Sampling Strategy Challenge

Below is an interactive "Sampling Strategy Challenge" activity to help students to understand the process behind planning a cruise. It introduces students to the tools scientists can now utilize (both prior to and during cruises) to more wisely choose the drop-off location for each instrument while maximizing data coverage for the SPURS sampling site. Using the JPL Trajectory Tracking Tool, students will walk through this process and become familiar with the challenges scientists face in conducting research on the open ocean.

The goals of the following activity are to:

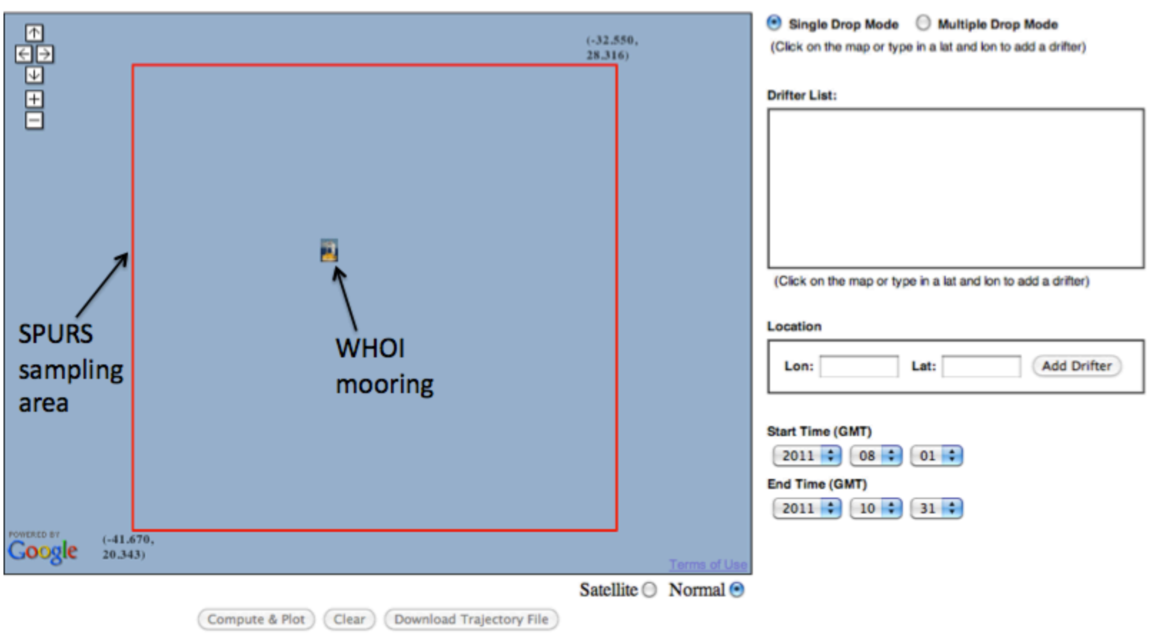
- Introduce a mathematical model,
- Illustrate how one example model works,
- Demonstrate how models can be used in real-life science research, and,
- Give insight into the process of planning an oceanographic cruise.

Some notes about this version of the Sampling Strategy Challenge

- Instructions and Notes: Although the instructions are the same as the students and written as if the students are following them, this version of the Challenge has additional details (*italicized)* that are not found in the Student Challenge. As you read this document, *italicized "Notes"* are provided to point out specific details of the tool or the activity.
- Questions: The **bolded questions (Q1, Q2, etc.)** indicate the questions that the students are asked to answer as they go along. In this version, below each **bolded question** there is a short *italicized* answer; these explanations are not in the student version. These are very brief and broad explanations to orient you to the concepts this exercise addresses.
- Sketching boxes: Students are instructed to sketch model outputs in boxes throughout the exercises. These sketching boxes are included in their worksheet, but we have not included them here. There is a page of boxes at the bottom of this document in case you need to make extra copies for students.
- Output Screen Grabs and Captions: In this version of the Challenge screen grabs of the model outputs are included to provide more information about what you and the students will be seeing throughout the exercises and to address any confusing details of the tool and its capacity. These screen grabs were not included in the student version (with the exception of one). Below each screen grab, there is also an *italicized* caption describing the figure.

