Food webs and the Micro-Marine World

Teachers

This unit of work has been designed to support your class visit for the 'Food Webs and the Micro-Marine World' programme at the National Aquarium of New Zealand. Students will participate in a range of interactive activities.

The primary focus of this programme is the Living World Strand of the Science Curriculum, however when planning your unit of work links can be made to other essential learning areas. Similarly, different essential skills can be emphasised depending on the needs of your students.

It is recommended that these materials be reproduced in their entirety for each of your students. It is hoped that students will be able to use this resource for preparatory work prior to their visit to the National Aquarium, as a workbook during their visit and as reference material after their visit.

Programme Overview

Why should you learn about food webs and marine micro-organisms at the aquarium?

Food webs are central to the understanding of how ecosystems function. The marine environment is a very important part of New Zealanders lifestyles, be it recreation and or a food resource. At the aquarium, students are able to see first hand, examples of food webs and develop an appreciation of the interactions between marine organisms (macro or microscopic) and how human impacts can affect the marine ecosystem.

Essential Learning Area: Science

Strand: Living World

Achievement Aim 4: investigate local ecosystems and understand the interdependence of living organisms, including humans, and their relationship with their physical environment.

Level	Essential Learning Area	Strand	Achievement Aim	Achievement Objective
4	Science	Living World	Interdependence of Living Things	Use simple food chains to explain the feeding relationships of familiar animals and plants, and investigate the effects of human intervention on these relationships.
5	Science	Living World	Interdependence of Living Things	Investigate and understand trophic and nutrient relationships between producers, consumers, and decomposers.
6	Science	Living World	Interdependence of Living Things	Investigate a New Zealand example of how people apply biological principals to plant and animal management.
7	Science	Living World	Interdependence of Living Things	Research and develop a defensible position, about a selected issue affecting the New Zealand environment.

Scientific Skills and Attitudes

- Focusing and Planning
- Information Gathering
- Processing and Interpreting
- Reporting

The 'Food Webs and the Micro-Marine World' programme at the National Aquarium of New Zealand lays the foundations for developing the above investigative skills and attitudes.

Specific Learning Outcomes

- To understand and describe the different trophic levels and how energy moves through each level

- To be able to identify some morphological features of primary producers, herbivores and carnivores

- To realise the importance of humans within the food web and how we can have negative and positive impacts on the marine environment

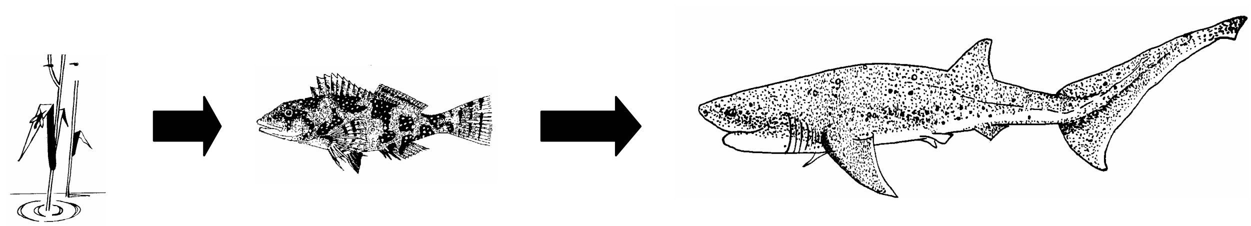
Food webs

What is a food web?

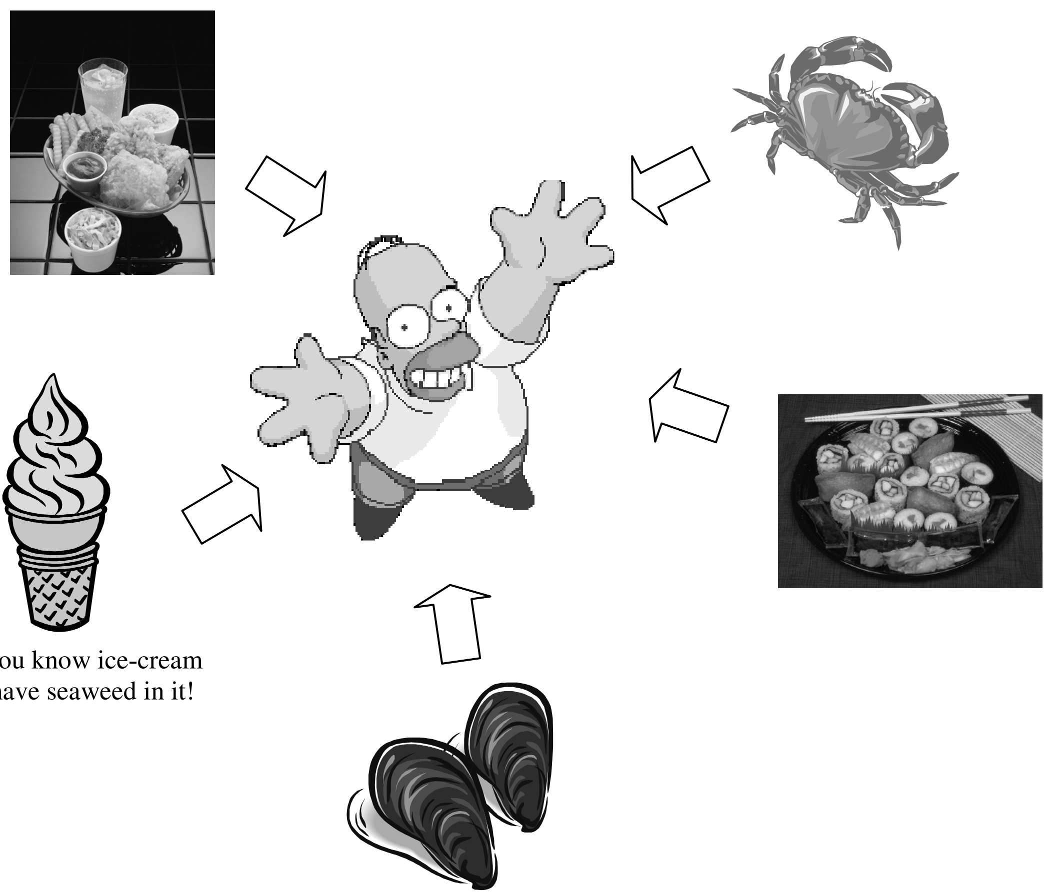
Food webs are the diagrammatic way of expressing how energy flows through different organisms within an ecosystem. Simple food chains (see the Homer Simpson example!) have often been used to explain how food (energy) is passed from one animal to another animal.

