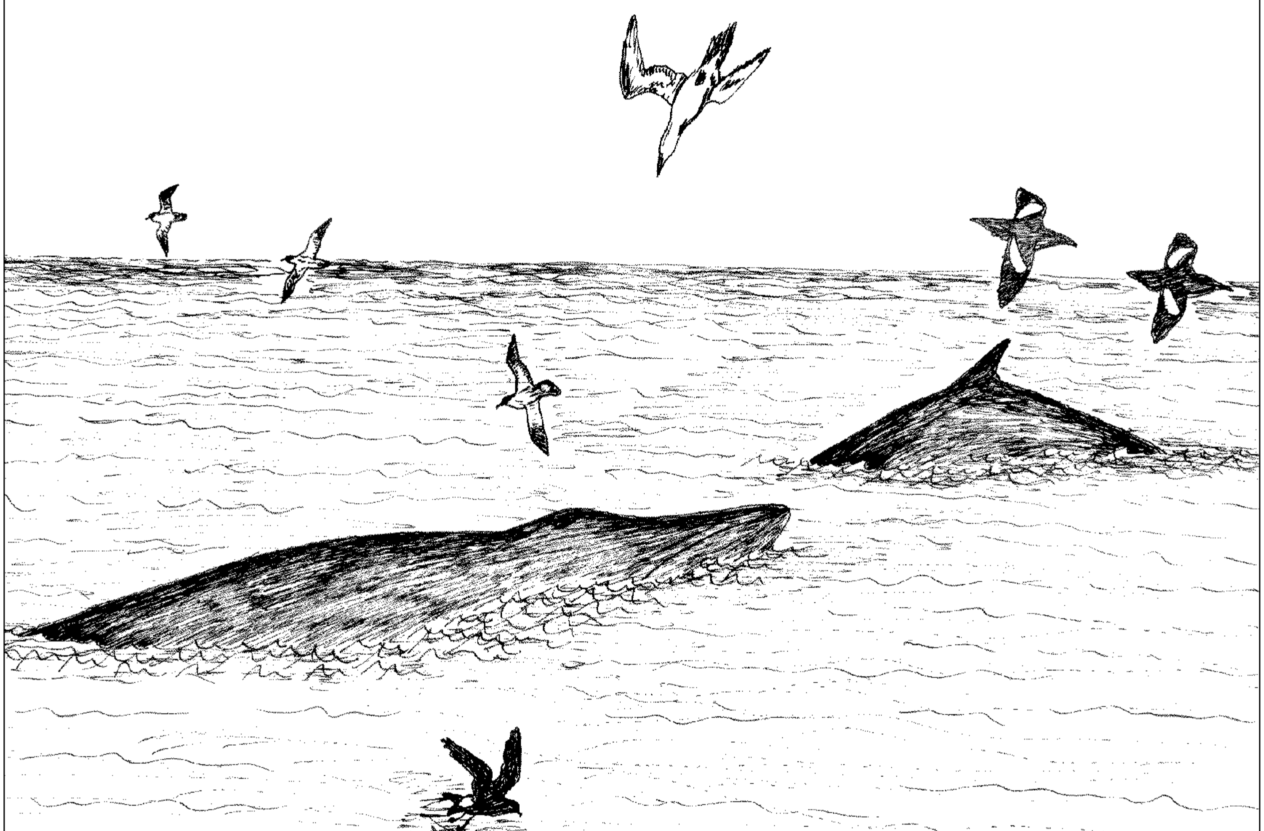
BY THE SEA

A GUIDE TO THE COASTAL ZONE OF ATLANTIC CANADA

MODULE 2:
TO THE HORIZON - THE NEARSHORE



Canada

ACKNOWLEDGMENTS:

FUNDING: Department of Fisheries and Oceans, Environmental Partners Fund of Environment Canada

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Comments and suggestions from the following people are gratefully acknowledged:

