Triaxus Data Issues

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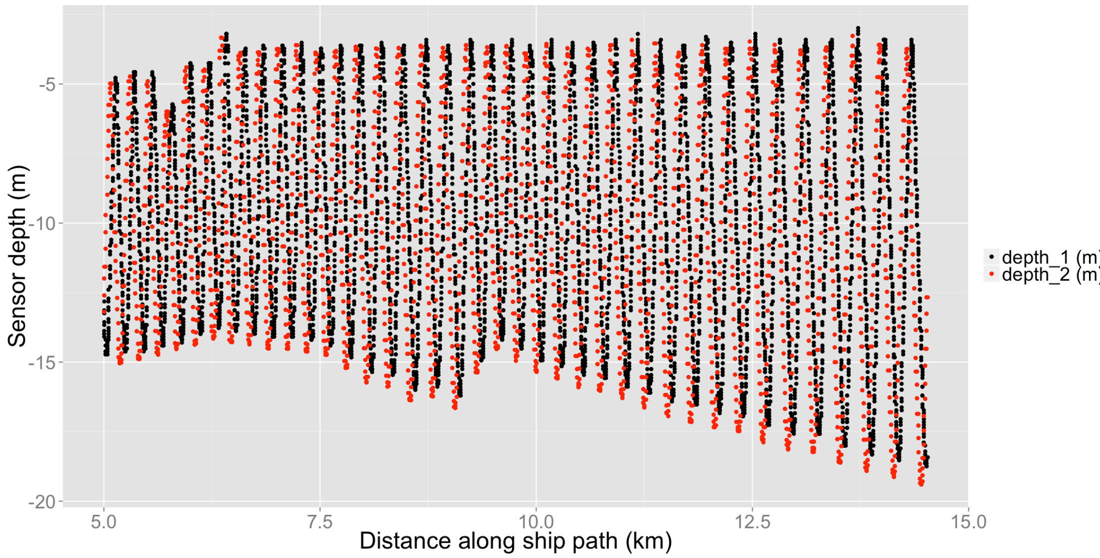
Two problems identified in the Triaxus data collected at Manitowoc River are outlined below. We seek guidance on the proposals suggested below for addressing these problems in analyzing the Triaxus datasets. We would be glad to discuss these issues further.

1. Data Alignment Problem

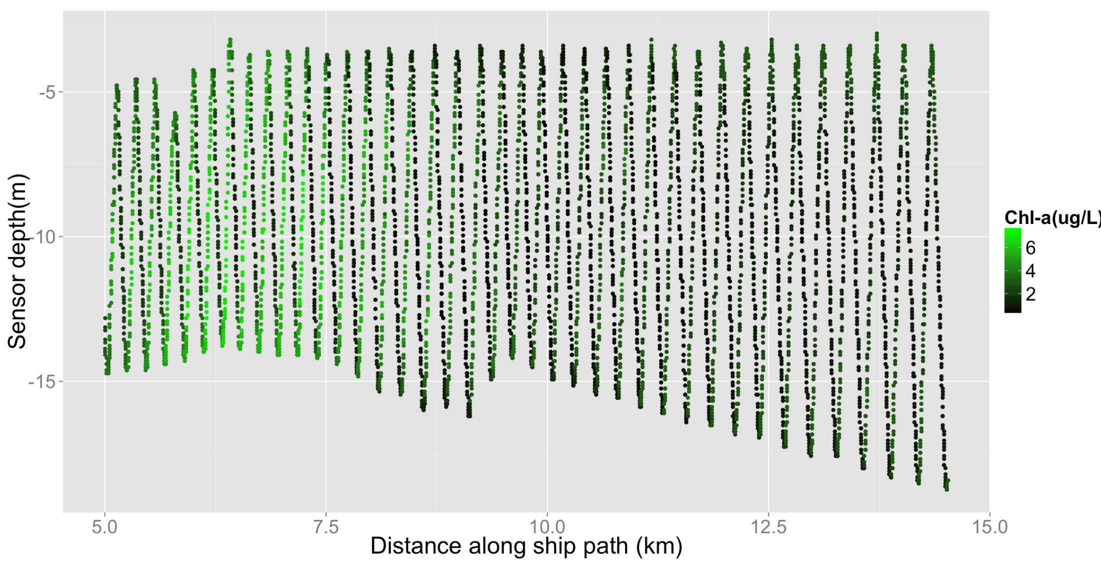
There are 4 sensors in Triaxus and these sensors have different sampling frequencies. SeaBird CTD sensor samples every 0.5 seconds and BBE Fluoroprobe sensor samples every 2 to 4 seconds. In the data file, the measurements from the CTD sensor are recorded line by line. With the Fluoroprobe sensor, which has lower sampling frequency, the previous measurement is repeated until a new measurement is recorded. This causes a problem. It takes some time for the Fluoroprobe sensor to analyze the water sample taken at depth *d1*. When the result is returned, the sensor has moved to another depth (*d2)* and the recorded Chl-a value at the *d2* line in the file reflects the attributes of the water sample taken at *d1*, instead of *d2*. So on each line, the CTD sensor gives a measurement at depth value of d2 while the Fluoroprobe sensor gives the Chl-a data from the water sample at d1. In other words, they are not sampling the same water simultaneously.

