Module 4 Assignment 2

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Assignment Details

Purpose

The goal of this assignment is to assess your ability to apply the concepts of population growth to determine sustainable fishing amounts.

Task

Write R code which produces the correct answers and correctly interpret the results of visualizations and models.

Criteria for Success

- Code is within the provided code chunks
- Code chunks run without errors
- Code produces the correct result
  - Code that produces the correct answer will receive full credit
  - Code attempts with logical direction will receive partial credit
- Written answers address the questions in sufficient detail

Due Date

December 10 at 11 am MST

Assignment Questions

We are finally going to decide which bay we are going to fish from down at our research station!

In Module 3, we determined that we could fish from either Hope Bay or Sulzberger Bay. Now, using everything we've learned about population growth, carrying capacity, and maximum sustainable yield, we fill determine (a) which bay to fish and (b) how many fish we can sustainably harvest each year.

Questions are worth 1 point unless otherwise noted.

Set-Up

As usual, we start by loading the packages we need.

1. In this case, we need **two** different packages: `tidyverse` and `drc`.

```
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.5
## v forcats   1.0.0     v stringr   1.5.2
## v ggplot2   4.0.0     v tibble    3.3.0
## v lubridate 1.9.4     v tidyr     1.3.1
## v purrr     1.1.0
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```r
library(drc)
```

```
## Loading required package: MASS
##
## Attaching package: 'MASS'
##
## The following object is masked from 'package:dplyr':
##
##     select
##
##
## 'drc' has been loaded.
##
## Please cite R and 'drc' if used for a publication,
## for references type 'citation()' and 'citation('drc')'.
##
##
## Attaching package: 'drc'
##
## The following objects are masked from 'package:stats':
##
##     gaussian, getInitial
```

2. We also need to load the data from our two bays of interest. Thankfully, we have data from 2010-2024.

```r
fish <- read_csv("../data/fish_abund_2010-2024.csv")
```

```
## Rows: 30 Columns: 3
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (1): Bay
## dbl (2): N_fish, Year
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

Make sure you take a look at the data to get familiar with it before you start coding!

Selecting a Bay

3. First, we should calculate some summary statistics. For each bay, calculate the maximum number of fish.

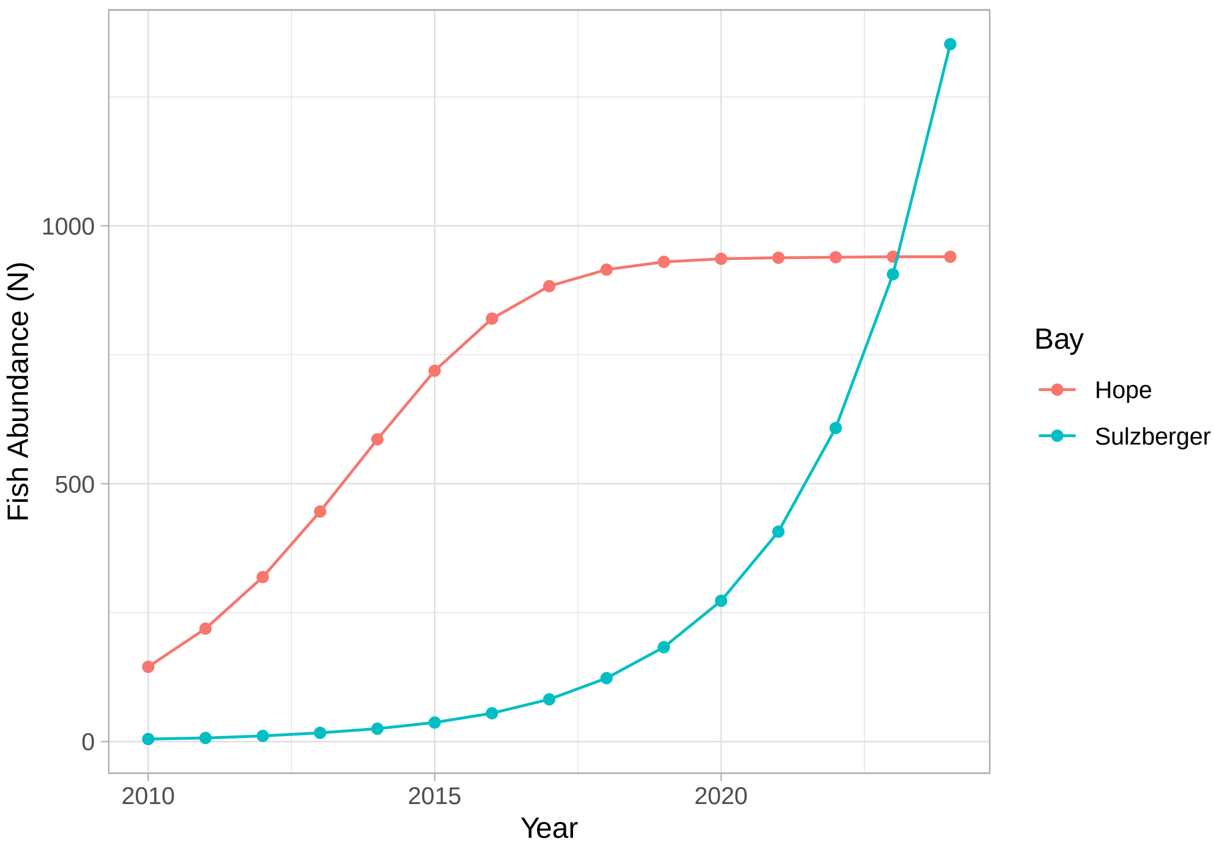
```r
fish %>%
  group_by(Bay) %>%
  summarise(maxN = max(N_fish))
```

