# Time Series Analysis of Acoustic Doppler Current Profiler in Humboldt Bay

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## Background

One of the most important instruments in physical oceanographic field research is the Acoustic Doppler Current Profiler (ADCP). The ADCP uses acoustics to measure *in situ* current velocities:

- ADCP transmits a sound pulse at a specific frequency through the water
- Due to the Doppler Effect, moving water particles receive the pulse at a different frequency (*Fig. 1*) proportional to their speed relative to the ADCP
- The received sound reflects back to the ADCP, which calculates the speed at which the water particles must have been travelling

Both stationary and shipboard ADCPs are common in oceanography. In this project, we studied stationary ADCP data in Humboldt Bay.

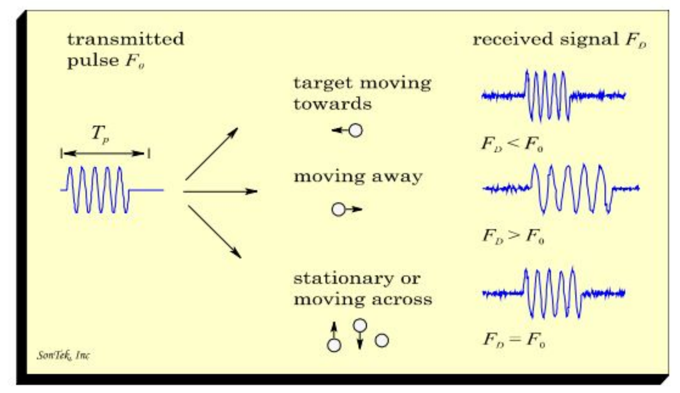
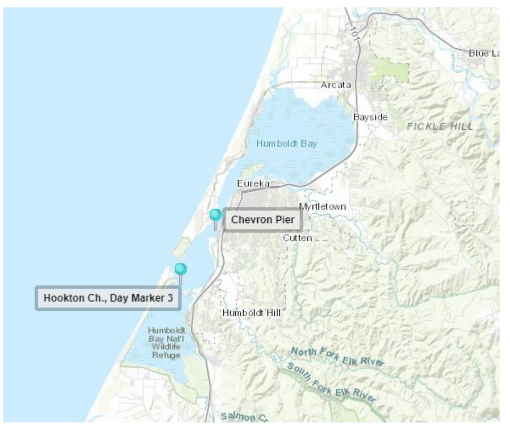



*Figure 1. Doppler shift for reflected sound (SonTek, 2000).*

### Humboldt Bay PORTS®




The NOAA PORTS® (Physical Oceanographic Real-time System) project monitors the conditions of harbors and bays across the country to ensure maritime safety, especially for large commercial vessels. In Humboldt Bay, PORTS® maintains two side-looking ADCPs, one mounted on Channel Marker 3 (just south of the entrance channel) and one on Chevron Pier. The ADCPs provide real-time current speed and direction along the width of the channel.

