Long-term Oceanographic Measurements in the Alaska Coastal Current from a Ferry

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Purpose: To measure long-term changes in the Alaska Coastal Current (ACC) ecosystem from a Ship of Opportunity – the Alaskan ferry *Tustumena*

Figure 1. An oceanographic monitoring system aboard the Alaska Marine Highway System ferry *Tustumena* measures the following at 4-m depth:

(1) **Temperature and salinity** - basic physical variables
(2) **Nitrate** - an essential phytoplankton nutrient
(3) **Chlorophyll fluorescence** - an indicator of phytoplankton concentration
(4) **Colored dissolved organic matter fluorescence** - an indicator of terrestrial runoff
(5) **Optical beam transmittance** - an indicator of suspended particle concentration.

This monitoring was begun under EVOSTC/GEM funding and is currently sponsored by NPRB. *Tustumena* photo copyright Mary Glover, Seldovia, AK.

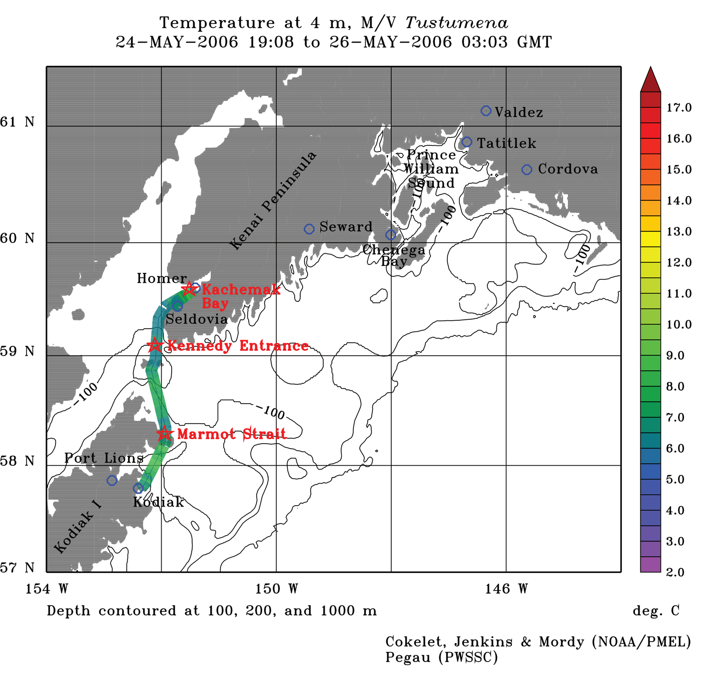

Figure 2. The ferry route between Homer and Kodiak.

