Part One

Project Report

Science Teaching Resource Kit

GCAS Personal Project

Renee Baldwin

GCAS IX 2006-2007

Background

With a background in Science and in recent years focusing studies towards ecology (freshwater and terrestrial), physical geography, resource management, environmental science and conservation disciplines, I have an educated understanding of physical systems from an ecosystem perspective. I am passionate about the Antarctic environment and the unique processes and natural phenomenon that occur. What I also find intriguing is how organisms are adapted to sustain a niche in the harsh Antarctic conditions. The importance of the Polar Regions at a global scale and their influence on the global ecosystem are concepts that should be understood. I believe these understandings need attention and that it is important that our younger generation are equipped with knowledge so that they too may develop passions for such exceptional natural landscapes. With this they may continue the work of our generation into the future to conserve and preserve such a pristine environment. Within our society, anthropogenic influences on the environment are something humans have been aware of but have only recently begun to react to. We can not change the actions of the past or remediate the effects, but what we can have an influence on is the future. My way of conserving and preserving Antarctica at this stage, is to help educate and whet the appetites of our younger generation so that they may understand the beauty and importance of spectacular regions of the world.

Introduction

The purpose of this report is to complement the teaching resource kit and provide background context of how it was accomplished. This educational resource kit is intended to be used by teachers who would like to use the Antarctic environment as a medium for achieving specific objectives from the science curriculum. The aim of this project is to summarise information and provide a resource for teachers of Year 9 and 10 (levels 4 and 5) students, relating to topics within an ecological theme. The rational of this project is to provide the younger generation with knowledge so that they may be able to play a role in the conservation of Antarctica, so it may remain a natural region on the earth devoted only to peace and science (Committee for Environmental Protection 2006). The other reason for a project of this nature is to fulfil my interest of educating and sharing experiences with others and promoting environmental awareness.

Method

The first priority was to establish a theme that would allow for the framework of the resource kit to be planned. The theme of ecology was chosen as this was of interest to me and my academic background. It was important to identify the topics within the premise of ecology and how they would complement the science curriculum. The curriculum was the next important component of the framework to understand, so that the topics would be relevant and the resource would be beneficial. The presentation was also a consideration because it has to be user friendly and the educational objectives identifiable for the user. Activities were planned and created to suit the intended teaching levels. Sources of information were needed at an appropriate level, secondary school library books aided in this. I met with a past GCAS student who is now fulfilling a teaching career in Christchurch. Through this I was able to finalise the structure of the curriculum and gain knowledge of how it worked and ideas of how the resource will work practically. This was very helpful and gave me confidence that I understood the framework and the resource was viable. I was also able to meet with a secondary school science teacher who clarified that the content was relevant and able to be used practically. Also it was confirmed that the activities were pitched at an appropriate level.

Results

This project is presented in four parts,

- Part one – Project report, background to the resource (for the purpose of GCAS).
- Part two – Teaching resource information, provides information related to each topic, an outline of possible learning activities and references.
- Part three – Teaching resource practical manual, provides activities for the topics.
- Part four – Supporting CD-Rom to provide digital copies of all resources.

Conclusion

The reason for creating this teaching resource was because I wanted to seize the opportunity to educate others. I felt that targeting the younger generation may have flow-on effects to perhaps further education and interests, which may ultimately lead to an enhanced network of passionate Antarctic preservers and conservationists. I would like to promote environmental awareness not only regarding such an important global region, but awareness of our environment and the effects that our behaviour has on Antarctica. The region may seem far away and out of our influence but our actions have enormous effects to the global system and New Zealand is in close proximity to the Antarctic continent.

Having no experience with teaching and the New Zealand Science curriculum, it was difficult to grasp the concept of how to present the information and in what format. Extra attention was needed to understand and make sense of the curriculum. This interpretation was accomplished and it was assured to me that I had achieved the task well. I experienced difficulty with respect to keeping the information in the resource kit relevant to the user and at an appropriate level of understanding. Once again this was assessed by a qualified science teacher and the resource is able to be practically used in a variety of situations.

The aims of the project have been met, an educational resource has been developed in a framework that can be used by a variety of teaching styles. The resource information will provide a teacher with relevant Antarctic knowledge that can be built upon to teach topics in science. I hope that this resource is a foundation to spark enthusiasm for the use of a different medium during teaching lessons.

During this project I have realised that I do enjoy educating and undertaking independent ways of enlightening others with respect to the unique environment and continent of Antarctica. I have learnt a lot about the process of creating teaching material.

Acknowledgments

I would like to thank Antarctica New Zealand and Gateway Antarctica, that I was fortunate to be able to fulfil my dream of living and working in Antarctica and that I now have personal experience and am able to educate others. The whole course has been a life changing and valuable experience. I would also like to thank both parties for their organisation and logistical support.

Thank you Yvonne Cook for your time and support throughout the GCAS course, I really appreciate the organising that you did for me.

Genevieve Murrell, thank you for your time to help me understand the curriculum and for giving me confidence that I was heading in the right direction and for the practical ideas.

I would like to thank Cassie Gifkins for your time and enthusiasm, you gave me a boost of confidence when I needed it that the resource was worthwhile and had useful potential, thank you. Also thank you for the ideas for some extra activities.

References

Committee for Environmental Protection, (2006), *Committee for Environmental Protection Handbook*, Antarctic Treaty Secretariat, Buenos Aires. (www.cep.ats.aq/cep/) or (www.cep.ats.aq/cep/handbook.shtm)

Part Two

Teaching Resource Information

Science Teaching Resource Kit

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Renee Baldwin

GCAS IX 2006-2007

Table of Contents

Introduction

Antarctica is the Southern Polar Region of the Earth, made up of the Antarctic continent and the Southern Ocean. The name Antarctica means 'opposite the Arctic' and it is in many ways a contrast to the Arctic. The physical environments are different as well as the living components of each region. The Antarctic is a frozen continent surrounded by ocean where the Arctic is frozen ocean surrounded by landmass. The Antarctic continent accounts for nine percent of the global continental surface, being twice the size of Australia (Trewby 2002). The Antarctic is the most isolated continent on the planet because of its polar geographical location and the nature of the surrounding Southern Ocean. However this isolation is not absolute. There are many interactions between Antarctica and global atmospheric and oceanic systems, and it is understood that the Antarctic can be used as a barometer of global climate change (Trewby 2002).

The Antarctic continent is characterised by ice sheets that are grounded on the bedrock of the continent and flow through ice streams towards the lowest relief or the continental margins. When the ice sheets become ungrounded from the bedrock and float on the ocean this is termed an ice shelf. Ice bergs are the direct result of calving from the ice shelf. Seasonal sea ice is an essential component of the Southern Ocean system. It is different to glacier ice on the continent as it is saline and forms by crystal growth rather than compressed snow. There are many processes that the sea ice influences and many conditions that it creates. The Antarctic region is also characterised by ice free areas, these are areas that are typically not covered in snow or ice. Scott Base is established on ice free land, although snow and ice are not absent from the area there is a lot of exposed rock. These different areas described above are the origin and influence of the abiotic (non-living) features of the region that influence the biotic (living) components.

Antarctica is the land of superlatives, it is the darkest, coldest, windiest, driest, highest continent of the Earth. With these extreme and seemingly harsh conditions, the abiotic environment is unique compared to other regions of the Earth. It is hard to imagine that there is any life in the Antarctic and it is surprising to learn and witness the existence of life, often at scales humans do not normally see. Life in the Antarctic

occurs both on the land and in the marine environment. There are many characteristic features of the Polar Regions that are different to temperate climates like New Zealand. These have effects on the environment and what life can exist. Some of these characteristics are temperatures that are constantly below freezing, which means there is seldom any liquid water. During the southern hemisphere summer, there is continual daylight which lasts from November to February. In the autumn the sun begins to track towards the horizon as the winter is devoid of light, until the following spring when the sun rises.

Why should the Antarctic be introduced into the New Zealand Science curriculum? New Zealand is one of few global gateways' to Antarctica and is a territorial claimant state. As the Antarctic is not occupied by any indigenous population it is not 'owned' by anyone. It is a global commons and as previously mentioned the region is of global significance and is influenced by the rest of the globe. It is one of the last great wilderness regions of the world which is protected by the Antarctic Treaty and is preserved for peace and science. The Antarctic environment enables humans to become aware of unique processes that occur, and is ideal for many scientific investigations as it offers conditions that are found in no other environment on the planet. Antarctica is a naturally dynamic, globally significant environment that needs to be conserved and preserved.

The aim of this resource is to be used as a medium in order to teach aspects of the New Zealand Science curriculum. It does not provide all information necessary to teach all achievement objectives (AO), but it does provide information and activities to cover some, between two strands and at two levels. It is expected and is possible to expand upon this material where relevant and to use only parts of the resource as appropriate to the teaching situation. It is an aid for those teachers who would like a refreshing change and be able to use some examples from Antarctica in their lessons.