*Figure 2. Location of ADCPs in Humboldt Bay (NOAA Tides and Currents, 2022).*

## Results

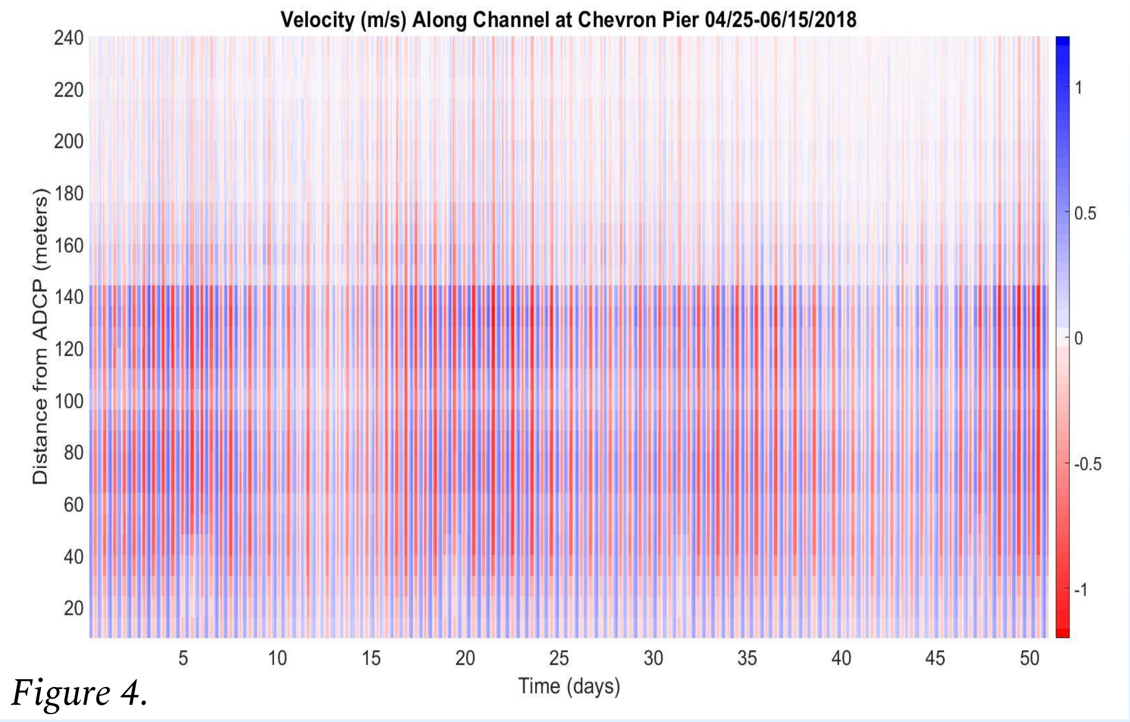



*Figure 4.*

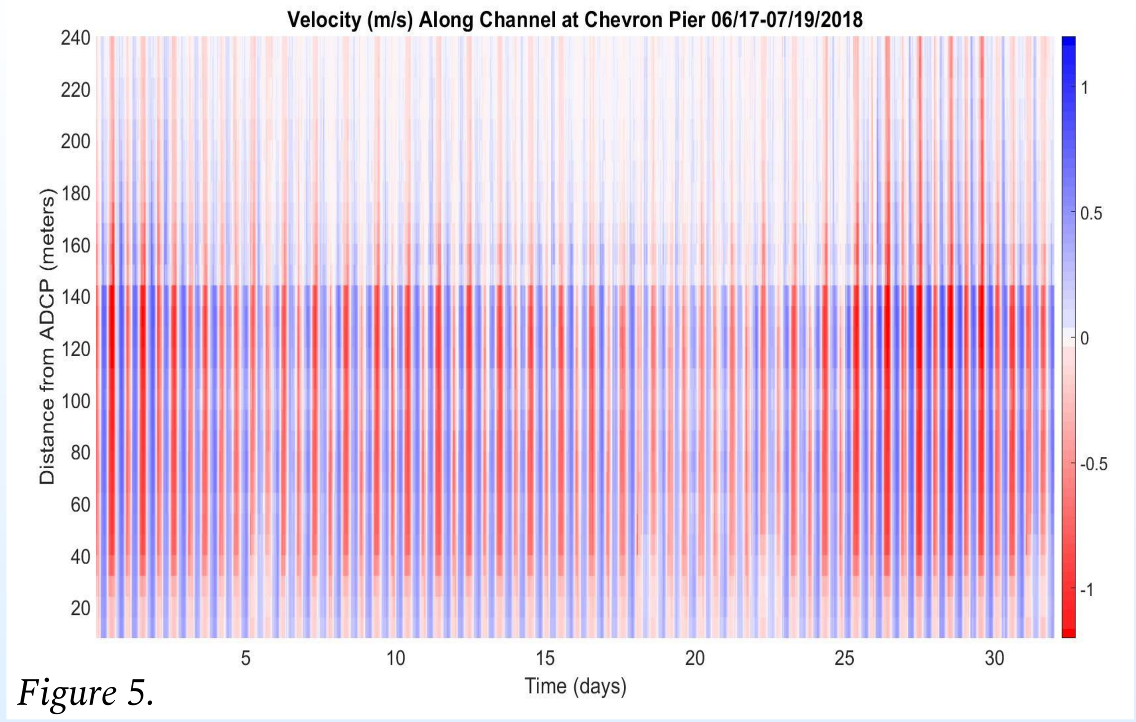



*Figure 5.*

*Figures 4,5. Velocity (m/s) along the channel at Chevron Pier from April 25 to June 15, 2018 (Fig 2) and from June 16-July 19, 2018 (Fig 3). The vertical axis is the distance from the ADCP in meters across the channel. The horizontal axis represents the period of ADCP deployment between the respective dates. The colorbar to the right side of the figures shows velocity, with positive values indicating rightward flow relative to the ADCP (approximately northeast flow into Humboldt Bay) and negative numbers indicating leftward flow (southwest/out to sea).*

## Acknowledgements

We would like to express our gratitude to the many people who made the collection and analysis of this data possible, including: the NOAA PORTS team and Jacob Partida (WHOI), Christopher DiVeglio (NOAA Federal), Caleb Gostnell (NOAA National Ocean Service CO-OPS Pacific Operations Branch), Larry Oetker, Humboldt Bay