Diane Amirault, T.C. Anderson, Sophie Bastien-Daigle, François Bélanger, Mark Bonan, Yves Bourassa, David Boyce, Alyre Chiasson, Harry Collins, Simon Courtenay, Rosemary Curley, Ted Currie, Jean-Yves Daigle, Adrianne Dorrington, Ernest Ferguson, Phil Ferraro, John Foley, Christopher Hawkins, Denise Henson, Peter Hicklin, Bob Hooper, John A. Legault, Claude Léger, Maurice LeRoy, Allison M. Lowe, Don McAlpine, Mark McLean, Inka Milewski, Randy Milton, Michelle Parsons, Jon Percy, Jim Petrie, Terry Power, Rob Rainer, Lisa Richard, Pierrette Robichaud, Anne Senechal, Tom Sephton, Wendy Skeard, Bruce Smith, Rick Swain, Jacques Thibault, Jackie Waddell, Heather Walters, Judy White.

Également disponible en français.

Fisheries and Oceans / Pêches et Océans

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Tabusintac, N.B.
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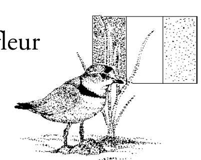

ENVIRONMENTAL PARTNERS FUND
Environment Canada / Environnement Canada
PARTENAIRES DE L'ENVIRONNEMENT

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343 Archibald Street
Moncton, N.B.
E1C 9B6

Prepared by: Corvus Consultants Inc.,
Tabusintac, N.B., Canada

Cat. no. S-23-289/1996 E ©1996
ISBN 0-660-16410-8

THE MODULES

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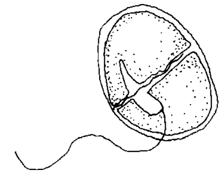


What is the Nearshore?

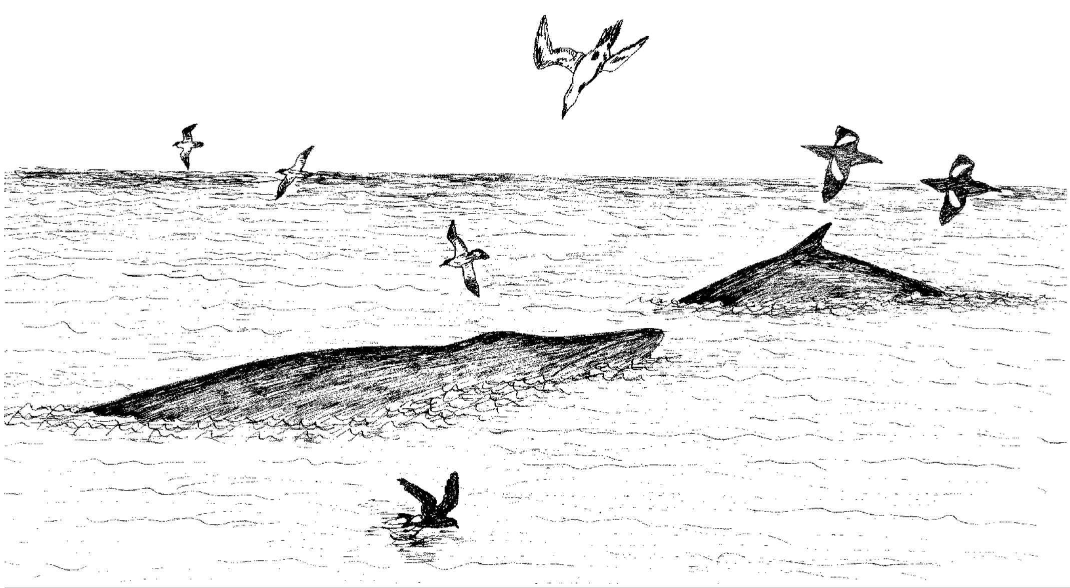
The coastal environment is more than what we see where the land meets the water, i.e., intertidal areas, estuaries, or salt marshes. It also includes that area of open water that stretches to the horizon, the bottom environment under that water, and the organisms that live there.

