

# *Malati*

*Mathematics learning and teaching initiative*

## **Statistics**

### **Data Handling** (without the graphing calculator)

### **Grades 8 and 9**

### **Teacher document**

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We acknowledge the valuable comments of Heleen Verhage and Donald Katz.

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The following activities are included as **core activities** for Data Handling in Grades 8 and 9:

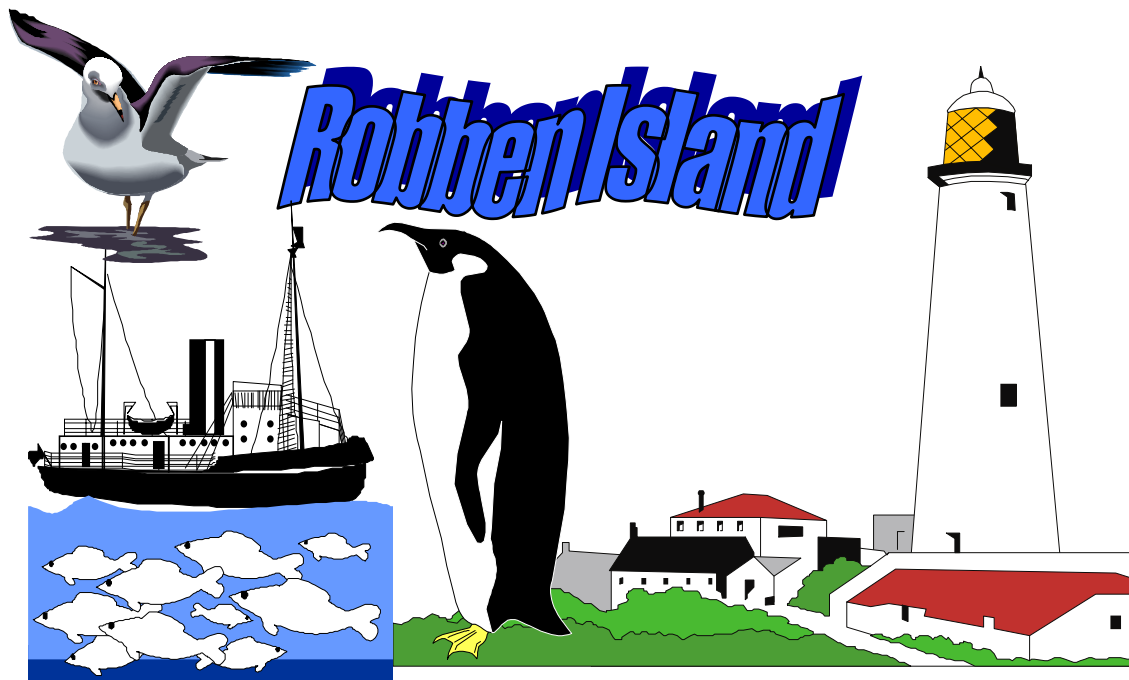
Activity	Content	Context
African Penguin 1	Describing one set of data: Frequency tables, bar graph, mode, pie chart	Biology, Ecology
History	Grouped bar graph, stacked column graph, trend, pie chart	History
Cape of Storms	Summarising data, bar graph, pie chart, statistical distortion	History
Weather	Mean, bar graph, line graph, range, influence of range on accuracy of predictions	Weather
African Penguin 2	Representing data (revision), bar graphs showing positive and negative values	Biology, Ecology
Water	A mini-project for determining water consumption. Sample, population, survey design, reporting findings	Environment
African Penguin 3	Regression between two variables: Scatterplots, dependent/ independent variables, trendline, correlations	Biology, Ecology

The following **enrichment** activities are also available:

- **Tourism:** Real data on tourists to Robben Island, and further practice in calculating means with bigger numbers. Mean percentage growth is also introduced.
- **Humidity:** Relationship between two variables, using scatterplots and modelling.

The following activity can be used for **consolidation and revision**:

- **Tourism Brochure:** A project in which pupils are required to collect and represent appropriate data.



"Robben Island has a harsh history as a place of banishment and dumping ground for people deemed to be a threat to the ruling society. Those imprisoned there over the centuries have included Khoikhoi leaders, exiled Muslims from the east and African chiefs opposing Dutch and British imperialism, as well as petty criminals, lepers and the mentally ill. It also served as a military base during World War II.

Then it became a prison for those fighting against Apartheid - youth leaders, MK soldiers and members of the African National Congress, the Pan Africanist Congress, the Black Consciousness Movement and other organisations. It became universally known as a place of hardship and suffering. But Robben Island is also a place that symbolises defiance, courage, perseverance and freedom. It was from here that the leaders and ideas that inspired the new South African democracy emerged. It is ultimately a place symbolising the triumph of the human spirit and the ability of humanity to transcend hardship and oppression."

*(Robben Island Tours Information Brochure)*



# The African Penguin

Robben Island is inhabited by African Penguins. Conservationists and scientists are concerned about the effect of hunting, fishing and pollution on the penguins, so they keep a careful record of the number of penguins on Robben Island.

## **Activity 1: Age Distribution**

In 1996 the scientists knew the ages of 66 penguins. The information is recorded in the table below:

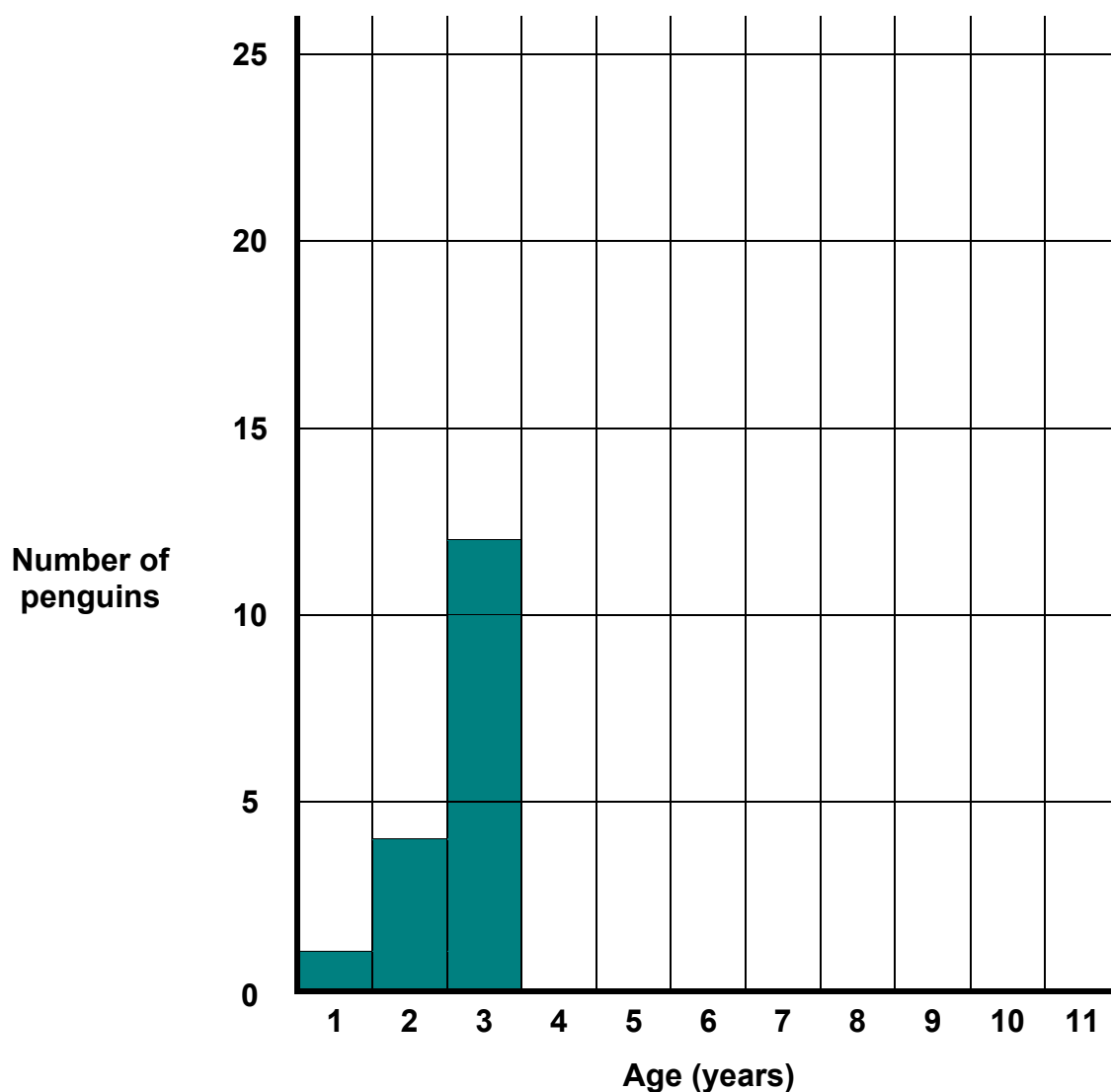
This information is also called *data*

Age (in years)	Number of penguins
1	1
2	4
3	12
4	24
5	12
6	7
7	2
8	1
9	2
10	1
11	1

This means that there are 4 penguins that are 2 years old. This particular kind of data is called *frequency data* or *frequencies*.

Table1: Age distribution of the African penguin

We can use a *bar graph* like the one below to represent the data in Table 1.



Graph 1: Age Distribution of the African Penguin

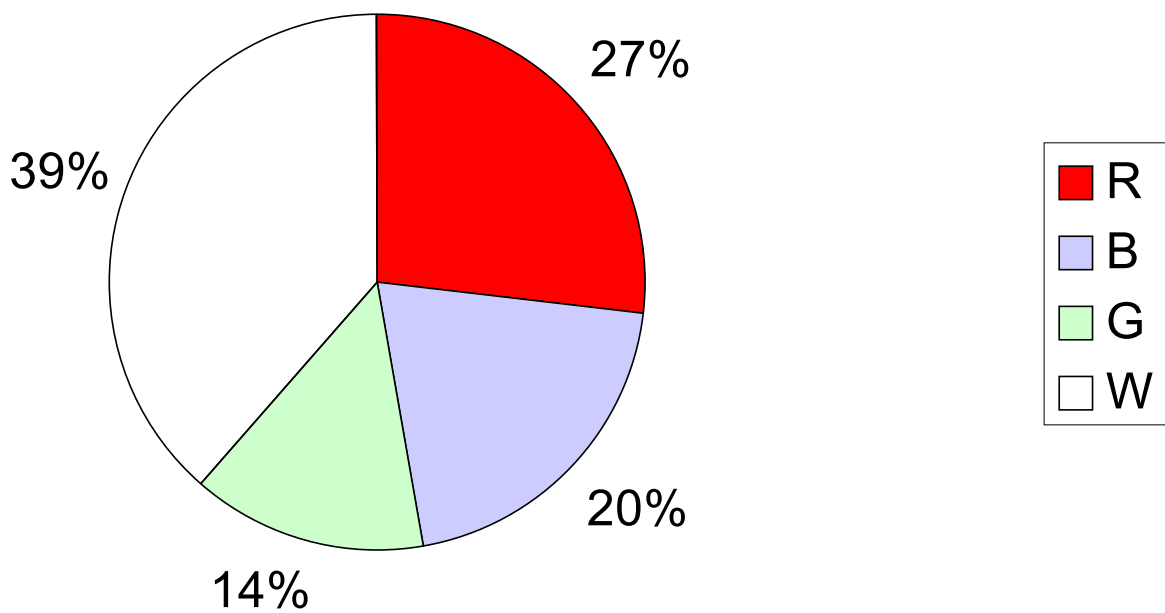
1. Complete this bar graph.
2. Why do you think this type of graph is called a bar or column graph?
3. Show how you can read off the number of three-year-old penguins from the graph.
4. What is the most common age?  

