THE UNIVERSITY OF AUCKLAND
DEPARTMENT OF STATISTICS

Investigating Bivariate Measurement Data using iNZight

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New AS 3.9 versus Old AS 3.5

Much less emphasis on calculations

More emphasis on:

- Visual aspects
- Linking statistical knowledge to the context
- Reasoning and reflecting

Data:

- 3.5 – collected or provided
- 3.9 – using existing data sets

Use and interpretation of R^2 is not expected

Achievement Criteria 3.9 vs 3.5

AS	A	M	E
3.5	Select and analyse continuous bivariate data	Carry out an in-depth analysis of bivariate data	Report on the validity of the analysis
3.9	Investigate bivariate measurement data	Investigate bivariate measurement data, with justification	Investigate bivariate measurement data, with statistical insight

Alignment of Standards with NZC (2007)

AS	A	M	E
3.9	Investigate bivariate measurement data	Investigate bivariate measurement data, with justification	Investigate bivariate measurement data, with statistical insight

One of the principles:

Grade distinctions should not be based on the candidate being required to acquire and retain more subject-specific knowledge.

Explanatory Note 2 (A)

Investigate bivariate measurement data involves showing evidence of using each component of the statistical enquiry cycle.

Explanatory Note 2 (M)

Investigate bivariate measurement data, with justification involves

linking components of the statistical enquiry cycle to the context, and

referring to evidence such as

statistics, data values, trends or features of data displays

in support of statements made.

Explanatory Note 2 (E)

Investigate bivariate measurement data, with statistical insight involves

integrating statistical and contextual knowledge throughout the investigation process, and may include

- reflecting about the process;
- considering other relevant variables;
- evaluating the adequacy of any models, or showing a deeper understanding of the models.

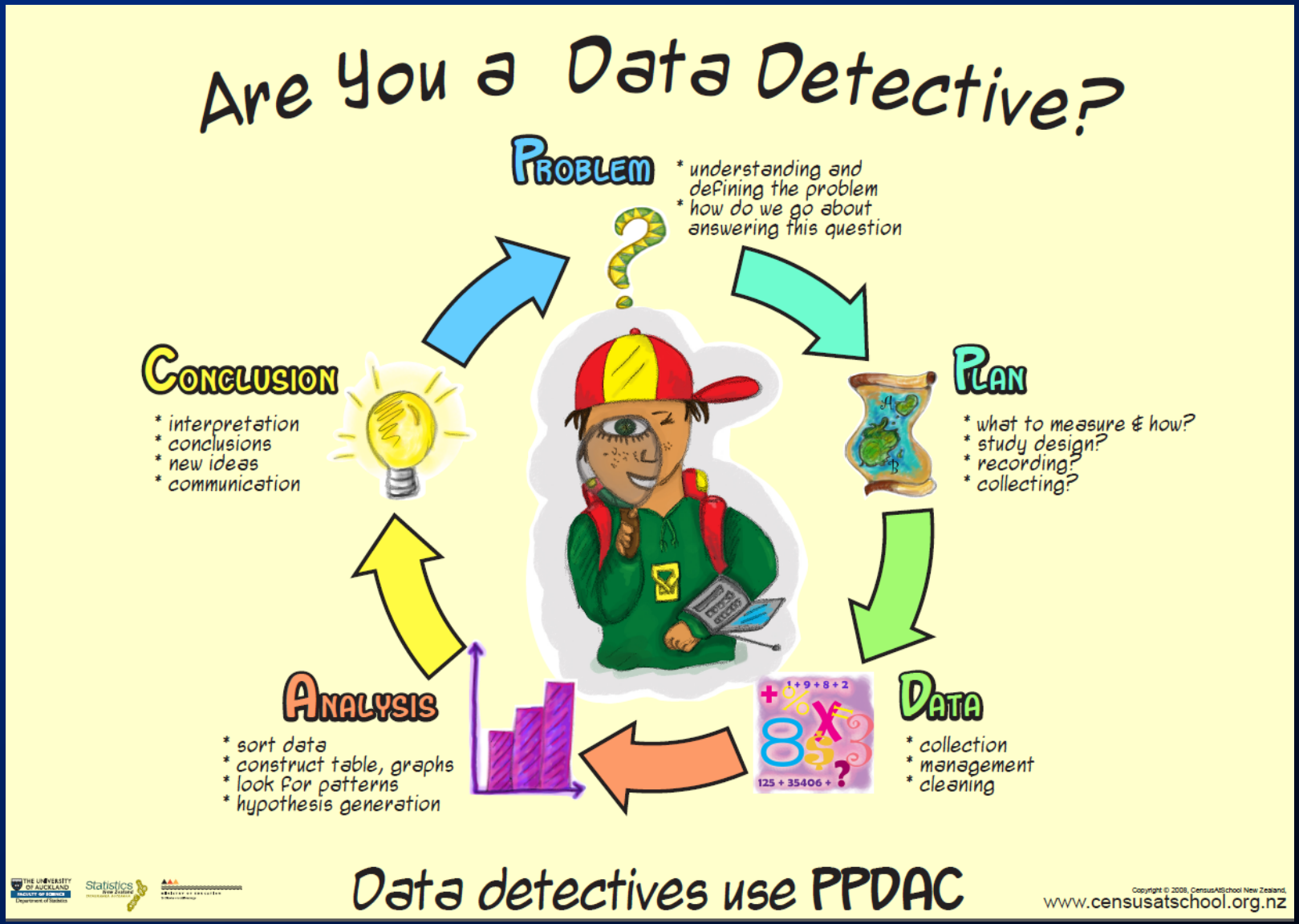
Explanatory Note 4

In regression analysis the *y*-variable, or response variable, must be a continuous variable.

The *x*-variable, or explanatory variable, can be either a discrete or continuous variable.

The relationship may be non-linear.

Statistical enquiry cycle (PPDAC)



Using the statistical enquiry cycle to …

investigate bivariate measurement data involves:

- posing an appropriate relationship question using a given multivariate data set
- selecting and using appropriate displays
- identifying features in data
- finding an appropriate model
- describing the nature and strength of the relationship and relating this to the context
- using the model to make a prediction
- communicating findings in a conclusion

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Posing relationship questions

Possibly the most important component of the investigation

- Time spent on this component can determine the overall quality of the investigation
- This component provides an opportunity to show justification (M) and statistical insight (E)

Posing relationship questions

What makes a good relationship question?

- It is written as a question.
- It is written as a relationship question.
- It can be answered with the data available.
- The variables of interest are specified.
- It is a question whose answer is useful or interesting.
- The question is related to the purpose of the investigation.
- Think about the population of interest. Can the results be extended to a wider population?