Each line in the data file indicates a location (i.e. ship distance and sensor depth). And both SeaBird CTD sensor and BBE Fluoroprobe sensor give measurements of depth so there are two depth measurements in each line. However, these two depths are not consistent. Consider one pass of the Triaxus (called Manitowoc_02) shown in Figure 1. In this path, the two different depth values at the same line are shown in Figure 1(a). Red dots are depths value from the Fluoroprobe sensor and black dots are from the SeaBird CTD sensor.

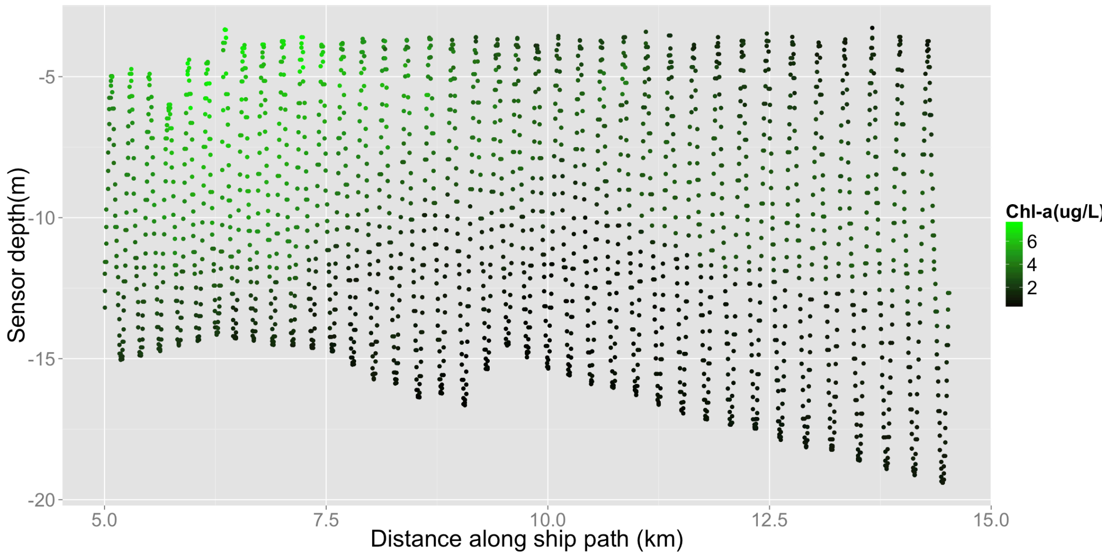
The Chl-a data with SeaBird CTD sensor depth and Fluoroprobe sensor depth are plotted in Figure 1(b) and 1(c), respectively. In Fig. 1(b), low Chl-a concentrations (black dots) and high concentrations (green dots) show an alternating pattern. Fig. 1(c) is more reasonable indicating the Fluoroprobe sensor depth is the correct depth value for the Chl-a data.



