

Science Methods & Practice BES 301
November 18, 2009

Data Analysis & Interpretation

Analyzing & Interpreting Scientific Data

% Cover of RCG in wetlands

Wetland Sampled	Bear Creek	North Creek
1	52.9	32.6
2	75.2	84.5
3	51.4	54.2
4	32.1	22.1
5	28.6	77.9
Mean	48.0	54.3
SD	18.7	27.3

What can we conclude?

Analyzing & Interpreting Scientific Data

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1	52.9	32.6
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4	32.1	22.1
5	28.6	77.9
Mean	48.0	54.3
SD	18.7	27.3

How can we decide if these sample averages represent two populations that are really different?

Analyzing & Interpreting Scientific Data

Comparing two mean values

Student's t-test

Some basic statistics to illustrate principles of data analysis & interpretation

For class purposes we will accept a 5% chance of making a type I error ($P < 0.05$)

Comparing Two Means

Comparing two mean values for a difference: Example 1

Question: Is there a difference in the size of coho salmon in Bear Creek as compared to North Creek?

Fish length (cm)

Fish #	Bear Creek	North Creek
1	55.9	52.9
2	64.1	75.2
3	51.4	51.4
4	47.6	32.1
5	62.3	28.6
6	56.9	54.2
7	68.7	44.9
8	77.2	34.0

Next steps?

To Excel

Take 10 minutes to start the analysis

Summarizing data with Excel ★

Fish #	Bear Creek	North Creek
1	55.9	52.9
2	64.1	75.2
3	51.4	51.4
4	47.6	32.1
5	62.3	28.6
6	56.9	54.2
7	68.7	44.9
8	77.2	34.0

Comparing Two Means with Excel 2007's t-test

- Make sure the data you wish to compare are located in columns
- Click on the "Data" tab; select "Data Analysis" function on far right
- Scroll down choices to select "t-test: Two-Sample Assuming Equal Variances"
- In the new dialog box select proper data ranges for variables 1 & 2 (use click & drag on column of numbers to select).
- Leave "Hypothesized Mean Difference" blank and "Labels" unchecked. Make sure Alpha is set to 0.05.
- For output options, indicate "New Worksheet Ply" (sends output table to a new worksheet).
- Click "OK" to perform analysis. Results table will automatically appear on a new worksheet.
- Check that the means and number of observations make sense.
- To see your P-value for comparing two means, look at the result for "P(T<=t) two-tail".

Comparing Two Means

Student's t-test

Question: Is there a difference in the size of coho salmon in Bear Creek as compared to North Creek?

Fish #	Bear Creek	North Creek
1	55.9	52.9
2	64.1	75.2
3	51.4	51.4
4	47.6	32.1
5	62.3	28.6
6	56.9	54.2
7	68.7	44.9
8	77.2	34.0

Conclusions ???

Comparing Two Means

Student's t-test

Question: Is there a difference in the size of coho salmon in Bear Creek as compared to North Creek?

New data set

Fish #	Bear Creek	North Creek
1	55.9	52.9
2	64.1	75.2
3	51.4	51.4
4	47.6	32.1
5	62.3	28.6
6	56.9	54.2
7	68.7	44.9
8	77.2	34.0

Bear Creek	North Creek
42.1	52.9
64.1	75.2
51.4	51.4
47.6	32.1
78.6	28.6
48.9	54.2
68.7	44.9
82.9	34.0

Summarize & test THESE DATA! – 15 min
No histogram needed

Comparing Two Means

Student's t-test

Question: Is there a difference in the size of coho salmon in Bear Creek as compared to North Creek?

Analysis Results ???

Fish #	Bear Creek	North Creek
1	55.9	52.9
2	64.1	75.2
3	51.4	51.4
4	47.6	32.1
5	62.3	28.6
6	56.9	54.2
7	68.7	44.9
8	77.2	34.0

Bear Creek	North Creek
42.1	52.9
64.1	75.2
51.4	51.4
47.6	32.1
78.6	28.6
48.9	54.2
68.7	44.9
82.9	34.0

Mean 60.5 46.7
SD 9.6 15.3

P = 0.048

Comparing Two Means

Student's t-test

Conclusions

Fish #	Bear Creek	North Creek
1	55.9	52.9
2	64.1	75.2
3	51.4	51.4
4	47.6	32.1
5	62.3	28.6
6	56.9	54.2
7	68.7	44.9
8	77.2	34.0

Bear Creek	North Creek
42.1	52.9
64.1	75.2
51.4	51.4
47.6	32.1
78.6	28.6
48.9	54.2
68.7	44.9
82.9	34.0

Mean 60.5 46.7
SD 9.6 15.3

P = 0.048

Comparing Means

Another example for **YOU** to practice

Question: Is there a difference in the water quality of Bear Creek as compared to North Creek?

Table 1. Water quality parameters of Bear and North Creeks. Values are means \pm 1 SD for five replicate measurements at each site.