Simple food chains

Example 1:

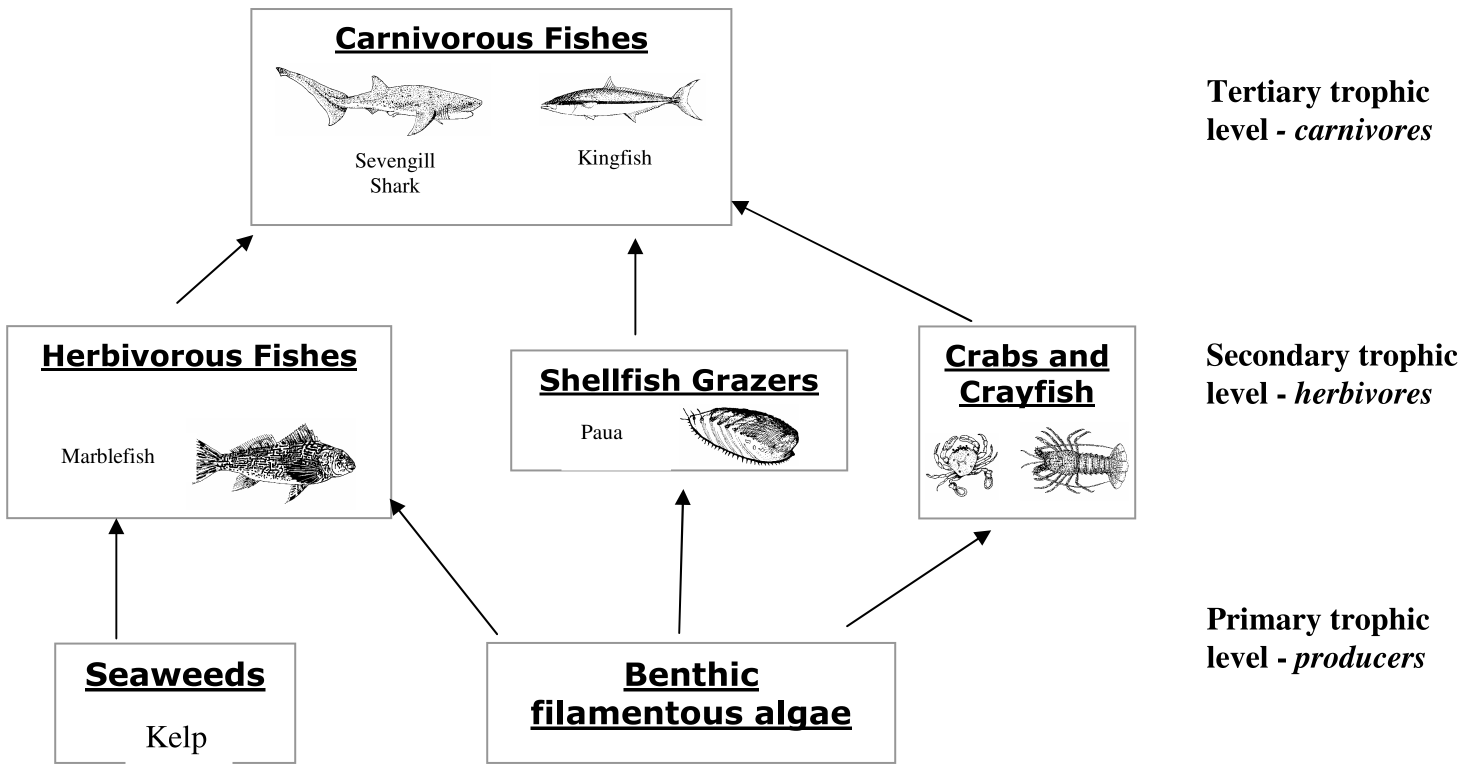


Example 2:



However food chains do not tell the whole story! Within an ecosystem, food chains are much more complex! For example, a fish can have many different interactions with other organisms within the marine environment and that fish may be a food source for many other marine organisms. Complex food chains are described as food webs.

Food webs: Oceanarium Food Web



Sections of the food web can be divided into different **trophic levels**. That is, the organisms within the food web can be separated into different groups according to what they produce or consume. The main trophic levels are primary producers, herbivores and carnivores:

Primary producers

Primary producers (e.g. algae, phytoplankton) are an **essential** part of food webs and without primary producers, consumers and predators wouldn't exist! Primary producers capture energy from the sun and convert it into an energy source that can be used by both themselves and other organisms. This process is termed **photosynthesis**.

