Unit 1: Life in the Water

Introduction and contents

Cape Farewell / Voyage of Discovery is a brand new schools science resource, supported by the Nuffield Curriculum Centre, that investigates the science of global warming. The Cape Farewell expedition is a voyage of discovery in a sailing schooner to Svalbard in the Norwegian arctic, by scientists, artists and teachers, to promote public understanding of global warming.

This first unit -Life In the Water - looks at the crucial place of plankton in the Arctic food chain and as indicators of global warming. Both video clips and classroom activities have been produced to the highest standard to resource the new GCSE Core Science specifications, but with a little adaptation, this is also suitable for all year groups 11-16. During trialling it was clear that children enjoyed this investigative approach to science and wanted to know more about the science of Global warming.

“I think other pupils should be taught this. On the whole it is sort of essential.”
“I prefer these lessons because they get us more involved.”
“Before these lessons I didn’t understand global warming or its effects. Now I know more I find it more interesting and I’m thinking of what I can do to prevent it.”

Pupils at Riddlesdown High School

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Introduction and contents

How to use these resources

The backbone of the resources is the story told by the video clips. It follows the five scientists as they collect plankton in the Arctic and return to the laboratory in Southampton where they record and analyse the data.

The DVD contains additional resources that support the video clips and incorporate them into lessons. You could use these lessons as part of your scheme in Year 11 to teach modules from the Additional Science specification

2: 11.3 How do plants obtain the food they need to live and grow?
2: 11.4 What happens to energy and biomass at each stage in a food chain?
The lessons will also cover and reinforce some of the ideas from modules in the Science A and Science B specifications.
If your learners are doing single science, you might find it useful to dip into some of the lessons to cover ideas on
1: 11.5 What determines where particular species live and how many there are?
1b: 11.7 Why have some species of plants and animals died out? How do new species of plants and animals develop?
1b: 11.8 How do humans affect the environment?

Activity F uses small plastic drinks bottles and old 4 litre plastic milk bottles. So it is worth collecting these early.

The same activity requires a culture of chlorella. This is available from Blades biological in small amounts. It is worth buying this early and growing up a larger culture before the lesson.

http://www.blades-bio.co.uk/

Approach 1

Use the 6 lesson plans below as a basis for part of your scheme of work. They take the learners through the story told by the video clips. Each clip is followed up with activities based on the clip and the science it relates to.

Approach 2

Use the lesson plans and the table of video clips as a guide and dip into the video clips and activities in your own way.
Notes on resources – Video Clips

Clip 1
The voyages
A general introduction to the voyage of The Noorderlicht to Svalbard, the Cape Farewell scientists - Simon, Val, Sarah, Mike and Subathra - and their work.

Clip 2
Life in the water
Phytoplankton and zooplankton have a crucial place in the arctic food chain which is highly sensitive to change. The Cape Farewell scientists need to study plankton to understand how they respond to global climate change.

Clip 3
The hypothesis
Phytoplankton absorb carbon dioxide and can act as indicators of global warming. Could it be that a hotter climate could mean more plankton absorbing more carbon dioxide? Or….

Clip 4
Measuring the oceans
Scientists use satellite images and optical measurements to detect phytoplankton in the oceans and they use various methods to capture their samples. On board the Noorderlicht the Cape Farewell scientists look at some of the plankton samples they have captured.

Clip 5
Analysis
At the National Oceanography Centre in Southampton, Mike and Sarah analyse the samples of phyto and zooplankton taken in the Arctic, identifying species and counting their abundance.

Clip 6
Recording plankton data
At the National Oceanography Centre, Mike and Sarah, look at how plankton data is recorded and used as evidence.

Clip 7
Plankton and global warming
Mike talks to Val about the three important carbon cycles at work in the oceans and their place in global warming.

Clip 8
Answering the Big Questions
At the National Oceanography Centre Simon talks to plankton scientist Sophie Fielding about how scientists from different disciplines work together to answer the big questions.
Activity A – Food Chains

This activity uses the arctic food chains to reinforce ideas about food chains and show why a pyramid of biomass is more useful than a pyramid of numbers.

Requirements for class
DVD player
Video clip 2 Life in the water

Teaching notes
Question 8 may need teacher input or you could put learners into groups to discuss the three parts.