(a) Two depth values on the same data row
(Red from Fluoroprobe sensor, black from Seabird CTD sensor)



(b) Total phytoplankton visualization with SeaBird CTD sensor depth



(C) Total phytoplankton visualization with Fluoroprobe sensor depth

Figure 1. Conflicting depth values and their effects on chlorophyll data

The coordinates of the sampling points in Fig. 1(c) are the same as the red dots in Fig. 1(a), which are sparser due to the lower sampling frequency of the Fluoroprobe sensor and are different from the black dots in Fig. 1(a). The black dots are the locations defined by the SeaBird CTD sensor and are regarded as the accurate sampling positions of the Triaxus sensor package. In order to have the correct Chl-a data value at each Triaxus sampling position (i.e. each line in the data file or the black dots in Fig 1a), a data modification method is proposed as follows.

Proposed Solution:

(1) Identify each undulating cycle for two sensors according to their depth values.
(2) For each cycle, linearly interpolate the phytoplankton value onto the SeaBird CTD depth based on depth and phytoplankton value of the Fluoroprobe sensor.

After linear interpolation, the total Chl-a value with SeaBird CTD depth and distance is shown in Figure 2, which looks much more consistent.

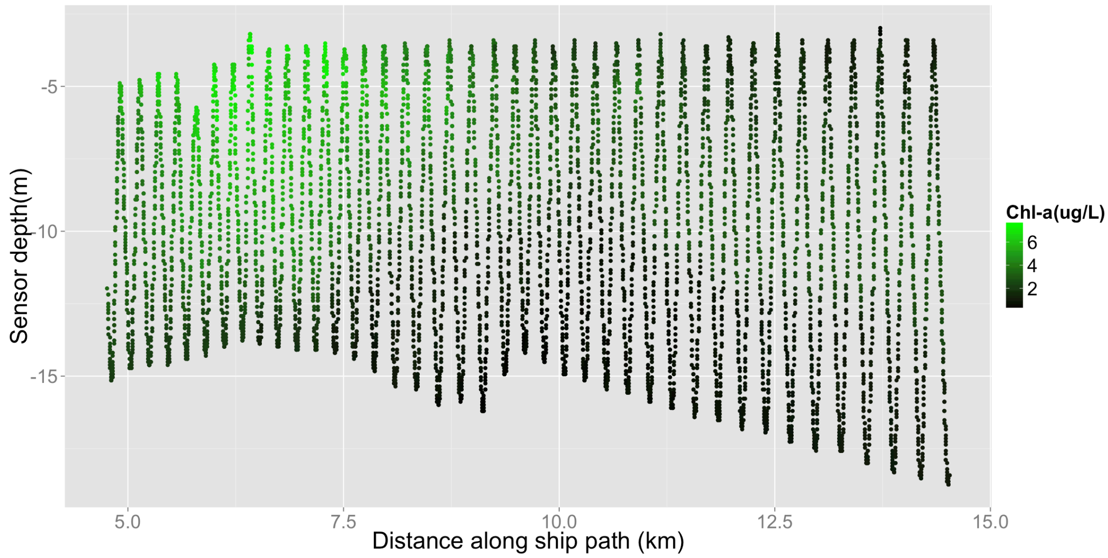


Figure 2: Linear correction of raw data

2. Dissolved Oxygen Problem

Dissolved oxygen (DO) shows an unusual phenomenon. From Figure 3 below, DO has an alternating pattern of high values and low values between the sensor's up-path and down-path. When the sensor goes up, a lower DO value is recorded. When the sensor goes down, a higher DO value is consistently recorded at the same depth.