How this resource fits within the Science Curriculum

This resource has been created within the framework of the New Zealand Science Curriculum. Six topics have been selected in relation to the overarching theme of ecology. Five of the six topics accomplish achievement objectives, the first topic does not but is useful for background information and holistic understanding. The topics are able to be incorporated into a number of teaching styles and units. The material is sourced from published works, tertiary education and personal experience. The information provided and the educational framework is relevant to today's teaching.

This resource has been created for use by an intended audience. It is envisaged that teachers will be the primary users but it is also possible for students whom are interested in the Antarctic environment. This is to complement the New Zealand Science Curriculum (Ministry of Education 2007), and the material provided will fulfil the following:

Contextual strands

- Making Sense of the Living World
    - Level Four
        - Achievement Objective – 2 and 4
    - Level Five
        - Achievement Objective – 2 and 4
- Making Sense of Planet Earth and Beyond
        - Achievement Objective – 4

How to use this resource

This resource provides the user with information pertaining to the ecology of Antarctica. It is envisaged that this provides relevant background information that can be used during lessons as examples to fulfil the curriculum at levels four and five. The New Zealand Science Curriculum should be used in conjunction with this resource to provide the context. It is stated in the New Zealand Science Curriculum that while a student is learning about topics in science they should gain an understanding of New Zealand and of the wider global environment (Ministry of Education 2007). This resource acknowledges this directive and provides examples of how some of the *Achievement Objectives* can be met using an understanding of the Antarctic environment. This is not a stand-alone resource to teach a topic in full but rather an information source that can be used as an example to compliment the topic being

taught. Make use of the outline flow diagram (Figure one) to find what topics are relevant to your situation and use the suggested activities to teach students these topics of science. For example, photosynthesis can be taught through a comparison of New Zealand and Antarctic examples. Use the Antarctic environment to increase awareness and make the scientific concepts and *Achievement Objectives* interesting.
This resource has been developed to suit a range of teaching styles and methods of curriculum delivery that varies between different schools. It is possible for teachers to use parts of this resource in a variety of unit plans and to expand on the information and the activities.

The teaching resource is made up of four parts:

- Part one – background information to the resource (for the purpose of GCAS).
- Part two – this provides information to teach an Antarctic example on a selected topic.
- Part three – selection of possible learning experiences that can be used and expanded upon, depending on the ability of the students.
- Part four – Supporting CD-Rom with a digital copy of material (part 2 and 3).

References that were used to compile the information are provided at the end of each topic section. This is not an exhausted list and there are many other books and published works at a variety of levels for more information. The books used were aimed at the same level as the intended users. Through experience of visiting high school libraries I am confident that there will be a variety of books and information files in school libraries that can be used for teaching information and research activities for the students. There is also a lot of information on the internet found through search engines such as Google.

Reference and links

Ministry of Education 2007. http://www.tki.org.nz/r/science/curriculum/ Retrieved February 1, 2007,

Trewby, M. (ed) (2002). *Antarctica, An encyclopaedia from Abbott Ice Shelf to zooplankton*. Bateman, Auckland

Waller, C. L., Barnes, D. K. A., and Convey, P., (2006). Ecological contrasts across an Antarctic land-sea interface. *Austral Ecology*, **31**, pp, 656-666.

Flow diagram

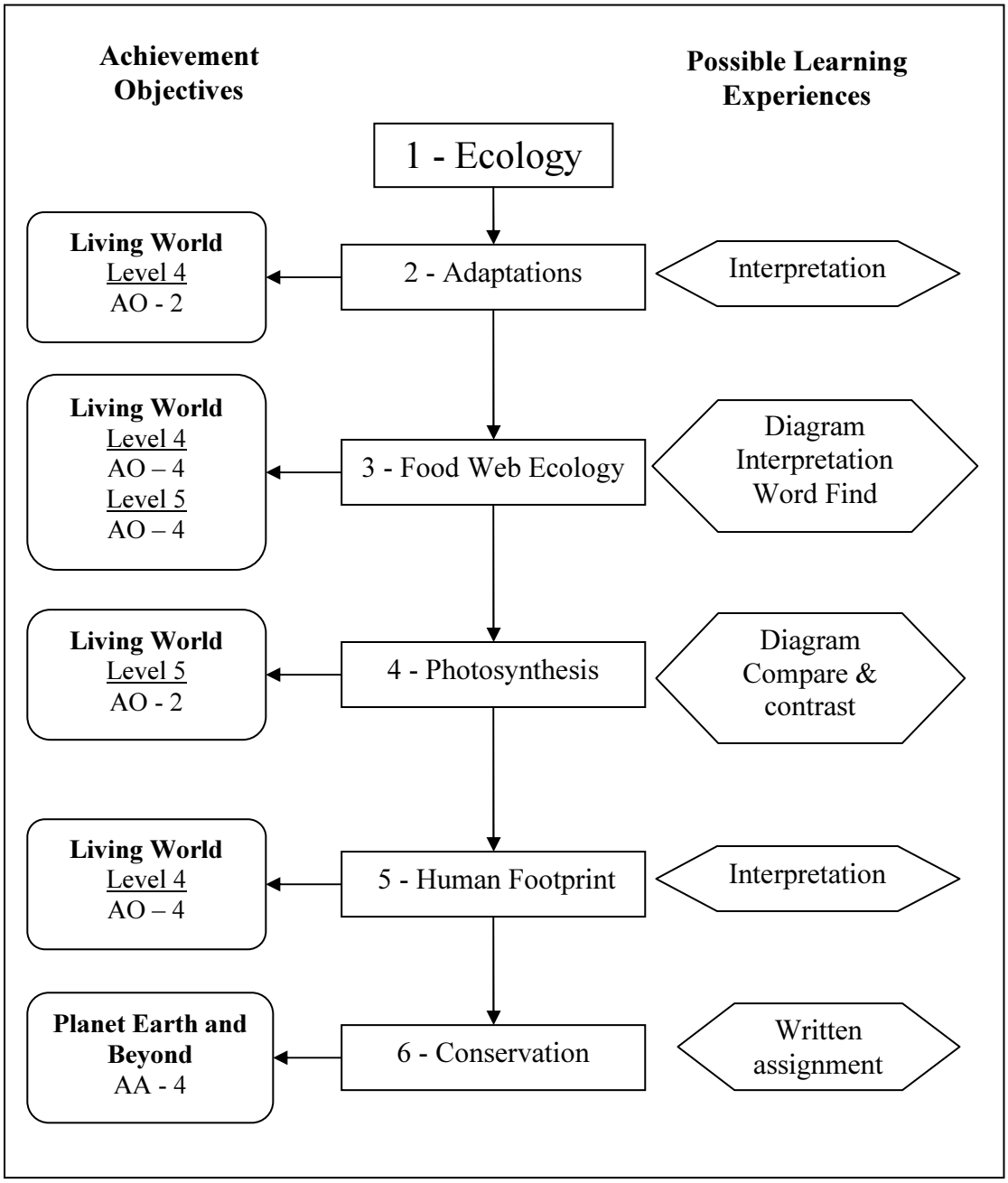


Figure one: Flow diagram to show the outline of the teaching resource, to be used as a visual index.

1 – Ecology

Achievement objectives

There are no achievement objectives that this material directly relates to, rather this information is the background in understanding the complexity of ecology and how dynamic the environment and its components are.

Background information

Antarctic biota exists in the terrestrial (land) and marine environment. The Antarctic terrestrial communities are depauperate with low biomass and few higher taxa (such as mites and nematodes). The marine environment in contrast, is rich and diverse and there are many endemic species (Waller *et. al.* 2006). It is also a phenomenon of Antarctic species to be slow growing and reach sizes of gigantism. The reason for such a difference between the marine and terrestrial communities is because the ecosystems are influenced by harsh and extreme abiotic conditions. The terrestrial communities experience the greatest variability in abiotic conditions and gradients. The intertidal zone is an environment that is suboptimal and hence a highly stressful habitat, as a result the communities are well established and relatively diverse (Waller *et. al.* 2006).

- Ecology studies the interactions between the abiotic and biotic components of the environment. Abiotic components relate to all those that are non-living and biotic components are those that are living. Living plants and animals rely on non-living things such as air, water, soil, energy and nutrients. The living components influence these non-living aspects also, by altering the environment.

- In regions where there non-living and living components of an environment are interacting, an ecosystem is formed, these can be in the marine (ocean), terrestrial (land) or cold desert environments. There are many other defined ecosystems on the planet but these are relevant to Antarctica. Dominant Antarctic ecosystems are lake ecosystems (surface and sub-glacial), terrestrial, Sub-Antarctic Island, and Southern Ocean (marine).