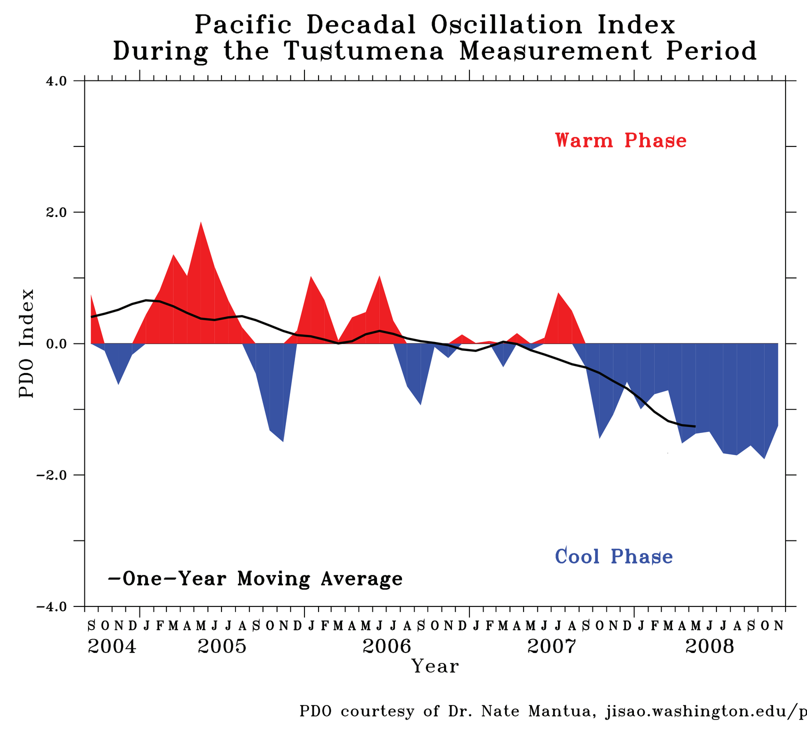

Figure 3. The Pacific Decadal Oscillation (PDO) is one index of basin-wide sea-surface temperature fluctuations in the North Pacific. During the 4 years of *Tustumena* monitoring, the PDO has cooled from the **Warm Phase** through Neutral to the **Cool Phase**.

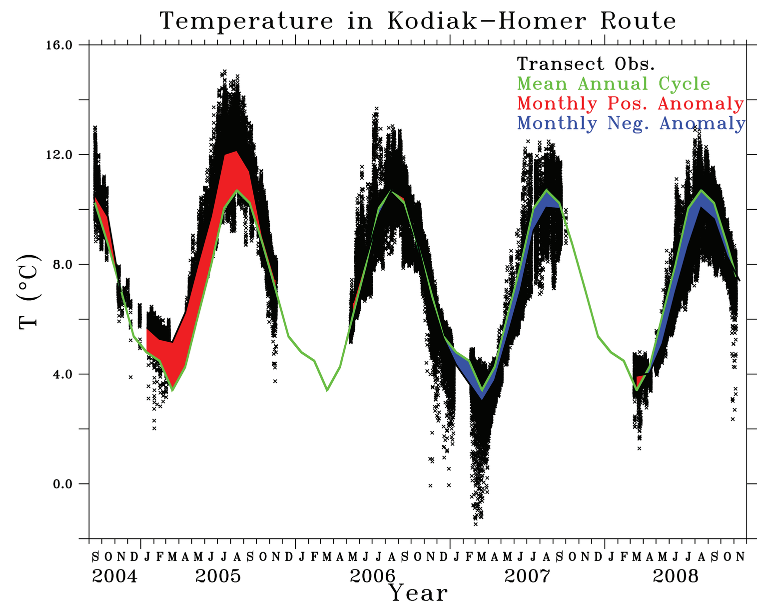

Figure 4. Measured time series of water temperature between Homer and Kodiak showing cold winter and warm summer temperatures. The **black** X's are the observations (decimated for purposes of presentation). **Green** lines represent the mean **annual cycles** over 4 years. **Red** and **blue** shadings represent **positive** and **negative** anomalies about the mean annual cycle. Blank intervals represent times when the ferry was in the shipyard or the instruments were being repaired. The time series differ markedly at individual local sites (not shown), but the anomalies about the mean annual cycles are similar throughout the region.

