Storm Surge Almanac for Southwestern British Columbia: Fall/Winter 2010-2011

Pre-season storm climatology forecast and discussion of climate and tidal conditions affecting extreme water levels

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1. Overview

This document provides a summary of the marine environment of southern British Columbia as it relates to the upcoming 2010/11 winter storm season. Since the risks of exposure to extreme marine water levels are highest for the lower mainland, this report focuses on the risk of water levels approaching or exceeding the historical high observed at Point Atkinson. The main factors determining anomalously high water level are seasonal high tides, storm intensity (wind velocity and sea-level pressure) and coastal water level anomalies (departures from the long-term mean) due to basin-scale ocean climate phenomena such as the El Niño/Southern Oscillation (ENSO).

2. Tides

The historical high water level at Point Atkinson occurred on December 16, 1982 when the water gauge measured a total water level of 5.61 m (4.71 m tide + 0.90 m anomaly). The factors that led to the historical high water level were a combination of high seasonal tide, strong winds, low atmospheric pressure and a coastal sea-level height anomaly of approximately 0.2 m driven by one of the most intense El Niño events on record.

The highest tides of the year, known as the perigean spring tides, occur near the summer and winter solstices. High tides during this period reach (or slightly exceed) 5.0 m at Point Atkinson. To illustrate the importance of these high tidal time windows, it is noted that a concurrent moderate storm surge of 0.6 m would cause a total water level equivalent to the 1982 peak, even without the presence of El Niño-induced elevated coastal sea levels.

Figure 1 shows the dates where peak tides exceed 4.7 m relative to station datum at Point Atkinson. Days with predicted tides in the range of 4.7-4.8 m are shaded yellow, while those with tides in the range of 4.9-5.0 m above chart datum are shaded red. The periods in late December 2010 and January 2011 are of particular note for the number of consecutive days when the peak tide exceeds 4.9 m. These periods offer broad windows during which a moderate storm surge could result in potentially damaging water levels. The December window overlaps completely with the Christmas holiday season.

