Measuring ocean currents

By Claude Belanger and Shelton Gay

Early this summer, Science Center oceanographers will deploy two arrays of moorings in Hinchinbrook Entrance and Montague Strait. Instruments on these moorings will measure the direction and speed of currents flowing through these two major entrances, which link Prince William Sound (PWS) to the Gulf of Alaska (GOA). The goal of this observational project is to improve our understanding of the magnitude and frequency of the exchange of water between the GOA and PWS and the forces driving these exchanges. This project will also provide much needed data for calibrating ocean models now under development.

To obtain measurements of water transport, four Acoustic Doppler Current Profilers (ADCPs) will be deployed at each inlet on subsurface moorings, instrumented with one upward looking and one downward looking ADCP (Fig. 1). At Hinchinbrook Entrance (HE) three of the ADCPs will be mounted in hydrodynamically streamlined buoys (Fig.1) that will provide stability necessary for the instruments in the high current environment. A fourth (upward looking) ADCP will also be moored near the bottom (Fig. 1).

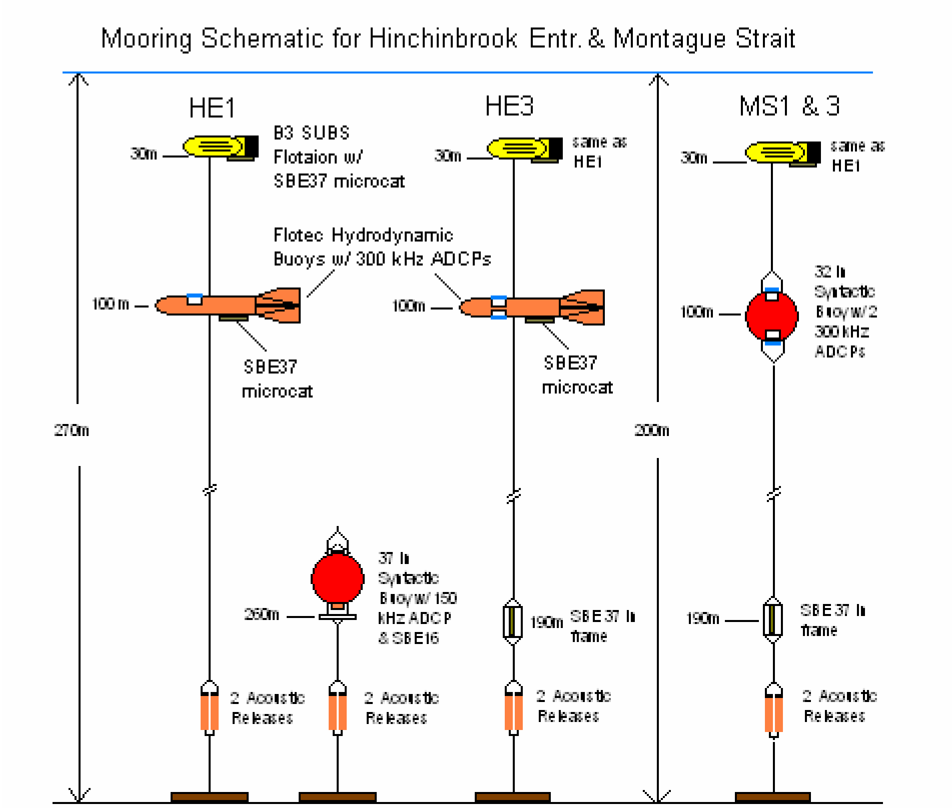

Figure 1. Schematic showing the various types of moorings and instruments contained within them, to be located at either Hinchinbrook Entrance or Montague Strait.

The arrangement of the various moorings across the two inlets is shown in Figure 2. Note that in addition to the subsurface moorings, a downward looking ADCP will be mounted on a National Data Buoy Center (NDBC) weather buoy located in the center of HE north of Seal Rocks. In the future a new NDBC weather buoy with an ADCP may also be deployed in Montague Strait (MS). An ADCP is also planned to be moored in Prince of Wales Pass, one of four relatively narrow and shallow passages northwest of MS.