The most common value is called the **mode**.
5. How old is the oldest penguin in this group of 66 penguins?
6. How many age groups have more than 10 penguins?
7. Is the shape of the bar graph what you would expect? Explain.
8. How could you use the graph to find the number of penguins that are less than five years old?

### Activity 2: Pie-charts

Another way of representing data is by using a *pie chart*.

Sipho was sitting at the side of the road waiting for his lift. While he waited he recorded the colour of 200 cars that drove past him. Below is a pie chart showing the number of red (R), blue (B), green (G) and white (W) cars that drove past Sipho.



Graph 2: Car colours

1. Which colour car did Sipho see the least?
2. How many white cars drove past Sipho?
3. Construct a similar pie chart for the age distribution of the African Penguin. Use the data from Table 1. Remember that the table gives us information about 66 penguins.
4. Discuss whether you think the bar graph or the pie chart is more suitable to represent the data about the age distribution of the African Penguin. Why?

### Activity 3: Eggs in Nests

Scientists also wished to know when the breeding penguins laid eggs. They studied 449 nests and recorded the month during which the **first** egg was laid in each nest. Below is a table giving this data.

Month when first egg was laid	Number of nests
Jan	50
Feb	179
March	123
April	64
May	58
June	9
July	8
Aug	8
Sept	0
Oct	0
Nov	0
Dec	0

During March, a first egg was found in 123 nests.

Table 2: First eggs per month

1. Draw a bar graph to represent this data. Remember to give your graph a title and carefully label both axes.
2. During which time of the year do penguins breed?
3. Indicate on your graph how you could read off the number of nests in which a first egg was laid during May.
4. Could you use a pie chart to represent this data? Which do you think represents this data better, a bar graph or a pie chart? Explain.

### **Teacher Notes: The African Penguin**

*This worksheet has been designed for pupils who have not encountered any data handling before. It introduces simple **tables** of data. This data is then represented using both **bar graphs** and **pie charts**.*

#### Activity 1: Age distribution

*Pupils are required to complete a bar graph (also called a histogram or column graph) and then to interpret the graph. Allow time for reflection and general classroom discussion when the term **mode** is introduced. The mode in this case is the age that occurs most frequently, namely 4 years old. In question 8 encourage pupils to discover a way of using the graph to find the number of penguins less than 5 years old. They should realise that they must add the number of penguins that are 1, 2, 3 and 4 years old together. Some discussion may be necessary on 'less than' - pupils may want to include 5-year-old penguins.*

#### Activity 2: Pie-charts

*A pie chart representing the frequency of the car colours is given. Pupils interpret this data and are required to convert from percentages into actual numbers (it is given that in total 200 cars drove past Sipho).*

*Having interpreted the pie chart that was given to them, pupils are then encouraged to construct a pie chart using the data in Activity 1.*

*Finally pupils are expected to **compare** the suitability of **bar graphs** and **pie charts** for the representation of the African Penguin data. Any justification provided by the pupils for their choice of representation should be discussed. However it would be useful to point out that as the ages are sequential the bar graph is probably more suitable. On the other hand, in Car Colours the colours can be given in any order and we are mainly interested in what percentage of the total number of cars each colour represents. Thus a pie chart is preferable in this case.*

#### Activity 3: Eggs in Nests

*In this activity pupils are required to draw their own bar graph. Thus they must decide which variable must go on which axis and they must choose appropriate scales for the two axes. Encourage pupils to think about these decisions before they start drawing the graph. Otherwise they may have to redo the graph if they have chosen inappropriate scales.*

*Again pupils are required to discuss the difference between bar graphs and pie charts and they must motivate why they think a bar graph was chosen for this activity. Clearly the months in the year are sequential so a bar graph is more suitable.*



# History

The following is a brief history of Robben Island. You may want to read it for background information. You will need it for Activity 3.

## Robben Island Timeline<sup>1</sup>

<u>Date</u>	<u>Events</u>
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1488	Bartolomeu Dias anchored at Table Bay.
1488- 1489-	<b>Informal habitation by passing sailors</b>
mid 1600's	Penguins, seals and sheep that had been left on the island were used for food for passing sailors. Portuguese convicts were left on the island.
1652-1805	<b>Establishment of Dutch colonial refreshment station</b> The first buildings, vegetable gardens and signal post were developed. In 1658 the first political prisoners were imprisoned. They quarried lime and slate for buildings on the island and the mainland (including the Castle).
1806-1846	<b>British military prison</b> Military convicts and people with contagious diseases were sent to Robben Island.
1846-1931	<b>General infirmary and prison</b> Robben Island was used for the isolation of physically and mentally ill people as well as as a prison. In 1931 all the patients were removed from the island and the buildings were burnt or demolished.
1931-1936	The <b>lighthouse keeper</b> and a few staff lived on the island.

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<sup>1</sup> All information and statistical data in this worksheet is based on the book EsiQithini by Deacon, Penn, Odendaal & Davison; South African Museum & Mayibuye Books; 1996.

1936-1945 **A military fortification**

Gun emplacements, observation posts, power stations, harbours, airstrips, etc. were built on the island in preparation for the war, but were never used. In 1945 the military staff left the island.

1948-1960 **Little development (still part of the Defence Department)**

Not much happened on the island at this time but the political situation in SA was changing in a way that would influence the island's future.

*General SA History during this stage:*

*1948 – National Party came into power and institutionalised apartheid.*

*1955 – Freedom Charter adopted by Congress Alliance*

*1960 – Sharpeville: 69 people killed by police while demonstrating against the pass laws.*

1960-1991 **High security prison**

Robben Island was taken over by the SA Prisons Service. Several ANC, PAC and SACP leaders were imprisoned on the island in an attempt by the NP to repress opposition movements. In 1964 Nelson Mandela was sentenced to life imprisonment and sent to Robben Island. The Prisoners endured harsh conditions and almost complete censorship of news (prisoners were only allowed newspapers from 1980 onwards). In 1982 Mandela and the other Rivonia trialists were transferred to Pollsmoor prison. In 1991 the last political prisoners were removed from the island.

1991- **The future of Robben Island**

From 1991 to 1994 there was a lot of debate about the future of Robben Island. An environmental impact assessment was carried out. In 1995 Robben Island was declared a National Monument and daily tours to the island were opened to the public. A museum and educational centre have been developed.

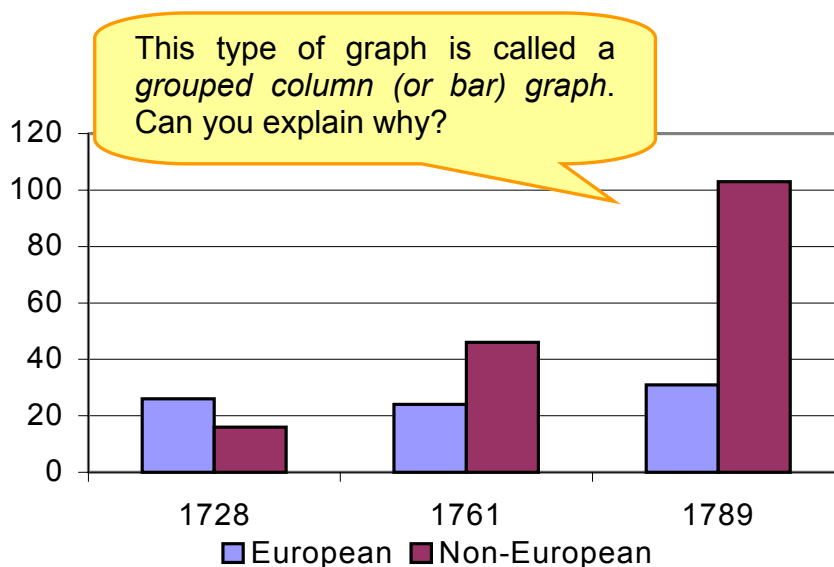
### Activity 1: Prisoners

The following table contains information about prisoners on Robben Island in the 18<sup>th</sup> century.

Date	European	Non-European	Total
1728	26	16	42
1761	24	46	70
1789	31	106	134

Table 1: Prisoner data as classified in the 18<sup>th</sup> century records

The following graph can be used to represent this information.



Graph 1: Prisoner data as classified in the 18<sup>th</sup> century records

1. How many European prisoners were on the island in 1761? Where could you read this from the graph?
2. Between what years was there a decrease in the number of European prisoners? Can you see this clearly on the graph? How could you alter the graph to emphasise this decrease? Explain.
3. What was the increase in the number of Non-European prisoners between 1761 and 1789? How could you get this information from the graph and the table?
4. What *trend(s)* can you identify in the above grouped column graph?

A *trend* is an overall pattern

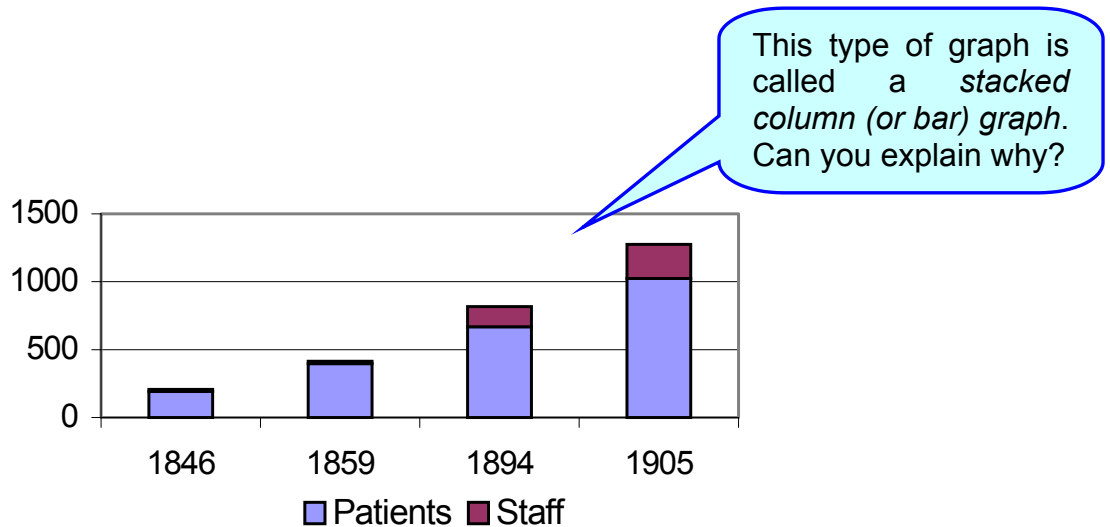
5. Do you think a grouped column graph is a sensible way of representing this data? Explain your reasoning clearly.
6. When do you think it would be more sensible to use a table to represent your data? When would you use a graph?