Developing question posing skills

Phase 1

- Introduce the data set and the variables
- Students (groups/individually) consider the variables (using context) and think about which variables could be related (encourage reasoning and justification)
- Pose several relationship questions (written with reasons/justifications)
- Possibly critique the questions
- The precise meaning of some variables may need to be researched

Developing question posing skills

Phase 2

- Students draw scatter plots to start to investigate their questions
- Reduce, add to and/or prioritise their list of questions
- Possibly critique the questions again

Developing question posing skills

Phase 3

Give students an opportunity to do some research

- Improve knowledge of variables and context
- May find some related studies that creates potential for integration of statistical and contextual knowledge

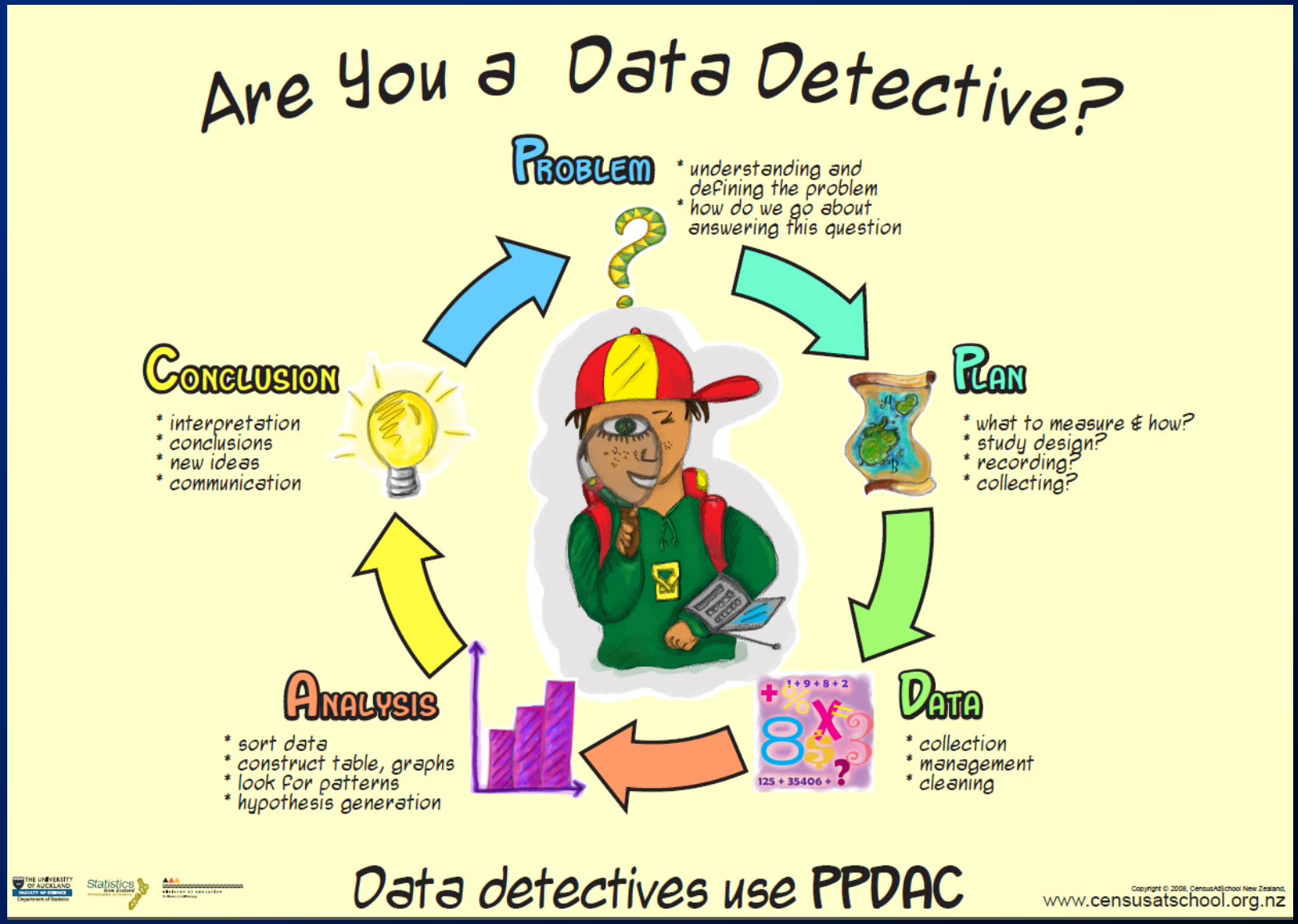
Different relationship questions

Is there a relationship between variable 1 and variable 2 for Hector's dolphins?

What is the nature of the relationship between variable 1 and variable 2 for athletes from the AIS?

Can a person's variable 1 be used to predict their variable 2 for athletes from the AIS?

Statistical enquiry cycle (PPDAC)



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Appropriate displays

Scatter plot – nothing else

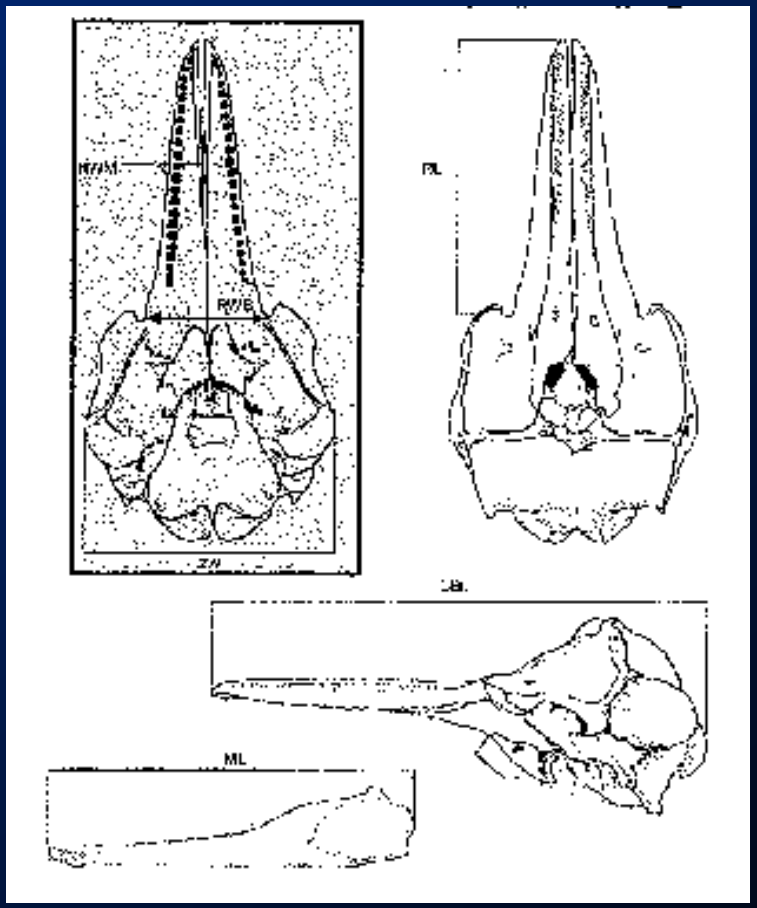
Which variable goes on the *x*-axis and which goes on the *y*-axis?

- It depends on the question and on the variables of interest
  - Is there a relationship between zygomatic width and rostrum length for Hector's dolphins?
    Is this relationship different for North Island and South Island Hector's dolphins?

Variables on axes

Is there a relationship between zygomatic width and rostrum length for Hector's dolphins?

Is this relationship different for North Island and South Island Hector's dolphins?