A simple equation explains the process of photosynthesis:

$$6CO_2 + 6H_2O + \text{SOLAR ENERGY} \rightarrow C_6H_{12}O_6 + 6O_2$$

What is the energy source that primary producers produce for themselves and indirectly for consumers?

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During the night there is no sunlight and thus no energy to help convert carbon dioxide and water to glucose and oxygen. However at night plants still need to be able to produce energy to live. What is the major energy making process that occurs during the night and what is the main by-product produced.

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What primary producers live in the aquatic environment??

The green pigment within primary producers that helps capture energy from the sun and converts it into another energy source (i.e. *glucose*) is called **chlorophyll** and it is contained in very small organelles called **chloroplasts**.

Look down the microscope -
How many chloroplasts are within one cell of Eloderia (oxygen weed).

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There are many types of seaweeds with different colours and morphology. See the seaweed display, what do they look and feel like?

Many of the seaweeds in the marine environment are not green in colour. Do they still contain chlorophyll?

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Consumers

Consumers directly or indirectly consume primary producers and can be divided into two types of consumers; primary and secondary.

Primary consumers

Primary consumers directly consume primary producers and are called **herbivores**. There is a wide-range of herbivores and all specialise in eating plants in some way. Some morphological features that identify herbivores are:

- a mouth suitable for scraping algae and plants off rocks, eg. short blunt teeth
- spines for protection from predators
- eye position, able to see all around
- tail shape, rounded indicating slow swimming speed…

Secondary consumers

Secondary consumers indirectly consume primary producers by preying on the herbivores and are known as **carnivores**. The carnivores have certain morphological features which make them good predators such as:

- sharp teeth
- stream-lined body shape
- highly developed sensory systems
- colouration, often silver and grey…

In the aquarium, Pacu and Carp are examples of herbivores, and Sharks and Piranha are obvious examples of carnivores. Give a list of three features which make these fish well adapted to being a herbivore or carnivore.

Herbivores	Carnivores
Carp: • • •	**Sharks:** • • •
Pacu: • • •	**Piranha:** • • •

Carnivores are at the 'top end' of the food web and generally in food webs there are few carnivores compared to herbivores. What would happen if there were lots of carnivores and few herbivores within a food web?

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Which trophic level contains the primary or secondary consumer?

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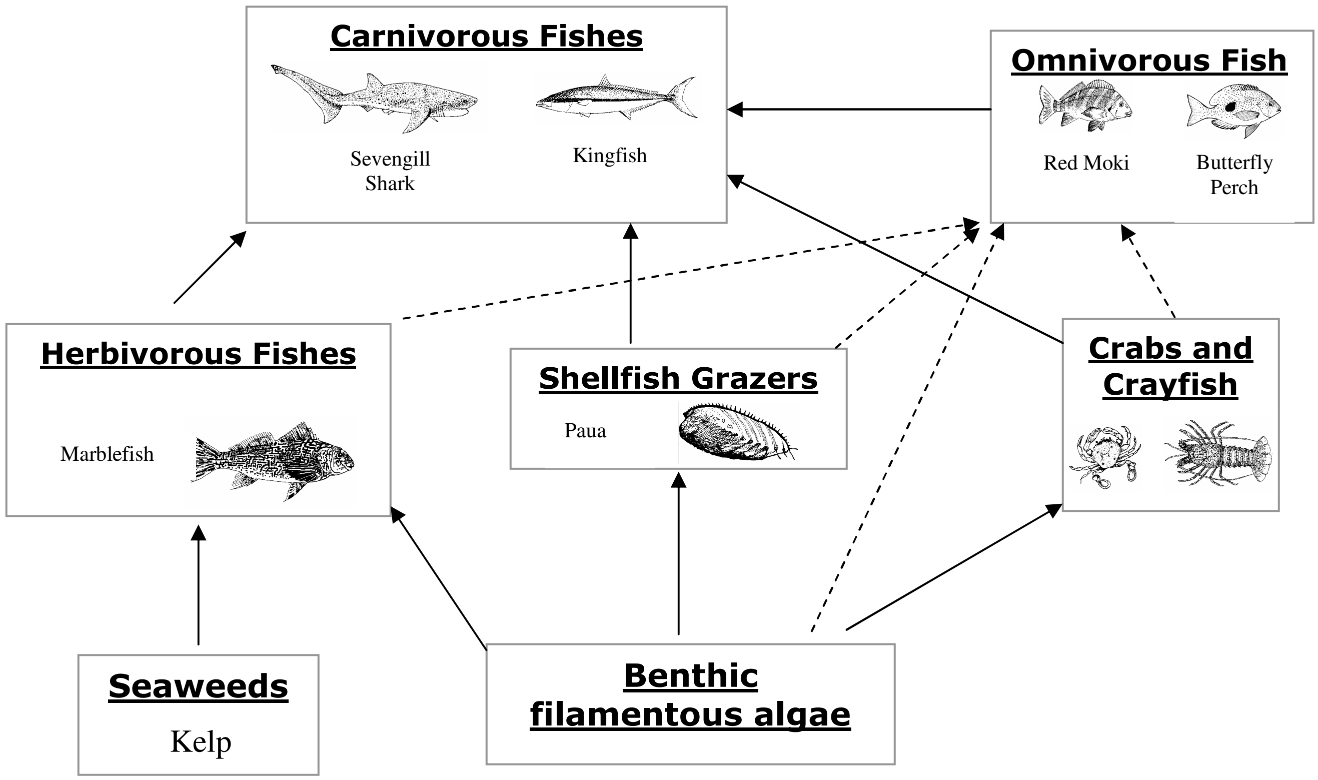
What do sharks eat????