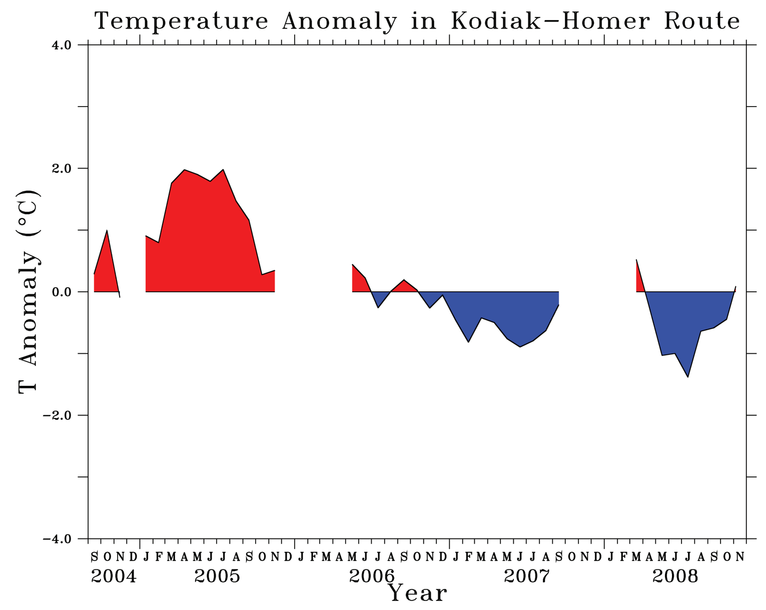

Figure 5. Time series of temperature anomalies on the Homer-Kodiak route showing warmer and cooler periods that persist from 1 to 2 years. The coastal ocean varies synchronously over this 200-km-wide swath across the Alaska Coastal Current. Notice that the transition from warm to cold is similar to the basin-wide PDO in Figure 3, but caution is needed because the annual mean cycles of the time series were computed from measurements of very different lengths – 94 years (1900-1993) for the PDO and 4 years (2004-2008) for the *Tustumena* time series.

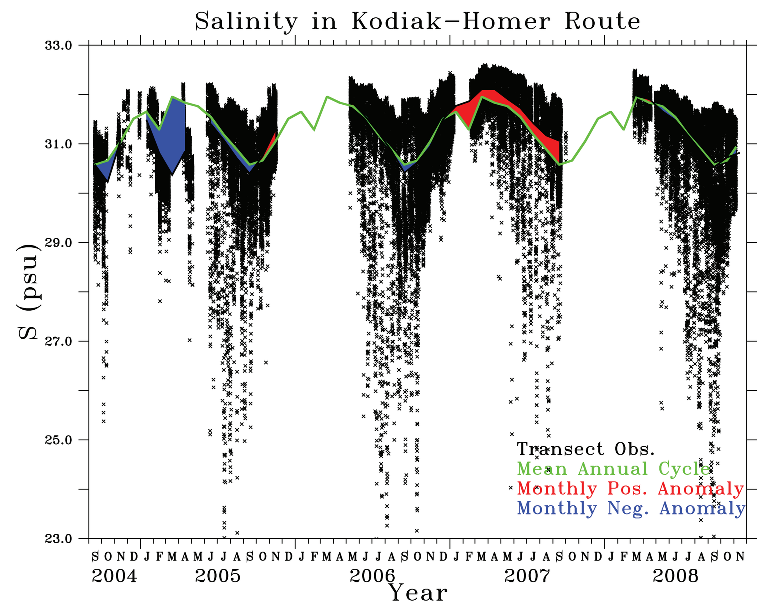

Figure 6. Salinity time series with color coding similar to Figure 4. Winters are saltier and summers fresher due to summer melt water entering the ACC flow along the Alaskan coast.

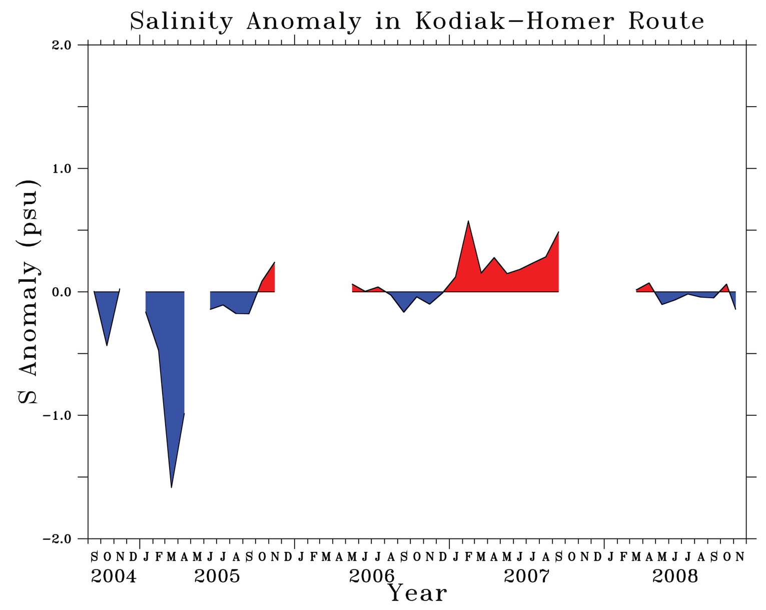

Figure 7. Salinity anomaly time series. Comparison with Figure 5 shows a tendency for warm-fresh and cold-salty periods for the first 3 years. This is consistent with the ACC driven by the inflow of coastal melt water. Warm years cause more snow and ice melt corresponding to fresher coastal water and vice versa. However this tendency breaks down in 2008.