Appropriate displays

Scatter plot – nothing else

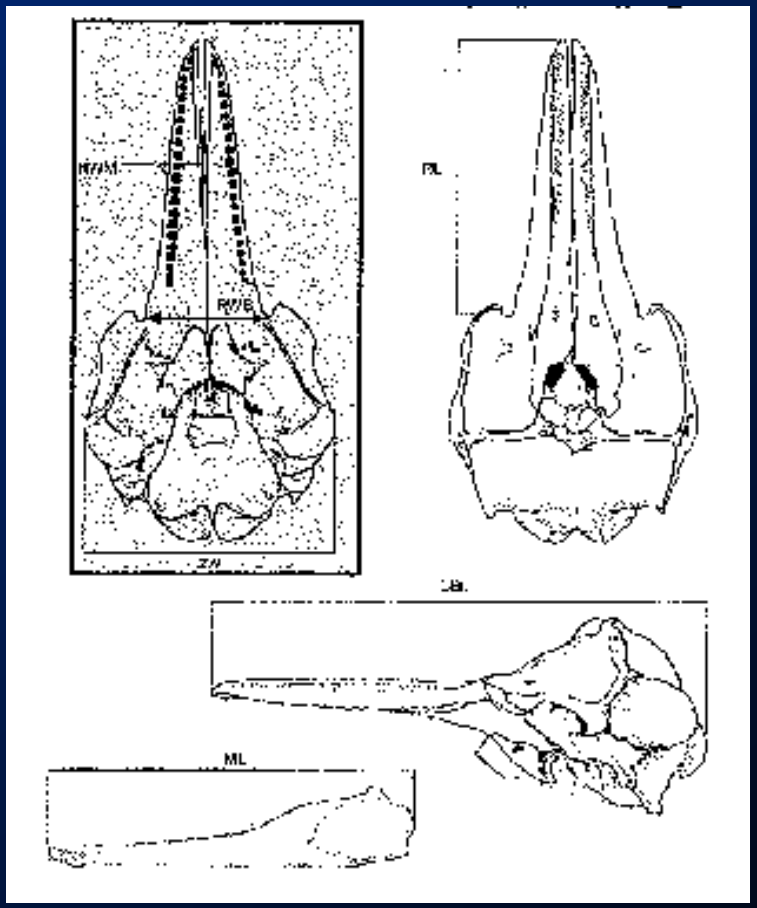
Which variable goes on the *x*-axis and which goes on the *y*-axis?

- It depends on the question and on the variables of interest
  - Is there a relationship between rostrum width at midlength and rostrum width at base for Hector's dolphins?
    Is this relationship different for North Island and South Island Hector's dolphins?

Variables on axes

Is there a relationship between rostrum width at midlength and rostrum width at base for Hector's dolphins?

Is this relationship different for North Island and South Island Hector's dolphins?



Appropriate displays

Scatter plot – nothing else

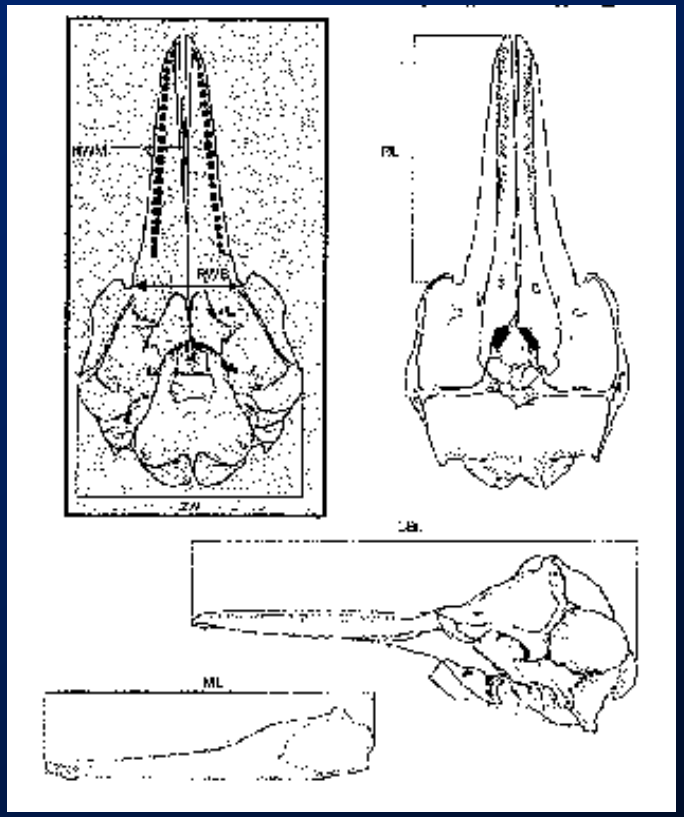
Which variable goes on the *x*-axis and which goes on the *y*-axis?

- It depends on the question and on the variables of interest
  - For Hector's dolphins, can rostrum length be used to predict mandible length?
    For a given rostrum length, would North Island and South Island dolphins have similar predicted mandible lengths?

Variables on axes

For Hector's dolphins, can rostrum length be used to predict mandible length?

For a given rostrum length, would North Island and South Island dolphins have similar predicted mandible lengths?



Appropriate displays

Scatter plot – nothing else

Which variable goes on the *x*-axis and which goes on the *y*-axis?

- It depends on the question and on the variables of interest

Encourage students to write about their choice of placement of variables on the axes

Choosing variables for axes – activity

Possible activity

- Introduce the data set and the variables
- Students (groups) pose several questions to investigate
- Students discuss whether or not it matters which variables go on each axis, and if it does matter, they make their selection

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Features, model, nature and strength

Generate the scatter plot

Features, model, nature and strength

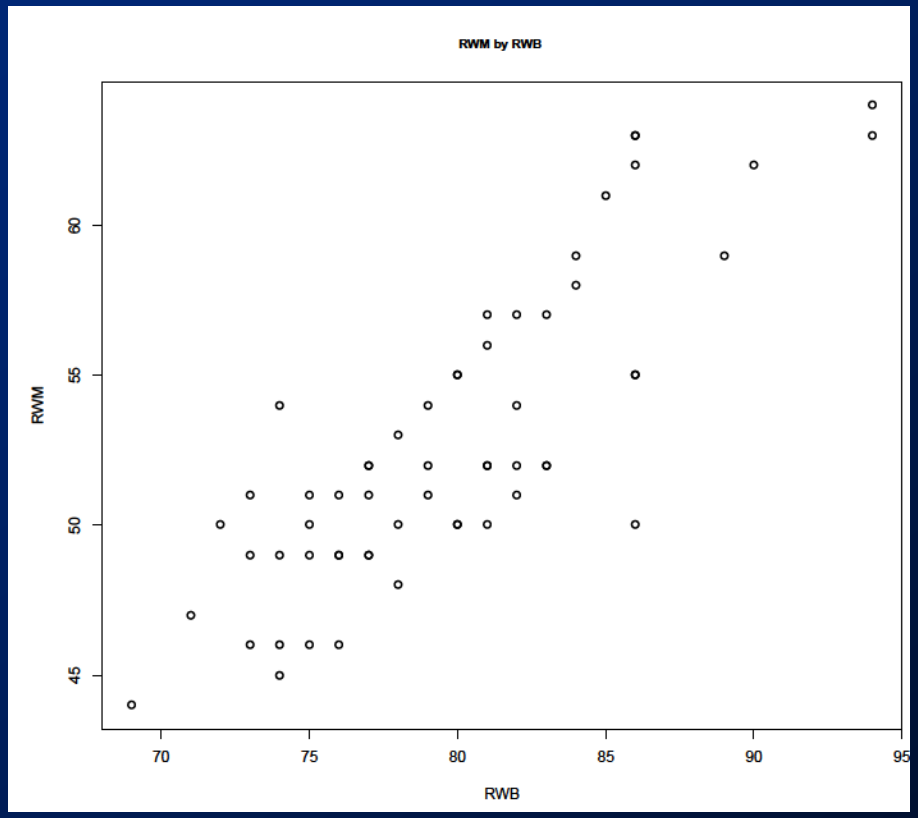
Generate the scatter plot

- Let the data speak
- Use your eyes (visual aspects)

