**Subject area/course**: Science/Biology; Mathematics/Algebra II

**Grade level/band**: 10-11

**Task source**: Achieve

**Honey Bee Colony Analysis**

**STUDENT INSTRUCTIONS**

1. **Task context**:

It is said that one out of every three bites of food that we eat comes from a plant that was pollinated by a bee. Honey bees transfer pollen as they move among many different flowers in their search for food/pollen, and account for 80% of all pollination by insects. Because of their huge pollination contribution, humans have come to rely on honey bees. For example, we depend on honey bees to pollinate crops, such as fruits, vegetables, and tree nuts. Indeed, honey bee-driven pollination is needed for high fruit and vegetable yields, resulting in an estimated $15 billion increase in crop value each year. Additionally, we use products that honey bees create, such as honey and beeswax, to make things the people want and need. For example, we use honey bee venom to make arthritis medicine.

Many honey bee colonies have experienced a significant drop in numbers of bees. This phenomenon is referred to as Colony Collapse Disorder (CCD). Overall, CCD is expected to have an economic impact on food production that significantly affects humans. As a result, government agencies and scientists from around the world are researching CCD. Part of that research involves identifying bee colonies that are affected and documenting changes in bee colony numbers in different geographic areas. Another important part of their research is studying the potential causes of CCD. Currently, scientists have identified at least three potential causes: parasites, pesticides, and poor nutrition of the bees. It is not yet clear if just one of these, or some combination of these, is causing CCD.

Task Component A

* Use the provided data on honey bee populations (Attachment 1) to graph the change in U.S. (not California- or South Dakota-specific data) bee colony numbers over time on a scatterplot. You may do this by hand or by using a graphing or spreadsheet program to create plots.
* Choose a mathematical function (linear, exponential, logarithmic, etc.) that can be used as a model of the change in bee populations over time for the entire time range of the dataset (1939-2013).
* Write an equation for the function that best fits the entire dataset.
* Using only the function created, describe the changes in bee colony numbers in the United States over time.
* Make a prediction for how bee colony numbers will change in the future, based on the mathematical function you chose.

Task Component B

Reconsider the scatterplot of U.S. bee colony numbers as follows:

* Subdivide the dataset and choose at least two different functions to describe the change in bee colonies over time.
* Write an equation for each of your functions.
* Describe why you might want to model different portions of the data with different functions
* Describe what this might mean for how the bee colony data would be interpreted.

Task Component C

Use the provided data on honey bee populations (Attachment 1) to graph the change in bee colony numbers over time in California and South Dakota on a scatterplot(s).

* Choose a mathematical function or functions (linear, exponential, logarithmic, etc.) that could be used to model the change in bee populations over time in each state.
* Write an equation(s) for the function(s) that best fits the entire dataset.
* Compare the U.S., California, and South Dakota datasets and cite specific similarities and/or differences among the scatterplots and the functions and equations that model the data.
* Answer the following questions:
* Can the smaller scale of state data be used to understand/make predictions about the larger scale model for the United States?
* Which state would you chose to use if you wanted to conduct a smaller scale experiment on bee colonies that could be used as a way to test solutions for the changes affecting bee colony numbers in the entire U.S.?
* Are there any additional factors you would need to consider? Describe the reasoning behind your answer.

Task Component D

* Using what you know about the limiting factors that affect populations in an ecosystem (predation, competition for food, competition for living space, disease, etc.).
  + Identify what factors may limit the bee population and
  + Determine or defined the carrying capacity of the bee population keeping it stable
  + Identify what factors may cause the drastic change in the bee populations.
* Students will also answer the following questions:
  + Based on the functions that you defined in Task Components A and B, at what point do you think these factors affecting the bee population changed? Describe the reasoning behind your choices. Cite the U.S. or state bee colony numbers, plots, functions, and/or equations as evidence as appropriate.
  + Consider and describe the pressures and influences of the larger-scale ecosystems that honey bees are a part of and/or interact with, including the human ecosystem. See Attachments 2 and 3 for a chart and scatter plots of human population data for the U.S., California, and South Dakota to reference when you are constructing your answer.