This pattern is more significant in layers where dissolved oxygen, temperature and other variables change rapidly (e.g. in the blue circle)

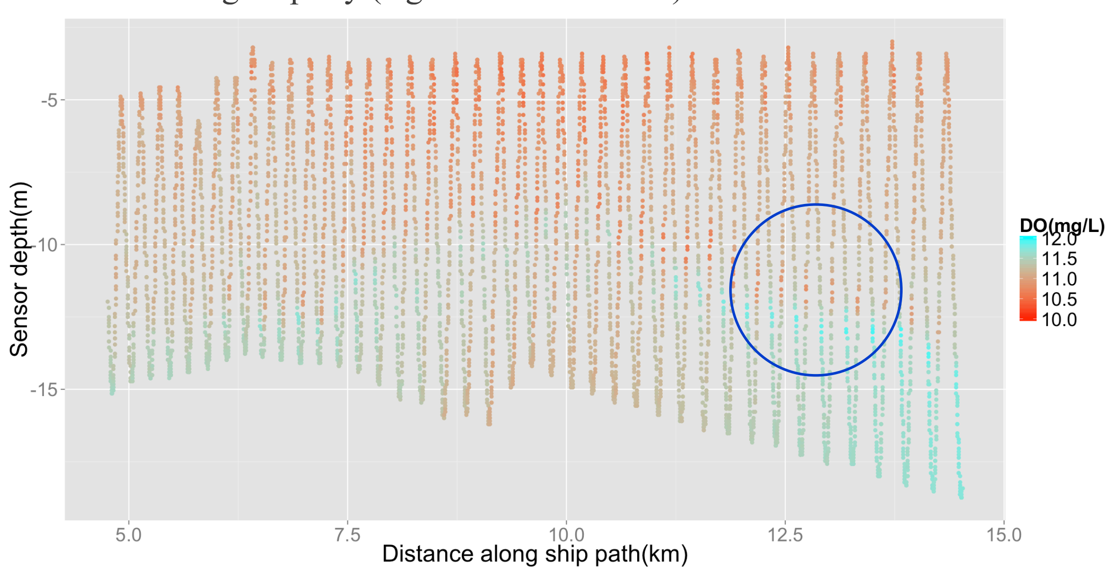
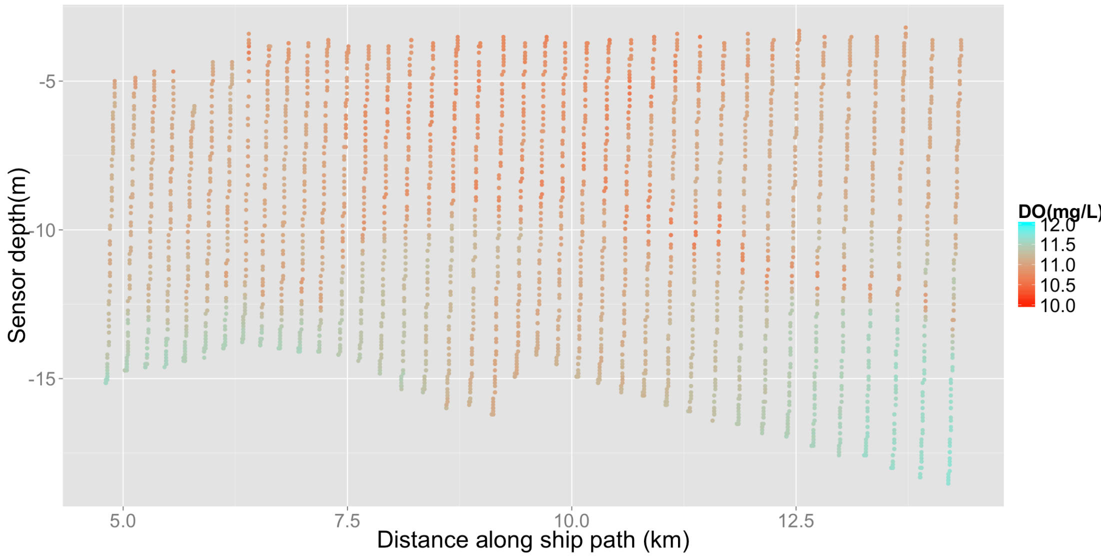


