Data Analysis Assignment #1

Submit both the .Rmd and .html files for grading. You may remove the instructions and example problem above, but do not remove the YAML metadata block or the first, “setup” code chunk. Address the steps that appear below and answer all the questions. Be sure to address each question with code and comments as needed. You may use either base R functions or ggplot2 for the visualizations.

The following code chunk will:

a. load the “ggplot2”, “gridExtra” and “knitr” packages, assuming each has been installed on your machine,
b. read-in the abalones dataset, defining a new data frame, “mydata,”
c. return the structure of that data frame, and
d. calculate new variables, VOLUME and RATIO.

Do not include package installation code in this document. Packages should be installed via the Console or ‘Packages’ tab. You will also need to download the abalones.csv from the course site to a known location on your machine. Unless a *file.path()* is specified, R will look to directory where this .Rmd is stored when knitting.

```
## 'data.frame':    1036 obs. of  8 variables:
##  $ SEX   : Factor w/ 3 levels "F","I","M": 2 2 2 2 2 2 2 2 2 2 ...
##  $ LENGTH: num  5.57 3.67 10.08 4.09 6.93 ...
##  $ DIAM  : num  4.09 2.62 7.35 3.15 4.83 ...
##  $ HEIGHT: num  1.26 0.84 2.205 0.945 1.785 ...
##  $ WHOLE : num  11.5 3.5 79.38 4.69 21.19 ...
##  $ SHUCK : num  4.31 1.19 44 2.25 9.88 ...
##  $ RINGS : int  6 4 6 3 6 6 5 6 5 6 ...
##  $ CLASS : Factor w/ 5 levels "A1","A2","A3",..: 1 1 1 1 1 1 1 1 1 1 ...
```

Test Items starts from here - There are 6 sections - Total 50 points

##### Section 1: (6 points) Summarizing the data.

(1)(a) (1 point) Use *summary()* to obtain and present descriptive statistics from mydata. Use *table()* to present a frequency table using CLASS and RINGS. There should be 115 cells in the table you present.

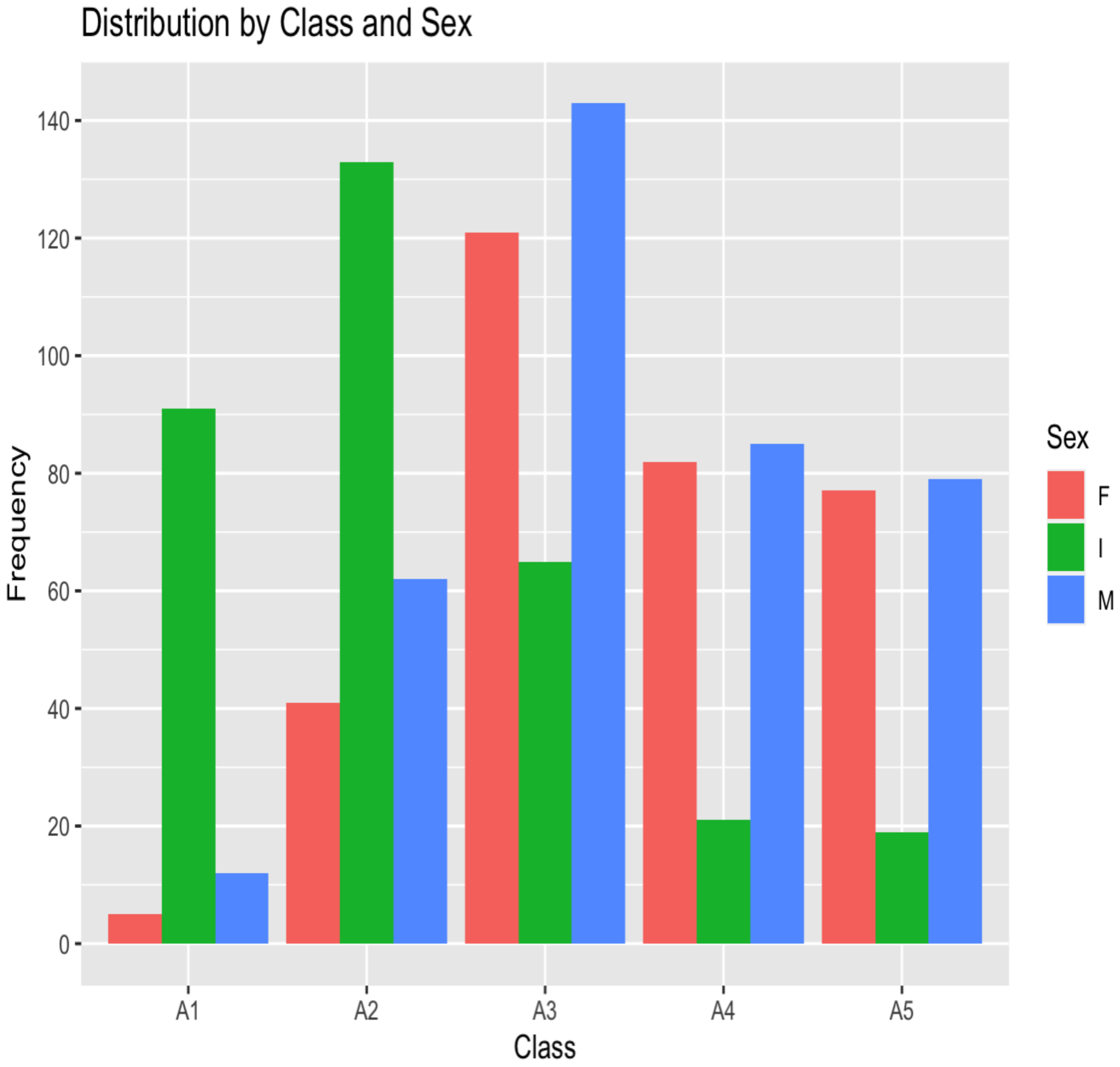
```
##  SEX         LENGTH           DIAM            HEIGHT          WHOLE
##  F:326   Min.   : 2.73   Min.   : 1.995   Min.   :0.525   Min.   :  1.625
##  I:329   1st Qu.: 9.45   1st Qu.: 7.350   1st Qu.:2.415   1st Qu.: 56.484
##  M:381   Median :11.45   Median : 8.925   Median :2.940   Median :101.344
##          Mean   :11.08   Mean   : 8.622   Mean   :2.947   Mean   :105.832
##          3rd Qu.:13.02   3rd Qu.:10.185   3rd Qu.:3.570   3rd Qu.:150.319
##          Max.   :16.80   Max.   :13.230   Max.   :4.935   Max.   :315.750
##      SHUCK              RINGS         CLASS         VOLUME
##  Min.   :  0.5625   Min.   : 3.000   A1:108   Min.   :  3.612
##  1st Qu.: 23.3006   1st Qu.: 8.000   A2:236   1st Qu.:163.545
##  Median : 42.5700   Median : 9.000   A3:329   Median :307.363
##  Mean   : 45.4396   Mean   : 9.993   A4:188   Mean   :326.804
##  3rd Qu.: 64.2897   3rd Qu.:11.000   A5:175   3rd Qu.:463.264
##  Max.   :157.0800   Max.   :25.000            Max.   :995.673
##      RATIO
##  Min.   :0.06734
##  1st Qu.:0.12241
##  Median :0.13914
##  Mean   :0.14205
##  3rd Qu.:0.15911
##  Max.   :0.31176
##
##        3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20
##   A1   9   8  24  67   0   0   0   0   0   0   0   0   0   0   0   0   0   0
##   A2   0   0   0   0  91 145   0   0   0   0   0   0   0   0   0   0   0   0
##   A3   0   0   0   0   0   0 182 147   0   0   0   0   0   0   0   0   0   0
##   A4   0   0   0   0   0   0   0   0 125  63   0   0   0   0   0   0   0   0
##   A5   0   0   0   0   0   0   0   0   0   0  48  35  27  15  13   8   8   6
##
##       21  22  23  24  25
##   A1   0   0   0   0   0
##   A2   0   0   0   0   0
##   A3   0   0   0   0   0
##   A4   0   0   0   0   0
##   A5   4   1   7   2   1
```