## Activity 2: Patients and Staff

The following table contains information about patients and staff during the time that Robben Island was a hospital:

Date	Patients	Staff	Staff to Patient ratio
1846	194	13	1:15
1859	396	19	
1894	668	150	
1905	1024	250	

Table 2: Patient and staff data from 1846 to 1905

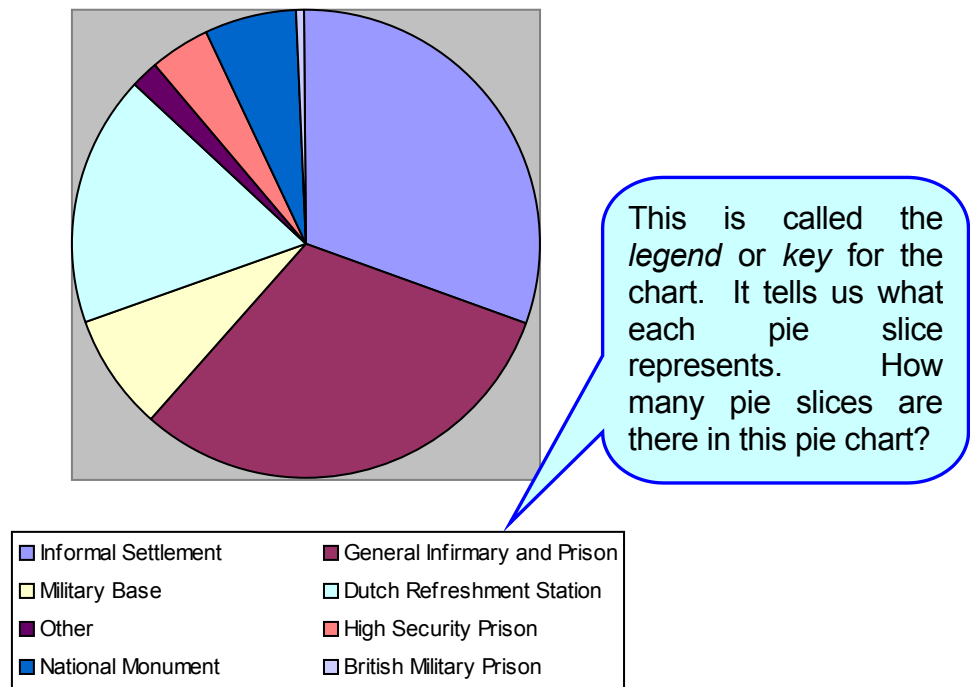


Graph 2: Patient and staff data between 1846 and 1905

1. Were there more than 1000 patients at any stage? Show how you got your answer from the table and from the graph.
2. Can you tell from the graph when there were the most staff members at the infirmary? Explain.
3. Between which years did the number of patients increase the quickest? Carefully explain your answer.
4. Why do you think a stacked column graph has been chosen to represent the data in Table 2? Can you suggest an alternative way of representing the data?
5. Complete the staff to patient ratio column in Table 2. (Round off to the nearest person – what happens when we round off?). If you were a patient at the infirmary, when would have preferred to have been there? Why?

### Activity 3: Robben Island's Uses

The following pie-chart is supposed to illustrate the uses of Robben Island over the years.



Graph 3: Uses of Robben Island between 1488 and 1998

**NB:** To answer the following questions you must use the [Robben Island Timeline](#).

1. Using the timeline (not the pie chart) to calculate how long Robben Island was used as a British Military Prison. Does the pie slice on the chart look correct? Explain.
2. The pie chart is meant to show what Robben Island has been used for since 1488. The size of each pie slice represents the amount of time that the island was used for the given purpose. Unfortunately the legend has got mixed up. Match each pie slice with the correct description of how the island was used.

## **Teacher Notes: History**

*This worksheet builds on the previous one. Bar graphs that **compare two variables** are introduced. Pupils should understand the concept of 'variable', although this does not have to be formally defined. They could, for example, be required to give examples of **variables** and **constants**. (If computing facilities are available they should be used in these activities as all the graphs can be produced on most spread sheet packages. For this reason the computer terminology for the various graphs has been used e.g we refer to a grouped column graph as opposed to a grouped histogram). Pupils are also expected to **collect data** from a written account of Robben Island's history and use it to rectify a pie chart in which the legend is incorrect.*

### Activity 1: Prisoners

*Pupils are given a table of data and a **grouped column or bar graph**. In a grouped column graph two variables are represented (in this case the number of European and Non-European prisoners). For each year that data is available, a column is drawn for each variable so that they can be compared. Pupils are required to interpret the graph. In question 2 they are asked how they could alter the graph to emphasise certain statistics; discussion on scale should arise from this. (If pupils are using a computer package they may also suggest different types of grouped column graphs that have 3-D effects or other visual impact effects such as colour contrasts).*

*The term **trend** is introduced. It is important that pupils grasp the concept that a trend gives us the overall picture of how data is changing in a data set.*

*Pupils are required to state when they are more likely to use a table or a graph. Any justification provided by the pupils for their choice of representation should be discussed. However it is important to stress that graphs, if carefully labelled, convey a message more quickly and easily, and make it easier to identify trends. Tables are useful when collecting and storing data. (It should be pointed out that spreadsheets on computers are tables in which we store and manipulate data).*

### Activity 2: Patients and Staff

*Pupils are given a table of data and a **stacked column graph**. In a stacked column graph two variables are represented (in this case the number of patients and staff at the infirmary). For each year that data is available a single column is drawn with one variable below the other variable. The height of the column represents the total number of people at the infirmary (patients plus staff). Because each data set has a different colour, one can quickly see how the total is made up from the two data sets (much in the same way that a pie chart shows you what part of the total each category is).*

*Pupils are required to interpret the graph. In question 3 the rate at which the number of patients increased is studied. Ensure that pupils note that the dates when data are available are not evenly spaced (the spaces are 11 years, 35 years and 11 years respectively).*

*In question 4 pupils are asked to suggest alternatives to the stacked column graph. Here they may suggest grouped column graphs or invent their own representation, and all suggestions should be discussed. Ensure that whichever representations they*

choose have suitable scales, that the information is concisely and clearly displayed, and that a key (or legend) is provided.

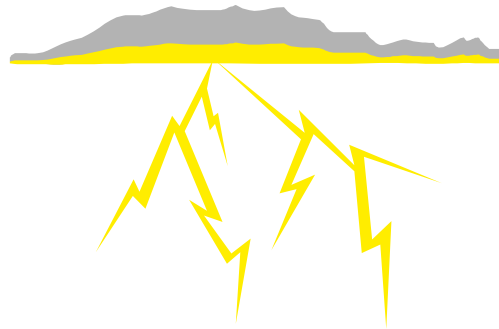
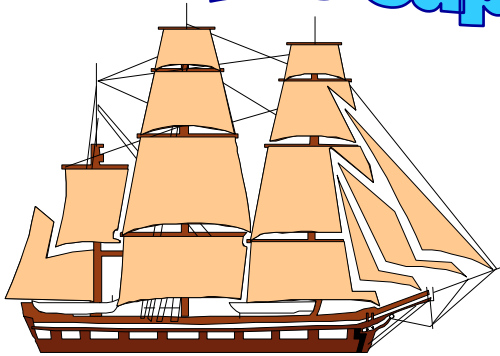
Question 5 refers back to the table. Pupils are required to calculate the staff to patient ratio. When each staff member is responsible for fewer patients we would expect the conditions to be better. Pupils should be referred to the graph at this point to see whether they could have predicted from the graph when the conditions would have been most favourable. In this activity pupils are required to round off to the nearest person when calculating staff: patient ratios. A discussion should be encouraged at this point on how this may affect the data. Discuss things such as:

- The degree of accuracy that is required to answer the questions;
- What type of questions might require us not to round off but work with as many decimal places as possible;
- Whether we would even notice a fraction of a person using the scale on the graph, etc.

### Activity 3: Robben Island's Uses

A pie chart that is meant to represent the various uses of Robben Island is given, but the **legend** is incorrect. By studying the Robben Island timeline, pupils need to gather the correct information and correct the legend. The pupils must use the categories given in the legend and match the correct pie slice to each category. An example is given.

# The Cape of Storms



The Cape coast has been treacherous over the years and many ships have been wrecked resulting in the sailors naming the Cape Peninsula as the “Cape of Storms”. Several of these shipwrecks have occurred around Robben Island. Below is a table showing most of the ships that have been wrecked around Robben Island.

Name of Ship	Date of wreck	Nationality of ship
Schaapejacht	15 August 1660	Dutch
Dageraad	20 January 1694	Dutch
Oosterland	24 May 1697	Dutch
Flora	17 November 1821	Dutch
Perseverance	12 March 1826	British
Gondolier	7 February 1836	British
Bittern	18 January 1848	British
Kingston	23 December 1852	United States
Sea Eagle	16 November 1856	United States
Timor	22 December 1856	Dutch
Bernicia	16 June 1861	British
AH Stevens	7 February 1862	United States
Forfarshire	15 September 1864	British
Il Nazereno	2 December 1885	Italian
Tantallon Castle	7 May 1901	British
Natal	24 May 1914	Norwegian
Rangatira	31 March 1916	British
C. de Eizaguirre	26 May 1917	Spanish
Golden Crown	18 July 1923	British
Hypatia	29 October 1929	British
Solhagen	11 September 1936	British
Fong Chung # II	4 July 1975	Taiwanese
Goel No. 1	27 January 1976	Canadian
Daeyong Family	30 March 1986	Korean
Chanson de la Mer	6 November 1986	South African
The Apollo Sea	20 June 1994	Chinese



1. During which season would you expect there to be the most shipwrecks around Robben Island? Explain.
2. Draw a bar graph showing the number of shipwrecks that happened at different times of the year.
3. According to your bar graph, is there a particular time of the year when shipwrecks are more likely to happen?
4. There was only one shipwreck in August, which is in the middle of winter, yet there were three in December, which is in the middle of summer. Is this what you expected? Can you explain why this might have happened?
5. Is there a nationality that has had more shipwrecks than any other nationality? Does this mean that this nationality is poor at sailing? Explain.
6. Draw a pie chart to illustrate the proportion of shipwrecks that each nationality has had around Robben Island. Why do you think a pie chart is used to represent the data?
7. A lighthouse was built after the Forfarshire was wrecked and a foghorn introduced after the Tantallon Castle was wrecked. Do you think these safety measures were successful? Give reasons for your answer.