- Ecosystems can have fixed boundaries and be defined but this is not always the case. There are some ecosystems that exist in close proximity and they are connected by animals that are mobile and occupy both. This is the case in the Antarctic where some ocean animals, seals, penguins and seabirds, use the land to breed, moult and rest, while they mate and gather food from the marine ecosystem. This has influences on food web ecology and the flow of nutrients between the ecosystems and determines how they are connected.

- It is the Antarctic Polar Front (non-living component) that isolates the Antarctic polar region, this is where the northern warm water meets the cold southern Antarctic water. This creates many strong environmental gradients such as salinity, temperature and nutrients, on either side of the Polar Front. It is these sharp differences that separate the ecosystems of the warm and cold oceans (Reid 2005).

References and links

Reid, G. (2005). *Antarctica; Ecosystems*. MacMillan Education, Australia.

Waller, C. L., Barnes, D. K. A., and Convey, P. (2006). Ecological contrasts across an Antarctic land-sea interface. *Austral Ecology*, **31**, pp, 656-666.

Other resources that would be able to be used for any of the topics

McMillan, B. (1995). *Summer Ice; life along the Antarctic Peninsula*. Houghton Mifflin Company, Boston.

Fothergill, A. (1993). *Life in the Freezer*. BBC Books, London.

British Antarctic Survey. www.antarctica.ac.uk/Resources/schoolzone/resources/SchoolsPack/12marine_pr.pdf. Retrieved February 13, 2007.

2 – Adaptations

Achievement objectives

Making Sense of the Living World, level four, AO two:

> Students can; i*nvestigate and describe special features of animals and plants which help survival into the next generation.*

By investigating selected plants and animals that live in Antarctica, special features and adaptations of them can be described to show how they survive in such a harsh environment and into the next generation.

Background information

- Adaptation of a species is the ability of organisms to survive in the present environment with the characteristic features they exhibit. Not all species or individuals have the required traits that allow them to survive, while others do. It is the organisms that survive who have the desired traits for survival in the ecosystem. It is these traits that are passed to subsequent generations. The adaptations that a population has are what enable them to survive in conditions and environments that other animals can not.

- All organisms that exist in Antarctica have unique adaptations that enable them to survive in such an extreme environment. There are many examples from Antarctic flora (plants) and fauna (animals) that show how their adaptations enable them to survive and exist in viable populations.

- Plant adaptations –
  Antarctic sea weeds have adapted to surviving in waters with a surface temperature of 0°C. They grow well during the summer months when there is constant light. Many of these seaweeds do not occur in warmer waters of the world (Reid 2005a).

- Mosses, lichen, liverworts, fungi and algae are able to survive in Antarctica. However they grow very slowly due to the cold and lack of fresh flowing water. Most of the fresh water is solid ice throughout the year. There are small areas where in the summer the ice melts and causes melt pools, ponds, lakes and small streams. These micro-organisms are adapted so that when there is liquid water they become active and undertake photosynthesis. In short time spaces (e.g., when the sun is shaded behind clouds) the water may freeze and the micro-organisms have to go into a state of dormancy. They also grow slowly because of the lack of light during the winter. The growing season of these plants is limited. They are able to photosynthesise in low temperatures and sub-optimal conditions. The need for nutrients also influences their distribution. Colonies of seals, penguins and other animal species are ideal environments for these plants, as these areas are often ice free, and there is available water and nutrients. There are only two species of flowering plants in Antarctica. Antarctic hairgrass (*Deschampsia antarctica)* is the most common and is found in small sheltered patches as far south as the Antarctic Peninsula (68°S). It grows well in soil that is created by lichens and mosses, this is an example of ecological interactions. The other species of flowering plant that occurs in Antarctica is found no further south than 60°S on the Antarctic Peninsula. Antarctic Pearlwort (*Colobanthus quitensis*) is less abundant than the previously mentioned species and requires warmer areas with a supply of nutrients, soil and water. Soil is made by colonising mosses and lichens, and nutrients from birds (Trewby 2002).

- Animal adaptations –

  Extremophiles are microscopic organisms that are adapted to harsh extreme environments like Antarctica and others such as volcanoes. There are three classifications of extremophiles based on the environment in which they thrive, methanogens, extreme halophiles and extreme thermophiles (Campbell and Reece 2002). The dominant organisms in Antarctica are bacteria and algae that are adapted to survive in extreme saline conditions (halophiles) and extreme hot environments (thermophiles), like the Mt Erebus crater (Reid 2005b).

- Animals that live in the Southern Ocean grow and move very slowly, this is an adaptation that has enabled them to conserve energy. There is a very slow turn over rate because there is not the urgency to grow large at a fast rate. This is because the organisms exist in an environment with sub-optimal growing conditions such as cold temperatures and lack of nutrients. Many marine dwelling species are larger and live longer than similar organisms in warmer waters. Their reproductive effort is also different with, fewer larger eggs and more energy used to care for them. These adaptations are important to note and understand when we are faced with issues of over harvesting of these ecosystems.

- There are species of fish that inhabit only Antarctic waters due to their adaptations. These fish, such as Patagonian toothfish and ice fish, produce antifreeze which prevents the freezing of their body fluids. Due to the cold water and its capacity to hold high concentrations of oxygen, Antarctic fish have adapted to having low levels of haemoglobin (red blood pigment which carries oxygen in the blood). Some fish species (ice fish) have adapted to having no red pigment which makes their blood and organs transparent. Another adaptation that is seen in fish that exist in the water column is to have no swim bladder as this would freeze, instead they store oil between their skin and muscles as a floatation mechanism (Reid 2005a).

- The Antarctic ecosystem is a niche for numerous species that are found nowhere else in the world. Approximately half of the global squid species live only in Antarctic waters. These organisms are an important component of the ecosystem and the food web of the ocean because many other animals depend on them for nutrition. Antarctic squid have no shells because in cold waters the shells grow too slowly. The world's largest invertebrate is the giant squid, these animals live in the deep ocean and an adaptation they have for this is an eye the size of a volleyball, being the largest animal eye in the world (Reid 2005a).

- Penguins are the most dominant bird in the Antarctic. There are 17 species of penguin in the world and 11 of these live in Antarctica. The adaptations that these birds have to survive the cold are, feathers that overlap in layers which creates insulation, they are able to waterproof their feathers using an oil gland near their tail, and for extra protection from the cold conditions they have a thick layer of fat under their skin. Each penguin species has specific and unique adaptations that enable them to inhabit the environments that they do. For example the Rockhopper penguins are adapted to climb rocks and steep terrain. Some penguins can dive deep to reach food sources that are deep dwelling while others are shallow divers. While most penguins build nests on the ground the Emperor and King penguins place their egg and young on their feet to protect them from the cold. The Emperor penguin has many adaptations with respect to feeding and reproduction that are unique because they live further south than any animal on Earth (Reid 2005a).

- There are many species of seals in the world and these are classified into two groups, true seals and eared seals. Antarctica is where half of the world's seals live. Like the other larger animals that live in Antarctica, seals are adapted to gather food from the marine environment and also mate in the ocean. They are able to dive deeply and swim fast to gather prey due to their special eye characteristics, ability to hold their breath and their body shape. They also are adapted to live on ice where they have their young and moult. It is the thick layers of blubber that enable them to do this. Because they need to breath in between dives they are able to grind the ice with their teeth to create and maintain breathing holes (Reid 2005a).

Possible learning experiences

An interpretation exercise is provided where four Antarctic organisms can be identified with specific adaptations and the benefits of these (Part 3 page 2).

If time allowed a questionnaire could be made from the movie 'March of the Penguins', regarding what adaptations the penguins have to survive the harsh Antarctic environment and aspects of their reproductive cycle.

References and links

Campbell, N. A., Reece, J. B., (eds). (2002). *Biology*. Benjamin Cummings, San Francisco.

Reid, G. (2005a), *Antarctica; Ecosystems*. MacMillan Education, Australia.

Reid, G. (2005b), *Antarctica; The frozen continent*. MacMillan Education, Australia.

Trewby, M. (ed) (2002). *Antarctica, An encyclopaedia from Abbott Ice Shelf to zooplankton*. Bateman, Auckland.

Other links

The DVD / Video of, 'March of the Penguins' would be a valuable resource to illustrate adaptations of Antarctic animals and their reproductive cycle.

3 – Food Web Ecology

Achievement objectives

Making Sense of the Living World, level four, AO four:

> Students can; u*se simple food chains to explain the feeding relationship of familiar animals and plants, and investigate effects of human intervention on these relationships.*

Making Sense of the Living World, level five, AO four:

> Students can; *investigate and understand trophic and nutrient relationships between producers, consumers, and decomposers.*

By using a simplified Southern Ocean ecosystem food web, students can explain the feeding relationships of animals and understand the effects that humans can have on this ecosystem. This concept will be expanded upon in topic 5. They will also be able to identify what trophic levels make up the food web and their importance.

