**North Pacific Climate Overview**

N. Bond (UW/JISAO)
Contact: Nicholas.Bond@noaa.gov
NOAA/PMEL, Building 3, 7600 Sand Point Way NE, Seattle, WA 98115-6349

**Last updated: August 2013**

***Summary***. *The state of the North Pacific atmosphere-ocean system during 2012-2013 reflected the combination of mostly near-neutral ENSO conditions and intrinsic variability. The Aleutian low was weaker than usual in the winter of 2012-13, and the sea level pressure was higher than normal in the eastern portion of the basin for the year as a whole. Cooler than normal upper ocean temperatures prevailed in the eastern portion of the North Pacific and mostly warmer than normal temperatures occurred in the west-central and then central portion of the basin. This pattern reflects a continuation of a negative sense to the Pacific Decadal Oscillation (PDO). The models used to forecast ENSO, as a group, are indicating a greater likelihood of near-neutral versus either El Niño or La Niña conditions for the winter of 2013-14.*

## 1. SST and SLP Anomalies

The state of the North Pacific from autumn 2012 through summer 2013 is summarized in terms of seasonal mean sea surface temperature (SST) and sea level pressure (SLP) anomaly maps. The SST and SLP anomalies are relative to mean conditions over the period of 1981-2010. The SST data are from NOAA's Extended Reconstructed SST analysis; the SLP data are from the NCEP/NCAR Reanalysis project. Both data sets are made available by NOAA's Earth System Research Laboratory at http://www.esrl.noaa.gov/psd/cgi-bin/data/composites/printpage.pl.

The climate forcing of the North Pacific during the year of 2012-13 began with a negative state for the PDO; the anomalies in the atmospheric forcing over the period considered here appears largely due to intrinsic variability. The tropical Pacific was warmer than normal during the autumn (Sep-Nov) of 2011 (Fig. 1a) and a majority of forecast models at that time indicated the probable development of a weak-moderate El Nino for the following winter. This often causes anomalous warming in the waters along the west coast of North America and in the Bering Sea, which then were mostly cooler than normal. The pattern of anomalous SLP during autumn 2012 featured strongly positive anomalies over the Bering Sea extending across Alaska into northwestern Canada (Fig. 1b). This pattern corresponds with easterly wind anomalies from roughly 40° to 50°N across most of the North Pacific, and was essentially opposite to that which occurred the year before in fall 2011.

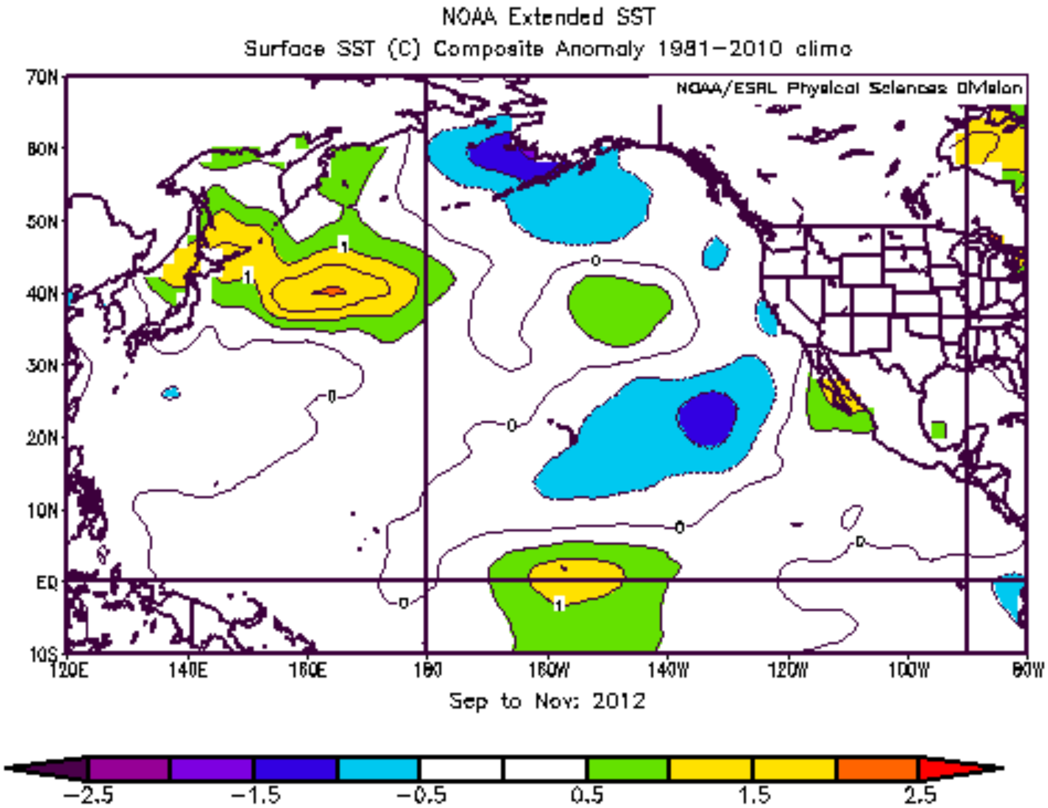


Figure 1a.  SST anomalies for September-November, 2012.