### **Teacher Notes: The Cape of Storms**

*This worksheet gives pupils further practice in constructing bar graphs and pie charts, but first they have to summarise the given data in a sensible way.*

*This activity is also designed to make pupils aware that statistics can be misleading. Historical data needs to be put in context. In this case the increase in shipping, the improved technology, and the seafaring history of various nations are not revealed in the statistics, but all these factors necessarily influence the number of shipwrecks.*

*Pupils are first given a table of data on all the shipwrecks that have occurred around Robben Island. In question 1 they are encouraged to make a prediction, which they will compare with their findings at a later stage. In question 2 the pupils must draw a bar graph showing the number of shipwrecks at different times of the year. The independent variable is the time of year, as the number of shipwrecks does not affect it. The dependent variable is the number of shipwrecks as we are trying to find out if this is affected by the time of year. The time of year can either be divided into months or seasons; pupils must justify their choice. Differences which arise in their resulting graphs must be discussed.*

*The teacher should allow time for discussion on various factors which may cause the bar graph to be different to that pupils predicted, for example, before the advent of modern technology, ships did not usually sail around the Cape when storms were expected (winter).*

*In question 6 pupils are required to draw a pie chart illustrating the proportion of shipwrecks that each nationality has had. Again it is important that pupils do not jump to conclusions about one nationality being 'poor sailors'. In Robben Island's early history, ships were predominantly Dutch and later they were mainly British. Clearly this will distort the statistics. In more recent times ships of various nationalities have sailed around the Cape.*

*Finally in question 7 pupils need to determine whether the various safety measures that were introduced were effective. Again, pupils need to think about the number of ships that sail around the Cape (more in recent times) and also the improved technology that is available today.*

# Weather

The weather at Robben Island affects the number of visitors at various times of the year. In 1993, the Weather Bureau established a weather station on Robben Island. The monthly rainfall and temperature data in this activity was supplied by the SA Weather Bureau.

## Activity 1: Rainfall

An X means that no data is available

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total
1993	X	X	4,2	103,8	114,8	35,2	93,6	55,0	2,0	1,8	7,8	15,2	
1994	6,0	0,0	3,2	14,4	28,0	162,6	56,8	9,6	19,2	5,2	6,6	2,4	
1995	7,0	1,6	4,2	14,8	44,8	98,4	77,4	10,8	14,0	22,0	6,6	18,0	
1996	1,0	27,8	16,4	26,2	33,0	94,8	48,6	50,0	50,8	27,8	22,2	26,4	
1997	6,8	2,2	0,2	6,4	69,2	56,0	5,4	62,4	4,6	7,6	43,6	X	
Mean	5,2	7,9	5,6	33,1	58,0	89,4							

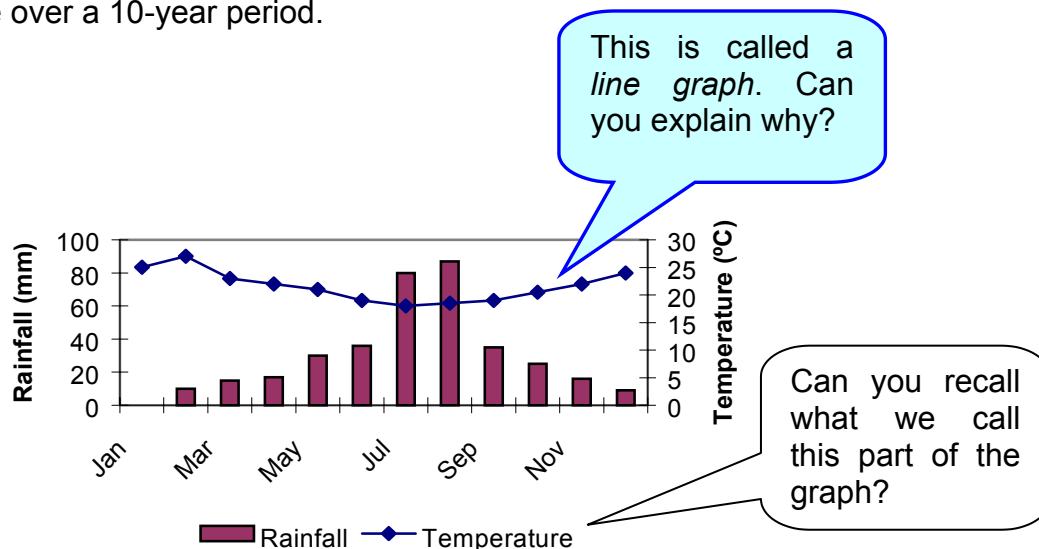
Table 1: Monthly rainfall figures (in mm) for Robben Island between 1993 and 1997

What does this mean?

1. During which months would you expect the most tourists to visit the island? Use the data in the table to explain why.
2. The last row of the table contains the *mean (average) monthly rainfall*. This is one way of *summarising* the data. What does it mean?  
Calculate the missing values and fill them in the last row of the table.
3. During which month would you expect the highest rainfall? Explain.
4. Calculate the total annual rainfall for each of the years where there is a complete record (i.e. where no month's figures are missing) and fill this in the final column of the table.
5. Calculate the mean annual rainfall on Robben Island.
6. Do you think 1997 had more or less than rainfall than the mean annual rainfall? Explain.
7. Describe in your own words what a *mean* (or average) is and how to calculate it.

## Activity 2: An Hypothetical Weather Station

For concise representation of rainfall and temperature data we often use a *bar graph* and a *line graph* on the same horizontal axis (showing the months of the year) but two vertical axes are used. An example of weather data at a **hypothetical** station is given below. The graph represents the mean monthly rainfall and the mean maximum temperature over a 10-year period.



Graph 1: Rainfall and temperature at a HYPOTHETICAL weather station

1. When would you like to visit this weather station? Why?
2. During which month does this weather station **usually** get the most rain? Why is the word **usually** used?
3. During which month is it **usually** the hottest at this weather station?
4. Is this weather station in the Northern or Southern Hemisphere? Explain.
5. Does this graph represent a winter or summer rainfall area?
6. Is the maximum temperature at this weather station 27°C? Explain.
7. Is it possible that during the 10-year recording period there was a year in which no rain occurred at this weather station in March? Explain.

### Activity 3: Weather on Robben Island

The rainfall and temperature data for Robben Island from 1993 to 1997 is given below.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1993	X	X	4,2	103,8	114,8	35,2	93,6	55,0	2,0	1,8	7,8	15,2
1994	6,0	0,0	3,2	14,4	28,0	162,6	58,8	9,6	19,2	5,2	6,6	2,4
1995	7,0	1,6	4,2	14,8	44,8	98,4	77,4	10,8	14,0	22,0	6,6	18,0
1996	1,0	27,8	16,4	26,2	33,0	94,8	48,6	50,0	50,8	27,8	22,2	26,4
1997	6,8	2,2	0,2	6,4	69,2	56,0	5,4	62,4	4,6	7,6	43,6	X

Table 2: Rainfall data for Robben Island between 1993 and 1997

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1993	X	24,1	24,4	19,5	17,4	17,1	17,5	17,9	18,3	20,2	22,7	24,1
1994	24,8	25,7	23,4	22,3	17,4	16,6	17,0	17,0	18,4	21,3	21,8	24,4
1995	24,5	25,7	24,8	20,8	19,1	17,2	15,1	15,1	18,2	19,2	21,5	23,8
1996	24,5	25,0	22,6	22,9	19,8	17,5	16,5	16,5	17,3	20,1	20,1	23,4
1997	25,2	24,7	23,0	20,3	19,4	15,7	17,3	17,3	20,3	22,1	21,6	X

Table 3: Maximum temperature data for Robben Island between 1993 and 1997

1. Create a rainfall and maximum temperature graph similar to the one in Activity 2.
2. Which month(s) do you think would be most attractive to tourists? Explain
3. In which month(s) can one expect the most rain on Robben Island?
4. Which month(s) has the greatest *range* of rainfall figures?

*Range* is the difference between the largest and smallest values.

5. Which month(s) has the smallest range of rainfall figures?
6. Use your answers to questions 4 and 5 to answer the following questions.
  - (a) During which month in 1998 do you think you would be most likely to correctly predict the rainfall figure? Explain.
  - (b) During which month in 1998 do you think you would be least likely to correctly predict the rainfall figure? Explain.
7. Was there any year between 1993 and 1997 that had substantially more rainfall than other years? Give reasons for your answer.

8. Was there any year between 1993 and 1997 that was much hotter than other years? Give reasons for your answer.
9. Which month(s) has the greatest range of mean maximum temperature figures?
10. Which month(s) has the smallest range of mean maximum temperature figures?
11. Use your answers to questions 8 & 9 to answer the following questions.
  - (a) During which month in 1998 do you think you would be most likely to correctly predict the mean temperature figure? Explain.
  - (b) During which month in 1998 do you think you would be least likely to correctly predict the mean temperature figure? Explain.

### **Teacher Notes: Weather**

*This worksheet introduces the concept of **mean**. The mean is calculated by adding all the values and dividing by the number of values. Pupils are given data about weather conditions and required to calculate the mean and develop an understanding of the mean as a measure of **central tendency**. The term central tendency implies that the data is grouped around this central value, e.g. a mean temperature of 22°C in May in Blikkiesdorp implies that one would expect temperatures close to 22°C in Blikkiesdorp in May. (At this point the difference between mean and mode could be discussed. Both are measures of central tendency. The difference is discussed again in a later worksheet.)*

*The worksheet also introduces the concept of **range**. Range is a **measure of the spread** of the data. If the range is large, some of the data points will be far away from the mean value of the data. If the range is small all the data points will be close to the mean value. Pupils should reflect that measures of central tendency (mean or mode) and measures of spread (range) provide us with a summary of the data. (Other measures of central tendency and spread exist, but are beyond the scope of this package).*

#### Activity 1: Rainfall

*The teacher should ensure that pupils answer question 1 before they are given the next page. This question encourages informal intuitions of mean / average. Rainfall data is given for Robben Island from 1993 to 1997. Pupils must understand that the figures for a given month represent the total amount of rain that fell during that month. An X means that no data is available for that month. Pupils should be made aware that in February 1994 the 0,0 means that no rain fell during the month, not that there is no data available. Pupils might intuitively calculate the mean rainfall figures in question 1. All the answers to question 1 should be discussed before the following page is attempted.*

*The second page requires pupils to compute both the monthly and annual mean rainfall for Robben Island during the period when data was recorded. It is important that pupils know that the mean monthly or annual rainfall can be used to predict possible rainfall in the future. However, they must also be aware that the actual rainfall that occurs in the future is likely to be different from the mean. In question 6 the data for December is missing. Pupils will need to estimate (predict) the rainfall that is likely to fall in December and then use this figure to estimate (predict) the annual rainfall for 1997. It is important to stress that what actually happened could well be very different to what they have predicted (Pupils should be encouraged to contact the SA Weather Bureau to get December's data in order to test their predictions).*