Most often referred to as the nearshore or inshore, this marine system can be defined in many ways. Geographically it ranges from the low tide mark and out to a portion of the continental shelf.

Some argue that it encompasses all of the shelf to the edge of the continental slope. From this perspective the nearshore would be a huge area extending out 200 km off Nova Scotia and 500 km off Newfoundland to the edge of the Grand Banks. It would also include all of the Gulf of St. Lawrence and all of the Bay of Fundy.

see activity 1

In a physical sense the nearshore has been defined as that area between the low tide shoreline and the point at which breakers (breaking waves) form. Beyond this is the offshore zone.



For the purpose of this module the nearshore is defined as that area known as the shallow subtidal, or roughly the area that can be seen from the shore to the horizon. It begins at the low tide mark and continues offshore to the 30-metre depth contour. This also defines what is known as the euphotic zone: that depth of water through which enough light penetrates for plants to grow.

The nearshore is also part of the larger oceanic system, which can be defined or separated into a variety of biological zones. The two basic units of the oceanic system include the pelagic zone or water environment and the benthic zone or bottom environment. Each of these can be subdivided into more specific units associated with particular oceanographic characteristics.

The Nearshore within the Coastal Zone

The nearshore is a part of all coastal systems, therefore it extends over a wide geographic area. For example, the nearshore environment along the East Coast of Canada is associated with a variety of climatic regions. It isn't static and its characteristics change over distance and time (i.e., seasonally).

Because it's a continuum of both offshore regions (oceanic) and coastal systems (estuaries, intertidal areas, and salt marshes) it's also affected by these in a variety of ways. Probably the most significant example of this is the transfer of energy (solar and detrital pathways) in the form of nutrients (dissolved carbon, particulate carbon) between all of these systems.

Location

In Atlantic Canada the nearshore environment consists of the Bay of Fundy/Gulf of Maine system, the Scotian Shelf region, the Gulf of St. Lawrence, and coastal areas around Newfoundland and Labrador.

