

North Pacific Climate Overview

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***Summary.** The state of the North Pacific atmosphere-ocean system during 2013-2014 featured the development of strongly positive SST anomalies south of Alaska. This warming was caused by unusually quiet weather conditions during the winter of 2013-14 in the region in association with a weak Aleutian low, and abnormally high SLP off the coast of the Pacific Northwest. The result was much reduced seasonal cooling of the upper part of the water column. The warm upper ocean conditions persisted through the summer of 2014. The unusual winter weather appears to be largely due to intrinsic variability rather than associated with leading modes of climate variability such as ENSO. The Bering Sea experienced less sea ice than during past winters since 2007, perhaps marking the end of the recent cold spell. With the warming in the eastern portion of the basin, the Pacific Decadal Oscillation (PDO) underwent a transition from negative to positive during the past year. The models used to forecast ENSO, as a group, are indicating a weak-moderate El Niño conditions for the winter of 2014-15, which should serve to maintain a positive sense to the PDO.*

1. SST and SLP Anomalies

The state of the North Pacific from autumn 2013 through summer 2014 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 (ESRL) at <http://www.esrl.noaa.gov/psd/cgi-bin/data/composites/printpage.pl>.

The climate forcing of the North Pacific during the year beginning with the autumn of 2013 featured a transition from a negative to a positive state in the Pacific Decadal Oscillation (PDO). This transition was accompanied by a shift in tropical Pacific SST, specifically the NINO3.4 region, was slightly cooler than normal to warmer than normal. The tropical Pacific does not appear to have been a primary cause of the conditions that developed in the North Pacific, in that the tropical Pacific conditions were not too different from normal, and the patterns in the anomalies in the North Pacific little resembled those that have accompanied past changes in ENSO.

The SST anomalies in the North Pacific during the autumn (Sep-Nov) of 2013 (Fig. 1a) were minimal over much of the basin, with the most prominent exception of an east-west oriented band of positive anomalies along 40° centered near the dateline. The pattern of anomalous SLP during autumn 2013 featured strongly positive anomalies from roughly 40° to 60°N across virtually the entire North Pacific, with particularly large anomalies south of Alaska. This pattern implies anomalous upwelling in the coastal waters extending from the south side of the Alaska Peninsula through the Gulf of Alaska (GOA) to the Pacific Northwest.

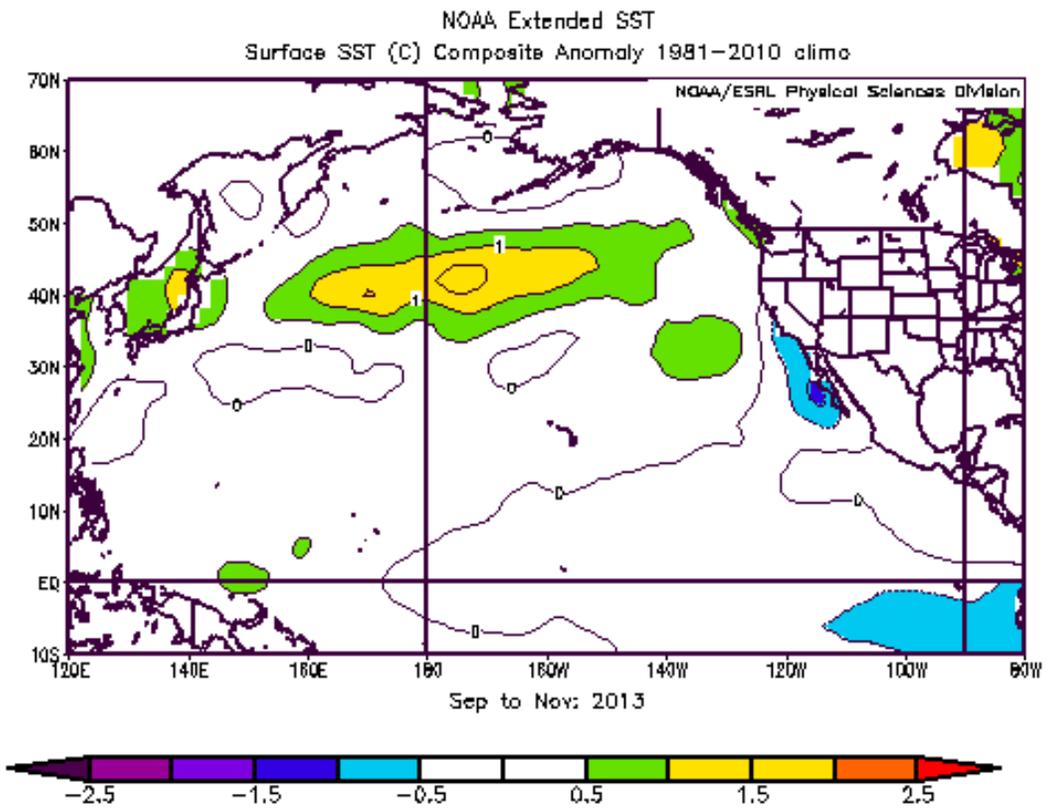


Figure 1a. SST anomalies for September-November 2013.