*It is important that when pupils answer question 7 they do not just give a method of calculating the mean but also give a description of their understanding of a mean. The teacher should try to ensure that the pupils have made a distinction between mean and mode. (Mean is the single value that represents the combined values of a variable, while mode is the value of the variable that occurs most often).*

### Activity 2: An Hypothetical Weather Station

*This activity is about a hypothetical weather station. (The term 'hypothetical' may need to be clarified).*

*In this worksheet a graph with **two vertical (dependent variable) axes** and a single independent variable axis is introduced. **Line graphs** are also introduced.*

*Mean monthly rainfall and temperature data is given. Asking pupils whether the data on the graph provides us with what always happens or usually happens may test pupils' understanding of the mean. If pupils have difficulty with this, one can return to Activity 1 and recap the procedure for calculating the mean. Pupils should see that several data points would be below the mean and others above the mean. Question 4 requires some geographical knowledge - a brief discussion about hemispheres and seasons may be necessary. If further elaboration is necessary, pupils can be referred to their geography teacher.*

### Activity 3: Weather on Robben Island

*In this activity rainfall and temperature data for Robben Island is given. Pupils are required to construct a graph similar to the one given in Activity 2. To do this they will need to calculate mean monthly temperature. (The rainfall figures have already been calculated in Activity 1).*

*The concept of range is introduced. Teachers should encourage pupils to come up with their own suggestions on what range is and on how to calculate it, and then facilitate a class discussion on it. Pupils should reflect on the difference between the mean of a data set and the range.*

*Pupils are asked to say for which month in 1998 they could predict the rainfall most and least accurately. If data has a small range most data points will be close to the mean; thus we would expect to be able to predict fairly accurately. If the data has a large range the data points could be scattered far from the mean; thus we would not be able to predict accurately what happens in future. Questions 8 to 10 provide further practice using the temperature data instead of the rainfall data.*



# Tourism

## (Enrichment Activity)

The following figures for the Cape Peninsula were provided by SATOUR.

Year	Number of foreign visitors	Number of domestic visitors
1993	346 000	X
1994	394 592	X
1995	493 240	660 000
1996	630 000	726 000 (unconfirmed)
1997	770 687 (unconfirmed)	X

Table 1: Visitors to the Cape Peninsula

1. What was the **mean** (average) number of foreign visitors per year to the Cape Peninsula? (from 1993 to 1997)
2. What was the **mean** (average) number of domestic visitors per year to the Cape Peninsula? (from 1995 to 1996)

It is important for the tourism industry to predict how the number of tourists will change each year. To do this they look at the increase relative to the number of visitors in the previous year. For instance:

In 1993 there were 346 000 foreign visitors. The following year there were 394 592 visitors so there was an increase of 48 592 visitors. This implies that the number of tourists grew by  $\frac{48592}{346000} = 0,14$  or 14 % from 1993 to 1994.

3. Calculate the percentage by which the number of foreign visitors to the Cape Peninsula grew from the years
  - (a) 1994 to 1995
  - (b) 1995 to 1996
  - (c) 1996 to 1997
4. What is the **mean** percentage growth of foreign visitors per year?

5. Using the **mean** percentage growth per year of foreign visitors, predict the number of visitors to the Cape Peninsula in 1998.
6. Very little data is available on the number of domestic visitors to the Cape Peninsula. Using what information you have available, predict how many visitors there would be in 1997 and 1998.

The number of tourists visiting Robben Island has a large impact on resources such as water and electricity; on income generated by the tourism industry; and on the flora and fauna on the island. For this reason it is necessary to carefully study the number of visitors to the island.

7. It is expected that 20% of all visitors to the Cape Peninsula will visit Robben Island. Estimate the total number of visitors to Robben Island in
  - (a) 1997
  - (b) 1998
8. Using you answers to question 7 estimate the **mean** number of visitors to Robben Island each day in
  - (a) 1997
  - (b) 1998
9. The Robben Island Tourism Company has two boats that can carry 150 passengers each. Estimate how many trips each boat must make daily in order to get all the visitors to Robben Island in
  - (a) 1997
  - (b) 1998
10. A boat can make a maximum of 5 trips per day. How many years do you think it will be before the Robben Island Tourism Company will need to purchase another boat? Show clearly how you obtained your answer.

**Teacher Notes: Tourism (Enrichment Activity)**

Data for the number of foreign and domestic tourists visiting the Cape Peninsula is given. Pupils are required to calculate the mean for both cases. The fact that the number of tourists is increasing annually should be noted and as a result, using the mean to predict what will happen in the future is not very useful. Allow time for a discussion on this fact. (The figures before 1996 are less than the mean and from 1996 onwards are greater than the mean – this trend is likely to continue). Thus the annual percentage growth is calculated. A description of and method for calculating the annual percentage growth is given. The teacher should try to ensure that pupils understand why this is necessary, what it actually means and how to calculate it. Some revision of fractions and percentages may be necessary. Pupils are then expected to calculate the mean annual percentage growth (by adding all the annual percentage growth rates then dividing by the number of years). The teachers should discuss the merits of this for predicting future number of tourists as opposed to just calculating the mean number of tourists. Questions 7 to 10 are given to show how information on tourism can be used when planning future developments (in this case when to buy a new boat). Pupils will need to predict the number of visitors to Robben Island using the mean annual percentage growth rate. Then they must calculate how many passengers can go to the island per day on the existing boats. From this they can make recommendations on when to purchase a new boat.



Initially Robben Island had many different animals, including several species of seabirds like the African Penguin<sup>2</sup>. Although many animals and plants were introduced onto the island, passing sailors and inhabitant of the island killed many of these for food and other purposes. Seabirds were also affected, and in 1654 Jan van Riebeeck issued the first conservation decree in South Africa, banning further slaughter of seabirds.

Unfortunately by 1980 the worldwide African Penguin population had decreased to 160 000 and there were none left on Robben Island. In 1983 nine breeding pairs returned to Robben Island. They were carefully looked after and monitored and as a result the population has rapidly increased again.

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<sup>2</sup> All information on the African Penguin was obtained from the Sea Fisheries Research Institute.

### **Activity 1: Number of Breeding Pairs**

Below is a table giving the number of breeding pairs of African Penguin on Robben Island for the period 1983 to 1997.

<b>Year</b>	<b>Number of breeding pairs</b>
1983	9
1984	24
1985	103
1986	227
1987	476
1988	849
1989	829
1990	1278
1991	1879
1992	2027
1993	2176
1994	2799
1995	2279
1996	3097
1997	3336

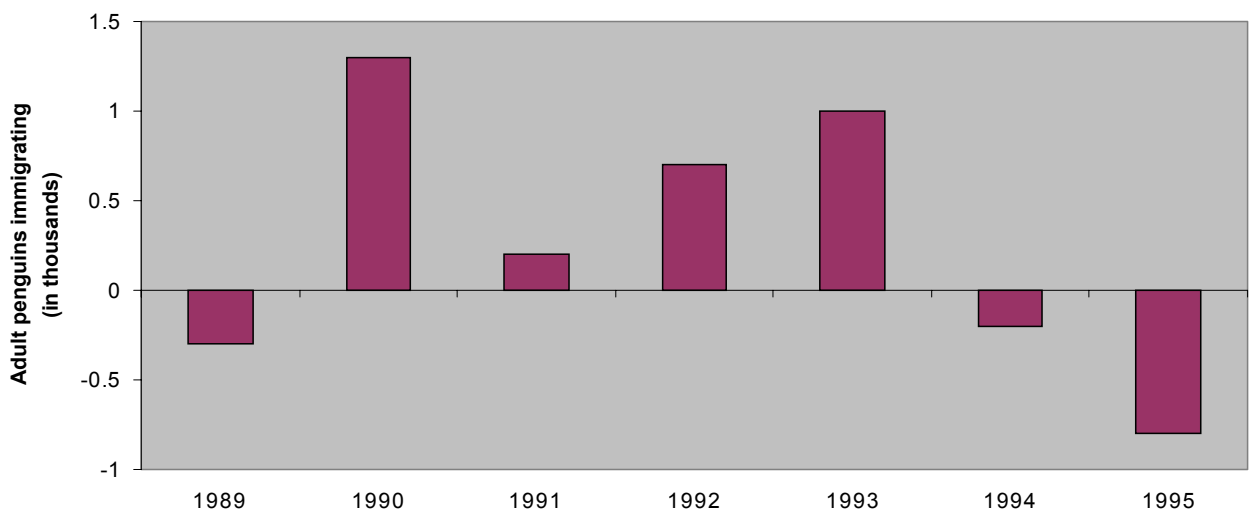
Table 1: Number of breeding pairs of African Penguins on Robben Island

1. Draw a graph that clearly shows how the number of breeding pairs of the African Penguin has changed since 1983.
2. Discuss the general trend in the number of breeding pairs of the African Penguin and explain any unusual events (You may need to look at the previous worksheets.)
3. Between which years was the increase in the number of breeding pairs of African Penguins the greatest?
4. Between which years was the percentage increase from the previous year the greatest?
5. Use your graph and your answers to questions 3 & 4 to predict the number of breeding pairs in 1998.
6. Do you think that the number of breeding pairs will continue to increase indefinitely? Discuss.

## **Activity 2: Penguins Immigrate!**

The increase in the number of breeding pairs on the island was due to two factors. Firstly, chicks are being reared successfully and becoming breeding adults. Secondly, penguins from other colonies moved to Robben Island and started breeding on the island. Scientists call this the 'immigration' of penguins.

The number of adult penguins immigrating to Robben Island is shown in the graph below.



Graph 1: Immigration of Penguins to Robben Island between 1989 and 1995

1. How many adult penguins immigrated to Robben Island in 1992?
2. During which year was the immigration of penguins the greatest?
3. During which years did more penguins leave the island than move to the island?
4. Is there a trend in the number of immigrant adults? Explain.
5. The graph indicates that there was a large 'emigration' of adult penguins in 1995. Does this mean that 800 penguins left the island? Discuss (You may wish to look back through your other worksheets)

## **Teacher Notes: The African Penguin 2**

*This worksheet has two main purposes. It aims to:*

- **Consolidate** concepts that have been introduced previously, such as: mean, mode, trend and percentage increase.
- Extend the use of bar graphs to include positive and **negative** values of the dependent variable (y-axis).

