The following supplement accompanies the article

Vertical and horizontal movement patterns of scyphozoan jellyfish in a fjord-like estuary

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Supplement. Depth-specific tidal current prediction model

In order to calculate the horizontal swimming rates of individual jellyfish, we used current velocity data collected just offshore of our active tracking location at Sund Rock to build a tidal current prediction model. Current velocity data were collected from April 2006 to July 2009 (with some data gaps) by the Hood Canal Dissolved Oxygen Program at the University of Washington's Applied Physics Laboratory (www.hoodcanal.washington.edu/). Data were collected using a 'doublet mooring' in which 2 acoustic-Doppler current profilers (ADCP) were deployed, with 1 ADCP looking upward and 1 ADCP looking downward. The ADCP data reported profiles of current velocity and direction every hour with vertical resolution of 1 m from 3 m below the mean sea surface to the bottom (120 m).

Using ADCP data from 12 January 2007 to 16 July 2009, we developed a tidal current prediction model. We performed harmonic regression of along-channel current at every depth against 7 major tidal constituents used in the tidal prediction model of Lavelle et al. (1988) using Matlab® (Fig. S1), and used the resultant tidal constants for a forward harmonic prediction of along-channel current for the period of our jellyfish observations. We then used 3 methods to measure the ability of the model to accurately predict tidal currents at various depths near Sund Rock.

First, we compared the timing of peak flood and ebb tides with tide and current predictions by the National Oceanic and Atmospheric Administration (NOAA) as reported by Nobletec® Tides and Currents™ Version 3.5.1 (http://cms.nobeltec.com/cms/Products/NavigationData/TidesCurrents.aspx). NOAA's closest tidal prediction station to Sund rock is ~16 km southeast in a constricted channel near Sister's Point (see Fig. 1 in the main text). The Nobletec® tidal current predictions also represent predictions of currents in the mid-level water column. For these 2 reasons, this dataset was not appropriate for measuring rates of movement of jellyfish; however, we can use it to compare the timing of peak flood and ebb tides between the 2 predictive sets of data during our active tracking dates. We found that, throughout the period of our observations, the timing between the 2 datasets match up well (Fig. S2), and the 2 time series are highly correlated with a correlation coefficient of 0.98.

Second, we used the model to generate tidal current predictions (hindcasts) for an earlier period (13 April 2006 to 12 January 2007) for which ADCP data were available but were reserved for the purpose of model verification. To calculate 'hindcast error,' we subtracted the tidal current predictions from the corresponding ADCP data. We then compared the hindcast error to the hindcast tidal current, using both the root mean square (RMS; standard deviation between the hindcast and the ADCP data) and the maximum across all depths (Fig. S3). For most of the water column, the RMS hindcast error was ~10 to 20% of the RMS tidal current. At depths near the surface to 6 m and at depths near the bottom, the maximum hindcast error exceeded the RMS tidal current, suggesting that the predictions may not be reliable at those depths (Fig S3). This uncertainty at shallow depths is most likely due to non-tidal currents caused by winds and freshwater input on the near-surface layer of Hood Canal.

Finally, using the same earlier period of data, we calculated the hindcast skill (100 × correlation coefficient, where 100 means perfect hindcast) of the model by calculating the correlation coefficient between the model's predicted tidal current and the ADCP data. The model's hindcast abilities were significant and high at all depths (Fig. S4), with skill level generally >98 for most of the water column and even >93 at shallow depths where the model should have more trouble with non-tidal currents (see above).

