Recent Trends in Waters of the Subarctic NE Pacific

by William R. Crawford

The winter of 2007–2008 in the northeast Pacific Ocean felt the full impact of a strong La Niña, especially in January when it reached peak intensity. **Figure 1** compares average sea surface air pressure in January for the years 1949 to 2007 with the same feature for January 2008. The black arrows in each panel show geostrophic winds blowing toward the North American coast along these pressure contours. Note the prevailing southwesterly winds of typical years that bring warmer air toward the west coast of the United States and Canada. By contrast, the winds in January 2008 blew from the west-northwest with much cooler air temperatures. These anomalous winds are attributed to an eastward shift of the Aleutian Low (**L** in Fig. 1) in January 2008, together with the strengthening and westward shift of the North Pacific High (**H** in Fig. 1).

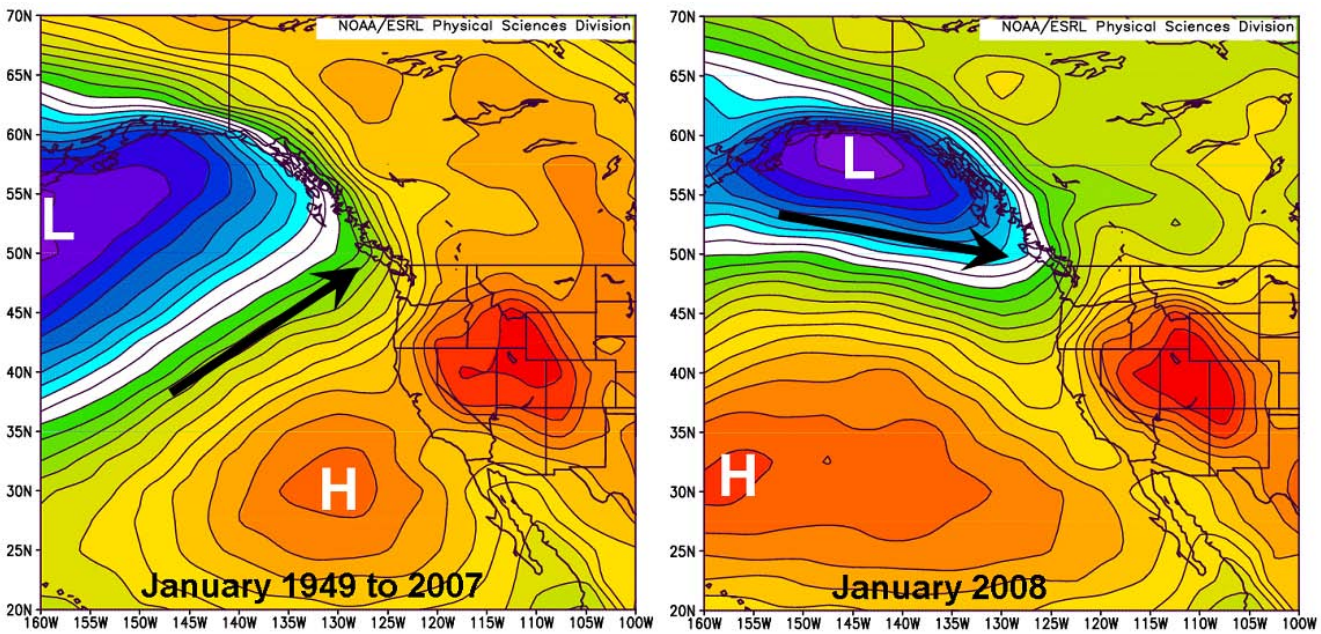


Fig. 1 Average sea surface pressure for January from 1949 to 2007 (left), and January 2008 (right) for western North America and the NE Pacific. Contours are at 1 mbar intervals. Images provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado.

This air pressure pattern set up the sea surface temperature (SST) anomaly pattern that was observed in January 2008 (**Fig. 2**). The largest negative anomalies lie on the equator, centred on the Niño 3.4 region, and along the entire west coast of North America. These two negative anomaly regions, together with the positive anomalies in the western and central Pacific, are typical of strong La Niña winters.

