Oceanographic conditions along the northern Gulf of Alaska's Seward Line, 1997-2008

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Abstract:

The Seward Line in the Northern Gulf of Alaska has been the focus of multidisciplinary observations of physical oceanography, nutrients, phytoplankton, and zooplankton for 10 years. Over the study period we have observed years favorable and unfavorable to primary production and the local zooplankton populations, and observed the summer import of southern species during warm years. Changes in the abundance, composition and especially the size-structure of the zooplankton communities affect the availability of prey to higher species such as juvenile salmon. With cool oceanographic conditions anticipated for 2008, it is likely that large copepod prey will be abundant, and this should result in higher survival of juvenile salmon released during this year.

Introduction:

We have long appreciated that the ocean experiences variation from year to year, but only recently appreciate that long-term trends and even pronounced shifts may also be occurring. Short-term events such as El Niño and La Niña can result in changes in ecosystem productivity that result in increased or decreased survival of commercial and non-commercial species. Longer term changes can result in fundamental shifts in ecosystem structure and function, such as the 1976 regime shift in the Gulf of Alaska that resulted in a change from a shrimp dominated fishery to one dominated by pollock, salmon and halibut. One of the greatest challenges to detecting and understanding such changes is the lack of appropriate oceanographic time-series that couple these physical events to their biological impacts. The multidisciplinary time-series of the northern Gulf of Alaska's Seward Line allows such observation of short and long-term changes in the oceanography of this region.

Methods:

From fall 1997-2004, 6 or 7 cruises were conducted annually under the GLOBEC program. During 2005-2007, NPRB funded cruises each early May and early September. Sampling during cruises consisted of 13 stations along the Seward Line stretching from the coast to well beyond the shelf break, and 3-5 stations in western Prince William Sound (Figure 1). Sampling during all cruises consisted of: A) profiles of temperature, salinity, nutrients and chlorophyll, B) stratified sampling of larger zooplankton and integrated sampling of smaller zooplankton, C) estimation of the community primary production and rates of secondary production for the dominant zooplankton.

Results (physical):

To date the study period has encompassed the strong 1997/98 El Niño, the strong 1999 La Niña, the moderate 2002/03 El Niño, and the anomalously warm non-El Niño years of 2000 & 2005 (Fig 2a). Each of these events is apparent in the physical time series (Fig 2c), except for the 2007 El Niño. It is not apparent if a 1998/99 regime shift, as suggested by a change in PDO sign (Fig. 2b), has occurred within the time-series. Although a long-term deep warming trend has been observed at the inshore station Gak1 (based on a 30-year physical time series), Spring 2007 temperatures were anomalously cold (Fig, 5c) - colder than any year since the early 1970s. Although surface water warms to more typical values during summer 2007, water below 100m remained colder than normal..

Fig.1. Sampling area. Experimental sites indicated in larger red dots.

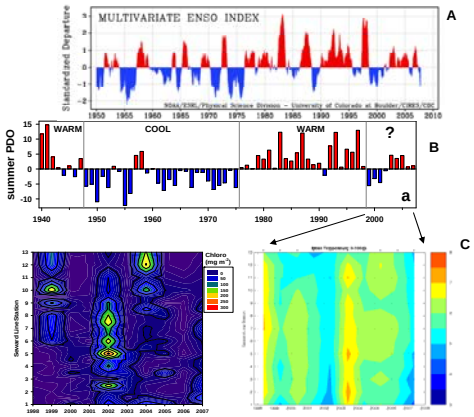

Fig.2. A) The El Niño Southern Oscillation (ENSO) Index, B) the Pacific Decadal Oscillation (PDO) and warm/cold regimes, C) May temperatures and chlorophyll along the Seward Line.

