# Tutorial 6: Refactoring R Code

## Introduction

In this tutorial, you will refactor the code into separate scripts corresponding to each section. The dataset we will use comes from the `palmerpenguins` package, which contains measurements of penguins from three species.

The R programming language (R Core Team 2019) and the following R packages were used to perform the analysis: knitr (Xie 2014), tidyverse (Wickham 2017), and Quarto (Allaire et al. 2022).

### Load Libraries and Data

```
Rows: 333 Columns: 8
-- Column specification --------------------------------------------------------
Delimiter: ","
chr (3): species, island, sex
dbl (5): bill_length_mm, bill_depth_mm, flipper_length_mm, body_mass_g, 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.
```

Table 1: Load libraries and data.

| species | island | bill_length_mm | bill_depth_mm | flipper_length_mm | body_mass_g | sex | year |
|---|---|---|---|---|---|---|---|
| Adelie | Torgersen | 39.1 | 18.7 | 181 | 3750 | male | 2007 |
| Adelie | Torgersen | 39.5 | 17.4 | 186 | 3800 | female | 2007 |
| Adelie | Torgersen | 40.3 | 18.0 | 195 | 3250 | female | 2007 |
| Adelie | Torgersen | 36.7 | 19.3 | 193 | 3450 | female | 2007 |
| Adelie | Torgersen | 39.3 | 20.6 | 190 | 3650 | male | 2007 |

| species | island | bill_length_mm | bill_depth_mm | flipper_length_mm | body_mass_g | sex | year |
|---|---|---|---|---|---|---|---|
| Adelie | Torgersen | 38.9 | 17.8 | 181 | 3625 | female | 2007 |

## Methods

In this section, we perform exploratory data analysis (EDA) and prepare the data for modeling.

```
Rows: 333
Columns: 8
$ species           <chr> "Adelie", "Adelie", "Adelie", "Adelie", "Adelie", "A~
$ island            <chr> "Torgersen", "Torgersen", "Torgersen", "Torgersen", ~
$ bill_length_mm    <dbl> 39.1, 39.5, 40.3, 36.7, 39.3, 38.9, 39.2, 41.1, 38.6~
$ bill_depth_mm     <dbl> 18.7, 17.4, 18.0, 19.3, 20.6, 17.8, 19.6, 17.6, 21.2~
$ flipper_length_mm <dbl> 181, 186, 195, 193, 190, 181, 195, 182, 191, 198, 18~
$ body_mass_g       <dbl> 3750, 3800, 3250, 3450, 3650, 3625, 4675, 3200, 3800~
$ sex               <chr> "male", "female", "female", "female", "male", "femal~
$ year              <dbl> 2007, 2007, 2007, 2007, 2007, 2007, 2007, 2007, 2007~
```

```
Rows: 1 Columns: 4
-- Column specification --------------------------------------------------------
Delimiter: ","
dbl (4): mean_bill_length, mean_bill_depth, mean_flipper_length, mean_body_mass

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.
```

Table 2: Summarise data.

| species | island | bill_length_mm | bill_depth_mm | flipper_length_mm | body_mass_g | sex | year |
|---|---|---|---|---|---|---|---|
| Adelie | Torgersen | 39.1 | 18.7 | 181 | 3750 | male | 2007 |
| Adelie | Torgersen | 39.5 | 17.4 | 186 | 3800 | female | 2007 |
| Adelie | Torgersen | 40.3 | 18.0 | 195 | 3250 | female | 2007 |
| Adelie | Torgersen | 36.7 | 19.3 | 193 | 3450 | female | 2007 |
| Adelie | Torgersen | 39.3 | 20.6 | 190 | 3650 | male | 2007 |
| Adelie | Torgersen | 38.9 | 17.8 | 181 | 3625 | female | 2007 |
| Adelie | Torgersen | 39.2 | 19.6 | 195 | 4675 | male | 2007 |
| Adelie | Torgersen | 41.1 | 17.6 | 182 | 3200 | female | 2007 |