Arctic Right whales are a type of baleen whale, which filter enormous amounts of water to retrieve and eat the tiny plankton. They live in the high Arctic and are found in the region of the Cape Farewell expeditions. They filter of the order of 6 swimming pools of water per day. They have a mass of about 75 tonnes and live for around a 100 years, feeding for half the year. The numbers in the pyramid are based on the area of ocean needed to support one whale.

Sample answers to questions
1 a phytoplankton  
b zooplankton  
c Minke whale.

2 It has to filter huge amounts of water to retrieve the tiny plankton; it has filter (baleen) plates; it can take in and pass through huge amounts of water.

4 The whale is so huge and the plankton so tiny that the numbers are probably the most extreme of any food chain.

5 a zooplankton  
b cod, polar bear  
c herring

6 a predators: herring, cod, polar bear  
b prey: zooplankton, herring, cod  
c polar bear
Activity B – Arctic Food Web

This activity develops the ideas from Activity A Food chains to show that the relationship between organisms is more complex than a simple chain. Even this food web is simplified. For example, the arctic fox is not here and only two examples of whales are included.

Requirements for class
DVD player
Video clip 2 Life in the water

Teaching notes
Question 1 may need teacher input and question 4 might work as a group activity.

The activity develops ideas about food webs and gets learners to think about adaptations of species. The baleen whales (including the minke) are grazers: large, slow and filter lots of water. The killer whale is adapted to killing – it is fast and has sharp teeth.

Sample answers to questions
2 a fast, sharp teeth, good senses and reactions
   b they are slow; filter lots of water; grazers; no teeth as such.

3 a Polar bear and killer whale.
   b An increase in phytoplankton would lead to an increase in their numbers.
   c Other top predators. E.g. humans fishing cod.

Activity C – Making and Testing Hypotheses

The video clip includes a discussion about a hypothesis. This activity follows up with some questions about what constitutes a hypothesis.

Requirements for class
DVD player
Video clip 3 The hypothesis

Teaching notes
We have avoided the use of the word theory. Instead, we use the idea of a scientific explanation. The more an explanation is tested, the more accepted it becomes. Before it has been tested, it is a hypothesis.
Activity D – Photosynthesis

This is a fairly standard activity to measure the rate of photosynthesis. Learners can try varying the amount of dissolved carbon dioxide to find out the effect and relate the activity to the video clip.

Requirements for class
- DVD player
- Video clip 3 The hypothesis
- Sodium hydrogencarbonate

Requirement per groups
- 500 mL beaker
- funnel
- test tubes
- piece of pondweed (or algae balls)
- stop clock

Teaching notes
The activity sheet is set up with pondweed which is readily available, familiar and releases bubbles. However, if you wanted to try something a bit more like plankton, you could use algae and put it into algae jelly balls. This would also make a link between this activity and Activity F Plankton blooms.

There is a description of algae jelly balls on the SAPs website at:
http://www-saps.plantsci.cam.ac.uk/worksheets/ssheets/ssheet23.htm

You can buy chlorella algae from, for example, Blades Biological at:
http://www.blades-bio.co.uk/

The rate of photosynthesis can be measured by measuring the volume of oxygen released or simply counting the bubbles in a fixed period. Learners should show you their answers before starting the experiment itself.

Sample answers to questions
1 a Bubbles form
   n Oxygen.

2 a Could count bubbles or measure volume.
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Activities

**Activity E – Collecting and checking**

This exercise follows up the ideas in the video.

**Requirements for class**
- DVD player
- Video clip 4 *Measuring the oceans*

**Teaching notes**
You can use the table provided and give learners as much help as you think appropriate.

**Sample answers to questions**
- See appendix C for a sample of the completed table.
- 1 To verify and reinforce their results.
- 2 In case they have collected a useless sample; it would be too late to retake it once they are back in Southampton.
- 3 So that results can be compared.

**Activity F – Plankton blooms**

This is an extended investigation using chlorella – a type of algae. This is a phytoplankton and therefore relates to the video. The density of the algae can be measured using a home-made Secchi disc (a small version of what you see in the video).

**Requirements for class**
- DVD player
- Video clip 4 *Measuring the oceans*
- nutrient mixture (see below)
- scissors
- black permanent marker pens
- Tipex
- culture of chlorella
- distilled water
- carbonated water (if required)

**Requirements for each learner**
- 3 or 4 small plastic drinks bottles (40 to 50 cL)
- Clean, empty 4 litre milk bottles
- (Microscope and water fleas for extension 2)

**Nutrient mixture**
- To 1 litre of distilled water add 1g Ammonium nitrate, 0.2g Magnesium Sulphate, 0.2g Potassium Chloride and a trace of Ferric Chloride. Adjust to pH7.