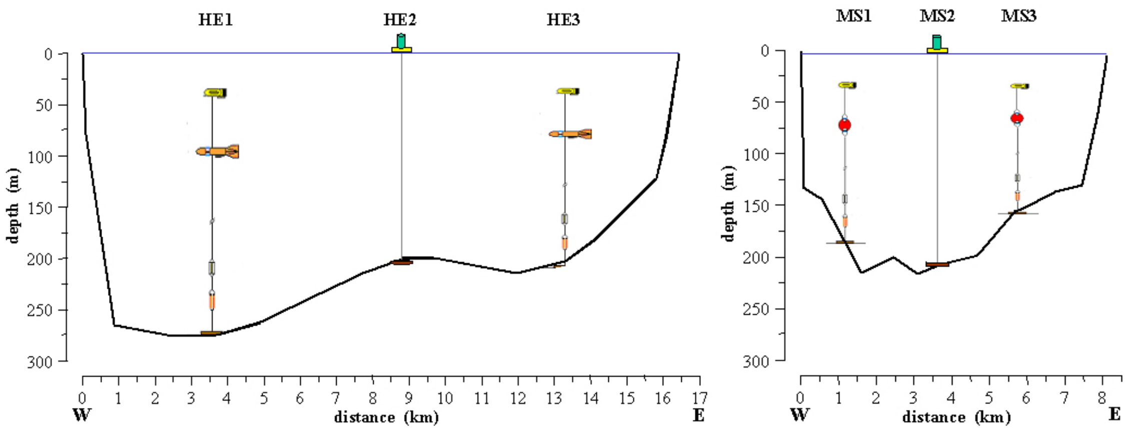

Figure 2. Four different moorings will be deployed early this summer as depicted for Hinchinbrook Entrance (right) and Montague Strait (left). Mooring HE2 is an existing weather buoy and the National Weather Service proposes MS2 for a future deployment

In addition to the ADCPs, each of the subsurface moorings will have three conductivity-temperature recorders (CTs) mounted at three different depths. These instruments will periodically sample temperature and salinity and thus track changes in water mass physical properties over time. Used in conjunction with the ADCP currents, they will help identify periods of deepwater exchange between PWS and the GOA.

As suggested by their name, ADCPs rely on a measure of the Doppler shift to calculate the speed of moving water. The Doppler affect occurs whenever a sound source is moving either away or towards a receiver, thus producing a respective (perceived) decrease or increase in the frequency. In the case of an ADCP, sound is first emitted as a series of pulses. The instrument then listens for echoes produced by particles (such as plankton) moving within the water column due to the currents. The frequency shift is measured within discrete depth bins (i.e. segments), where the distance between the instrument and the reflecting particles is estimated from the delay between the emission of the sound and the arrival of the echo. Should the echoes from a given depth bin arrive with a higher frequency than the emitted sound, then the volume of water at this distance is moving toward the instrument, and should the echoes arrive with a lower frequency, then this volume of water is moving away. The relative speed is directly proportional to the amount of frequency shift (or phase difference). When this is done with three beams of sound emitted in precisely known different directions, then the results from the three beams can be mathematically treated to provide a three-dimensional velocity.

In the past, oceanographers at the Science Center have measured currents in HE using a deep, single upward-looking moored ADCP shown in Figure 1. This instrument was unable to measure currents in the upper 30 meters of the water column, thus leaving continuous measurements of near surface flows unresolved. Water exchange calculations were further limited in accuracy by measurements being made at only a single point across the 12-kilometer wide strait. This time the ADCP sampling will cover the entire water column and the array of three moorings will provide information on the cross channel variability of the flow. Together with the moorings in Montague Strait and Prince of Wales Pass, the data collected should allow for calculations of the time-evolving budget of flow (i.e. water transport) between PWS and the GOA.

This major project is funded through grants from NOAA and the Exxon Valdez Oil Spill Trustee Council. It is part of the regional Prince William Sound Observing System which is a pilot project for the Alaska Ocean Observing System. With maintenance support funded by the Oil Spill Recovery Institute, plans are to operate the two arrays of moorings through 2010. This will result in an unprecedented substantial multi-year data set. Other concurrent observational and modeling efforts not mentioned here are expected to amplify the usefulness of the ADCP data in our understanding of PWS. For example, past researchers identified the water mass exchange between the northern GOA and PWS as one of three physical processes that exert the most influence on the biology of phytoplankton, zooplankton, and juvenile fish within the Sound. The other two processes involve seasonal heat and freshwater flux. A better understanding of these linkages will ultimately contribute to more effective management of marine resources. Therefore, we believe that this five year campaign will lead to a significant improvement in our understanding of the physical processes of PWS and how they affect biological species important to PWS coastal communities.

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