Activity Introduction:
To get started, go to the JPL Trajectory Tracking Tool website (http://ourocean3.jpl.nasa.gov/SPURS/drifters.jsp) to get the 'lay of the land' (ocean?). In the browser window students will see a map with a red box outlined in the middle of the Atlantic Ocean. This area represents a region in which a model is run that can be used to create simulated drifter tracks for deployment in the SPURS sampling area. They will use the "+" button in the top left-hand corner to zoom in until the box is large enough to fill most of the viewing window. The tiny image inside the red SPURS box shows where the Woods Hole Oceanographic Institution (WHOI) mooring will be located within the sampling area. A mooring is an instrumentation package that is anchored to the sea floor and does not move. On the right are controls for the tool. The following activity will acquaint your students with manipulating the tool.

Note: This tool only uses water currents and circulation data from August 1, 2011, until October 31, 2011, based on the assumption that scientists have made that circulation patterns would be similar from year-to-year in this area.

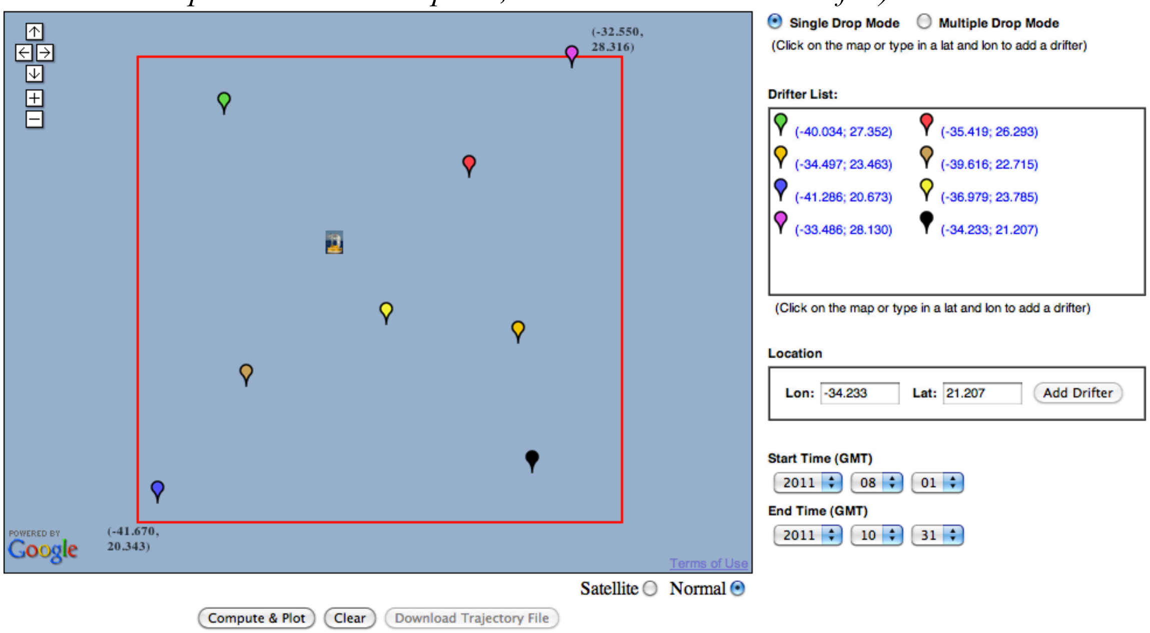


Screenshot of the JPL Trajectory Tracking Tool viewing window with the WHOI mooring and the SPURS sampling area identified.

Part 1: What is a model and how does it work?

