Traditional narrowband sonar is limited to “viewing” the ocean in a single acoustic frequency, analogous in the visual world to looking at a black and white image. By using a broadband sonar signal, we can capture far more details, in essence changing our black and white image into a colour one. Clearly, we have a much easier time identifying objects when we see them in full colour.

Once per second, the SciFish 2100 transmits a broadband “chirp” signal that sweeps through the acoustic frequencies between 85 and 155 kHz.

With a typical underwater sound speed of 1480 m/s, the acoustic wavelengths contained within the chirp vary between 1.75 and 0.95 cm. The sonar logs the raw transducer voltage time series digitized at 500 kHz. Two information rich products can be calculated from these data. The first involves calculating spectra as a function of range for each ping. This yields estimates of volume scattering strength (Sv) as a function of depth, time, and now also acoustic frequency. Spectrags of Sv, with the vertical axis as water depth and the horizontal axis as the acoustic frequency, can be stacked into an animation.

(Continued on page 2)
Here is a link to a streaming video showing ten minutes of spectrograms. The Sv data can also be displayed as an “acoustic colour” plot, seen in Figure 2, more akin to what is output by traditional narrowband sonar. The acoustic colour plot reduces the avi-movie into a single plot by selecting three acoustic frequencies and assigning each a colour. Lighter means stronger scattering, darker less scattering; redder means more scattering at lower frequencies, bluer means more at high frequencies. Note the bluish colour of the migrating zooplankton layer, while the discrete targets below, which are likely fish, often have a reddish tint.

Performing pulse compression on the raw returns creates a second data product, seen in Figure 3. Pulse compression takes advantage of the chirp form of the transmitted signal, not to gain spectral information, but to increase both the spatial resolution and signal-to-noise ratio (SNR) of the returns. An ideal pulse compressed signal can temporally resolve scatterers separated by 1/BW, where BW is the bandwidth of the signal. With the 70 kHz bandwidth of the SciFish 2100, this leads to a resolution of 1 cm (as compared to a resolution of around 1 m for both the spectral calculation from this sonar and for a typical narrowband sonar). Again for ideal signals, the SNR increases by 2*BW*PL through pulse compression, where PL is the length of the chirp pulse. The PL is typically 1 ms for the SciFish 2100, leading to a SNR increase of around 140. The increased resolution of the scattering data seen in Figure 3 is quite remarkable. The increase in SNR is less remarkable, which is a consequence of the careful selection of noise-free acoustic frequencies in the creation of the acoustic colour plot.

The SciFish 2100 is a sophisticated oceanographic echosounder. It is a 48 VDC Ethernet instrument, and can easily generate 1 GB of data per hour. It is therefore ideally suited for a cabled observatory. Dr. Ross has VPN (virtual private network) access to communicate directly with the SciFish from Halifax, where she will adjust the sample configuration and collect data for her research. Data plots and products will be posted on the VENUS web site as this research progresses.
laboratory on VENUS will help researchers examine many processes at this critical river/ocean interface.

The DDL is a standard Venus Instrument Platform equipped with two Science Instrument Interface modules (SIIMs) to accommodate a suite of instruments. Currently the platform has a SBE CTD, a 600 kHz RDI ADCP, a Wetlabs fluorescence and turbidity sensor, and two scanning Imagex sonars. We plan to develop two acoustic Doppler velocimeters, and three SLIPs (see page 4). Data from the CTD and the Fluorometer already reveal short, tidal, and longer term variations (Figure 1). In early May, the Fraser freshet appeared, with temperatures rising, salinities dipping, and turbidity increasing. These trends, however, were modulated by both the diurnal tides and the fortnightly variations. Seawater density (\(\sigma_t\)) variations are dominated by the salinity dependence, while chlorophyll at 40m increases slightly during the elevated vertical mixing associated with the stronger spring tides. A closer look (Figure 2) reveals the strong diurnal variations associated with the tides, as well as short periods of rapid fluctuations in the salinity. Both chlorophyll and turbidity increase with the current speed, both during ebb (falling tide) and flood (rising tide). The 600 kHz acoustic Doppler current profiler (ADCP) is set to record 30 second ensembles of 2 Hz ping data (Figure 3). This rich dataset probes up into the water column, revealing the interactions between the broad tidal currents and the shallow river plume. The ADCP measures the SE ebb and NW flood currents (Figure 3), corresponding well with the falling and rising pressures in Figure 2. The upper (shallowest) few bins capture the river plume flowing westward (blue, top panel) over the deeper eastward ebb tide (red, top panel). The acoustic backscatter (bottom panel) reveals strong turbidity throughout the water column following the ebb tide (1300-1500 PDT). Researchers can monitor these data streams to assess the influence of the Fraser River on the delta region.

In fall 2008 the Delta Dynamics Laboratory will be enhanced with the installation of a suite of instruments and sensors specifically designed to monitor the stability of the Fraser Delta slope. Three Seismic Liquefaction In Situ Penetrometers (SLIPs) are being designed and built by Weir-Jones Engineering Consultants Ltd. of Vancouver for deployment during the scheduled September maintenance cruise. Sediment slope failure can be the result of many factors. Monitoring the conditions at various depths beneath

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**Figure 2.** A 24 hour section (May 7, 2008) of the CTD data from the 40m deep DDL platform.

**Figure 3.** A day (May 7, 2008) of 600 kHz ADCP data from the DDL platform in 41m of water. (Continued on page 4)
VENUS Research Highlight:  
The Surface to Bottom Zooplankton Conveyor Belt 
Verena Tunnicliffe

In April 2008, Kathryn Baumann completed an Honours thesis examining the interactions of descending zooplankton with the bottom in Saanich Inlet. Katie accompanied the VENUS Team on its maintenance cruise to collect samples and deploy experiments. Then she used the ZAP plots to predict the time that the scattering layer would contact the bottom and triggered the sediment trap on the Instrument Platform. The objective of this work is to determine the quantity and types of plankton that contact the bottom and thus are available as food to bottom animals.

In plankton tows just above the bottom (done with the ROV), the copepods at 64m depth in Pat Bay were mostly Corycaeus sp while at 95m near the VENUS node, it was Calanus spp that predominated. Katie examined careful suction samples taken in the surface sediments. At the 64m site, abundances of plankton in the mud were low but included copepods, ostracods and mysids. At 95m, however, she encountered large numbers of Calanus copepods on the sediments and, therefore, available as food to the abundant bottom animals (flatfish, galatheid crabs, shrimp) at this site.

Silhouetted against a leg of the VENUS camera at 95m in Saanich Inlet, the zooplankton of the scattering layer (in ZAP profiles) are abundant on the bottom. Euphausiids, amphipods and copepods are visible. Inset is an image of Themisto sp., an amphipod abundant in bottom tows at 95 m depth.

Because these zooplankton feed at the surface and swim to the seafloor each day, they represent a very rapid ‘conveyor belt’ of surface productivity: bottom animals benefit immediately from the surface plankton blooms. We suspect that the larger euphausiids and chaetognaths avoided our nets as they can commonly be seen with the VENUS camera.


(Continued from page 3)

the sediment/water interface is essential for an assessment of the conditions that lead to slope failure. The SLIPs (Figure 4) will be equipped with multiple pore pressure transducers and thermistors, full tilt and heading orientation sensors, and triaxial accelerometers. Real-time monitoring of the surface to depth pressure and temperature variations in the sediment, along with the tides, river discharge, and atmospheric forcing will make the VENUS Delta Dynamics instrumentation one of the most advanced delta systems ever deployed. Watch for further updates later in the year.

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