Diving Deeper Data Analysis 2015

All of the data we collected from 2015 is now entered and analyzed. We analyze the data for two reasons.

1. **To find out what happened in 2015:**
   - What can we learn about Suttons Bay?
   - Are there any trends?
2. **To plan for 2016:**
   - What new questions do we have now that we have seen the 2015 data?
   - What do we want to look at next year?

The Diving Deeper experience is intended to be an authentic research experience for students. Students planned their research, carried it out on the ship, and analyzed their data in the classroom with you. The research process will continue next year and the next step is to consider how we can get useful data in 2016.

Enclosed are the data from 2015 and several analyses we performed. Additionally I provided questions that can be asked after looking at the data. Ultimately we hope you will share parts or all of this data with your students and get back to us about how the students think we should proceed for 2016 – what questions or protocol do they recommend?

You can give the figures to students and ask them to interpret the figures, give the data to the students and have them re-create the figures we created, and/or give the data to the students and have them create any figures of interest. There are many, many things to investigate beyond the figures included here!

For each figure these are the questions to ask:

1. What are the patterns or trends in the data?
2. What conclusions, if any, can be drawn from these data?
3. What questions do I have now?
4. How can I redesign the study for next year to better answer my questions?

One other thing that came up in our analysis was the diversity of data we collected. For example, minnow trap groups all did something different with their bait, and plankton students all collected data from different depths. This meant there was a lot of data that was only collected once, so there wasn't enough information to draw a conclusion about it. We wonder what we should do about this. **Is it more important to get a strong dataset** (with every group collecting data with the same variables), **or is it more important to let students design their own protocol** (even if that means some of the data won't be usable in the analysis)?

Would you have been just as motivated if we had told you which depths to measure, which baits to select, and which devices to use to collect the data? Would it make a difference to your interest or ownership if you knew every other group was doing exactly the same thing?

Is there a way to maintain choice in the methods design while also getting data on a relatively consistent set of variables? What do you think?

Water Quality

The question we asked: *How do temperature, dissolved oxygen (DO), and pH vary in the water column, and how do these vary throughout the year?*

Figures: **1a-1u: Temperature and Dissolved Oxygen profiles for every trip**
2: Temperature profiles for all trips

Questions to ask now

1. **For Figures 1a-1u:**
    a. What is the trend of Temp for an individual trip?
    b. What is the trend of DO for an individual trip?
    c. How do DO and Temp profiles differ in spring vs. fall?
    d. Are there any profiles that look suspicious? For what reason?
    e. What additional information would you like that isn't displayed here? What questions do you have as you look at these profiles?
    f. How would you redesign the study for next year to better answer your questions?

2. **For Figure 2:**
    a. What is the trend in temp in spring vs. fall?
    b. Where is the time of greatest change?
    c. Are there any dates for which the data look suspicious? For what reason?
    d. Does the water in Suttons Bay stratify by temperature? What evidence supports this assertion? What additional information do you need in order to be sure?
    e. What additional information would you like that isn't displayed here? What questions do you have as you look at these profiles?
    f. How would you redesign the study for next year to better answer your questions?

Benthos – Mussels and Midge Larvae

The question we asked: *What is the density of zebra and quagga mussels in Suttons Bay (Grand Traverse Bay)?*
We also examined the samples for other species and asked: *How does the number of midge larvae vary with depth?*

Figures: **3: Density of live quagga mussels in Suttons Bay, 2015**
4: Quagga mussel length distribution in shallow and deep water
5a-b: Number of midge larvae per petite PONAR sample vs. depth

Questions to ask now

1. **For Figure 3:**
    a. What is the density of quagga mussels in Suttons Bay? How does it compare to the density of quagga mussels elsewhere in Lake Michigan?
    b. Is the density of quagga mussels different in shallow vs. deep water? What evidence supports your answer?
    c. What additional information would you like that isn't displayed here? What questions do you have as you look at this figure?
    d. How would you redesign the study for next year to better answer your questions?

2. **For Figure 4:**
    a. How big are quagga mussels in Suttons Bay?
    b. Is quagga mussel length different in shallow vs. deep water? What evidence supports your answer?
    c. What additional information would you like that isn't displayed here? What questions do you have as you look at this figure?
    d. How would you redesign the study for next year to better answer your questions?

3. **For Figures 5a-b:**
    a. Is there a difference in Midge density at different depths? What evidence supports your answer?
    b. Is there a difference in midge density in the fall vs. in the spring? What evidence supports your answer?
    c. What additional information would you like that isn't displayed here? What questions do you have as you look at these figures?
    d. How would you redesign the study for next year to better answer your questions?

Fish

The question we asked: *What is the best bait for capturing round gobies with a minnow trap?*

Figures: **6a-c: Number of round gobies per treatment**
7: Length of round gobies
8: Number gobies collected per trip

Questions to ask now

1. **For Figures 6a-c:**
    a. Which treatments were clearly successful? What evidence supports your answer?
    b. Which treatments were clearly unsuccessful? What evidence supports your answer?
    c. Which treatments might have been successful, but could use more testing to know for sure?
    d. What additional information would you like that isn't displayed here? What questions do you have as you look at these figures?
    e. How would you redesign the study for next year to better answer your questions?