Question (1 point): Briefly discuss the variable types and distributional implications such as potential skewness and outliers.

Answer: Sex and Class are non-metric, qualitative data. The rest are quantative data, specifically ratio data. Positive skews/outliers are a concern for the variables whole, shuck, rings, volume, and ratio. The mean is significantly higher than the median for all of those, and we can see at a glance that the difference between the third quartile and the max is a lot bigger than between the first quartile and the median. So when we go to calculate the skew, we see a .047 skew for whole, 0.64 for shuck, 1.24 for rings, .44 for volume, and .71 for ratio. Concerns about negative skewness and outliers arise for length and diameter, where we see the median significantly below the mean. After running calculations, we can see length has a negative skew of -.67 and diameter has a negative skew of -0.62.

(1)(b) (1 point) Generate a table of counts using SEX and CLASS. Add margins to this table (Hint: There should be 15 cells in this table plus the marginal totals. Apply *table()* first, then pass the table object to *addmargins()* (Kabacoff Section 7.2 pages 144-147)). Lastly, present a barplot of these data; ignoring the marginal totals.

```
##
##          A1   A2   A3   A4   A5  Sum
##   F       5   41  121   82   77  326
##   I      91  133   65   21   19  329
##   M      12   62  143   85   79  381
##   Sum   108  236  329  188  175 1036
```

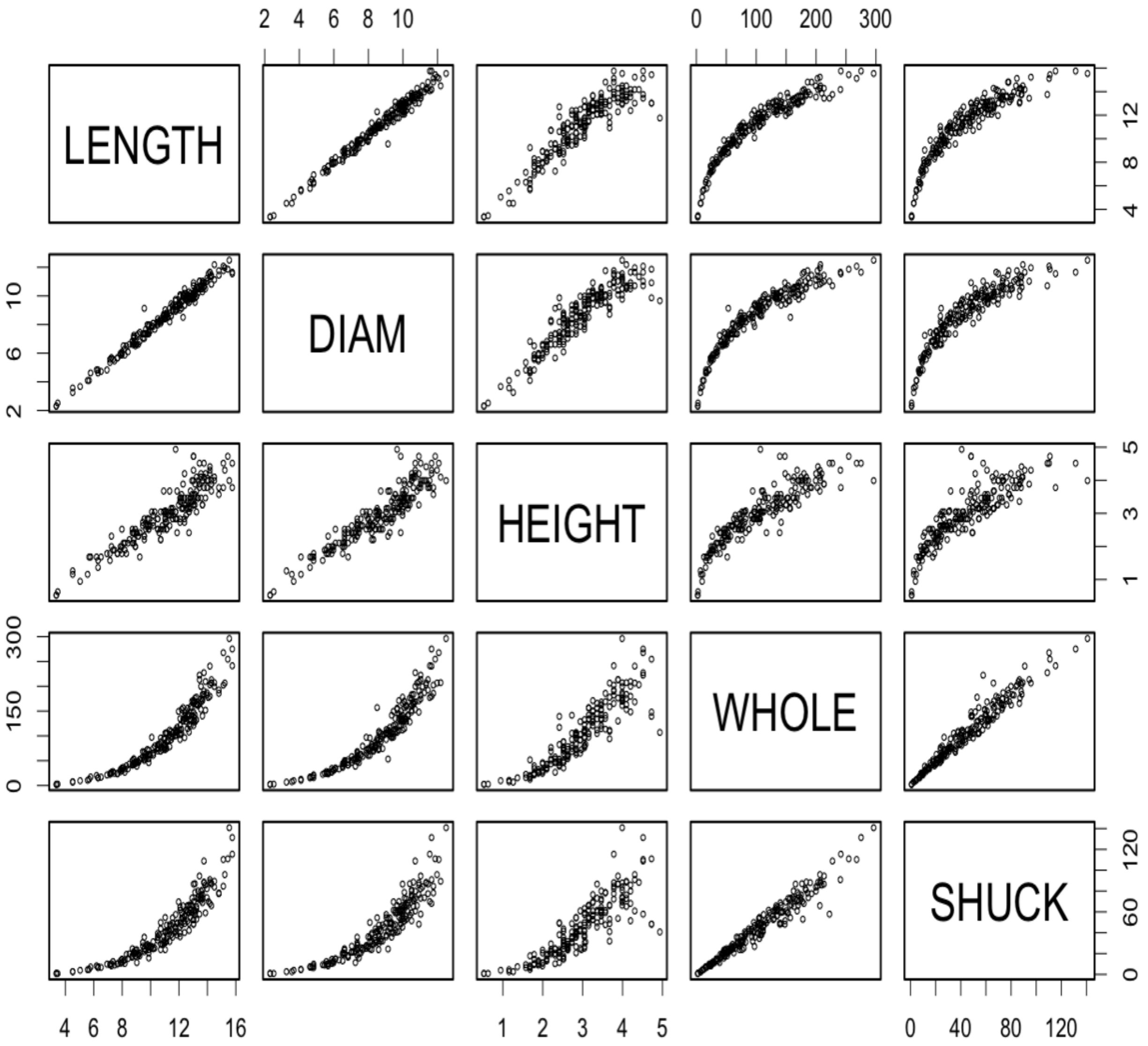


Essay Question (2 points): Discuss the sex distribution of abalones. What stands out about the distribution of abalones by CLASS?

