Ocean Robots & Data: What? How? Why?

Materials

For the leader:

Projector

Computer

Board with markers

2 Glider Models

Syringe with water

Tank with water

Paper towels

For the students:

Worksheets

RU01 Glider Data Profiles (Temperature, Salinity, and/or Chlorophyll)

Dry Erase Markers

Overview

A glider is an Autonomous Underwater Vehicle (AUV) – autonomous = can move by itself; underwater vehicle = submarine. More simply it is a robot submarine. A robot is a machine that works automatically, or by computer control (usually programmed, or remote/computer controlled), to do a job. The Slocum Gliders (gliders) are named for Joshua Slocum, the first man to sail around the world alone, and their gliding motion.

Gliders move by changing their buoyancy using a battery powered pump in the front nose cone to pump seawater in and out. When seawater is pumped in, the whole glider is more dense than the surrounding water (negatively buoyant) and it sinks. At the programmed depth (it measures pressure to know the depth) the water is pumped back out which makes the glider less dense than the surrounding water (positively buoyant) and it rises to the surface. The wings make the glider glide in an arc rather than moving straight up and down. They turn using a rudder on the tail. The glider can also change how steeply it dives (the angle) by moving the battery more towards the nose or more towards the tail (changing the center of gravity).

Typically a glider will have electronic sensors for conductivity (how much electricity the water conducts which is related to salinity), temperature, and pressure (for depth). Temperature, salinity and pressure are used to calculate density. Gliders can also have sensors for light and chlorophyll (the photosynthetic pigment in phytoplankton), as well as a variety of other possible instruments.

Glider data is presented as a profile of the measured conditions of the water column. The data is often presented using false color – a rainbow spectrum of colors used to represent numbers. Red often means high or a lot, while blue often means low or a little. For example, red means hot (temperature), salty (salinity), and/or lots of chlorophyll and blue means cold (temperature), low salt (salinity), and/or very little chlorophyll.

Though gliders look fast, they are actually rather slow and can only move at roughly half a mile per hour or slower. This means they can't fight a strong current head-on. But, gliders can navigate some currents and thus don't have to only move where currents carry them. Scientists pilot the glider by providing it with a series of waypoints, or GPS coordinates (latitude and longitude) that they want it to reach. The glider will check its current location in order to figure out what direction it has to go to get to its next waypoint. Slocum Gliders cannot reach the bottom of most parts of the ocean but can reach depths of about 1000 meters.

The major benefit of using gliders for ocean research is they can collect a lot of data, much more quickly than a scientist could with single instruments on a boat. Scientists use gliders often to study temperature, salinity, density, and currents; having a lot of detail about as many places in the ocean as possible helps scientists figure out if and how the ocean functions and is changing.

Motivating Questions:
- **What kinds of data do gliders collect?**
- **What can the data from gliders tell us about the variation in ocean water?**

Take Home Message
Gliders enable scientists to collect lots of information about the ocean conditions (e.g., temperature, salinity, phytoplankton) throughout the water column. Data from gliders informs us of the variety of conditions throughout the ocean from the surface to deep areas, which vary in their properties.

Structure
Through a class demonstration, the students will make observations about how the glider works and moves. Building upon these observations, the students will brainstorm why and how scientists use ocean robots (i.e., gliders) to collect data as well as become oriented to glider data to look for variations of ocean conditions throughout the water column. The students will then begin to think about how the scientists navigate a glider.

Time Required
One 45-minute class period

Activity Outline

Engage: Students will make observations about how gliders work.	10 minutes
Explore: Students will apply their observations to brainstorm how and why scientists use gliders and orient to glider data profiles to look at the variation in ocean conditions with depth.	25 minutes
Make Sense: Through a video and class discussion, students will learn how scientists at Rutgers University are using gliders and brainstorm how they navigate a glider to collect data.	10 minutes
Total:	**45 minutes**

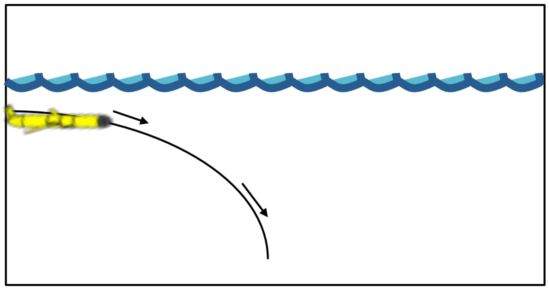
Audience
Middle and early high school students (6^{th}-9^{th} grade).