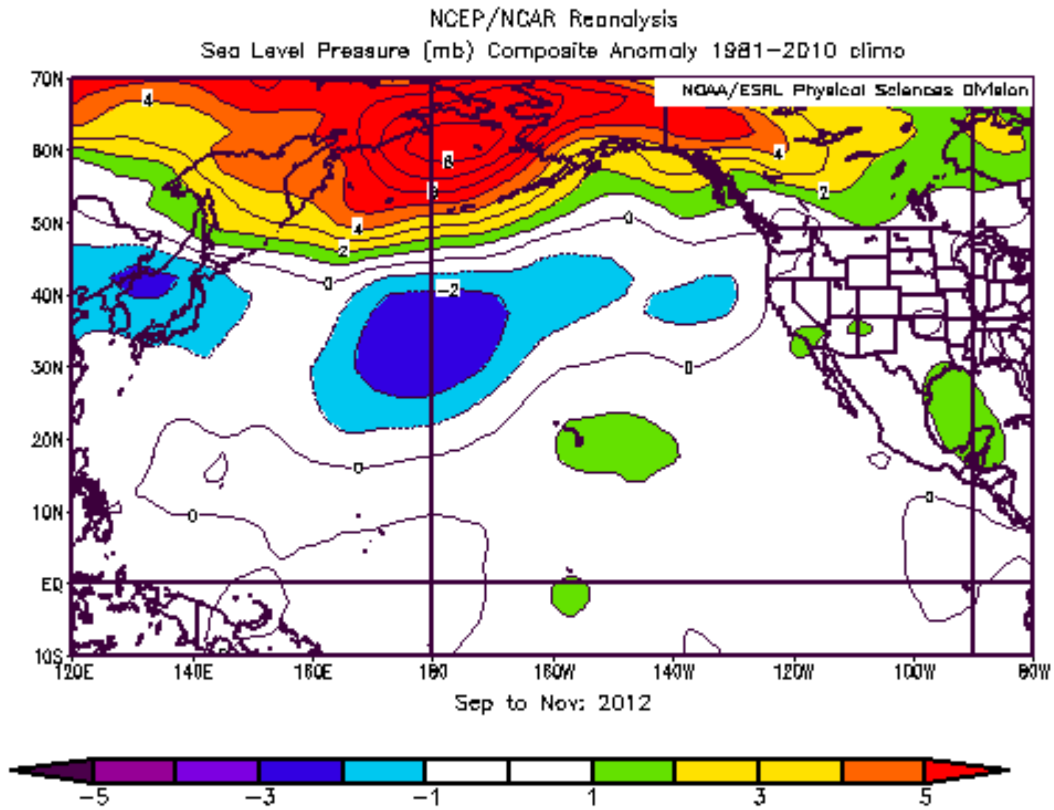


Figure 1b. SLP anomalies for September-November, 2012.

The pattern of anomalous SST in the North Pacific during winter (Dec-Feb) of 2012-13 (Fig. 2a) resembled its counterpart during the previous fall. There was some modest cooling, relative to seasonal norms, in portions of the eastern North Pacific, and in the eastern tropical Pacific. The latter was insufficient to qualify as La Niña conditions. The anomalous SLP during winter 2012-13 was dominated by a large high (>10 mb) centered near 40°N, 145°W (Fig. 2b). This anomaly pattern closely resembles that from a year ago. The anomalous SLP pattern shown in Figure 2b indicates westerly wind anomalies in the mean for the Gulf of Alaska and anomalous upwelling along the coast of California. For Alaskan waters, the SLP pattern promoted the delivery of cold air of Siberian origin to the Bering Sea and Gulf of Alaska; the higher than normal pressure west of California meant suppressed storminess in the far eastern North Pacific and below normal precipitation for the west coast of the lower 48 states.

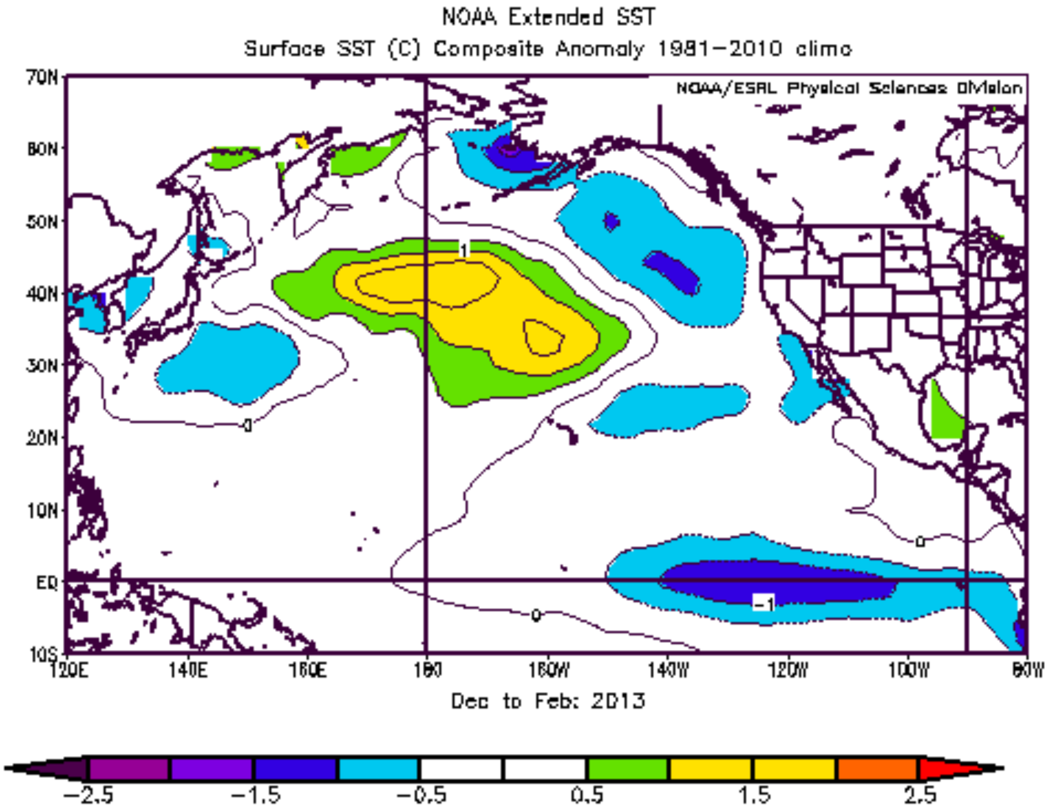


Figure 2a. SST anomalies for December 2012 - February 2013.