Sharks eat a range of foods such as, small fishes, octopus, crabs and even seals! They rarely scavenge for food preferring live or freshly killed food and humans are not normally on the menu! Shark attacks on humans are usually a case of mistaken identity. Sharks can confuse swimmers or surfers with other marine animals such as seals or turtles.

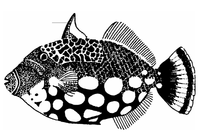
See what a dogfish shark had for breakfast! From the dissected shark carefully pull out some stomach contents into a small petri dish, rinse with salt water and see if you can identify from fins, heads, shells what the shark has eaten.

Are there other types of producers and consumers?

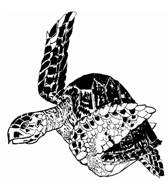
Food webs containing primary producers, herbivores and carnivores are not too complex. However, within the aquarium, many of the animals eat both plants and animals (**omnivores**) and some animals called **detritivores,** specialise in eating dead plant or animal matter (detritus). Omnivore consumers are difficult to place into separate trophic levels because they really belong to both secondary and tertiary trophic levels. This highlights the problems with simple classification systems and sometimes it can be better not to use particular classification types. However, we can still produce a food web although the number of energy flows / interactions increases, making food webs a little more complex.



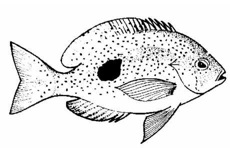
Looking through the tanks at the aquarium, choose three of the following six omnivores and suggest what food types they might consume.



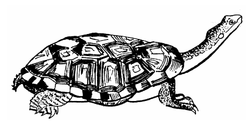
Clown Triggerfish



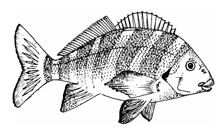
Hawke Bill Turtle



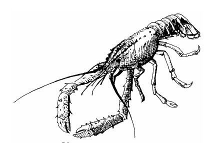
Butterfly Perch



Snake Necked Terrapin



Red Moki



Freshwater Crayfish

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2. ____

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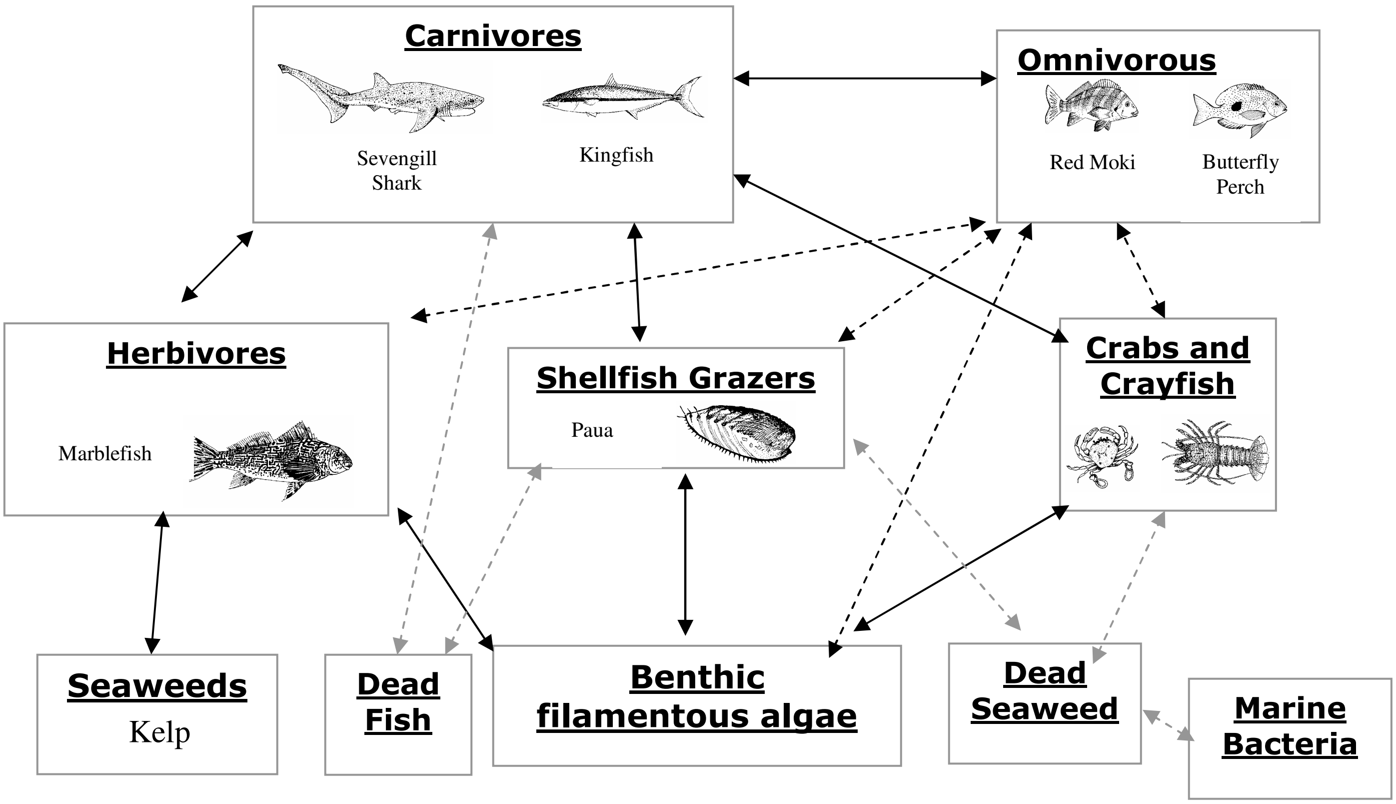
Detritivores are an interesting and very important type of consumer, specialising in eating detritus. Just imagine the number of dead animals, the amount of animal waste and plant material that would be cluttering up the environment if the detritivores didn't devour it!!! Detritivores break-up, recycle and release nutrients and energy from dead material. All sorts of organisms are detritivores, for example fungi, bacteria, crustaceans (e.g. crabs and crayfish) and lampreys (e.g. blind eels). Detritivores can be separated into two main groups; **decomposers** and **scavengers**. Decomposers are generally micro-organisms such as bacteria and fungi. They break down and absorb some of the dead material using enzymes. Scavengers are generally macro-organisms such as crabs, eels and some other fish types which feed off dead plant material and animal carcasses.

