

ISSUES : DATA SET

Exploring the population dynamics of wintering bald eagles through long-term data

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Photo 1: Adult bald eagle flying in a winter sky. Photo by Tom Michalski.

THE ECOLOGICAL QUESTION:

How does a bald eagle population change over time at a winter migratory stopover and which factors influence its abundance?

ECOLOGICAL CONTENT:

Bald eagle biology, conservation biology, endangered species, population ecology, and migration ecology (stopover)

WHAT STUDENTS DO:

Guided Approach: Students will generate questions about bald eagle numbers influenced by weather and food availability. Students will then use graphing software (JMP or Excel) to compile the data in a graphical form to answer their questions.

Open-ended Approach: Students will generate their own hypotheses of interest from the larger bald eagle data set. This approach is encouraged for upper division ecology students in conservation biology, wildlife management, or population ecology classes.

Optional: Field trip to see migrating bald eagles.

STUDENT-ACTIVE APPROACHES:

Brainstorming, critical thinking, concept mapping, cooperative learning, guided inquiry, and/or open-ended inquiry

SKILLS:

Generation of a hypothesis, critical thinking, experimental design, data management using a spreadsheet, graph preparation, data analysis and interpretation, and/or written or oral presentation.

ASSESSABLE OUTCOMES:

Proposal of research, figures from spreadsheet data, written interpretation of data, short or full research reports, and/or oral reports

SOURCE:

U.S. Department of the Interior, Bureau of Land Management, Coeur d'Alene Field Office, archived data.

ACKNOWLEDGEMENTS:

This data set was developed for Biology 323, Conservation Biology, at Gonzaga University and was improved by input from students in that course. We would like to thank Joe Lint for the initiation and creation of this bald eagle survey; Bureau of Land Management (BLM) employees and volunteers, Lew Brown, Terry Kincaid, and Corinne Cameron, for their years of bald eagle data collection; BLM Coeur d'Alene Field Office for the funding that made these data collections possible; Idaho Fish and Game for kokanee salmon data; Elizabeth Bart and Scott McCloskey for initial teaching ideas; Tracy Morgan for the creation of the survey site map; Ann-Scott Ettinger for aid in developing the checklist assessment tool; Carol K. Augspurger for use of the research proposal and glossary; and Ed Dole, Sheila Lyons-Sobaski, Jennifer Rubin and three anonymous reviewers for helpful comments on previous drafts.

OVERVIEW OF THE ECOLOGICAL BACKGROUND

The availability of long-term data on bald eagles (*Haliaeetus leucocephalus*; Photo 1) provides a unique opportunity to study the population dynamics of this culturally and ecologically important bird. In conservation biology, the bald eagle provides a unique example of a species that has overcome the imminent threats of extinction (Grier 1982). Because of its endangered status in the early 1970s (Buehler 2000), several agencies and biologists initiated long-term surveys. Some of these surveys have been implemented at a local scale, and others are nationwide, such as the Midwinter Bald Eagle Survey (Steenhof et al. 2008). Some of the data from these long-term surveys have been analyzed (Arizona see Grubb 2003, Western Washington see Dunwiddie and Kuntz 2003, and Glacier National Park see McClelland et al. 1994), but other data sets have yet to be fully investigated.

Several of these long-term data sets have been gathered during the winter migration when bald eagles aggregate at stopover sites on lakes and rivers along their migration routes. In the U.S., the eagles move from their summer resident locations in the north towards the south. The primary hypothesis for this movement is that the food supply (primarily fish and, to a lesser degree, ducks) becomes less available as winter approaches and drives the eagles south (McClelland et al. 1994). Several factors influencing bald eagle populations along their migration stopovers have been studied, including weather (Grubb 2003), feeding site characteristics (Dunwiddie & Kuntz 2003; Mull and Wilzbach 2007) and human disturbance (Stalmaster and Kaiser 1998; Dunwiddie and

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Kuntz 2003). Long-term patterns may also differ among adult versus immature eagles (see McClelland et al. 1994; Dunwiddie and Kuntz 2003; Grubb 2003). The data sets we use in this activity come from the Bureau of Land Management in Northern Idaho. Since 1974, they have counted migrating bald eagles every midwinter at Lake Coeur d'Alene. The eagle counts are taken on a weekly basis at several sites on the northeast end of the lake. The adult and immature eagles are counted separately. Additional data on the kokanee salmon (*Onorhynchus nerka*) abundance in the lake, weather events, and site characteristics have been assembled.