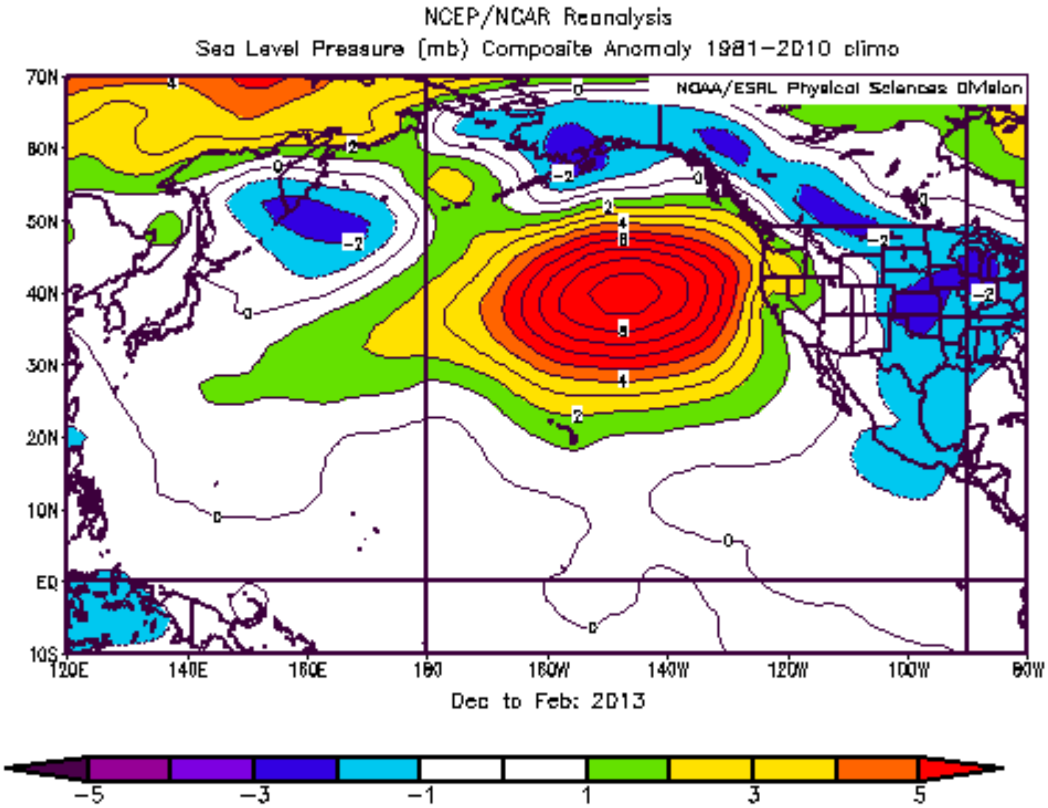


Figure 2b. SLP anomalies for December 2012 - February 2013.

The distribution of SST in spring (Mar-May) of 2013 (Fig. 3a) indicates a continuation of colder than normal temperatures in the waters of the eastern Bering Sea and northwestern Gulf of Alaska waters and the development of anomalous warmth in the central North Pacific north of Hawaii. The SST anomalies in the tropical Pacific were generally weak, with more prominent anomalies developing in the far eastern portion off the coast of South America. The concomitant SLP anomaly map (Fig. 3b) indicates a pattern closely resembling that of autumn 2012. This set-up implies suppressed storminess across the Bering Sea and Gulf of Alaska, and an early start to the upwelling season for the California Current System.