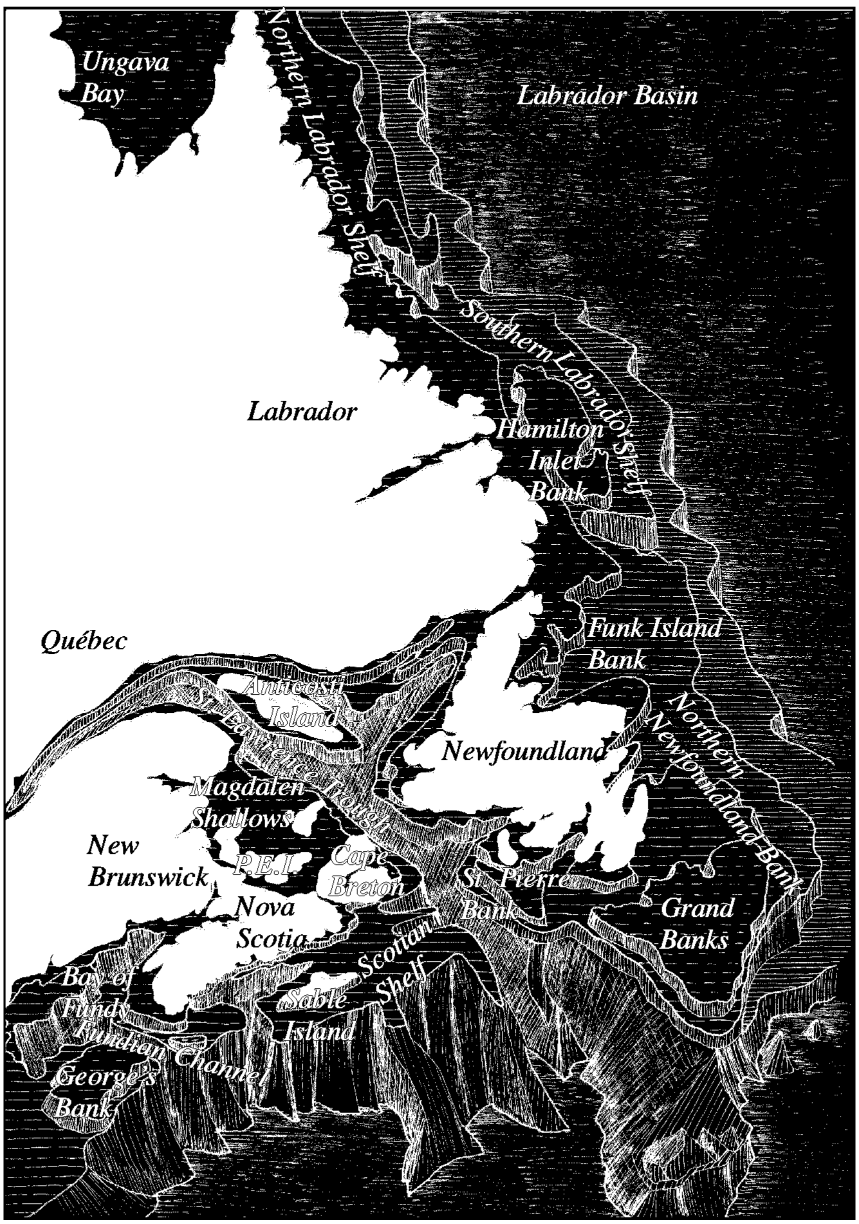
THE PHYSICAL ENVIRONMENT

Formation

The formation of the nearshore must be looked at in the context of the formation of the region as a whole and the formation of the continental land masses versus the ocean basins.

Geologically the nearshore is really part of the continental land mass. It became a marine environment only within the last few million years as coastal lands were flooded.

Relief map of Atlantic Canada's coastline



The Earth's surface in its most basic form is made up of continents and ocean basins. The nearshore is a part of the continental shelf, an area defined by geologists as an extension of the continents themselves. This is because its structure, or the rocks that it's made of, is similar to those of adjacent coastal areas. The shelf extends to the continental slope, an area offshore that slopes dramatically to the deep ocean floor. This marks a change from the continents to the open oceans.

What's on the bottom

Just as shorelines are created by either land- or water-based processes, so are nearshore systems. For example, much of what makes up the floor of the Gulf of St. Lawrence is a result of erosion on the land (specifically New Brunswick) and the deposition of this eroded material beyond the coastal boundaries.

The bottom of the Northumberland Strait and Gulf of St. Lawrence is covered with sands and gravels that were once part of a great depositional plain. These sediments were derived from the erosion of the northern extension of the Appalachian mountains, which existed further west. Large rivers and then swamps once dominated the landscape. Flooding sea-water then covered part of this in what is now the Gulf.

Georges Bank within the Bay of Fundy/Gulf of Maine system, Sable Island and its associated banks, and the Grand Banks off Newfoundland have all been formed in part from glacial deposits occurring in the last two million years. During the last glaciation ice extended out over what today is water offshore. The terminus (or end) of these large continental glaciers was the present-day location of these banks. The glaciers during their advance piled up rocks and sediments, which were deposited at their terminus.

Nearshore in motion

Large-scale movements of water such as the Labrador current and the Fundy tides are affected by bathymetry. In the Bay of Fundy tides range from four metres at Westport, Brier Island, to greater than 15 m in the Minas Basin. One reason for this is the fact that the bathymetry changes from the mouth to the head of the Bay. At its entrance the Bay of Fundy averages about 150 m in depth. Moving towards the head of the bay the depth decreases to 20 m. An incoming tide responds to this shelving and narrowing by moving higher and higher up the shore, helping to create the extreme tidal range at the head of the bay.

The bottom topography is not uniform. Moving water hitting ledges, underwater cliffs, or flowing into depressions will create upwellings, whirlpools, and turbulence. These can affect the movement of nutrients, water temperatures, and living things.