**Safety**
You need to decide whether to use scissors with some groups.
You could pre-cut the Secchi discs.
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Teaching notes
The chlorella will grow well under a cool fluorescent lamp in distilled or carbonated water that has been treated with the nutrients above. Possible hypotheses might include the temperature or the amount of carbon dioxide in the water. You will probably find that the biggest single limiting factor is the amount of nutrients in the water. This has implications for the amount of plankton that will grow in the oceans if the global temperature rises or the amount of carbon dioxide rises.

Extension 1
You could set up an experiment with data loggers to measure the amount of light transmitted through a culture over the course of the week. Possibly, set up a few data loggers in parallel pointed at bottles (or beakers) with different growing conditions. It is also interesting to try measuring the transmitted light through blue, red and green filters.

Extension 2
You could collect some water fleas from a pond and look at these and the chlorella down a microscope.

Activity G – Plankton Analysis
Learners use mocked up photographs and an identification chart to count up how many zooplankton are on microscope slides.

Each student (or pair) analyse one of ten photographs. Each photograph has 4 squares out of a grid of 200. At the end of the identification and analysis, you can combine the results from all the learners. Bring out the idea of collaboration (i.e. this is not cheating – it is a sensible way of saving time). Also, some groups will have done the same photograph. You can bring out the idea of checking and validation of data by comparing the results of groups that did the same photograph.

Requirements for class
DVD player
Video clip 5 Analysis
Powerpoint file Zooplankton Identification

Requirements per group
Computer with spreadsheet (probably Excel) and powerpoint installed

Teaching notes
It is assumed that you and the learners have some skill using a spreadsheet. This activity can form a part of your school’s policy for ICT Across the Curriculum. If you use it to develop new ICT skills, you may need to generate additional help sheets based on the learners’ existing ICT capability.

You can bring out the fact that the counting is necessary but can be tedious. Collaboration is useful in science for some of these jobs – especially when they are as extensive as plankton around the world.
You may want to divide the powerpoint presentation into two sections – one for the ID photographs and one for the grids. You might even print out the ID photographs.

Sample answers to questions
1 a Balanus has more legs.
   b Oithona has a more V shaped tail and is slightly smaller.
   c Amphipoda has a more arched body – looks more like a shrimp.

5 a Multiply by 50 (counted 4 squares out of 200)

6 Multiply by 1000.

7 a Shared data so only needed to count four squares each
   b Useful for verifying data.

8 a To look for global trends. Too big a job for a single group of scientists.
   Saves travelling too far.
   b So they can compare numbers.

9 Bigger.

10a Lower.
   b To be able to see the whole shape – it would fill the screen at high magnification.

11 In case they reproduce or eat each other. To fix the number as it was when it was sampled.

Activity H – Plankton Data

This activity uses the same data that the scientists use in the video clip. It has been simplified in some of the tabs within the Excel workbook.

Requirements for class
DVD player
Video clip 4 Measuring the oceans
Video clip 5 Analysis
Video clip 6 Recording plankton data

Teaching notes
It is assumed that you and the learners have some skill using a spreadsheet. This activity can form a part of your school’s policy for ICT Across the Curriculum. If you use it to develop new ICT skills, you may need to generate additional help sheets based on the learners’ existing ICT capability.

Sample answers to questions
1 Using a Niskin bottle to collect water samples.
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2 a i None. No dinoflagellates
   ii 41

b Lack of light; pressure.

c The small ones. They can survive the pressure. Plus, the data shows they are.

3 a 16402
   b 16,402,000

4 a 3750 m³
   b About 61 billion
   c Because the phytoplankton are so small and it is so big.

5 a Diatoms
   b About 4 times more than dinoflagellates

6 a Nitzchia spp
   b Rhizosolenia alata and Ceratium tripos

7 a Rhizosolenia setigera at station 4

8 Eucampia zodiacus and Ceratium furca

9 No. It is different.

10 Stations 3 and 4 have similar trends. They all have similar numbers of ceratum.

11 Stations 1 & 3 each have a species that the others do not have. Other differences.

12a To look for global trends. Different places have different species.
   b To allow data be collected continuously. To save travel.

