Recent trends in waters of the subarctic NE Pacific

By William Crawford and Marie Robert

Warm near-surface waters

Near-surface waters of the northeast Pacific Ocean have been unusually warm since the summer of 2004. Figure 1 reveals this warming through a sequence of plots of temperature anomalies for the summers of 2004 and 2005, plus winter 2005. The summer temperatures have warmed significantly since 2001, with almost no observations of colder-than-normal temperatures in 2004 and 2005.

Anomalies are computed relative to a climatology of median values for all observations in the U.S.A. and Canadian data archives[1]. Briefly, within-year median values are computed first, then intra-annual medians. Shelf, slope, and mid-gulf climatologies are computed separately. Summers of major El Niño and La Niña years are excluded. Summer is defined as August 1 – September 30; winter is January 1 to March 31. Data from coastal observations of the summer of 2005 were not available at press time, but Line-P and Argo profiles provided many deep-sea and some coastal observations for this summer.

Temperatures at 10-m depth were selected to enable better comparison between ship-based and Argo measurements. Argo profiles report at only one depth between ocean surface and 10-metres, so the ocean surface observation is always an extrapolation from a deeper layer, whereas the temperature at 10-m depth is an interpolation of measurements between two depths. The Canadian Coast Guard Ship (CCGS) *John P. Tully*, the base for most deep-sea observations in these plots, collects profile observations off its stern where surface waters are normally mixed in the upper 5 to 8 metres. Measurements at 10-m depth are less impacted by this mixing.

The summer of 2004 was warmest ever[1] observed along Line-P. The comparable calculations for the summer of 2005 are not yet available, but Figure 1 indicates it was warm. A look at depth distribution of temperature and salinity anomalies along Line-P is provided in Figure 2. Warm surface waters extend to about 50-m depth. These surface waters are also fresher.

Spring of 2005 a disaster for seabirds

Unprecedented numbers of dead seabirds were found along the US west coast from California to Washington in spring, and chick survival was a record low from California to northern Vancouver Island (Canada). The cause is suspected to be reduced food supply in winter and spring due to the absence and delay of upwelling winds along this coast. Figure 3 indicates warm waters on the west coast of Vancouver Island all through the first six months of 2005. Warmer temperatures are an indicator of enhanced downwelling or reduced upwelling on the continental shelf. Normally, in the spring and summer, winds blow southward along the Pacific Coast and push warmer surface