Looking at both the terrestrial and aquatic displays, give two examples of dead materials that bacteria and fungi are responsible for decomposing. Can you suggest a conglomerate of dead materials that bacteria and fungi are responsible for breaking down? Hint: *Look at the Australian outback and NZ gecko displays.*

List three animals from the New Zealand stream, deep river or rocky shore displays which are scavengers, and suggest what type of dead material they are likely to scavenge.

So if we now add the detritivores to the food web …… we find that food webs can be VERY complex!!!

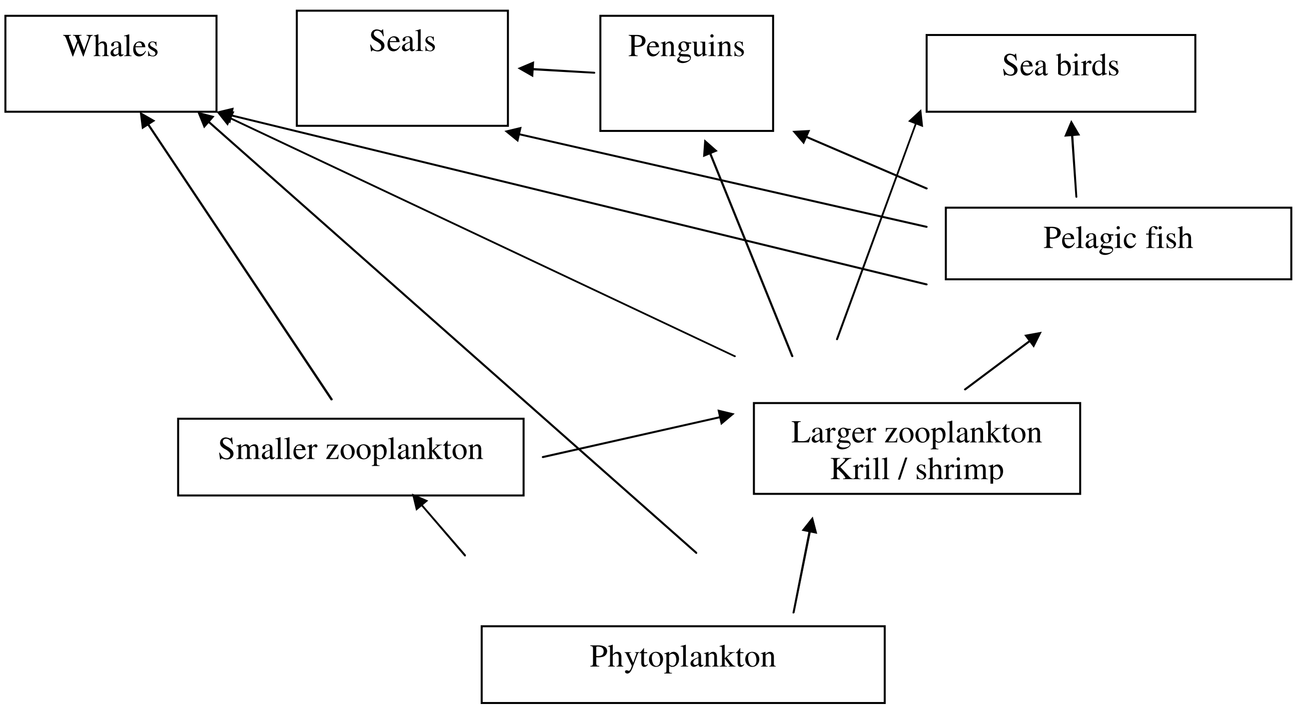

Carnivores
Sevengill Shark
Kingfish
Omnivorous
Red Moki
Butterfly Perch
Herbivores
Marblefish
Shellfish Grazers
Paua
Crabs and Crayfish
Seaweeds
Kelp
Dead Fish
Benthic filamentous algae
Dead Seaweed
Marine Bacteria

Create a food web! Choose and draw six marine organisms from the rocky shore tank and draw lines between them showing energy flows (what eats what!) Can you guess whether your organisms are carnivores, omnivores, herbivores or decomposers / scavengers?

Learning about the plankton food web

The plankton food web is an amazingly complex and interesting type of food web where the largest animals in the world rely on some of the smallest organisms in the world for survival! For example, a blue whale may consume four tonnes (i.e. approx. the weight of a small truck) of krill in one day!