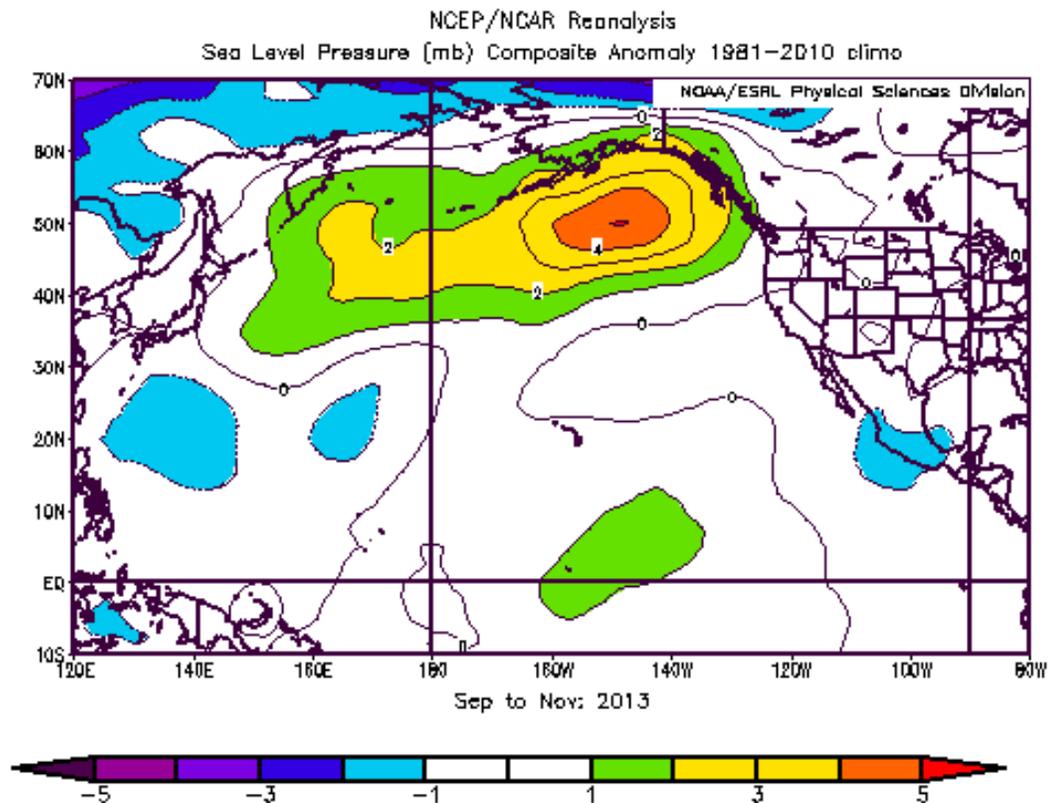


Figure 1b. SLP anomalies for September-November 2013.

Remarkably warm SST anomalies developed in the northeast Pacific during winter (Dec-Feb) of 2013-14 (Fig. 2a). The maximum values of these anomalies exceeded 2.5°C . The anomalies for most of the rest of the basin were little changed from the previous season. The development of the positive SST anomalies off the west coast of North America can be attributed to the continuation of much higher than normal SLP in the northeast Pacific (Fig. 2b). This region experienced an unusually strong and persistent ridge of high pressure or “block”. This block resulted in fewer storms and hence abnormally low magnitude of heat loss from the upper ocean to the atmosphere and also less mixing of cool water from depth into the waters near the surface. It also implies easterly wind anomalies and hence poleward Ekman transport anomalies. Much higher than normal SLP was also present from east Siberia across the Bering Sea to south of the Aleutian Island. The overall pressure pattern favored fewer and weaker cold-air outbreaks than normal over the northern Bering Sea and mainland Alaska, leading to relatively warm surface air temperatures (not shown). Coastal winds from the GOA to California continued to be upwelling favorable in an anomalous sense.