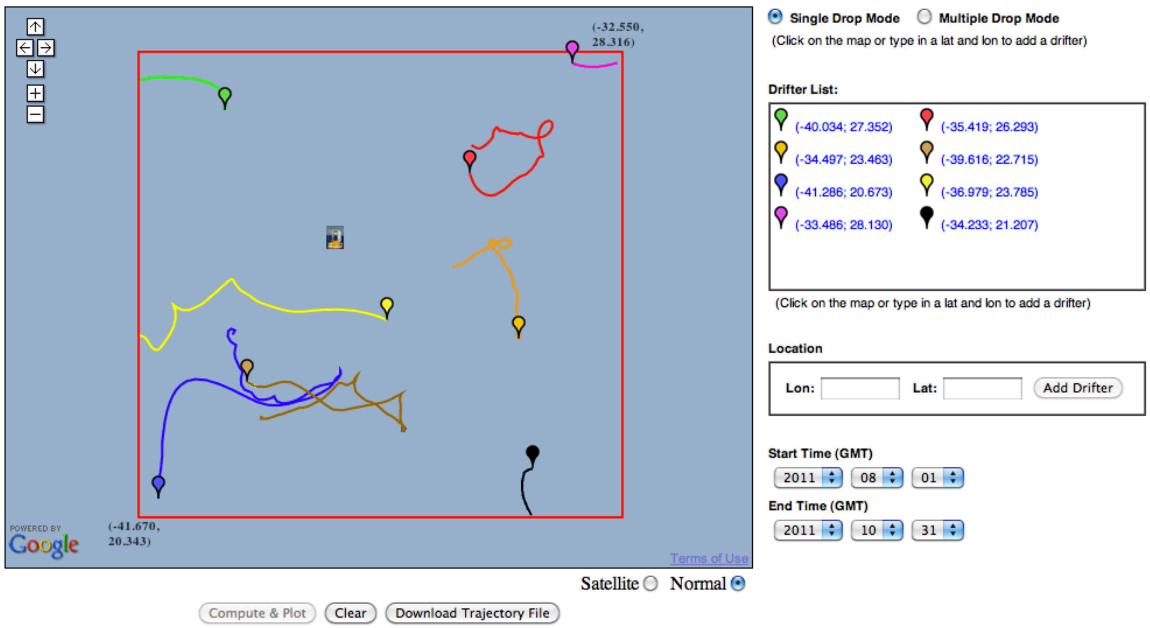
Goal: This part of the Challenge will introduce you to a model that simulates movements of oceanographic equipment in a specific area, getting you familiar with how some models work, the different types of data they use and the outputs they deliver.

1.) Select the "Single Drop Mode" option in the JPL Trajectory Tracking Tool controls in the top right corner of the window.
2.) Move the cursor into the red box and click. Each click will place a drifter to be tracked (colored balloon). Place a total of eight drifters within the SPURS sampling site.
    a. *Note: For each click/placement, a colored balloon will appear on the map, and the longitude (lon, e.g. 45W) and latitude (lat, e.g. 30N) of this drifter will be recorded in the "Drifter List" box.*
3.) Record the longitude ("lon"; e.g., 45 degrees W) and latitude ("lat"; e.g., 30 degrees N) coordinates of each drifter from "Drifter List" box on the right – you will need this information for the following steps.
    a. *Note: Students may also be instructed to use the mouse to highlight all the info in the Drifter List box, and then copy/paste the info into a separate place onto the computer, such as a Word or Notes file).*



Viewing window in the JPL Trajectory Tracking Tool showing "balloons" representing deployed drifters, lon/lat coordinates and control options.

4.) Click on "Compute and Plot" button underneath the map to run the model simulation.
    a. *Note: After the model completes its calculations, it will display the model output, and students will be shown eight drifter tracks (paths across the ocean) in colored lines within the red sampling site box. If a drifter crosses out of the red sampling box during the model simulation time period, then that track ends at the location where the drifter exits.*



Example of "drifter track"output after running the simulation.

5.) Take a "screen grab" image (use combinations of buttons: Mac = Command+Shift+4, PC = "PrtSc" button or "snipping tool") of the model output for this drifter simulation and save it for the following steps. Alternatively, sketch the model results in the box provided.

Q1: Explain what the model output is showing.

The model output shows the different tracks drifters take over a period of three months based on their deployment location and the oceanographic data used in the model.

6.) Click on the "Clear" button below the map to reset the tool.
7.) Manually enter the same lon/lat coordinates in the Location window.

Q2: Make a prediction about what you will see in this second output.