### Activity 1: Number of Breeding Pairs

*Question 1 requires pupils to draw a graph showing how the number of breeding pairs of the African penguin has changed. The choice of graph is left to the pupil. A class discussion can be held on which type of graph (bar graph, pie chart, line graph, etc.) is most suitable.*

*Question 2 requires pupils to describe the trend. They should note that 1995's data is not in keeping with the trend. If they refer back to "SHIPWRECKS" they will see that the Apollo Sea was wrecked during this period. Numerous penguins and other marine birds and animals died due to oil pollution following this wreck.*

*Questions 3 to 5 examine the difference between the **actual increase** in the number of breeding pairs and the **percentage increase** (refer to 'Tourism'). Pupils should decide which of these two they should use to predict future growth and why. They should use the **mean percentage growth rate** to predict the number of breeding pairs in 1998. As the population increases a large increase in actual number of breeding pairs might only be a small percentage increase. For this reason the percentage increase gives a better indication of how the whole population is doing.*

*Question 6 is designed to encourage reflection on the usefulness of trends. The pupils should realise that the number of breeding pairs cannot continue to grow indefinitely. Eventually there would be no space left on the island and there would not be sufficient food for all the penguins. To be able to make long term projections, further information would be necessary, e.g. the carrying capacity of the island, the projected amount of fish available for the penguins to eat, etc.*

### Activity 2: Penguins Immigrate!

*The questions in this activity refer to a new kind of bar graph. The dependent variable, the number of adults immigrating to the island, has negative as well as positive values. Pupils should realise that a negative value implies that more penguins left (emigrated) the island than immigrated to the island. Question 1 might lead to the discussion about the meaning of the values given on the graph - these are net values (total number immigrated – total number emigrated). If this does not occur it is recommended that the teacher initiate this discussion. We cannot say exactly how many penguins actually arrived on the island during 1992, but we know that 750 more adult penguins moved to island than left the island. The graph implies that the net movement of penguins away from the island in 1995 was 800. Once again this is when the Apollo Sea was wrecked, so penguins that died would be recorded as having left the island (emigrated).*



*“In the next century wars will be fought over water”*

Ismale Serageldon, World Bank (Date unknown)

We will look at the water situation in South Africa generally then more specifically on Robben Island.

South Africa is classified as a semi-arid country and water is rapidly becoming one of our scarcest resources. Researchers predict that by 2010 we will not have sufficient water to satisfy the demand for water. In 1997 there was a demand for 26 000 000 kℓ of water, and 33 000 000 kℓ was available (A kiloliter is 1000 litres). In 2010 the projected demand will be 49 000 000 kℓ .

*(‘Keeping Track’ magazine, Feb/March 1997).*

### **Activity 1: Water in Your Community**

You are going to investigate the water consumption of your community, to determine the following:

- a) The average daily water consumption for each person in your survey.
- b) How people obtain their water, e.g. taps in house, communal taps, streams etc.

In order to do this, you are going to conduct a *survey* of at least 3 households to determine the following:

When conducting a survey it would be too time-consuming to interview everyone in your community so instead you interview a small number of people (in this case the people in three households). This smaller group of people is called a *sample*. It is important that the *sample* has similar water consumption to the general *population* (in this case, your community).



1. Would the local football team make a good sample to investigate water consumption in your community? Discuss.
2. Would the local old age home make a good sample to investigate water consumption in your community? Discuss.
3. Write a paragraph explaining how you will choose the three households for your sample that will best reflect your community's water consumption.
4. Carefully design a questionnaire that will supply you with the information you need.
5. Conduct the survey.
6. Put all the data you have collected into a *database*.

A *database* is a table with information displayed in various columns. Each row represents a person.

E.g. **Part** of your database may look like this. What else will you put in your database?

Name	Number of baths per week	Number of showers per week	Number of hand washes per week	Number of litres used for cooking and drinking per week	Number of litres used in the garden per week
<b>Sipho</b>	2	1	14	20	50
<b>Maureen</b>	3	0	20	15	Lives in flat
<b>Dale</b>	0	7	7	12	125

The following table may help you. It contains *estimates* of the amount of water used for various activities. The figures are taken from 'Keeping Track' magazine. They may not be *representative* of the amount of water consumed for the same activities in **your** community. Check them carefully and change them if necessary.

<b>Activity</b>	<b>Number of litres used</b>
<i>Flush toilet</i>	13
<i>Full bath</i>	120
<i>Shower</i>	60
<i>Dripping tap</i>	1 ℓ per 20 minutes
<i>Washing dishes</i>	18
<i>Wash clothes by hand</i>	60
<i>Wash clothes by machine</i>	265
<i>Wash hands under running tap</i>	5
<i>Wash car</i>	300
<i>Sprinkler in garden for 1 hour</i>	900

7. Use any appropriate form of representation to show the results of your survey. Discuss the means and ranges of your data. Discuss where inaccuracies may have occurred e.g in collecting the data, estimating the number of litres used, etc.
8. How do people in your community obtain their water? Compare your findings to the statistics for South Africa in general<sup>3</sup>. Explain any differences you observe.

<b>Source of water</b>	<b>Percentage of population</b>
<b><u>Urban</u></b>	
<i>Tap in house or on site</i>	66,4 %
<i>Tanker or public tap</i>	12,8 %
<i>Bore-hole or rainwater tank</i>	8,5 %
<i>Stream</i>	7,1 %
<i>Other</i>	5,2 %
<b><u>Rural</u></b>	
<i>Tap in house or on site</i>	13 %
<i>Communal taps</i>	55 %
<i>No formal access to water</i>	32%

9. The World Health Organisation says that for a person to maintain basic health standards they require 25ℓ of water daily.
  - (a) Do you think people in your community have enough water to maintain basic health standards?
  - (b) Write down five things that people in your community could do to save water.

<sup>3</sup> Taken from "Population Policy for South Africa" A Green paper for public discussion and 'Keeping Track' magazine, Feb/March 1996.

## **Activity 2: Water on Robben Island**

Already Robben Island does not have sufficient water for its residential community and now several tourists are visiting the island daily. To help alleviate this problem, water is ferried across from the mainland every 3 days.

You have been asked design a storage reservoir on the island to help cope with the additional demand on water caused by the tourists.

The tour operators have provided you with the following information:

- a) There are 7 boat trips a day to the island in peak-season and 4 during off-season.
- b) Each boat can carry 150 passengers.
- c) Tourists are on the island for approximately 2 hours, teas are served and restroom facilities are available.

Estimate what the additional water consumption on the island will be due to the tourists. Then design a circular reservoir to store the water.

**Note:** If you have access to a computer or graphic calculator, you may use it.

### **Teacher Notes: Water**

*This worksheet has several purposes. It aims to:*

- *Introduce the difference between **sample** and **population**.*
- *Introduce the term **representative sample** and encourage pupils to select a sample that is representative of the population they wish to study (their community).*
- *Encourage pupils to **design a questionnaire** and **conduct a survey**.*
- *Encourage pupils to **process and represent their data** and store it in a suitable **database** (table).*
- *Encourage pupils to use their data to **draw conclusions** about their community.*
- *Allow pupils to **compare their data** with other data sets.*

### Activity 1: Water in Your Community

*Pupils are required to design a survey to obtain the relevant data. Questions 1 to 3 require pupils to reflect on the possible bias that may occur should their sample not be representative of their community. Question 4 requires pupils to design their own survey. The teacher should ensure that pupils have read the whole worksheet before they choose their questions or they may find that they need to re-survey their sample at a later stage. Pupils should be allowed sufficient time to choose what questions they would like to ask before participating in a class discussion. Pupils should see the importance of asking simple questions and asking only relevant questions that will provide useful information.*

*Questions 5 and 6 require pupils to conduct a survey and to store their data in a suitable database. Pupils can collect daily, weekly or monthly figures, but should ensure that they are consistent.*

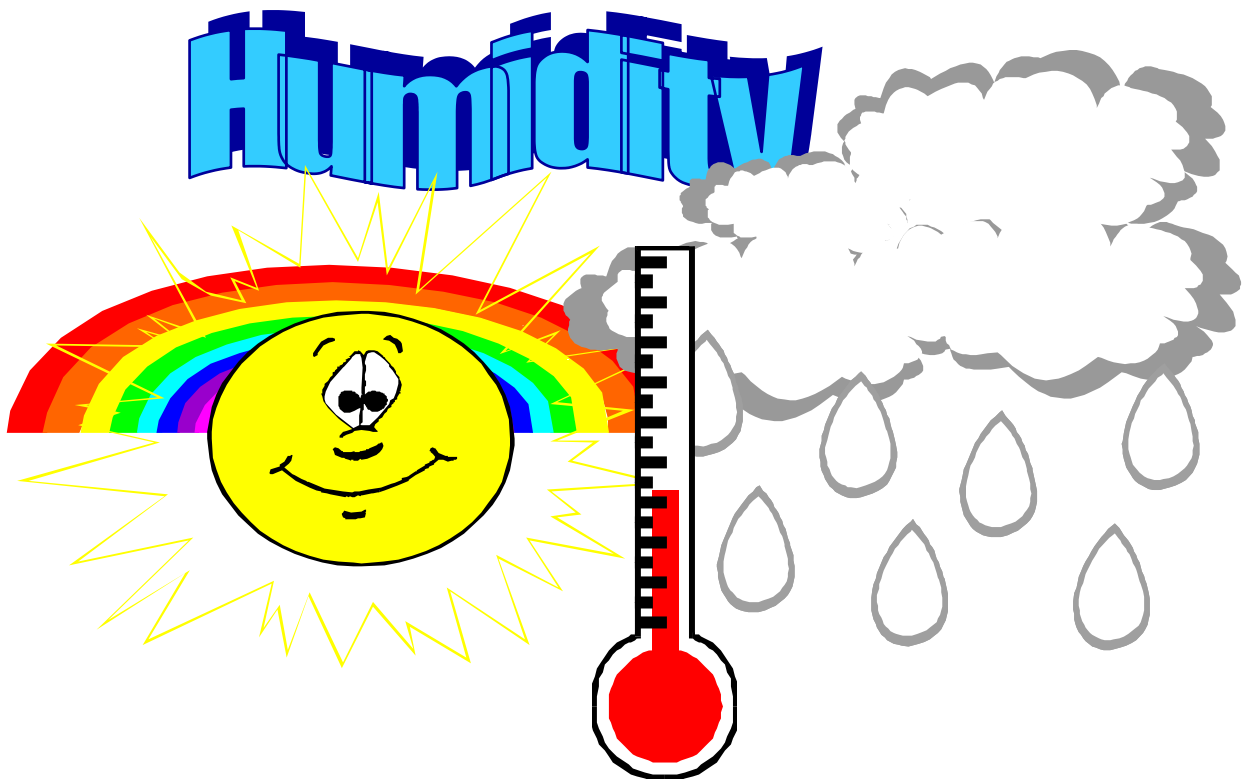
*Pupils are required to convert activities, such as washing hands, into the number of litres of water used. A table is provided for this purpose but pupils should check whether they agree with the information in the table. The figures are only rough guidelines and may differ between various communities. Pupils should also be made aware of inaccuracies that could affect their data, for example:*

- *People might underestimate the number of times they wash their hands or go to the toilet;*
- *They may bath more often in summer;*
- *They might not water their gardens in winter;*
- *They may have visitors coming to stay;*
- *Their toilet may have a very large cistern;*
- *Their taps might leak;*
- *Their bath might be smaller or larger than an average sized bath; etc.*

*After completing their survey and processing their data, pupils are required to draw conclusions about their community and recommend ways of saving water. This is probably summarised best in a class discussion.*

### Activity 2: Water on Robben Island

*This activity returns to the Robben Island context and requires geometry skills. A storage reservoir needs to be built on the island and pupils have to choose a suitable size, based on their knowledge of water consumption. Pupils should make sure that the reservoir is sufficiently large to store enough water for a whole week during peak season. All steps in calculations should have suitable explanations.*



## (Enrichment Activity)

Humidity is a measure of the amount of water vapour in the air. Humidity affects how hot or cold you feel - although the temperature may be  $25\text{ }^{\circ}\text{C}$  you may feel hotter or colder depending on the humidity. In Activity 1 we investigate how the humidity affects the **apparent temperature** (how hot or cold you feel the surroundings to be). The apparent temperature may differ from the actual temperature.

