Ecosystems

Ocean Explorer
Module 10

Bayworld Centre for Research & Education
BCRE

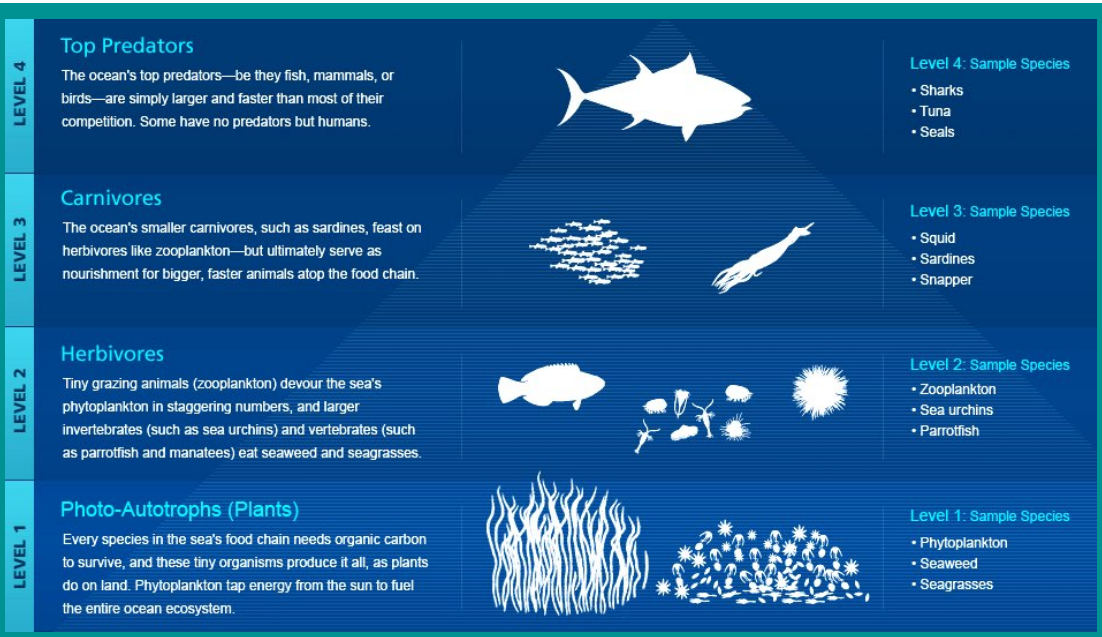
Overview

Info +

*A **food chain** is a sequence of organisms that feed on each other. All food chains are made up of the same basic trophic levels. Trophic levels are the levels within the food chain where an organism obtains its energy.*

Trophic pyramid

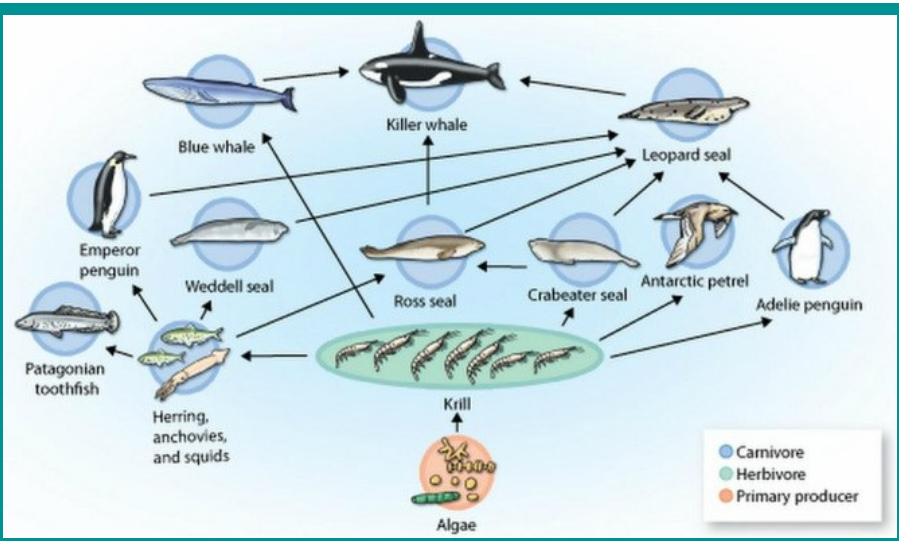
This is the basic structure of interaction in all biological communities characterised by the manner in which food energy is passed from one trophic level to the next along the food chain. The base of the pyramid is composed of species called autotrophs, the primary producers of the ecosystem. All other organisms in the ecosystem are consumers called heterotrophs, which either directly or indirectly depend on the primary producers for food energy.