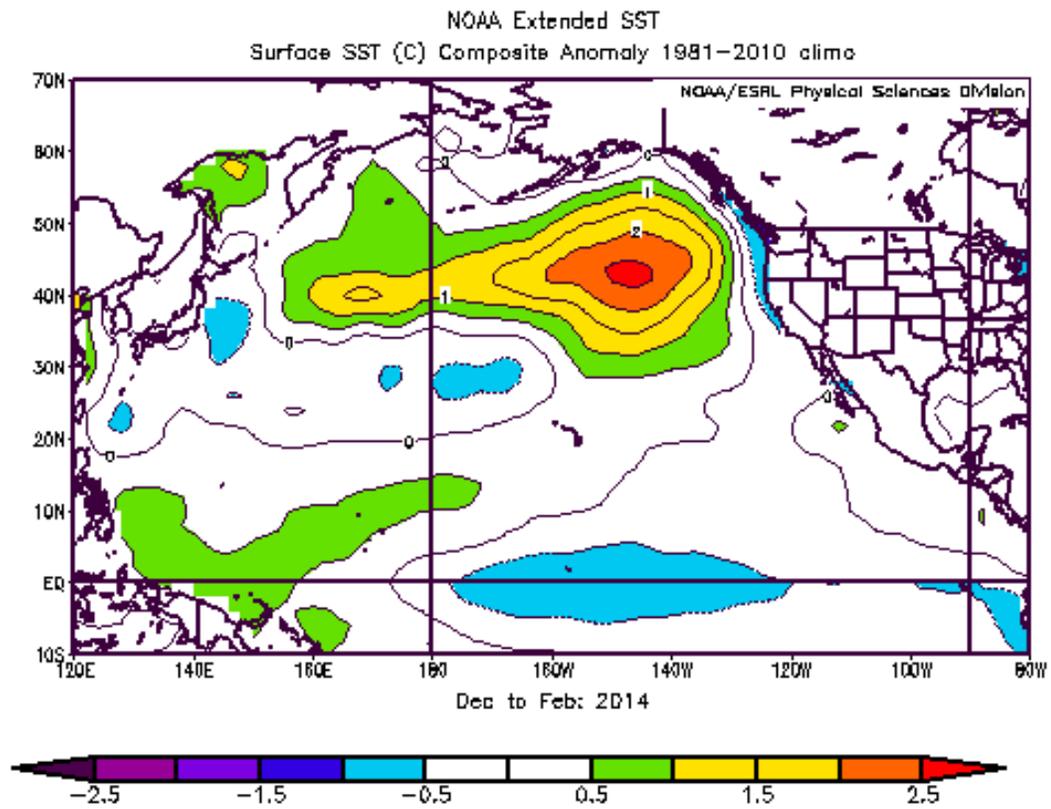


Figure 2a. SST anomalies for December 2013 - February 2014.

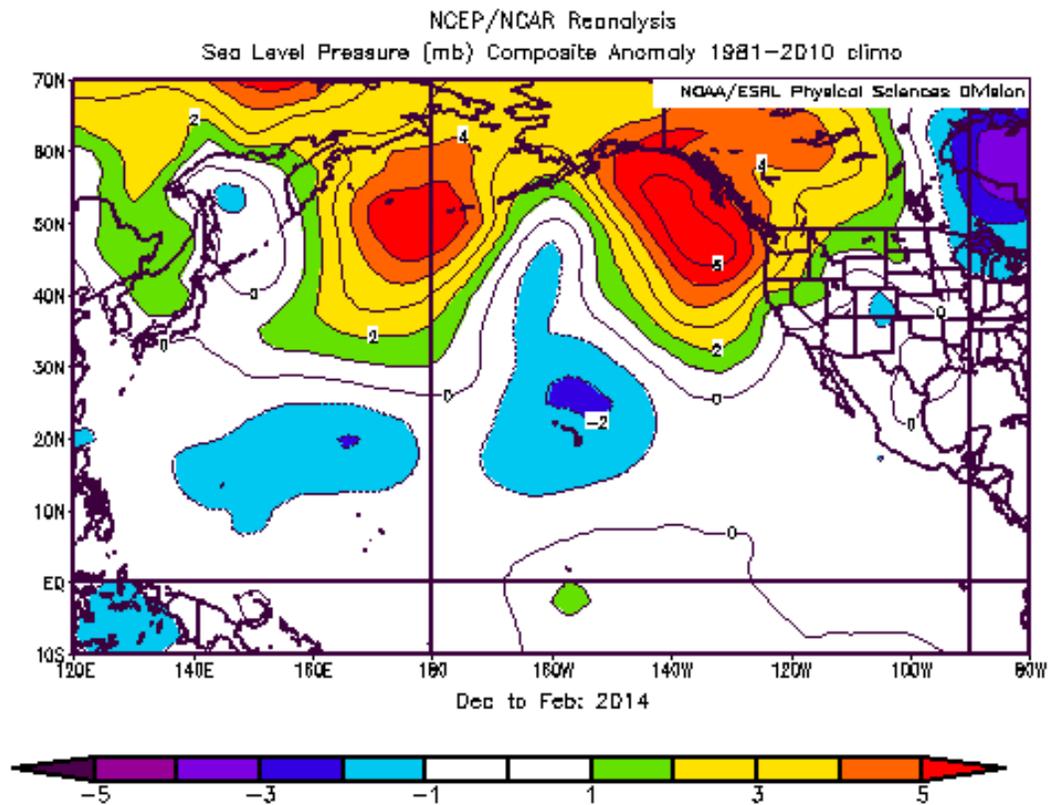


Figure 2b. SLP anomalies for December 2013 - February 2014.

The distribution of anomalous SST in the North Pacific during spring (Mar-May) of 2014 (Fig. 3a) resembled that of the season before, with lessening of the positive anomalies off the coast of the Pacific Northwest. The SST anomalies in the tropical Pacific were weakly positive in the west and near neutral in the east. There was some warming, but the overall tropical Pacific atmosphere-ocean system remained in the near-neutral category. The SLP anomaly pattern (Fig. 3b) for spring 2014 was substantially different than that for the previous winter. The most prominent feature was a region of negative anomalies extending from the southern portion of the Sea of Okhotsk to near 50° N and the dateline, with an extension of weaker negative anomalies stretching almost to Vancouver Island.