Preparation (30 minutes)

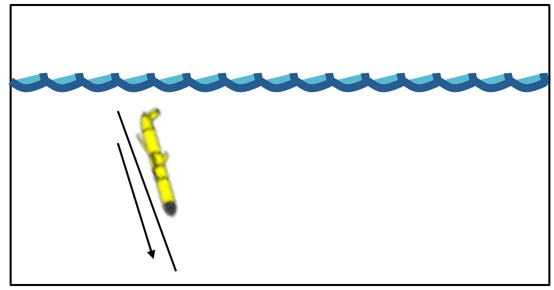
1. Fill the tank with freshwater.
2. Prepare the Glider model demonstration by filling the syringe with salt water. Hold one of your glider models upright and attach the tubing to the nozzle. Connect the tubing to the syringe and depress the plunger on the syringe to fill the model glider with a kosher salt-water mixture. Once full, detach the tubing and hold the model nose up. Press up on the plunger of the glider with your finger to press out any air bubbles.

3. Test fly your gliders by placing each model, water-filled and empty horizontal in a tank of fresh water (at the surface if it is water filled or near the bottom if it is empty) and releasing. Adjust the amount of salt water/air to get a good flight path.

Sinking should be like this:

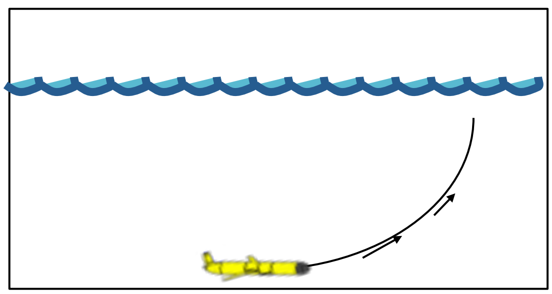


Not this:

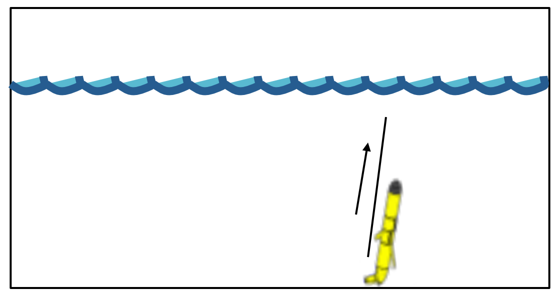


NOTE - Make sure the glider sinks nose first, not tail first. Also, you can make your water saltier if the glider is not sinking.

Floating should be like this:



Not this:



4. Prepare the RU01 Glider Data Profiles for the small groups. Make sure each group has one of the three variables (Temperature, Salinity, or Chlorophyll) to interpret.
5. Write the opening prompting questions on the board: How deep are penguins going to find their food? What is going on in the ocean below the surface?
6. Write the motivating questions on the board (but keep them covered to start):

   Q. What kinds of data do gliders collect?

   Q. What can the data from gliders tell us about the variation in ocean water?
7. Set up the projector and make sure the PowerPoint presentation works.
8. At the end of the activity, empty and rinse the model gliders, syringe, and tube.

Engage (10 minutes)

1. As the students are coming in, have them talk to their neighbor about the questions on the board: How deep may penguins go to find their food? What could be going on in the ocean below the surface? (Slide #2)

   * NOTE - There are no specific or intended answers to these questions. These are just intended to get the students to start thinking about the ocean in three dimensions, which will be explored throughout the rest of the lesson.

2. Once class starts, explain to the students that you will be spending today learning about how scientists use robots to study the ocean water from the surface down and across space to gain a better understanding of the conditions in the ocean, including where different parts of the food web are found.
3. First, as a class you need to come up with a definition of a robot (Slide #3). Be accepting of all additions and comments to the definition. Towards the end of the conversation, help the students understand that a robot is a machine that can move by itself or by computer control.
4. Once you have a definition, project Slide #4 of the glider. Point to the picture of the glider and explain that the glider is one type of ocean robot and that it is an Autonomous Underwater Vehicle (AUV), meaning it can move by itself as a submarine, and can be programmed with where to go before it is put in the water or while it is at sea by scientists at a computer in their lab thousands of miles away.
5. Tell the students that the Science Team in Antarctica will be using gliders. Have the students work in small groups to brainstorm why the scientists would use gliders (Slide #5). Ask the students to come up with a list of potential pros and cons for measuring the ocean from a glider. Ask the students to take notes on their worksheets as they brainstorm this question.
6. After a few minutes, ask for volunteers to share with the class what they were discussing.

   * NOTE - This is just a brainstorming session. There are no correct answers, especially considering the students may not know anything about the gliders. This is intended to engage them in thinking about the glider before being told of its benefits.