An example of a marine trophic pyramid.

Food chains and Food webs

Because all species are specialized in their diets, each trophic pyramid is made up of a series of interconnected feeding relationships called food chains. Most food chains consist of three or four trophic levels. A typical sequence may be plant, herbivore, carnivore, top carnivore; another sequence is plant, herbivore, parasite of the herbivore, and parasite of the parasite. Many herbivores, detritivores, carnivores, and parasites, eat more than one species, and a large number of animal species eat different foods at different stages of their life histories. In addition, many species eat both plants and animals and therefore feed at more than one trophic level. Consequently, food chains combine into highly complex food webs. Even a simplified food web can show a complicated network of trophic relationships.



Food chains can be very complicated because they contain different types of interaction. On this food chain, not every trophic relationship is represented. For example, there is no parasites or bacterias !

Two of the main ways that populations interact with one another is by competition and by predation. In competition, individuals seek to obtain the same environmental resource. In predation, one population is the resource of the other.

Predation

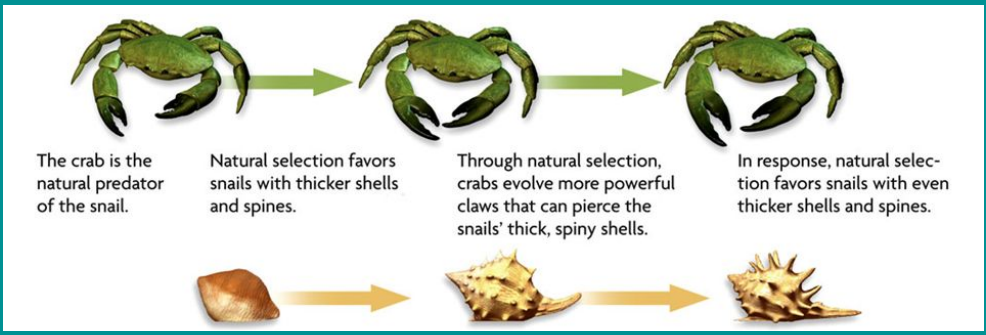
Predation is a strong, selective pressure that drives prey organisms to find ways to avoid being eaten. Prey organisms that are difficult to find, catch or consume are the ones that will survive and reproduce. The result is that over evolutionary time, prey organisms have developed a stunning array of strategies to avoid being eaten.

Coevolution

Predators and prey are in a constant battle to gain an advantage that will help them survive. Whenever a predator develops an advantage that helps them acquire prey, there is selective pressure on the prey to adapt and find a way to avoid this new method of predation. The organisms that most effectively adapt to and avoid predation will survive and reproduce.

It works in the opposite direction too. When prey organisms develop an effective defense against predation, predators must adapt to the change and find a way around the defense, or find a new organism to prey on. Predators that don't adapt and can't capture prey will starve to death.

The end result is that predators and prey evolve in response to interactions with each other. These tight evolutionary relationships can result in **coevolution**, which is when two species evolve in a coordinated fashion by adapting to changes in each other.