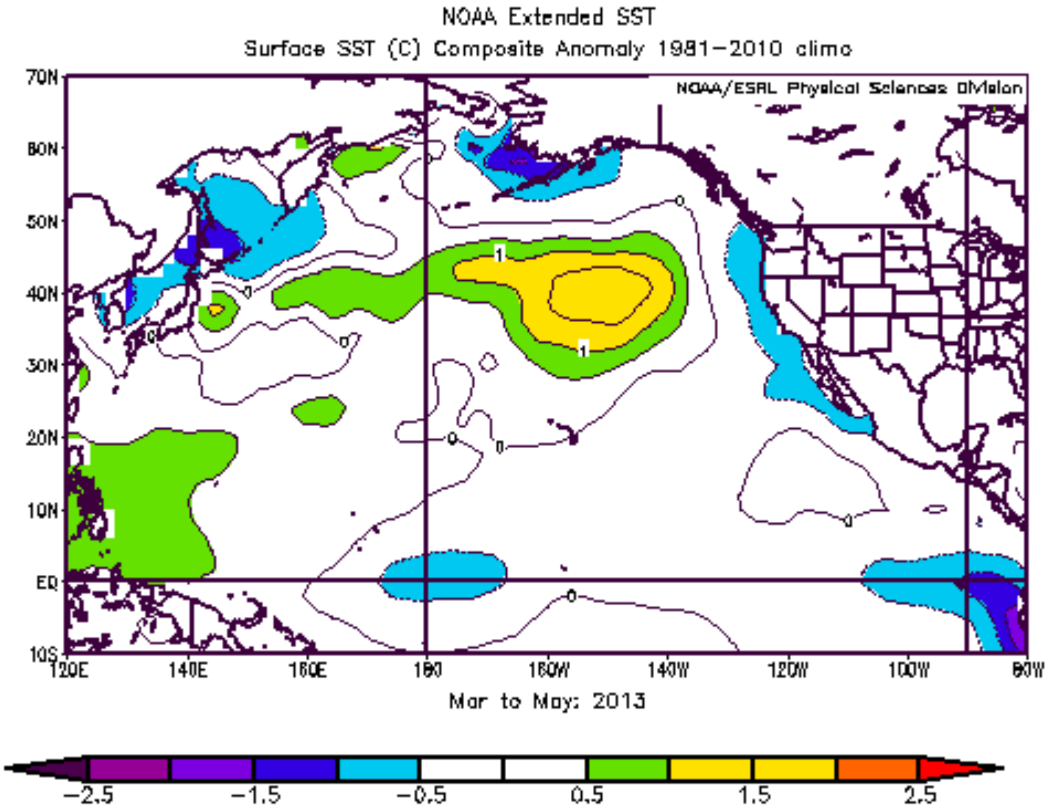


Figure 3a. SST anomalies for March – May, 2013.

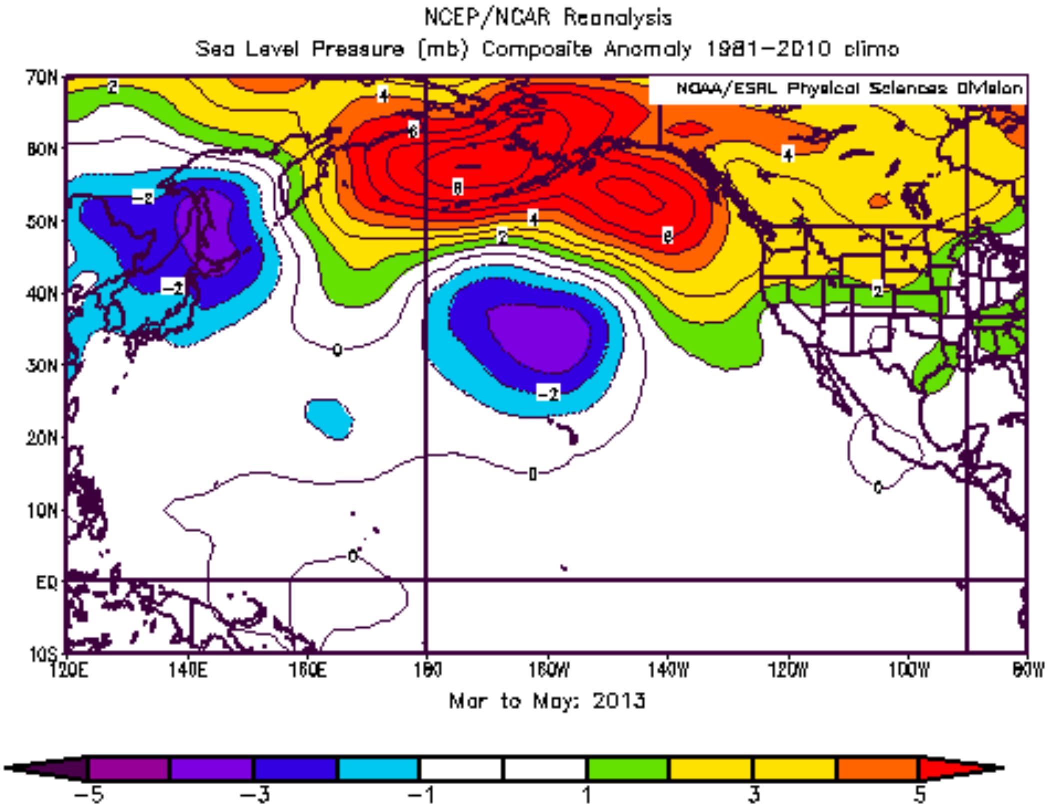


Figure 3b. SLP anomalies for March – May, 2013.

The pattern of anomalous SST in summer (Jun-Aug) 2013 (Fig. 4a) featured the continued warming of the eastern North Pacific relative to seasonal norms. Positive anomalies developed along the coast of the northeastern portion of the Gulf of Alaska, and the eastern Bering Sea warmed to near-normal values. It remained slightly cooler than normal in the eastern tropical Pacific. The overall pattern represents a weakly negative expression of the Pacific Decadal Oscillation (PDO), as further discussed below. The distribution of anomalous SLP (Fig. 4b) included a continuation of positive anomalies stretching from the eastern Bering Sea across the Gulf of Alaska into Canada. The associated wind anomalies from the east in the eastern North Pacific between about 35˚ and 45˚ N meant poleward Ekman transport anomalies, which is consistent with the warming in the same region. The gradients in the SLP anomalies along the west coast of North America supported slightly greater than normal upwelling in the southeast Gulf of Alaska and relatively weak upwelling along California. This result is for the summer months as a whole; the SLP and wind anomaly patterns in the eastern North Pacific during July and August were almost mirror images of one another.