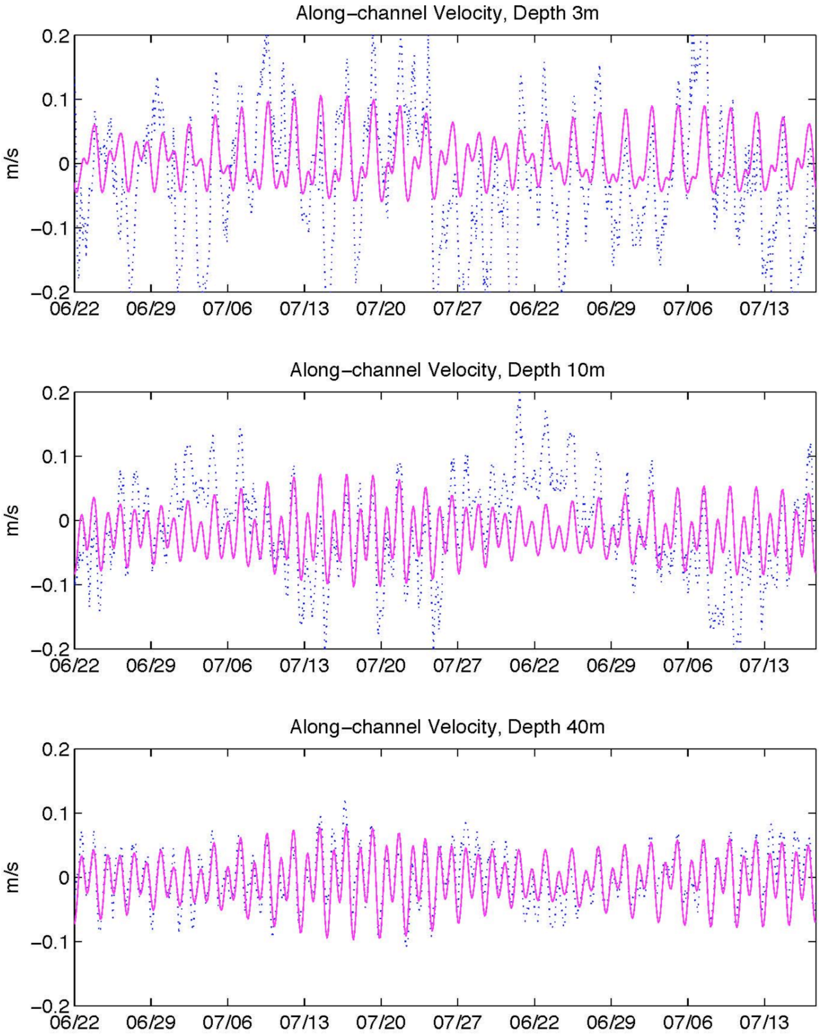

Fig. S1. Comparison between measured acoustic-Doppler current profiler (ADCP) data (dotted lines) and the resultant tidal current prediction model (solid pink lines) at depths of 3 m, 10 m, and 40 m for 23 June to 22 July 2008

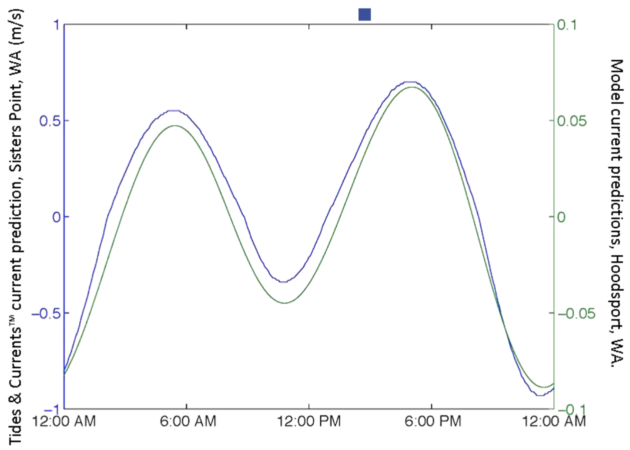

Fig. S2. Example comparison of timing of peak flood and ebb currents on 7 July 2010 between data from Nobeltec® Tides and Currents™ software (based on National Oceanic and Atmospheric Administration current predictions) at Sisters Point, Washington, USA (blue line), and our tidal current prediction model just offshore of the jellyfish tracking site near Hoodsport, Washington (green line)