Students should predict that they will see the same exact tracks as in the first simulation.

8.) Click the "Compute and Plot" button underneath the map to run the model simulation.
   a. *Note: These will have to be manually entered. However, the tool requires that* ***at least one of the coordinates be "dropped"*** *rather than manually entered.*

9.) Take a "screen grab" image or sketch the second output in the box provided.
10.) Compare the outputs of the first and second drifter track simulations.

Q3: Are there differences between the outputs of the first and second drifter track simulations? Explain why or why not?

There should be no difference because the model uses the same data during the same time period to determine the drifter tracks.

11.) Clear the simulation.
12.) Place two drifters side-by-side at the far right side of the sampling area and run the simulation. Take a screen grab or sketch the output in the box provided.
13.) Now place one drifter in the upper right corner of the box and another at the bottom right corner of the box and run the simulation. Take a screen grab or sketch the output in the box provided.

Q4: Do the side-by-side drifters go in the same path? Why or why not?

They should not follow the exact same path. Various physical factors (e.g. currents, density, wind, etc.) affect the path they take and influence each drifter differently.

Q5: What oceanographic processes might be influencing drifter paths? Do they influence drifters the same in all areas of the sampling site? Why or why not?

Factors such as currents, wind, density may influence drifters differently because these physical factors interact together in complex ways. Even small changes in one factor may have large impacts on the outcome.

Q6: Based on the results of your "experiments" above, briefly explain how this model works and the types data you think it uses.

The model takes oceanographic data from a certain time period (August-October 2011) and uses that data, assuming that the influences of these factors would be similar from year to year, to simulate the track of drifters released in that area for the same time period in 2012.

Q7: Based on what you've learned from the JPL Simulation tool, define a model. Are there different types of models? Can you think of any models that we rely upon in our everyday lives?

A model is a human-made/ human-defined representation of how we think a certain phenomenon works/looks/acts. It is not the actual reality, but rather the best we can do to recreate that phenomenon with our limited knowledge at the moment (i.e., models are always being refined or updated based on new information gathered by scientists and engineers). A recent example is the latest "model" of multiple universes in the astronomy world, or the "god particle" discovery for quantum physicists, which helps refine subatomic particle models! Here's a 'mind-bender' quote on models for you by George E.P. Box: "All models are wrong but some are useful."

There are many different types of models: A model could be a physical representation of a train, building, solar system, or it could be a mathematical model that defines how a population of animals or plants changes over time (e.g., what is the birth rate, death rate, growth rate of this population?) Check out this website for more info on models in general and more great quotes from famous people about modeling efforts: http://serc.carleton.edu/introgeo/models/WhatIsAModel.html

One common example of a model from every day life is a weather report. Meteorologists rely upon sophisticated weather models developed by scientists (global, regional, local - many different scales in fact) to predict your local weather. Changing conditions over air/sea/land make it difficult to predict out too far in the future, but models are getting "smarter" every year as we add in new data streams from powerful new scientific instrumentation - some placed on land-based packages, and some deployed on space-dwelling satellites with global views. Other great examples of models you may have come in contact with: Hurricane prediction models, stockmarket or financial models, oceanic tide and wave predictions, Farmers' Almanac (very fun to investigate:http://www.almanac.com/). Remember, some models may be more scientific and reliable than others!