References:

- Buehler D. A. 2000. Bald Eagle (*Haliaeetus leucocephalus*). In A. Poole and F. Gill, editors. The Birds of North America. Philadelphia. No. 506, The Birds of North America, Inc., Philadelphia, PA.
- Dunwiddie P. W., and R. C. Kuntz II. 2001. Long-term trends of bald eagles in winter on the Skagit River, Washington. *The Journal of Wildlife Management* 65:290-299.
- Grier J. W. 1982. Ban of DDT and subsequent recovery of reproduction in bald eagles. *Science* 218:1232-1235.
- Grubb T. G. 2003. Wintering bald eagle trends in Northern Arizona, 1975-2000. *The Southwestern Naturalist* 48:223-230.
- McClelland B. R., L. S. Young, P. T. McClelland, J. G. Crenshaw, H. L. Allen, and D. S. Shea. 1994. Migration ecology of bald eagles from autumn concentrations in Glacier National Park, Montana. *Wildlife Monographs* 125:3-61.
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- Stalmaster M. V., and J. L. Kaiser. 1998. Effects of recreational activity on wintering bald eagles. *Wildlife Monographs* 137:3-46.
- Steenhof, K., L. Bond, and L. L. Dunn. 2008. The midwinter bald eagle survey results and analysis 1986-2005. U.S. Geological Survey, National Biological Information Infrastructure, and Northwest Alliance for Computational Science and Engineering. Available on-line at <http://www.nacse.org/nbii/eagles>. (Accessed November 22, 2010.)

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STUDENT INSTRUCTIONS

This data set explores factors affecting the population numbers of bald eagles (*Haliaeetus leucocephalus*; Photo 2) surrounding Lake Coeur d'Alene, Idaho. The Bald eagle is a large bird of prey that demands our attention by its physical features, its history of near extinction, and its dynamic population seen today.

Background Information:

The population trend of the bald eagle during the past 70 years provides a history with several important lessons. After World War II, the insecticide, dichlorodiphenyl-trichloroethane (DDT), was allowed for widespread agricultural use. Despite its effectiveness in killing insect pests on crops, the chemical accumulated in the body tissues of bald eagles (through biomagnification), making the birds unhealthy and causing them to lay thin-shelled eggs that broke as soon as the parents sat on them to begin incubation. The numbers of bald eagles in the contiguous United States, which were already declining due to hunting, plummeted as a result. The bald eagle was listed as endangered under the Endangered Species Act of 1973, and this protection, combined with the national ban on DDT in 1972, is credited with leading to the recovery of these magnificent birds.

Bald eagle numbers not only vary over historical time, but they also vary across the landscape with changes in the seasons. Like many birds, most bald eagles migrate in the winter in search of food. The primary food source for bald eagles is fish, and the eagles need open water to access the fish, which in many locations consists of spawning salmon at the shallow edges of lakes and streams. Once the lakes and streams freeze over, the eagles have to use an alternative food source (i.e., carrion such as dead deer or elk) or go elsewhere. Bald eagles will also feed on ducks, although not as frequently as fish. During the migration the eagles follow a route with several stopovers at lakes and streams along a southward corridor. The bald eagles travel individually, and although a given eagle may spend only a week or two at a stopover, collectively the eagles may be present for several months. Although the birds travel as individuals, once at a stopover, they will roost together in the evening (i.e., location where eagles gather to sleep for the night) and perch together in the same or adjacent trees.

Because of its endangered status in the early 1970s, several agencies and biologists initiated long-term surveys. Some of the surveys are ongoing nationwide surveys, such as the Midwinter Bald Eagle Survey, and others are local surveys such as the data set that is the focus of this activity. Since 1974, just two years after the ban on DDT, the Bureau of Land Management in Northern Idaho has counted migrating bald eagles every winter.