Background information

- Food webs are complicated diagrams that help us to understand the relationships between plants and animals of a selected ecosystem. It is possible to isolate an ecosystem, identify all the organisms, group them according to their way of living and identify which species rely on each other and observe the flow of energy. Essentially food webs are diagrams that identify the feeding links between all plants and animals in an environment. Most organisms gather their food from more than one source and are eaten by more than one predator, this produces a complicated network of pathways and interactions.

- Antarctic terrestrial (land) and marine food webs are much simpler compared to other global food webs. The Southern Ocean ecosystem is more diverse compared to the very simple terrestrial food web. It is also unique on a global scale because the entire food web relies on one species for its existence, this is krill (*Euphausia superba*) (Trewby 2002).

- A community that exists in an ecosystem is dependent on the feeding relationships between all the organisms. This is referred to as the trophic structure of the community, what makes this structure is various trohpic levels. Food energy is transferred from its source through a series of these different levels and this transfer is referred to as the food chain, food chains are linked together into food webs (Campbell and Reece 2002). The different trophic levels from bottom to top are primary producers, primary consumers, secondary and tertiary consumers, to decomposers. Primary producers are plants and other photosynthetic organisms like marine phytoplankton. At the base of the trophic structure by the process of photosynthesis, they produce a food source that the entire food web relies on. Primary consumers are organisms that consume primary producers, in the terrestrial food web these are herbivores and in the marine food web these are zooplankton. Secondary and tertiary consumers (predators) feed on the primary consumers and at various other levels of the trophic structure, more specifically they are referred to as carnivores or omnivores. Carnivores eat meat only and omnivores feed at a range of trophic levels, both plants and meat.

- The Southern Ocean that surrounds Antarctica is a unique marine ecosystem. On a global scale it is considered to be simple and relatively easy to identify all the interactions between the organisms of the community. This environment is rich in oxygen due to the extreme cold and has high nutrient levels, it is for these reasons that there is a high diversity of plants and animals. The production from the phytoplankton (plant-like algae) is the basis of the food web and what supports all of the life in the Southern Ocean. The next trophic level is the primary consumers and in this ecosystem they are the zooplankton. These organisms are krill and are very important to the Southern Ocean food web because larger animals depend on them. The predators of the ocean are, seabirds, fish, seals, penguins, squid and baleen whales. These all eat krill and each other. The top predators of the food web are the toothed sperm and killer whales (Reid 2005).

- Humans are not apart of the naturally occurring Southern Ocean ecosystem but they have made a presence and are affecting the natural balance of species abundance. This has many flow-on effects throughout the food web. This is elaborated upon in topic five.

Possible learning experiences

Provided in part three (starting at page 4) of this resource are three activities, one is a food web diagram with blank spaces which are to be completed using the cut out pictures of the animals. The second is an interpretation exercise relating to trophic levels. The third is a word-find to be used to allow the students to think about terminology relating to the topic.

References and links

Campbell, N. A., Reece, J. B., (eds). (2002). *Biology*. Benjamin Cummings, San Francisco.

Reid, G. (2005), *Antarctica; Ecosystems*. MacMillan Education, Australia.

Trewby, M. (ed) (2002). Antarctica, An encyclopaedia from Abbott Ice Shelf to zooplankton. Bateman, Auckland.

Other links

British Antarctic Survey. www.discoveringantarctica.org.uk/teachers_4.php. Retrieved February 12, 2007.

4 – Photosynthesis

Achievement objectives

Making Sense of the Living World, level five, AO two:

> Students can; *investigate and describe structural, physiological, and behavioural adaptations which ensure the survival of animals and flowering plants in their environment, e.g., photosynthesis.*

Antarctica is a unique environment where processes such as photosynthesis become interesting when compared to the same process in temperate environments. Students can learn about adaptations of some Antarctic plants that enable them to photosynthesise for their survival and also so that the animals depending on the food source survive.

Background information

- Photosynthesis is the basis of life, a natural process where organisms sustain themselves without eating other organic matter. They are able to produce organic molecules from inorganic raw materials obtained from the environment (Campbell and Reece 2002). The organic molecules that they produce are the vital sources of organic matter for all other organisms of the food web. Organisms at trophic levels higher than the primary producers are unable to produce their own food and they rely on the organic material produced by the photosynthesising plants. Plants are the most common organisms that do this and these are both from the marine and terrestrial ecosystems.

- The organic matter that is produced by photosynthesis is what creates and sustains a food web. Photosynthesising organisms are eaten by the primary consumers and the matter is transferred to a higher level in the food chain. This matter is transformed and taken to the next level by the secondary consumers, and so on. All life depends on the production of the primary producers of an ecosystem and the process of photosynthesis.

- The process of photosynthesis is complex but can be simplified by concentrating on the inputs and outputs. The green colour of plants is due to the green pigment of chlorophyll which is found in the chloroplast. The chloroplast is a structure located within a cell and is the site of photosynthesis. The leaves of plants are where most photosynthesis takes place. Light energy that is absorbed by the chlorophyll, drives the synthesis of organic compounds and oxygen from inputs of carbon dioxide and water (Campbell and Reece 2002). A simplified explanation of photosynthesis is where plants require carbon dioxide, water and minerals from the environment, and light as an energy source to allow the reaction to work and synthesise the organic carbons, with oxygen as a by-product.

- Typical photosynthesising organisms in the Antarctic terrestrial and marine ecosystems are not as large as those in temperate environments like New Zealand. On the land the plants are small and sometimes only visible under microscope or in large colonies. Mosses, lichens and algae are the dominant terrestrial biomass. In the ocean phytoplankton are the primary producers, these are small simple plant like organisms. The majority (99 percent) of the Antarctic phytoplankton is made up of diatoms, which are microscopic single celled algae. Diatoms have silica cell walls for strength and each species has a detailed design on the shells. There are no trees or plants like we have in New Zealand, this is because of the harsh Antarctic conditions and only certain species are adapted to survive the extreme conditions.

- Photosynthesis is possible in the Antarctic because the essential conditions do exist but they occur at different time scales compared to temperate environments like New Zealand. The low temperatures of the marine environment mean that more carbon dioxide and oxygen is dissolved in the water which is available for photosynthesis. During spring and summer there is constant up-welling of water from the deep ocean that is rich in nutrients. The sun is constantly in the sky during summer months so continuous photosynthesis is possible. Photosynthetic organisms in Antarctica are adapted to seasonal production. Productivity is at its lowest during winter and in October

levels increase rapidly as the conditions improve for photosynthesis. From February to April levels decrease again.

In the terrestrial ecosystem carbon dioxide is sourced from the atmosphere where it is in smaller amounts compared to the marine environment. The abundance of plant life is determined by the availability of the essential conditions. Nutrients are sourced from the rocks or trace elements from the air, the most abundant areas are penguin colonies. Photosynthesis can only occur during the summer months when there is constant light availability and when there is warming to melt ice and snow for liquid water availability. Depending on the environment liquid water is not always constantly available, for example small streams and ponds can freeze and thaw daily. The organisms that occupy these habitats are adapted to withstand the sporadic optimal conditions that enable them to photosynthesise. They are able to effectively shut down and restart within a short time frame to make use of the ideal conditions. It is these conditions that have influenced what primary producing organisms can live in Antarctica, and why they are small and slow growing. The growing season is shortened by the availability of light and liquid water.

- A physiological adaptation that Antarctic plants have is the ability to shut down, remain dormant and when the conditions are optimal, begin to function again. This is because at short time scales conditions can become unfavourable for example, when the sun is covered by cloud a small stream of melt water can freeze. Also for substantial lengths of time, such as over winter, plants remain dormant because there is no sunlight. Structural adaptations of plants are that they are small low stature plants that can grow in small places to optimise heat and be sheltered from wind. Also some species grow in colonies to maximise chlorophyll capacity and surface area.

Possible learning experiences

In part three (page 10) a schematic diagram can be completed illustrating the inputs and outputs of photosynthesis.

A compare and contrast template is provided in Part 3. Carry out investigations regarding the conditions that are required for photosynthesis, how the Antarctic environment differs from temperate environments like New Zealand and how plants still survive in Antarctic conditions.

References and links

Campbell, N. A., Reece, J. B., (eds). (2002). *Biology*. Benjamin Cummings, San Francisco.

Trewby, M. (ed) (2002). *Antarctica, An encyclopaedia from Abbott Ice Shelf to zooplankton*. Bateman, Auckland.

5 – Human Footprint

Achievement objectives

Making Sense of the Living World, level four, AO four:

> Students can; *use simple food chains to explain the feeding relationship of familiar animals and plants, and* ***investigate effects of human intervention on these relationships.***

This topic looks at the second part of this AO, and draws on previous knowledge gained in topic three (Food Web Ecology). By investigating the food web of the Southern Ocean the effects that humans are having on the ecological relationships can be examined.