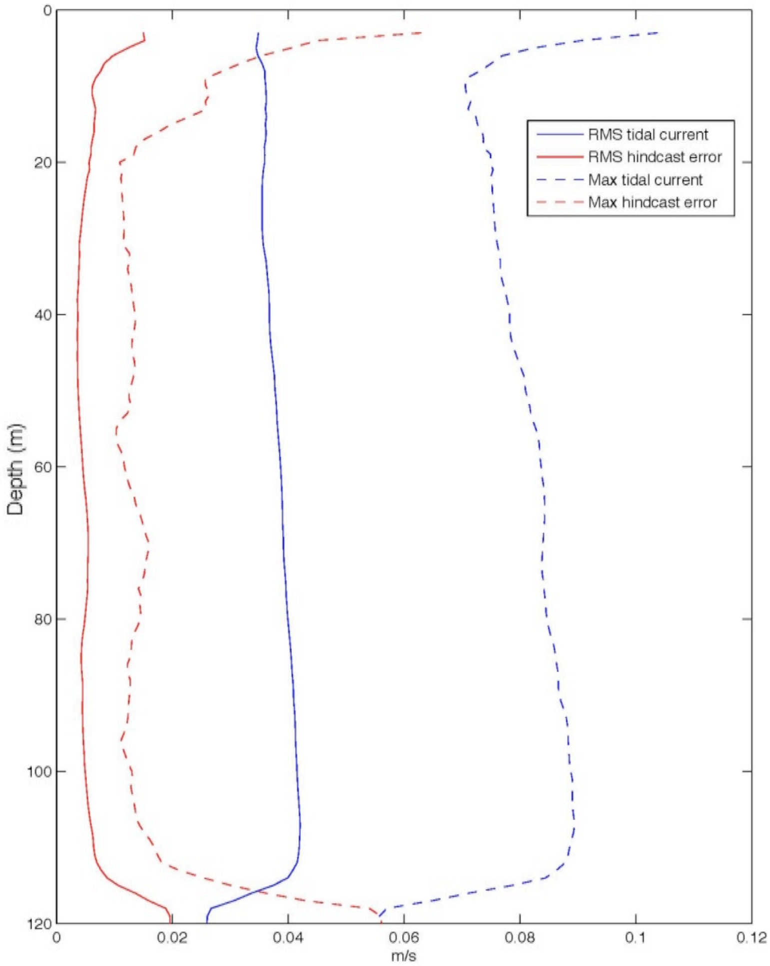

Fig. S3. Performance measures of tidal current prediction model. Root mean square (RMS) and maximum tidal currents show the magnitude of currents just offshore of the jellyfish tracking site. RMS hindcast error is the standard deviation of the difference between the model's predicted tidal current and the corresponding acoustic-Doppler current profiler (ADCP) data across all depths

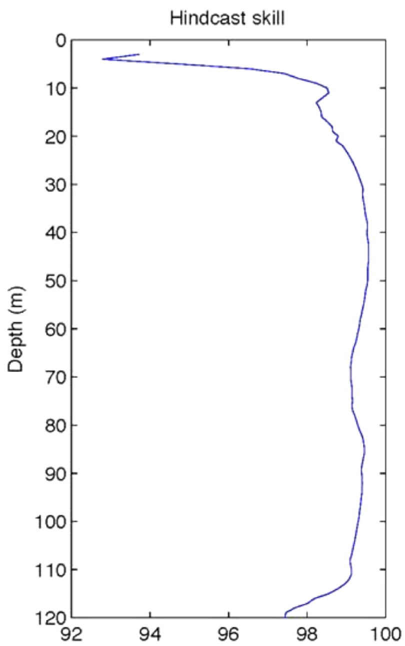

Fig. S4. Hindcast skill (correlation coefficient × 100) represents the model's ability to predict measured currents from a time period for which acoustic-Doppler current profiler (ADCP) data were available (13 April 2006 to 12 January 2007); a skill score of 100 represents perfect correlation between the hindcast prediction and ADCP data

LITERATURE CITED

Lavelle JW, Mojfield HO, Lempriere-Doggett E, Cannon GA and others (1988) A multiply-connected channel model of tides and tidal currents in Puget Sound Washington and a comparison with updated observations. NOAA Technical Memorandum ERL PMEL-84, U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Environmental Research Laboratories, Seattle, WA