```
## # A tibble: 2 x 2
##   Bay         maxN
##   <chr>      <dbl>
## 1 Hope         940
## 2 Sulzberger  1352
```

The maximum abundance is somewhat helpful, but we need more information.

4. Let's now make a plot with the fish populations for each bay as different colors. Include both points and lines for each population. Make sure you add more descriptive axes labels, legend label, and a theme. (2 points)

```
ggplot(fish, aes(x = Year, y = N_fish, color = Bay)) +
  geom_point() +
  geom_line() +
  labs(y = "Fish Abundance (N)") +
  theme_light()
```



5. How should be interpret this plot? Which type of growth is being shown in the fish populations in each bay?

   Answer: Hope is showing logistic growth and Sulzberger is showing exponential growth. (Additional information, but students don't need to say any of it for full credit: the Sulzberger population has a larger population, but that only occured recently. It seems to have a lower instrinsic growth rate (r) because it takes longer to increase)

6. Based on the plot and what we know about logistic and exponential growth populations, which fish population would be the *safest* population to choose for sustainable fishing? Why? (See Module4_2_SustainableFishing lesson is you're confused.)

Answer: Even though Sulzberger has a higher population, it could have overshot it's carrying capacity and could crash. Hope looks like it has stabilized at its carrying capacity, making it the much safer option.

7. Now that you've chosen a bay that we should fish in, let's create a new dataframe that contains only rows with data from that bay for us to use in our remaining calculations.

```
hope <- fish %>%
  filter(Bay == "Hope")
```

Calculating Carrying Capacity

Now that we know which bay to fish, we need to determine how many fish we can harvest per year sustainably.

8. Our first step is to estimate the carrying capacity. Using the `drm()` function from the `drc` package, run and save the model that will give us our estimate of carrying capacity. Remember to include the argument `fct = LL.4()`!

```
# NOTE: You might get output that says "Warning: NaNs produced" repeatedly. That's ok! Keep going.
hope_model <- drm(N_fish ~ Year, data = hope, fct = LL.4())
```

9. Save the vector of estimates as an object.

```
estimates <- coef(hope_model)
estimates
```

```
## b:(Intercept) c:(Intercept) d:(Intercept) e:(Intercept)
##   -1328.63705      65.15513     949.03021    2013.40270
```

10. Select the 3rd value (`d:(Intercept)`) from the vector using square brackets.