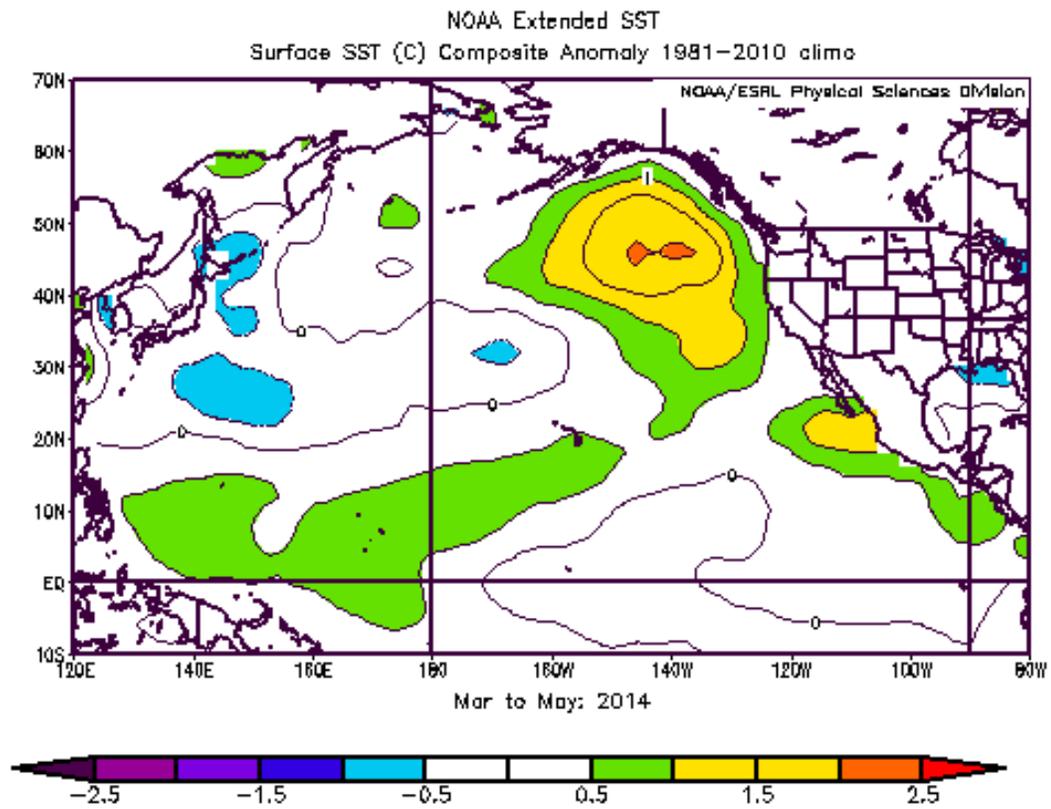


Figure 3a. SST anomalies for March – May 2014.

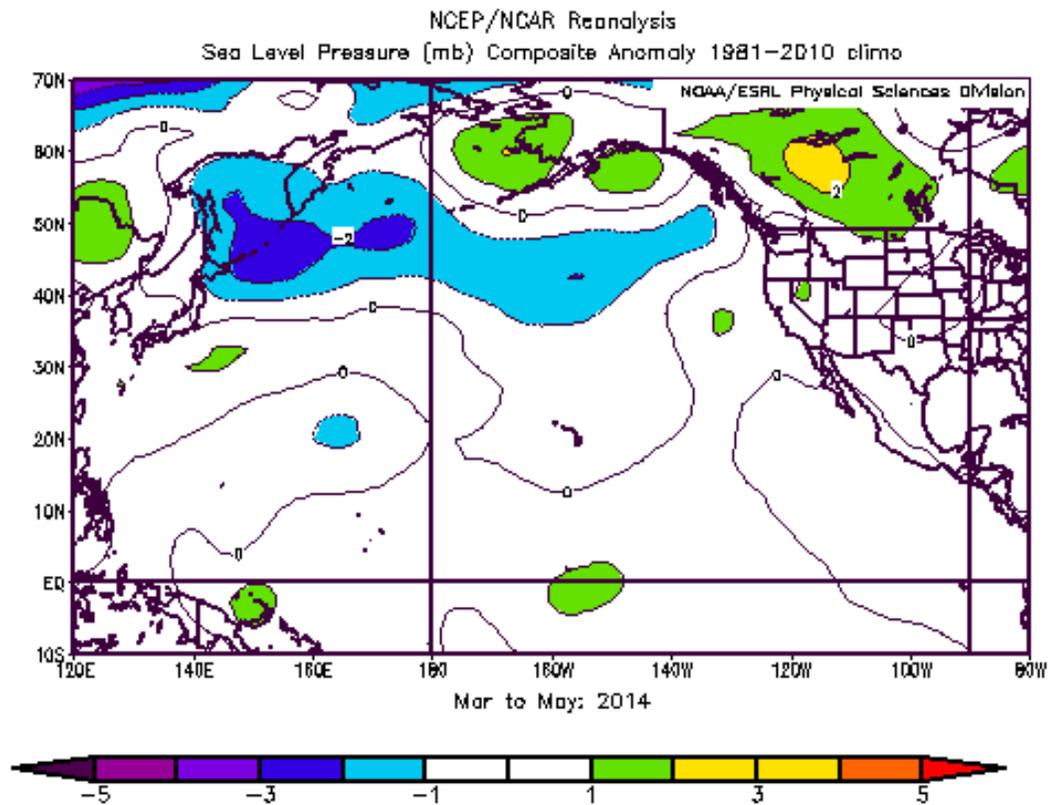


Figure 3b. SLP anomalies for March – May 2014.