In addition, just as topography can affect how landscapes evolve and change over time, bathymetry can have the same effect on the ocean bottom. Erosion and the movement of loose material in response to gravity occurs underwater as well as on land. Where steep slopes are present there is a greater potential for erosion.

During the past much of the shelf was exposed, the actual coastal boundary moving back and forth across the shelf over time. As a result one can predict the general shape, depth, and slope of the bottom (bathymetry) by looking at the topography of the adjacent shoreline. The large coastal features will, in most cases, extend out onto the shelf.

For further information on geological formation please refer to module 1: Introductory module.

Physical Characteristics

Location and season affect the temperature of the water and the mix of plants and animals that live there. The nearshore region off the coast of Labrador is considered sub-Arctic; that of the Gulf of St. Lawrence, boreal; and the Bay of Fundy, boreal with some Virginian and sub-Arctic influences. These influences are generally a result of local conditions such as cold water upwellings at the mouth of the Bay of Fundy and shallow, warm water conditions at the head of the Bay.

Currents

The East Coast of Canada is influenced greatly by water masses, mainly the cold Labrador current flowing out of the Arctic, the St. Lawrence River flowing into its Gulf, and the tides of the Bay of Fundy. The warm northeasterly flowing Gulf Stream current flows hundreds of kilometres offshore. It often influences the waters of Georges Bank, Brown's Bank, and parts of the Scotian Shelf through eddies or 'warm core rings.' It mixes with the cold Labrador current over the Grand Banks and creates large upwellings.

Water density contributes to the movement of water. It's affected by temperature, salinity, and pressure. Generally increases in each or all of these will increase density. It is of importance because water of varying densities will move. Moving water creates currents. Currents are responsible for the distribution of larval lifeforms from the intertidal to the nearshore and back to the intertidal areas where many will live their adult lives.

The most common currents are those created at the junction of land and water. Waves will break on shore and then run back and along the shoreline. The currents associated with this constant back and forth movement of water work to move sediments, seaweed, animals, debris, and other elements from the shore, offshore, and back again at another location farther along the coast.

Salt

The salinity or salt content of the water of the nearshore varies slightly from place to place. Those areas that face the open Atlantic likely have less difference in their salinity than the Bay of Fundy or the Gulf of St. Lawrence.

Around and around, up and down - currents

At the mouth of the bay, off Grand Manan island, a smaller gyre, or circular pattern (whirlpool), is created. Here currents meet underwater ledges, smaller islands, and submarine channels creating a number of upwellings and turbulent waters. Turbulent waters are also created closer to the mainland between a number of smaller islands including Campobello and Deer islands. Relatively narrow channels and the random location of islands create a virtual maze for flooding and ebbing tide waters. As a result, water is coming together (converging) and diverging in many places. It is in one of these situations that a large whirlpool, the 'Old Sow,' is created. Situations like these bring nutrients to the surface, providing food for primary producers.

How much salt?

Both the Gulf of St. Lawrence and the Bay of Fundy are somewhat enclosed. They're also influenced by freshwater input from adjacent large river systems. In the Gulf, for example, the St. Lawrence River and, to a lesser extent, smaller rivers from New Brunswick (the Miramichi, the Restigouche, Nepisiguit) discharge over 4.5 million cubic metres of water per second every day. This results in salinity values ranging between 26 ppt and 32 ppt. The greatest variation occurs as a result of spring run-off. The salinity of nearshore areas on the Atlantic coast of Nova Scotia may only vary by 10 ppt, staying close to 31 ppt. Normal salinity content in the open ocean off the Canadian East Coast is 32 ppt. The Labrador current has relatively low salinity levels with 30 ppt, whereas the Gulf Stream has a salinity level of about 35 ppt.

These variations are certainly not as dramatic as those that occur in estuaries. In addition, below 20 m there is little variation in salinity and temperature at any time. Bottom conditions are more stable than surface conditions.

For further information on salt please refer to module 1: Introductory module, and module 13: Activities.