Activity I – Carbon Cycle

This activity shows students the three carbon cycles and the timescales involved.

Requirements for class
DVD player
Video clip 7 Recording plankton data

Teaching notes
You will need to run this activity in close conjunction with the video clip. Learners will need to refer to the clip to get their information to build up the cycles. We suggest that you break the activity into three stages. There will be some discussion at the end of each stage.
Activity J – A Good Argument

This is an activity to develop learners skills in thinking about and presenting a good argument. It is based on the argument that Mike makes in Video clip 7 Recording plankton data.

Requirements for class
DVD player
Video clip 7 Recording plankton data

Teaching notes
Show learners the video clip before the activity and at least once during it. Encourage them to come up with their own ideas in the activity. There aren’t necessarily right and wrong answers. though there are probably higher and lower quality ones.

On the worksheet, they start by seeing some basic ideas about what constitutes an argument and how it is different from an opinion.
The activity is based on Stephen Toulmin’s model, developed in 1984, for supporting students’ argumentation skills. It relies heavily on the work of Jonathan Osborne of Kings college London and the BioEthics Education project. You can find out more at: http://www.beep.ac.uk/content/284.0.html

Sample answers to questions
1 a The world is getting warmer.
   b Measurements of ocean temperature.

2 a B. For example, we are taking carbon (in the form of fossil fuels) out of the long term geological carbon cycle.
   C. For example, people are buying more cars; developing countries are using more carbon burning processes.

3 a Warmer oceans and more atmospheric carbon dioxide will lead to more dissolved carbon dioxide. As this rises, phytoplankton numbers will increase. This will lead to greater numbers in each stage of the food chain. And eventually more polar bears.
   c That the phytoplankton also need nutrients. If anything, these will decrease as global temperatures rise.
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Completed table for Activity E Collecting and checking

Cape Farewell video clips
- Clip 1. The voyages
- Clip 2. Life in the water
- Clip 3. The hypothesis

Specification references
- To interpret pyramids of biomass and construct them from appropriate information
- The mass of living material (biomass) at each stage in a food chain is less than it was at the previous stage. The biomass at each stage can be drawn to scale and shown as a pyramid of biomass.
- At each stage in a food chain, less material and less energy are contained in the biomass of the organisms. This means that the efficiency of food production can be improved by reducing the number of stages in food chains. Also covered:
  - to suggest how organisms are adapted to the conditions in which they live
  - to suggest the factors for which organisms are competing in a given habitat
  - to suggest reasons for the distribution of animals or plants in a particular habitat.

Their skills, knowledge and understanding of how science works should be set in these substantive contexts:
- To survive, organisms require a supply of materials from their surroundings and from the other living organisms there.

Objectives
- Introduce the voyage with an overview of the work of the scientists
- Establish the reasons for looking at plankton
- Look at the arctic food chain and
- Introduce ideas of pyramids of numbers and biomass
- Discuss hypotheses

Start
(10 minutes)
Show clip 1 The voyages and use Presentation 1 The context to discuss the Arctic and put the voyages into context.
Discuss why the waters don’t freeze. And the ecosystem that it supports.
Encourage learners to ask questions about the climate, 24 hour days and so on.
Also the work of scientists (and artists) in monitoring and drawing attention to global climate change.

Main
(40 minutes)
Why study plankton? They are the base of the arctic food chain. Without them, life in the oceans would cease. They are also a useful predictor of global changes.

Show clip 2. Life in the water. You could take questions and discuss ideas it raises. Show it again before going on to the activity.

Activity A. Food chains.
Discuss effect of changing plankton numbers. Bring out the fact that the Sun is the ultimate source of energy for all the animals in the chain.
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Show Clip 3. Take questions and discuss issues. Discuss the effects of increasing the number of phytoplankton.
Encourage students to discuss the idea given in the hypothesis that increasing phytoplankton could balance the effects of global warming. Emphasis it is just a hypothesis.

Use the food chain diagrams to set up discussion of various hypotheses on changing the balance within it. E.g. how might polar bears become extinct?
Lead on to the ideas of interdependence: extend the food chain to a food web.

End (5 minutes)
Look at Activity B Arctic food web. Prepare learners for their homework.