The SST in summer (Jun-Aug) 2014 (Fig. 4a) indicated anomalous warmth across the northern portion of the Pacific basin from the Kamchatka to nearly the west coast of North America. A much smaller band of relatively cool water was present west of the dateline along about 30° N. The tropical Pacific included substantial warming in its far eastern portion off the coast of South America. The overall distribution represented a positive expression of the PDO, with the most positive anomalies in the northeastern Pacific to the west of their location in the classic PDO pattern. The distribution of anomalous SLP (Fig. 4b) during summer 2014 featured a dipole of higher than normal SLP over the western Aleutian Islands and lower than normal SLP to the south extending from 30° N and the dateline northeastward into the Gulf of Alaska and mainland Alaska. The SLP and associated wind anomalies were very weak over virtually the entire North Pacific east of about 150° W.

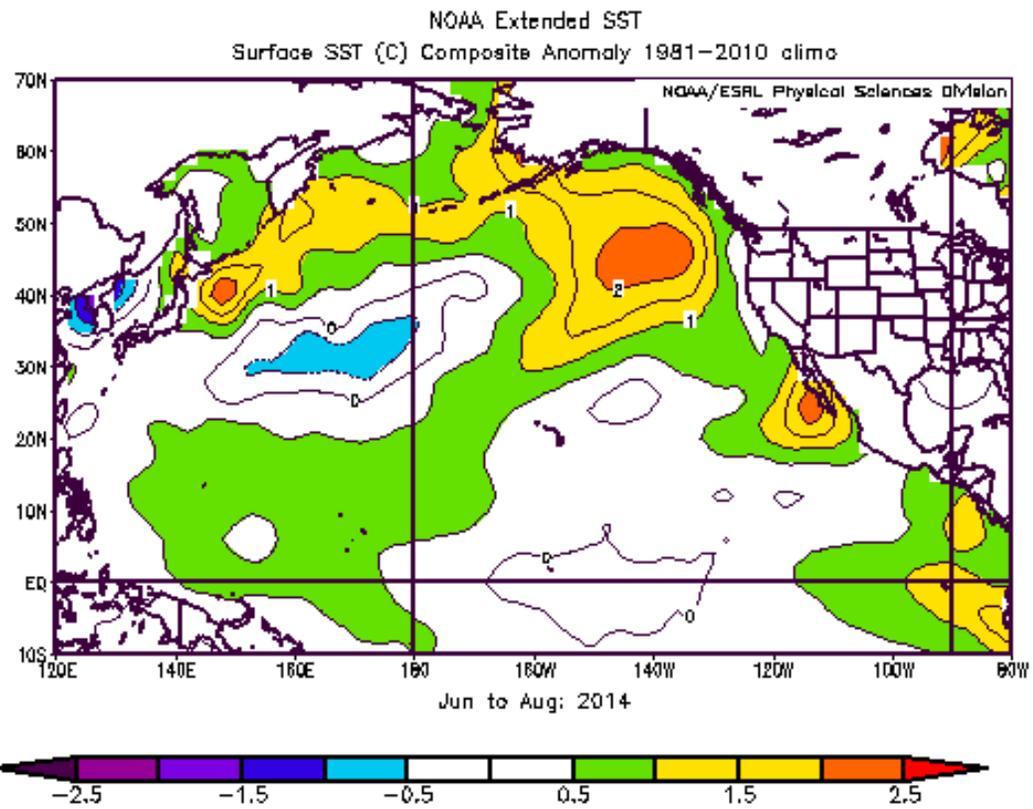


Figure 4a. SST anomalies for June – August 2014.

