Mid-year update of Ocean Conditions through June 2013

PDO and ONI. For the last 7 months, the PDO has been weakly negative. Similarly, the ONI values have been weakly negative, maintaining ENSO neutral conditions and a continued forecast from the Climate Prediction Center for neutral conditions into October.

Upwelling Index at 45°N. This year had a very mild winter with no large southwesterly storms, and therefore almost no downwelling in January-March (Figure 11), as indexed by the Cumulative Upwelling Index (CUI). The day of spring transition (based on the CUI) was on 7 April, which is six days earlier than average(40-year climatology). Despite the near-average date of transition (which signifies the end of the winter downwelling season and beginning of the upwelling season), upwelling was not particularly strong in April-June. In fact, the average CUI for April-May was ninth weakest of the past 15 years. Upwelling continued to be weak through most of May and included a two-week period in mid June of southwesterly winds which, as shown later in this report, was accompanied by a stranding of massive amounts of euphausiids on the beaches of Oregon and N. California.

Compared to other years, 2013 is similar to the years 2007-2009, years in which winter storms were infrequent, but also years in which upwelling was not particularly strong.

Sea Surface Temperatures at NOAA Buoy 46050. The first few months of the year showed negative SST anomalies ranging from -0.5 to -1°C from Jan-May followed by a strong positive anomaly through the latter half of June as a result of a lengthy period of southwesterly winds and downwelling (Figure 6).

Temperature and salinity properties in bottom waters on the continental shelf. Bottom waters on the shelf at our baseline station NH 5, in spring of the year 2013, had the second highest salinity and third coldest temperature since 1997 (Figure 17). The other "cold-and-salty" years were 2002, 2007 and 2008. The presence of cold and salty water may be indicative of deeper, potentially more nutrient-rich water upwelling onto the shelf.

Oxygen Concentrations. June (and early July) had the lowest concentrations of oxygen that we have measured in that time period since we began taking data in 2005. Values in June were 1.28 ml L-1 (07 June) and 1.1 ml L-1 (19 June), and in early July, 0.94 ml L-1. Values < 1 ml L-1 have in the past not been seen until August or September at station 5 along the Newport Line.

Winter Ichthyoplankton. The winter-time (Jan-March) abundance of larval stages of fish species common in salmon diets was above average this year (Figure 34), ranking 6th highest over the 16 years of data. Abundance of all larval fish species combined ranked 7th of 16.

Zooplankton. During winter (Nov 2012–March 2013), copepod species richness (Figure 21) and the biomass of southern (warm water") copepods (Figure 24) were moderately high, which likely corresponded to positive values of the Oceanic Niño Index during autumn 2012. In the spring (April - June) of 2013, copepod species richness and the biomass of southern copepods declined, while the biomass of northern ("cold water") copepods increased dramatically. This increase in northern copepods is an indicator of good ocean conditions and generally follows strongly negative values of the PDO. However, the PDO during this time was only moderately negative. Low copepod species richness and high biomass of northern species point to greater–than–average transport of subarctic water into the northern California Current.

Spring Chinook returns: The spring Chinook salmon counts at Bonneville Dam were much lower than anticipated, based on ocean conditions in 2011 when the juveniles were entering the ocean. Only ~ 83,300 Chinook salmon were counted at Bonneville Dam from 15 March - 31 May which is less than half of what was predicted based on the ocean indicators (Figures A - C). The ocean indicators are based on information collected off Oregon and Washington. Once spring Chinook salmon enter the ocean from the Columbia River, they migrate away from this region and are found in the Gulf of Alaska and along the Aleutian Islands. We are working on gathering more information about environmental conditions in the Gulf of Alaska as a way to improve ecosystem-based assessments of this salmon group.

2013 marks the first time that our outlooks on salmon returns have missed significantly since our first attempts in 2006. We wrote on our **webpage** that local ocean conditions in

2011 were in general above average thus we expected above-average returns of coho salmon in 2012 and spring Chinook salmon in 2013:

We further noted that similar to the past [2009 and 2010], individual indicators have sent a mixed message. Certain indicators suggest the potential for above average returns: persistence of strong La Niña conditions, a negative PDO, positive copepod anomalies from May-September, and reasonably high catches of coho salmon in the September survey. However, negative indicators include relatively warm surface waters on the continental shelf, weak upwelling in spring, a short upwelling season, and low abundances of ichthyoplankton during January-March. Because of these mixed signals, we were less certain of our prediction for coho salmon in 2012 and Chinook salmon in 2013.

This "miss" lends the opportunity to re-examine our approach and our set of ecological indicators to determine if we are missing a key variable or variables expressed for the first time in 2011. One hypothesis which we will explore is that some aspect of ocean conditions elsewhere was the cause of poor returns in 2013. Because spring Chinook salmon migrate north into the Gulf of Alaska within 4-6 weeks after exiting the Columbia River, we are going to look at ocean conditions for waters off northern British Columbia and Alaska to determine if perhaps they encountered poor ocean conditions in those waters. Other north-migrating stocks that entered the ocean in 2011 had poor returns in 2013 -- returns of sockeye salmon to the Fraser and Skeena Rivers are expected to be poor in 2013, as are Chinook salmon returns to the Fraser.

Another option is to re-examine the indicators and use only those indicators that are best correlated with returns of various species and life history types, rather than using all indicators for all species and life history. This approach may produce better results because it is not necessarily true that each species and life history type responds the same way to the common set of indicators. We know that coho, spring Chinook and fall Chinook salmon occupy different habitats at sea (Peterson et al. 2010; Peterson et al. In prep), thus it may be that each responds to different combinations of ocean conditions.