Planktonic food web:



This is a simplified food web. Why do you think this is a simplified food web?

The plankton food web is similar to the other food webs that we have been investigating, in that it has **primary producers**; phytoplankton, **primary consumers**; zooplankton and krill and **secondary consumers**; krill, whales, seabirds, pelagic fish, seals and penguins.

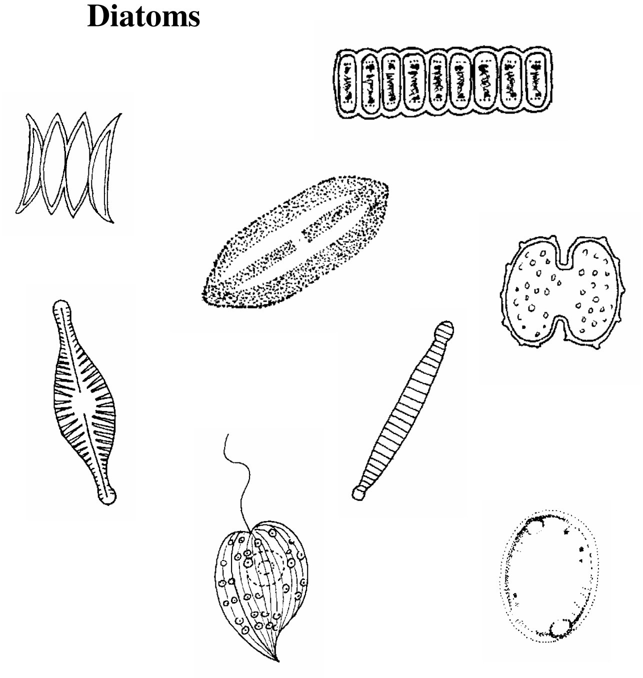
Phytoplankton

Phytoplankton refers to very small unicellular organisms within the sea which photosynthesise (‘phyto’ = plant, ‘plankton’ = floating free, ‘uni’ = one, ‘cellular’ = cell). Phytoplankton uses the dissolved nutrients in coastal and oceanic waters and sunlight to produce oxygen and energy (i.e. glucose).

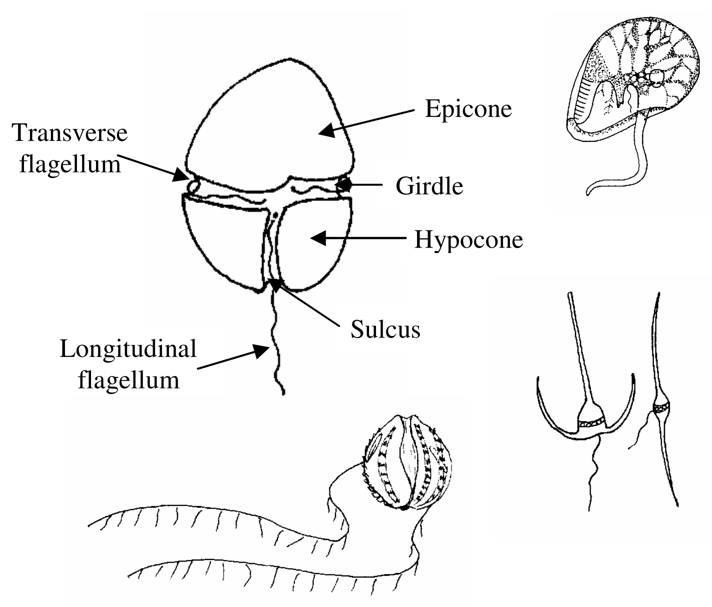
Phytoplankton has been referred to as ‘the forests of the sea’ because they are responsible for using up large amounts of CO_2 *and producing* O_2*. In fact some scientists predict that phytoplankton will be the answer to the problem of increased production of* CO_2 *and will help decrease or slow down the effects of global warming. Referring to what you know about photosynthesis, respiration and detritivores, do you think phytoplankton can help solve the problem of global warming??*

There are two main groups of phytoplankton, **diatoms** and **dinoflagellates**. Diatoms are disc-like in shape and have shells (frustules) which are made out of silica. Dinoflagellates are different from diatoms, in that they have two flagellae which are used to swim with.

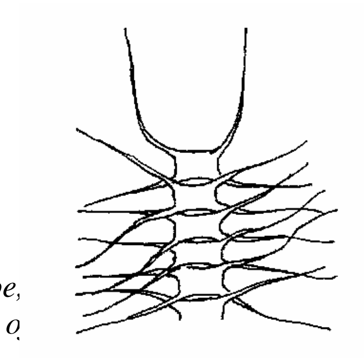
Diatoms



Dinoflagellates



Phytoplankton is mostly unicellular but can also form simple chains and colonies of photosynthesising cells.



Look down the microscope, ... ıkton and label the distinguishing features. Identify the type o... st of key characteristics below.