| species | island | bill_length_mm | bill_depth_mm | flipper_length_mm | body_mass_g | sex | year |
|---|---|---|---|---|---|---|---|
| Adelie | Torgersen | 38.6 | 21.2 | 191 | 3800 | male | 2007 |
| Adelie | Torgersen | 34.6 | 21.1 | 198 | 4400 | male | 2007 |
| Adelie | Torgersen | 36.6 | 17.8 | 185 | 3700 | female | 2007 |
| Adelie | Torgersen | 38.7 | 19.0 | 195 | 3450 | female | 2007 |
| Adelie | Torgersen | 42.5 | 20.7 | 197 | 4500 | male | 2007 |
| Adelie | Torgersen | 34.4 | 18.4 | 184 | 3325 | female | 2007 |
| Adelie | Torgersen | 46.0 | 21.5 | 194 | 4200 | male | 2007 |
| Adelie | Biscoe | 37.8 | 18.3 | 174 | 3400 | female | 2007 |
| Adelie | Biscoe | 37.7 | 18.7 | 180 | 3600 | male | 2007 |
| Adelie | Biscoe | 35.9 | 19.2 | 189 | 3800 | female | 2007 |
| Adelie | Biscoe | 38.2 | 18.1 | 185 | 3950 | male | 2007 |
| Adelie | Biscoe | 38.8 | 17.2 | 180 | 3800 | male | 2007 |
| Adelie | Biscoe | 35.3 | 18.9 | 187 | 3800 | female | 2007 |
| Adelie | Biscoe | 40.6 | 18.6 | 183 | 3550 | male | 2007 |
| Adelie | Biscoe | 40.5 | 17.9 | 187 | 3200 | female | 2007 |
| Adelie | Biscoe | 37.9 | 18.6 | 172 | 3150 | female | 2007 |
| Adelie | Biscoe | 40.5 | 18.9 | 180 | 3950 | male | 2007 |
| Adelie | Dream | 39.5 | 16.7 | 178 | 3250 | female | 2007 |
| Adelie | Dream | 37.2 | 18.1 | 178 | 3900 | male | 2007 |
| Adelie | Dream | 39.5 | 17.8 | 188 | 3300 | female | 2007 |
| Adelie | Dream | 40.9 | 18.9 | 184 | 3900 | male | 2007 |
| Adelie | Dream | 36.4 | 17.0 | 195 | 3325 | female | 2007 |
| Adelie | Dream | 39.2 | 21.1 | 196 | 4150 | male | 2007 |
| Adelie | Dream | 38.8 | 20.0 | 190 | 3950 | male | 2007 |
| Adelie | Dream | 42.2 | 18.5 | 180 | 3550 | female | 2007 |
| Adelie | Dream | 37.6 | 19.3 | 181 | 3300 | female | 2007 |
| Adelie | Dream | 39.8 | 19.1 | 184 | 4650 | male | 2007 |
| Adelie | Dream | 36.5 | 18.0 | 182 | 3150 | female | 2007 |
| Adelie | Dream | 40.8 | 18.4 | 195 | 3900 | male | 2007 |
| Adelie | Dream | 36.0 | 18.5 | 186 | 3100 | female | 2007 |
| Adelie | Dream | 44.1 | 19.7 | 196 | 4400 | male | 2007 |
| Adelie | Dream | 37.0 | 16.9 | 185 | 3000 | female | 2007 |
| Adelie | Dream | 39.6 | 18.8 | 190 | 4600 | male | 2007 |
| Adelie | Dream | 41.1 | 19.0 | 182 | 3425 | male | 2007 |
| Adelie | Dream | 36.0 | 17.9 | 190 | 3450 | female | 2007 |
| Adelie | Dream | 42.3 | 21.2 | 191 | 4150 | male | 2007 |
| Adelie | Biscoe | 39.6 | 17.7 | 186 | 3500 | female | 2008 |
| Adelie | Biscoe | 40.1 | 18.9 | 188 | 4300 | male | 2008 |
| Adelie | Biscoe | 35.0 | 17.9 | 190 | 3450 | female | 2008 |
| Adelie | Biscoe | 42.0 | 19.5 | 200 | 4050 | male | 2008 |
| Adelie | Biscoe | 34.5 | 18.1 | 187 | 2900 | female | 2008 |

| species | island | bill_length_mm | bill_depth_mm | flipper_length_mm | body_mass_g | sex | year |
|---|---|---|---|---|---|---|---|
| Adelie | Biscoe | 41.4 | 18.6 | 191 | 3700 | male | 2008 |
| Adelie | Biscoe | 39.0 | 17.5 | 186 | 3550 | female | 2008 |
| Adelie | Biscoe | 40.6 | 18.8 | 193 | 3800 | male | 2008 |
| Adelie | Biscoe | 36.5 | 16.6 | 181 | 2850 | female | 2008 |
| Adelie | Biscoe | 37.6 | 19.1 | 194 | 3750 | male | 2008 |
| Adelie | Biscoe | 35.7 | 16.9 | 185 | 3150 | female | 2008 |
| Adelie | Biscoe | 41.3 | 21.1 | 195 | 4400 | male | 2008 |
| Adelie | Biscoe | 37.6 | 17.0 | 185 | 3600 | female | 2008 |
| Adelie | Biscoe | 41.1 | 18.2 | 192 | 4050 | male | 2008 |
| Adelie | Biscoe | 36.4 | 17.1 | 184 | 2850 | female | 2008 |
| Adelie | Biscoe | 41.6 | 18.0 | 192 | 3950 | male | 2008 |
| Adelie | Biscoe | 35.5 | 16.2 | 195 | 3350 | female | 2008 |
| Adelie | Biscoe | 41.1 | 19.1 | 188 | 4100 | male | 2008 |
| Adelie | Torgersen | 35.9 | 16.6 | 190 | 3050 | female | 2008 |
| Adelie | Torgersen | 41.8 | 19.4 | 198 | 4450 | male | 2008 |
| Adelie | Torgersen | 33.5 | 19.0 | 190 | 3600 | female | 2008 |
| Adelie | Torgersen | 39.7 | 18.4 | 190 | 3900 | male | 2008 |
| Adelie | Torgersen | 39.6 | 17.2 | 196 | 3550 | female | 2008 |
| Adelie | Torgersen | 45.8 | 18.9 | 197 | 4150 | male | 2008 |
| Adelie | Torgersen | 35.5 | 17.5 | 190 | 3700 | female | 2008 |
| Adelie | Torgersen | 42.8 | 18.5 | 195 | 4250 | male | 2008 |
| Adelie | Torgersen | 40.9 | 16.8 | 191 | 3700 | female | 2008 |
| Adelie | Torgersen | 37.2 | 19.4 | 184 | 3900 | male | 2008 |
| Adelie | Torgersen | 36.2 | 16.1 | 187 | 3550 | female | 2008 |
| Adelie | Torgersen | 42.1 | 19.1 | 195 | 4000 | male | 2008 |
| Adelie | Torgersen | 34.6 | 17.2 | 189 | 3200 | female | 2008 |
| Adelie | Torgersen | 42.9 | 17.6 | 196 | 4700 | male | 2008 |
| Adelie | Torgersen | 36.7 | 18.8 | 187 | 3800 | female | 2008 |
| Adelie | Torgersen | 35.1 | 19.4 | 193 | 4200 | male | 2008 |
| Adelie | Dream | 37.3 | 17.8 | 191 | 3350 | female | 2008 |
| Adelie | Dream | 41.3 | 20.3 | 194 | 3550 | male | 2008 |
| Adelie | Dream | 36.3 | 19.5 | 190 | 3800 | male | 2008 |
| Adelie | Dream | 36.9 | 18.6 | 189 | 3500 | female | 2008 |
| Adelie | Dream | 38.3 | 19.2 | 189 | 3950 | male | 2008 |
| Adelie | Dream | 38.9 | 18.8 | 190 | 3600 | female | 2008 |
| Adelie | Dream | 35.7 | 18.0 | 202 | 3550 | female | 2008 |
| Adelie | Dream | 41.1 | 18.1 | 205 | 4300 | male | 2008 |
| Adelie | Dream | 34.0 | 17.1 | 185 | 3400 | female | 2008 |
| Adelie | Dream | 39.6 | 18.1 | 186 | 4450 | male | 2008 |
| Adelie | Dream | 36.2 | 17.3 | 187 | 3300 | female | 2008 |
| Adelie | Dream | 40.8 | 18.9 | 208 | 4300 | male | 2008 |