Have a template for features (but allow flexibility)

- Trend
- Association (nature)
- Strength (degree of scatter)
- Groupings/clusters
- Unusual observations
- Other (e.g., variation in scatter)

Trend

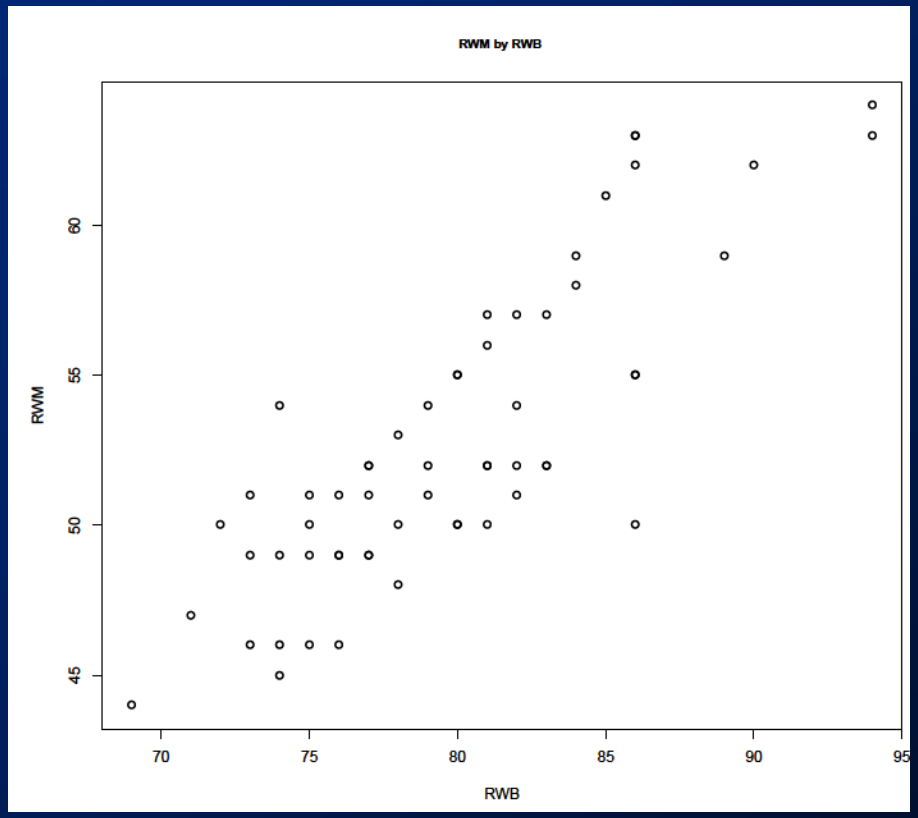


From the scatter plot it appears that there is a linear trend between rostrum width at base and rostrum width at midlength.

This is a reasonable expectation because two different measures on the same body part of an animal could be in proportion to each other.

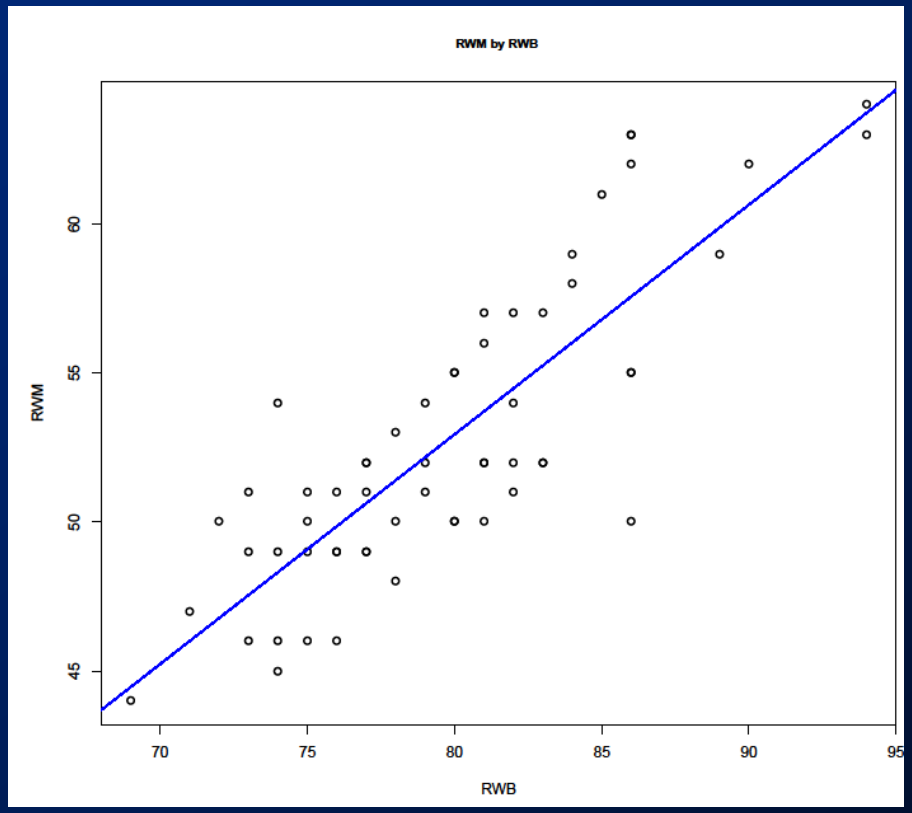
Association

The scatter plot also shows that as the rostrum width at base increases the rostrum width at midlength tends to increase.



This is to be expected because dolphins with small rostrums would tend to have small values for rostrums widths at base and midlength and dolphins with large rostrums would tend to have large values for rostrums widths at base and midlength.