Notes
This is a relatively straightforward food chain; it can provide information about global warming because it is sensitive to environmental change.

Plankton are at the bottom of the food chain. Studying them can give an indication/warning of environmental changes.

As we will see later, the amount of phytoplankton is probably limited by the nutrients in the ocean. So global warming will not increase the numbers enough to balance its effects.

Set up a growth of algae along the lines of Activity F so that you can show this to learners in lesson 3.

Extension/differentiation
Food pyramids.

Homework
Complete Activity B Arctic food web.

Lesson 2 – Photosynthesis

Cape Farewell video clips
Clip 2. Life in the water
Clip 3. The hypothesis

Specification references
• Green plants use light energy to make their own food. They obtain the raw materials they need to make this food from the air and the soil.
• Photosynthesis is summarised by the equation: carbon dioxide + water (+ light energy) → glucose + oxygen
• During photosynthesis:
  - light energy is absorbed by a green substance called chlorophyll which is found in chloroplasts in some plant cells
  - this energy is used by converting carbon dioxide and water into sugar (glucose)
  - oxygen is released as a by-product.

Objectives
• Develop ideas about hypotheses
• Make hypotheses on photosynthesis
• Develop knowledge and understanding of photosynthesis
# Unit 1: Life in the Water
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**Start**  
(10 minutes)  
Follow up the ideas about hypotheses from the previous lesson.  
Show Clip 2. *Life in the water.*  
Discuss what affects the rate of photosynthesis.

**Main**  
(40 minutes)  
Time will vary. Could be set up as a demo before.  
Activity D. *Photosynthesis.*  
Encourage learners to do rough trials and adapt their measurements.  
Then let them collect data on the rate of photosynthesis and help them to analyse it.

**End**  
(5 minutes)  
Round up ideas.  
Discuss the hypothesis in the video clip and what we mean by hypothesis.  
Set up Activity C as a homework activity.

**Extension/differentiation**  
By outcome of the activity and amount of analysis.

**Homework**  
Activity C *Making and testing hypotheses*  
Write up what they have found out about photosynthesis.

### Lesson 3 – Collecting data

**Cape Farewell video clips**  
Clip 1. *The voyages*  
Clip 3. *The hypothesis*  
Clip 4. *Measuring the oceans*

**Specification references**  
- Light, temperature and the availability of carbon dioxide interact and in practice any one of them may be the factor that limits photosynthesis.  
- The rate of photosynthesis may be limited by:  
  - low temperature  
  - shortage of carbon dioxide  
  - shortage of light.  
- to evaluate methods used to collect environmental data and consider their validity and reliability as evidence for environmental change.

**Objectives**  
- Find out about how scientists work  
- Understand some real data collection techniques  
- Make hypotheses  
- Investigate growth of simple plankton (algae)

**Start**  
(5 minutes)  
Re-show Clip 1. *The voyages.* Discuss how scientists work and what it is they need to measure and collect in the Arctic expeditions.
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| Main (45 minutes) | Show Clip 4. *Measuring the oceans.*  
|                  | Use Activity E *Collecting and checking* to get learners to focus on the techniques. You can reshown the clip to help them.  
|                  | Look at chlorella and possibly water fleas down a microscope. You could use Presentation 2 *Colours* to discuss the way that the Secchi disc works. You can also show your algae growth that was set up in lesson 1. Try the model Secchi disc with this.  
|                  | Bring out the ideas of Big Science. These measurements are being made by collaborating groups around the world. Discuss why the scientists analyse results on the boat (to check they have good data).  
|                  | Ask learners to make hypotheses about what they think will affect the rate of growth and amount of plankton that grows.  
|                  | Use Activity F *Plankton blooms* to set up tests for their hypotheses.  
| End (5 minutes)   | Round up ideas.  
| Homework         | Research more about Secchi discs and Niskin bottles using the internet.  

### Lesson 4 – Analysis

#### Cape Farewell video clips
- Clip 5. *Analysis*
- Clip 6. *Plankton data*

#### Specification references
- to evaluate methods used to collect environmental data and consider their validity and reliability as evidence for environmental change.

#### Objectives
- Understand about techniques for analysing and collating data
- Understand how scientists work
- Have a chance to access and analyse some real data

#### Start (5 minutes)
Discuss the fact that the data has been collected and had an initial check in the Arctic. Now it is time to analyse it.