Background information

- Recall the information from food web ecology (topic three) and how ecosystems function by interactions between different organisms and non-living conditions. Also the trophic structure that creates food chains and how higher ordered organisms rely on the organisms at a lower trophic level.
- The Southern Ocean is understood to be a highly productive ecosystem of the world. As exploitation continues in the world's oceans, fisheries are being directed towards the resources of the Southern Ocean.
- Seal and whale hunters were among the first humans to discover and explore the Southern Ocean and the Antarctic region. Many seal species were hunted to near extinction as these sailing vessels exploited seal colonies for their blubber, oil and thick fur (Reid 2005a). The seals were not aware of the danger that these boats and humans would have on them and were easily hunted. Whales were hunted for their blubber. There have been legal measures put in place to conserve and preserve the seals and whales of the Southern Ocean (Reid 2005b). Different species of seal interact at various levels of the trophic structure, they do not all feed on the same organism. With many species being hunted to extinction there was an increase of some species that the seals fed on and a decease in others that relied on the seals.

- Over fishing is another issue that faces the stability of the Southern Ocean food web. Some species are being hunted illegally and others are being over harvested. This causes instability in the food web because higher order species that rely on a food source that is being unnaturally depleted by humans, will also be threatened.

- Krill is the best example that shows the effects humans are having on the ecological relationships within a food web. Krill is depended upon either directly or indirectly by most of the animals of the Southern Ocean. Humans harvest krill for a number of reasons and over harvesting will cause problems in the food web because so many species rely on krill for their survival. If there is a limited amount of krill then there will be a food shortage in the ocean.

- Antarctic fish have special adaptations that allow them to survive in the Southern Ocean. Most fish in the Southern Ocean are small and slow growing and are of no interest to the fishing industry. But not all Antarctic fish are small there are some species that are slow growing and reach very large sizes, for example the Patagonian toothfish. The fishing industry targets one or two species of fish and threatens the populations by over harvesting. What intensifies the issue is the species that are a targeted fishery, are those that are adapted to Antarctic conditions and have life histories that are not compatible with the high demand and capability of fishing. These species grow slowly, have slow reproductive cycles and are therefore vulnerable to the process of fishing which is fast and irreversible.

- Another important species of the ocean ecosystems is squid. Although squid grow rapidly in the Southern Ocean a number of other animals rely on them for a food source. Humans also fish for squid and this needs to be managed so that the balance of the food web is not adversely affected (Reid 2005a).

- Seabirds are apart of the ocean food web and are also affected by humans. They are affected through over-exploitation of food resources such as fish and squid and are directly affected by fishing. Species of Albatross are endangered because in the past they have been caught in large numbers as bi-catch to long-line fishing (Reid 2005a). The practice of fishing and the technology has improved as it has become a well known fact that fishing was having huge effects to the populations of these species. Guidelines and laws have been put in place to minimise the direct effects that fishing was having on these species.

- Fishing is the main activity in the Southern Ocean that is having an impact on the relationships between the species of the food web. This is occurring by over harvesting and causing an imbalance in the food web where there is a lower amount of prey for the predator.

- Ecological sustainability is the ability of an ecosystem to remain in balance at present and into the future (Reid 2005b). The impacts that humans are having in this environment has caused issues for the ecological sustainability of the Antarctic region. This is important to understand so that human behaviour can be managed in order to protect Antarctic wilderness.

Possible learning experiences

A written interpretation exercise of food webs is provided in part three (page 14) where students answer questions relating to possible changes in the food web diagram.

References and links

Reid, G. (2005a), *Antarctica; Ecosystems*. MacMillan Education, Australia.

Reid, G. (2005b), *Antarctica; Exploration*. MacMillan Education, Australia.

6 – Conservation

Achievement objectives

Making Sense of Planet Earth and Beyond, all levels, Achievement Aim four:

> Students will be able to; *investigate how people's decisions change planet Earth's physical environment, and develop a responsibility for the guardianship of planet Earth and its resources.*

Making Sense of Planet Earth and Beyond, Level five, AO four

> Students can; *research a national environmental issue and explain the need for responsible and co-operative guardianship of New Zealand's environment.*

An understanding of how the Antarctic environment is connected to and influenced by the globe will allow students to understand how our impact on the New Zealand environment influences the Antarctic. Global warming is a good research example into a global environmental issue that has an impact on Antarctica and also on New Zealand.

Background information

- Antarctica is a unique continent in many ways, one of these is that it is not inhabited by an indigenous population. Antarctica is an environment that is largely unexplored and untouched by humans. It is for this reason that it remains a pristine environment and can be used to gauge human impacts both directly and indirectly. Humans have the chance to reassess their attitudes to the environment by investigating the impacts that our actions have on unspoiled environments such as Antarctica (Trewby 2002). Conservation issues in the Antarctic have a high profile in the international community and issues are constantly under debate and negotiation. Because Antarctica does not have an indigenous population the country is governed by international law through the Antarctic Treaty System. The Treaty has been signed by a number of nations who agree to conserve the Antarctic environment through co-operation and other agreements under the Treaty System. Some of these are, Agreed Measures for the Conservation of Fauna and Flora (1964); Convention for the Conservation of Antarctic Seals (1972); Convention for the Conservation of

Antarctic Marine Living Resources (1982), and the Protocol on Environmental Protection (1991) (Reid 2005a, 2005c).

- Humans have direct influences on the Antarctic environment by their presence alone as well as the associated needs and requirements for this to occur. Logistical support has a major influence on the environment, areas for aircraft need to be created and maintained, vehicle transport require well maintained roads, and the establishment of bases. It is inevitable that where ever humans are there are going to be impacts to the environment. In a pristine environment such as Antarctica humans are foreign to the environment and everything associated with our presence is foreign. The Treaty and agreed measures aim to minimise our impact and conserve the environment. Humans are also having an indirect influence on the Antarctic environment. The global ecosystem is connected in a number of ways, through global commons such as the atmosphere and the ocean. It is well understood that the globe influences the Antarctic and Antarctica has influences on the globe. Natural and human induced global warming is having an effect globally and a feedback from this is that the melting of ice landscapes is having a global effect by the increase in sea level.

- Global warming is a large and complex issue. Natural warming is occurring but this has been enhanced by human activities. The main cause of warming has come from the increase in carbon dioxide levels in the atmosphere, caused by the burning of fossil fuels (coal, oil and natural gas) (Reid 2005b). Carbon dioxide is a naturally occurring greenhouse gas which is found in the atmosphere to trap some of the radiation from the sun in order to make the Earth inhabitable. However an increase in the concentrations of this gas has meant that too much radiation is being trapped and the temperatures are increasing. It must be noted that the effects are not only an increase in temperature but others such as increased extremes of weather. Different environments are being affected and reacting in different ways. There are many issues that face the Antarctic ecosystem with respect to increasing temperatures. A warmer atmosphere has the ability to hold more moisture so there is a possibility that

there could be an increase in precipitation in some areas of the continent. Animals will be affected as their food webs are altered and may change distributions depending on the abiotic conditions. The biggest global influence would be the melting of Antarctic ice and the increase in global sea level. Ice that is grounded on the land will have an impact on sea level, but the ice that is floating on the ocean will not cause sea level to rise as it is already displacing the water. There have been international initiatives formed with the aim of controlling the amount of carbon emissions that the globe produces (Kyoto Protocol).

- There are a number of conservation issues that are currently effecting the Antarctic environment. Over fishing and illegal fishing; scientific bases and research; tourism; introduced species; mining; bio prospecting; global warming and the ozone 'hole' (Ried 2005a). All of these issues are being addressed under the Treaty system. Some of the issues have reached a point where solutions have been made to conserve the environment and reduce the human impact.

- The Antarctic Treaty system was a result of the International Geophysical Year (1957-1958). It was during this time that global scientific co-operation was experienced and this co-operation effort continues today as the nations of the treaty system recognised its need in the Antarctic environment (Reid 2005a). Recently there has been international co-operation to protect Antarctica's unique ecosystems. Cape Hallett station was an abandoned research station that was built and used jointly by the New Zealand and United States Antarctic Programs. The effects that establishing this base has had on the ecosystem was made evident in an Environmental Site Assessment. This led to the development of a strategy to remediate the effects and essentially clean up the area in an effort to return it to its original state (Waterhouse 2001). The Cape Hallett clean up operation was accomplished through the co-operation and aid of a number of nations as they all supplied a different resource for the resource pool.

- The isolation of Antarctica does not mean that it is isolated from the globe and distant human influences. Our attitudes which influence the way we live and act, do have an impact on the global system through our individual footprint. We can choose to live in a more sustainable manner in New Zealand to reduce our ecological footprint and impact that we have on the natural system of the Earth. Reducing our waste is an important concept as well as reducing our consumption of commodities. Choosing what we eat and where it has been sourced from is also influential, for example it is more beneficial to eat fruit or vegetables that have been produced locally as opposed to internationally.