| species | island | bill_length_mm | bill_depth_mm | flipper_length_mm | body_mass_g | sex | year |
|---|---|---|---|---|---|---|---|
| Adelie | Dream | 38.1 | 18.6 | 190 | 3700 | female | 2008 |
| Adelie | Dream | 40.3 | 18.5 | 196 | 4350 | male | 2008 |
| Adelie | Dream | 33.1 | 16.1 | 178 | 2900 | female | 2008 |
| Adelie | Dream | 43.2 | 18.5 | 192 | 4100 | male | 2008 |
| Adelie | Biscoe | 35.0 | 17.9 | 192 | 3725 | female | 2009 |
| Adelie | Biscoe | 41.0 | 20.0 | 203 | 4725 | male | 2009 |
| Adelie | Biscoe | 37.7 | 16.0 | 183 | 3075 | female | 2009 |
| Adelie | Biscoe | 37.8 | 20.0 | 190 | 4250 | male | 2009 |
| Adelie | Biscoe | 37.9 | 18.6 | 193 | 2925 | female | 2009 |
| Adelie | Biscoe | 39.7 | 18.9 | 184 | 3550 | male | 2009 |
| Adelie | Biscoe | 38.6 | 17.2 | 199 | 3750 | female | 2009 |
| Adelie | Biscoe | 38.2 | 20.0 | 190 | 3900 | male | 2009 |
| Adelie | Biscoe | 38.1 | 17.0 | 181 | 3175 | female | 2009 |
| Adelie | Biscoe | 43.2 | 19.0 | 197 | 4775 | male | 2009 |
| Adelie | Biscoe | 38.1 | 16.5 | 198 | 3825 | female | 2009 |
| Adelie | Biscoe | 45.6 | 20.3 | 191 | 4600 | male | 2009 |
| Adelie | Biscoe | 39.7 | 17.7 | 193 | 3200 | female | 2009 |
| Adelie | Biscoe | 42.2 | 19.5 | 197 | 4275 | male | 2009 |
| Adelie | Biscoe | 39.6 | 20.7 | 191 | 3900 | female | 2009 |
| Adelie | Biscoe | 42.7 | 18.3 | 196 | 4075 | male | 2009 |
| Adelie | Torgersen | 38.6 | 17.0 | 188 | 2900 | female | 2009 |
| Adelie | Torgersen | 37.3 | 20.5 | 199 | 3775 | male | 2009 |
| Adelie | Torgersen | 35.7 | 17.0 | 189 | 3350 | female | 2009 |
| Adelie | Torgersen | 41.1 | 18.6 | 189 | 3325 | male | 2009 |
| Adelie | Torgersen | 36.2 | 17.2 | 187 | 3150 | female | 2009 |
| Adelie | Torgersen | 37.7 | 19.8 | 198 | 3500 | male | 2009 |
| Adelie | Torgersen | 40.2 | 17.0 | 176 | 3450 | female | 2009 |
| Adelie | Torgersen | 41.4 | 18.5 | 202 | 3875 | male | 2009 |
| Adelie | Torgersen | 35.2 | 15.9 | 186 | 3050 | female | 2009 |
| Adelie | Torgersen | 40.6 | 19.0 | 199 | 4000 | male | 2009 |
| Adelie | Torgersen | 38.8 | 17.6 | 191 | 3275 | female | 2009 |
| Adelie | Torgersen | 41.5 | 18.3 | 195 | 4300 | male | 2009 |
| Adelie | Torgersen | 39.0 | 17.1 | 191 | 3050 | female | 2009 |
| Adelie | Torgersen | 44.1 | 18.0 | 210 | 4000 | male | 2009 |
| Adelie | Torgersen | 38.5 | 17.9 | 190 | 3325 | female | 2009 |
| Adelie | Torgersen | 43.1 | 19.2 | 197 | 3500 | male | 2009 |
| Adelie | Dream | 36.8 | 18.5 | 193 | 3500 | female | 2009 |
| Adelie | Dream | 37.5 | 18.5 | 199 | 4475 | male | 2009 |
| Adelie | Dream | 38.1 | 17.6 | 187 | 3425 | female | 2009 |
| Adelie | Dream | 41.1 | 17.5 | 190 | 3900 | male | 2009 |
| Adelie | Dream | 35.6 | 17.5 | 191 | 3175 | female | 2009 |