Harbor, Recreation, and Conservation District: Captain Corey Mooers and Captain Robert Provolt, the Chevron Corporation: Ken Nielsen and Kevin Cliborn, COAST and the Humboldt Marine and Coastal Science Institute

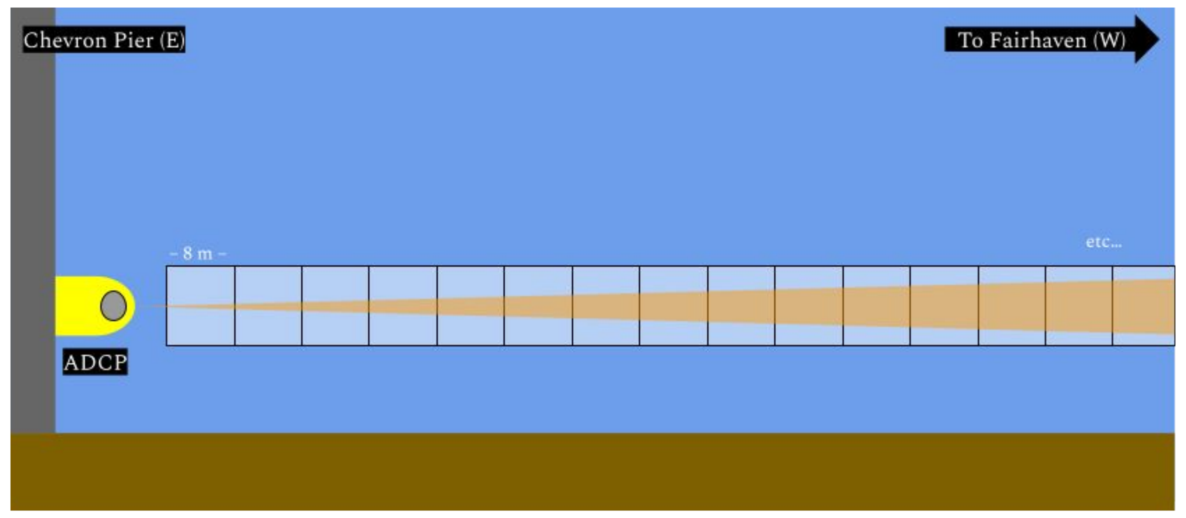
## Methods

Humboldt Bay PORTS® maintains two side-looking SonTek ADCPs (*Fig. 2*). These instruments collect data every six minutes, internally averaging the current velocity they record using 30 eight-meter-wide bins (*Fig. 3*). A side-looking ADCP is capable of capturing velocity in two dimensions, across-shore and along-shore. Since there is little crossshore flow in our study areas, we only considered longshore velocity. We chose to focus on data from Chevron Pier as the channel is wider than at Marker 3. Data was retrieved from the Humboldt Bay PORTS® archive and during onsite maintenance.

Data was initially processed to merge data collected over multiple days. The ADCP is brought offline during maintenance, so to avoid issues caused by a gap in data we chose to keep each (approximately four-to-six week) period between maintenance trips separate.