Possible learning experiences

A template for a written report research assignment is provided in Part 3 (page 15), students have the opportunity to undertake research relating to conservation in Antarctica and how we can make a difference in New Zealand. It will be important to relate the research to the students environs.

References and links

Reid, G. (2005a). *Antarctica; Ecosystems*. MacMillan Education, Australia.

Reid, G. (2005b). *Antarctica; The frozen continent*. MacMillan Education, Australia.

Reid, G. (2005c). *Antarctica; Human impacts*. MacMillan Education, Australia.

Trewby, M. (ed) (2002). *Antarctica, An encyclopaedia from Abbott Ice Shelf to zooplankton*. Bateman, Auckland.

Waterhouse, E. (ed) (2001). *A state of the environmental report for the Ross Sea region of Antarctica*, Christchurch, New Zealand Antarctic Institute.

Other links

Antarctic Treaty Consultative meeting 2006. Retrieved February 13, 2007 from http://www.southpolestation.com/news/atcm29_ip115_e.pdf
Information paper 115. *Clean up of abandoned Cape Hallett station*.

Gordon, S. Retrieved February 12, 2007 from http://www.lgp.aq/downloads/MayHallettReview.pdf *Site description and literature review of Cape Hallett and surrounding areas*. Antarctica New Zealand

Part Three

Teaching Resource Practical Manual

Science Teaching Resource Kit

GCAS Personal Project

Renee Baldwin

GCAS IX 2006-2007

Adaptations

Interpretation exercise

Identify the organisms in the pictures, identify adaptations that they have for survival in Antarctica and explain why they are of benefit to the organism.

Weddell Seal

Adaptations:

What are the benefits?

Antarctic Ice Fish

Adaptations:

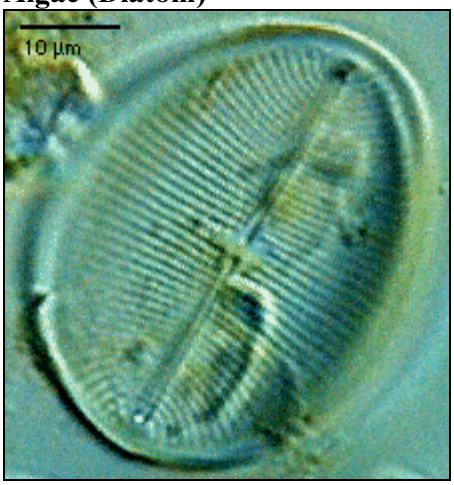
What are the benefits?

Emperor Penguin

Adaptations:

What are the benefits?

Algae (Diatom)



Adaptations:

What are the benefits?

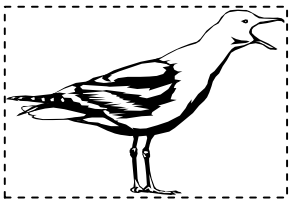
Food Web Ecology

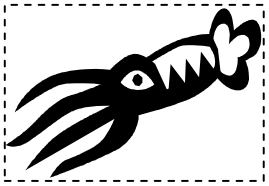
There are **three activities** for this topic.

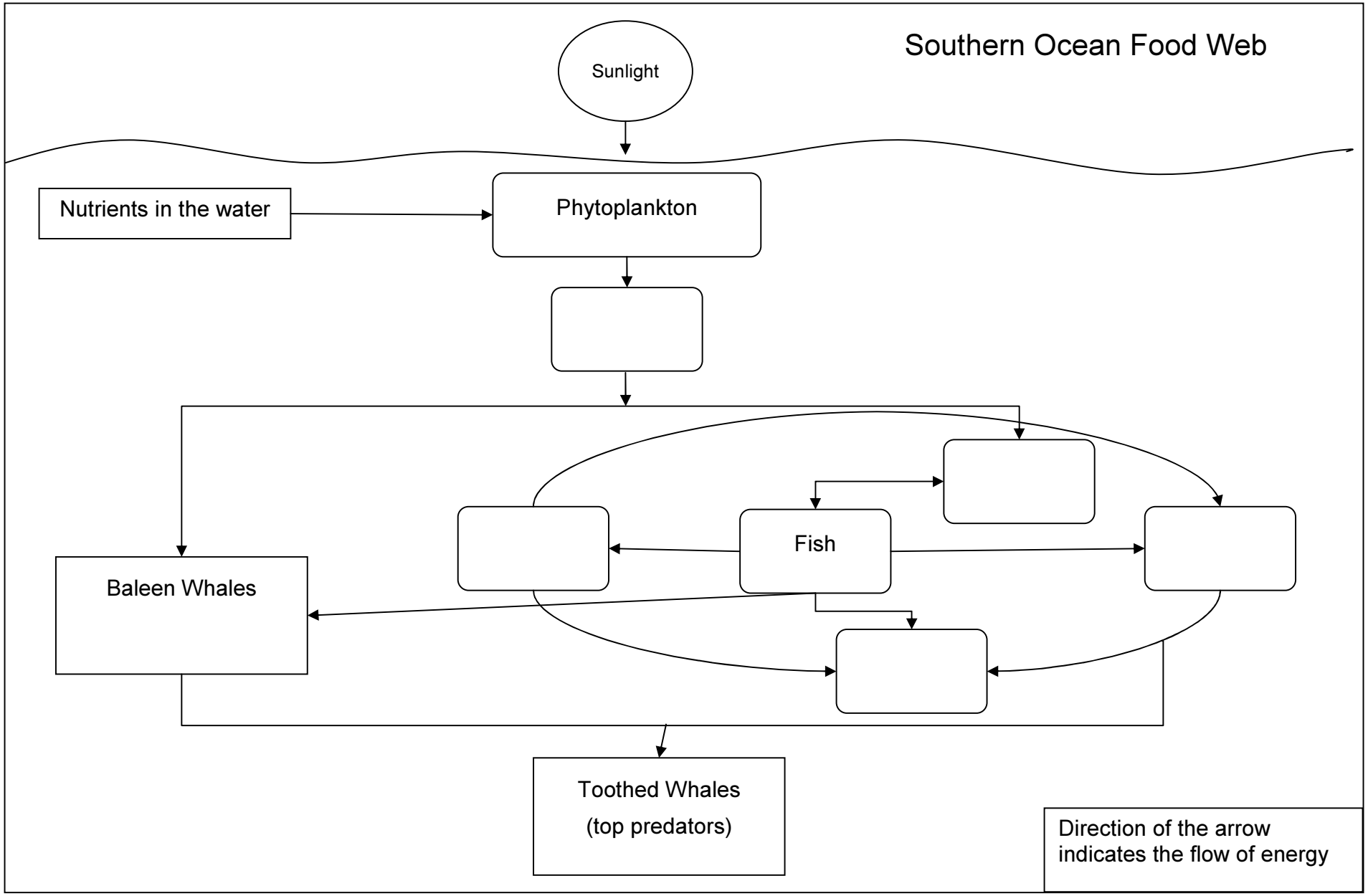
The **first** is a food web diagram, this activity requires the student to determine where in the food web selected animals occur by illustrating the relationships between species and how they depend on each other for food. A simplified flow diagram of the Southern Ocean food web is supplied with blank boxes, this is to be copied for the student along with the picture illustrations below. They are to cut out the five animals and use them to determine where on the food web they occur. The arrows indicate the flow of the energy or food source. The second diagram is a copy of the correct placement of the animals. The animals are, from top to bottom, left to right: Seabird, squid, seal, penguin, krill.