Phytoplankton key characteristics:

Diatoms:

Frustule consists of two valves (i.e. discs) with a groove in between
Frustule shape: pennate (oblong and elongated) or centric (circular or domed shaped)
Groups of diatoms: Long tubes of interlocking discs (simple chain) which can bear large spines and other projections

Dinoflagellates:

A visable longitudinal flagellum
Round or oval in shape
Can be armored or thecate - interlocking cellulose plates (a bit like armor!)
Can be naked – no interlocking cellulose plates
Can bear large spikes, wings or parachute extensions

Some species of dinoflagellates produce highly toxic substances which they secrete into the water. Marine organisms, such as fish can die when they come into contact with the toxins. Other marine organisms such as shell fish are not killed by the toxins but instead accumulate the toxins by filter feeding on phytoplankton and thus become contaminated and poisonous to other organisms in the food web, including humans!! Dinoflagellates normally occur in relatively small numbers. However, sometimes dinoflagellates increase in numbers due to a change in environmental factors within the sea. Events where toxin producing dinoflagellates increase in numbers and therefore increase the level of toxins within the water are called **Algal blooms**. Sometimes the algal blooms are called **red tides** because the red pigments in the dinoflagellates make the sea look red!!

Why do Algal blooms occur?

To understand why algal blooms occur we first need to know a little about the water currents and the way nutrients are cycled within the sea.

Water currents

During the different seasons the temperature of the water changes and this changes the movement of currents within the water. In the summer the water surface temperature is a lot warmer than deeper layers of water and therefore a thermocline ('thermo' = temperature, 'cline' = step) develops. The warmer water on the top layer stops water from deeper layers rising to the surface and therefore there is no mixing of the different layers of water. In winter, the temperature of the water surface cools and mixing of the two layers is able to occur. See Figure 1.

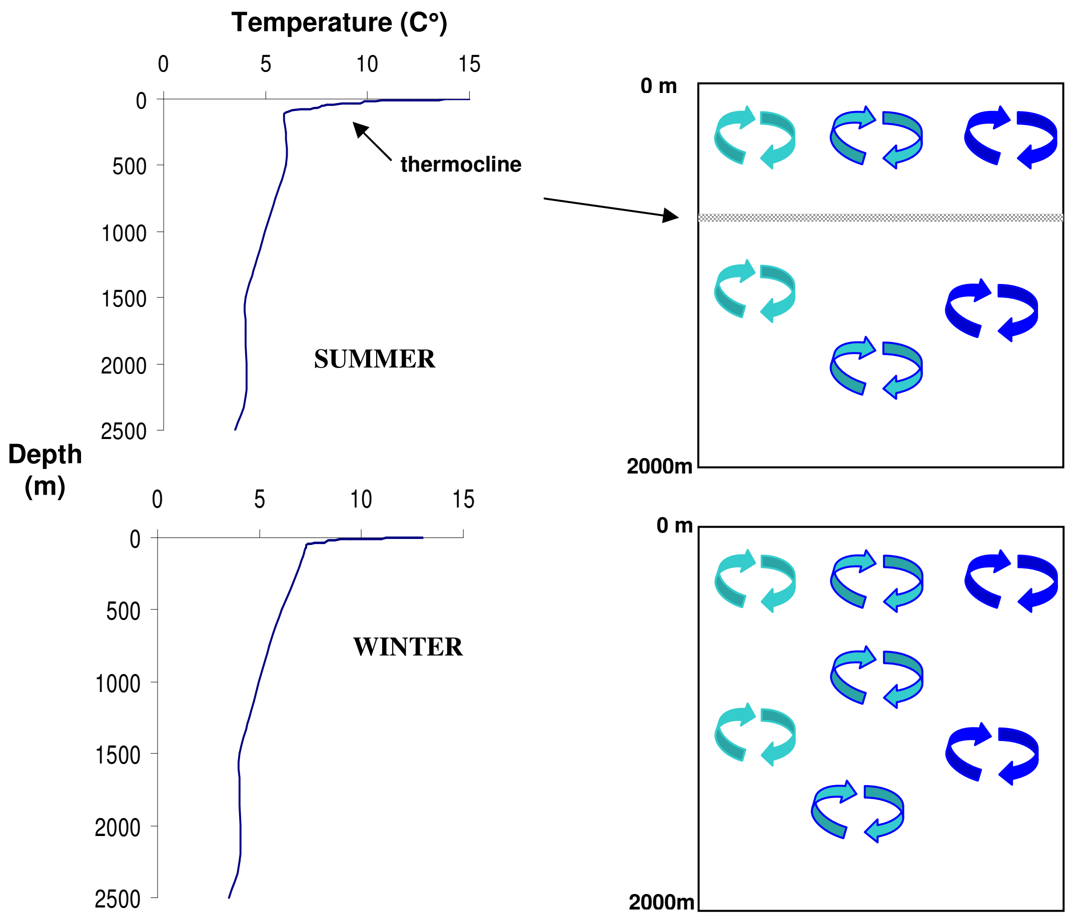


Figure 1: The temperature of ocean water over summer and winter at different depths and a diagram showing the mixing of water in the different water layers.

Nutrient cycling

Nutrients, such as broken down detritus, settles on the sea floor. Sea currents stir the sediment up into the different layers of water. In the winter, the two water layers mix and therefore there is a plentiful supply of nutrients within the whole water column. In the summer, the currents on the water surface don't flow down into deeper layers so the nutrients within the surface layers are limited. In the spring, when the sea temperature and daylight increases and there are lots of nutrients available, phytoplankton, including dinoflagellates, begin to grow in numbers and small spores (the dormant stages of phytoplankton) germinate adding to the numbers of phytoplankton in the water. So the combination of warm temperatures, high light levels and increased nutrients and an influx of dinoflagellate spores germinating can cause algal blooms to occur

Algal blooms can occur in early autumn as well, can you explain why this happens?