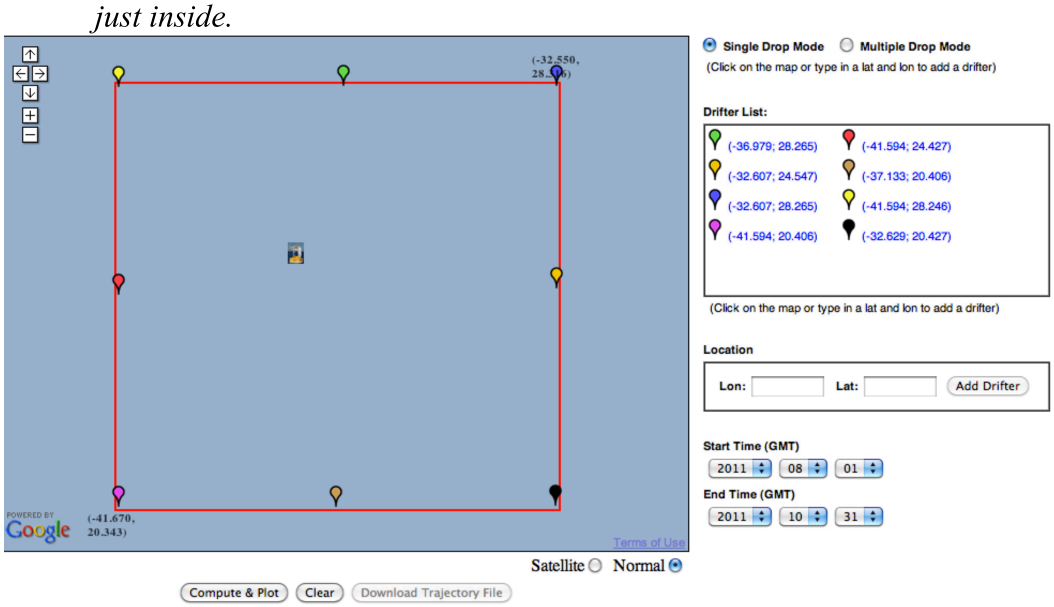
Part 2: How do scientists use models?

Goal: Now that we know a little more about how this model works and the data it's using, we want to explore how scientists use them as tools for planning a research cruise and in their experimental design. Scientists are exploring the salinity patterns in this area at different scales, so they need to maximize data for different regions of the sampling area.

Note: In addition to the "Single Drop Mode" option, students will also be using the "Multiple Drop Mode" option in the Tool. This option allows students to increase the number of drifters they can deploy in a matrix pattern (matrix size is variable: 4x3, 5x5, etc.) and select an area of the sampling grid in which to deploy their drifters. Sampling boxes of various shapes and sizes can be created using this tool for students to explore different arrangements and numbers of drifter deployment. Discussions that may arise from this part of the exercise may address different sampling protocols and how changing the number of drifters you deploy may change the amount of data you get in a certain area, influencing the scale at which you can make observations.

1.) Using the cursor, determine and record the lon/lat for each corner of the SPURS sampling site (red box). Note: Coordinates are only shown in the "Location" box when your cursor is placed **within** the red box.
    a. *Note: Using the mouse to place the cursor on one corner of the box, the longitude and latitude of that location will be displayed in the "Location" box. This will be the "corner point" coordinate. Because different student groups will use different methods of determining the center points, coordinates will vary from student to student or group to group.*

2.) Determine and record the coordinates for the center of each side of the sampling site.
    a. *Note: The tool will not let you put a drifter ON the red line, so it must be just inside.*



Example of "boundary center point" and corner point coordinates.

3.) Determine and record the coordinates nearest the center of the entire SPURS sampling area ("SPURS center point"). When finished, you will have a total of nine coordinates (four corner coordinates, four "boundary center point" coordinates and one "SPURS center point" coordinate).

Q1: Define longitude and latitude.