The Bottom and Bottom Sediments

As a physical characteristic, bathymetry is important when considering many aspects of the nearshore environment. The shape of the bottom will have an effect on the movement of currents, the creation of waves, and on the presence or absence of plants and animals. The movement of currents will affect the accumulation and deposition of sediments; waves can affect coastal erosion rates and the distribution of plants and animals.

The bottom of the nearshore is likely to be a mirror of the intertidal area adjacent to it. In Atlantic Canada that typically means that the character of rocky intertidal areas usually extends subtidally (below the low tide mark). Likewise, where sandbeaches and mudflats occur, these loose sediments will cover the bottom and extend offshore.

Erosion of the coast by waves and of inland areas by rivers bring sediments to the nearshore where they are deposited, building up layer upon layer of mud, sand, and cobbles. This is especially true in embayments and inlets. These are areas of deposition and the bottom will reflect this. Dead plankton settle to the bottom over time, building up layers of what is called biogenic ooze, an ooze that has a biological origin rather than a geologic origin.

Temperature

Just as temperatures vary from place to place and season to season on land, so do temperatures in water. In Atlantic Canada surface water temperatures range from minimum monthly readings that are about as cold as they can get in salt water (-1.8½C), to temperatures that are the best summer swimming conditions north of Virginia (20½C).

The temperature of the surface water closely reflects changing air temperatures from season to season, however temperatures are also affected by physical characteristics such as bathymetry.

Water temperature also has an effect on local climatic conditions. Land conditions beside the coast are influenced by the water. Summer and winter temperatures are generally not as extreme in coastal regions as they are further inland.

In the Gulf and along the Atlantic coast water temperatures will dip down to -1.8½C in winter. This allows ice to form in the Gulf. In the Bay of Fundy average minimum temperatures are warmer, a robust 3½C! This and the Bay's extreme tides keep it ice-free.

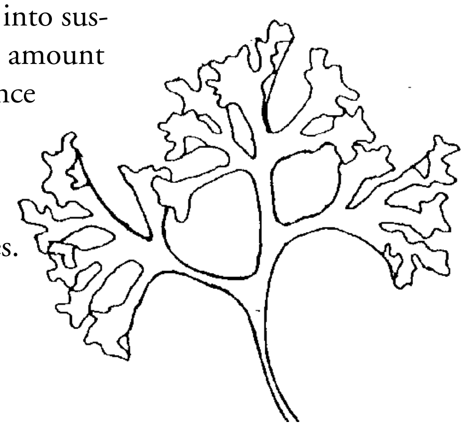
Maximum monthly temperatures also vary significantly. The Bay of Fundy region has summer surface temperatures that reach 15½C at the mouth and a few degrees warmer in the upper basins. These relatively cool temperatures are primarily the result of upwellings of cold bottom water off of Grand Manan and from the Northeast Channel.

On the Atlantic coast summer temperatures reach 18½C and within the Gulf they can exceed 25½C in bays and inlets but are more commonly closer to 20½C in open water.

In the summer months strong temperature variations (gradients) also exist from the surface to the bottom. While surface waters reach into the upper teens and higher in the Atlantic and Gulf regions, below 20 m temperatures rarely rise above 10 degrees. That's a difference of one degree every couple of metres. In the Fundy region however, tidal mixing creates a somewhat more homogeneous water column with temperatures varying only about three to four degrees with depth.

Light

Light is a limiting factor in primary production (plant growth). In the nearshore, light penetration is affected by the presence or absence of sediment in suspension and by the depth of water. In low energy coastal environments where sands and muds build up on the bottom or along the shore, waves, tides, and currents will throw these sediments into suspension. Run-off also contributes to the amount of sediment in the water. The St. Lawrence River, for example, delivers so much sediment to the Gulf in the spring that only 1% of the light penetrating the surface is able to reach below four metres. The same happens in the Bay of Fundy where the high turbulence of the water constantly throws sediments into suspension.



Irish Moss (red)

Clearer conditions exist off Newfoundland and the Atlantic Shore of Nova Scotia. Depth also limits the amount and type of light in the water. In the uppermost 15 to 20 metres, in clear water, longer wavelengths (reds) of light are absorbed; yellow light disappears by 100 m and green light by 250 m. This means that certain seaweed will grow only to specific depths.