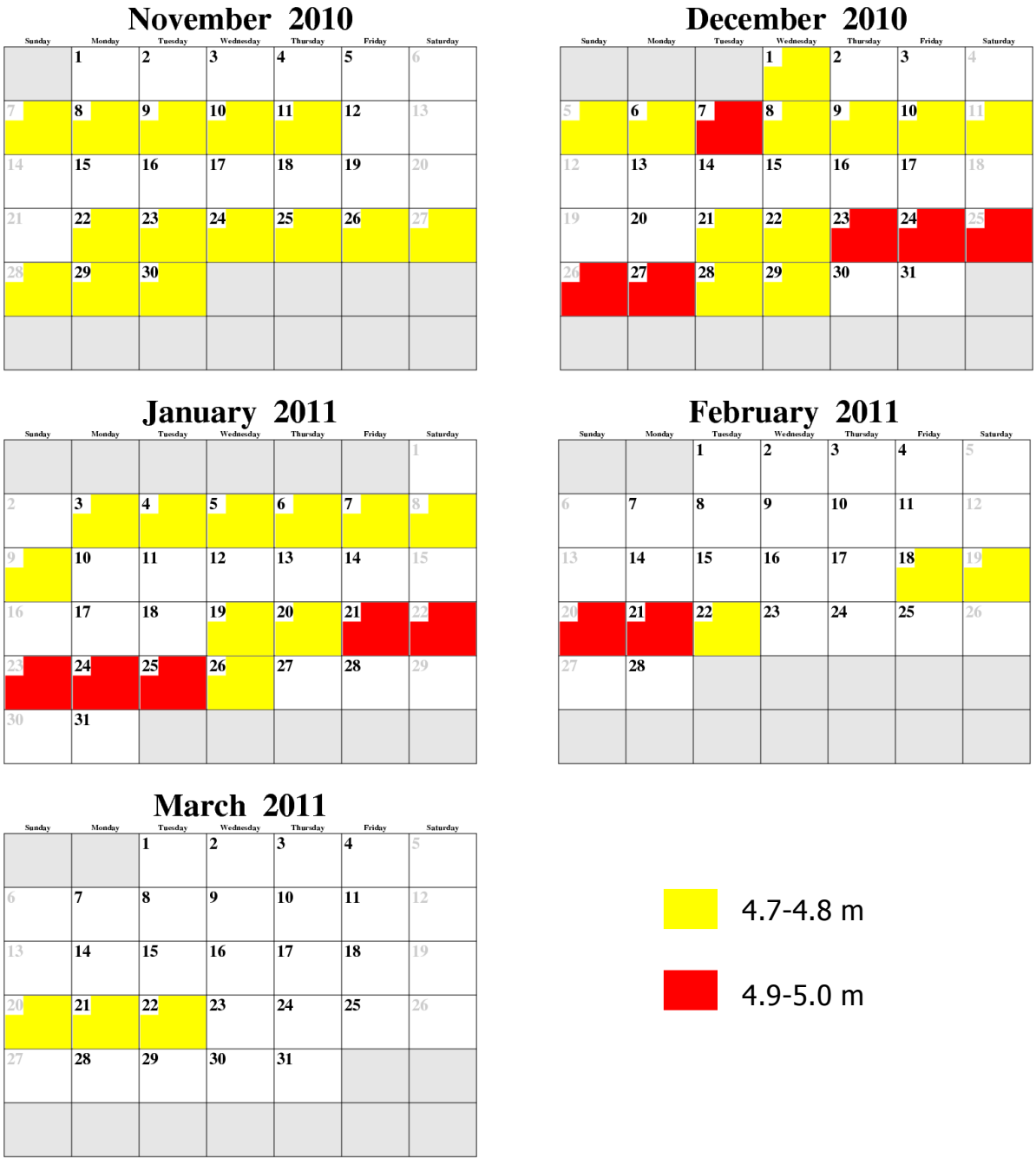

Figure 1. Calendar of dates with tides exceeding 4.7 m at Point Atkinson. The peak tides during this five month period occur in late December and late January (5.0 m).

3. Sea Surface Height (SSH) Anomaly

Sea surface height anomalies as derived from the JASON radar altimetry satellite are processed by the Jet Propulsion Laboratory (JPL) at the California Institute of Technology to show the interannual variability of SSH by removing the mean and seasonal signals, and the trend. The SSH anomalies can indicate effects of large scale interannual phenomena, such as ENSO. As of August 16, 2010, moderate positive anomalies (2-6 cm) are indicated off the British Columbia coast (Figure 2). Negative anomalies are strongly present in the equatorial Pacific coinciding with the rapid shift from last year's moderate El Niño conditions to the forecast moderate to strong La Niña for winter 2010/11.