Answer: Younger classes, like A1 and A2, have the highest number of ifant/neither identifiable male nor female abalones, which logically checks out and will skew the data. Over time, it becomes easier to determine male or female, which means the number of them goes up by class. However, one strange thing is that A3 has a drastically higher frequency of males than A4 and A5, when intuitively one might thing that the frequency of males and females identified would be a a continuous, linear, positive trend over time. The number of females also go down, just not quite as drastically as the men. Additionally, even pretty late into classes, there is still a decent number of infants/abalones declared neither male nor female, and that number does not seem to notably decrease between classes A4 and A5 like it does classes 1-3.

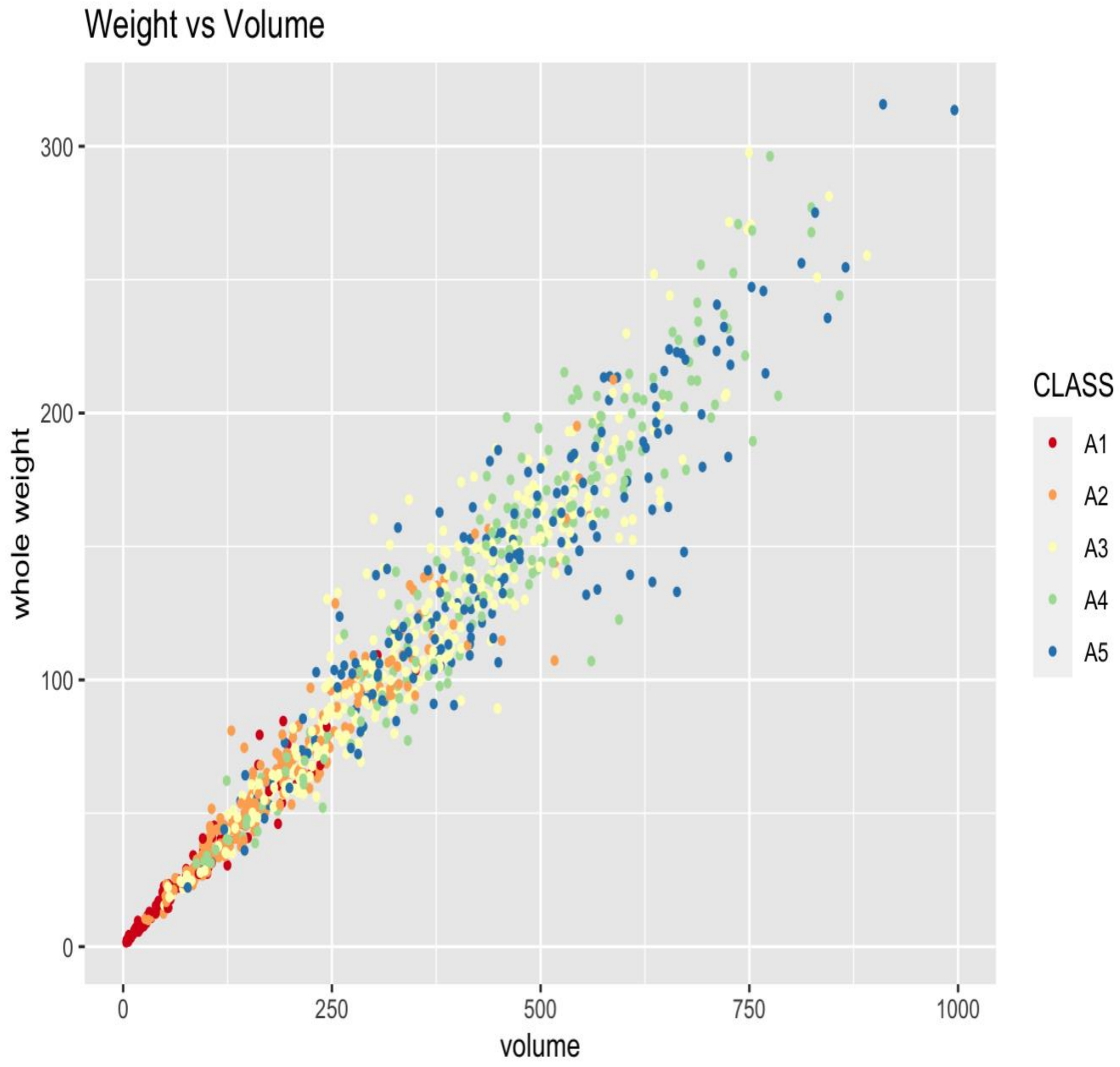
(1)(c) (1 point) Select a simple random sample of 200 observations from “mydata” and identify this sample as “work.” Use *set.seed(123)* prior to drawing this sample. Do not change the number 123. Note that *sample()* “takes a sample of the specified size from the elements of x.” We cannot sample directly from “mydata.” Instead, we need to sample from the integers, 1 to 1036, representing the rows of “mydata.” Then, select those rows from the data frame (Kabacoff Section 4.10.5 page 87).

Using “work”, construct a scatterplot matrix of variables 2-6 with *plot(work[, 2:6])* (these are the continuous variables excluding VOLUME and RATIO). The sample “work” will not be used in the remainder of the assignment.