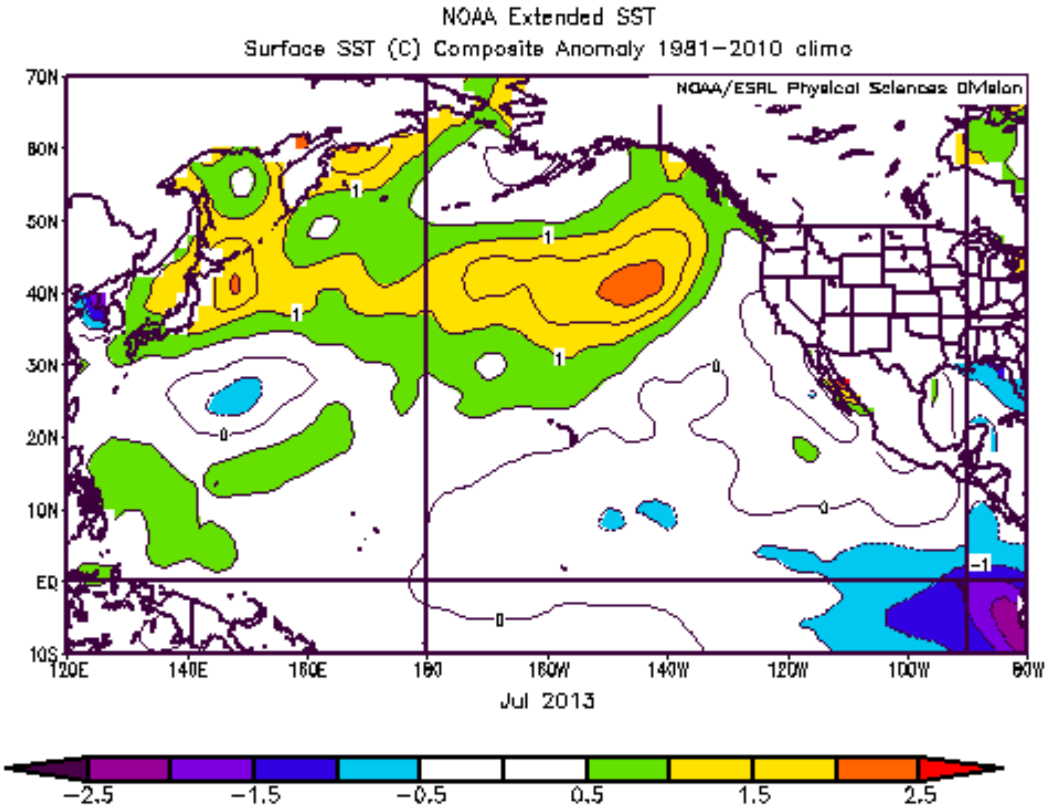


Figure 4a. SST anomalies for June – August, 2013.

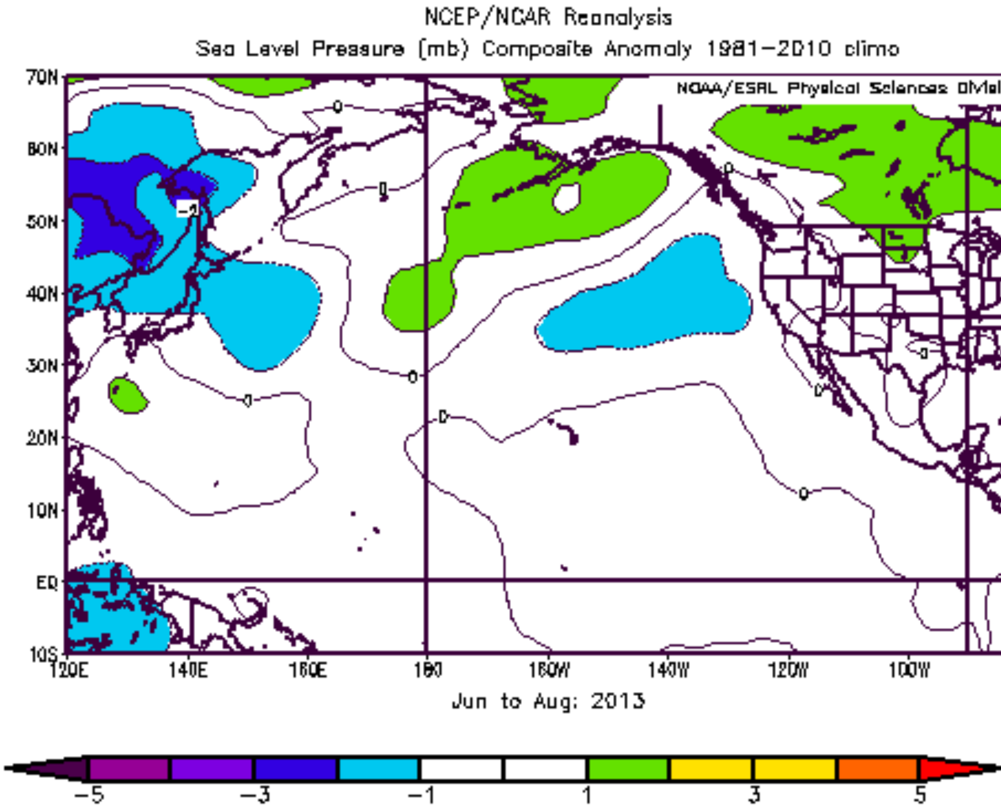


Figure 4b. SLP anomalies for June – August, 2013.

**2. Climate Indices**

Climate indices provide a complementary perspective on the North Pacific atmosphere-ocean climate system to the SST and SLP anomaly maps presented above. The focus here is on five commonly used indices: the NINO3.4 index to characterize the state of the El Niño/Southern Oscillation (ENSO) phenomenon, Pacific Decadal Oscillation (PDO) index (the leading mode of North Pacific SST variability), North Pacific Index (NPI), North Pacific Gyre Oscillation (NPGO) and Arctic Oscillation (AO). The time series of these indices from 2003 through early summer 2013 are plotted in Figure 5.

