Appendix H. Comparison of Observed and Predicted Phytoplankton Primary Productivity

Phytoplankton primary productivity at various locations within Puget Sound has been measured and published intermittently over the past several decades using mainly C-14 incubation methods, but other methodologies have also been used (Campbell et al., 1977; Devol et al., 2007; Newton et al., 1998; Newton and Van Voorhis, 2002; Welch, 1968; Winter et al., 1975). These measurements show that both the spatial and interannual variability of gross primary productivity (GPP) within Puget Sound is large. Processes that may drive these large productivity differences, including vertical mixing due to bathymetric features and local winds, density driven stratification, variations in incoming solar radiation, and freshwater flows, are well described in the references above, particularly in Winter et al. (1975). Cloern et al. (2014) compiled GPP and net primary production (NPP) measurements in estuarine-coastal ecosystems throughout the world, and determined that phytoplankton primary production can vary up to tenfold within estuaries, and fivefold from year to year. Available annual Puget Sound data for productivity fall within a wide interannual range (see for example, Table H1). However, due to lack of sufficient GPP published data, it is unclear whether the spatial variability within Puget Sound is as large as cited by Cloern et al. (2014) for other ecosystems.

GPP observations are not available for 2006, 2008, or 2014. For this analysis, we use modeled GPP for 2008 to compare with observations for years when data is available. Table H1 shows a comparison between observed and modeled data at three locations, which correspond to locations with the longest period of Puget Sound GPP published data. Modeled 2008 GPP values are consistently lower than measured values at these locations during 1999 through 2001. For comparison, Winter et al. (1975) measured at a mid-channel site located northwest of West Point in 1964 and 1965 and obtained annual productivity values of 460–470 g/m^2/year or 1260 and 1287 mg C/m^2/day, respectively. These observed GPP values from the mid-sixties are lower than recent observed values.

Since observations available were obtained during years other than those modeled, differences are expected. Significant GPP differences are expected due to interannual variability as noted above. Jaeger and Stark (2017) compiled annual averages of monthly chlorophyll data obtained near the surface, shown in Figure H1. Their data imply that lower productivity was prevalent in 2008 when compared to 1999 through 2001, suggesting that modeled values may reflect the expected lower productivity in 2008. Nonetheless, the Jaeger and Stark dataset was collected near the surface (less than 2 m depth) at multiple sites within Central Puget Sound, so it does not directly correspond to the GPP observations collected during 1999 through 2001.

Figure H2 shows the predicted daily average values at three central Puget Sound locations (Admiralty Inlet, Possession Sound, and West Point) where GPP measurements were obtained from 1999 to 2001. Note that both modeled and observed values for West Point (PSB003) are higher than the other two stations. Observed *peak* values recorded at all three sites in 1999 through 2001 are almost two times larger than the modeled values for 2008 (11.3 g C/m^2/day compared to 6.8 g C/m^2/day). Figure H3 shows a comparison of observations and predicted chlorophyll-a concentrations at PSB003 during 2006, 2008, and 2014.

Notably, early data from multiple sources generally correspond with lower daily peak GPP values than those measured from 1999 to 2001. For comparison, Welch (1968) reported 4 to 5 g C/m^2/day during the peak annual bloom in 1965 near the mouth of the Duwamish. Newton et al. (1998) reported almost 6 g C/m^2/day peak GPP in Budd Inlet. Campbell et al. (1977) reports spring peaks equivalent to 5.6, 5.8, and 4.8 g C/m^2/day during 1975, 1966, and 1967, respectively, in a main basin station off of West Point. The highest peak value reported at that station occurred at the end of August in 1975 and was close to 10 g C/m^2/day. It is necessary to conduct more model runs for different years to assess whether the model produces higher peak average daily GPP values corresponding to years in which observations are available. Unfortunately, we are not aware of an effort to obtain further GPP observations in Puget Sound.

Table H1. Comparison of Observed and Predicted Annual Average Daily Gross Primary Production (mg C/m2/day) at Central Puget Sound Sites.

Years	**Admiralty Inlet**	**Possession Sound**	**Main Basin–West Point**
1999 (C-14 uptake Observations)	1886	2127	2559
2000 (C-14 uptake Observations)	2694	2135	3460
2001 (C-14 uptake Observations)	3356	3525	3551
2008 SSM	1894	1330	1970

All observations cited in this table are from Newton and Van Voorhis (2002).

