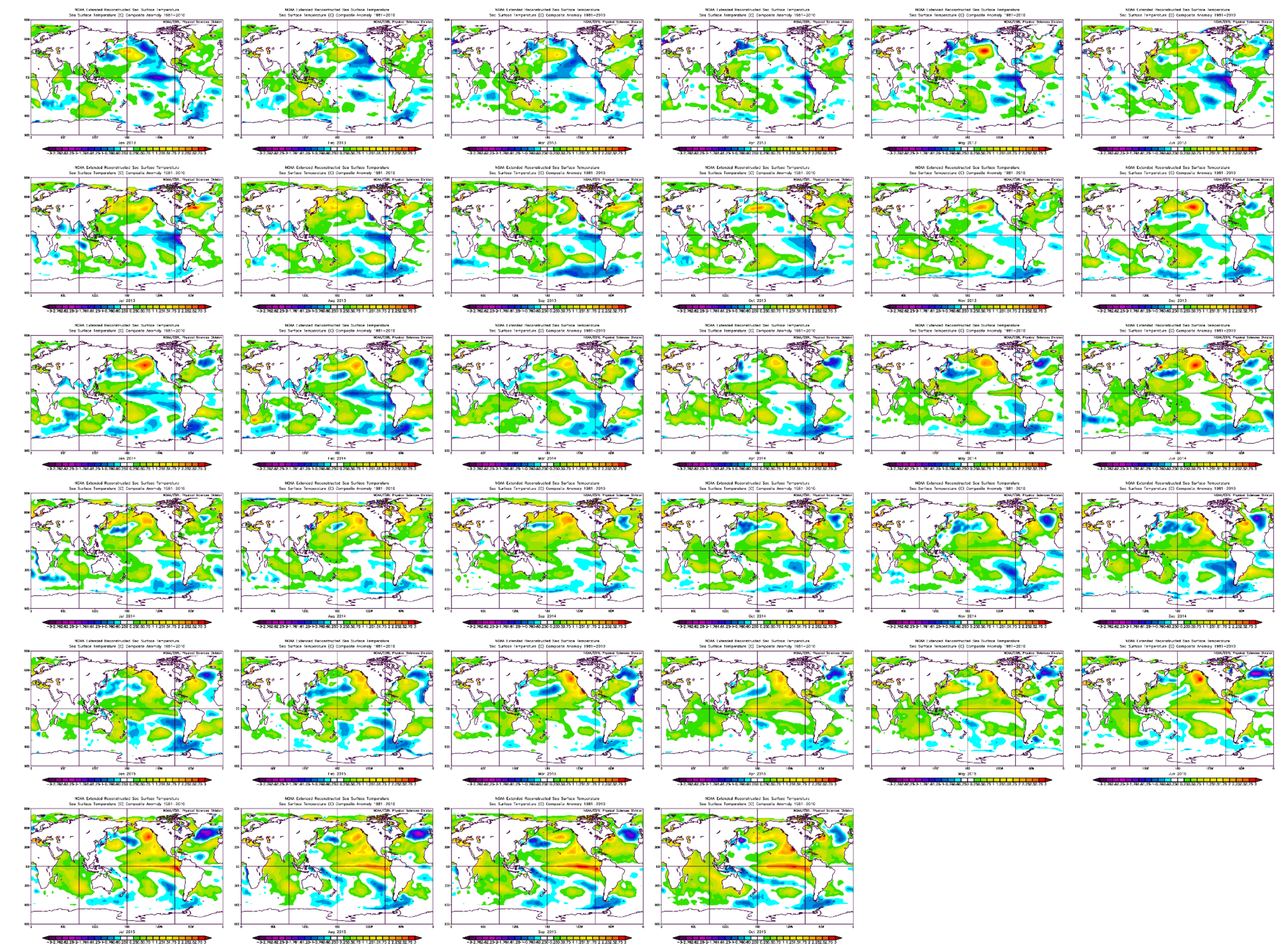
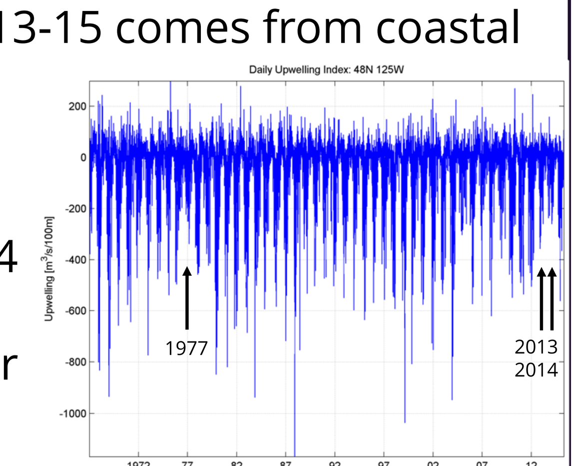