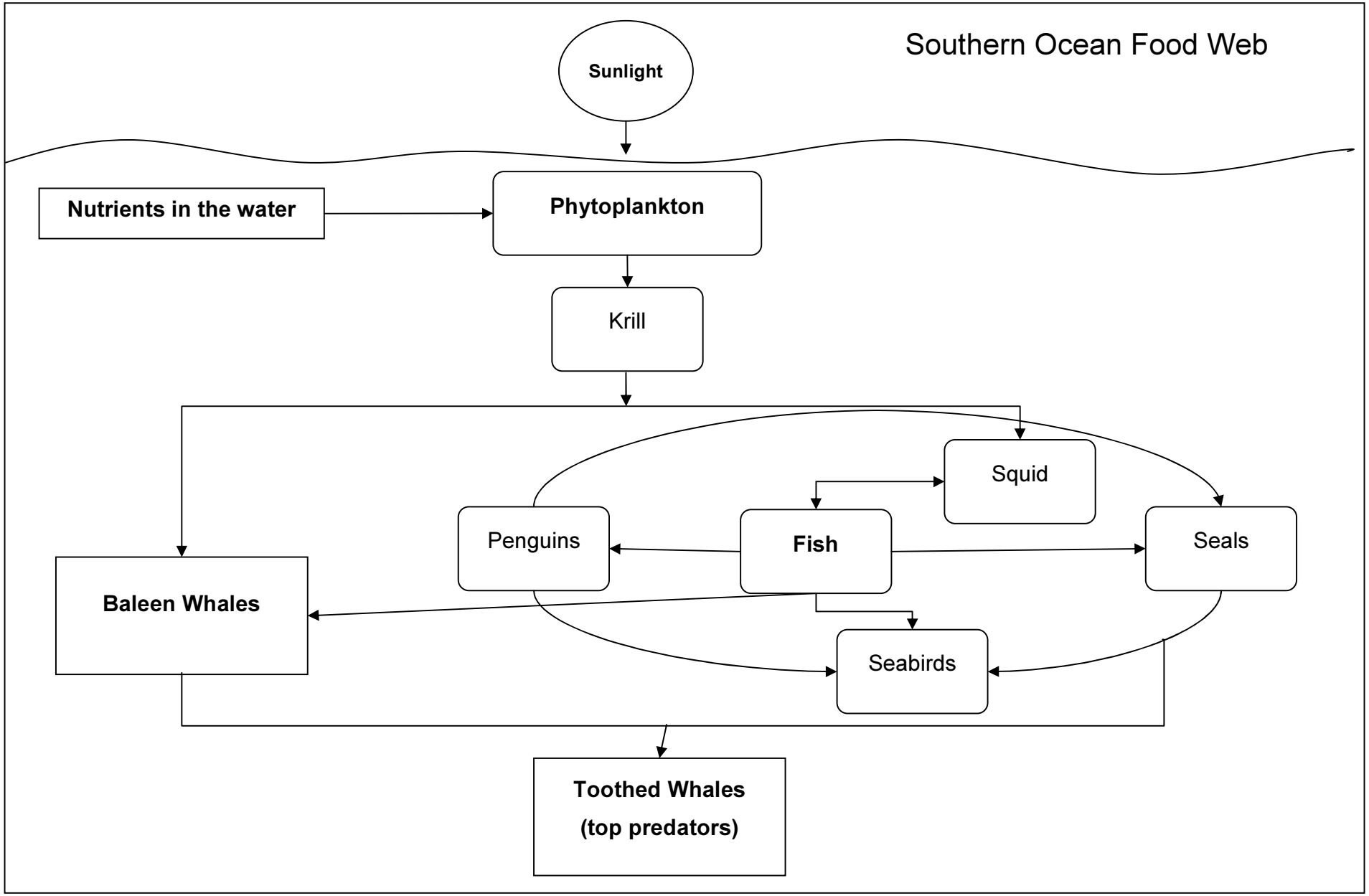
The **second** exercise is related to trophic levels and structure of an ecosystem.

The **third** activity is a word find, the first is a copy for the student and the second is the solution.



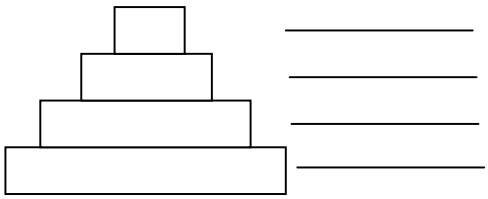



Southern Ocean Food Web
Sunlight
Nutrients in the water
Phytoplankton
Fish
Baleen Whales
Toothed Whales
(top predators)
Direction of the arrow indicates the flow of energy


Southern Ocean Food Web
Sunlight
Nutrients in the water
Phytoplankton
Krill
Squid
Penguins
Fish
Seals
Baleen Whales
Seabirds
Toothed Whales
(top predators)

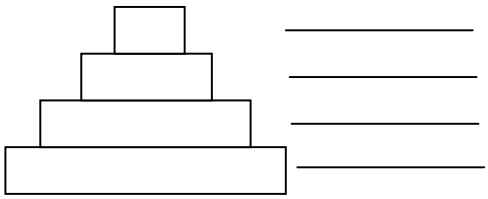
Trophic levels

Label each trohpic level on the pyramid with the appropriate label from the word list.



Tertiary consumer
Primary producer
Secondary consumer
Primary consumer

Label each trohpic level on the pyramid with the appropriate label from the word list.



Krill
Toothed whale
Marine Phytoplankton
Seal

Antarctic Food Webs

S Q K L I S S X O I L Z S T Y S Z G E M
R J R N L T E A P J Q P J E X W F C N A
E F I S H I Z A H C I U Q R Z L O E S R
M J W U T G R E L H F U Z R C S K L L I
U M J P J L N K S F B U W E Y C G A A N
S O U T H E R N O C E A N S Z I D H A E
N M Y J R Y O I D T S N T T U S C W X D
O L T G N I T I Y P Y E H R U O L S X C
C H Y P T O U O O Z M S V I H M N B I Z
J B X A I Q X U P S P U P A S X A H L Z
X Y L H S W I P S L P E D L A K P V Z I
D E A I A C I T C R A T N A Q O H J B K
R N L A N I M A L S E N S G R Z L A K D
Q S T N A L P W Y N W C K T U E E O S V
S N G F U U B C K N O W U T Q I K K A K
V K U H B J C R Y P X E U D O C N M H G
R F E V R M X H K Y V T P Z O N F M E H
C I I B N J R W T R V L E J E R D X A Y
Z D D I L B B E L B H A R P M Q P S W P
M Q V W Q P A I L T B Z P K D X G H A Y

ANIMALS
ANTARCTICA
CONSUMERS
ECOSYSTEMS
ENERGY
FISH
KRILL
MARINE
PENGUIN
PHYTOPLANKTON
PLANTS
PRODUCERS
RELATIONSHIPS
SEAL
SOUTHERNOCEAN
SQUID
TERRESTRIAL
TROPHIC
WHALE