In Activity 2, we investigate the impact of humidity on potential tourism on Robben Island.

### **Activity 1: How Humidity Affects the Apparent Temperature**

Scientists have collected data on how the humidity affects the apparent temperature, for a given fixed actual temperature. Relative humidity (**RH**) and apparent temperature (**AT**) data is given in the tables on the next page. Table 1 is for a fixed actual temperature of  $25\text{ }^{\circ}\text{C}$  and Table 2 is for a fixed actual temperature of  $13\text{ }^{\circ}\text{C}$ .

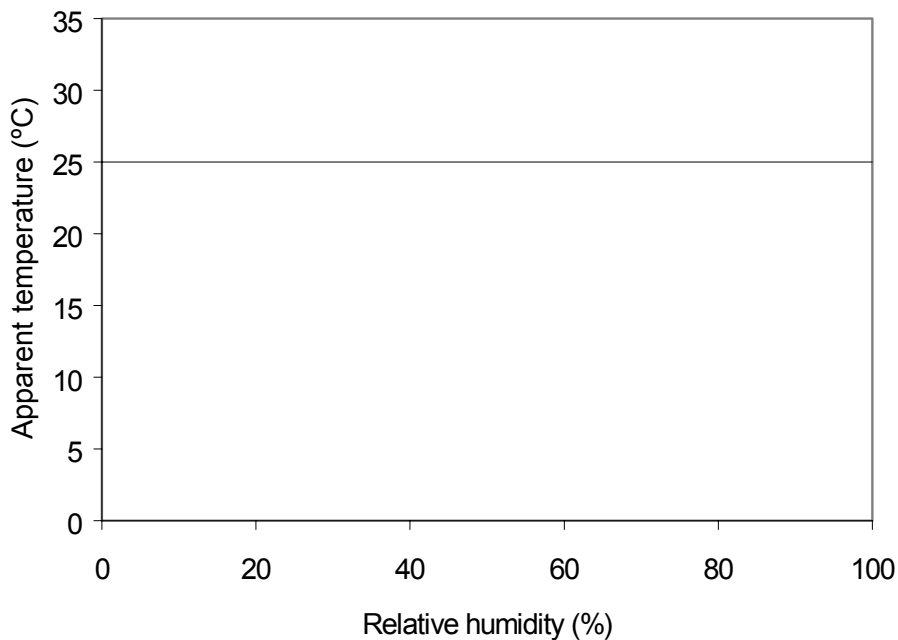
<b>RH (%)</b>	0	10	25	40	56	65	72	88	97
<b>AT (°C)</b>	22,0	22,8	23,9	25,0	26,3	26,9	27,5	28,7	29,4

Table 1: Relative humidities and apparent temperatures for actual temperature 25 °C.

<b>RH (%)</b>	0	13	24	36	55	62	74	82	99
<b>AT (°C)</b>	11,2	10,3	9,6	8,8	7,25	7,0	6,2	5,6	4,5

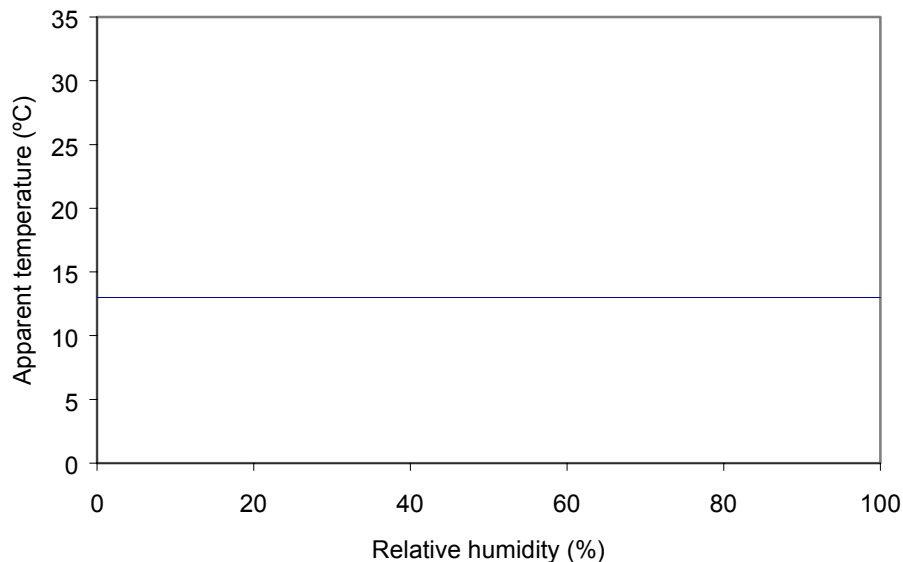
Table 2: Relative humidities and apparent temperatures for actual temperature 13 °C.

1. Plot the data in Table 1 on the chart below. The horizontal line indicates the actual temperature of 25 °C.



Graph 1: Relative humidities and apparent temperatures for actual temperature 25 °C

2. Plot the data in Table 2 on the chart on the next page. The horizontal line indicates the actual temperature of 13 °C.



Graph 2: Relative humidities and apparent temperatures for actual temperature 13 °C

3. What do you notice about the two graphs you have drawn?
4. Predict for each of the above cases, what the apparent temperature would be for a relative humidity of 50%.
5. What effect does a high humidity have for a high temperature?
6. What effect does a high humidity have for a low temperature?
7. For each of the above cases, find the humidity when the apparent temperature the same as the actual temperature. Discuss.

From the data given you can predict what effect the humidity has on the apparent temperature for the two given temperatures (25 °C and 13 °C). Scientists developed a **model** that gives the effect of the humidity for any temperature<sup>4</sup>. The model is as follows: *(the coefficients have been rounded to 1 decimal place)*

$$AT = -0,5 + 0,9t - 22,4h + 1,2th$$

Where  $t$  = actual temperature measured in degrees Celsius  
 $h$  = relative humidity (given as a decimal, e.g. 35 % is given as 0,35)

8. Calculate the apparent temperature when the actual temperature is 25°C and the relative humidity is 65 %. Does your value agree with the value in Table 1?

<sup>4</sup> Bosch, William & Cobb, *Temperature and Humidity Indices*, 1989

### **Activity 2: Humidity on Robben Island**

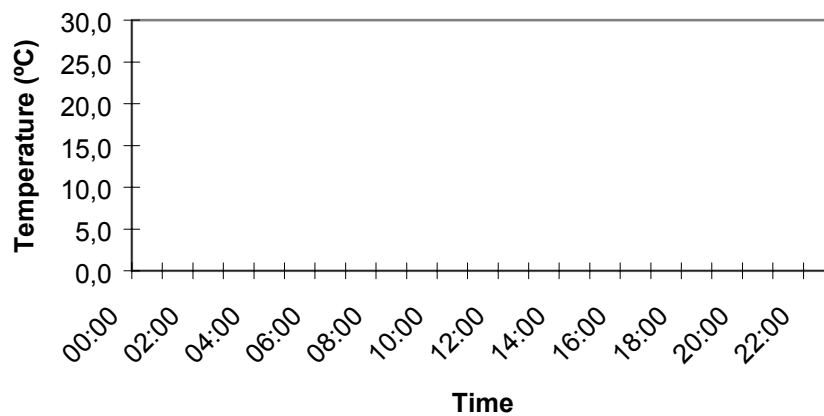
Below is a table containing the average hourly temperature and the average hourly relative humidity for Robben Island for March 1993. Determine the apparent temperature for each hour using the model given above.

<b>Time</b>	<b>Relative Humidity</b>	<b>Temperature</b>
0:00	86	15,6
1:00	87	15,3
2:00	86	14,7
3:00	88	14,3
4:00	89	14,1
5:00	89	14,0
6:00	90	13,9
7:00	90	15,3
8:00	88	16,6
9:00	83	18,3
10:00	78	20,1
11:00	73	21,8
12:00	69	22,9
13:00	67	23,8
14:00	66	24,4
15:00	67	23,9
16:00	68	23,2
17:00	71	22,4
18:00	75	21,3
19:00	80	20,3
20:00	83	19,3
21:00	83	18,2
22:00	84	17,3
23:00	85	16,4

Table 3: Average hourly data for Robben Island for March 1993

1. Plot the actual and apparent temperatures on the axes on the next page.





Graph 3: March 1993

2. How did the apparent temperature differ from the actual temperature on Robben Island during March 1993?
3. Do you think these differences could have had any effect on the tourism?

Similar data for a midsummer and a midwinter month (January and July) is given in Tables 4 and 5 respectively.

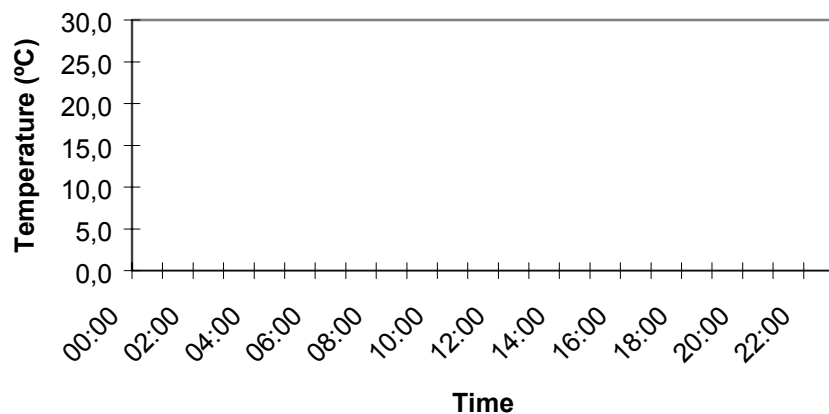
4. Perform similar calculations on this data. Then plot the appropriate graphs on the axes on the following page.