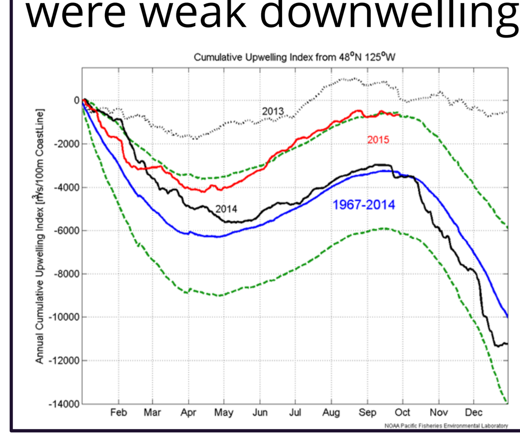
Figure 5. The evolution of the "Blob", as revealed by monthly mean SSTa plots (NOAA-ESRL) from January 2013 (upper left), through to October 2015 (lower right). The 2015 El Nino does not show up until May 2015.

Coastal Upwelling/Downwelling

Another indicator of the weak Aleutian Low of 2013-14, and the weak NEP winter storm seasons of 2013-15 comes from coastal weather buoys and upwelling indices.

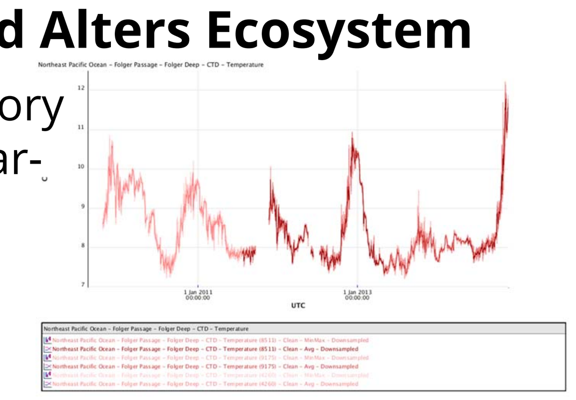


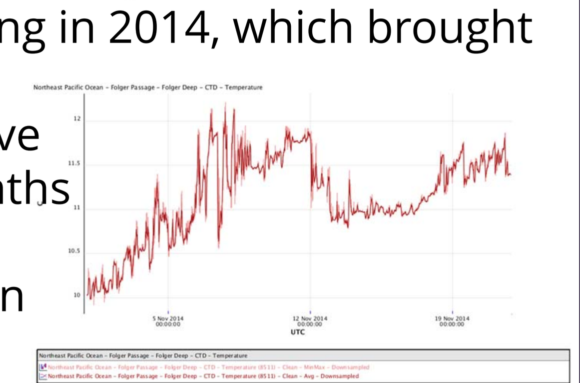
A 47 year record of Upwelling Index (Figure 6, NOAA-PFEL) off the coast of Washington reveals that 2013 and 2014 were weak downwelling years, with no storms, similar to 1977. Cumulative upwelling (Figure 7) emphasizes that 2013 had the least downwelling in the NOAA buoy record (1967). Downwelling here is a proxy for the strength of the AL.



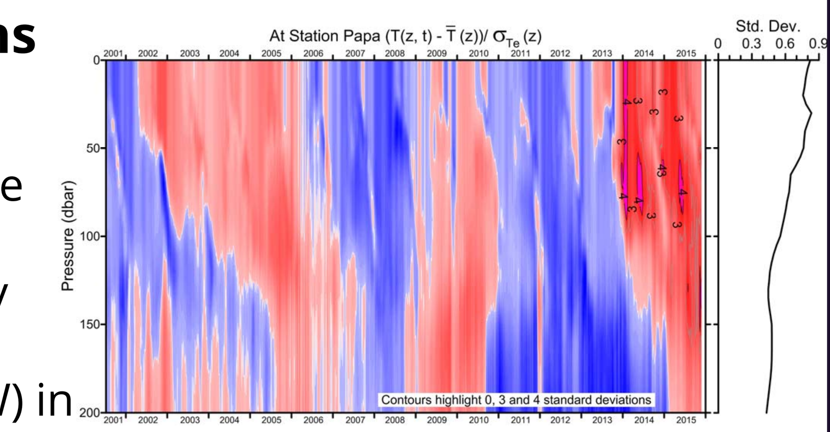
The Blob Comes Near-Shore and Alters Ecosystem

The NEPTUNE cabled ocean observatory has sensors at 100m depth at the near-shore station at Folger Passage, near the entrance to Barkley Sound on the west coast of Vancouver Island. Here (Figure 8) is the six-year temperature record, showing how weak the down-welling was in 2013, and the return of more typical down-welling in 2014, which brought the Blob near-shore (Figure 9, ONC). Temperatures rose by over 1.5°C above previous highs, lasting for over 3 months from Nov. 2014 – Jan 2015. Reduced surface nutrient supply has resulted in far fewer krill-like zooplankton and many more jellies, dramatically altering the food-web. Many more Sunfish (Mola Mola) were present in the NEP, and returning BC salmon in 2015 were significantly under weight.