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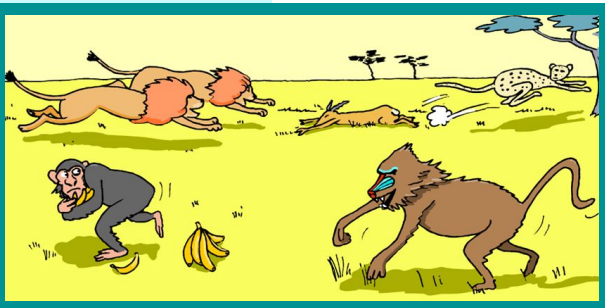
Interspecific *: relationship between animals from 2 different species.*
Intraspecific *: relationship between animals from the same species.*

Competition

Competition occurs when individuals share a resource which is in short supply. Sometimes competition is a head-to-head confrontation, but more often one individual uses a resource before another individual gets to it and deprives the other of something it needs. Competition can be interspecific or intraspecific.



Interspecific competition

Intraspecific competition

3 - Specialization and parasitism

The parasite lives on and feeds off its host, usually decreasing the host's ability to survive but not killing it outright.

Types of parasites

Parasitism is thought to be the most common way of life, and parasitic organisms may account for as many as half of all living species. Examples include pathogenic fungi and bacteria, plants that tap into the stems or roots of other plants, insects that as larvae feed on a single plant, and parasitic wasps. Parasites live in or on a single host throughout either a stage in their lives or their entire life span, thereby decreasing the survival or reproduction of their hosts. This lifestyle has arisen many times

throughout evolution. The most species-rich groups of organisms are parasites, which, in becoming specialized to live off their hosts alone, eventually become genetically distinct from their species, sometimes to the degree that they are considered a new species.

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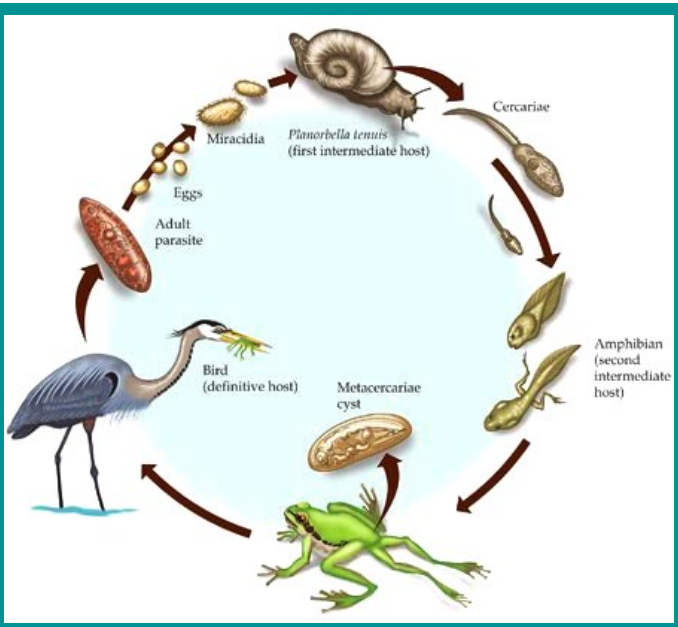
Speciation *: the formation of new and distinct species in the course of evolution*

Specialization in parasites

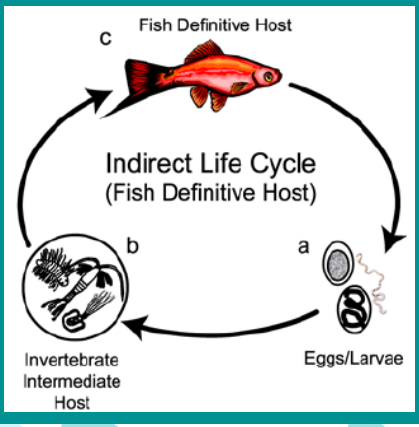
The parasitic lifestyle favours extreme specialization to a single host or a small group of hosts. Living for a long period of time on a single host, a parasite must remain attached within or on its host, avoid the defenses of its host, and obtain all its nutrition from that host. Unlike grazers or predators, parasites cannot move from host to host.