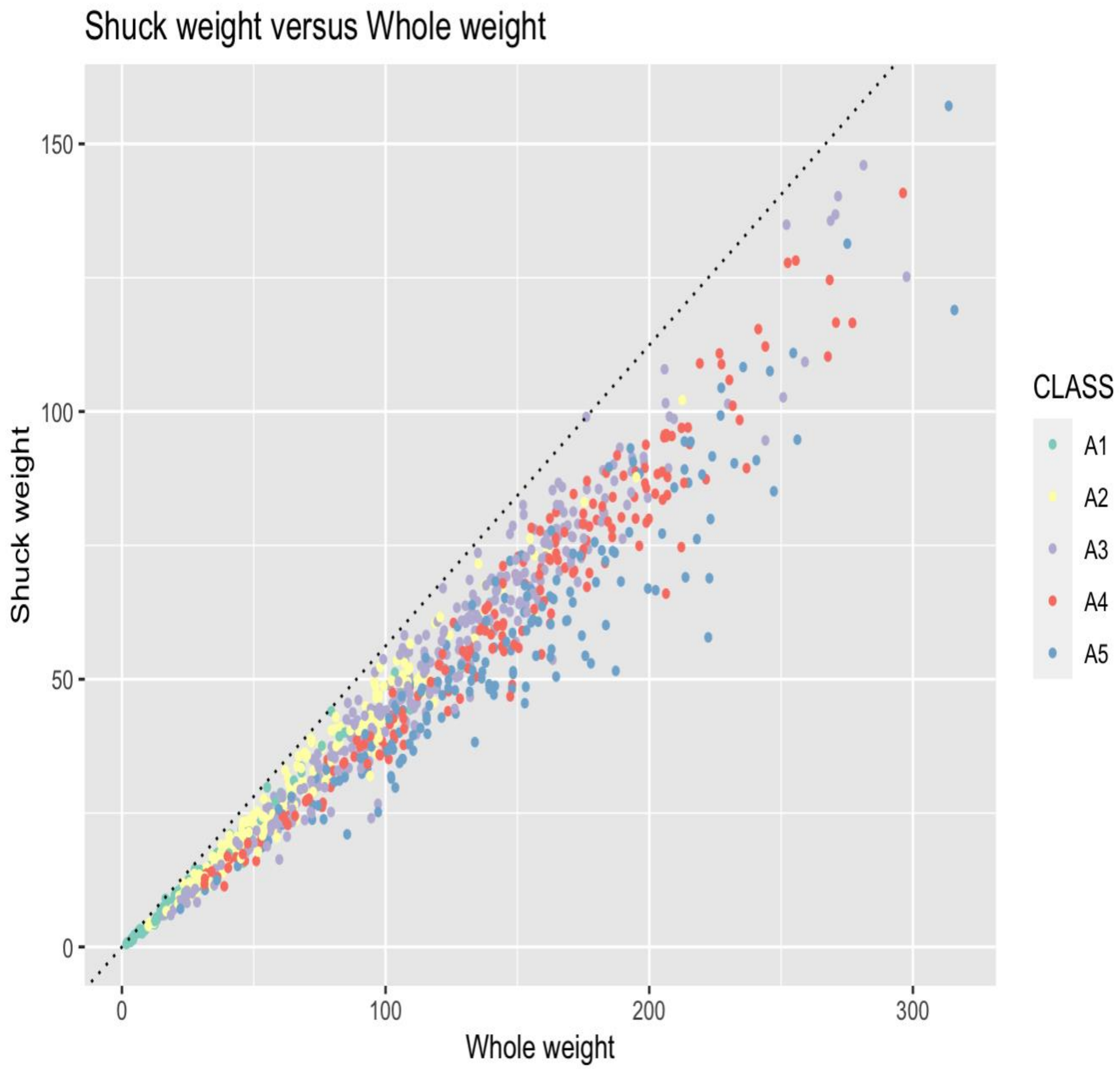
##### Section 2: (5 points) Summarizing the data using graphics.

(2)(a) (1 point) Use “mydata” to plot WHOLE versus VOLUME. Color code data points by CLASS.