The state of the North Pacific atmosphere-ocean system reflected intrinsic variability during 2012-13. The NINO3.4 index was weakly positive in the fall of 2012, and has been slightly negative since late 2012. The small magnitude of this signal implies a near-neutral state for ENSO, and hence the tropical Pacific is unlikely to have contributed significantly to the perturbations in the climate of the North Pacific that have occurred over the last year. The overall positive trend in the NINO3.4 index is consistent with a positive trend in the PDO in the last year or so. The PDO has been in a largely negative state since the latter part of 2007; it is uncertain whether the recent tendency of an upward trend in the PDO will persist, or whether it will revert back to negative values. The NPI was strongly positive (implying a weak Aleutian Low) during the winter of 2012-2013. This often occurs in association with La Niña, but as mentioned above, was not the case in this instance.

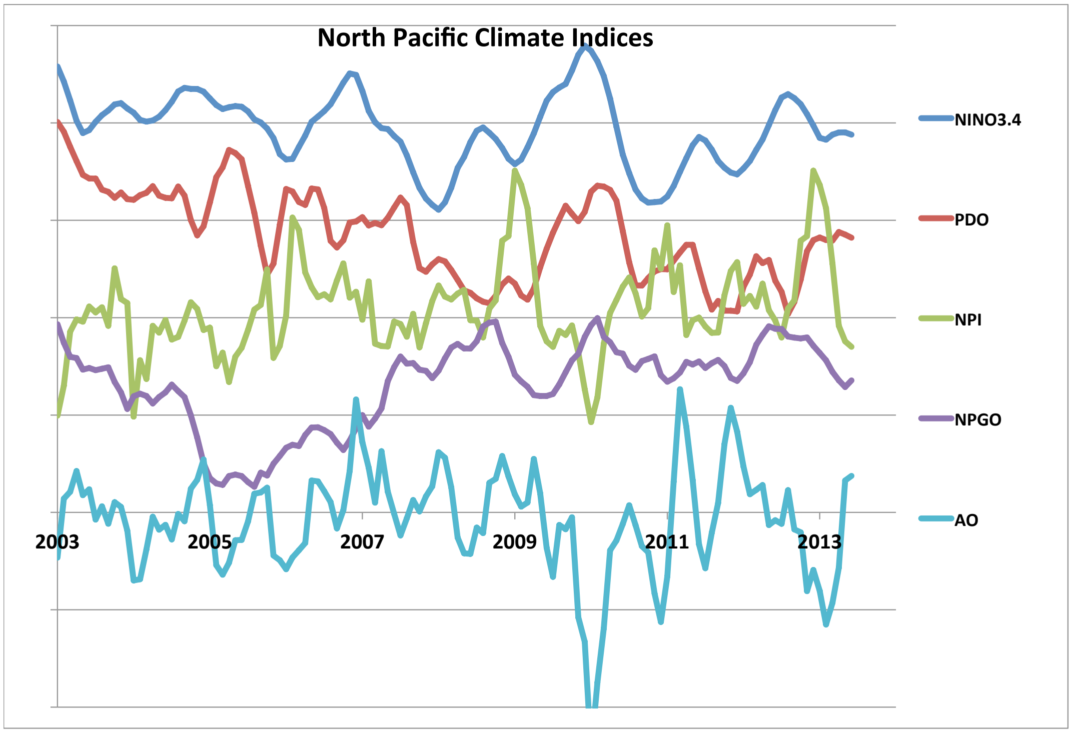


Figure 5. Time series of the NINO3.4 (blue), PDO (red), NPI (green), NPGO (purple), and AO (turquoise) indices. Each time series represents monthly values that are normalized and then smoothed with the application of three-month running means. The distance between the horizontal grid lines represents 2 standard deviations. More information on these indices is available from NOAA's Earth Systems Laboratory at http://www.esrl.noaa.gov/psd/data/climateindices/.

The North Pacific Gyre Oscillation (NPGO) represents the second leading mode of variability for the North Pacific, and has been shown to relate to chemical and biological properties in the Gulf of Alaska and the southern portion of the California Current (DiLorenzo et al. 2008, 2009). It has been in a positive state since 2007, which projects on stronger than normal flows in both the Alaska Current portion of the Subarctic Gyre and the California Current. The AO represents a measure of the strength of the polar vortex, with positive values signifying anomalously low pressure over the Arctic and high pressure over the Pacific and Atlantic, at a latitude of roughly 45° N. It has a weakly positive correlation with sea ice extent in the Bering Sea. During periods of positive AO, cold air outbreaks to mid-latitudes are suppressed. The AO was strongly negative during the winter of 2012-13. That has been the case during three out of the last 4 winters, with 2011-12 being the exception. It has been suggested that the declines in sea ice coverage in the Arctic in fall may be responsible, in part, for the recent tendency for the AO to be negative in the following winter season. This is a matter of considerable controversy and interest to the polar climate community.