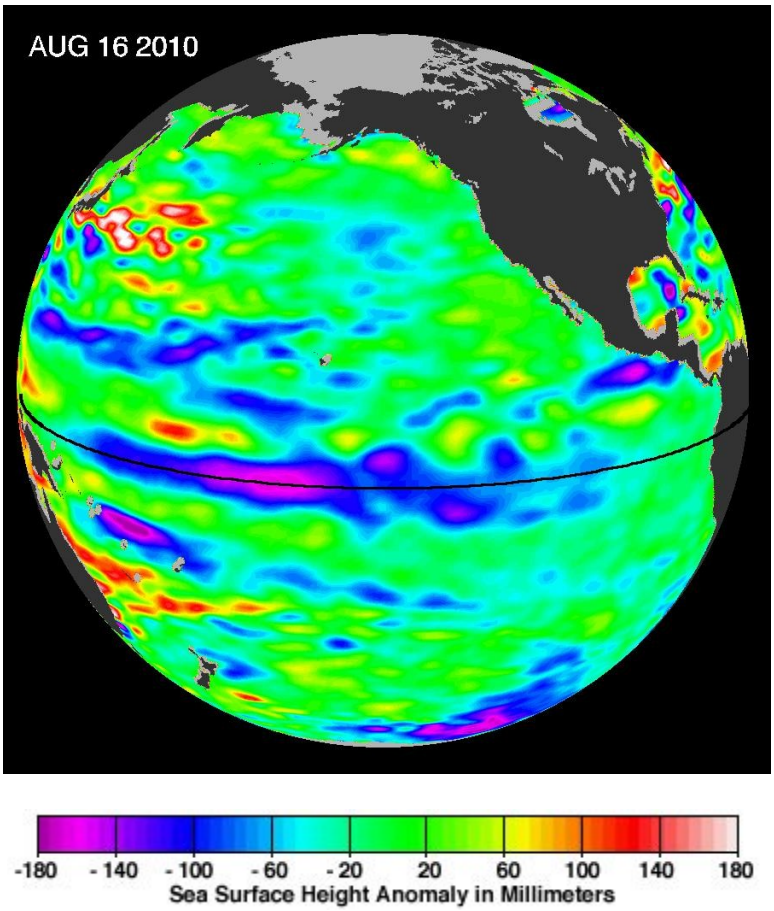

Figure 2. JPL image of 10-day averaged SSH anomaly over the Pacific Ocean for August 16, 2010. The equatorial pattern indicates the onset of La Niña for fall/winter 2010/11. The present SSH anomaly off coastal British Columbia is slightly positive.

4. El Niño/La Niña Projection

The Climate Prediction Center (CPC) of the National Center for Environmental Prediction (NCEP) provides regular updates to the ENSO state of the Pacific Ocean. As of the September 9, 2010, commentary, a **La Niña advisory** is in effect. La Niña conditions are present and expected to strengthen through the fall and winter 2010/11. The complete commentary is available at:

http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/ensodisc.pdf

From the CPC commentary of September 9, 2010:

" Nearly all models predict La Niña to continue at least through early 2011 (Fig. 6). However, the models continue to disagree on the eventual strength of La Niña. Based on current observations and model guidance, we expect the SST anomalies in the Niño-3.4 region to either persist near the present strength, or to strengthen into the winter as is consistent with the historical evolution of La Niña... The transition into the Northern Hemisphere Fall means that La Niña will begin to exert an increasing influence on the weather and climate of the United States. These impacts include an enhanced chance of above-average precipitation in the Pacific Northwest..."

Model projections cited in the ENSO monthly update (Figure 3) are shown below.