Find a model

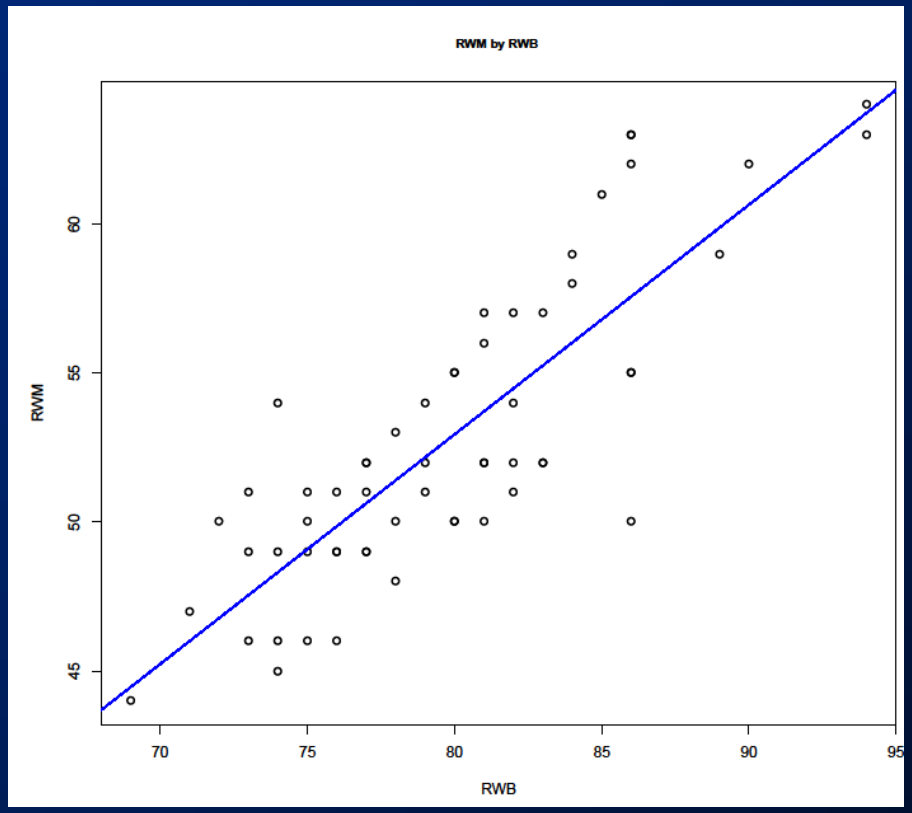


Because the trend is linear I will fit a linear model to the data.

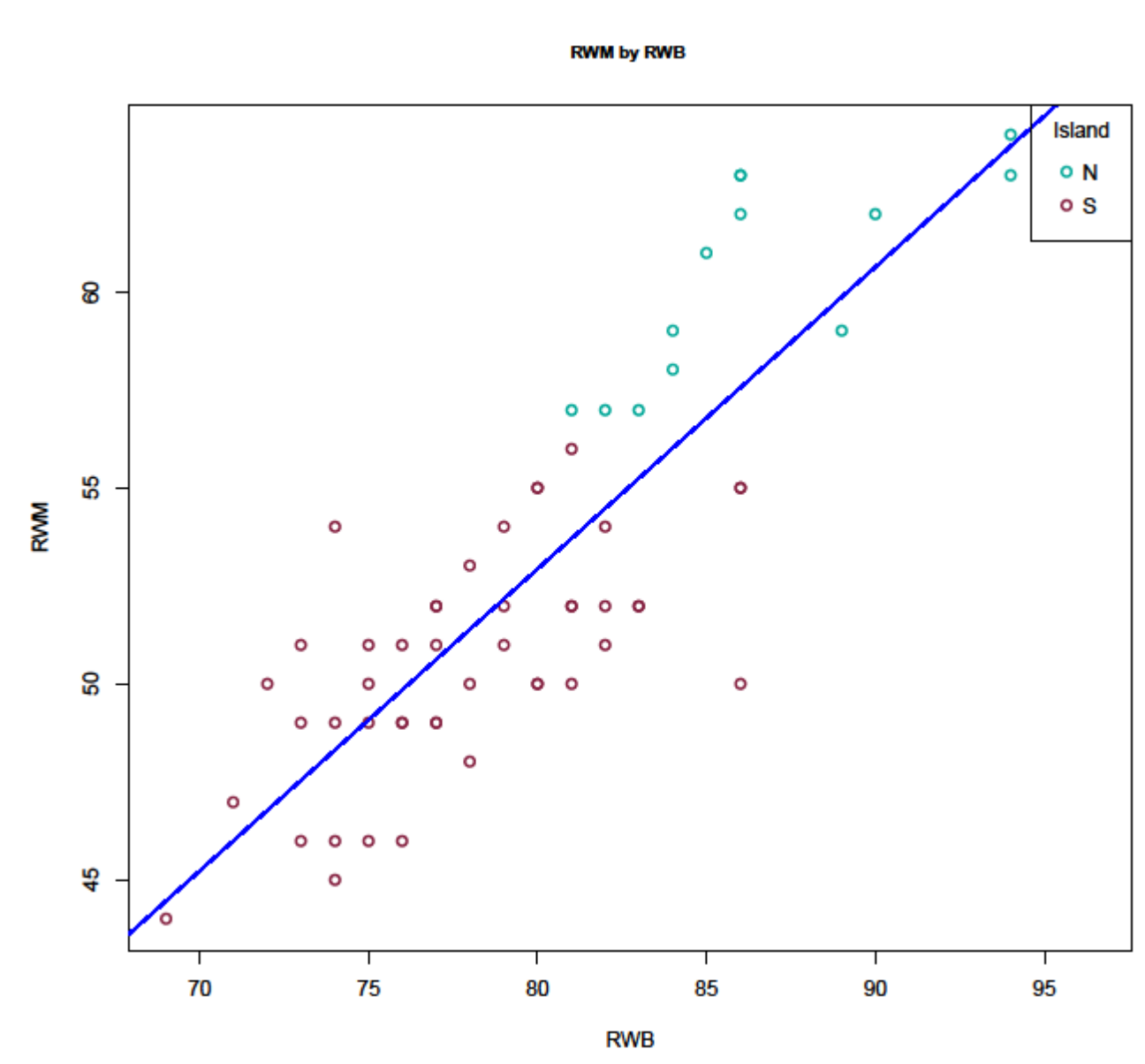
The line is a good model for the data because for all values of rostrum width at base, the number of points above the line are about the same as the number below it.

Strength

The points on the graph are reasonably close to the fitted line so the relationship between rostrum width at midlength and rostrum width at base is reasonably strong.