Antarctic Food Webs <u>Solution</u>

```
S + + L + S + + + + + + S T + + + + E M
R + + + L + E + + + + P + E + + + C + A
E F I S H I + A + + I + + R + + O E + R
M + + + + + R E L H + + + R + S + L + I
U + + P + + N K S + + + + E Y + + A + N
S O U T H E R N O C E A N S + + + H + E
N + + + R Y O + D + + + T T + + + W + +
O + + G + I T I + + + E + R + + + + + C
C + Y + T + U O + + M + + I + + + + I +
+ + + A + Q + + P S P + + A + + + H + +
+ + L + S + + + S L + E + L + + P + + +
+ E + + A C I T C R A T N A + O + + + +
R + + A N I M A L S E N + G R + + + + +
+ S T N A L P + + + + C K T U + + + + +
+ + + + + + + + + + + + U T + I + + + +
+ + + + + + + + + + + + + D O + N + + +
+ + + + + + + + + + + + + + O N + + + +
+ + + + + + + + + + + + + + + R + + + +
+ + + + + + + + + + + + + + + + P + + +
+ + + + + + + + + + + + + + + + + + + +
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(Over, Down, Direction)
ANIMALS(4,13,E)
ANTARCTICA(14,12,W)
CONSUMERS(1,9,N)
ECOSYSTEMS(19,1,SW)
ENERGY(8,4,SW)
FISH(2,3,E)
KRILL(8,5,NW)
MARINE(20,1,S)
PENGUIN(11,10,SE)
PHYTOPLANKTON(4,5,SE)
PLANTS(7,14,W)
PRODUCERS(17,19,NW)
RELATIONSHIPS(1,13,NE)
SEAL(6,1,SE)
SOUTHERNOCEAN(1,6,E)
SQUID(5,11,NE)
TERRESTRIAL(14,1,S)
TROPHIC(14,14,NE)
WHALE(18,7,N)

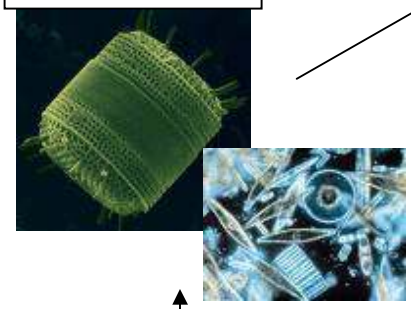
Photosynthesis

The following diagram (p11) can be copied for students to fill in the boxes from the provided word list in the corner of the diagram. The arrows indicate inputs and outputs of photosynthesis. The second diagram provides the solution to the activity.

Photosynthesis is occurring in the centre of the diagram where the primary producers (diatoms) are. The inputs and outputs are directional to the primary producers.

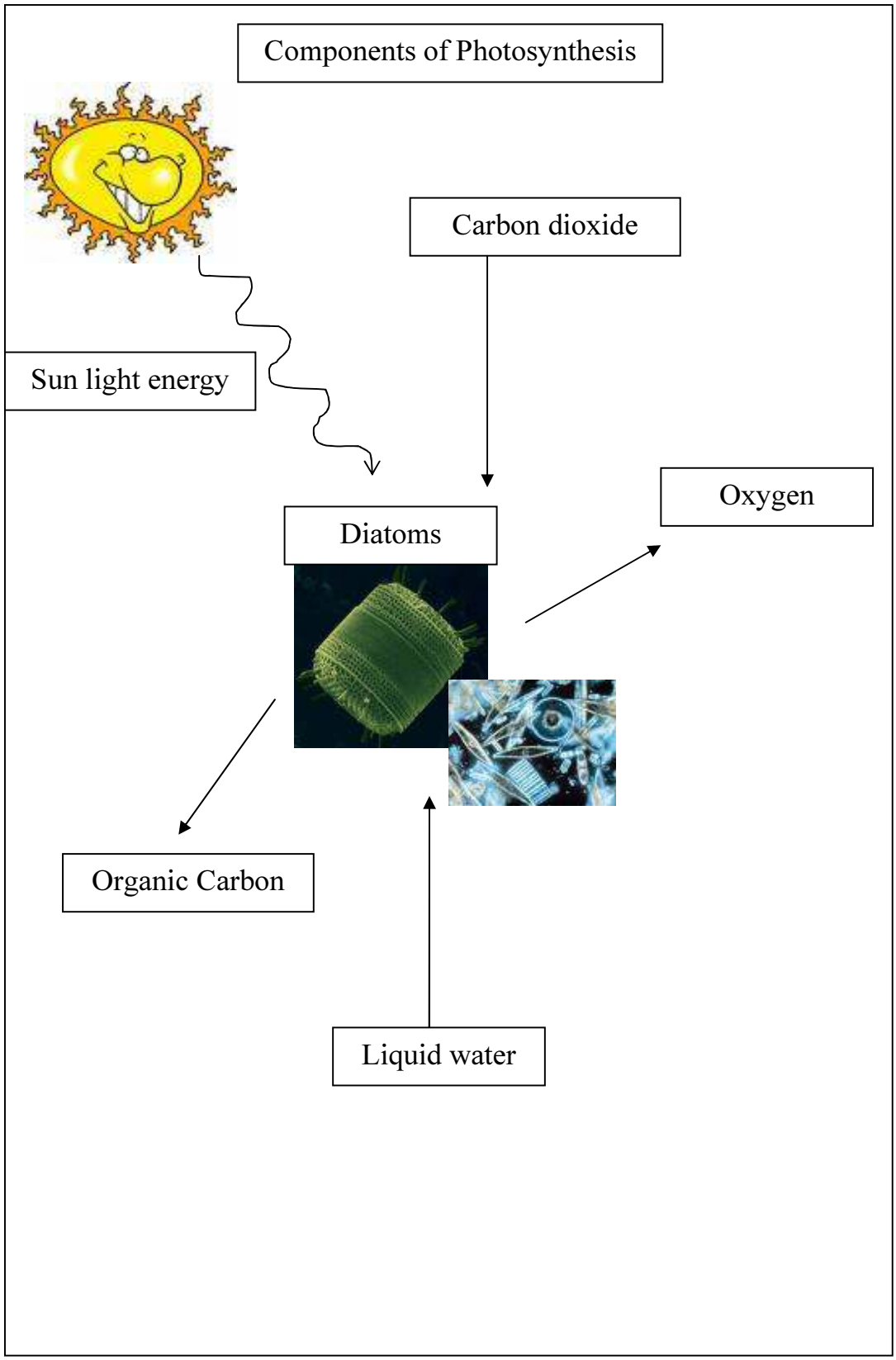
A **second** activity is a compare and contrast exercise. They are to fill in the boxes by comparing and contrasting conditions in New Zealand and Antarctica and the effects this has on the natural process of photosynthesis.

Components of Photosynthesis



Word List

Diatoms
Sun light energy
Liquid water
Carbon dioxide
Organic carbon
Oxygen


Components of Photosynthesis
Carbon dioxide
Sun light energy
Oxygen
Diatoms
Organic Carbon
Liquid water

Compare and Contrast
Photosynthesis

New Zealand Environment	Antarctic Environment

How is the process alike?

How is it with regard to:

	Plant type	
	Plant structure	
	Growing season	

Patterns of significant similarities and differences

Conclusion or interpretation

Human footprint

This is an exercise that requires interpretation of the questions with regard to the food web. By using the diagram answer the questions relating to human influences in this ecosystem.

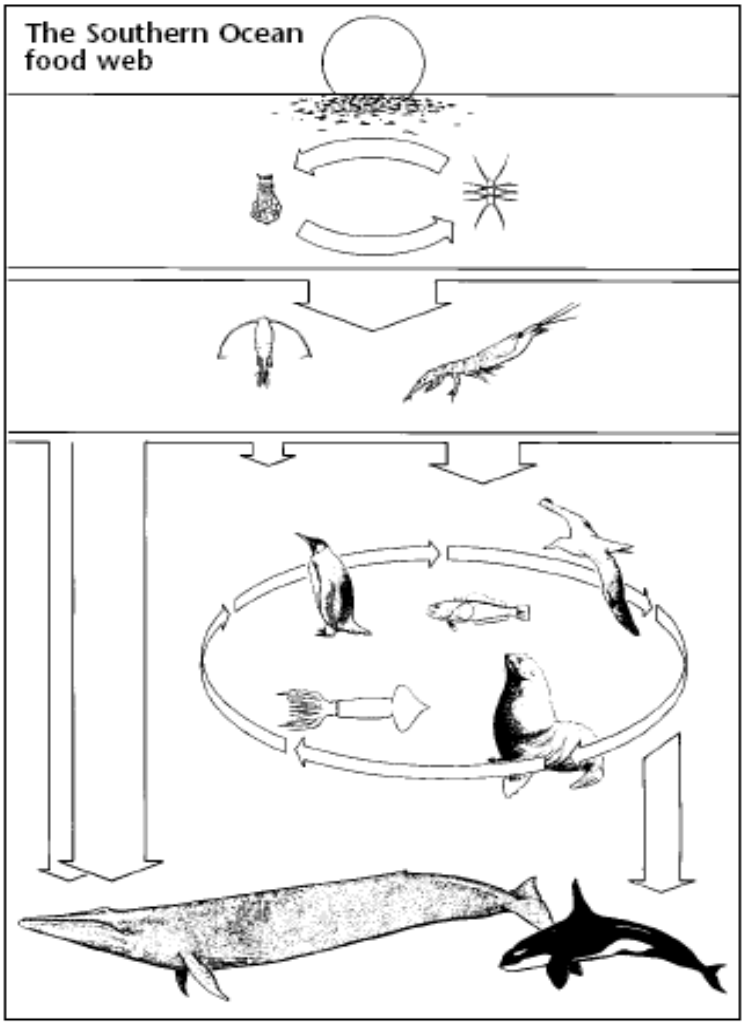


Diagram sourced from:
www.antarctica.ac.uk/Resources/schoolzone/resources/SchoolsPack/12marine_pr.pdf

Questions:

In what ways do humans influence the balance of the Southern Ocean food web?

If the quantity of zooplankton (primary consumers) declined what would be the flow-on effects to the rest of the food web?

If the abundance of seals increases rapidly what would be the potential cause and what are the likely effects. Hint: for the cause think of global conservation efforts and legal agreements as well as natural causes.

Conservation

For a longer term research assignment and for practice in writing for higher levels this would be an effective research assignment. This is able to be modified to suit the appropriate level of students and teaching situation.

Antarctic Conservation Assignment

Introduction – Antarctica is a unique continent and a region on Earth that is still found in pristine condition. The Antarctic Polar environment is very different to what we experience in New Zealand. There is no indigenous population, however humans are having an impact on the environment through activities such as, scientific research, tourism and fishing. Because Antarctica is one of the only remaining wilderness areas on the planet conservation is an important priority. As a society we must manage our behaviour so that our impacts on the globe are minimised.

In this assignment you will be asked to research some information relating to conservation in the Antarctic. You may choose from a selection of topics:

- **Outline human impacts in Antarctica**
- **Global warming effects on Antarctica, what we can do in New Zealand to reduce the impact we have on the globe**
- **What is the current status of conservation in Antarctica**

This assignment is to be an individual written report between 800 and 1000 words. You may use diagrams, tables or graphs to illustrate what you have presented or to add information.

To find information use a variety of resources such as books, newspapers and internet. You must show that you have used at least three different resources by recording them in a bibliography on a separate piece of paper.

Your report should have the following structure:

Introduction – This is to introduce the topic and what information you will be presenting.

Main body – Separate paragraphs relating to the main points or ideas that you have found in your research, each idea should have a new paragraph.

Conclusion – A summary of the report and what the main findings are, you may include you own opinion but do not include new material.

YOUR REPORT IS DUE: _____