(2)(b) (2 points) Use “mydata” to plot SHUCK versus WHOLE with WHOLE on the horizontal axis. Color code data points by CLASS. As an aid to interpretation, determine the maximum value of the ratio of SHUCK to WHOLE. Add to the chart a straight line with zero intercept using this maximum value as the slope of the line. If you are using the ‘base R’ *plot()* function, you may use *abline()* to add this line to the plot. Use *help(abline)* in R to determine the coding for the slope and intercept arguments in the functions. If you are using ggplot2 for visualizations, *geom_abline()* should be used.

```
## Warning: Using `size` aesthetic for lines was deprecated in ggplot2 3.4.0.
## ℹ Please use `linewidth` instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```



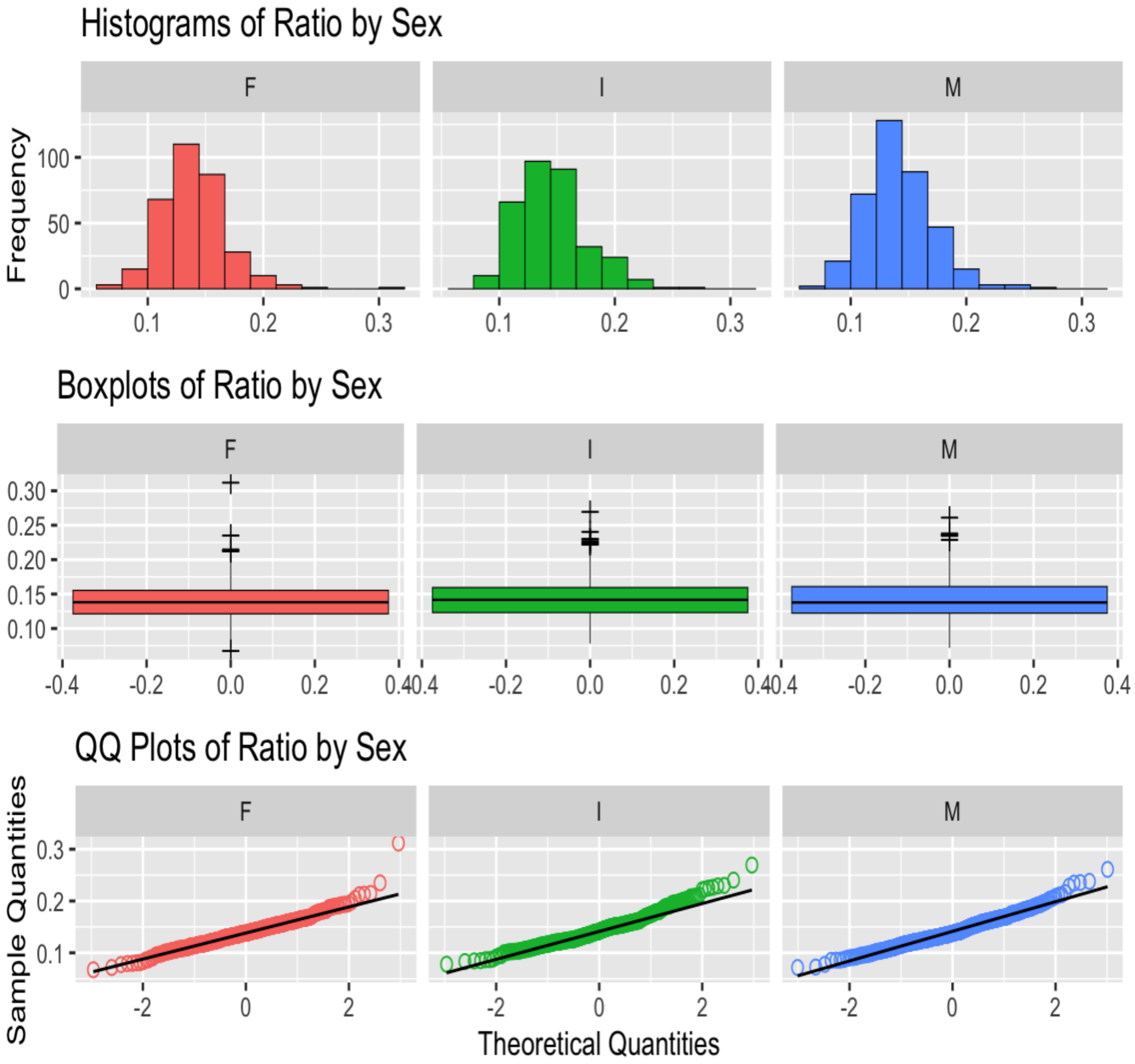
Essay Question (2 points): How does the variability in this plot differ from the plot in (a)? Compare the two displays. Keep in mind that SHUCK is a part of WHOLE. Consider the location of the different age classes.

Answer: Answer: Plot A has more variations for the classes than plot B, meaning there is more correlation in classes between shuck and whole weight than there is for volume an whole weight. Additionally, for

the most part, we can see that over time the weight of the abalones go up but the shuck weight begins to stall out or even decrease. Overall, there is a clearer picture of growth over time with Plot B.

### Section 3: (8 points) Getting insights about the data using graphs.

(3)(a) (2 points) Use "mydata" to create a multi-figured plot with histograms, boxplots and Q-Q plots of RATIO differentiated by sex. This can be done using *par(mfrow = c(3,3))* and base R or *grid.arrange()* and ggplot2. The first row would show the histograms, the second row the boxplots and the third row the Q-Q plots. Be sure these displays are legible.



Essay Question (2 points): Compare the displays. How do the distributions compare to normality? Take into account the criteria discussed in the sync sessions to evaluate non-normality.

Answer: For Infants, Females, and Males, all the distributions are non normal. The qq plot and histograms show that all are skewed to the right, but that it is especially present in the female and infant graphs. For the female graphs, it looks like the biggest issue is that the outliers are much more extreme than they are in the infant or male graphs. The infant distribution has a lot more outliers, but they aren't as extreme. Outliers are also present in the male graphs but it does not have as many as the infants have and it isn't as extreme as the female group. That said, all are still effected by outleirs which makes the distribution non normal.

(3)(b) (2 points) The boxplots in (3)(a) indicate that there are outlying RATIOs for each sex. *boxplot.stats()* can be used to identify outlying values of a vector. Present the abalones with these outlying RATIO values along with their associated variables in "mydata". Display the observations by passing a data frame to the kable() function. Basically, we want to output those rows of "mydata" with an outlying RATIO, but we want to determine outliers looking separately at infants, females and males.