Show Clip 5. *Analysis.*

#### Main (45 minutes)
Activity G *Analysis.* Learners use the photographs to build up their own mock data set. They could use a spread sheet similar to the one that the scientists use. Use the repetitive nature to make the point that collaboration is a way to build up bigger sets of data.

Activity H *Plankton data.* Introduce them to the spreadsheets. Start them off analysing the data using charting and other functions. Learners will need varying amounts of guidance in this activity depending on their existing experience.
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and skill with spreadsheets. The activity can form a part of the school’s strategy for ICT Across the Curriculum (ICTAC).

End
(5 minutes)

Make the point that it is only by combining the results from many measurements that scientists can get a full picture. Collaboration is essential.

Notes

Activity G assumes good ICT literacy. The activity is designed to consolidate, practice and develop their skills with spreadsheets rather than introduce them to them. Learners may need plenty of hands-on guidance with the use of a spreadsheet.

Homework

Continue to analyse the spreadsheet data and produce a report.

Lesson 5 – Global carbon

Cape Farewell video clips

Clip 6. Plankton data
Clip 7. Plankton and global warming

Specification references

• The constant cycling of carbon is called the carbon cycle. In the carbon cycle:
  - carbon dioxide is removed from the environment by green plants for photosynthesis; the carbon from the carbon dioxide is used to make carbohydrates, fats and proteins which make up the body of plants
  - some of the carbon dioxide is returned to the atmosphere when green plants respire
  - when green plants are eaten by animals and these animals are eaten by other animals, some of the carbon becomes part of the fats and proteins which make up their bodies
  - when animals respire some of this carbon becomes carbon dioxide and is released into the atmosphere
  - when plants and animals die, some animals and microorganisms feed on their bodies; carbon is released into the atmosphere as carbon dioxide when these organisms respire
  - by the time the microorganisms and detritus feeders have broken down the waste products and dead bodies of organisms in ecosystems and cycled the materials as plant nutrients, all the energy originally captured by green plants has been transferred.

Objectives

- understand the carbon cycle
- understand the importance of the carbon cycle and keeping it in balance
- know the importance of the oceanic carbon cycle

Start
(10 minutes)

Reshow Clip 6. Plankton data. Discuss what they found from the spreadsheet activity. Ask some learners or groups to feed back.

Main
(40 minutes)

Plankton provides key data for our understanding of global climate change. It is the root of the food chain. It is also an essential link in the carbon cycle.

Show Clip 7. Plankton and global warming.

Draw attention to the three main carbon cycles. You could show the clip (or first part of it, stopping before the discussion) again.

Pausing to draw attention to each cycle.
Activity 1 *The carbon cycle*. Reshow Clip 7 to learners on request. Bring out the stability and length of the time scales involved in the carbon cycle. Discuss how it might become imbalanced by human activity and whether it can be re-balanced by plankton.

Reshow clip 7, including the last bit on discussion of the effects of global warming on plankton. Use their carbon cycles as a basis for discussion. Finish off the investigation from lesson 3.

End (5 minutes) Discuss what they have found in their investigation of algae growth and how this relates to the questions raised in the clips. You will probably find that nutrients in the water has a very big influence on growth.

Homework Prepare a presentation on how the scientists on the voyages worked, what they found out and what ideas they are generating. They could write this as an imagined journal – ‘A week in the life of a Cape Farewell Oceanographer’.

**Lesson 6 – What does the secondary data tell us?**

Cape Farewell video clips Clip 7. *Plankton and global warming*  
Clip 8. *Answering the Big question*

Specification references • Plant roots absorb mineral salts including nitrate needed for healthy growth. For healthy growth plants need mineral ions including . . .  
• to analyse and interpret scientific data concerning environmental issues;  
• to weigh evidence and form balanced judgements about some of the environmental issues facing society, including the importance of sustainable development;  
• to evaluate methods used to collect environmental data and consider their validity and reliability as evidence for environmental change.

Objectives - use secondary sources to investigate and form arguments  
- understand how scientists have arrived at their ideas about global climate change

Start (5 minutes) Re-show clip 7 *Plankton and global warming*. Use this as an introduction to presenting an argument.

Main (40 minutes) What makes a good argument. Introduce Activity J *Argumentation*.

Show Clip 8. *Answering the big question*. How do scientists work towards big questions and answers? What are the different disciplines involved?