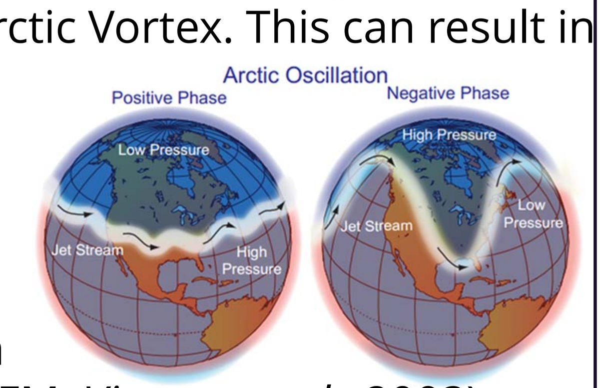
Warm NEP Conditions Continue Thru 2015

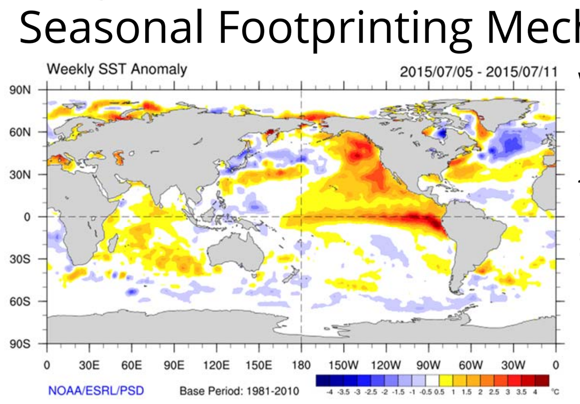


Plotted here (Figure 10) are the temperature anomaly time series (normalized by the std. dev.) at Ocean Station Papa (50°N, 145°W) in the central Gulf of Alaska, interpolated from Argo observations. The warming event that started in late 2013 first penetrated to nearly 100m, but persists through November 2015, extending beyond 200m depth. Surface anomalies exceeding 4 standard deviations in early 2014 have been replaced by sub-surface extreme anomalies. The right hand profile shows the standard deviation profile with depth.

Teleconnections: Cause and Effect

Research continues as to what caused the Aleutian Low to be so weak in 2013, and whether the Blob played a role in triggering the present El Nino, although two links may exist from the north and to the south. September 2012 saw the lowest permanent sea-ice extent in the Arctic. The reduced albedo and resulting ocean heat flux delayed and weaken the 2013 Arctic Vortex. This can result in a Polar Jet Stream that has large and persistent undulations, a key feature of the NH winters throughout 2013-2015 (Figure 11). Southern branches of the Blob in early 2015 are consistent with a SSTa Seasonal Footprinting Mechanism (SFM, *Vimont et. al.*, 2003), which can lead to a reduction in the eastern tropical Pacific high pressures, that drive the trade winds, one of several conditions known to be necessary for the triggering of an El Nino (Figure 12, NOAA-ESRL).





Conclusions

Anomalous atmospheric conditions (weak Aleutian Low and no storms) throughout 2013 and 2014 lead to the formation of an extraordinarily warm pool of near-surface waters throughout the entire Gulf of Alaska, that has persisted through 2015. Related weather impacts extend from California to Alaska, and though much of central North America. The lack of cold, nutrient rich surface waters has dramatically impacted the ecology of the NEP. While satellite images may suggest the Blob is waning, Argo float data from November 2015 suggest it remains, at least in part, down to depths beyond 200m.

References and Data Sources:

Vimont, D.J., J.M. Wallace, and D.S. Battisti, 2003: The Seasonal Footprinting Mechanism in the Pacific: Implications for ENSO., *J. Climate*, **16**, 2668-2675

NOAA-National Climate Data Center: http://www.ncdc.noaa.gov/

NOAA-Earth System Research Laboratory: http://www.esrl.noaa.gov/

NOAA-Pacific Fisheries Environmental Laboratory: http://www.pfeg.noaa.gov/

Ocean Networks Canada Oceans 2.0: http://www.oceannetworks.ca/

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