Figure 3 shows time series representing climate of the North Pacific Ocean plus El Niño and the Southern Oscillation Index (SOI). Most of these series display common variability, with blue regions prevailing prior to the regime shift near 1977, and red regions after that time. All time series shift from red toward blue for several years centred on 2000. This shift was accompanied by cooling of the ocean layer at 10 to 50 m depths in the eastern Gulf of Alaska (Line P) and along the west coast of Vancouver Island (Amphitrite Point), and in Niño 3.4 (Oceanic Niño Index). In general, this cooling aligns with La Niña, negative PDO and Aleutian Low Pressure Index, positive Victoria Mode and Southern Oscillation Index. Warming along Line P and at Amphitrite Point in 2002–2004 coincides with El Niño, positive PDO and negative PDO–Victoria Mode. Cooling since 2005 accompanies La Niña, with decreasing PDO and increasing PDO–Victoria Mode.

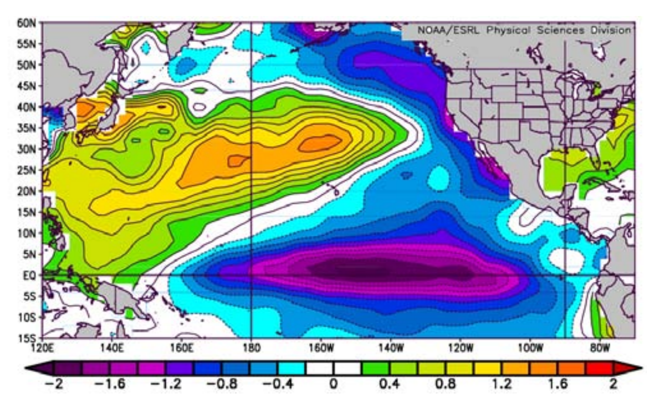


Fig. 2 Temperature anomalies (°C) in the Pacific Ocean north of 15°S for January 2008, referenced to January average temperatures of 1971 to 2000. Image provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado.