The speciation occurs because different parasitic populations become adapted to living on different hosts and coping with the defenses of these hosts. Over time, many of these different parasite populations evolve into genetically distinct species. It is through this speciation that parasitism appears to have become the most common way of life on Earth.



Parasite life cycles

Sometimes, parasites go through different phases or transformations, each one attached to a different host.



Mutualism

It is a symbiosis that is beneficial to both organisms involved. Mutualistic interactions between species are just as common as antagonistic relationships (predation/parasitism), with some mutualistic interactions forming the most basic elements of many communities.

In many mutualistic relationships, one species acts as the host, and the other plays the role of visitor or resident. Plants are hosts for insects that pollinate them, eat their fruit or even use them as a house and in return protect the plant. In other mutualisms, such as fish cleaning the mouth of other bigger fish, no species acts as host. Mutualisms also vary in the benefits the participants derive from the interaction. An individual may gain food, protection from enemies, a nesting site, or a combination of benefits.

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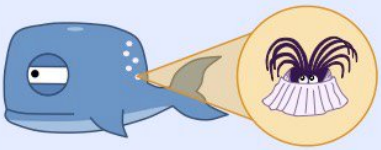
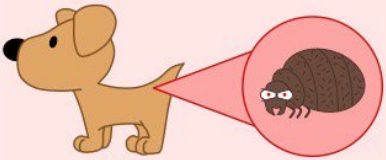
The Eucaryote cell, which we are constituted of, originated from the mutualist association of several single-cell species !

INTERACTION	TYPE OF SYMBIOSIS	EXAMPLE
	**Mutualism** Species A benefits Species B benefits	
	**Commensalism** Species A benefits Species B unaffected	
	**Parasitism** Species A benefits Species B harmed	

Mutualism and cheating

No species behaves altruistically to promote the good of another species. Mutualisms evolve as species that come in contact manipulate each other for their own benefit.

Because mutualisms develop through the manipulation of other species, they are always susceptible to invasion by "cheaters," those organisms that can exploit an existing relationship without reciprocating an advantage. Theft of a resource is one type of crime a cheater engages in. Another form of cheating involves mimicking the appearance of one species in order to subvert an existing mutualistic association. This has occurred between cleaner fish and their hosts. Cleaner fish are highly specialized fish that pick parasites off the skin of other fish. Host fish arrive at specific sites where they present themselves to the cleaner fish that groom them. Other fish have evolved to resemble the cleaner fish, but, rather than search for parasites, these imposters take a bite out of the host fish !

As cheaters evolve to exploit a mutualism, they can cause the symbiotic relationship itself to break down.

This shark is not eating the small black banded fish : it is opening its mouth for a personal parasite removal treatment !

Commensalism

In commensal interactions, one species benefits and the other is unaffected. The commensal organism may depend on its host for food, shelter, support, transport, or a combination of these. For example, clownfish live in the stinging tentacles of sea anemones thanks to their protective mucous coating. The clownfish gets a shelter and protection from the anemone, but the anemone doesn't get anything in return !

The structure of communities is constantly changing. All communities are subject to periodic disturbances, ranging from events that have only localized effects, such as the loss of a tree that creates a gap in the canopy of a forest, to those that have catastrophic consequences, which include wildfires or storms.