| species | island | bill_length_mm | bill_depth_mm | flipper_length_mm | body_mass_g | sex | year |
|---|---|---|---|---|---|---|---|
| Adelie | Dream | 40.2 | 20.1 | 200 | 3975 | male | 2009 |
| Adelie | Dream | 37.0 | 16.5 | 185 | 3400 | female | 2009 |
| Adelie | Dream | 39.7 | 17.9 | 193 | 4250 | male | 2009 |
| Adelie | Dream | 40.2 | 17.1 | 193 | 3400 | female | 2009 |
| Adelie | Dream | 40.6 | 17.2 | 187 | 3475 | male | 2009 |
| Adelie | Dream | 32.1 | 15.5 | 188 | 3050 | female | 2009 |
| Adelie | Dream | 40.7 | 17.0 | 190 | 3725 | male | 2009 |
| Adelie | Dream | 37.3 | 16.8 | 192 | 3000 | female | 2009 |
| Adelie | Dream | 39.0 | 18.7 | 185 | 3650 | male | 2009 |
| Adelie | Dream | 39.2 | 18.6 | 190 | 4250 | male | 2009 |
| Adelie | Dream | 36.6 | 18.4 | 184 | 3475 | female | 2009 |
| Adelie | Dream | 36.0 | 17.8 | 195 | 3450 | female | 2009 |
| Adelie | Dream | 37.8 | 18.1 | 193 | 3750 | male | 2009 |
| Adelie | Dream | 36.0 | 17.1 | 187 | 3700 | female | 2009 |
| Adelie | Dream | 41.5 | 18.5 | 201 | 4000 | male | 2009 |
| Gentoo | Biscoe | 46.1 | 13.2 | 211 | 4500 | female | 2007 |
| Gentoo | Biscoe | 50.0 | 16.3 | 230 | 5700 | male | 2007 |
| Gentoo | Biscoe | 48.7 | 14.1 | 210 | 4450 | female | 2007 |
| Gentoo | Biscoe | 50.0 | 15.2 | 218 | 5700 | male | 2007 |
| Gentoo | Biscoe | 47.6 | 14.5 | 215 | 5400 | male | 2007 |
| Gentoo | Biscoe | 46.5 | 13.5 | 210 | 4550 | female | 2007 |
| Gentoo | Biscoe | 45.4 | 14.6 | 211 | 4800 | female | 2007 |
| Gentoo | Biscoe | 46.7 | 15.3 | 219 | 5200 | male | 2007 |
| Gentoo | Biscoe | 43.3 | 13.4 | 209 | 4400 | female | 2007 |
| Gentoo | Biscoe | 46.8 | 15.4 | 215 | 5150 | male | 2007 |
| Gentoo | Biscoe | 40.9 | 13.7 | 214 | 4650 | female | 2007 |
| Gentoo | Biscoe | 49.0 | 16.1 | 216 | 5550 | male | 2007 |
| Gentoo | Biscoe | 45.5 | 13.7 | 214 | 4650 | female | 2007 |
| Gentoo | Biscoe | 48.4 | 14.6 | 213 | 5850 | male | 2007 |
| Gentoo | Biscoe | 45.8 | 14.6 | 210 | 4200 | female | 2007 |
| Gentoo | Biscoe | 49.3 | 15.7 | 217 | 5850 | male | 2007 |
| Gentoo | Biscoe | 42.0 | 13.5 | 210 | 4150 | female | 2007 |
| Gentoo | Biscoe | 49.2 | 15.2 | 221 | 6300 | male | 2007 |
| Gentoo | Biscoe | 46.2 | 14.5 | 209 | 4800 | female | 2007 |
| Gentoo | Biscoe | 48.7 | 15.1 | 222 | 5350 | male | 2007 |
| Gentoo | Biscoe | 50.2 | 14.3 | 218 | 5700 | male | 2007 |
| Gentoo | Biscoe | 45.1 | 14.5 | 215 | 5000 | female | 2007 |
| Gentoo | Biscoe | 46.5 | 14.5 | 213 | 4400 | female | 2007 |
| Gentoo | Biscoe | 46.3 | 15.8 | 215 | 5050 | male | 2007 |
| Gentoo | Biscoe | 42.9 | 13.1 | 215 | 5000 | female | 2007 |
| Gentoo | Biscoe | 46.1 | 15.1 | 215 | 5100 | male | 2007 |