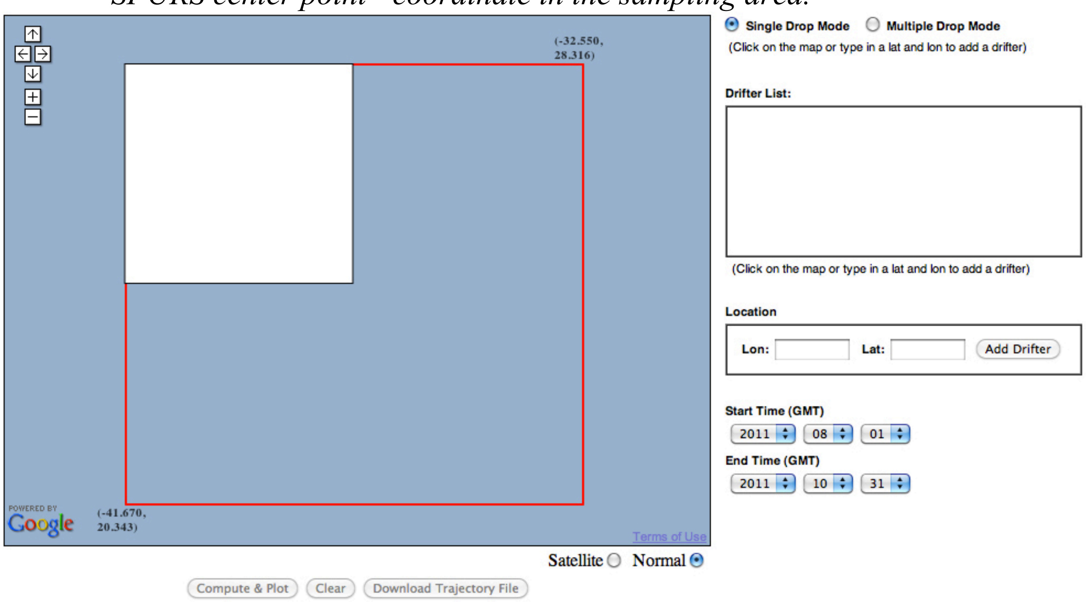
Longitude: a geographic coordinate that specifies the east-west position of a point on the Earth's surface. Points with the same longitude lie in lines running from the North Pole to the South Pole. It is usually expressed in degrees.

Latitude: a geographic coordinate that specifies the north-south position of a point on the Earth's surface. Points with the same latitude, or ***parallels****, run east–west as circles parallel to the equator.*

Used together to indicate precise location of features on the Earth's surface.

4.) Using the "Single Drop Mode" option, drop 12 drifters within the northwest (NW) quadrant (square) of the SPURS sampling area (see white square at upper left in the figure below). **Remember, you are trying to place the drifters so that they stay within the sampling site box, but also cover the most geographic space within the sampling area to maximize your data in that area.**

a. *Note: For example, the NW quadrant of the SPURS sampling site would be made up of the NW "corner point" coordinate, the "boundary center point" coordinate of the Northern and Western boundary lines and the "SPURS center point" coordinate in the sampling area.*



Example of the area of the northwest corner to be sampled within the SPURS sampling site.

5.) Take a screen grab (or sketch it in the box provided) of the **starting arrangement of drifters**.

6.) Run the simulation and take a screen grab of the output and save it or sketch it on the box provided.

7.) Clear this run and repeat steps 4-6 with a new arrangement of drifters in the NW corner. Take a screen grab or sketch the starting arrangements and final outputs provided.

Q2: Did one arrangement of drifters work better than the other to sample the NW quadrant? Explain why this might be.

These answers will vary depending upon the arrangement the students chose for deployment. The goal is for them to discuss different factors affecting drifter tracks based upon where they were dropped and to begin thinking about sampling strategies and planning.

8.) Clear this run.

9.) Select the "Multiple Drop Mode" option.

   a. *Note: Using this mode allows students to increase the number of drifters they can deploy while taking away some of the control they have as to where they are released.*

      i. Number of Drifters: *You will notice there is a box labeled "Number of Drifters" in which there are 2 boxes to input numbers. You can decide how many drifters to deploy within a box using X and Y coordinates. So, if you put 3 in the X dimension and 3 in the Y dimension, you will get an arrangement of drifters in a 3-by-3 box.*

      ii. ***Drifter Release Area:*** *Rather than clicking to place each drifter, you draw a box within the sampling area where your drifters, in the X-Y arrangement, will be released in a matrix pattern. To make this box, once you have identified the numbers of drifters to be released, you simply put your cursor at a desired spot within the sampling area and click once to establish your initial corner coordinate (a red "push pin" icon will show up). Then you drag the box out to identify the total release area. Your drifters will be deployed in your designated arrangement within this box.*

Example of the drag and drop box created using the "Multiple Drop Mode" option (top) and resulting grid of released drifters as indicated in the X and Y dimensions box (bottom).

10.) Within the "Number of Drifters" control, put 4 in the X dimension and 3 in the Y dimension. This is called a "4-by-3 arrangement".