Groupings



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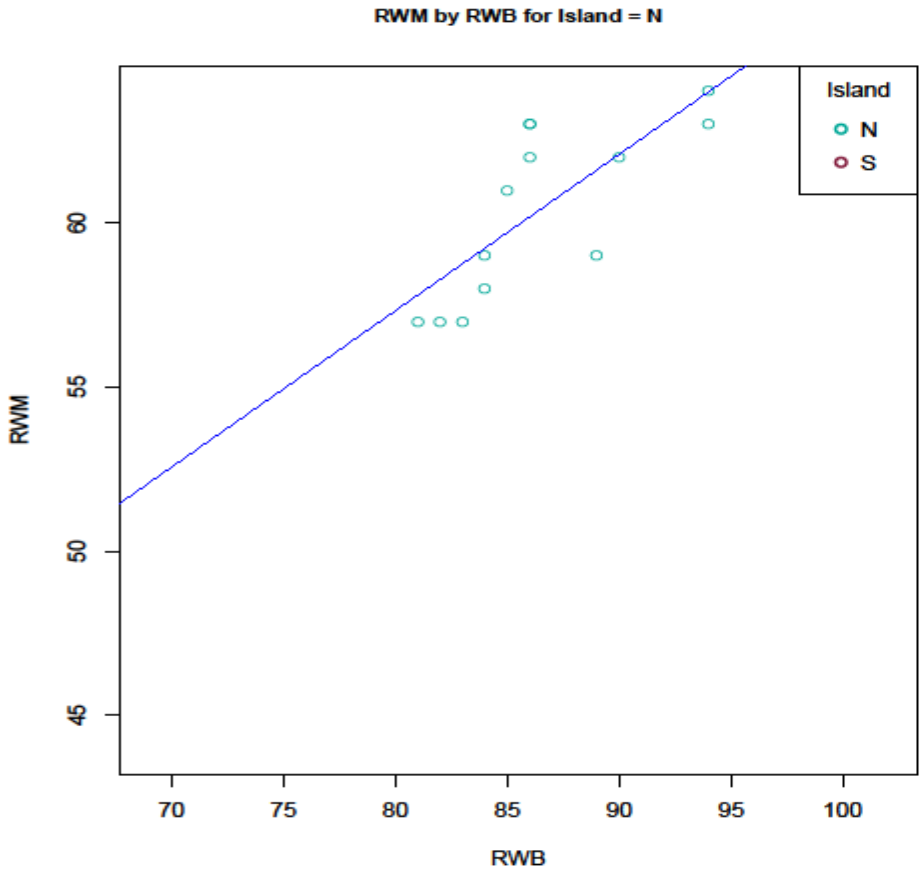
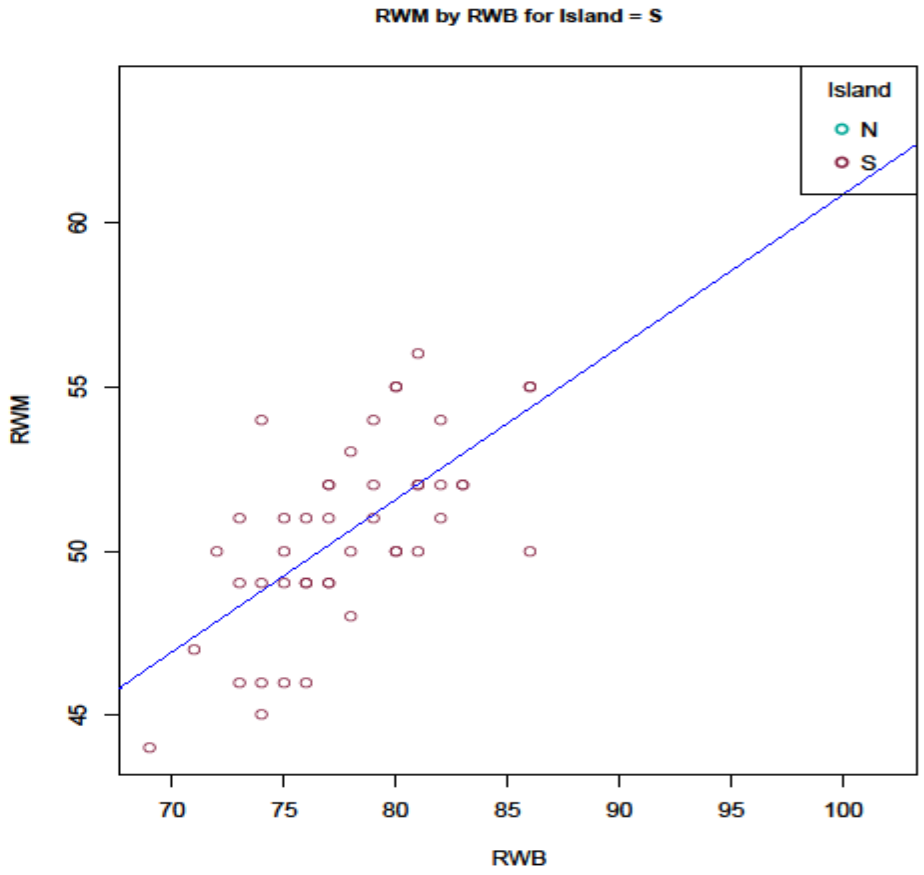
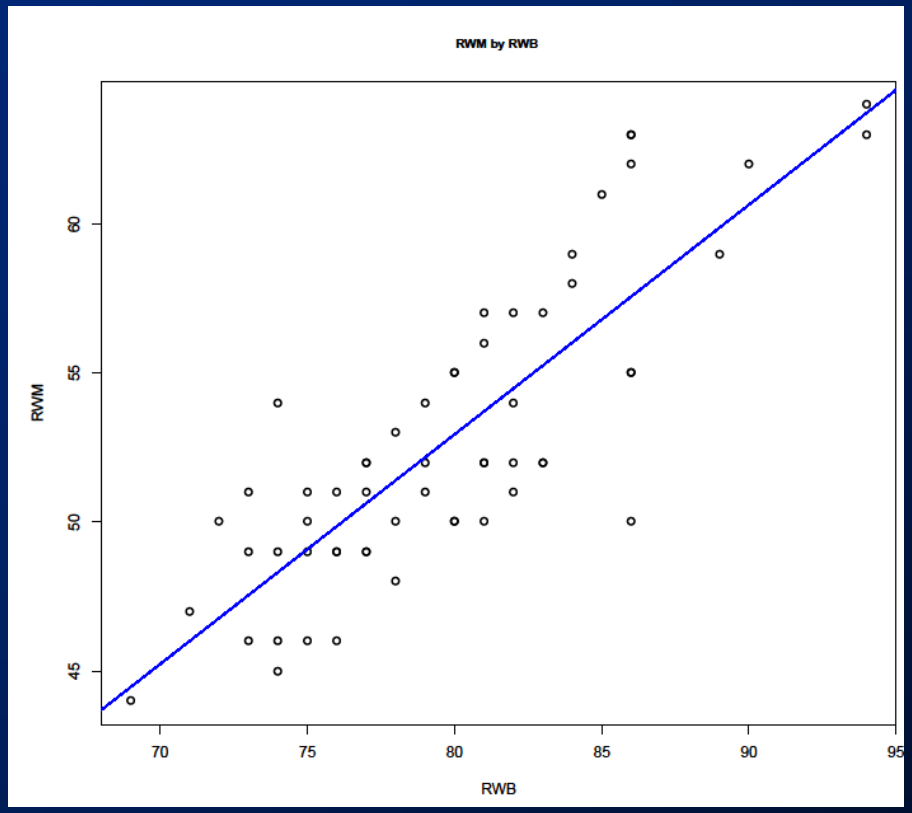