Task Component E

* Review the suspected causes of colony collapse disorder (see the USDA-Agricultural Research Services “Honey Bees and Colony Collapse Disorder” webpage or any other external references you may find helpful).
* While reviewing above, make a chart of the evidence that connects each suspected cause to CCD and any information on when these cause agents may have become an issue or problem, such as when an invasive species may have been introduced.
* Based on your research and the data and plots produced in previous task components, revise your discussion for (a) what factors they think limited the bee populations and determined or defined the carrying capacity of the bee population, keeping it stable, and (b) what factors they think caused the drastic change in the bee populations.
* Based on the functions students defined in Task Components A and B and the data plots, students should evaluate at what point they think these factors affecting the bee populations changed, and how does this timing relate to what is known about the timing of the suspected cause agents?

Task Component F

Reconsider their comparison of the U.S., California, and South Dakota bee colony number datasets as follows:

* Based on what you have learned about the suspected causes of CCD and through your evaluation of the U.S. bee colony numbers dataset, revise your explanation for how the smaller scales of state data can be used to understand/make predictions about the larger scale model for the United States.
* Include in your revision a description of what you think the data suggest about whether each of the smaller-scale state bee ecosystems are affected by the same causes/stressors as is the larger U.S. bee ecosystem.

Task Component G

* Construct an argument of how continued trends related to changes in bee colony numbers might be impacting the stability and biodiversity of ecosystems in which the bees participate. Describe effects on ecosystems outside of the human agricultural system as well as effects on the human ecosystem, specifically related to food production. Clearly state the boundaries and scale of the human and non-human ecosystems that you are describing.
* Cite your data plots, functions, and equations as evidence and describe why they can be used as evidence.
* Review and cite scientifically relevant external references and examples as evidence.

Task Component H

* Based on external research, construct a list of suggested solutions for CCD. In the list, include solutions that require or use new forms of technology as well as those that are associated with changes in beekeeping practices.
* Choose one of these solutions and evaluate the solution using your understanding of population changes and ecosystem stability and any evidence or data uncovered in research of the solution.
* Describe how this solution is intended to work to decrease the effects of CCD, determine how well the solution meets the criteria and constraints that are listed below, and define trade-offs in instances of competing criteria:
  + The solution is effective in decreasing the effects of CCD on bee populations
  + It is low in cost
  + It isn’t too complex (doesn’t require a large number of different types of changes)
  + It is safe for beekeepers to use or administer
  + It has minimal effect on other species in the ecosystems in which the bees participate
  + It addresses as many suspected causes of CCD as possible
  + It is reliable through repeated use
  + It addresses any cultural, social, or aesthetic concerns of the human community in which the solution is being used
  + If it involves technology, it is an accessible solution for beekeepers with a range of technological knowledge and capabilities
* Respond to the prompt: Based on your evaluation, do you feel that the solution is a viable solution for CCD given the constraints? Describe your reasoning.

1. **Final product**:

In this task, you will (1) investigate bee colony population numbers, (2) consider factors that are affecting these numbers, and (3) develop and evaluate potential solutions to decrease bee colony loss due to CCD.

**ADDITIONAL INFORMATION**

1. **Knowledge and skills you will need to demonstrate on this task**

* Making scatter plots
* Creating a mathematical equation for the pattern of the data
* Analyze and compare data and problem solve real life reasons for the differences
* Bee life
* Density dependent and density independent population change
* Limiting factors that might affect populations
* Integrate multiple sources of information to support your argument/position

1. **Materials needed:**

* Access to graphing calculators and/or a computer plotting or spreadsheet program
* Access to the Internet
* Suggested resources:
  + Honey Bees and Colony Collapse Disorder, from U.S. Department of Agriculture Agricultural Research Service with information on CCD: [www.ars.usda.gov/News/docs.htm?docid=15572](http://www.ars.usda.gov/News/docs.htm?docid=15572)
  + Optional introductory video: [www.youtube.com/watch?v=eB4HdG8he4g](http://www.youtube.com/watch?v=eB4HdG8he4g)
  + U.S. Historical Population Data: [www.census.gov/popest/data/historical/](http://www.census.gov/popest/data/historical/)
  + USDA National Agriculture Statistics Service’s reports: <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1191>

1. **Time requirements:**

This task will take approximately two weeks to complete. Your teacher will provide additional details.

1. **Scoring:**

Your work will be scored using the SCALE Scientific Literacy Rubric (Bee Colonies). You should make sure you are familiar with the language that describes the expectations for proficient performance.