Results (biological):

Like all biological communities we can see changes in abundances of species between years. Of the large copepods that dominate the spring, the largest, *Neocalanus cristatus*, shows no significant pattern across years, while the slightly smaller *N. plumchrus/flemingeri* show significantly higher abundances in 3 years and lower abundances in 3 years (Fig 3), with tentative number for 2007 also high. Similarly, *Eucalanus bungii*, and *Metridia pacifica*, show significant variation between years, while *Calanus marshallae* shows large increases in abundance during 2005& 2006, then declines in 2007. Smaller species (i.e. *Oithona*, *Pseudocalanus*, *Acartia*) are also variable, but there appears to be little consistency in pattern between species. Although warm years may not affect abundance, they do effect growth rates & passage of stages through the ecosystem (Fig 4). Like the copepods, the mucus-net feeding *Oikopleura* was variable, but for *Limacina* after several years of high abundance, numbers declined in 2007 (Fig 3).

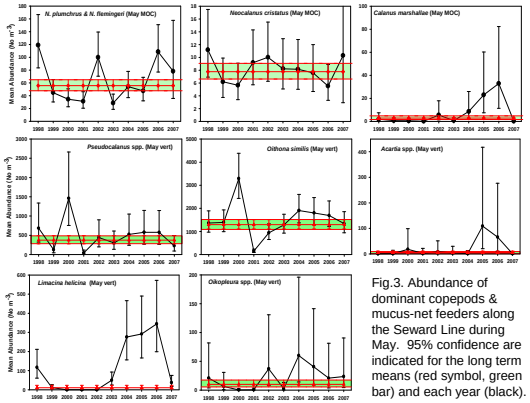

Fig.3. Abundance of dominant copepods & mucus-net feeders along the Seward Line during May. 95% confidence are indicated for the long term means (red symbol, green bar) and each year (black).

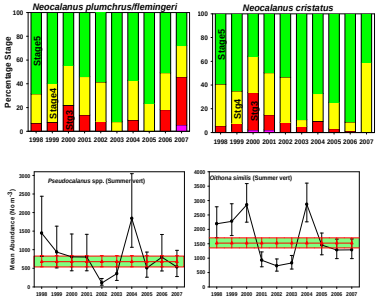

Fig.4. Stage distribution of the *Neocalanus* copepods during May. During warm years, later stages are more abundant, they complete the growth phase of their life cycle and descend to depth earlier. During 2007, stage progression was clearly delayed compared to other years.

Fig.5. Abundance of small copepods that dominate the summer zooplankton along the Seward Line.

Results (continued):

During the late summer, water temperatures are at their highest and we continue to see significant variability in abundance of the small copepods that dominate the zooplankton (i.e. *Oithona*, *Acartia*, *Pseudocalanus* – Fig 5). More interestingly, during warm years "southern" species often appear within the zooplankton communities. During the 1997/98 El Niño, the copepod *Mesocalanus tenuicornis* became common in nearshore waters, while during 2005 the small copepod *Paracalanus parva* was spread completely across the Seward Line (Fig 6) . The southern-affinity copepod *Calanus pacificus* has become consistently common during summers in recent years, especially in offshore waters. When common, these "warm" water species have the potential to change the size-spectra of the zooplankton and may alter the foraging efficiency of visual predators such as fish.

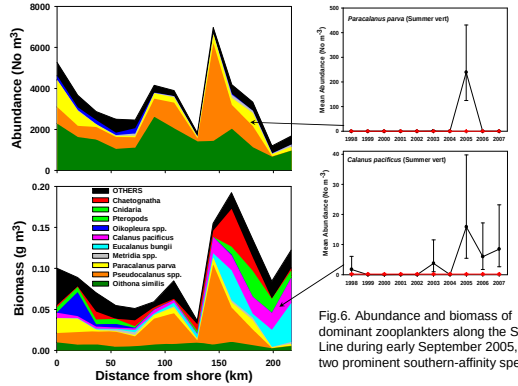

Fig.6. Abundance and biomass of dominant zooplankters along the Seward Line during early September 2005, noting two prominent southern-affinity species.

Expectations for 2008:

In general, large spring copepods such as *Neocalanus* appear to be more abundant in cool springs then in warm ones (provided there is not a complete mis-match between the timing of *Neocalanus* arrival and the spring bloom). With cool oceanographic conditions anticipated for 2008, it is likely that large copepods will be abundant. Since these are critical prey items for salmon at ocean entry, this should result in higher survival of juvenile salmon released during 2008 and returning in 2009.

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