# climate

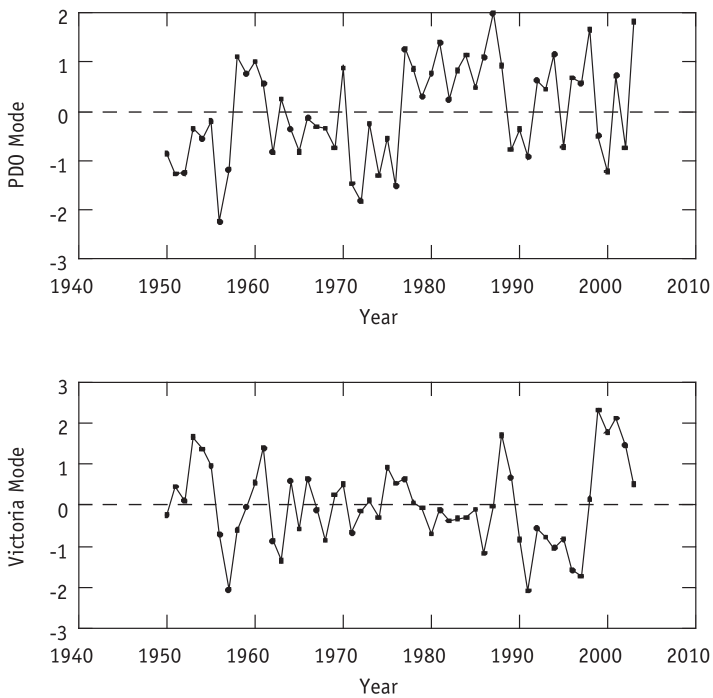
El Niño and La Niña events are oscillations of the ocean-atmosphere system in the tropical Pacific that affect the atmosphere and surface waters of the North Pacific Ocean. Their influence tends to be greater in the eastern North Pacific than in the west. Two of the largest El Niño episodes occurred in 1983 and in 1997. The latter was followed by a major La Niña in 1998 and a moderate El Niño in 2002/03.

During the 1990s, it was recognized that ocean/climate patterns in the North Pacific tend to persist for many years, shifting abruptly in both the ocean and atmosphere from one pattern to another. These climate *regimes* appear, for example, as years of persistently warmer/cooler (dryer/wetter) conditions on average, depending upon the particular region in the North Pacific under consideration. The cause(s) are not well understood.

Recent studies indicate two major ocean-climate patterns in the North Pacific, each having a positive and negative phase. These patterns are easily recognized in sea surface temperatures. The most prevalent pattern of the past half century is the Pacific Decadal Oscillation (PDO). In its positive phase, the PDO is characterised by warmer than average sea surface temperatures along the entire North American coast, and a broad expanse of cooler than average temperatures in the mid-latitudes of the central and western Pacific.

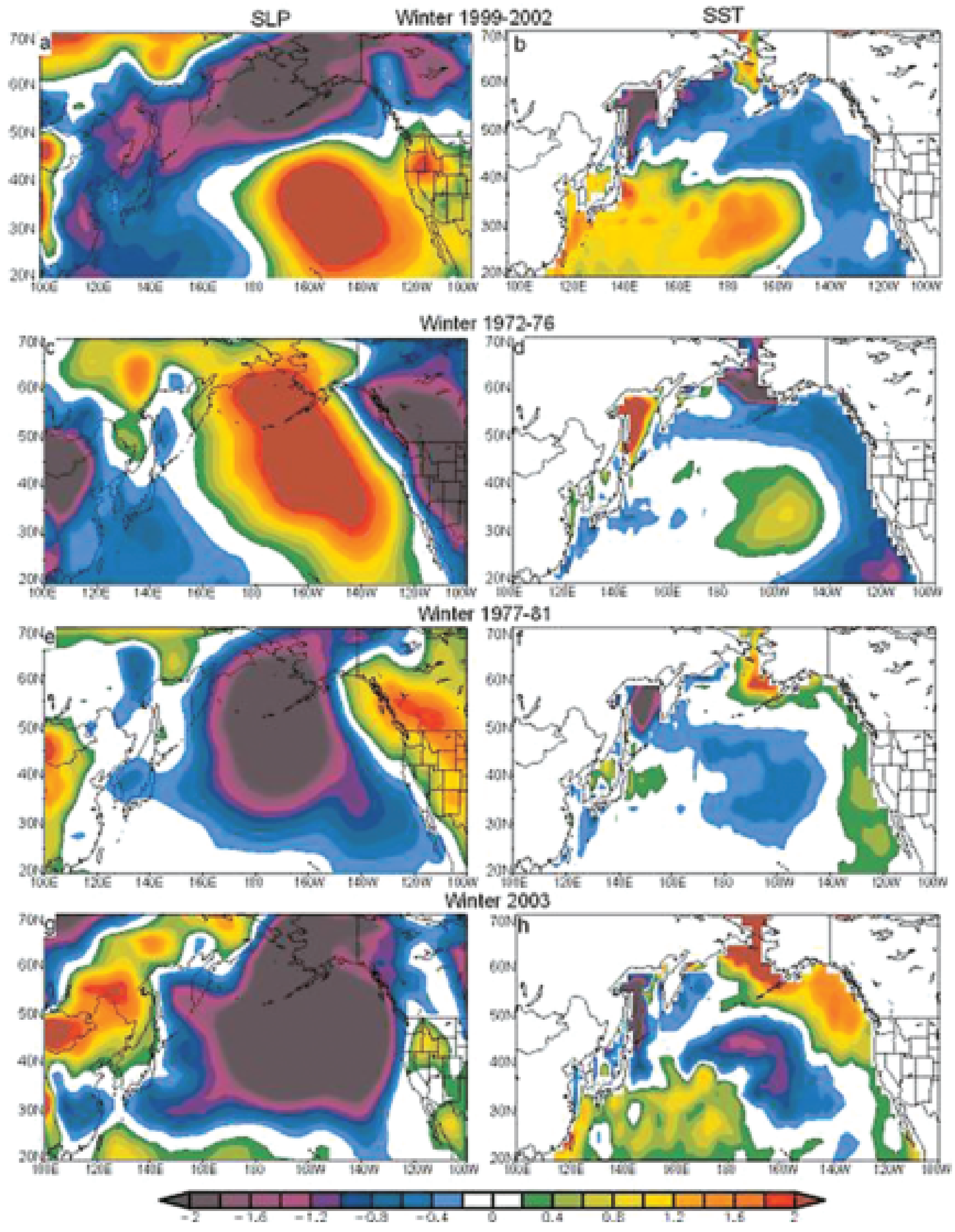
The negative phase is the inverse of the positive phase with cooler temperatures along the entire North American coast and warmer temperatures offshore and in the western Pacific. It is called an oscillation because the cold/warm regions shift abruptly; exemplified by the regime shift to a warmer North American coastal regime that occurred in 1976/77. Most climate indices for the North Pacific show strong changes in 1976/1977 during the shift from the negative to positive phases of the PDO. The significance of these regime shifts is that they affect many aspects of marine ecosystems including those of economic interest, e.g. fisheries.