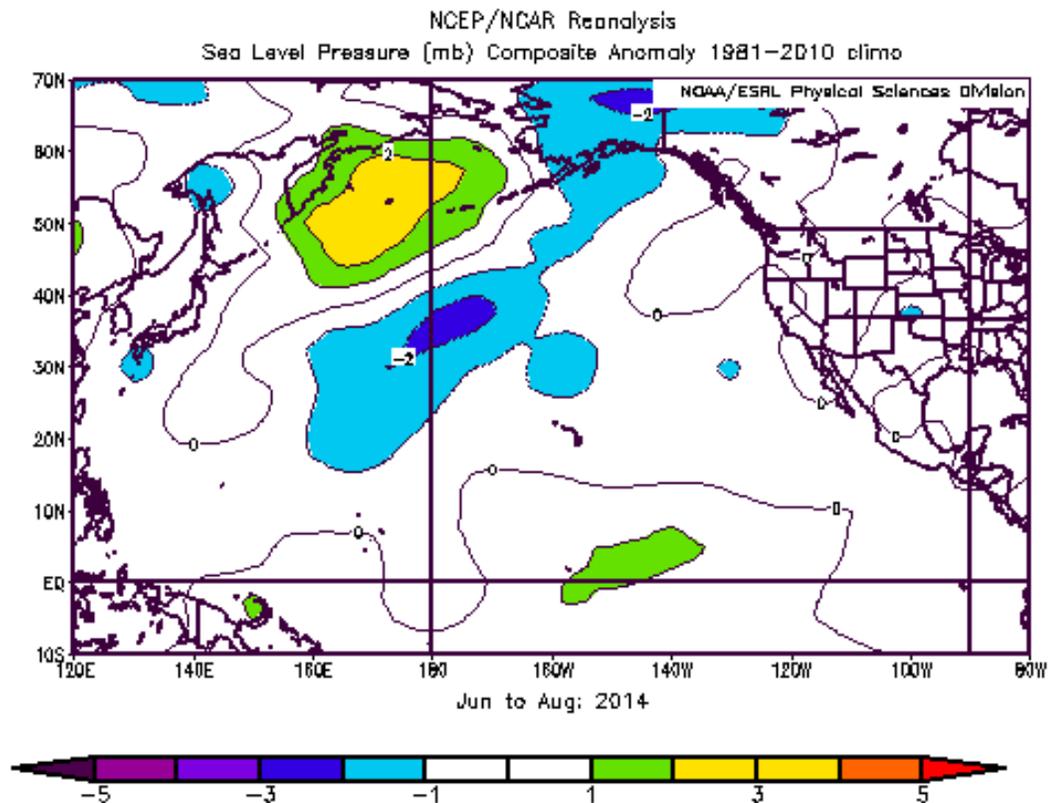


Figure 4b. SLP anomalies for June – August 2014.

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 2004 through early summer 2014 are plotted in Figure 5.

The North Pacific atmosphere-ocean climate system underwent significant changes during 2013-14. These kinds of changes in previous years have often been associated with ENSO events. For the present case, however, ENSO has been in a near-neutral state over the past year, as indicated by the time series of the NINO3.4 index shown in Figure 5. The PDO became significantly positive during the past year in a continuation of a general increasing trend that began in autumn 2012. Changes in the PDO typically lag those in ENSO by a few months due to the North Pacific oceanic response to atmospheric teleconnection patterns emanating from the tropical Pacific, but the past year appears to represent an exception. The NPI was positive (implying a weak Aleutian Low) during the last few months of 2013. This often occurs in association with La Niña, but as discussed above, was not the case in this instance.

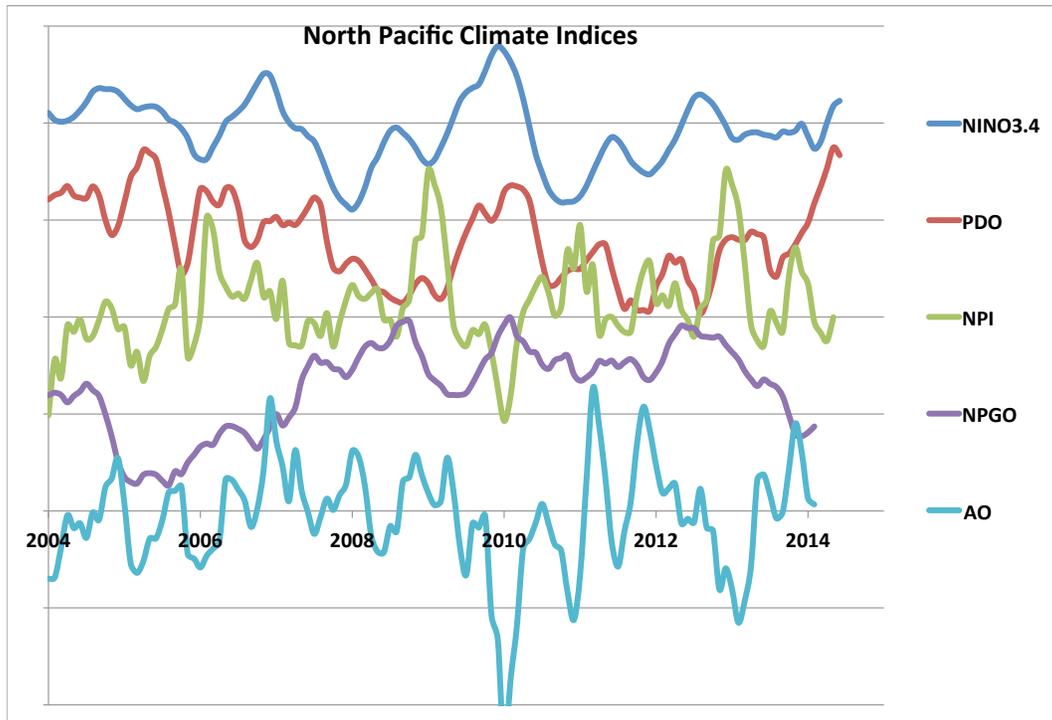


Figure 5. Time series of the NINO3.4 (blue), PDO (red), NPI (green), NPGO (purple), and AO (turquoise) indices. Each time series represents monthly values that are normalized and then smoothed with the application of three-month running means. The distance between the horizontal grid lines represents 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 northeastern Pacific, in particular the Gulf of Alaska. The NPGO has undergone a systematic decrease from a strongly positive state in 2012 to weakly negative in 2014. A negative sense of this index implies a reduced west wind drift and projects on weaker 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. The AO was positive late in 2013 and decreased to near-zero on average during the early part of 2014. It does not appear that the variations in the AO were strongly related to conditions in the vicinity of Alaska during the last year or so. The fluctuations in the AO during the last 5-10 years, and in particular the linkages between the AO and arctic sea ice, continue to be a subject of interest and controversy for the climate community.