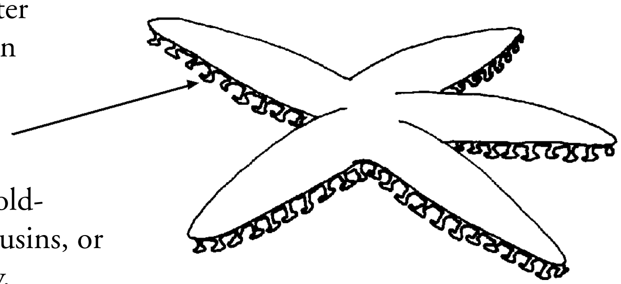
Tides

The daily rise and fall of the tides vary significantly from place to place. The Gulf of St. Lawrence has a tidal range between one and three metres. Along the Atlantic shore it's a modest two to three metres, on the north and east coast of Newfoundland only 1 m, and in the Bay of Fundy it ranges from four to 15 metres, among the highest in the world. Upwellings caused by tidal currents not only bring nutrients to the surface but water of different temperature and salinity. They may also churn up bottom sediments, increasing the turbidity (cloudiness) of the water. In macrotidal regions (areas of great tidal range) like the Bay of Fundy, tidal motion reduces the natural layering or stratification of water, characteristics that would occur in the nearshore.

Waves

Waves within the nearshore are considered shallow water waves. This means their movement is detected or 'felt' by the bottom.

Waves are a primary source of energy. Their interaction with the coast is a driving force of erosion, continuously changing its shape. Waves are also a primary stress to animals and plants living in the nearshore. Although living things are constantly covered by water in subtidal areas, wave action, especially during winter storm surges, can affect life on the bottom down to five metres. At these and shallower depths plants and animals must have ways of holding on like their intertidal cousins, or they too could be swept away.



tube feet of a sea star

For the same reason many types of seaweed grow during the summer season, when wave action is less eroding, temperatures are warmer and there is more light. Many animals migrate further offshore in winter, where waves are not felt the same way as close to shore.

Wind

The primary influence of wind in the nearshore is the creation of waves. Wind will also work to move ice packs during the winter months and at the beginning of spring. In the winter months ice movement can be quite dramatic along the Northumberland Strait and the Gulf from day to day. For example on any given day ice may be piled up on the New Brunswick shore, a result of wind blowing onshore. A change in wind direction can move that ice offshore.

Dissolved Gases

Oxygen, carbon dioxide, and nitrogen are all present in sea-water. The amount present depends on a number of variables. Within the nearshore, concentrations will vary depending primarily on temperature. Lower temperatures increase the ability of water to dissolve gases. In cool water areas optimum conditions exist in summer when days are long for phytoplankton and macroalgae (seaweed) growth. This is especially true in the nearshore regions of Atlantic Canada.

Dissolved Nutrients

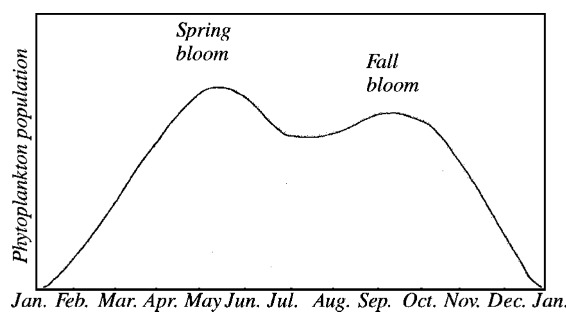
In temperate regions like Eastern Canada, nearshore waters are considered eutrophic. This means they have high concentrations of nutrients such as carbon, phosphates, and nitrates. Nutrient concentrations are responsible for high primary productivity. The nutrients are brought to the primary producers by waves and currents. Some seaweed only grow in wave zones where fresh nutrients and dissolved gases are rushing past at all times.