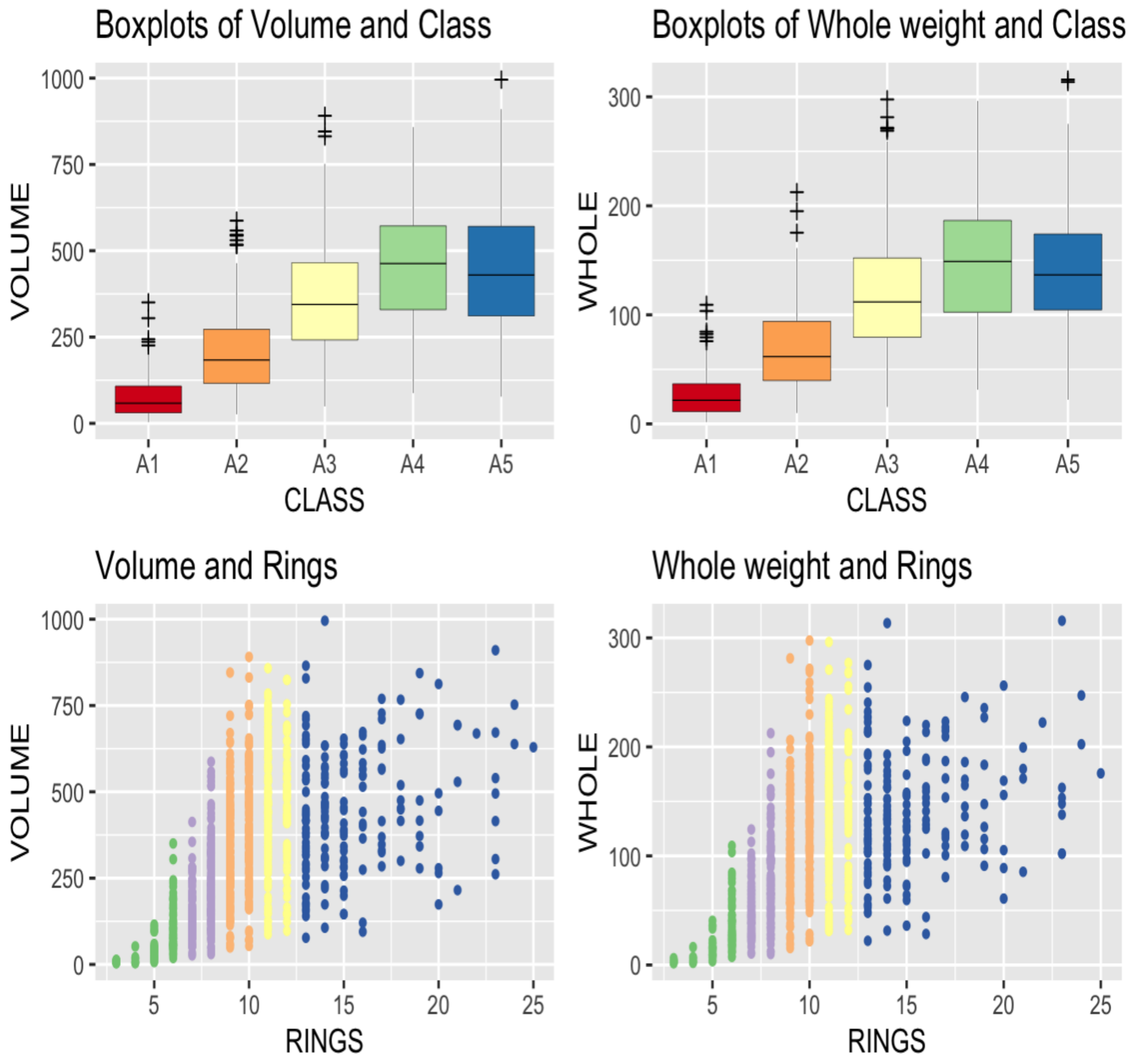
	SEX	LENGTH	DIAM	HEIGHT	WHOLE	SHUCK	RINGS	CLASS	VOLUME	RATIO
3	I	10.080	7.350	2.205	79.37500	44.00000	6	A1	163.364040	0.2693371
37	I	4.305	3.255	0.945	6.18750	2.93750	3	A1	13.242072	0.2218308
42	I	2.835	2.730	0.840	3.62500	1.56250	4	A1	6.501222	0.2403394
58	I	6.720	4.305	1.680	22.62500	11.00000	5	A1	48.601728	0.2263294
67	I	5.040	3.675	0.945	9.65625	3.93750	5	A1	17.503290	0.2249577
89	I	3.360	2.310	0.525	2.43750	0.93750	4	A1	4.074840	0.2300704
105	I	6.930	4.725	1.575	23.37500	11.81250	7	A2	51.572194	0.2290478
200	I	9.135	6.300	2.520	74.56250	32.37500	8	A2	145.027260	0.2232339
746	M	13.440	10.815	1.680	130.25000	63.73125	10	A3	244.194048	0.2609861
754	M	10.500	7.770	3.150	132.68750	61.13250	9	A3	256.992750	0.2378764
803	M	10.710	8.610	3.255	160.31250	70.41375	9	A3	300.153640	0.2345924
810	M	12.285	9.870	3.465	176.12500	99.00000	10	A3	420.141472	0.2356349
852	M	11.550	8.820	3.360	167.56250	78.27187	10	A3	342.286560	0.2286735
350	F	7.980	6.720	2.415	80.93750	40.37500	7	A2	129.505824	0.3117620
379	F	15.330	11.970	3.465	252.06250	134.89812	10	A3	635.827846	0.2121614
420	F	11.550	7.980	3.465	150.62500	68.55375	10	A3	319.365585	0.2146560
421	F	13.125	10.290	2.310	142.00000	66.47062	9	A3	311.979938	0.2130606
458	F	11.445	8.085	3.150	139.81250	68.49062	9	A3	291.478399	0.2349767
586	F	12.180	9.450	4.935	133.87500	38.25000	14	A5	568.023435	0.0673388

Essay Question (2 points): What are your observations regarding the results in (3)(b)?

Answer: These results confirm suspicions held that the infant group held the most outliers and the female held the most extreme (particularly case 586.) Additionally, the outliers occur the most in the A3 and A1 classes. Despite the higher frequency of infants in A2, the outliers are almost all in A1 for infants.

### Section 4: (8 points) Getting insights about possible predictors.

(4)(a) (3 points) With "mydata," display side-by-side boxplots for VOLUME and WHOLE, each differentiated by CLASS There should be five boxes for VOLUME and five for WHOLE. Also, display side-by-side scatterplots: VOLUME and WHOLE versus RINGS. Present these four figures in one graphic: the boxplots in one row and the scatterplots in a second row. Base R or ggplot2 may be used.



Essay Question (5 points) How well do you think these variables would perform as predictors of age? Explain.

Answer: Rings is obviously the best predictor of age, as the more rings the abalones have, the older they are, and the class is based on rings. Volume and weight have a more loose correlation, generally, the volume and weight increase the older they get, but there's a lot of outliers and the weight and volume vary less as they get older, making it hard to distinguish between A4 and A5 abalones as there's a lot of

overlap in their whole weight and volume. Because of the lack of meaningful different between most A4 and A5 abalones in volume/weight and the outliers present in A1 and A3 especially, it would not be a great predictor of age and could lead to a lot of mistakes.