| species | island | bill_length_mm | bill_depth_mm | flipper_length_mm | body_mass_g | sex | year |
|---|---|---|---|---|---|---|---|
| Gentoo | Biscoe | 47.8 | 15.0 | 215 | 5650 | male | 2007 |
| Gentoo | Biscoe | 48.2 | 14.3 | 210 | 4600 | female | 2007 |
| Gentoo | Biscoe | 50.0 | 15.3 | 220 | 5550 | male | 2007 |
| Gentoo | Biscoe | 47.3 | 15.3 | 222 | 5250 | male | 2007 |
| Gentoo | Biscoe | 42.8 | 14.2 | 209 | 4700 | female | 2007 |
| Gentoo | Biscoe | 45.1 | 14.5 | 207 | 5050 | female | 2007 |
| Gentoo | Biscoe | 59.6 | 17.0 | 230 | 6050 | male | 2007 |
| Gentoo | Biscoe | 49.1 | 14.8 | 220 | 5150 | female | 2008 |
| Gentoo | Biscoe | 48.4 | 16.3 | 220 | 5400 | male | 2008 |
| Gentoo | Biscoe | 42.6 | 13.7 | 213 | 4950 | female | 2008 |
| Gentoo | Biscoe | 44.4 | 17.3 | 219 | 5250 | male | 2008 |
| Gentoo | Biscoe | 44.0 | 13.6 | 208 | 4350 | female | 2008 |
| Gentoo | Biscoe | 48.7 | 15.7 | 208 | 5350 | male | 2008 |
| Gentoo | Biscoe | 42.7 | 13.7 | 208 | 3950 | female | 2008 |
| Gentoo | Biscoe | 49.6 | 16.0 | 225 | 5700 | male | 2008 |
| Gentoo | Biscoe | 45.3 | 13.7 | 210 | 4300 | female | 2008 |
| Gentoo | Biscoe | 49.6 | 15.0 | 216 | 4750 | male | 2008 |
| Gentoo | Biscoe | 50.5 | 15.9 | 222 | 5550 | male | 2008 |
| Gentoo | Biscoe | 43.6 | 13.9 | 217 | 4900 | female | 2008 |
| Gentoo | Biscoe | 45.5 | 13.9 | 210 | 4200 | female | 2008 |
| Gentoo | Biscoe | 50.5 | 15.9 | 225 | 5400 | male | 2008 |
| Gentoo | Biscoe | 44.9 | 13.3 | 213 | 5100 | female | 2008 |
| Gentoo | Biscoe | 45.2 | 15.8 | 215 | 5300 | male | 2008 |
| Gentoo | Biscoe | 46.6 | 14.2 | 210 | 4850 | female | 2008 |
| Gentoo | Biscoe | 48.5 | 14.1 | 220 | 5300 | male | 2008 |
| Gentoo | Biscoe | 45.1 | 14.4 | 210 | 4400 | female | 2008 |
| Gentoo | Biscoe | 50.1 | 15.0 | 225 | 5000 | male | 2008 |
| Gentoo | Biscoe | 46.5 | 14.4 | 217 | 4900 | female | 2008 |
| Gentoo | Biscoe | 45.0 | 15.4 | 220 | 5050 | male | 2008 |
| Gentoo | Biscoe | 43.8 | 13.9 | 208 | 4300 | female | 2008 |
| Gentoo | Biscoe | 45.5 | 15.0 | 220 | 5000 | male | 2008 |
| Gentoo | Biscoe | 43.2 | 14.5 | 208 | 4450 | female | 2008 |
| Gentoo | Biscoe | 50.4 | 15.3 | 224 | 5550 | male | 2008 |
| Gentoo | Biscoe | 45.3 | 13.8 | 208 | 4200 | female | 2008 |
| Gentoo | Biscoe | 46.2 | 14.9 | 221 | 5300 | male | 2008 |
| Gentoo | Biscoe | 45.7 | 13.9 | 214 | 4400 | female | 2008 |
| Gentoo | Biscoe | 54.3 | 15.7 | 231 | 5650 | male | 2008 |
| Gentoo | Biscoe | 45.8 | 14.2 | 219 | 4700 | female | 2008 |
| Gentoo | Biscoe | 49.8 | 16.8 | 230 | 5700 | male | 2008 |
| Gentoo | Biscoe | 49.5 | 16.2 | 229 | 5800 | male | 2008 |
| Gentoo | Biscoe | 43.5 | 14.2 | 220 | 4700 | female | 2008 |