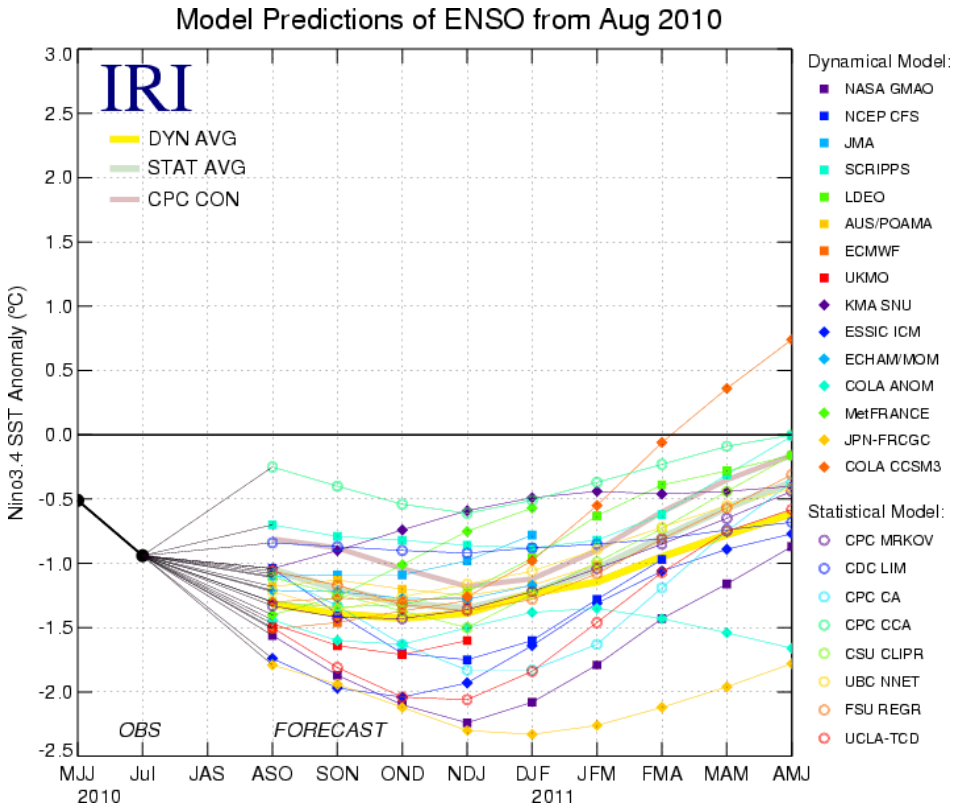

Figure 3: Original caption from CPC ENSO discussion: "Forecasts of sea surface temperature (SST) anomalies for the Niño 3.4 region (5°N-5°S, 120°W-170°W). Figure courtesy of the International Research Institute (IRI) for Climate and Society. Figure updated 17 August 2010."

Eichler and Higgens (2006 - referred to hereafter as EH) compared North American extratropical storm activity to ENSO phase based on the NCEP reanalysis period of 1950-2002 and the European ECMWF 40-year reanalysis data from 1971-2000. They categorized years based on an ENSO Intensity Scale (EIS) equal to twice the "Oceanic Niño Index" (see Table 1).

Table 1: (From Eichler and Higgens (2006) Table 1)

EIS > 3	strong El Niño	1958, 1966, 1973, 1983, 1992, 1998, 2003
0 < EIS < 3	weak/moderate El Niño	1964, 1969, 1977, 1978, 1987, 1988, 1995
EIS = 0	neutral	1952, 1953, 1954, 1959, 1960, 1961, 1963, 1967, 1970, 1979, 1980, 1981, 1982, 1986, 1990, 1991, 1993, 1994, 1997, 2002
-3 < EIS < 0	weak/moderate La Niña	1951, 1955, 1957, 1962, 1965, 1968, 1971, 1972, 1975, 1984, 1985, 1996, 2001
EIS < -3	strong La Niña	1950, 1956, 1974, 1976, 1989, 1999, 2000

Over the entire reanalysis period, EH showed an average seasonal frequency of storms for the northeast Pacific impacting the southern coast of British Columbia as three in the period spanning October to December (OND) and four in the period from January to March (JFM). When the storms were binned by ENSO phase (as described in Table 1), the JFM storm track frequency was shown to be highest (four or more) in a moderate or strong La Niña phase and during a strong El Niño.

The high tide periods at the end of November, December and January should be monitored carefully for storm activity as we are entering a period of moderate La Niña conditions, following a moderate El Niño where we experienced intense and frequent stormy periods extending into April, 2010. The year-to-year variability in storminess has been very high the past few seasons, going from a 46-year low in extreme water levels in 2008/09 to many near misses for record water levels in 2009/10.

5. Summary

From the data available as of September 2010, the winter 2010/11 storm season will be characterized by the following:

1. Peak spring tides will reach 4.9-5.0 m above chart datum at Point Atkinson near the end of December 2010, January 2011, and for a short period near the middle of February, 2011.
2. Normal to high frequency and intensity of storms is expected based on historical storm climatology for the predicted moderate La Niña conditions through winter 2010/11.
3. Ambient coastal SSH anomalies are slightly positive at present and will be monitored as La Niña conditions strengthen throughout the winter.

The spring tides will offer several windows during which high total water levels can occur, particularly in late December and January.

6.0 References

Eichler T. and W. Higgins, 2006: Climatology and ENSO-related variability of North American extratropical cyclone activity. *J. Clim* 19:2076-2093.