Recent trends in waters of the subarctic NE Pacific

By William Crawford

Surface waters of the Gulf of Alaska returned to nearly-normal temperatures in late 2005 and early 2006, following several years of warming that included record high temperatures in the summer of 2004. **Figure 1** reveals this return to normal through a sequence of plots of temperature anomalies for the winters of 2005 and 2006, plus the summer of 2005.

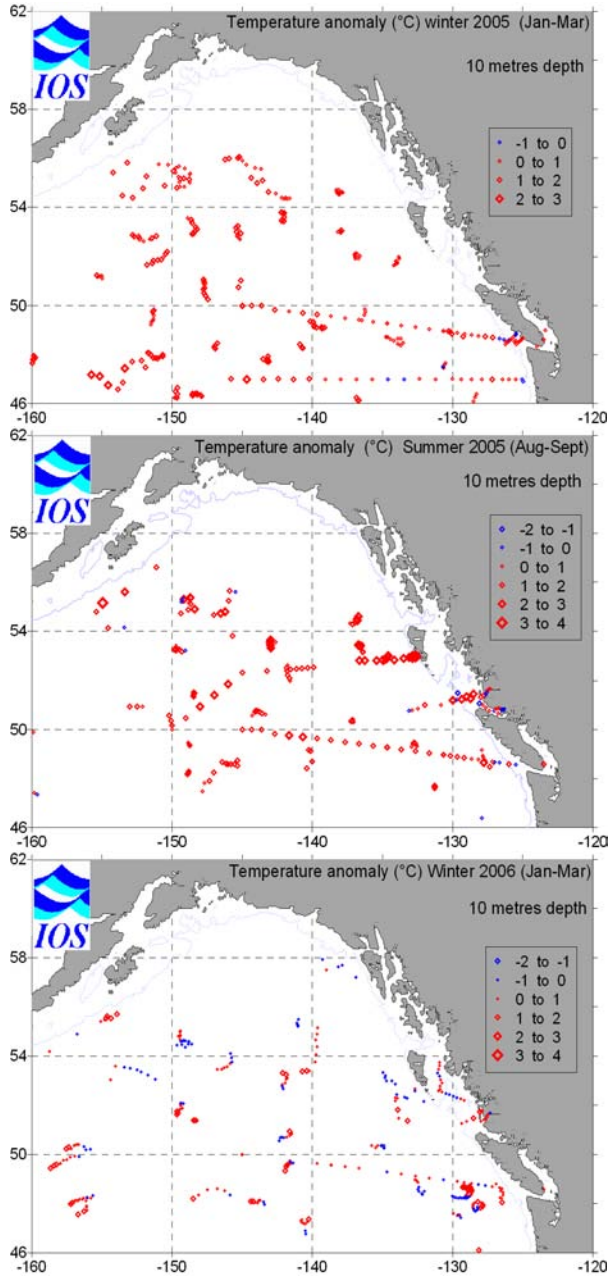

Fig. 1 Anomalies of temperature in the Gulf of Alaska from winter 2005 to winter of 2006. Symbols denote cold (blue) or warm (red) anomalies, with magnitude of anomaly denoted by symbol size. Each symbol represents a single profile from a Canadian research vessel, or by an Argo profiler.

Anomalies are computed relative to climatology of all observations in the U.S. and Canadian data archives. This climatology covers shelf, inshore and deep-sea regions. Summer includes the two-month interval from August 1 to September 30, avoiding the month of July when surface temperatures are still warming through most of these regions. Winter extends through the three months from January 1 to March 31. Anomalies are computed from observations by Canadian research vessels, and by Agro profilers operating in these waters. Temperatures at 10-m depth were selected to enable better comparison between ship-based and Argo measurements, and to avoid waters stirred at depths above 10 m by vessels while on station.

This decline in the warm anomalies began after the record high temperatures observed in the Gulf of Alaska in the summer of 2004. For example, temperatures measured between 10 and 50 m below surface along Line-P, which extends from the mouth of Juan de Fuca Strait to Ocean Station Papa at 50°N, 145°W (position shown in **Figure 2**), in August 2004 were the warmest ever observed in almost 50 years of sampling along this line.

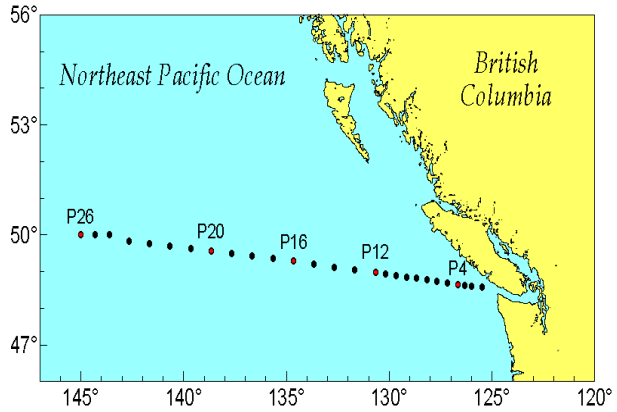

Fig. 2 Stations along Line-P. Ocean Station Papa lies at P26.