Section 5: (12 points) Getting insights regarding different groups in the data.

(5)(a) (2 points) Use *aggregate()* with "mydata" to compute the mean values of VOLUME, SHUCK and RATIO for each combination of SEX and CLASS. Then, using *matrix()*, create matrices of the mean values. Using the "dimnames" argument within *matrix()* or the *rownames()* and *colnames()* functions on the matrices, label the rows by SEX and columns by CLASS. Present the three matrices (Kabacoff Section 5.6.2, p. 110-111). The *kable()* function is useful for this purpose. You do not need to be concerned with the number of digits presented.

Volume

	A1	A2	A3	A4	A5
Female	255.29938	276.8573	412.6079	498.0489	486.1525
Infant	66.51618	160.3200	270.7406	316.4129	318.6930
Male	103.72320	245.3857	358.1181	442.6155	440.2074

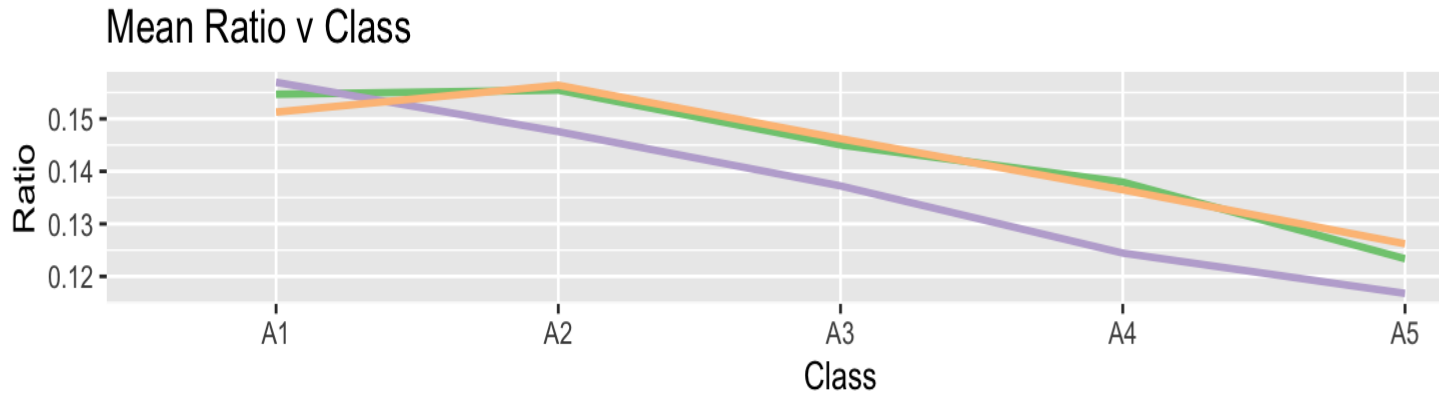
Shuck

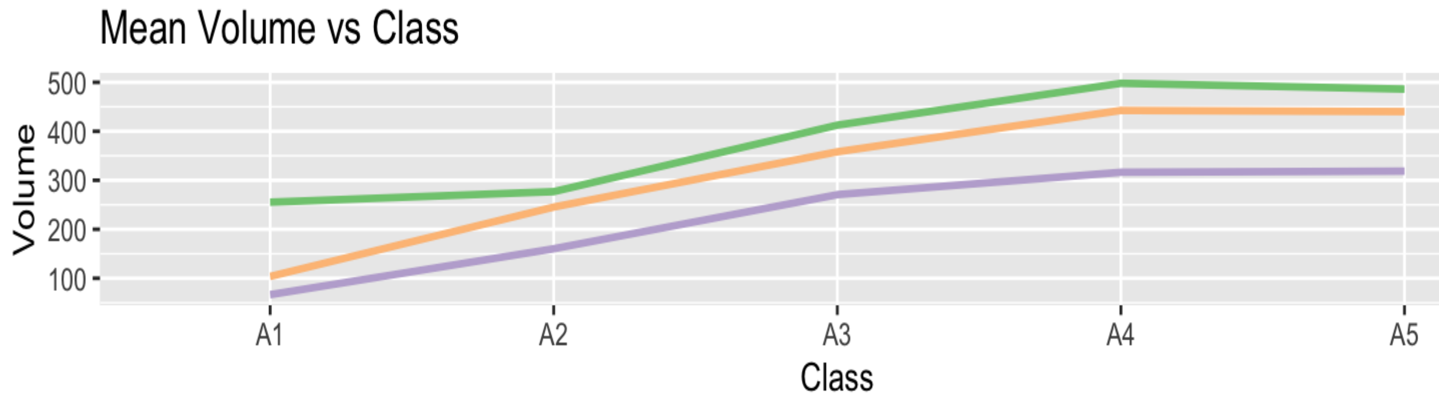
	A1	A2	A3	A4	A5
Female	38.90000	42.50305	59.69121	69.05161	59.17076
Infant	10.11332	23.41024	37.17969	39.85369	36.47047
Male	16.39583	38.33855	52.96933	61.42726	55.02762

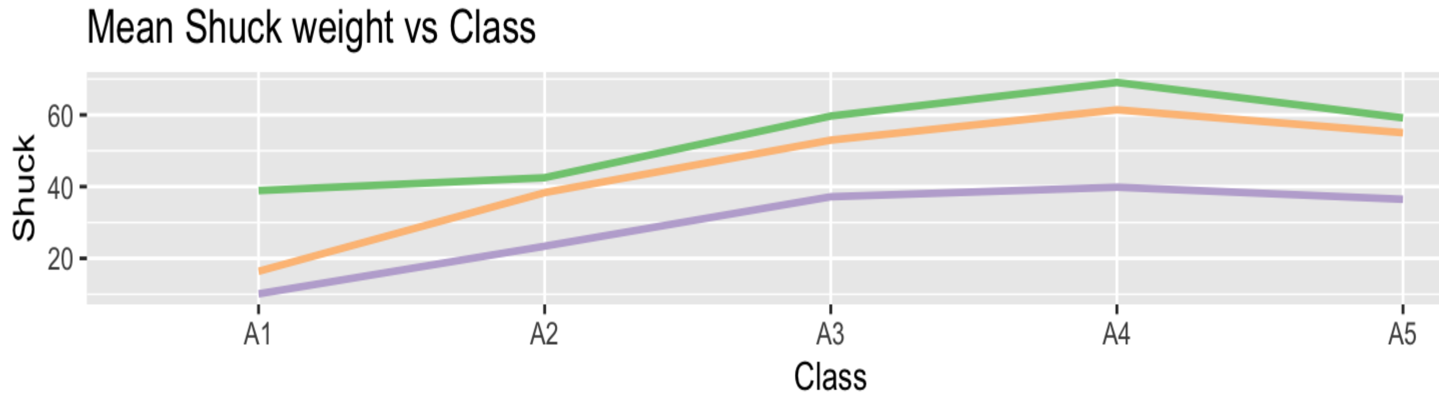
Ratio

	A1	A2	A3	A4	A5
Female	0.1546644	0.1554605	0.1450304	0.1379609	0.1233605
Infant	0.1569554	0.1475600	0.1372256	0.1244413	0.1167649
Male	0.1512698	0.1564017	0.1462123	0.1364881	0.1262089

(5)(b) (3 points) Present three graphs. Each graph should include three lines, one for each sex. The first should show mean RATIO versus CLASS; the second, mean VOLUME versus CLASS; the third, mean SHUCK versus CLASS. This may be done with the 'base R' *interaction.plot()* function or with ggplot2 using *grid.arrange()*.





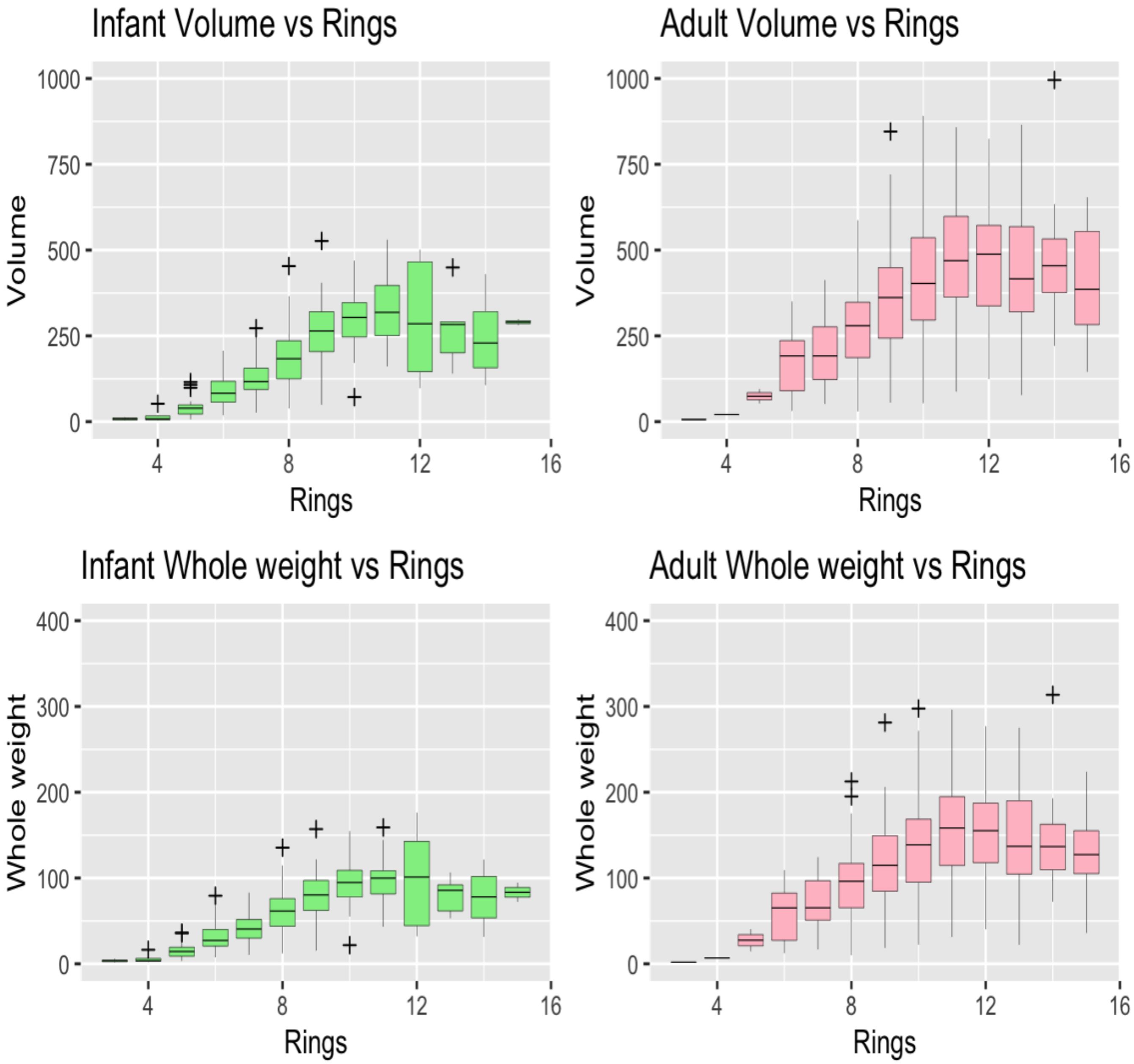


Essay Question (2 points): What questions do these plots raise? Consider aging and sex differences.

Answer: The ratio of shuck weight to volume deceases pretty consistetly fo all sexes over time. Meanwhile, females are larger in volume and in shuck weight than males, but not in a significant enough way that shuck weight or volume would be a great indicator if a abalone was male or female. Infants are always considerably lighter and smaller in volume regardless of age, which is why it is harder to identify them most likely. Feamles also seem to be start out larger but don't grow as much as males or infants do over A1-A5. The ratio for volume and shuck rate is extremely similar among males and female regardless of how old they are, but is much smaller for infants.

5(c) (3 points) Present four boxplots using *par(mfrow = c(2, 2)* or *grid.arrange()*. The first line should show VOLUME by RINGS for the infants and, separately, for the adult; factor levels "M" and "F," combined.

The second line should show WHOLE by RINGS for the infants and, separately, for the adults. Since the data are sparse beyond 15 rings, limit the displays to less than 16 rings. One way to accomplish this is to generate a new data set using subset() to select RINGS < 16. Use ylim = c(0, 1100) for VOLUME and ylim = c(0, 400) for WHOLE. If you wish to reorder the displays for presentation purposes or use ggplot2 go ahead.