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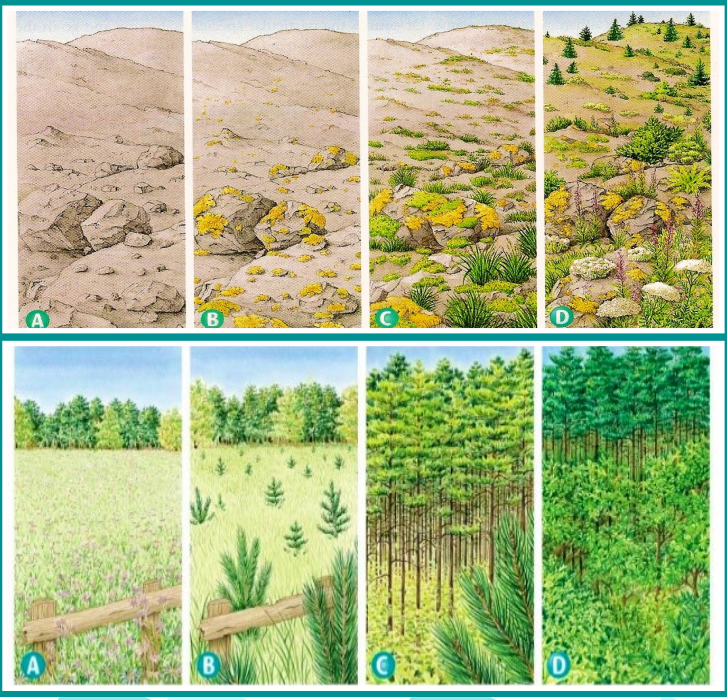
Community *: (= biocoenosis) association of populations of 2 or more different species in the same geographical area at a particular time*

Ecological succession

This is the gradual process by which ecosystems change and develop over time. Nothing remains the same and habitats are constantly changing.
There are two types of succession : primary and secondary.

Primary and Secondary Succession



Primary succession occurs in essentially lifeless areas, regions in which the soil is incapable of sustaining life as a result of such factors as lava flows, newly formed sand dunes, or rocks left from a retreating glacier.

Secondary succession occurs in areas where a community that previously existed has been removed due to smaller-scale disturbances that do not eliminate all life. Events such as a fire or a storm open areas to secondary succession.

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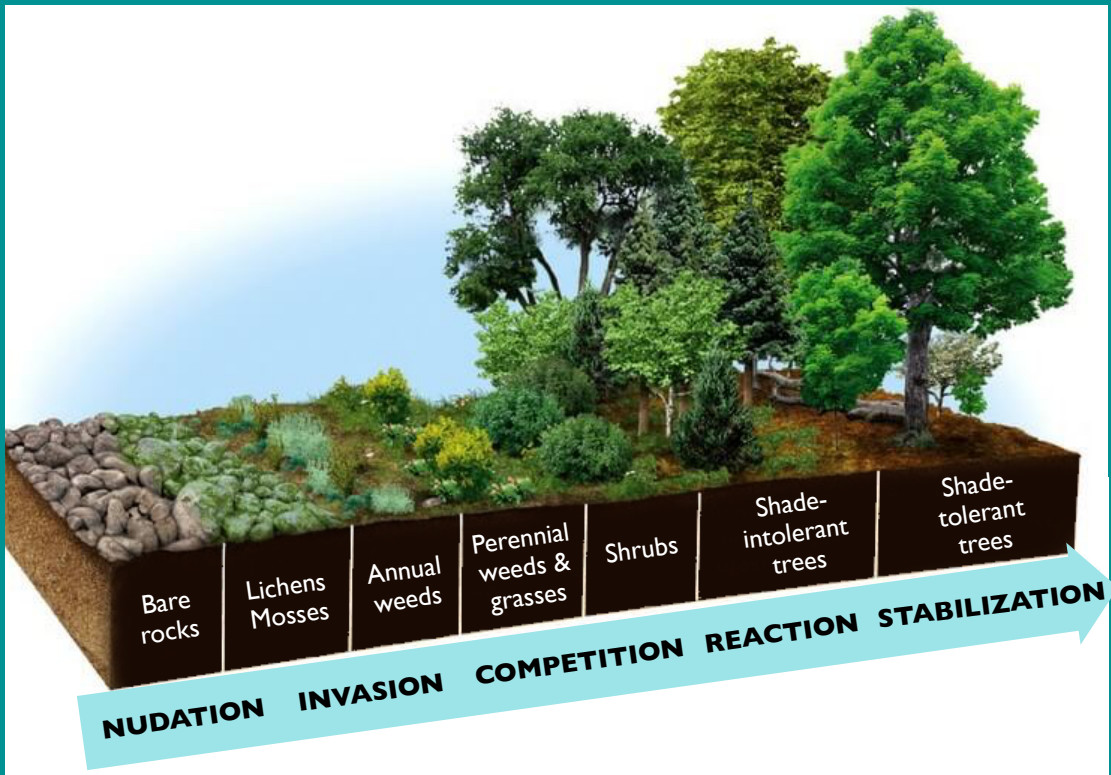
Some plants in fire-prone environments produce dormant seeds. These will only germinate after a fire !

