Ocean Classroom – Waves Across the Pacific[1]

The United World Challenge

If you have been following Tez, you will know that he left Monterey harbor on July 3 (milestone 1), heading off to Hawaii. Initially, Tez was planning to leave from San Francisco. In our programming exercise today, we will use publicly accessible data[2] from the CDIP program to compare the waves Tez faced when he rowed out of Monterey, with the waves he would have faced had he rowed out of San Francisco. Perhaps this will allow us to better understand his decision. First, a bit more about waves…

The Science

When a storm brews over the ocean, strong winds interact with the ocean surface and generate waves of all sizes, going in all directions. In milestone 2, Tez described waiting out a storm in his cabin and feeling as if he was in a washing machine. This is what we call a mixed sea. As waves move away from storms, longer waves travel faster, which means that the waves sort themselves and the movement of the ocean becomes more regular. Waves that have moved away from storms are called swell waves. Plastic or other objects floating at the ocean surface will be moved up and down by these waves, but they will not be entrained by the waves.

If waves are powerful enough, they can travel great distances and eventually reach beaches for surfers to enjoy. As waves move into shallower waters, they grow taller, become steeper, and then break. Floating objects that encounter steep waves will be entrained by the waves. If you have watched surfers in the past, you probably noticed that they wait in a spot where waves start steepening quickly. The surfers that are waiting in deeper water mostly move up and down, but the ones that 'catch' a steepening wave can ride it towards shore. When Tez left California, he first had to row against steep waves that were bringing him back to shore. A large powerful swell was not something he wanted! Now that Tez is away from the coast and storms, he can bob up and down the swell waves without being carried by them.

Programming Activity

In this activity, we will plot the significant wave height recorded by three different CDIP buoys for the week leading up to Tez's departure from California. The term significant wave height refers to the average of the 30% largest waves. 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.

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[1] The title references seminal work on waves conducted by Walter Munk and a team of scientists. A documentary on the topic can be found at https://waltermunkfoundation.org/uncategorized/waves-across-the-pacific/

[2] Data were furnished by the Coastal Data Information Program (CDIP), Integrative Oceanography Division, operated by the Scripps Institution of Oceanography, under the sponsorship of the U.S. Army Corps of Engineers and the California Department of Parks and Recreation.

[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_Waves.R*
- The data files:
  - *CDIP142_SF_JuneJuly2020.csv*
  - *CDIP157_PointSur_JuneJuly2020.csv*
  - *CDIP158_CabrilloPoint_JuneJuly2020.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_Waves.R*

☐ When RStudio opens, find your working windows:

- The OceanClassroom_Waves.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. You do not have to use the **Console** for this activity.
- 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_Waves.R")` in the console.

☐ Note that the script installs an R library called ***ggplot2***. This library is very useful to make plots. You will see that a plot also appears, and that it is automatically saved in your folder under the name *OceanClassroom_WavesPlot.png*

☐ Now, the only line you see shows the height of the waves out of San Francisco Bay the week before Tez's departure. Lines 25 and 26 are currently commented and ignored when you run the script.

☐ **Delete** the # in front of lines 25 and 26 to show the height of the waves in Monterey Bay (where Tez left) and at Point Sur, an area just outside Monterey Bay. The lines should change color when they are uncommented.

```
# geom_line(data = Tez, aes(x = PDT, y = Hs, colour = '3'), size = 1)+
# geom_line(data = PS, aes(x = PDT, y = Hs, colour = '1'), size = 1)+
```

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

- ☐ Which waves are smallest? Can you guess why Tez started in Monterey Bay, an area partially sheltered from the waves? Note that *OceanClassroom_WavesPlot.png* has been updated with your new plot. If you want to save different plots, you will have to change the name of the file.

- ☐ It is sometimes useful to draw people's attention to important areas of our plots. In our case, we want to show the time when Tez started to row. This way, we will know if the waves were getting bigger or smaller prior to his departure.

- ☐ To show the time when Tez left, we will add a vertical line to our plot. Uncomment line 30, **save** your modifications, and click **Source**.
  ```
  # geom_vline(xintercept = as.POSIXct("2020-07-02 23:00:00 PDT"), colour = 'magenta3')
  ```

- ☐ 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:

    - Change your x-axis and y-axis labels by editing the text in green on line 27 and 28. Do not remove the apostrophes, or add them back if you delete them by accident. If you put the apostrophes in the right place, only the words in the parentheses will be green.
      ```
      xlab('Date')+
      ylab('Wave height (m)')+
      ```

    - Change the colors of the lines by modifying one color word on line 32 at a time. You can find color names at the following link: http://www.stat.columbia.edu/~tzheng/files/Rcolor.pdf
      ```
      values=c('steelblue1', 'magenta3', 'steelblue4'))+
      ```

    - Change the name of the file that contains your plot by modifying line 37
      ```
      ggsave('OceanClassroom_WavesPlot.png')
      ```