RWM by RWB for Island = N
Island
N
S
RWM
RWB
45
50
55
60
70
75
80
85
90
95
100


RWM by RWB for Island = S
Island
N
S
RWM
RWB
45
50
55
60
70
75
80
85
90
95
100

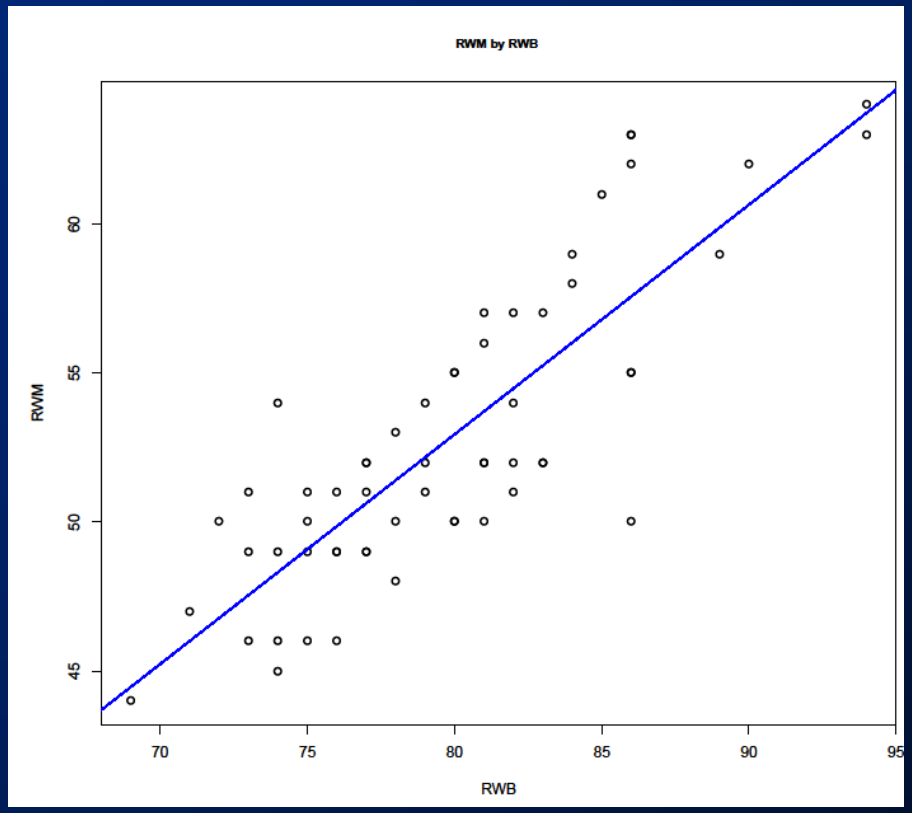
Unusual points

One dolphin, one of those with a rostrum width at base of 86mm, had a smaller rostrum width at midlength compared to dolphins with the same, or similar, rostrum widths at base.



Anything else

Variation in scatter?



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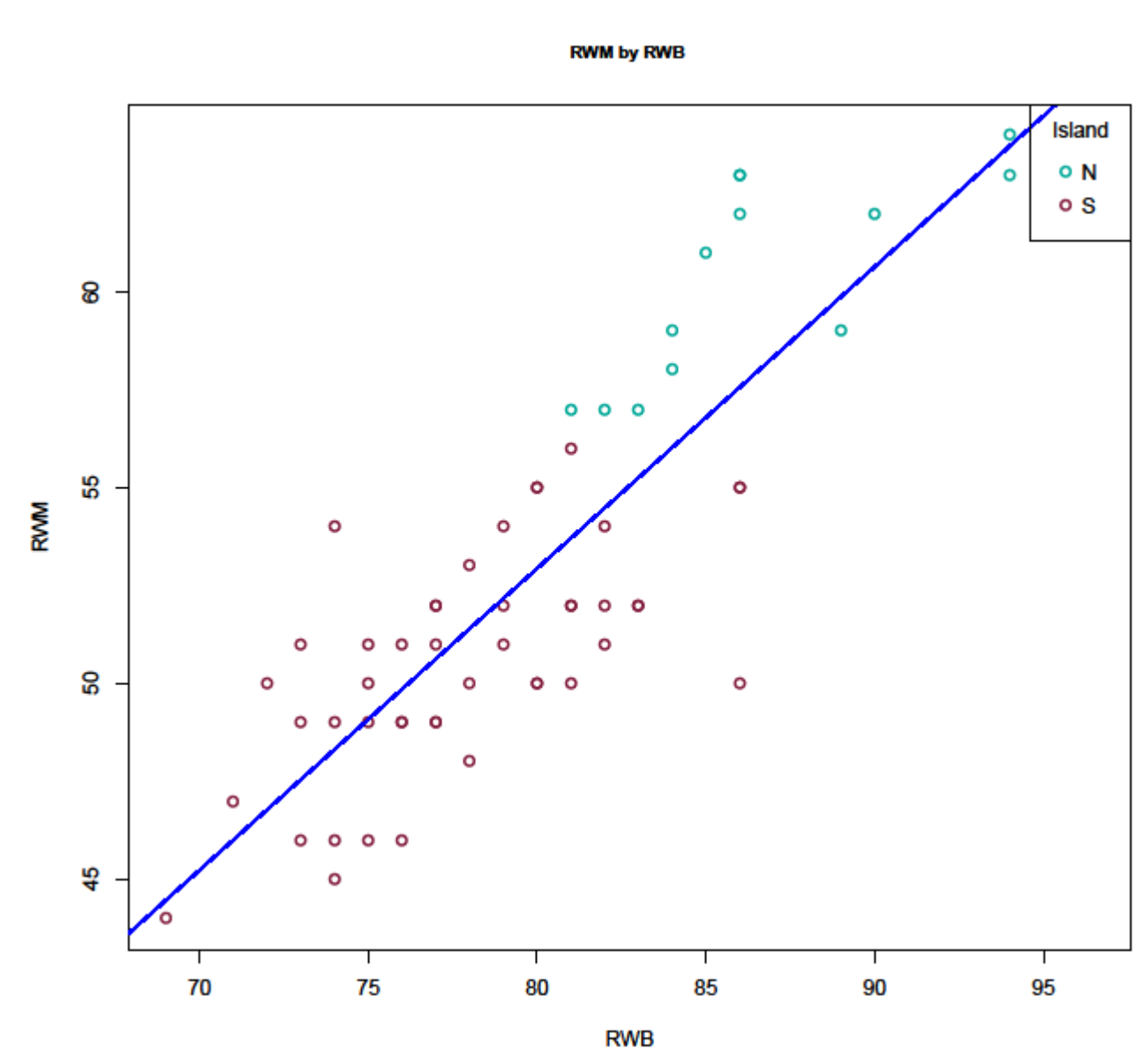
Prediction