3. Regional Highlights

- a. **West Coast of Lower 48** – This region experienced a very quiet winter, with less downwelling-favorable winds than normal, especially from northern California to the Canadian border. Spring included anomalous upwelling along the central and northern coast of California and downwelling farther north. The waters in the immediate vicinity of the Pacific Northwest coast tended to be mostly cool, especially as compared with offshore, with some low oxygen concentrations observed at depth during summer 2014. Relatively high concentrations of sub-arctic versus sub-tropical zooplankton were observed in this region during 2011-2013; there are some indications of a reversal over the past couple of seasons. The southern portion of California experienced downwelling-favorable wind anomalies from spring through summer 2014, accompanied by the development of relatively high upper-ocean temperatures and low chlorophyll-A concentrations. 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 upper ocean in this region was fresher than usual with a relatively strong pycnocline. The sub-arctic front was farther north than usual, which is consistent with the poleward surface currents shown in the Ocean Surface Currents – Papa Trajectory Index section (Stockhausen and Ingraham). The coastal winds were upwelling favorable in an anomalous sense, which helped maintain relatively normal SST along the coast as compared with the much warmer than normal water offshore.
- c. **Alaska Peninsula and Aleutian Islands** – The wind anomalies in this region were of the sense to produce reduced flow of Pacific water northward through Unimak Pass and a relatively broad and weak Alaskan Stream over much of the last year, with spring 2014 being an exception. 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) warmed from near normal to above normal during the past year.
- d. **Bering Sea** – The Bering Sea shelf experienced a much lighter ice year than during the previous years of the recent cold period dating back to 2007. Anomalous warming was particularly prominent during spring 2014. The summer cold pool during 2014 was mostly restricted to north of 60° N. There was less storminess than usual during most of the year, especially for the eastern Bering Sea shelf.
- e. **Arctic** – There was an earlier onset of ice on the Beaufort Sea shelf in fall 2013 than most previous years; the onset in the Chukchi Sea was more typical of the recent past. The winter along the Arctic coast was relatively warm, with surface air temperature anomalies of ~ 4° C.

There is reduced sea ice cover in the Arctic during the summer of 2014 compared to long-term seasonal norms, but not to the extent that occurred in 2011 and 2012.

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 8 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 a continuation of warm conditions in the northern and eastern portions of North Pacific between the Hawaiian Islands and Alaska through the end of the year (Oct-Nov 2014) with a smaller region of slightly cooler water than normal in the western North Pacific (Fig. 6a). This overall pattern is maintained, with a slight weakening in magnitude, through the 3-month periods of December 2013 – February 2014 (Fig. 6b) and February – April 2015 (Fig. 6c). These SST patterns project onto a positive sense for the PDO, which represents a marked contrast with the previous year. All three 3-month periods feature weak-moderate El Niño conditions in the tropical Pacific. At the time of this writing (late summer 2014) 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 almost a 80% chance of El Niño and virtually no chance of La Niña. The skill in these projections is limited. For example, earlier this year there were indications that warming in the tropical Pacific would materialize by summer 2014, and would be of moderate or stronger amplitude but recent observations and model results suggest a much more modest event with presumably lesser effects on the global climate.

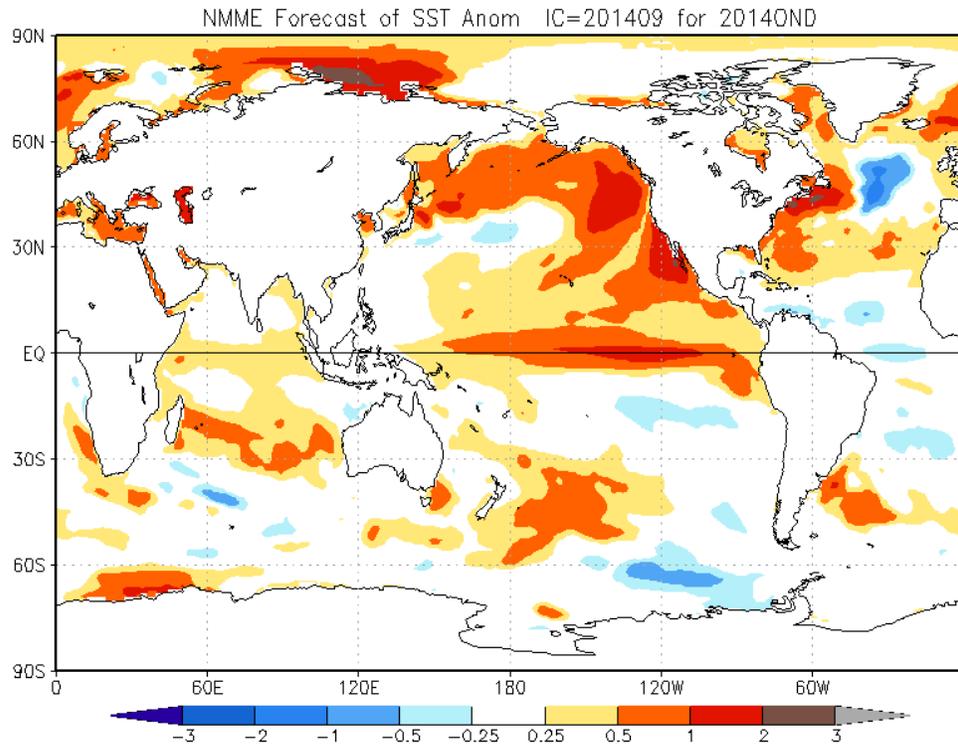


Figure 6a Predicted SST anomalies for October-December 2014 (1 month lead) from the National Multi-Model Ensemble (NMME) of coupled atmosphere-ocean climate models. See text for details.