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The bald eagle counts are taken on a weekly basis at eleven sites around Wolf Lodge Bay on Lake Coeur d'Alene in the Pacific Northwest (Figure 1). The eagles stop at Lake Coeur d'Alene because of the availability of kokanee salmon, which is a land-locked strain of sockeye salmon (*Onorhynchus nerka*). The salmon live to about three years of age and then spawn in November or December, dying immediately after spawning and leaving a large number of carcasses in the shallow water for the eagles to feed on. The biologists go out by car and count the number of eagles on perch trees or flying at these sites. The adult and immature eagles are counted separately. The sites are usually visited once per week in the morning from mid-November to the beginning of February with the highest numbers of eagles usually being present during December. In addition, the biologists record weather conditions, human activity at each site, salmon abundance, and various other factors that could influence the counts of migrating eagles.

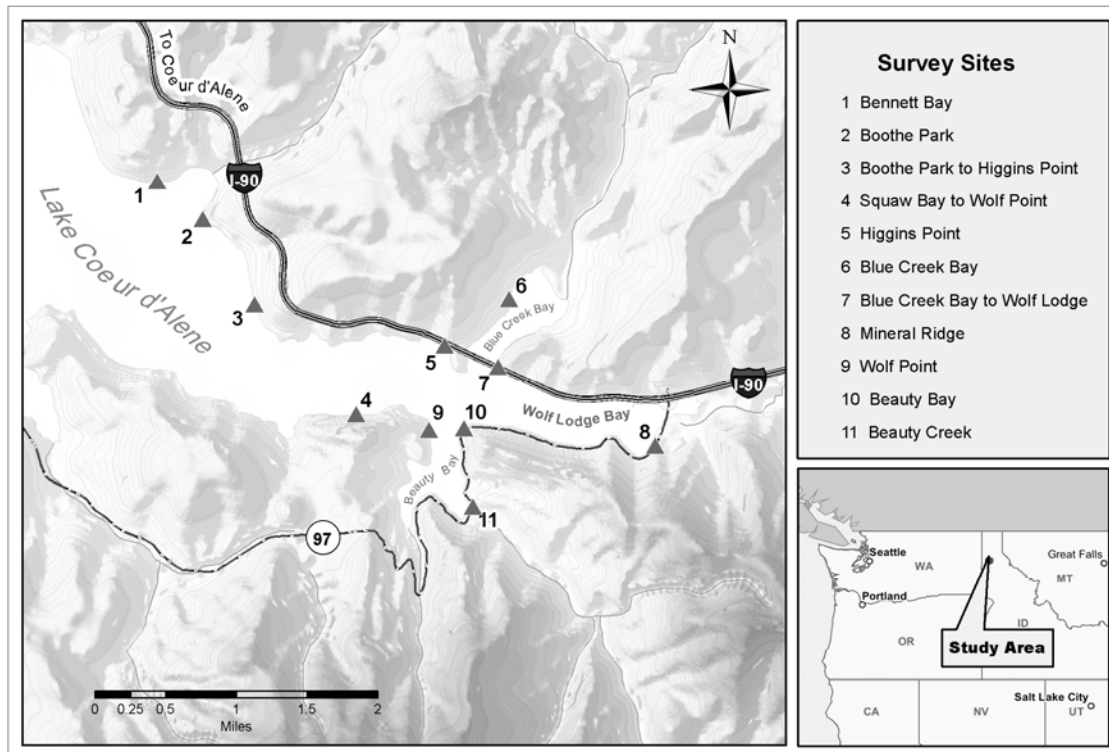


Figure 1: Map of the study area in the Pacific Northwest (United States) and the bald eagle winter survey sites along Lake Coeur d'Alene, Idaho.

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Instructions (Instructor will assign one of the approaches below):

Guided approach:

Part I: How does the bald eagle population at a winter stopover change over three decades?