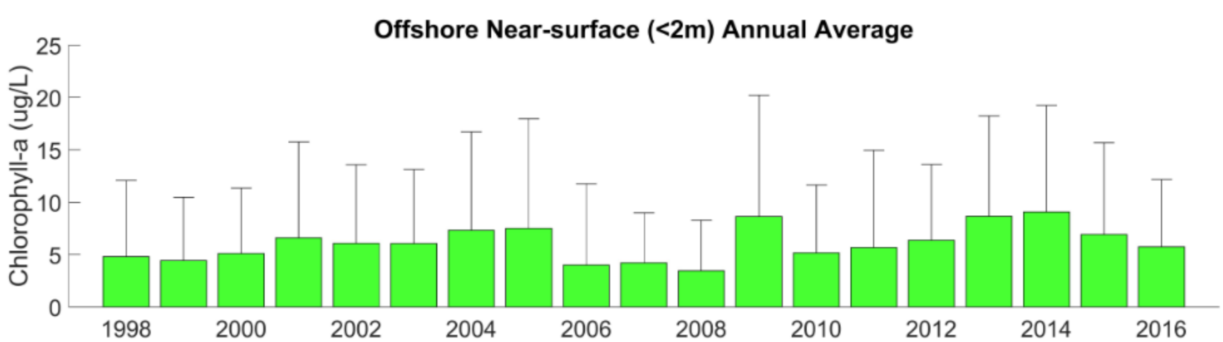

Figure H1. Annual average chlorophyll based on monthly data from Central Puget Sound (Jaeger and Stark, 2017).