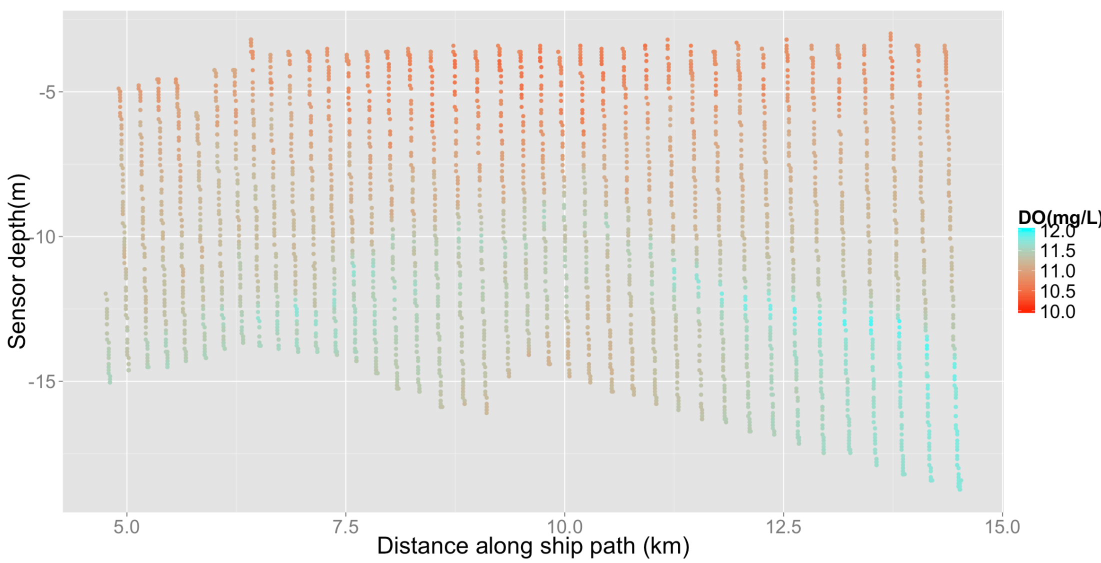
Figure 3: Dissolved Oxygen visualization of raw data

Proposed Solution:

(1) Separate the dataset into two parts: the upward dataset and the downward dataset (Figure 4).



(a) Sensor going up



(b) Sensor going down

Figure 4: DO data when sensors go up (a) and down (b)

(2) Interpolate each dataset separately. (Figure 5)