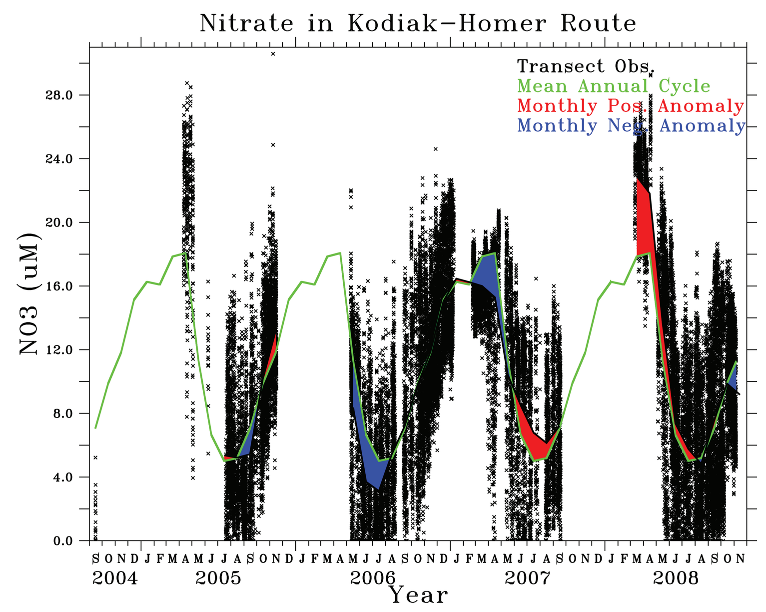

Figure 8. Nitrate time series with color coding similar to Figure 4. Winters are nutrient-rich and summers depleted because phytoplankton production draws down the nutrients with the onset of summer stratification and sunlight. Nitrate is replenished in winter owing to vertical mixing, advection and reduced plant uptake.

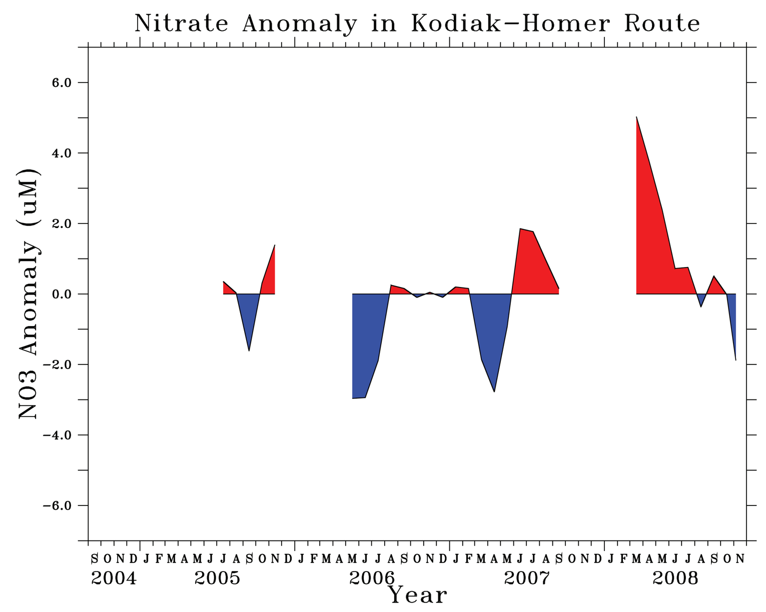

Figure 9. Nitrate anomaly time series. Nitrate anomalies result from the complex interaction between physical replenishment and biological uptake. The anomalies bear no simple relationship to the other variables measured. Long-term nitrate observations are only practical from new optical instruments (e.g. an ISUS nitrate meter) making in-water measurements.