1. Look over the terms in the glossary and the proposal worksheet (provided by your instructor). For example, what is the difference between the dependent variable versus the independent variable? Open the excel file with the data for the guided approach (provided by your instructor) and examine the data. Apply the terms from the glossary to the data in the excel file. Are the data continuous or categorical?
2. You already know the question we want to ask about bald eagle numbers over the last thirty years since the ban on DDT, so make a prediction. Do you think there are more migrating bald eagles at Lake Coeur d'Alene? Less? Will the numbers fluctuate over time? Why did you make this prediction? Your explanation for your prediction is your hypothesis. Some scientists will combine the prediction and hypothesis into one "If-then" hypothesis. The "if" clause contains the hypothesis and the "then" clause contains the prediction that is to be tested (see instructor provided examples). When making a hypothesis you are making assumptions for factors that will not vary with your treatments. For example, you are assuming that the eagles will migrate along a similar path each year.
3. To answer your question, you need to determine the data needed (i.e., experimental design). There are different types of experimental approaches, such as manipulative (you manipulate the independent variable and measure the dependent variable) and observational (you measure a response in nature, dependent variable, and nature provides the manipulation, independent variable). We are dealing with the latter situation. Complete the research proposal worksheet (provided by your instructor), using your resources.
4. Graph the data from the provided excel file (provided by your instructor), using your proposal to assist you. What does your graph say or what is the pattern that your data shows? What does your graph *mean* or what is your interpretation of the data pattern? Was your prediction accurate? Do the data support your hypothesis?
5. If your instructor tells you to do so, perform the appropriate statistical analysis and re-evaluate your response to the graph.

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Part II: How do salmon abundance and December temperatures influence bald eagle numbers?

1. In the Excel file (provided by your instructor), you will notice two more columns of data, one for salmon numbers and one for December temperatures at Lake Coeur d'Alene. Your instructor will assign you one of these topics to explore. Complete the proposal worksheet (provided by your instructor) for your assigned topic and create the associated graph. If your instructor tells you to do so, perform the appropriate statistical analysis.

2. What does your graph say? What does your graph *mean*? Was your prediction accurate? Do the data support your hypothesis?

3. *Optional:* Create an additional graph that shows your assigned variable plotted over time. Compare this time graph with the original eagle over time graph. Do you see any patterns that may help you to better understand the data?

4. If your hypothesis was not supported, list some possible reasons why the trend could have deviated from what you predicted. Could there be other factors at work?

Questions for Discussion:

1. Some people may argue that the bald eagle population is definitely recovering based on these data. Do you agree? Why/why not? Also, do you expect these trends to be the same at all sites within Northern Idaho? at sites in adjacent states? during the current decade or in future decades?

2. Explain the relationship between bald eagles and salmon abundance. Is it possible that there are other factors at work? If so, what are they? What would you predict for the bald eagles in the future, based on your results?

3. Explain the relationship between bald eagles and December air temperatures at Lake Coeur d'Alene. What other weather factors might be at work, and what impact would these have on the migrating eagles?

Open-ended Approach:

Read the background information and look over the data available (provided by your instructor). As you explore, make notes about the factors influencing bald eagle numbers that interest you. Select one of those factors to investigate. For example, this could be a question relating to weather and eagle numbers or how human activities have affected eagle numbers. After you have decided on a

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question to investigate, complete the research proposal worksheet. If you have questions on the proposal components then see the guided approach Part I above and/or the glossary associated with the proposal worksheet (provided by your instructor).

Following completion of the proposal worksheet, conduct your experiment with the provided data. Use a statistical package such as JMP or a data management package such as Excel—your instructor will tell you what program you have available for use. Graph your data using JMP, Excel or another graphing package. Keep a record of your statistical outcomes and graphs. Your instructor will advise you on what kind of report or project he/she would like you to complete.

Questions for discussion:

1. What physical changes could have occurred at the survey sites surrounding Lake Coeur d'Alene over the time scale of the survey that might have an impact on the data? Would these changes affect your conclusions?
2. Would patterns of abundance be the same for immature and adult bald eagles?
3. What factors did you choose to analyze and why?
4. Given the results of your analyses, what would you predict for the bald eagle population in the near future? Can you propose some alternative hypotheses for your project or some follow-up related hypotheses to test?



Photo 2. Adult bald eagle (left) with distinctive physical features perched in a cottonwood tree and an immature bald eagle (right) with a mixture of brown and white plumage in the winter environment. Photo by Tom Michalski.