## 3. Regional Highlights

a. **West Coast of Lower 48** – This region experienced a relatively quiet winter, with less downwelling-favorable winds than normal, especially along the Oregon coast.. The waters near the coast tended to be mostly cool and salty, with particularly low oxygen concentrations noted at depth during summer 2013. The cooler waters were accompanied by a greater preponderance of sub-arctic than sub-tropical zooplankton than usual in spring 2013 (B. Peterson, NOAA/NWFSC). For the spring and summer of 2013, the winds have tended to be more upwelling favorable than usual. Additional information on the state of the California Current system is available at www.pacoos.org and http://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/index.cfm.

b. **Gulf of Alaska** –The weather in this region included near normal air temperatures and below normal precipitation. The mixed layer depths in the Gulf were slightly deeper than usual during the winter of 2012-2013 suggesting that the supply of nitrate to the euphotic zone for the spring bloom was also enhanced.The winds during spring and summer 2013 were of the sense to favor more coastal upwelling than usual in the northern and eastern portions.

c. **Alaska Peninsula and Aleutian Islands** – Easterly wind anomalies prevailed in this region during the fall of 2012 and spring of 2013. Anomalies in this sense tend to enhance the northward transport through Unimak Pass and perhaps also the Aleutian North Slope Current. These periods also featured SLP patterns indicating suppressed storminess. There is relatively little direct monitoring of the physical oceanography of this region, but SST values (based in large part on remote sensing from satellites) appear to have been near normal during the past year.

d. **Bering Sea** – The Bering Sea shelf also experienced less storminess than normal in fall 2012 and spring 2013. On the other hand, the weather during fall and winter was cold, which resulted in another relatively heavy ice year. The extent of this ice on this shelf appears to have been more variable than usual, with a series of advances and retreats. Based on previous observations, it can be expected that the cold pool was somewhat more extensive than usual during the summer of 2013, but that is uncertain (at the time of this writing) due to the reduction in hydrological survey data.

e. **Arctic** – There is reduced sea ice cover in the Arctic during the summer of 2013 compared to seasonal norms, but not to the extent that occurred in 2011 and 2012. The ice edge was very near the shore for much of the Beaufort Sea as late as early August 2013, but is rapidly retreating at the time of this writing (14 August). Ice concentrations in the Chukchi Sea have been observed to be greater during the summer of 2013 than in 2012. In general, the sea ice of the Arctic is thinner than its long-term climatological mean, and so there is the potential for a relatively swift reduction in ice cover over the remainder of summer.

## 4. Seasonal Projections from the National Multi-Model Ensemble (NMME)

Seasonal projections of SST from the National Multi-Model Ensemble (NMME) are shown in Figures 6a-c. The uncertainties and errors in the predictions from any single climate model can be substantial. An ensemble approach incorporating different models is particularly appropriate for seasonal and longer term simulations; the NMME represents the average of 6 models. More detail on the NMME, and projections of other variables, are available at the following website: http://www.cpc.ncep.noaa.gov/products/NMME/.

These NMME forecasts of 3-month average SST anomalies indicate warming in the central North Pacific between the Hawaiian Islands and Alaska into fall (Sep-Nov 2013) and a continuation of slightly cooler water than normal in the northeastern Bering Sea (Fig. 6a). This overall pattern is maintained, with some weakening in magnitude, through the 3-month periods of November 2013 – January 2014 (Fig. 6b) and January 2014 – March 2014 (Fig. 6c). In an overall sense, these patterns project onto a negative sense for the PDO, largely because of the relatively warm anomalies near the dateline. The NMME forecasts also include a slight warming in the tropical Pacific, especially in the western portion. The ensemble mean values of these anomalies are too weak to qualify as El Niño, but it is still possible that an ENSO event (probably of modest amplitude at best) could develop. At the time of this writing (early August 2013) the probabilistic forecast provided by NOAA's Climate Prediction Center (CPC) in collaboration with the International Research Institute for Climate and Society (IRI) for the upcoming fall through spring is a slightly greater than 50% chance for a near-neutral state for ENSO and roughly equal and lesser odds of El Niño or La Niña. It bears noting the NMME projections are suggesting the continuation of rather cold SST for most Alaskan waters. It is emphasized that the skill in these projections is limited. For example, during August 2012 there were strong indications of warming in the tropical Pacific, and concomitant effects on the North Pacific climate, that did not materialize.

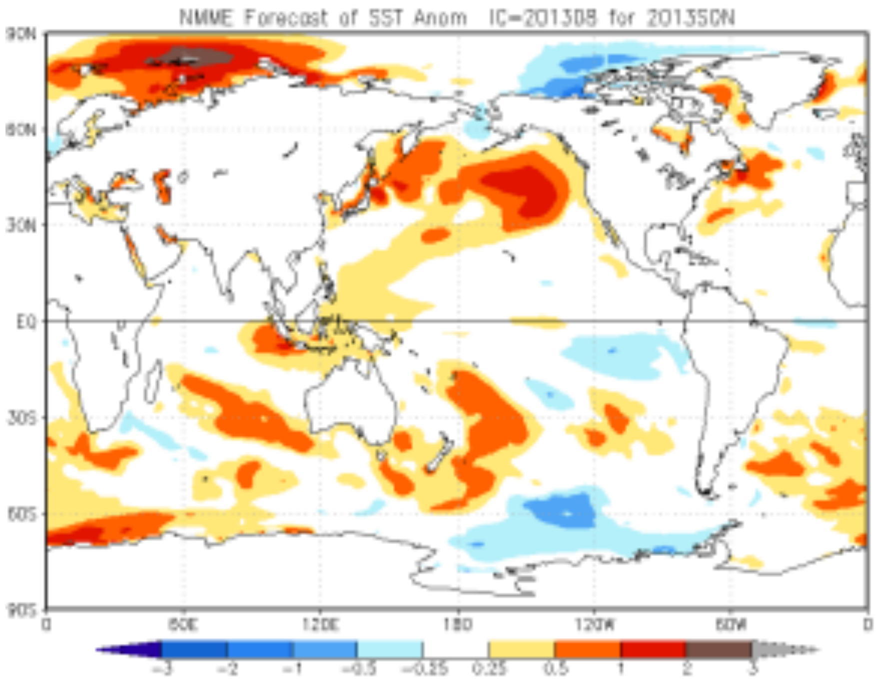


Figure 6a Predicted SST anomalies for September-November 2013 (1 month lead) from the National Multi-Model Ensemble (NMME) of coupled atmosphere-ocean climate models. See text for details.