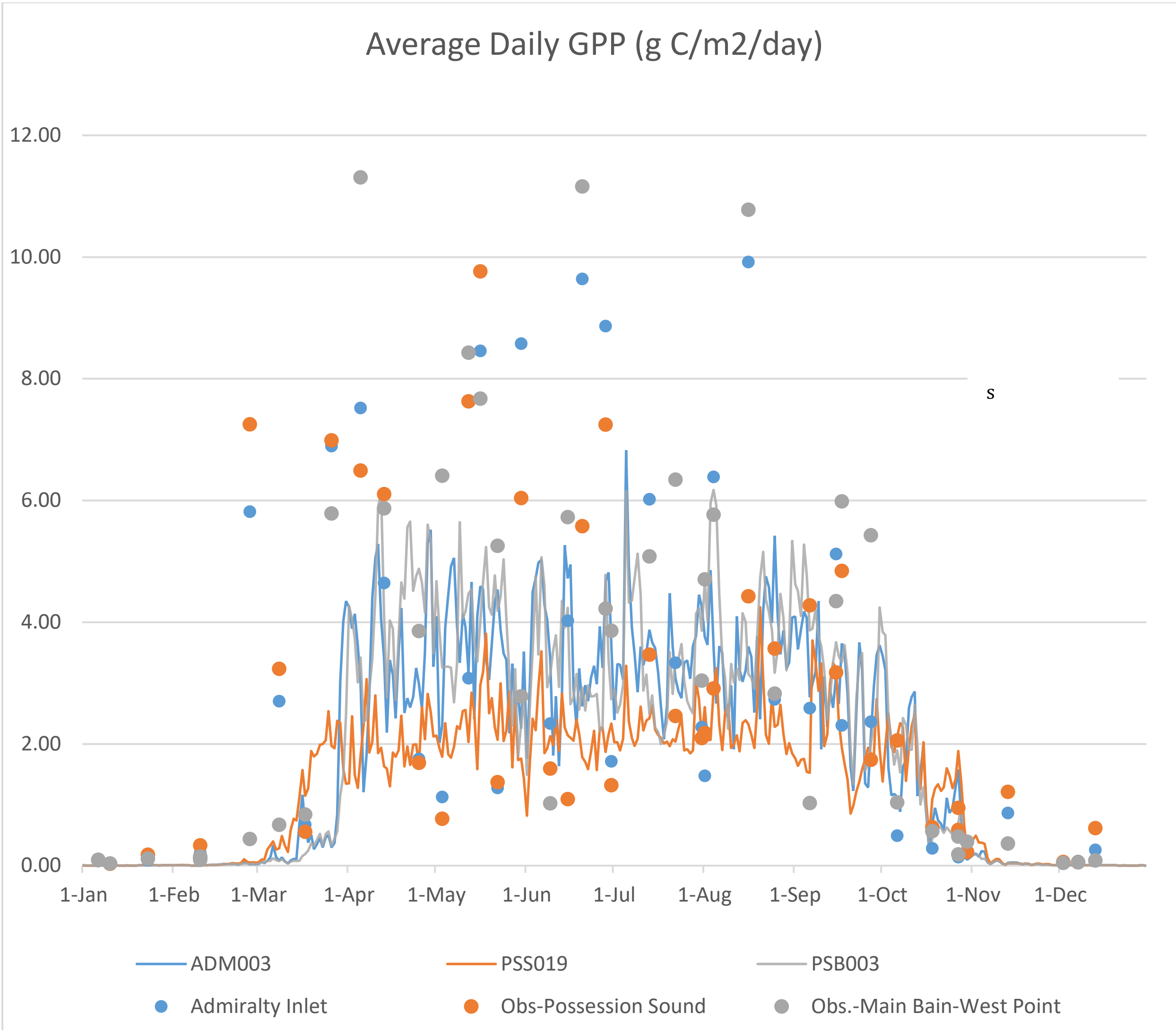

Figure H2. Comparison of 2008 average daily GPP SSM model output for Admiralty Inlet (blue line), Possession Sound (orange line) and Main Basin- West Point (grey line), with observations from 1999 to 2001 at Admiralty Inlet (blue circle), Possession Sound (orange circle), and Main Basin-West Point (grey circle). Observations are from Newton and Van Voorhis (2002).

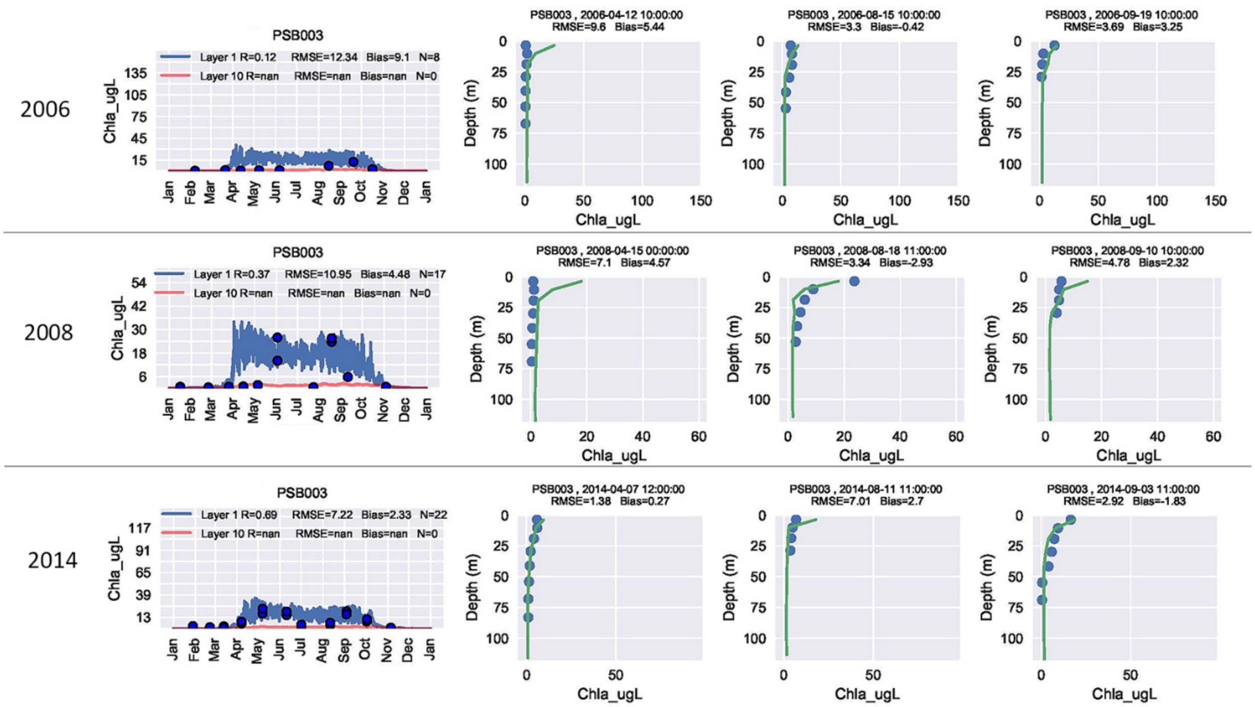

Figure H3. Comparison of chlorophyll-a observations at the West Point site (PSB003) and predicted modeled concentrations in micrograms per liter.

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