NOTES TO FACULTY

Description of Excel Files:

- Student Data Guided Approach: Contains a subset of the data for students to use in the guided approach. [[xls](#)]
- Student Data Open-ended Approach: contains all data for students to reference and use at will. [[xls](#)]

Description of other Resource Files (Files with “Student” in the title are meant for student use and files with “Faculty” in the title are meant ONLY for faculty use):

- Student Research Proposal and Glossary: contains the elements of the scientific process and experimental design to guide students in the activity. Also included is a glossary of associated terms. [[doc](#)]
- Faculty Experiments for Guided Approach: Table 1 that includes the scientific process and experimental design for the three experiments described in the guided approach. [[doc](#)]
- Faculty Data Analysis for Guided Approach: contains graphed data and data analysis for the three guided approach questions. [[doc](#)]
- Faculty Sample Experiments for Open-ended Approach: Table 2 that includes the scientific process and experimental design for five possible student experiments. [[doc](#)]
- Student Graph Rubric for Guided Approach: contains a rubric to aid in grading student created graphs and answers to discussion questions. [[doc](#)]
- Student Short Checklist for Guided Approach: contains an example of an assessment tool for a short report. [[doc](#)]
- Student Full Checklist for Open-ended Approach: contains an example of an assessment tool for a full research report. [[doc](#)]

How to Use this Data Set in a Class:

This data set can be utilized for two separate kinds of exercises: a guided approach and an open-ended approach. Either method will involve students working in small groups and a graphics/analysis program (i.e., Excel or a statistical package like JMP). Regardless of which approach is used, instructors are advised to communicate (oral or written) to the students as to which data set(s) should be used, the approach used, and the assessments involved. Initially, the instructor may want to create a format (discussion or written) for

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students to brainstorm about the various factors that can affect bald eagle populations and to organize the factors into a logical conceptual framework (i.e., concept map).

To enhance the students' experience with bald eagles, the instructor can add a winter field trip to local bald eagle or raptor populations in their area. Perhaps local federal biologists, state biologists, or members of the Audubon society can accompany students on the field trip. We recommend the field trip prior to the activities below.

Guided Approach:

The guided approach to this data set is subdivided into three parts. Part I could be completed within a thirty-minute period of lecture or lab. Part II would take an additional thirty-minutes beyond Part I, most likely in a lab setting, however could be assigned for homework in a lecture setting. Part III is an extended activity that the instructor could develop on their own, and depending on the desired complexity, students would probably need an additional hour to hour and a half.

Part I: Bald eagles over time

Depending on the students' familiarity with the scientific process and formulating hypotheses, it might be worthwhile for the instructor to lead the students as a large group through Part I. Specific instructions for working Excel or another spreadsheet program are not included due to the variety of programs available, so students may require additional help with graphing and performing statistical analyses. Frequent problems include students mislabeling axes or swapping the variables (e.g. putting dependent variable on the x axis). Sometimes students will make the mistake of assuming the eagles migrate as a flock. Remind them that the bald eagle migration is largely solitary and birds arrive and leave as individuals. Instructors will need to provide the students with the [Student Research Proposal and Glossary handout](#) and the excel data file [Student Data Guided Approach](#).

Part II: Salmon and Temperature exploration

This is more easily done with students in groups of two or three, though students can also work as individuals. For the sake of a short time period, assign each group—or allow them to choose—to test either salmon abundance or air temperature, or allow them to do both if the time allows. Use the [Faculty Data Analyses for Guided Approach handout](#) to ensure your students are making the proper graphs, and refer to Table 1 ([Faculty Experiments for Guided Approach handout](#)) for samples of hypotheses for the salmon abundance and air temperature variables. If time permits at the end, have students briefly share their hypothesis and results with the rest of the class.

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Part III: Bald eagle patterns at larger scales

Expanding on the above activities, the instructor can utilize the Midwinter Bald Eagle Survey, which includes data from the entire contiguous United States. The data can be found at: <http://ocid.nacse.org/nbii/eagles/>. The excel file for the [Student Data Open-ended Approach](#) contains several tips if this activity is incorporated. We suggest an activity that allows students to compare the bald eagle pattern from Part I above to the surrounding Northern Idaho area. Students could also locate data from different regions of the country. We do recommend that prior to implementing this activity that the faculty member spend some time using/exploring the online database.