7. Explain to the students that we are first going to observe how the glider works and how it moves through the water in a demonstration and then we will look at data from the glider to understand more about the ocean.
8. Point out to the students that one glider model is filled with water, and one glider model only has air inside (Slide #6).
9. Explain that you will place the water-filled glider model horizontally at the surface of the water and let it go to see what happens. The students should draw how the glider moves on their worksheets and write in a description of the movement. They should think about the angle and direction of the path the glider moved.
10. Then place the empty glider model horizontally underwater and give it a small push to see what happens. The students should draw how the glider moves on their worksheets and write in a description of the movement.
11. Explain how these two glider models represent two halves of a glider's flight path (Slide #7). Ask the students to construct an explanation of how the real glider moves up and down.
12. After a few suggestions, explain to the students using Slide #8 how the real glider uses a battery powered pump to bring seawater in and out, which changes their buoyancy.

   * NOTE - Buoyancy is the upward force that a fluid exerts on an object. Try not to define buoyancy in terms of whether the object floats or not, as it is actually the force acting upon the object.

Explore (25 minutes)

1. Explain that the glider communicates with the scientists using a cell phone like instrument in its tail when at the surface (Slide #9). It also has GPS, so the glider can let the scientists know where it is. The phone & satellites enable the glider to send back the previously collected data back to the scientists and to check for new instructions on where to move.
2. Show the students Slide #10 and explain to the students about the payload section (center of the glider where the scientific instruments are housed) and how the scientists add different instruments in the payload to collect different data about the ocean.
3. Remind your students that the scientists are working in the Western Antarctic Peninsula (Slide #11), at Palmer Research Station (Slide #12), and the data that they will be looking at came from glider RU01 that was navigated through the waters near the research station (Slide #13). And this is the glider track (path). It started at the red dot (left side of profile) and traveled to the blue dot (right side of profile) on Slide #14.
4. Orient your students to Glider Data Profiles using Slides #15-21.
    a. Glider Data Profile maps are similar to other graphs that we look at in that the data is presented in the center (Slide #15).
    b. The y-axis of the map represents water depth, with the surface of the water up top and the deepest the glider went on the bottom. For the maps we will be looking at the deepest is 100m (Slide #16).
    c. The x-axis of the map represents the position along the transect or path of the glider. So the left side is the start (remember denoted by a blue dot) and the right side is the end (denoted by a red dot) of the track (Slide #17).
    d. Remember from the glider path map, for the data that we will be looking at the start of the track was inshore and then the glider moved offshore (Slide #18).
    e. In order to know what data we are looking at we will need to read the data label on the far right of the map (Slide #19).
    f. And to understand what the data means we will need to use the Data Legend/Color Bar to understand the differences in the data in the map (Slide #20).
    g. So this is what it looks like with the data (Slide #21). Remember the glider is moving up and down from the surface to 100m deep along the transect so we get a profile, or all of the data up/down and left/right, for that part of the ocean. Glider profile maps use a "false color scheme," this means that they use the colors to represent numbers but that does not mean that the color on the profile map is what the water color was. (NOTE – this is a very difficult concept for kids so take the time to make sure they understand this before you have them look at the data.)
5. Explain to the students that they will be looking at data of temperature (Slide #22), salinity (#23), and chlorophyll (Slide #24).

* NOTE - Do not explain anything else on the profiles or data, as the intention is for the students to engage with the figure to determine their own questions.

6. Pass out the Temperature, Salinity, and/or Chlorophyll RU01 Glider Data Profiles and dry erase markers out to each small group.
7. Have the students look at the data figure to orient to a profile (leave Slide #24 projected). Give the students a few minutes to look at the figure and make notes of questions they have about what is in the figure or how it is structured, by writing onto the figure.
8. After a few minutes, bring the students back together and ask what questions they came up with about the profiles. Answer their questions until it seems that most of the students have a good understanding of what is in the figure and how it is structured.
9. Then, have the students make observations from the data in the profiles about how the ocean water may vary from the surface to the bottom and across space in their profile (i.e., is it uniformly the same or is there variation, Slide #25). The students should work together to interpret the data and then complete their own Scientific Explanation section of the worksheet. Stress to the students that there are no correct answers; instead they are just exploring the variation in the data that they observe.
10. Walk around and help the students interpret the RU01 Glider Data Profiles.

Make Sense (10 minutes)

1. Once the students have completed their Scientific Explanations, bring the students back together as a class and discuss what they found in their data. As the students report out what they saw in the data about the ocean water with depth and through space, write their statements on the board (Slide #26). Use Slides #27-29 to show the whole class the data that each group is presenting about when they are talking.

   * NOTE – The intention of this activity is to help students see that all three variables vary with depth and across space (distance along transect). The values for each variable are different. The intention is NOT for the students to understand why that is, but just that the variation exists in the ocean.