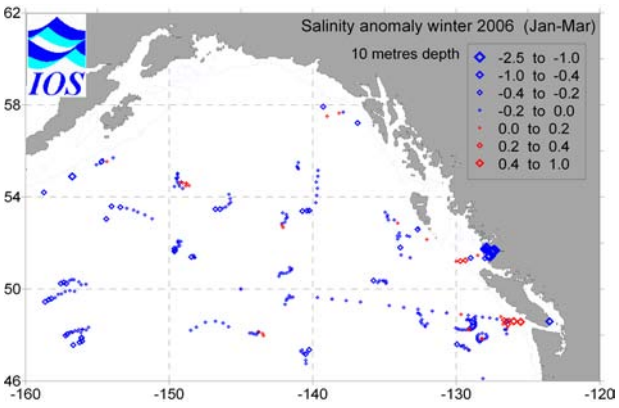

Fig. 3 Anomalies of salinity in the Gulf of Alaska for the winter of 2006. Symbols denote fresher (blue) or saltier (red) anomalies, with magnitude of anomaly denoted by symbol size.

Figure 3 displays salinity anomalies for the Gulf of Alaska for early 2006, revealing a continuation of fresher conditions that began several years earlier. Only a few profiles of salinity show saltier waters in the mid-gulf, and the great majority report fresher waters at 10 m depth.

The warm era from late 2002 through 2005 can be observed in several climate indices, including the Pacific Decadal Oscillation (PDO) and another index recently developed by Patrick Cummins of Fisheries and Oceans Canada at the Institute of Ocean Sciences. His index is based on sea surface height (SSH) reported by altimetry satellites at 1° resolution over a region extending from the west coast of North America to the dateline and from 25°N to 60°N, excluding the Bering Sea. His SSH index is focussed more on the eastern North Pacific than is the PDO, and is less subject to short-term variability than the PDO because SSH observations represent a deeper water layer than do measurements of surface temperature. His plot of indices is presented in **Figure 4**.

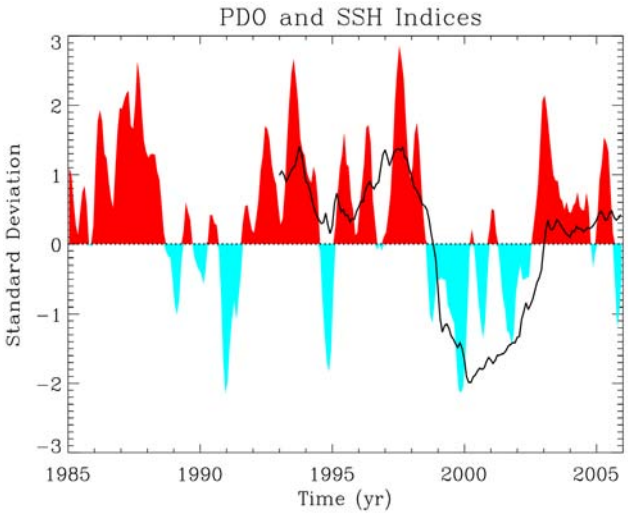

Fig. 4 The PDO index is shown in solid blue and red. Blue indicates the PDO cold phase and red the warm phase. The solid black curve gives the sea level index with positive values indicating elevated sea level off the west coast of North America and sea level anomalies of opposite sign in the central Pacific.

Both the PDO and SSH indices show that persistent changes in the state of the Northeast Pacific occurred in winter 1998/99 that were marked by colder sea surface temperatures and lower SSH over the Gulf of Alaska. These changes were characteristic of the cold phase of the PDO and occurred in association with a significant La Niña event in the tropical Pacific in the winter of 1998/99. The effects of the 1998/99 regime shift persisted for about four years, ending in 2003.

During the last three years (2003–2005) the indices shown in **Figure 4** indicate a return to the warm phase of the PDO, characterized by above-average sea surface temperatures and sea levels in the Gulf of Alaska. In late 2005, the PDO shifted to the cold phase, apparently in response to the recurrence of La Niña conditions in the tropical Pacific. However, the SSH index did not change sign in 2005, suggesting that a persistent cold phase in the Gulf of Alaska has yet to develop.

In summary, we observe a return toward normal surface temperatures in the Gulf of Alaska in late 2005 and early 2006, following several warm years, and possibly associated with a weak El Niña in early 2006. This cooling was not accompanied by a drop in the SSH index in the gulf in late 2005.

During the warm years of 2002 to mid-2005, the Pacific coastal waters of Canada experienced an increase in numbers of warm-water visitors. For example, sardines returned to Canadian waters in 1992 after a 45-year absence. With warmer waters of 2004 and 2005, their numbers increased again.

Humboldt squid (*Dosidicus gigas*), a tropical squid normally ranging from central California to southern Chile, was captured incidentally in the summer and fall of 2004–2005, by commercial fishermen and in research surveys throughout British Columbia (for details see the article on "*Unusual invertebrates and fish observed in the Gulf of Alaska, 2004–2005*" by Bruce Wing in this issue). Until 1997, none had been reported in coastal waters north of Oregon.

Pacific hake expanded their range northward through Canadian waters in 2004 and 2005.

Finally, returns of west coast Vancouver Island sockeye salmon are expected to drop in the next few years, due to prey and predator changes associated with warm ocean waters.

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