11.) To create a sampling box, place the cursor at a desired spot within the sampling area and click once to get your initial corner coordinate (a red "push pin" icon will appear). Drag the box out to create the total release area for your drifters.

Q3: What is the difference between the "Single" and "Multiple" drop modes? Do you think this will affect sampling ability?

Students will hopefully address the differences in control between the two modes and discuss how the Single Drop allows you to explore random sampling versus the more precise sampling protocol using the Multiple Drop. Also, students are expected to comment on the increased number of drifters to be released and discuss the pros or cons of this ability.

12.) Run the simulation and save a screen grab of the output or sketch it in the box provided.

13.) Repeat the simulation again in the NW quadrant using the "Multiple Drop Mode" option with a 5-by-5 arrangement of drifters this time. Save a screen grab of the output or sketch it in the box provided.

Q4: Did the drifters sample the NW quadrant better in a 4-by-3 arrangement or in a 5-by-5 arrangement? Explain your answer.

This question is to provide a chance for students to defend their opinion on one or the other, so you may get many explanations. We can assume some will argue that more drifters will provide more complete sampling of an area, but that may not be the case depending upon where they placed them.

Q5: How can the number of drifters deployed change the scale at which you might be gathering data?

More drifters in an area will allow you to gather more information about any one area, possibly allowing you to observe smaller-scale patterns and interactions from influencing physical factors than will fewer drifters.

Q6: Compare and contrast the sampling ability of the "Single Drop" and "Multiple Drop" options. What are the pros and cons of each option?

Single drop allows you to place the drifters wherever you like or randomly, Multiple drop places them in a more uniform fashion and allows you to increase the number of drifters. Depending on your research goals and the area you're sampling, one may be better than the other. Increased numbers of drifters allows you to gather more information about the area.

Q7: Can you think of a reason you would use one option over the other?

Encourage students to think of situations where they might want to sample randomly versus more uniformly (e.g. specific research goals about specific factors in an area, gathering information on a previously unexplored area, etc.).

Part 3: Plan a Cruise!!

Goal: In this section you need to think like a scientist to plan a sampling strategy to maximize data gathering in specific areas of SPURS sampling site. You also have to think about how much a trip like this might cost. For this exercise, it costs $100 to deploy one drifter and you have a budget of $2000 for each sampling region (see 1a-d, below). You should be familiar with the model now and the different methods you can use to sample, so plan accordingly!!

1.) Use either the "Single Drop Mode" or the "Multiple Drop Mode" to maximize sampling in these regions:
   - **a.** The entire SPURS sampling area**.**
   - **b.** A 20 x 20-mile square around the WHOI mooring. (This will require you to determine the distance between different lon/lat coordinates to find a 20 x 20-mile box. There are on-line converters or, if you're up for a challenge, there is some good algebra behind the calculation, which you can also find on-line!).
   - **c.** The southwest (SW) quadrant.
   - **d.** The southernmost part of the sampling area: the region covering the width of the red box *below* 22 degrees north latitude.

Note: Below you will find a few pages of sketch boxes to use to compare your outputs if you are not using screen grabs. Make sure to label them accordingly so you don't get them mixed up!

Q1: Which arrangement of drifters best samples each of the above regions?

Again, these responses will differ between groups or students. The goal is to get them to think critically about why they think one is better than the other and allow them to use evidence to defend their position.

a.

b.

c.

d.

Q2: What are some of the challenges or limitations to using modeling tools in planning cruises or sampling strategies?

Models like this forecast what might happen under previously-observed ocean conditions. However, since the future will have new ocean conditions, models cannot exactly predict what will happen.

Q3: How does changing the size of your sampling area affect your ability to gather data? How does it change the information you gather about the oceanography an area?

Again, looking to discuss scale here and how sampling can affect at which scale you are making observations. For example, scientists would be able to get more detailed oceanographic information about features by concentrating their drifters in a smaller area versus getting a more "synoptic" (i.e., general) idea of larger region.

Q4: What other types of considerations or challenges might scientists need to account for when planning a cruise or sampling strategy?

This question is to encourage students to think about factors affecting research outside of the science itself. Factors they might consider are weather, money or funding, equipment failure, human error, etc.