End (15 minutes) Discuss the group of lessons based on cape Farewell. What have they found out about global climate change, plankton and food chains and the way that scientists work.

Homework Imagine you have control of a budget that funds scientific research. You have been asked to provide money for a third trip to Svalbaard. Write a letter to the organisers explaining whether or not you are going to fund it and give reasons for your decision. Describe how useful you think the expedition will be.
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Appendix A

**B1a1 Environment**

- describe food chains quantitatively using pyramids of biomass B1 a 1.1
- describe how organisms in an ecosystem compete with each other for resources B1 a.1.2

**B2.3 Energy flow**

- recall the reactants (carbon dioxide, water) for and products (glucose, oxygen) of photosynthesis B2 3.2
- analyse data on the effects of limiting factors on the rate of photosynthesis and draw conclusions B2 3.4
- describe how mineral salts are taken up in the roots by active transport using energy from respiration B2 3.5
- understand and interpret data on the carbon cycle as representing the flow of carbon in nature, including the roles of microorganisms, photosynthesis, respiration and combustion B2 3.6
- describe environmental changes, such as global warming as threatening human life on the planet as we know it B2 3.11
- demonstrate an understanding of how secondary sources of data about global warming can be collected from the internet and briefly summarise the date using ICT. B2 3.15

**B2.4 Interdependence**

- explore the principles of interdependence, adaptation, competition and predation and explain how these factors influence the distribution and population sizes of organisms in a given terrestrial or aquatic environment B2 4.1
- use primary and secondary data to consider how human activity, including differing economical and industrial conditions, can affect the environment and cause changes in sizes of population B2 4.2
- investigate, using primary and secondary data, the impact of human activity on the environment, including the pollution of air and of water; and the effects of air pollutants (including carbon dioxide, sulphur dioxide, carbon monoxide) and of water pollutants (including sewage, nitrates and phosphates) B2 4.3
- interpret data on environmental change B2 4.4
- explain the importance of protecting natural populations B2 4.5
- describe the special nature of some extreme environments, notably deep sea volcanic vents, the Antarctic and high altitudes B2 4.6
- interpret data to show the impact of human activity on the environment to include:
  - living indicators eg lichen distribution and incidence of skin cancer
  - non-living indicators eg global temperature and ozone depletion B2 4.7
## Relating activities to video clips

<table>
<thead>
<tr>
<th>Clip</th>
<th>Related activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 The Voyages</td>
<td>Powerpoint presentation</td>
</tr>
<tr>
<td>2 Life in the water</td>
<td>A Food chains</td>
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<tr>
<td></td>
<td>B Arctic food web</td>
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<td>3 The hypothesis</td>
<td>C Making and testing hypotheses</td>
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<td>D Photosynthesis</td>
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<td>4 Measuring the oceans</td>
<td>E Collecting and checking</td>
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<td>F Plankton blooms</td>
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<td>Coloured filters</td>
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<td>5 Analysis</td>
<td>G Plankton analysis</td>
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<tr>
<td>6 Recording plankton data</td>
<td>H Plankton data</td>
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<tr>
<td>7 Plankton and global warming</td>
<td>I Carbon cycle</td>
</tr>
<tr>
<td></td>
<td>J A good argument</td>
</tr>
<tr>
<td>8 Science – the Big Questions</td>
<td>K Expert groups</td>
</tr>
<tr>
<td>Description</td>
<td>What the oceanographer does</td>
</tr>
<tr>
<td>-------------</td>
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</tr>
<tr>
<td>Satellite image</td>
<td>Images of ocean taken from satellite way above the Earth.</td>
</tr>
<tr>
<td>Plankton net</td>
<td>Long net with fine mesh.</td>
</tr>
<tr>
<td>Optical sensors</td>
<td>Two colorimeters (colour sensitive sensors). One is pointed at the sky and one at the surface of the ocean.</td>
</tr>
<tr>
<td>Niskin bottle</td>
<td>A bottle that can be opened and closed at both ends when it is under water.</td>
</tr>
<tr>
<td>Secchi disk</td>
<td>Both ends are open so it doesn’t hold any water until the operator shuts both ends using a cable.</td>
</tr>
</tbody>
</table>

The chlorophyll in phytoplankton absorb blue light. So the Secchi disk disappears at a lower depth through a green filter depending on how much phytoplankton is in the water.