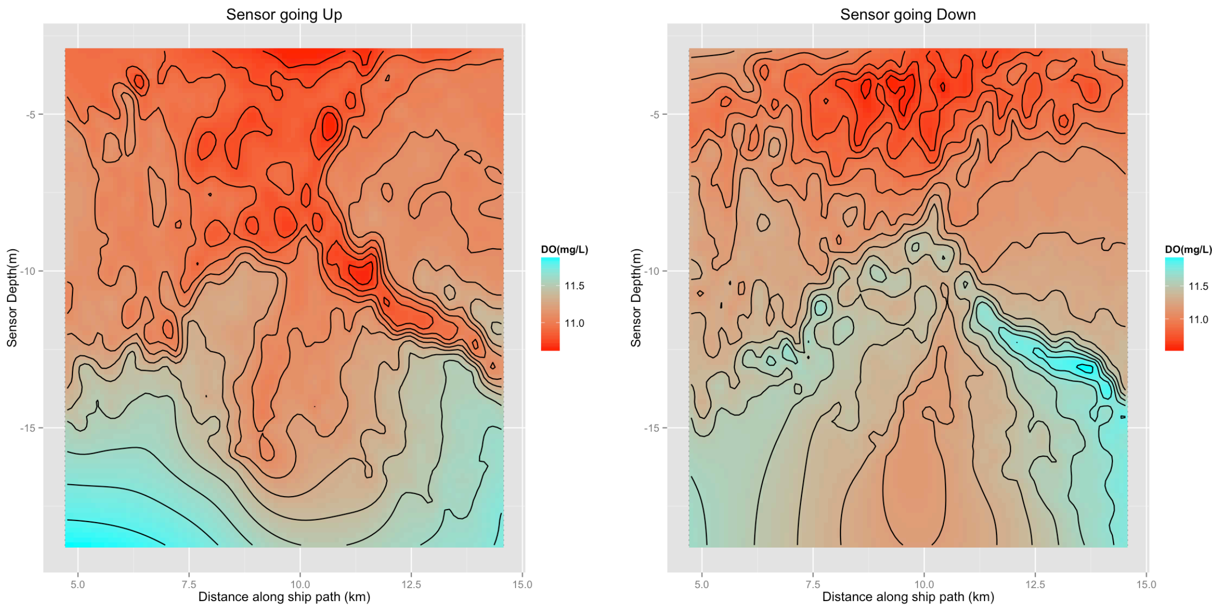


Figure 5: Interpolation result for upward (left) and downward (right) datasets.

(3) Combine the two interpolated results by averaging (Figure 6). Alternatively, one of the two datasets could be eliminated if the data are thought to be corrupted (e.g., perhaps the upward dataset has errors introduced by mixing).

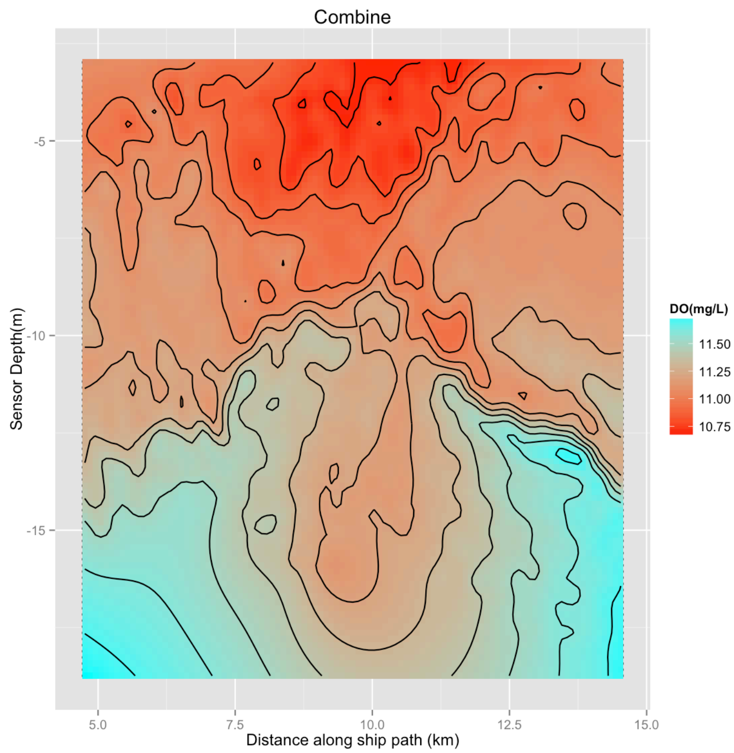


Figure 6: Final interpolation result of DO

It should be mentioned that the zooplankton data (zooplankton biomass and zooplankton density) have similar alternating behavior as shown in Figure 7. The zooplankton data are higher when the sensor goes up (see the data in the blue circle)