2. After the groups have reported out, ask the students these series of questions to help them think about what variation in chlorophyll, for example, in the ocean water column could mean for the food web (Slide #30):
   a. Why is most of the chlorophyll at and near the surface? – *Because phytoplankton, which has the chlorophyll, needs sunlight to grow and light does not travel far into the water.*
   b. If most of the chlorophyll is at and near the surface, where would you expect to see most of the krill? Why? – *At and near the surface because krill feed on phytoplankton, which are at the surface.*
   c. What does that mean for where we may find penguins eating? – *Penguins feed on krill, and thus you would expect to find penguins at the depth that the krill are, so at and near the surface of the ocean water.*
3. Show the students the video clip from of how gliders work (Slide #31):

a. If you feel comfortable narrating an animation of the yo-yo pattern of the glider through the water and want to include your own comments: https://www.youtube.com/watch?v=0zWEjKjX_Uk

b. If you only have a minute or so and/or don't feel comfortable doing your own narration: https://www.youtube.com/watch?v=H_78-JRP3KQ

   * NOTE – We have also provided you "Atlantic Crossing" a documentary about how Rutgers University and partners successfully navigated the first glider across the Atlantic Ocean. The first 25 minutes has great information and animations about how the glider works, why scientists use gliders, and animations of the glider moving and recording data.

4. Once their questions have been answered, point to the motivating questions and review with the students:

   Q. What kinds of data do gliders collect? – *Gliders provide information about the water column by collecting data on such variables as temperature, salinity, chlorophyll, etc. and thus provide an excellent compliment to satellite data about the ocean.* (Slide #32)

   Q. What can the data from gliders tell us about the variation in ocean water? – *Glider data demonstrates that the water column is not homogeneous, but rather there is variation throughout the ocean water with depth through space and time.* (Slide #33)

5. Ask if the students have any final questions about the glider and data from the day.

* Not to necessarily use in the lesson, but this is an entertaining music video that Rutgers University graduate students and technicians put together about the glider that successfully navigated across the Atlantic Ocean titled "We're Going to Fly the Glider" (to "We Didn't Start the Fire"): https://www.youtube.com/watch?v=iiRXbq5Wr3g.

Common Core State Standards Connections: ELA/Literacy and/or Math (Middle School)

English Language Arts

WHST.6-8.1	Write arguments to support claims with clear reasons and relevant evidence.
WHST.6-8.8	Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ESS3-3)
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Mathematics

MP.2	Reason abstractly and quantitatively.
7.RP.A.2	Recognize and represent proportional relationships between quantities.

Next Generation Science Standards (Middle School)

Motion and Stability: Forces and Interactions, MS-PS2-2 – Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Science & Engineering Practice	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations – Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.	*PS2.A: Forces and Motion* - The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.	*Stability and Change* – Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

Earth and Human Activity/Human Impacts, MS-ESS3-3 – Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Science & Engineering Practice	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions – Apply scientific principles to design an object, tool, process or system.	*ESS3.C: Human Impacts on Earth Systems* - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.	*Cause and Effect* – Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.

New Jersey Core Curriculum Content Standards – Science (Middle School)

Content Area	Cumulative Progress Indicator (CPI)	CPI#
Science Practices: Generate Scientific Evidence Through Active Investigations	Gather, evaluate, and represent evidence using scientific tools, technologies, and computational strategies.	5.1.8.B.2
	Use qualitative and quantitative evidence to develop evidence-based arguments.	5.1.8.B.3
Science Practices: Reflect on Scientific Knowledge	Monitor one's own thinking as understandings of scientific concepts are refined.	5.1.8.C.1
	Revise predictions or explanations on the basis of discovering new evidence, learning new information, or using models.	5.1.8.C.2
Science Practices: Participate Productively in Science	Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences.	5.1.8.D.1
	Engage in productive scientific discussion practices during conversations with peers, both face-to-face and virtually, in the context of scientific investigations and model-building.	5.1.8.D.2
Physical Science: Forces and Motion	Sinking and floating can be predicted using forces that depend on the relative densities of objects and materials.	5.2.6.E.4
	Forces have magnitude and direction.	5.2.8.E.2

New York Science Learning Standards (Middle School)

Standard Area	Key Idea	KI#
Standard 1: Analysis, Inquiry, and Design (Mathematical Analysis)	Use inductive reasoning to construct, evaluate, and validate conjectures and arguments, recognizing that patterns and relationships can assist in explaining and extending mathematical phenomena.	M2.1
Standard 1: Analysis, Inquiry, and Design (Scientific Inquiry)	Construct explanations independently for natural phenomena, especially by proposing preliminary visual models of phenomena.	S1.2
	Represent, present, and defend their proposed explanations of everyday observations so that they can be understood and assessed by others.	S1.3
	Seek to clarify, to assess critically, and to reconcile with their own thinking the ideas presented by others, including peers, teachers, authors, and scientists.	S1.4
	Interpret the organized data to answer the research question or hypothesis and to gain insight into the problem.	S3.2
Standard 6: Interconnectedness: Common Themes (Patterns or Change)	Observe patterns of change in trends or cycles and make predictions on what might happen in the future.	5.2