2. **For Figure 7:**
    a. What is the pattern or trend in the number of gobies captured this fall?
    b. What conclusions, if any, can be drawn from this figure?
    c. What additional information would you like that isn't displayed here? What questions do you have as you look at these figures?
    d. How would you redesign the study for next year to better answer your questions?

3. **For Figure 8:**
    a. What is the pattern or trend in the length of gobies captured? Which lengths are the most common? the least common?
    b. What additional information would you like that isn't displayed here? What questions do you have as you look at these figures?
    c. How would you redesign the study for next year to better answer your questions?

Plankton

Note: This data set was the most difficult to analyze. We created several figures to examine the data, but it is difficult to come to any conclusions about them. But, for what it is worth, I have included the work we did.

The question we asked: *How does the composition of plankton vary at different depths?*

Figures: **9a-b: Frequency of capture of plankton types at different depths**
10a-c: Spring/Fall comparison of plankton capture rates of copepod species
11a-c: Increase in plankton diversity as more samples are taken

Figure notes:

These figures all analyze data from the plankton net, so remember that when data is shown for 30 feet, for example, it really means that the net sampled the whole column of water from 0-30 feet.

These figures are more complex than the others presented so far. It was not meaningful to simply graph the percent of drops for each of the species when compiling data from multiple trips, mostly because different groups examined different numbers of drops. Instead we looked at the frequency of capture for each of the species (number of times a species was seen/number of times that depth was sampled).

Figure 9a-b:
Even though multiple species are shown for each depth, it is probably most meaningful to look at each species individually rather than compare species to one another.

Figure 10a-c:
Since plankton diversity and concentrations are radically different in fall vs spring we compared data for the copepods species in the two seasons. It was not possible to make this type of comparison for other species since only copepods are present all year in any meaningful abundance.

Figure 11a-c:
This set probably needs some explanation. Each of the graphs in Figure 9 show an accumulation of species as more samples are taken. They are modified species area curves, which help us determine the number of samples necessary to collect all of the species diversity in a particular area. We would never expect to find all of the species diversity present with only one sample, but how many samples do we need to take? The species area curve will tell us. When the curve levels off, it shows that every time we take an additional sample we keep collecting the species we have seen before – no new species are being collected. This means we have probably found all of the diversity in that area and we can stop collecting samples.

For example, look at Figure 11a. The first time we sampled at 10 feet was trip #2 in the spring and we found zero species in that sample. The second time we sampled at 10 feet was trip #10 in the spring, and this time we found three species. The third time we sampled at 10 feet was trip #11 in the spring. This time we found one species that hadn't been found yet at 10 feet, so now we have a total of 4 species at 10 feet. The fourth time we sampled at 10 feet was trip #13 in the spring. This time we found two species, but both of them had already been seen at 10 feet so there is no addition of new species. After 4 samples at 10

feet we have found 4 distinct plankton species. By the 8th sample, on trip number 21 in the fall, we found 10 species at 10 feet, and that number did not increase when 10 feet was sampled in trip number 22. Does this mean we captured all of the diversity at 10 feet? It's hard to say. I'd want to see several samples with no change before I felt satisfied that I had found all of the species at that depth.

Questions to ask now

1. **For Figure 9a-b:**
    a. Look at each species individually. What is the pattern or trend as depth increases?
    b. Before you try to interpret the meaning of any patterns you found, make some predictions about what you would expect to see. What is the pattern or trend you would expect if a particular species were evenly concentrated throughout the water column? What is the pattern you would expect if a particular species were concentrated at a specific depth?
    c. What conclusions, if any can be drawn from these data? Are any species more or less common at a particular depth? Can you use these data to understand how plankton are distributed throughout the water column?
    d. What additional information would you like that isn't displayed here? What questions do you have as you look at these figures?
    e. How would you redesign the study for next year to better answer your questions?

2. **For Figure 10a-c:**
    a. What is the pattern or trend for spring as depth increases? What is the pattern or trend for fall as depth increases? Compare and contrast the two patterns.
    b. Before you try to interpret the meaning of any patterns you found, make some predictions about what you would expect to see. What is the pattern or trend you would expect if a particular species were evenly concentrated throughout the water column? What is the pattern you would expect if a particular species were concentrated at a specific depth?
    c. What conclusions, if any can be drawn from these data? Does the distribution in the water column vary by season for any species?
    d. What additional information would you like that isn't displayed here? What questions do you have as you look at these figures?
    e. How would you redesign the study for next year to better answer your questions?

3. **For Figure 11a-c:**
    a. What are the patterns or trends in the data? Does there appear to be a different pattern at different depths? Can you see a difference between spring and fall?
    b. Does it appear we sampled all or most of the diversity at each depth? What evidence supports your answer?
    c. What additional information would you like that isn't displayed here? What questions do you have as you look at these figures?
    d. How would you redesign the study for next year to better answer your questions?