Essay Question (2 points): What do these displays suggest about abalone growth? Also, compare the infant and adult displays. What differences stand out?

Answer: Abalone growth mostly ocurs between rings 1-11, with the most significant jump occuring around ring 5.Both infants and adults follow a similar timeline of growth, but the whiskers show us that there is a bit more variance in the adults than there is in the infants. Most variance occurs for infants in *year 12, otherwise they tend to be around the same volume/weight with a few outliers. For adults, heavy variance starts at ring 5 and never stops.*

### Section 6: (11 points) Conclusions from the Exploratory Data Analysis (EDA).

Conclusions

Essay Question 1) (5 points) Based solely on these data, what are plausible statistical reasons that explain the failure of the original study? Consider to what extent physical measurements may be used for age prediction.

Answer: The lack of difference between A3, A4, and A5 abalone in weight and volume, or basically any abalone after ring 10/11, makes those categories useless for identifying exact age of an abalone. Additionally, the similarity in weight/shuck ratio between genders makes it hard to identify the gender by weight/shuck. The only consistent factor is that female abalones weigh a lot more than male or infant ones over time. Volume and weight are probably best for helping you figure out if the Abalone is A1/A2 or A3/A5, but even with that, a A1 female and A3 infant are very similar in weight and shuck size, so that would only work if you also had the sex. Lastly, the gendering of the Abalones may have some inaccuracies, as there are infant abalones who have a lot of rings, ad rings usually correlate directly with age. Thus, some smaller abalones may have been inaccurately gendered

Essay Question 2) (3 points) Do not refer to the abalone data or study. If you were presented with an overall histogram and summary statistics from a sample of some population or phenomenon and no other information, what questions might you ask before accepting them as representative of the sampled population or phenomenon?

Answer: How was this sample determined? Who is in charge of the study? Is it a random or non random sample, and how did they execute their sampling/where was it done? How big is this sample compared to the population?

Essay Question 3) (3 points) Do not refer to the abalone data or study. What do you see as difficulties analyzing data derived from observational studies? Can causality be determined? What might be learned from such studies?

Answer: observational studies are all done by humans, who themselves ar subject to a number of factors that can impact their performance. Whether its intentional or unintentional bias, lack of equipment, or just simply mental error, that can mess with the data. Observational studies are best as a starting point rather than actually determining causality. You may get an idea of what could be a causality, or what variables are all being effected in a similar way, but further research is recommended after that initial starting point to gage the environment of what you are studying.