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If a farmer put fertiliser on his/her paddocks to improve the state of the grass and some of the fertiliser eventually ended up in the sea via small creeks and rivers, could this action lead to an algal bloom? Give your reasoning…

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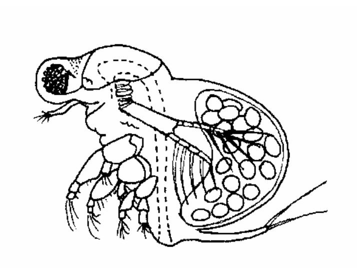
ZOOPLANKTON

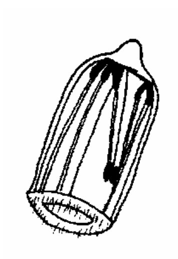
Zooplankton ('zoo' = animals, 'plankton' = floating free) are a large group of organisms which graze on the phytoplankton (**herbivores**), eat dead organic material (**detritivores**), prey on other zooplankton (**carnivores**) or eat both phytoplankton and zooplankton (**omnivores**). Zooplankton can be divided into two main categories; **holoplankton** and **meroplankton**.

Holoplankton

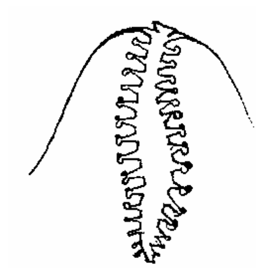
Holoplankton are organisms that spend their whole life history within the plankton, for example, ciliates, copepods and krill



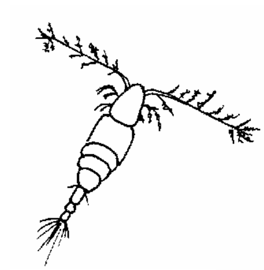
Daphnia



Trachymedusa

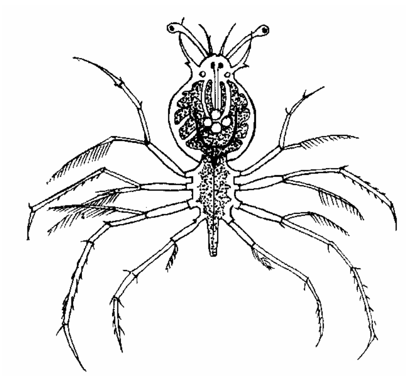


Polychaeta

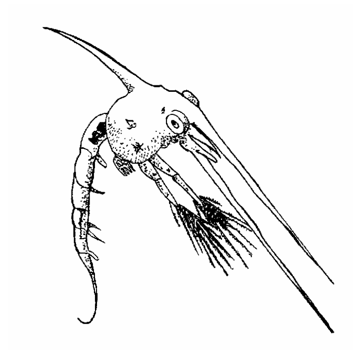


Copepod

Meroplankton are organisms which only spend a part of their life history, such as larval stages within the plankton, for example larvae of barnacles, crabs, mussels, lobsters and sea urchins.



Spiny Lobster



Brachy Uran Crab

Looking down the microscope, draw two types of zooplankton and label the distinguishing features.

Human involvement in food webs

Humans are an important part of the oceans food webs and can have a great impact on the energy flows between organisms within the food web. Fisheries and marine reserves are the two main ways humans alter the marine food webs.

Fisheries

In the past fisheries exploited the marine environment; there were no guidelines on how many fish, sea urchins, shellfish, prawns etc. could be taken without depleting stocks. Many fisheries went bust because what they were fishing went extinct or there weren't enough left to make it profitable to fish anymore. In one case, on the western coast of America, a company fished out an entire species of sea urchin. Once that had occurred the company started on the next species of sea urchin. The company only finished operating once it had wiped out six species of sea urchin!!!

How do you think the food webs on the western coast of America were altered with the loss of sea urchins? Which trophic groups would have responded well or badly to the loss of sea urchins?

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It is important that we take some responsibility for what and how much we catch. To get an idea about how much we can catch and in doing so, minimise our impact on the marine food-web, we need to know a lot about the biology and life history of the marine organisms. Scientists try to gain information about marine organisms' life history, from egg to adult. Here is a list of some features they research;

- How quickly an organism grows and reaches maturity (i.e. can start breeding)
- The fecundity of an organism (i.e. how fertile, how many eggs are produced)
- The environmental factors influencing brooding and survival
- Where spawning and nursery areas of young fish are
- How many fish die at the different life stages due to predators or disease
- What the organism eats!

Many of these features can be researched within a lab however this is not ideal because the real marine environment can be very hard to duplicate. Also for many deep sea fish (e.g. Orange Roughy) it is not possible to emulate their environment, so little is known about these fishes biology.

Look at the growth rings on fish scales under the microscope. Scientists used to believe that the growth rings could be used to age a fish but this method has proved to be inaccurate. Discuss possible reasons why this method of aging fish can be inaccurate.

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MAF (Ministry of Agriculture and Fisheries) has guidelines in place regarding what size the fish, crayfish, paua etc. has to be before we are allowed to catch it and how many we are allowed to take. Using MAF guidelines, work out which of the paua shells are the legal size and how many your classroom group would be allowed to take.

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Marine reserves

Marine reserves are one way where we can allow fish to reproduce and grow without being caught and allow marine food webs to interact without human impact. There are many marine reserves along the coast of New Zealand.

MARINE RESERVES IN NZ

Give a list of the benefits of reserves and the problems with reserves. Do you think the problems are out-weighed by the benefits? Why?

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What is another industry recently set up, which helps us minimise the impacts on natural fisheries and marine food webs?

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Foster, G. and Hall J. (2000) Sea Links, the planktonic marine food web. National Institute of Water and Atmospheric research, Wellington