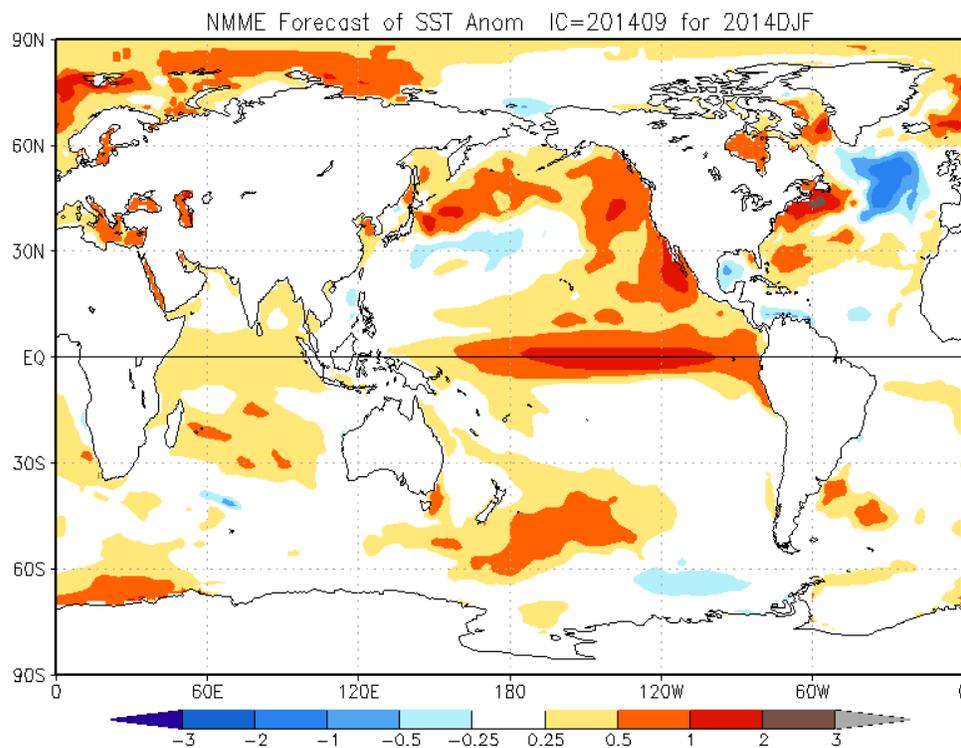


Figure 6b As in Fig. 6a, but for December 2014-February 2015 (3 month lead).

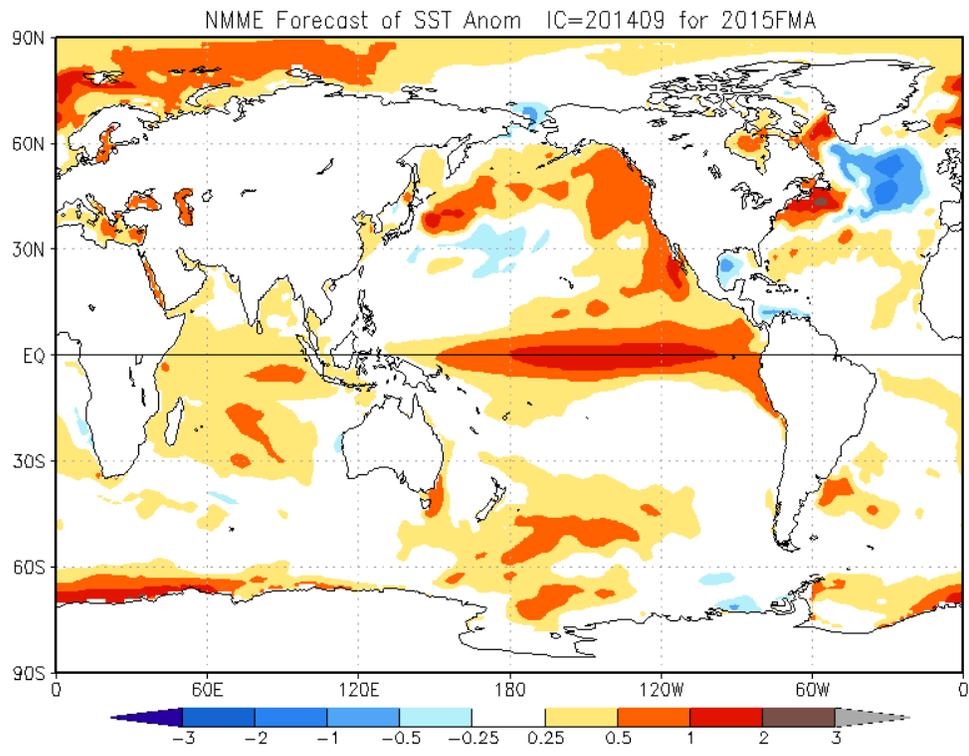


Figure 6c. As in Fig. 6a, but for February-April 2015 (5 month lead).