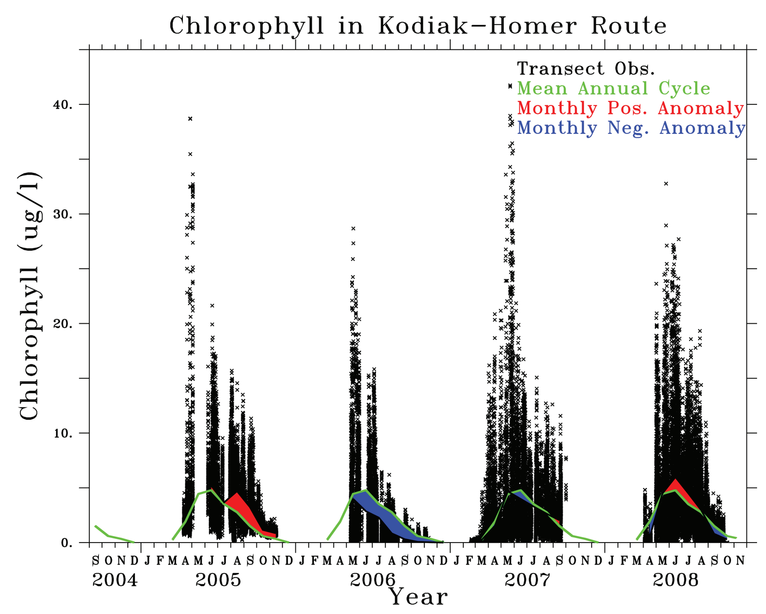

Figure 10. Chlorophyll time series with color coding similar to Figure 4. Chlorophyll, an indicator of phytoplankton biomass, is greatest during the spring bloom and least during the dark days of winter. In practice its measurement requires a self-cleaning fluorometer and periodic discrete sampling with laboratory analyses for fluorometer calibration.

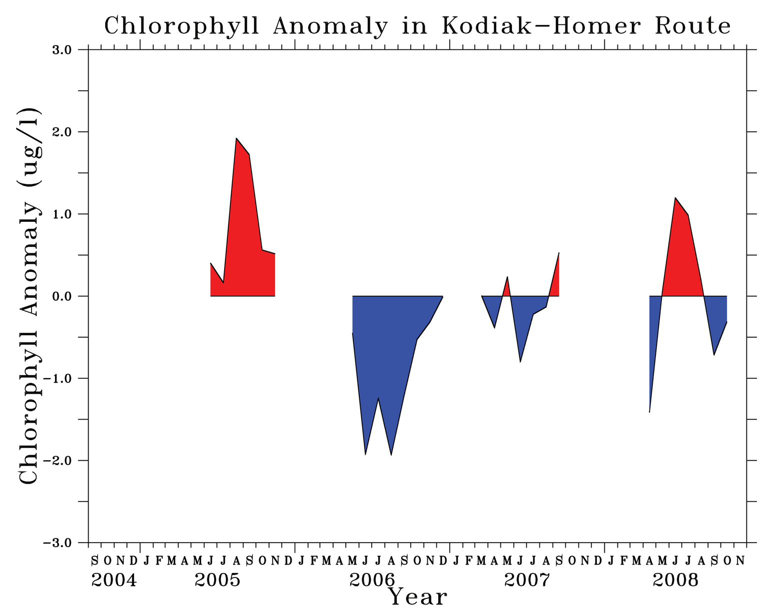

Figure 11. Chlorophyll anomaly time series. The chlorophyll anomalies reflect long-term changes in phytoplankton biomass – an indicator of the base of the oceanic ecosystem. These anomalies have no simple relationship with the other anomalies, thus showing the complexity of the ecological system. Ship observations are invaluable for making chlorophyll measurements in the Gulf of Alaska where cloudiness severely hampers satellite viewing.