| species | island | bill_length_mm | bill_depth_mm | flipper_length_mm | body_mass_g | sex | year |
|---|---|---|---|---|---|---|---|
| Gentoo | Biscoe | 50.7 | 15.0 | 223 | 5550 | male | 2008 |
| Gentoo | Biscoe | 47.7 | 15.0 | 216 | 4750 | female | 2008 |
| Gentoo | Biscoe | 46.4 | 15.6 | 221 | 5000 | male | 2008 |
| Gentoo | Biscoe | 48.2 | 15.6 | 221 | 5100 | male | 2008 |
| Gentoo | Biscoe | 46.5 | 14.8 | 217 | 5200 | female | 2008 |
| Gentoo | Biscoe | 46.4 | 15.0 | 216 | 4700 | female | 2008 |
| Gentoo | Biscoe | 48.6 | 16.0 | 230 | 5800 | male | 2008 |
| Gentoo | Biscoe | 47.5 | 14.2 | 209 | 4600 | female | 2008 |
| Gentoo | Biscoe | 51.1 | 16.3 | 220 | 6000 | male | 2008 |
| Gentoo | Biscoe | 45.2 | 13.8 | 215 | 4750 | female | 2008 |
| Gentoo | Biscoe | 45.2 | 16.4 | 223 | 5950 | male | 2008 |
| Gentoo | Biscoe | 49.1 | 14.5 | 212 | 4625 | female | 2009 |
| Gentoo | Biscoe | 52.5 | 15.6 | 221 | 5450 | male | 2009 |
| Gentoo | Biscoe | 47.4 | 14.6 | 212 | 4725 | female | 2009 |
| Gentoo | Biscoe | 50.0 | 15.9 | 224 | 5350 | male | 2009 |
| Gentoo | Biscoe | 44.9 | 13.8 | 212 | 4750 | female | 2009 |
| Gentoo | Biscoe | 50.8 | 17.3 | 228 | 5600 | male | 2009 |
| Gentoo | Biscoe | 43.4 | 14.4 | 218 | 4600 | female | 2009 |
| Gentoo | Biscoe | 51.3 | 14.2 | 218 | 5300 | male | 2009 |
| Gentoo | Biscoe | 47.5 | 14.0 | 212 | 4875 | female | 2009 |
| Gentoo | Biscoe | 52.1 | 17.0 | 230 | 5550 | male | 2009 |
| Gentoo | Biscoe | 47.5 | 15.0 | 218 | 4950 | female | 2009 |
| Gentoo | Biscoe | 52.2 | 17.1 | 228 | 5400 | male | 2009 |
| Gentoo | Biscoe | 45.5 | 14.5 | 212 | 4750 | female | 2009 |
| Gentoo | Biscoe | 49.5 | 16.1 | 224 | 5650 | male | 2009 |
| Gentoo | Biscoe | 44.5 | 14.7 | 214 | 4850 | female | 2009 |
| Gentoo | Biscoe | 50.8 | 15.7 | 226 | 5200 | male | 2009 |
| Gentoo | Biscoe | 49.4 | 15.8 | 216 | 4925 | male | 2009 |
| Gentoo | Biscoe | 46.9 | 14.6 | 222 | 4875 | female | 2009 |
| Gentoo | Biscoe | 48.4 | 14.4 | 203 | 4625 | female | 2009 |
| Gentoo | Biscoe | 51.1 | 16.5 | 225 | 5250 | male | 2009 |
| Gentoo | Biscoe | 48.5 | 15.0 | 219 | 4850 | female | 2009 |
| Gentoo | Biscoe | 55.9 | 17.0 | 228 | 5600 | male | 2009 |
| Gentoo | Biscoe | 47.2 | 15.5 | 215 | 4975 | female | 2009 |
| Gentoo | Biscoe | 49.1 | 15.0 | 228 | 5500 | male | 2009 |
| Gentoo | Biscoe | 46.8 | 16.1 | 215 | 5500 | male | 2009 |
| Gentoo | Biscoe | 41.7 | 14.7 | 210 | 4700 | female | 2009 |
| Gentoo | Biscoe | 53.4 | 15.8 | 219 | 5500 | male | 2009 |
| Gentoo | Biscoe | 43.3 | 14.0 | 208 | 4575 | female | 2009 |
| Gentoo | Biscoe | 48.1 | 15.1 | 209 | 5500 | male | 2009 |
| Gentoo | Biscoe | 50.5 | 15.2 | 216 | 5000 | female | 2009 |