An ecological succession is a series of changes, done in a predictable sequence. Initially only a small number of species from surrounding habitats are capable of thriving in a disturbed habitat. As new plant species take hold, they modify the habitat by altering such things as the amount of shade on the ground or the mineral composition of the soil. These changes allow other species that are better suited to this modified habitat to succeed the old species.

Stages in ecological succession



Stages in ecological succession

1 - Nudation

It starts without any form of life. This can be a bare area with no life before (primary succession) or an area which had had life before, but was destroyed by external factors (secondary succession).

2 - Invasion

This bare area is attacked by primitive lifeforms coming from neighbouring areas that can survive in minimum environmental conditions. This can be plant life or animal life (like fungus, bacteria, etc.). The process is subdivided into three steps

- Migration : organisms migrate from other areas by means of wind, water, animals, etc.
- Ecesis (= Establishment) : once the organisms have reached the area, they adjust with the prevailing conditions and begin to function normally.
- Aggregation : once the species is established, it starts breeding and colonizing. Many, many offsprings are formed and they begin to aggregate and form small colonies in this area.

All this while, the environmental factors like soil, water, temperature, humidity, etc are being influenced by the species living there. As this modification continues, new species begin to arrive and they form a community.

3 - Competition and Coaction

Once a community is formed, the various organisms in the community begin to fight for common resources of raw material and shelter. The competition is both among different species and also between individuals of the same species.

Organisms begin to affect each other's way of life, both directly and indirectly. Primitive food chains with two or three trophic levels begin to form (Coaction).

4 - Reaction

The most influential changes in the environment takes place due to actions of the community living in the area. Due to this modification, the area eventually becomes unsuitable for the existing community. Therefore, the first community is replaced by the next community that can live there stably. Each community that takes its place in the area is called a seral community.

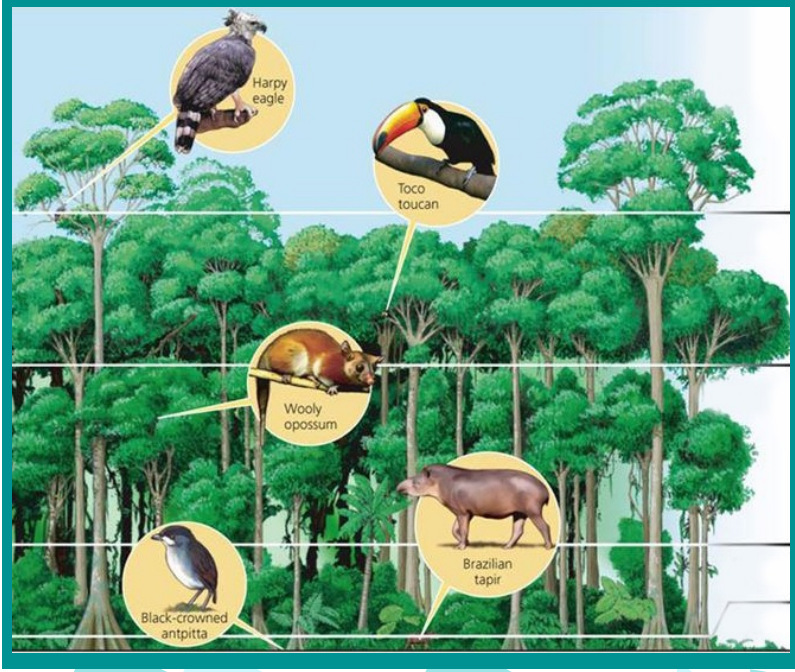
5 - Stabilization

Finally, a time comes where the community existing in the area reaches equilibrium with the conditions there. It remains in the area for much longer than other communities before it. This community, is not replaced and is called **climax community**.