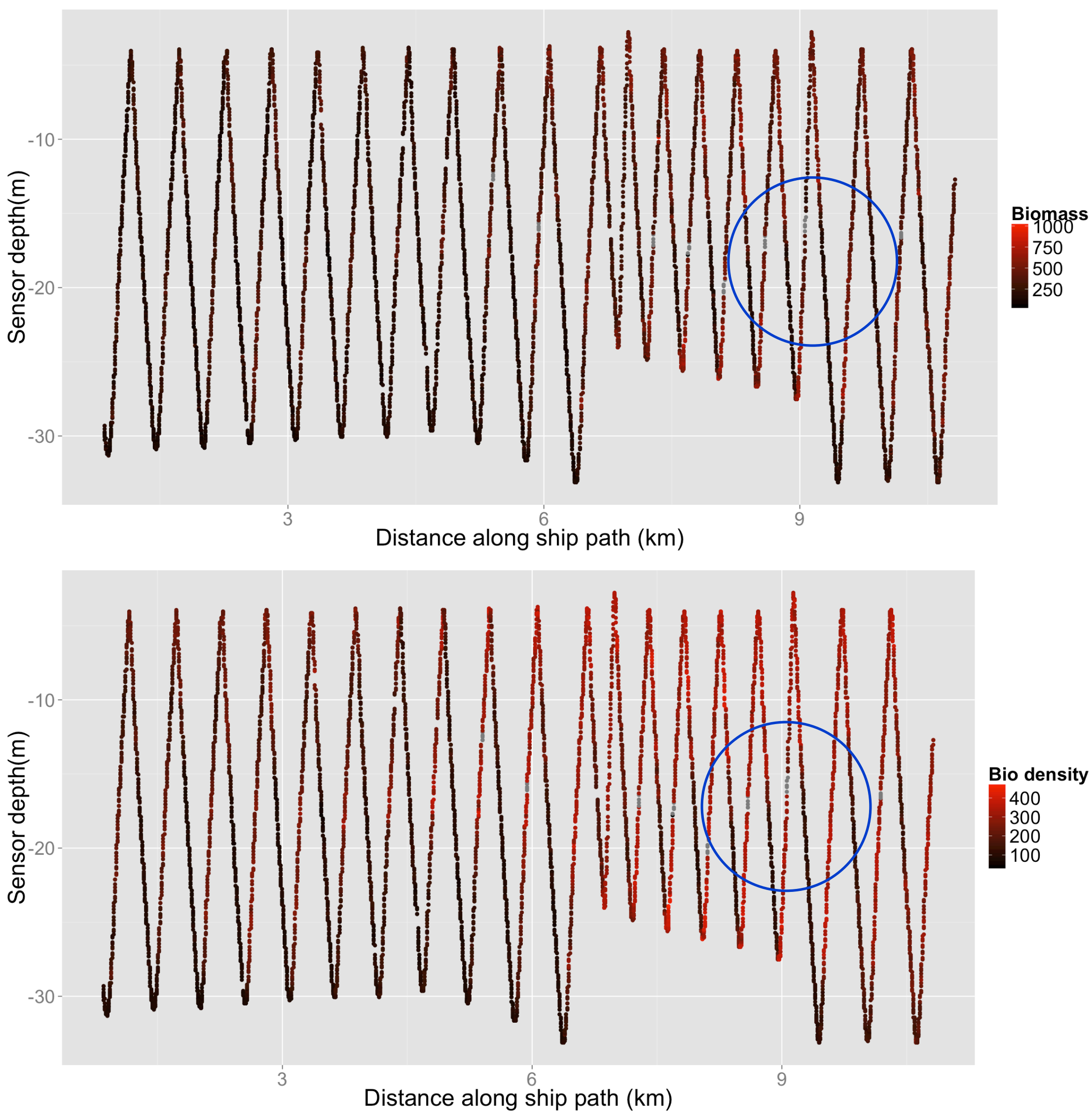


Figure 7. Zooplankton data visualization at Manitowoc River