Ocean Classroom – Ocean Depth

The United World Challenge

If you have been following Tez since Day 1, you might remember that in milestone 2, he mentioned using a para-anchor to stabilize his boat. The para-anchor looks like a small parachute. It adds drag to the boat, preventing it from being pushed by the winds, which are much faster than ocean currents. But why did Tez not simply drop an anchor to the bottom? As Tez pointed out in his milestone, the seafloor was over 6,000 feet (or more than 1,800 m) below him! In our programming exercise today, we will use the Oce package in R to map Tez's daily progress and calculate the depth of the seafloor below him. The Oce package has been created by Halifax-based oceanographers Dan Kelley, Clark Richards, and Chantelle Layton to help scientists around the world work with their data.

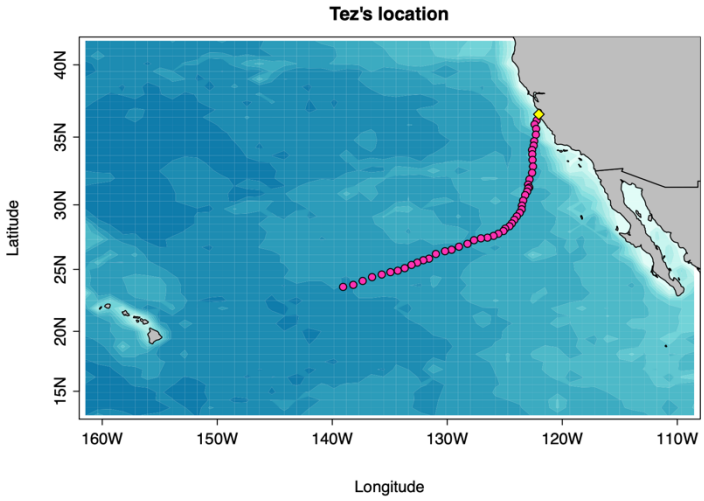
The Science

At more than 8,800 m (or 8.8 km), Mount Everest is the highest point on earth. Yet, if we placed Mount Everest at the deepest point in our oceans, we would not see its summit! Reaching depths below 11,000 m (11 km) in the Western Pacific, the Mariana Trench is the deepest point on earth. So far, only two manned submersibles have reached these depths: the Trieste in 1960, and the Deepsea Challenger[1] in 2012.

In 2020, scientists described a new species of crustacean, *Eurythenes plasticus*[2], which they found in the Mariana Trench, at depths greater than 6 km. Despite being so far away from land, plastic was found in one specimen's gut, which is why the team of scientists included the word plastic in the species' name.

Programming Activity

In this activity, we will create a map of Tez's location (shown right) and plot the water depth below him at each point. We will be using the R programming language and the RStudio software, which are both free and open source. First, you will need to install R and RStudio[3]. You will then be ready to begin.



[1] James Cameron – movie director and National Geographic explorer-in-residence – completed the record-breaking solo dive. More information on the expedition and on the film documenting the accomplishment can be found at http://www.deepseachallenge.com/

[2] Information on the discovery can be found at https://www.oceanographicmagazine.com/news/eurythenes-plasticus/

[3] Instructions to install RStudio can be found at https://rstudio.com/products/rstudio/download/

Before You Start

☐ Download all files for this activity and put them in the same folder:

- The programming script:
  - *OceanClassroom_OceanDepth.R*
- The data files:
  - *Track_Tez_Aug21.csv*

☐ Make a copy of the .R file in case the script stops working after some lines of code are modified.

☐ Double-click on the .R file called *OceanClassroom_OceanDepth.R*

☐ When RStudio opens, find your working windows:

- The OceanClassroom_OceanDepth.R panel contains your script.
  - This is where you will make modifications.
  - In the top right corner of this panel, locate the **Run** button (runs the line where you cursor is located) and the **Source** button (runs the entire script).
  - Notice that some line starts with #. These lines will be ignored when you run your script. We say that the lines are commented.
- The **Console** can be used to test some lines of code before adding them to the script.
- The **Plots** panel will display the plot you create.

Getting Started

☐ Make sure your working directory is the one with all your files. At the very top, click:
Session > Set Working Directory > Choose Directory...

☐ Click **Source** to run your script. You can also type `source("OceanClassroom_OceanDepth.R")` in the **Console**.

☐ Note that the script installs R libraries called ***Oce*** and ***Ocedata***. These two libraries contain the functions and data we need to make our map.

☐ If the script ran properly, you should see a figure appear with two panels:

- The top panel shows a map with Hawaii near longitude 155W and latitude 20N, and North America on the right. Darker blues mean deeper water depths.
- The bottom panel shows you the water depth below Tez – in kilometers! The blue line at depth = 0 km shows you where the water surface is. The yellow diamond shows you where Tez started: you can see that he started on land because the water depth was 0. He then rowed towards the West (increasing westward longitude values), and quickly found himself above ocean depths greater than 4 km.

☐ This figure would be much more useful if we knew where Tez was when he was above the water depths shown in the bottom panel. Your task is to add Tez's track to the map and save your figure.

- ☐ To understand a bit more about R programming, go to **line 82**. You can see a function called `points()`, with a variety of arguments within the parentheses. In R, functions are always followed by parentheses. In this case, this function adds the yellow diamond to the bottom panel. Typing `?points` in the **Console** will display information about the function where your plot used to be. Don't worry, your plot did not disappear! Simply toggle back to the panel **Plots** at the top of the instructions.

- ☐ If you want to know more about functions you see in the script simply type `?` followed by the function's name in the **Console**.

- ☐ Now, back to adding Tez's location to our map. The comment on **line 52** gives you a hint that the lines below add Tez's location. Delete the `#` in front of **lines 53** and **54** to add pink dots showing Tez's daily location. The line should change color when they are uncommented. In this case, the two lines work together – notice that the function `mapPoints()` starts on one line and ends on the other. This means that you can either comment or uncomment both lines, but not one or the other.

```
# mapPoints(track$Longitude, track$Latitude, pch = 21,
#           col='black', bg='maroon1')
```

- ☐ **Save** your changes and click **Source** to run your modified script.

- ☐ Can you figure out how to add a yellow diamond on the map to show Tez's starting point? **Hint:** look for the lines below the comment that says `### Add Tez's starting point`.

- ☐ **Save** your changes and click **Source** to run your modified script.

- ☐ To save your figure to a PDF file, uncomment **line 33**:

```
# pdf("Map_Tez.pdf", width=8, height=11)
```

  and **line 86**:

```
# dev.off()
```

  Line 33 opens a PDF document named *Map_Tez.pdf*, then the following lines create your figure in the document, and **line 86** closes the file. **If you make any change to your code and run it, it will now appear in the PDF document instead of the Plots panel.**

- ☐ Now that you understand a bit more about coding, make as many changes to your plot as you want. If something stops working and you cannot find the mistake, go back to the saved copy or re-download the .R file. We call programming mistakes ***bugs***. It can be very hard to find a bug. The colors in the script can help you see if you forgot an apostrophe or a parenthesis, but it can take some time to get used to how they should look. Some suggestions of the changes you can make:

    - Try changing the colors of the points. **Hint:** look for a `col =` argument in functions.

    - Copy-paste the `mapPlot()` function on **lines 39 to 43** into a new R script. Modify the latitude and longitude limits (`longitudelim =` and `latitudelim =`) to create a new map. Don't forget to update the latitude and longitude labels (`lonlabels =` and `latlabels =`) accordingly. **Can you find your location on Google and add a point to your new map?**