Using Matlab, we plotted the bin-averaged velocities over each deployment period.

*Figure 3. Diagram of the instrument at Chevron Pier. The ADCP is mounted to the pier on the eastern side of the channel and faces west. As the beam of sound (orange) travels across the channel, the ADCP records current speed data. The data is then averaged across evenly-spaced "bins". Note that the acoustic signal spreads as is travels outward from the instrument; this limits the ADCP's range. Not to scale.*




## Discussion

Our plots show that current speeds in this part of Humboldt Bay reach a maximum of about 1.2 m/s, both into and out of the channel. The fastest current speeds occur between 40 and 140 meters from the ADCP, roughly at the center of the channel. The strongest current signals occur at about fifteen days apart, corresponding with the spring-neap tidal cycle. Close inspection also shows a strong correlation between the current velocities observed by the ADCP and the daily tidal cycle (*Fig. 6*).

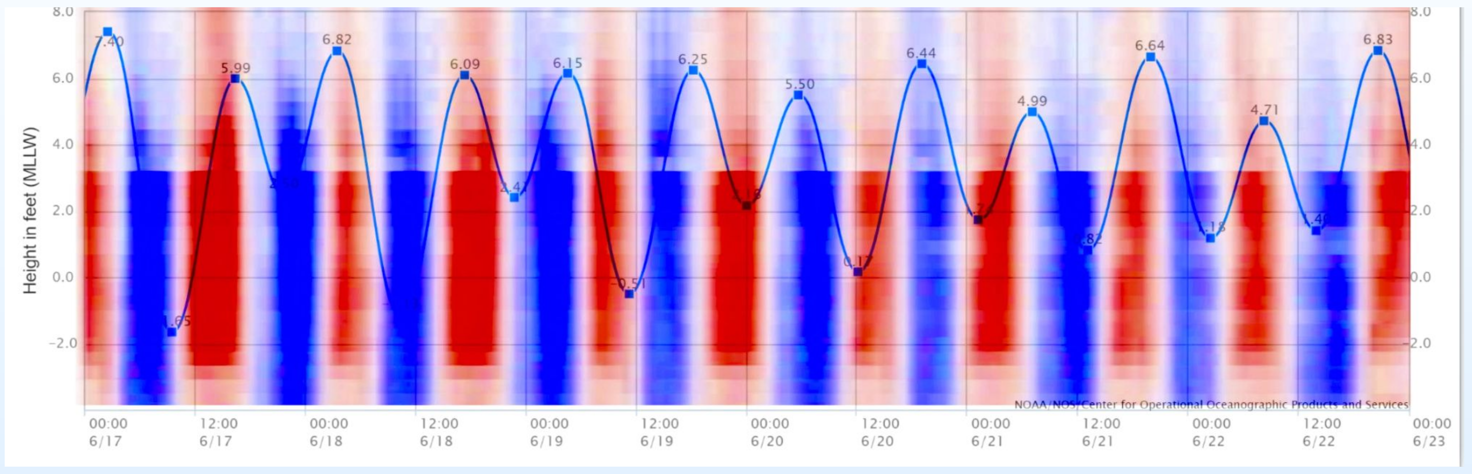



*Figure 6. The tidal measurements from June 17 to June 22, 2018 imposed over the velocity data from the same dates at Chevron Pier. The vertical axis is the tidal height in feet. The horizontal axis represents the 5 day period over a 24 hour cycle. The tidal overlay is taken from Tide Predictions - NOAA Tides & Currents.*

### Further Research

- Repeat plots with Marker 3 data, compare to Chevron Pier. How does current velocity vary between each location?
- Now that we have a time series of velocity, we could perform a Fourier transform to identify the dominant frequencies in our data. For example, we could quantify the strength of the tidal signals we see in the plots we have already produced. Another potential area of research is the presence of internal waves in Humboldt Bay, which are identifiable by their characteristic long frequencies.

## References

NOAA Tides & Currents. (2022, April 25). Humboldt Bay PORTS. Retrieved April 25, 2022, from https://tidesandcurrents.noaa.gov/ports/index.html?port=hb

SonTek, 2000. "Acoustic Doppler Profiler Principles of Operation". 4–9.