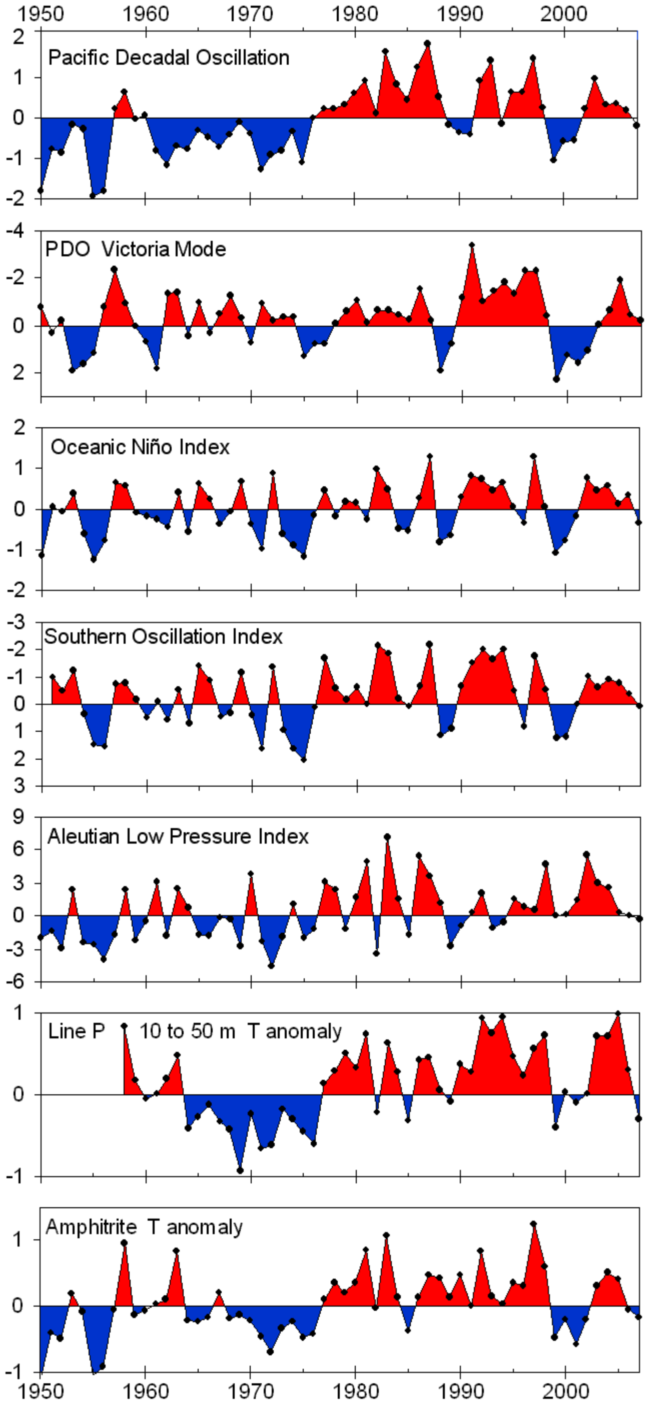


Fig. 3 *Annual indices of Pacific Ocean climate plus temperature anomalies (°C) of the Oceanic Niño Index and at Amphitrite Point and along Line P. The Southern Oscillation Index and the PDO–Victoria Mode are inverted so their variability is in phase with other series. Sources of time series and full description of these climate indices are in the State of the Ocean Report, DFO 2008 (sci.info.pac.dfo.ca/PSARC/OSR's/OSR.htm).*

These relationships generally hold, but there are several exceptions. For example, El Niño of 1972 was a major event in the tropical Pacific, but Line P and Amphitrite remained cool. Skip McKinnell at PICES has found that once a winter climate pattern becomes established over the tropical Pacific, its teleconnection to the Northeast Pacific has, over the last 60 years, provided a reliable leading indicator of ocean temperatures in spring (**Fig. 4**).

The bottom two panels in **Figure 3** reveal strong decadal and interannual variability in temperature that dominates the long-term trend. This temperature variability has caused significant changes in marine life along the west coast of Oregon to British Columbia, with boreal and sub-arctic zooplankton thriving in cool eras, Pacific hake penetrating much farther north in warm summers, and sardines increasing in numbers along the Canadian west coast in warm times. Numbers of sockeye salmon in rivers of the west coast of Vancouver Island tend to be lower if they went to sea as juveniles during a warm year. We expect this past variability provides insight into changes that will accompany future climate warming of the NE Pacific.

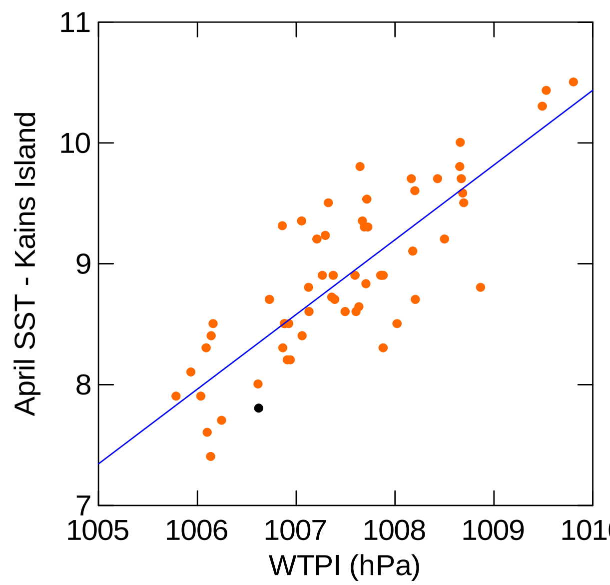
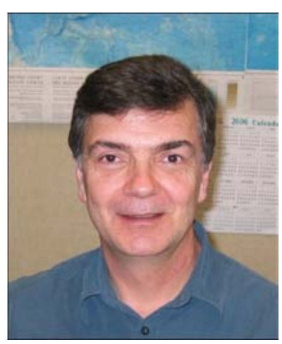


Fig. 4 *Mean April sea surface temperature (SST) at Kains Island, BC, Canada versus December/January average sea level pressure (SLP) in the Solomon Sea (1948–2008). The black dot represents 2008 and the coldest April since 1972. SST data are from Fisheries and Oceans Canada; SLP data are from NOAA/NCEP re-analysis.*



Dr. William (Bill) Crawford (crawfordb@pac.dfo-mpo.gc.ca) is a Research Scientist with Fisheries and Oceans Canada at the Institute of Ocean Sciences. He conducts research into the movement of water masses in the Gulf of Alaska and their impacts on marine biota. Bill co-chairs the Fisheries and Oceanography Working Group that prepares the annual "State of the Ocean" report for Canada's Pacific Region and neighbouring waters. He is the senior Canadian delegate to the International Association of Physical Sciences of the Ocean, and also serves as the Canadian member of the Pacific Panel of CLIVAR and the PICES Climate Forcing and Marine Ecosystem Response Task Team.