Water Quality Parameter	Bear Creek	North Creek
pH	5.9 \pm 0.2	5.3 \pm 0.1
Nitrate (mg/L)	6.4 \pm 1.2	9.2 \pm 4.9
Dissolved Oxygen (ppm)	17.5 \pm 1.8	11.3 \pm 3.3

Summarize the data & analyze the differences 10 MINUTES!

Come see me when you are done or have questions

Comparing Two Means



Question: Is there a difference in the water quality of Bear Creek as compared to North Creek?

The t-test results:

Water Quality Parameter	Bear Creek	North Creek	P value
pH	5.9 ± 0.2	5.3 ± 0.1	
Nitrate (mg/L)	6.4 ± 1.2	9.2 ± 4.9	
Dissolved Oxygen (ppm)	17.5 ± 1.8	11.3 ± 3.3	

What are the probabilities of making Type I errors?

Which means are "significantly" different?

Comparing Two Means



Question: Is there a difference in the water quality of Bear Creek as compared to North Creek?

Water Quality Parameter	Bear Creek	North Creek
pH	5.9 ± 0.2	5.3 ± 0.1
Nitrate (mg/L)	6.4 ± 1.2	9.2 ± 4.9
Dissolved Oxygen (ppm)	17.5 ± 1.8	11.3 ± 3.3

Indicate statistical results on this table!

Interpreting Results



Question: Is there a difference in the water quality of Bear Creek as compared to North Creek?

Water Quality Parameter	Bear Creek	North Creek
pH	5.9 ± 0.2	5.3 ± 0.1
Nitrate (mg/L)	6.4 ± 1.2	9.2 ± 4.9
Dissolved Oxygen (ppm)	17.5 ± 1.8	11.3 ± 3.3

Conclusions?

Be careful how you talk about these results:

The higher nitrate levels in North Creek are not statistically significant.

Interpreting Results



Question: Is there a difference in the water quality of Bear Creek as compared to North Creek?

Water Quality Parameter	Bear Creek	North Creek
pH	5.9 ± 0.2	5.3 ± 0.1
Nitrate (mg/L)	6.4 ± 1.2	9.2 ± 4.9
Dissolved Oxygen (ppm)	17.5 ± 1.8	11.3 ± 3.3

Conclusions?

Be careful how you talk about these results:

The higher nitrate levels in North Creek are not significantly greater than Bear Creek.

Interpreting Results



Question: Is there a difference in the water quality of Bear Creek as compared to North Creek?

Water Quality Parameter	Bear Creek	North Creek
pH	5.9 ± 0.2	5.3 ± 0.1
Nitrate (mg/L)	6.4 ± 1.2	9.2 ± 4.9
Dissolved Oxygen (ppm)	17.5 ± 1.8	11.3 ± 3.3

Conclusions?

Be careful how you talk about these results:

The nitrate levels were the same in both creeks.

There was no difference in the nitrate levels of the two creeks.

Interpreting Results



Question: Is there a difference in the water quality of Bear Creek as compared to North Creek?

Water Quality Parameter	Bear Creek	North Creek
pH	5.9 ± 0.2	5.3 ± 0.1
Nitrate (mg/L)	6.4 ± 1.2	9.2 ± 4.9
Dissolved Oxygen (ppm)	17.5 ± 1.8	11.3 ± 3.3

ANY ADDITIONAL Conclusions?

The nitrate levels were the same in both creeks.

Statistical Assumptions

All statistical tests make critical assumptions about the nature of the data

Some assumptions for a Two-sample t-test

1. Samples taken at random
2. From population(s) with normal distributions
 - Examine frequency distribution of samples
 - Consider underlying theory and past research about distribution of your populations
 - Consider data transformation to normalize distribution
 - Consider "nonparametric" tests – appropriate for non-normal data distributions
3. Comparing data sets with equal variances
 - Bartlett's test for homogeneity of variances
 - T-test with unequal variances is available

T-tests are relatively ROBUST with regard to assumption violations – not all statistical tests are!

Data Presentation & Interpretation Exercise

DUE November 26

- Analyze the data in the handout (using principles from class today and previous two periods)
- Present data in a table with accompanying text appropriate for a "Results" section of a research paper
 - ✓ Use principles from today and Wednesday's class (11/19)
 - ✓ Use principles gained from class discussions of structure of a research paper and your readings of research papers
 - ✓ Double-space text (up to two pages in length)
- Present "Results Summary" & "Discussion" paragraphs
 - ✓ Results: highlight most significant trends, results
 - ✓ Discussion: implications of results based upon background info
 - ✓ About ½ page in length each
- See assignment handout for details

Comparing Means

Data from earlier in-class example (not homework assignment)

Question: Is there a difference in the water quality of Bear Creek as compared to North Creek?

pH		Nitrate		Dissolved O ₂	
Bear Creek	North Creek	Bear Creek	North Creek	Bear Creek	North Creek
5.9	5.3	7.9	9.2	19.1	15.1
5.7	5.4	5.7	5.4	16.5	12.6
6.1	5.3	6.4	3.5	15.8	8.1
5.8	5.2	4.8	15.6	18.6	13.1
6.1	5.1	7.0	12.2	18.9	7.5