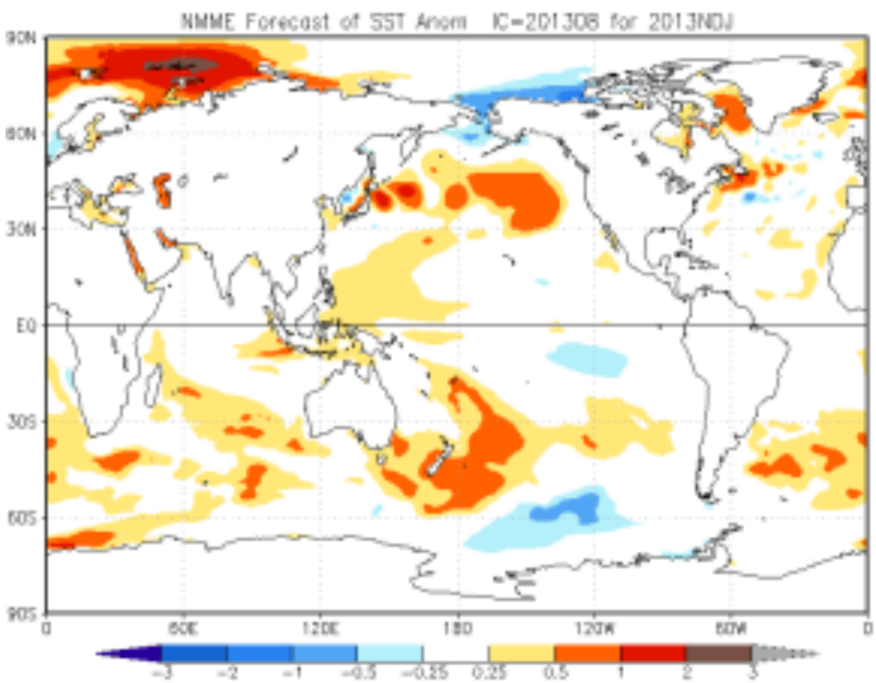


Figure 6b As in Fig. 6a, but for November 2013-January 2014 (3 month lead).

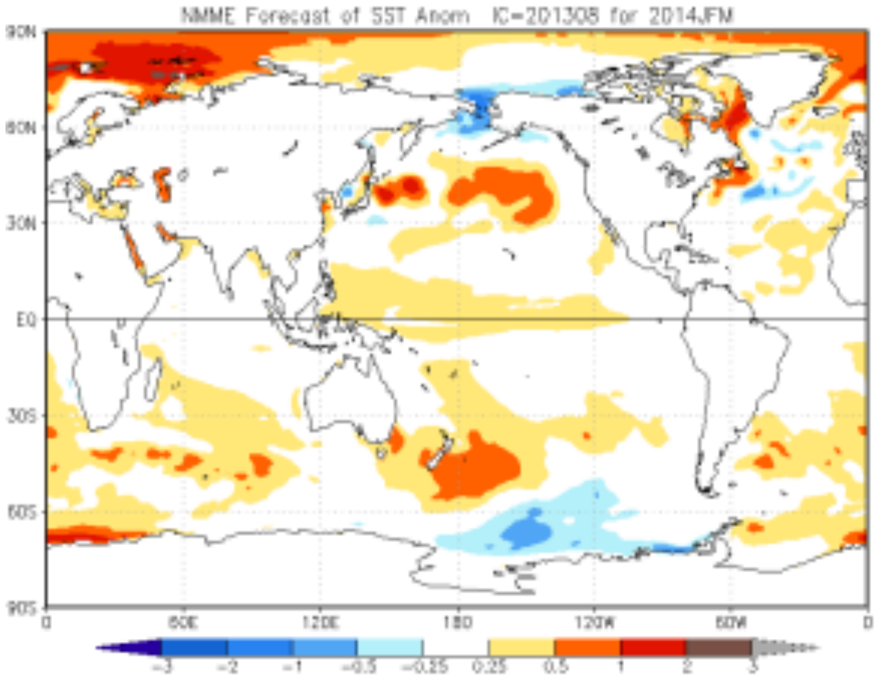

Figure 6c. As in Fig. 6a, but for January-March 2014 (5 month lead).

**5. Literature Cited**

Di Lorenzo E., Schneider N., Cobb K. M., Chhak, K, Franks P. J. S., Miller A. J., McWilliams J. C., Bograd S. J., Arango H., Curchister E., Powell T. M. and P. Rivere (2008): North Pacific Gyre Oscillation links ocean climate and ecosystem change. Geophys. Res. Lett., 35, L08607, doi:10.1029/2007GL032838.

Di Lorenzo E., Fiechter J., Schneider N., Miller A. J., Franks P. J. S., Bograd S. J., Moore A. M., Thomas A., Crawford W. and Pena and Herman A. (2009): Nutrient and salinity decadal variations in the central and eastern North Pacific. Geophys. Res. Lett., doi:10.1029/2009GL038261.