Time	Relative humidity	Temp
0:00	81	15,6
1:00	83	15,2
2:00	84	15,0
3:00	86	14,8
4:00	86	14,5
5:00	86	14,3
6:00	87	15,1
7:00	85	15,9
8:00	77	16,8
9:00	74	18,0
10:00	68	19,5
11:00	64	20,9
12:00	63	22,5
13:00	61	23,7
14:00	59	24,8
15:00	59	24,6
16:00	60	24,0
17:00	64	23,2
18:00	65	22,4
19:00	69	21,3
20:00	75	19,5
21:00	78	18,2
22:00	80	17,1
23:00	79	16,0

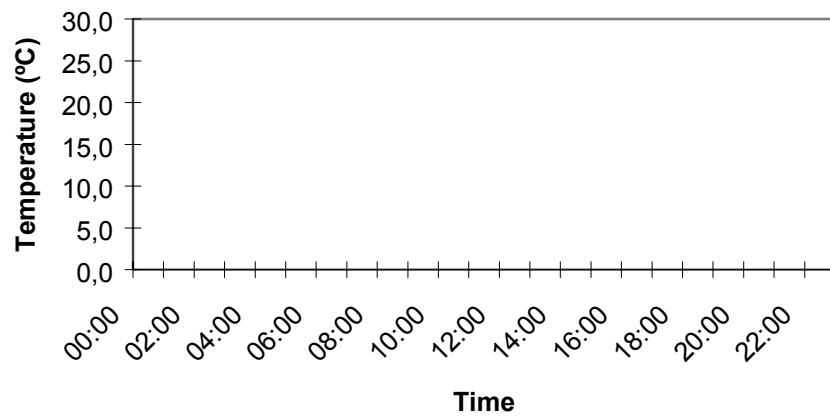
Table 4: January 1993

Time	Relative humidity	Temp
0:00	92	12,6
1:00	92	12,2
2:00	92	11,9
3:00	90	11,6
4:00	90	11,3
5:00	89	10,9
6:00	90	10,7
7:00	90	11,5
8:00	90	12,6
9:00	90	13,5
10:00	87	14,6
11:00	86	15,7
12:00	83	16,6
13:00	83	17,5
14:00	82	17,3
15:00	80	17,0
16:00	81	16,6
17:00	84	16,2
18:00	87	15,8
19:00	89	15,0
20:00	90	14,3
21:00	91	13,6
22:00	91	13,2
23:00	92	13,0

Table 5: July 1993



Graph 4: January 1993



Graph 5: July 1993

5. Comment how the tourism industry on Robben Island could be affected by the humidity in summer and winter.
6. How could tour operators minimise the affect of humidity on the tourism industry?

### **Teacher Notes: Humidity**

*This worksheet is for enrichment. It requires pupils to work with a fairly complicated **mathematical model** of abstract ideas. This should possibly be done with co-operation from the Geography department.*

*Pupils are given actual humidity and temperature data. They are required to plot this data to see what effect humidity has on temperature. They are then given a mathematical model and are expected to use this data to determine how humidity might affect tourism to the island. The model given here is an example of how data has been used to derive a model (formula), in other words the **formula** has been derived to **fit the data**.*

#### Activity 1: How Humidity Affects the Apparent Temperature

*Initially pupils are required to merely plot given data and interpret the graphs. They are then required to draw conclusions about how the apparent temperature is affected if the humidity is high or low. Pupils should realise that if the actual temperature is 13°C, then no matter what the humidity is the apparent temperature will always be less than 13°C. This may be extremely surprising and should be verified with the Geography department.*

*After becoming familiar with the model, pupils are given data for Robben Island for March, January and July. They are required to use the model to calculate the apparent temperatures. They must then plot the apparent temperatures and the actual temperatures on the charts that are provided. Finally pupils need to make suggestions on how tour operators might be able to reduce the effects of humidity on the tourism industry. Possible suggestions are:*

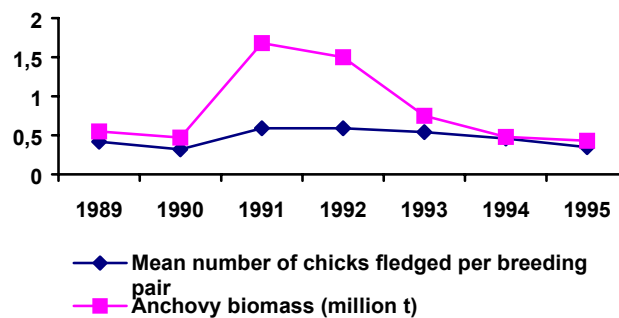
- *Have air-conditioned buses;*
- *In summer, have early morning or late afternoon tours;*
- *In winter, concentrate the tours around midday when the temperature is greatest;*
- *Cancel tours when it is raining heavily (100 % humidity).*



Researchers at the Sea Fisheries Institute have been keeping records on the breeding of the African penguins on Robben Island as well as the anchovy fish they eat in the waters around Robben Island.

Anchovy fish are too small to count individually so researchers estimate the number of tons of fish in the water using acoustic techniques. They call this the anchovy *biomass*.

When the researchers plotted the mean number of fledged (successfully raised) chicks per breeding pair and the anchovy biomass from 1989 to 1995 there appeared to be some similarity between the two variables.

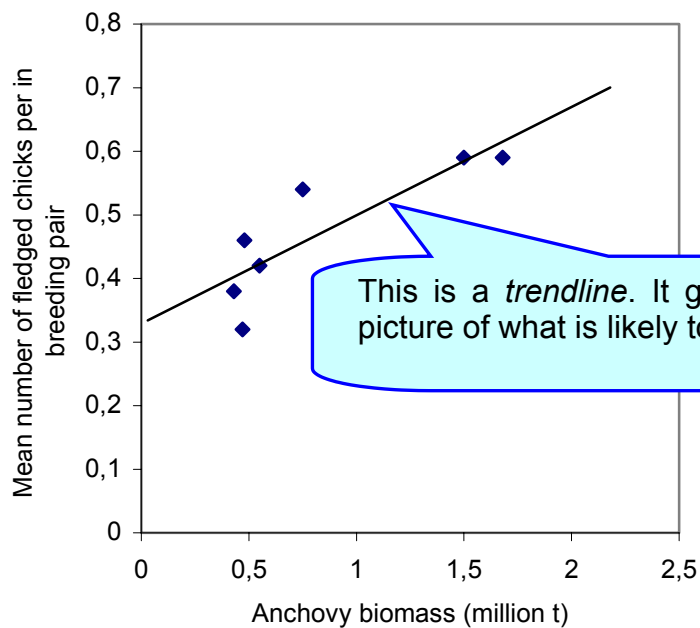


Graph 1: The relationship between the mean number of chicks fledged per breeding pair and the anchovy biomass

1. Describe the relationship between the anchovy biomass and the mean number of chicks fledged per breeding pair.

Another way of determining whether two variables are related is to construct a *scatter plot*. To do this we put the one variable along the *x-axis* and the other along the *y-axis*. When two variables are related one variable is often *dependent* on the other variable. It is conventional to put the dependent variable on the *y-axis* and the *independent* variable on the *x-axis*.

Below is a *scatter plot* that was constructed using the information in Graph 1.



Graph 2: The relationship between the mean number of chicks fledged per breeding pair and the anchovy biomass.

2. Why do you think the anchovy biomass was chosen as the independent variable in the scatter plot? Explain.
3. Does your description in question 1 agree with what this scatter plot tells us? Explain any differences.
4. According to the trendline, if there were no anchovies the mean number of chicks fledged per breeding pair would be 0,33. What do you think? Explain.
5. If the anchovy biomass were to increase to 20 million tons estimate what would be the mean number of chicks fledged per breeding pair? *Make sure your answer makes sense!*

The African Penguin at Robben Island not only eats anchovy, but also eats sardines and various other types of fish. The Sea Fisheries Institute has collected the following data about the proportion of mature adult penguins breeding at Robben Island and the sardine biomass.

Year	Sardine biomass (million t)	Proportion of mature adults breeding
1989	0,36	0,70
1990	0,27	0,74
1991	0,45	1,00
1992	0,32	0,86
1993	0,47	0,77
1994	0,60	0,99
1995	0,58	0,91

- Perform a similar analysis to that of the anchovy biomass and the number of chicks fledged per breeding pair. Construct a 2-line graph with 2 different scales on the y-axes (as in Graph 1) and a scatter plot graph (as in Graph 2). Draw what you think is the best trendline for the scatter plot graph.
- What can you conclude about the relationship between the sardine biomass and the proportion of mature adult penguins breeding on Robben Island?

If two variables are related we say that they are *correlated*. In the first case, we saw that if the anchovy biomass was high the number of fledged chicks per breeding pair was high, and similarly low biomass was associated with a low number of chicks fledged. We call this a *positive correlation*. The fact that the data points were scattered closely around the *linear (straight-line)* trendline, means that it is also a *strong linear correlation*.

If one variable decreases while the other variable increases, we say that it is a *negative correlation*. If all the data points are widely scattered away from the trendline, then they have a *weak linear correlation*. If it is impossible to draw a trendline through the data points because they are so scattered then there is *no linear correlation*.

Is it positive or negative, weak or strong? How do you know?

- According to your trendline, would the African Penguins on Robben Island be affected if all the sardines were fished and there were no sardines left for the penguins to eat?

**Enrichment:**

- Is there a relationship between the anchovy biomass and the sardine biomass?

### **Teacher Notes: The African Penguin 3**

*This worksheet introduces the concept of **correlation** between two variables. Graphs with two dependent variable axes are revisited and **scatter plots** are introduced.*

*Question 1 requires pupils to interpret a chart that has two dependent variables. They should notice that over time, the mean number of chicks fledged per breeding pair and the anchovy biomass have behaved in a similar way. Between 1989 and 1990 both variables decreased, then during the following year they both increased, etc. Pupils may realise that writing a description about the relationship between the variables is time consuming and does not give us an accurate measure of how closely the two variables are related. A more accurate measure of the relationship can be obtained from a **scatter plot**. A scatter plot is obtained by taking one of the y-axes from the previous chart and making it the independent variable (or x-axis). From the given scatter plot, pupils should be able to see that when the anchovy biomass is small, less chicks are fledged and when the biomass is large, more chicks are fledged. A **trendline** is drawn on the graph (If pupils are using computers or graphic calculators, the calculator or computer will draw the best fit straight line for the trendline).*

*Questions 4 and 5 are designed to encourage pupils to reflect on the situation. If there were no anchovies there would still be other food so we would expect the penguins to continue breeding even if their success rate was not as high. If there were 20 million tons of anchovies we could not expect the number of successfully raised chicks to increase proportionally as we know that they usually only lay two eggs. Thus it is highly unlikely that the number of fledged chicks will ever exceed 2.*

*Questions 6 to 8 require the pupils to do a similar analysis to see if there is any correlation between the sardine biomass and the proportion of mature adults that are breeding. Pupils should discuss whether they would expect more adults to breed if the conditions were good (lots of food available). They can then test their predictions using a scatter plot.*

*In question 9, pupils should predict whether they think there will be any correlation before they draw a scatter plot. The correlation is not strong and pupils should suggest reasons for this, e.g. if anchovies and sardines eat the same food then they are competing against each other. Thus when there are lots of sardines you would expect a drop in the number of anchovies and vice-versa.*





Robben Island is a National Monument. You have learnt about aspects of its history, climate and ecology. There is much more to learn about Robben Island by going to the island and visiting its educational museum and also by reading books written about Robben Island.

Design a tourist information brochure for Robben Island. Tourists like to learn as much as they can in a short space of time. For this reason your brochure must only be the front and back of one sheet of A4 paper (the size of this page).

You may include any information that you think is relevant.