Considering only the past 20 years, however, the PDO has not been the dominant pattern. The PDO has varied between negative and positive without persistence or a regime-like character. However, the Victoria Pattern, named after the location where its significance was first identified, has a more regime-like character since it became persistently negative between 1989 and 1990, then shifted to strongly positive values between 1998 and 1999. The 1998/99 shift was also strongly evident in sea surface heights in the North Pacific measured from satellite.




[Figure 1] Strongly positive winter PDO values (top panel) indicate years with warm sea surface temperatures along the North American coast and cool temperatures in the central and western Pacific. Strongly positive values of the Victoria Pattern (bottom panel) indicate cooler sea surface temperatures from the U.S. mainland westward with warmer temperatures northwest of Hawaii.

Average winter (November – March) air pressures at sea level and sea surface temperatures have been significantly different from either the positive or negative phases of the Pacific Decadal Oscillation from 1999-2002 (Figure 2, top panels). Strong westerly winds across the mid-latitude North Pacific (~ 45°N), driven by high sea level pressures to the south-southwest and low sea level pressures to the north-northwest appear to establish this pattern.




[Figure 2] Average air pressures at sea level (left) and sea surface temperature (right) for winter (November to March). Contour levels are expressed as millibars (pressure) or degrees celcius (temperature) above or below average.[28]

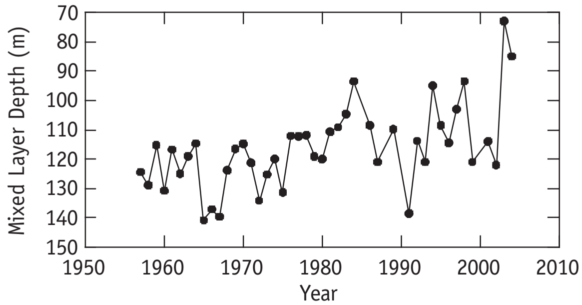
The consequences of the Victoria Pattern differ in each region of the North Pacific. Some regions experienced no change from previous years because the local expression of the Victoria Pattern is not very different from that of the PDO Pattern in these regions. In other regions, the expression of the Victoria Pattern will be very different from the PDO, and large changes have occurred.

The Okhotsk Sea and Bering Sea continued to experience wind patterns similar to those experienced after the regime shift of 1976/1977. Winds control sea ice conditions, and sea ice controls many physical characteristics of the ocean in these regions. In the Okhotsk Sea, there was a return to heavier ice coverage in 1999, comparable to that during the 1970s. However, winter-spring storm intensity has also increased since the 1970s, which may account for the increasing sea ice extent and the colder sea temperatures in this area since 1999.

The shift from negative to positive phases of the Victoria Pattern in 1998/99 had a strong effect in the California Current System producing wind patterns that were similar to those observed before the 1976/1977 regime shift. These higher sea level pressures off the west coast of North America reversed the wind patterns associated with the negative phase of the Victoria Pattern to generate a locally "cold" regime with more subarctic characteristics. This shift is thought to have forced an unusual pulse of subarctic water into the California Current, creating cooler and fresher ocean conditions in 2002.

The winter of 2002/03 was a moderate El Niño. As often occurs during these events, a strong positive PDO pattern developed in the winter in the North Pacific (Figure 2, bottom panels). This is rather clearly evident in the value of the PDO index for that year (Figure 1). However, this has abated since (as of March 2004) and it remains to be seen whether the Victoria Pattern will re-emerge, or whether the regime-like character of the PDO will resume, or whether some new variant will be expressed.

Stronger westerly winds in the central part of the Gulf of Alaska from 1999-2002 deepened the upper mixed layer of the ocean compared with the shoaling of the mixed layer that was occurring through the 1990s (Figure 3). Light winds during the winter of 2002/03, and an unusually warm surface layer, possibly initiated by the modest 2002/03 El Niño, produced the shallowest mixed layer on record in the central Gulf of Alaska. The preliminary value for 2004 indicates a second consecutive winter with a very shallow mixed layer depth. A shallow mixed layer in winter causes a smaller pool of nutrients for phytoplankton growth in spring, thereby limiting ocean productivity.




[Figure 3] Depth of the winter mixed layer at Ocean Station Papa (50°N 145°W) [1]