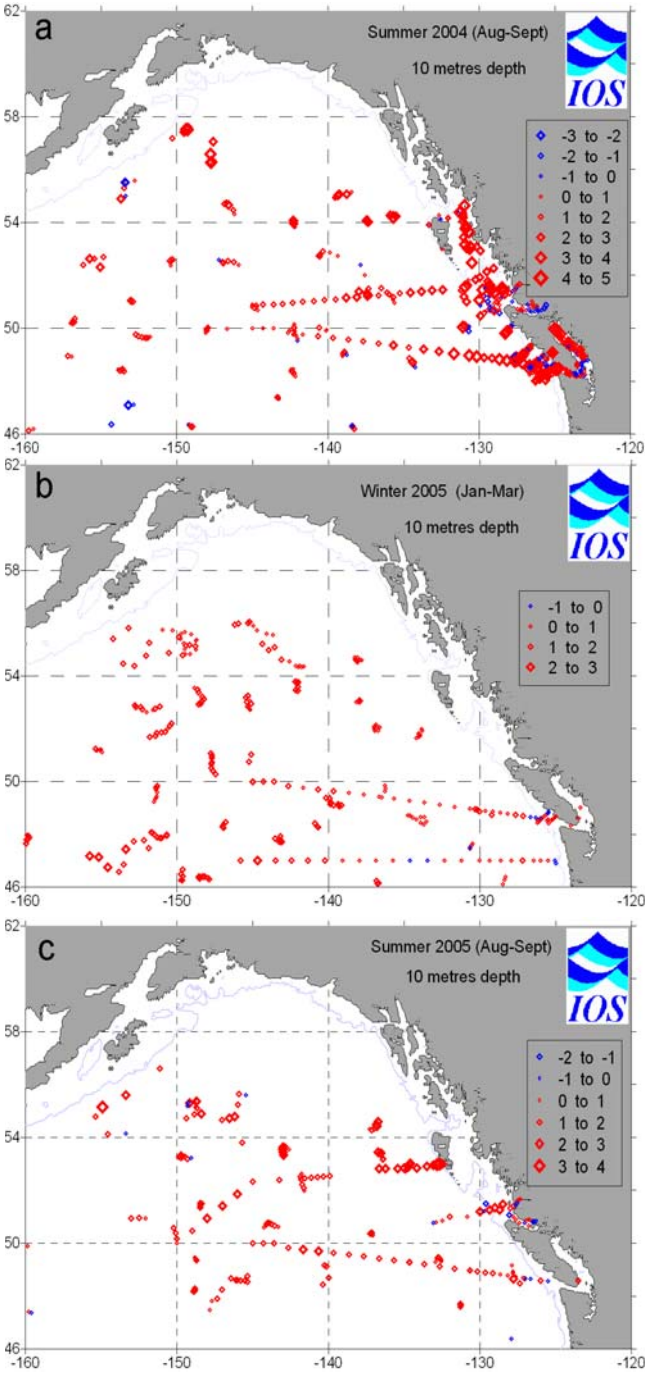

Fig. 1 Maps of temperature anomalies at 10-m depth in (a) summer 2004, (b) winter 2005, and (c) summer 2005. Observations in 2004 and 2005 are mainly ship-based CTD profiles and Argo measurements.

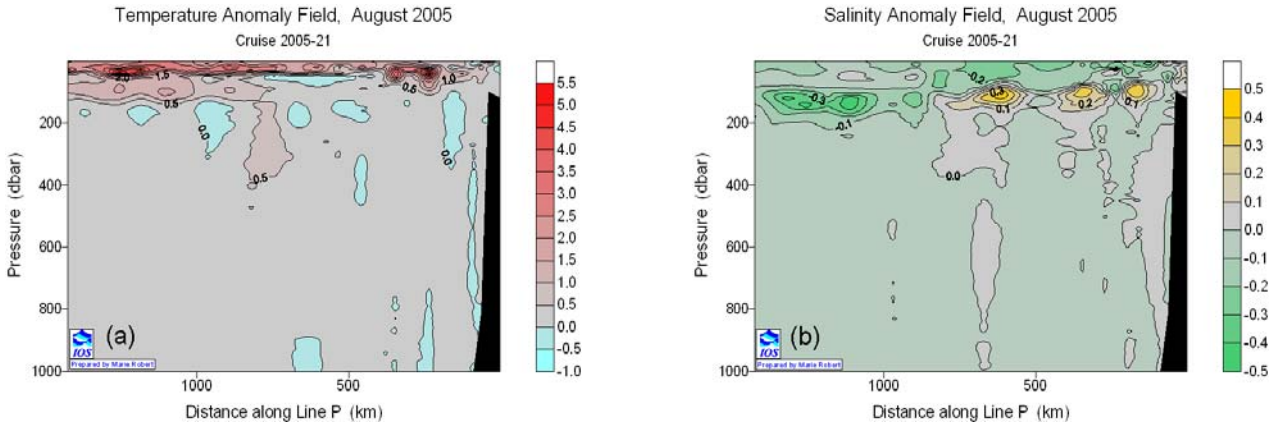

Fig. 2 Anomalies of (a) temperature and (b) salinity measured along Line-P by the CCGS John P. Tully. *Units are degrees C for temperature and psu for salinity.*

waters away from shore, allowing colder, nutrient-rich water to well up to the surface and support phytoplankton blooms, which in turn stimulate a food chain that provides food for seabirds. Upwelling winds turned on in mid-July 2005, and subsequent oceanographic cruises found ample plankton on the continental shelf, whose arrival was too late for seabird chicks hatched in spring.

Several ship-based surveys along the Washington coast and southern British Columbia coast reported fewer numbers of juvenile salmon in some stocks than in previous years. We might expect these stocks to be reduced in numbers when they return to spawn.

[1] Crawford, W.R., J. Galbraith, N. Bolingbroke. Anomalies of Line-P ocean temperatures since 1950. *J. Geophys. Res.*, submitted in August 2005.

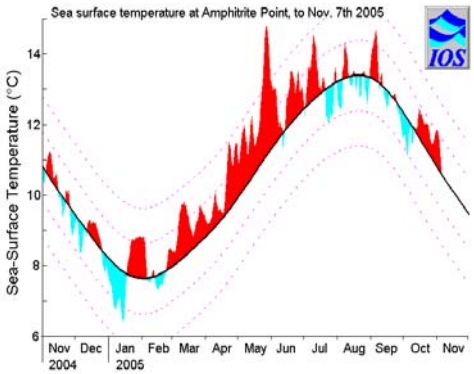

Fig. 3 Temperatures at Amphitrite Point on the west coast of Vancouver Island, Canada. Red and blue shading denotes anomalies from long-term temperatures. Dashed lines denote 1 and 2 standard deviations from the annual cycle.

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