```
K <- estimates[3]
K
```

```
## d:(Intercept)
##      949.0302
```

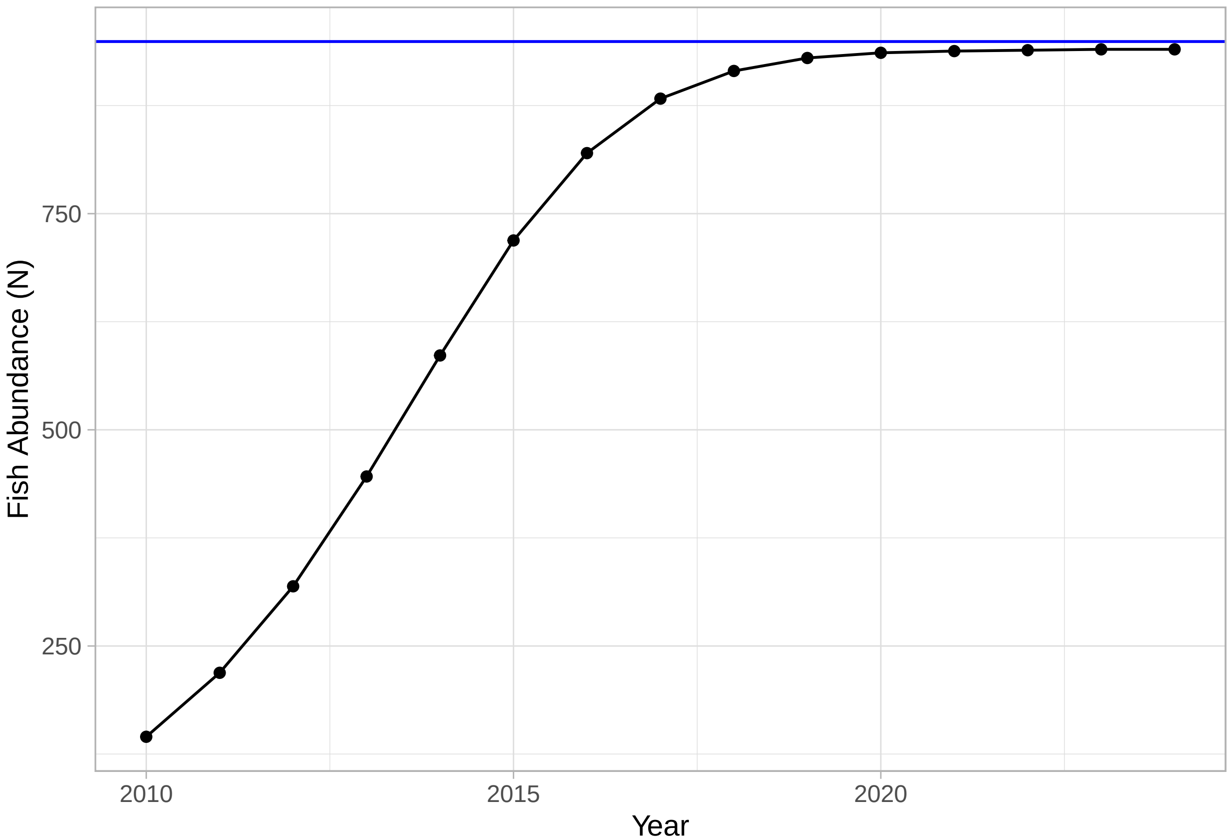
11. For clarity, let's remove the name from the value using the `unname()` function. Save the unnamed output.

```
K <- unname(K)
K
```

```
## [1] 949.0302
```

12. Let's go ahead and add a horizontal line onto our plot where the estimated carrying capacity hits the y-axis using `geom_hline()`.

```
ggplot(hope, aes(x = Year, y = N_fish)) +
  geom_point() +
  geom_line() +
  geom_hline(aes(yintercept = K), color = "blue") +
  labs(y = "Fish Abundance (N)") +
  theme_light()
```



Maximum Sustainable Yield

13. Calculate the Maximum Sustainable Yield for this population.

```
MSY <- K / 2
MSY
```

```
## [1] 474.5151
```

How Many Fish Do We Need?

Calculating how many fish we need each year at the station to support our staff requires a bit of math. Due to our limited amount of ships, we can only go out for one fishing expedition per year, so we need to figure out how to much we need to feed the station for an entire year.

We've been given some critical pieces of information:

a. Number of people to feed: 349 people
b. Amount of fish each person needs: 0.45 lbs/day
c. Number of days people need to eat from this fishing expedition: 365
d. Weight of one Antarctic toothfish (assume all weight is edible): 154 lbs

14. Create objects for each one of these pieces of information and assign the correct number to each object.

```
people_to_feed <- 349
amount_fish <- 0.45
days <- 365
fish_weight <- 154
```

15. How do we translate this to the number of Antarctic toothfish we need? First, let's multiple the

number of people to feed by the amount of fish eaten per day and again by the number of days in a year. Use the objects you created in Question 14, not the numbers themselves. Save this output as `total_annual_fish_weight`. *Hint: the symbol for multiplying is* `*` *in R.*

```
total_annual_fish_weight <- people_to_feed * amount_fish * days
total_annual_fish_weight
```

```
## [1] 57323.25
```

16. If we divide the `total_annual_fish_weight` by the weight of the average Antarctic toothfish we catch, we will have determined the total number of fish that we need to catch to sustain the base for a year. Remember to use objects, not the numbers directly.

Hint: the symbol for dividing is `/` *in R.*

```
total_annual_fish_weight / fish_weight
```

```
## [1] 372.2289
```

Interpretation

17. Based on everything you've learned in this module, determine whether or not we can sustainably fish our chosen population. Explain how you determined your answer using the concepts we've covered in class. Your answer should be 3-4 sentences long. (3 points)

Answer: Yes, we can sustainably fish the Hope Bay fish population and successfully feed the station each year. This is because the number of fish we need to take from the population each year is 372, which is below the maximum sustainable yield of the population, which is 474. This means the population will be able to replace the fish that have been removed from the population successfully, leading to a stable population.