Open-ended Approach:

We conduct the open-ended approach with a field trip prior to the labs and then two consecutive three-hour labs. During the first lab period, we have a guest speaker talk to our students about bald eagles (30 minutes). The presentation is followed by a short discussion about experimental design using the “Guided Approach Part I” and data management instruction (30 minutes). The students spend the majority of the time brainstorming in small groups about possible questions to answer, complete the [research proposal worksheet](#), and assemble their data into a spreadsheet. In our case we hand students the handwritten raw-data sheets from the field and they enter the data. This latter task has largely been completed for your students. During the second lab period, we provide an initial statistical introduction (30 minutes, in addition to a pre-lab statistical reading assignment (*not provided*) and initial statistical JMP training for our students (30 minutes) prior to the data activity. The students spend their time revising their proposal with feedback from the instructor, graphing the data, and performing the appropriate statistical analyses. At the end of this lab, we have our students briefly share their hypothesis and results with the rest of the class. This open-ended analysis allows students some creativity in exploring factors of interest and will utilize the [full dataset](#). This approach is appropriate for discussions of conservation biology, wildlife management, and population ecology, involving upper division students. Each student or small group of students should form an hypothesis to test with the data. Possible hypotheses are included but not limited to those in Table 2 ([sample experiments](#)). Courses using GIS could collect additional site information. Students may require additional knowledge about various statistical techniques.

Assessment Methods:

We envision a variety of potential assessments, depending on the activities chosen, the students’ skill level, and the goals of the instructor. Options include a short report, a full scientific report, answer to questions and graphs, and lab notebook and graphs. The [short scientific report](#) (not to exceed two pages)

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includes a title, question, hypothesis (“If-then” format), written results, their graph, and the take home message. For more advanced students or those who complete Part III guided approach or the open-ended approach, a [full scientific report](#) including a full introduction, methods, and discussion may be a better assessment. Additionally, for classes with limited time, handwritten or typed answers to the questions for discussion or a written account in a lab notebook, both including graphs, may be sufficient ([sample graph rubric](#)). The students should, regardless of the assessment method, be able to describe their hypothesis and prediction and be able to apply their results to the “big picture” of bald eagle population dynamics.

Specifically, for the guided activity, we have found the short report to work well. For the open-ended approach, we have used the short report for the initial assessment and provided the students with feedback. Then we used the full scientific report for the final assessment. We have not used the research proposal worksheet for formal assessment but it could be incorporated if desired.

Resources for Further Information:

Bald Eagle

- Stalmaster M. V. 1987. *The Bald Eagle*. Universe Books, New York. Book on the history and ecology of the bald eagle
- <http://www.fws.gov/Midwest/eagle/recovery/biologue.html>
U.S. Fish and Wildlife Service’s bald eagle fact sheet
- <http://www.epa.gov/history/topics/ddt/02.htm>
EPA Information on DDT
- http://www.blm.gov/id/st/en/fo/coeur_d_alene/special_areas/Mineral_Ridge-Wolf_Lodge_Bay.html
Bureau of Land Management and wintering bald eagles in Northern Idaho
- <http://www.llbc.leg.bc.ca/public/pubdocs/bcdocs/167109/wr62.pdf>
Status of the bald eagle in British Columbia
- <http://ocid.nacse.org/nbii/eagles/>
Midwinter Bald Eagle Count Web Site conducted from 1986-2005 along 746 routes in 43 states

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Bald Eagle Field Trip

- Breining G., F. F. Oberle. 1994. Return of the eagle: how America saved its national symbol. Falcon, Helena, Montana.
Book that includes an eagle-viewing directory for the United States
- <http://www.nwf.org/News-and-Magazines/National-Wildlife/Birds/Archives/2005/Where-the-Eagles-Are.aspx#WebExclusive>
National Wildlife Federation information on viewing wintering bald eagles

Graphing, Writing and Data Analysis

- <http://people.usd.edu/~bwjames/tut/excel/>
Excel tutorials (if available to the students)
- http://www.jmp.com/support/knowledge_base.shtml
JMP tutorials (if available to the students)
- Pechenik, J.A. 1993. A short guide to writing about biology. Second edition. HarperCollins College Publishers, New York, N.Y. 240 pages.

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