| species | island | bill_length_mm | bill_depth_mm | flipper_length_mm | body_mass_g | sex | year |
|---|---|---|---|---|---|---|---|
| Gentoo | Biscoe | 49.8 | 15.9 | 229 | 5950 | male | 2009 |
| Gentoo | Biscoe | 43.5 | 15.2 | 213 | 4650 | female | 2009 |
| Gentoo | Biscoe | 51.5 | 16.3 | 230 | 5500 | male | 2009 |
| Gentoo | Biscoe | 46.2 | 14.1 | 217 | 4375 | female | 2009 |
| Gentoo | Biscoe | 55.1 | 16.0 | 230 | 5850 | male | 2009 |
| Gentoo | Biscoe | 48.8 | 16.2 | 222 | 6000 | male | 2009 |
| Gentoo | Biscoe | 47.2 | 13.7 | 214 | 4925 | female | 2009 |
| Gentoo | Biscoe | 46.8 | 14.3 | 215 | 4850 | female | 2009 |
| Gentoo | Biscoe | 50.4 | 15.7 | 222 | 5750 | male | 2009 |
| Gentoo | Biscoe | 45.2 | 14.8 | 212 | 5200 | female | 2009 |
| Gentoo | Biscoe | 49.9 | 16.1 | 213 | 5400 | male | 2009 |
| Chinstrap | Dream | 46.5 | 17.9 | 192 | 3500 | female | 2007 |
| Chinstrap | Dream | 50.0 | 19.5 | 196 | 3900 | male | 2007 |
| Chinstrap | Dream | 51.3 | 19.2 | 193 | 3650 | male | 2007 |
| Chinstrap | Dream | 45.4 | 18.7 | 188 | 3525 | female | 2007 |
| Chinstrap | Dream | 52.7 | 19.8 | 197 | 3725 | male | 2007 |
| Chinstrap | Dream | 45.2 | 17.8 | 198 | 3950 | female | 2007 |
| Chinstrap | Dream | 46.1 | 18.2 | 178 | 3250 | female | 2007 |
| Chinstrap | Dream | 51.3 | 18.2 | 197 | 3750 | male | 2007 |
| Chinstrap | Dream | 46.0 | 18.9 | 195 | 4150 | female | 2007 |
| Chinstrap | Dream | 51.3 | 19.9 | 198 | 3700 | male | 2007 |
| Chinstrap | Dream | 46.6 | 17.8 | 193 | 3800 | female | 2007 |
| Chinstrap | Dream | 51.7 | 20.3 | 194 | 3775 | male | 2007 |
| Chinstrap | Dream | 47.0 | 17.3 | 185 | 3700 | female | 2007 |
| Chinstrap | Dream | 52.0 | 18.1 | 201 | 4050 | male | 2007 |
| Chinstrap | Dream | 45.9 | 17.1 | 190 | 3575 | female | 2007 |
| Chinstrap | Dream | 50.5 | 19.6 | 201 | 4050 | male | 2007 |
| Chinstrap | Dream | 50.3 | 20.0 | 197 | 3300 | male | 2007 |
| Chinstrap | Dream | 58.0 | 17.8 | 181 | 3700 | female | 2007 |
| Chinstrap | Dream | 46.4 | 18.6 | 190 | 3450 | female | 2007 |
| Chinstrap | Dream | 49.2 | 18.2 | 195 | 4400 | male | 2007 |
| Chinstrap | Dream | 42.4 | 17.3 | 181 | 3600 | female | 2007 |
| Chinstrap | Dream | 48.5 | 17.5 | 191 | 3400 | male | 2007 |
| Chinstrap | Dream | 43.2 | 16.6 | 187 | 2900 | female | 2007 |
| Chinstrap | Dream | 50.6 | 19.4 | 193 | 3800 | male | 2007 |
| Chinstrap | Dream | 46.7 | 17.9 | 195 | 3300 | female | 2007 |
| Chinstrap | Dream | 52.0 | 19.0 | 197 | 4150 | male | 2007 |
| Chinstrap | Dream | 50.5 | 18.4 | 200 | 3400 | female | 2008 |
| Chinstrap | Dream | 49.5 | 19.0 | 200 | 3800 | male | 2008 |
| Chinstrap | Dream | 46.4 | 17.8 | 191 | 3700 | female | 2008 |
| Chinstrap | Dream | 52.8 | 20.0 | 205 | 4550 | male | 2008 |