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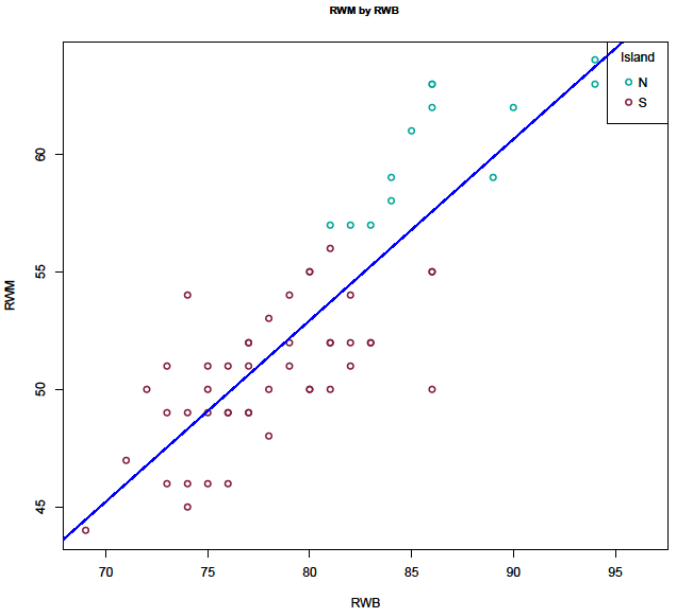
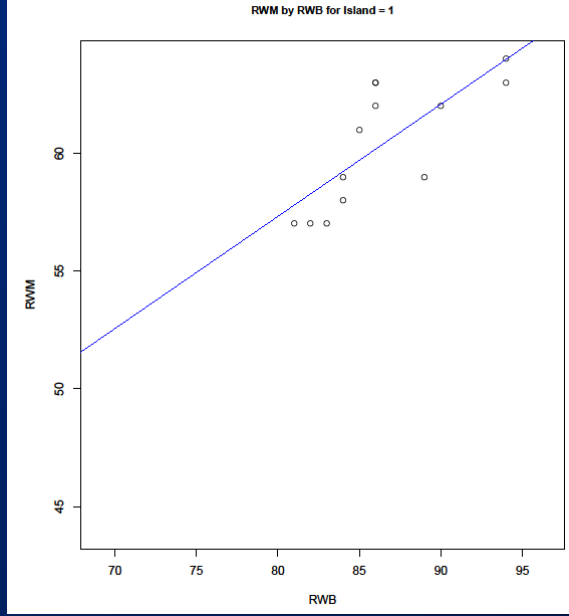
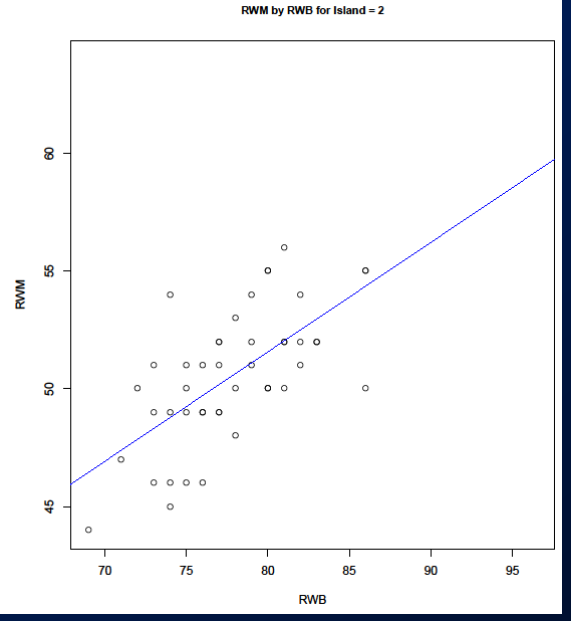







```
Linear Trend
RWM = 0.77 * RWB + -8.72
```

```
Summary for Island = N
Linear Trend
RWM = 0.48 * RWB + 19.19
```

```
Summary for Island = S
Linear Trend
RWM = 0.46 * RWB + 14.37
```

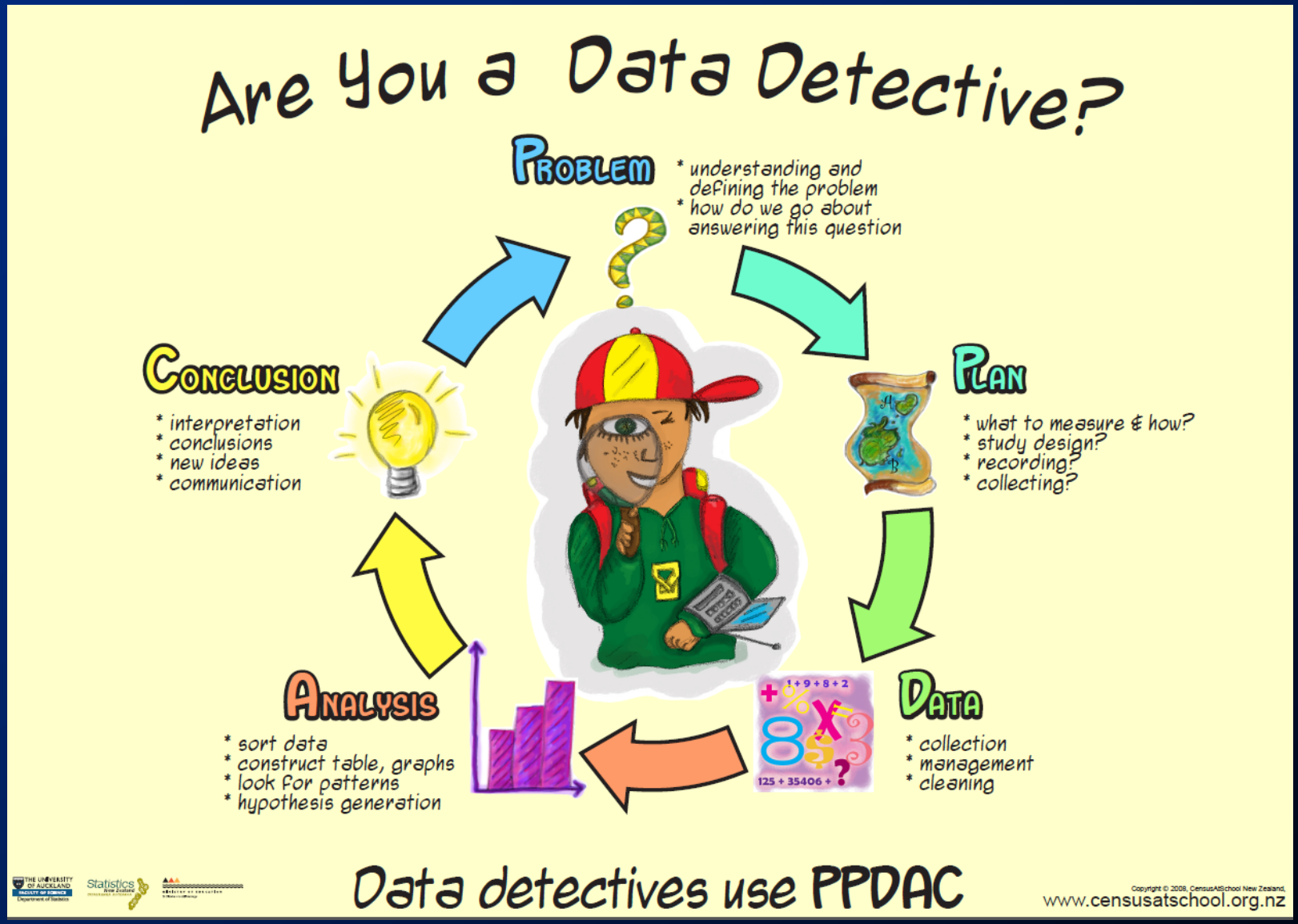
Using RWB = 85mm

All points: RWM = 0.77 x 85 – 8.72 = 56.73

NI dolphins: RWM = 0.48 x 85 + 19.19 = 59.99

SI dolphins: RWM = 0.46 x 85 + 14.37 = 53.47

Statistical enquiry cycle (PPDAC)



Communicating findings in a conclusion

Each component of the cycle must be communicated

The question(s) must be answered

Summary

Basic principles

- Each component
- Context
- Visual aspects

Higher level considerations

- Justify
- Extend
- Reflect

Other issues (if time)

- The use or articles or reports to assist contextual understanding
- How to develop understanding of outliers on a model
- Should the least-squares process be discussed with students?
- The place of residuals and residual plots
- Is there a place for transforming variables?