6 - Stratification and gradation

Community structure is usually stratified both vertically and horizontally during the process of succession as species become adapted to their habitat. Gradations in environmental factors such as light, temperature, or water are responsible for this division. For example the vertical stratification that occurs within forests or in the ocean results from the varying degrees of light that the different strata receive. In a forest, the taller the plant and the more foliage it produces, the more light it can intercept. This is the reason why a forest usually contains 3 or more vertical strata of plants (an herb layer, a shrub layer, a small tree layer, and a canopy tree layer), each one adapted to the amount of light it receives. Animals are also affected by this stratification of plant life. Although they can move from one layer to another, they often adhere closely to one layer.

Tropical forest stratification



Emergent layer (highest trees + epiphyte plants)

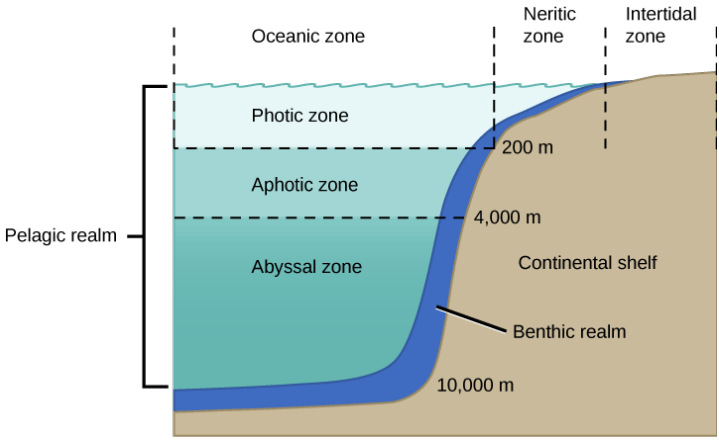
Canopy (High trees)

Under story (Smaller trees)

Shrub layer

Ground/Herb layer

Stratification under the sea



Stratification also occurs in large bodies of water such as lakes and oceans. In these, the layers are distinguished by light penetration, temperature, amount of dissolved oxygen, etc.

The **Photic zone** is the surface water. Light penetrates throughout the Photic zone, so photosynthesis occurs. It may be further subdivided into :

- The littoral zone (**Neritic zone**), where the water is shallow and light penetrates to the bottom : this zone is characterized by rooted plants (emergent vegetation and floating plants).
- The **Limnetic zone**, which is open water with photosynthetic phytoplankton, fish and invertebrates which move freely despite any currents which may be present.

The **Aphotic zone** is the depth where light is so low that not much photosynthesis occurs. At the beginning of this level, cellular respiration and photosynthesis balance each other, while above this level, there is more photosynthesis, and at the bottom of this level, there is more respiration and decomposition.

The **Abyssal zone** is part of the Aphotic zone. It is the area beyond the depth of light penetration. Organisms here depend on settling organic material from above as their source of nutrients and energy.

How much meat do you actually need to grow the 100g of tuna you need for your sandwich ?

Questions

1 - Identify the trophic levels on the picture above. What kind of relationships have these populations (species) ?

2 - It is said that, on average, only 10% of the weight of the prey is transferred to its predator, which means that for example 1kg of shrimp is needed to grow 100g of salmon. Thanks to this ratio, calculate the amount of phytoplankton needed to grow 100g of tuna.

Info +

The amount of energy at each trophic level decreases as it moves through an ecosystem. As little as 10% of the energy at any trophic level is transferred to the next level; the rest is lost largely through metabolic processes as heat. This means that in an ecosystem that has 10000 kilocalories of energy, only about 1000kcal will be transferred to primary consumers, and only 10kcal will make it to the tertiary level. The number of consumer trophic levels that can be supported is dependent on the size and energy richness of the producer level.