| species | island | bill_length_mm | bill_depth_mm | flipper_length_mm | body_mass_g | sex | year |
|---|---|---|---|---|---|---|---|
| Chinstrap | Dream | 40.9 | 16.6 | 187 | 3200 | female | 2008 |
| Chinstrap | Dream | 54.2 | 20.8 | 201 | 4300 | male | 2008 |
| Chinstrap | Dream | 42.5 | 16.7 | 187 | 3350 | female | 2008 |
| Chinstrap | Dream | 51.0 | 18.8 | 203 | 4100 | male | 2008 |
| Chinstrap | Dream | 49.7 | 18.6 | 195 | 3600 | male | 2008 |
| Chinstrap | Dream | 47.5 | 16.8 | 199 | 3900 | female | 2008 |
| Chinstrap | Dream | 47.6 | 18.3 | 195 | 3850 | female | 2008 |
| Chinstrap | Dream | 52.0 | 20.7 | 210 | 4800 | male | 2008 |
| Chinstrap | Dream | 46.9 | 16.6 | 192 | 2700 | female | 2008 |
| Chinstrap | Dream | 53.5 | 19.9 | 205 | 4500 | male | 2008 |
| Chinstrap | Dream | 49.0 | 19.5 | 210 | 3950 | male | 2008 |
| Chinstrap | Dream | 46.2 | 17.5 | 187 | 3650 | female | 2008 |
| Chinstrap | Dream | 50.9 | 19.1 | 196 | 3550 | male | 2008 |
| Chinstrap | Dream | 45.5 | 17.0 | 196 | 3500 | female | 2008 |
| Chinstrap | Dream | 50.9 | 17.9 | 196 | 3675 | female | 2009 |
| Chinstrap | Dream | 50.8 | 18.5 | 201 | 4450 | male | 2009 |
| Chinstrap | Dream | 50.1 | 17.9 | 190 | 3400 | female | 2009 |
| Chinstrap | Dream | 49.0 | 19.6 | 212 | 4300 | male | 2009 |
| Chinstrap | Dream | 51.5 | 18.7 | 187 | 3250 | male | 2009 |
| Chinstrap | Dream | 49.8 | 17.3 | 198 | 3675 | female | 2009 |
| Chinstrap | Dream | 48.1 | 16.4 | 199 | 3325 | female | 2009 |
| Chinstrap | Dream | 51.4 | 19.0 | 201 | 3950 | male | 2009 |
| Chinstrap | Dream | 45.7 | 17.3 | 193 | 3600 | female | 2009 |
| Chinstrap | Dream | 50.7 | 19.7 | 203 | 4050 | male | 2009 |
| Chinstrap | Dream | 42.5 | 17.3 | 187 | 3350 | female | 2009 |
| Chinstrap | Dream | 52.2 | 18.8 | 197 | 3450 | male | 2009 |
| Chinstrap | Dream | 45.2 | 16.6 | 191 | 3250 | female | 2009 |
| Chinstrap | Dream | 49.3 | 19.9 | 203 | 4050 | male | 2009 |
| Chinstrap | Dream | 50.2 | 18.8 | 202 | 3800 | male | 2009 |
| Chinstrap | Dream | 45.6 | 19.4 | 194 | 3525 | female | 2009 |
| Chinstrap | Dream | 51.9 | 19.5 | 206 | 3950 | male | 2009 |
| Chinstrap | Dream | 46.8 | 16.5 | 189 | 3650 | female | 2009 |
| Chinstrap | Dream | 45.7 | 17.0 | 195 | 3650 | female | 2009 |
| Chinstrap | Dream | 55.8 | 19.8 | 207 | 4000 | male | 2009 |
| Chinstrap | Dream | 43.5 | 18.1 | 202 | 3400 | female | 2009 |
| Chinstrap | Dream | 49.6 | 18.2 | 193 | 3775 | male | 2009 |
| Chinstrap | Dream | 50.8 | 19.0 | 210 | 4100 | male | 2009 |
| Chinstrap | Dream | 50.2 | 18.7 | 198 | 3775 | female | 2009 |

Rows: 333 Columns: 5

```
-- Column specification --------------------------------------------------------
Delimiter: ","
chr (1): species
dbl (4): bill_length_mm, bill_depth_mm, flipper_length_mm, body_mass_g

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.
```

Table 3: Prepare data for modelling.

| species | bill_length_mm | bill_depth_mm | flipper_length_mm | body_mass_g |
|---|---|---|---|---|
| Adelie | 39.1 | 18.7 | 181 | 3750 |
| Adelie | 39.5 | 17.4 | 186 | 3800 |
| Adelie | 40.3 | 18.0 | 195 | 3250 |
| Adelie | 36.7 | 19.3 | 193 | 3450 |
| Adelie | 39.3 | 20.6 | 190 | 3650 |
| Adelie | 38.9 | 17.8 | 181 | 3625 |

## Model

We will fit a classification model using `tidymodels` to predict the species of a penguin based on its physical characteristics.

Table 4: Fit classification model.

| species | bill_length_mm | bill_depth_mm | flipper_length_mm | body_mass_g |
|---|---|---|---|---|
| Length:333 | Min. :32.10 | Min. :13.10 | Min. :172 | Min. :2700 |
| Class :character | 1st Qu.:39.50 | 1st Qu.:15.60 | 1st Qu.:190 | 1st Qu.:3550 |
| Mode :character | Median :44.50 | Median :17.30 | Median :197 | Median :4050 |
| NA | Mean :43.99 | Mean :17.16 | Mean :201 | Mean :4207 |
| NA | 3rd Qu.:48.60 | 3rd Qu.:18.70 | 3rd Qu.:213 | 3rd Qu.:4775 |
| NA | Max. :59.60 | Max. :21.50 | Max. :231 | Max. :6300 |

## Results

We evaluate the performance of the model using the test dataset.

Table 5: Model results.

| | Adelie | Chinstrap | Gentoo |
|---|---|---|---|
| Adelie | 36 | 0 | 0 |
| Chinstrap | 1 | 17 | 0 |
| Gentoo | 0 | 0 | 30 |

### Libraries Run

Test the usage of packages in the report.

```
Rows: 1 Columns: 4
-- Column specification --------------------------------------------------------
Delimiter: ","
dbl (4): mean_bill_length, mean_bill_depth, mean_flipper_length, mean_body_mass

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.
```

Table 6: Test the usage of packages in the report.

| mean_bill_length | mean_bill_depth | mean_flipper_length | mean_body_mass |
|---|---|---|---|
| 43.99279 | 17.16486 | 200.967 | 4207.057 |

## Conclusion

In this tutorial, we:

- Loaded and cleaned the `palmerpenguins` dataset.
- Performed exploratory data analysis.
- Built a k-Nearest Neighbors classification model using `tidymodels`.
- Evaluated the model's performance.

## References


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Xie, Yihui. 2014. "Knitr: A Comprehensive Tool for Reproducible Research in R." In *Implementing Reproducible Computational Research*, edited by Victoria Stodden, Friedrich Leisch, and Roger D. Peng. Chapman; Hall/CRC. http://www.crcpress.com/product/isbn/9781466561595.