The rise and fall of nutrients

In Atlantic Canada nutrient levels have a yearly cycle. They are highest in winter, become lower in the summer, and then increase again through the fall. However, primary productivity is relatively low during the winter and fall because of the reduced availability of sunlight (the days are shorter) and its low angle of incidence. This results in less light being absorbed in the surface waters.

Nutrient levels remain high in the spring because nutrients have not been used up over the winter, the sun rises higher in the sky and penetrates deeper, the days also become longer so penetration lasts longer, and exponential (very rapid) growth of primary producers occurs. This expanding population puts an extreme demand on the nutrient supply.

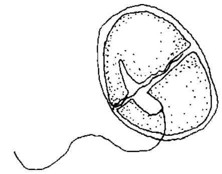
As the summer approaches and progresses the surface waters are warmed and become separated from deeper water by a thermocline (rapid change in water temperature over a small change in depth). This results in little exchange between the two layers. Nutrients used up in the surface waters cannot be replaced from below. The population of primary producers declines.



In the autumn another increase is observed as water temperatures cool, fall winds mix the water, bringing nutrients to the surface, and increased rainfall brings nutrients into the nearshore surface waters via run-off.

This scenario is followed closely in the Gulf of St. Lawrence and Atlantic nearshore regions. In the Bay of Fundy, however, tidal action and the presence of submerged ledges, islands, and channels create opportunities for upwellings. Because water is moving and mixing to a greater degree, thermoclines or boundaries between surface waters and the bottom do not develop. This means nutrients are continually brought to the surface from deeper waters.

BIOLOGICAL FEATURES



Water World

The nearshore environment is only for the truely marine. Terrestrial animals, mostly birds, may use it, but the vast majority of animals found here cannot survive out of saltwater, even for a short time.

see activity 13

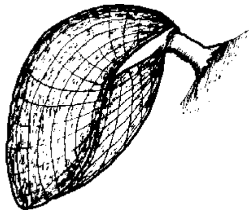
This area is ecologically crucial. Eighty per cent of the world's atmospheric oxygen is produced by phytoplankton. Marine environments generate most of the ecological services (i.e. maintenance of the ozone layer), and fish production is the world's largest single source of animal protein.

A home for weird and wonderful organisms

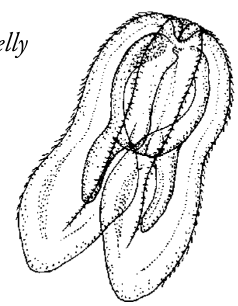
Life in the ocean may have begun in shallow tide pools. The marine origin of life may help to explain why representatives of most major groupings of organisms, called phyla, are found in the ocean.

There are many strange organisms that can be found in the sea. The pace of evolution may have been slower in the ocean, because the water moves organisms around, ensuring that different populations of a single species continue to mix. On land, a group of organisms can more easily become isolated from the main population, allowing them to evolve into a new species.

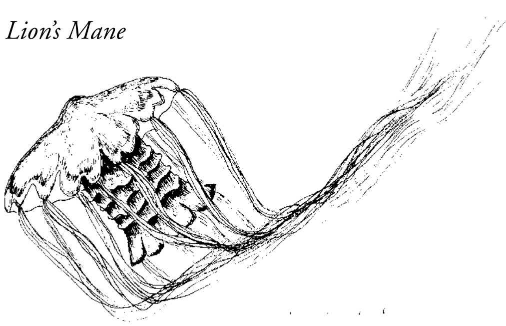
brachiopod



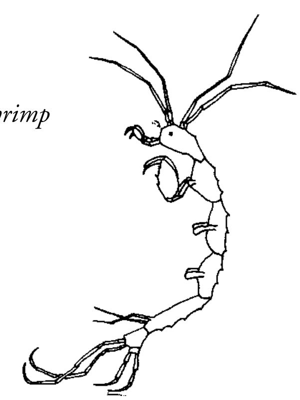
comb jelly



Lion's Mane



skeleton shrimp

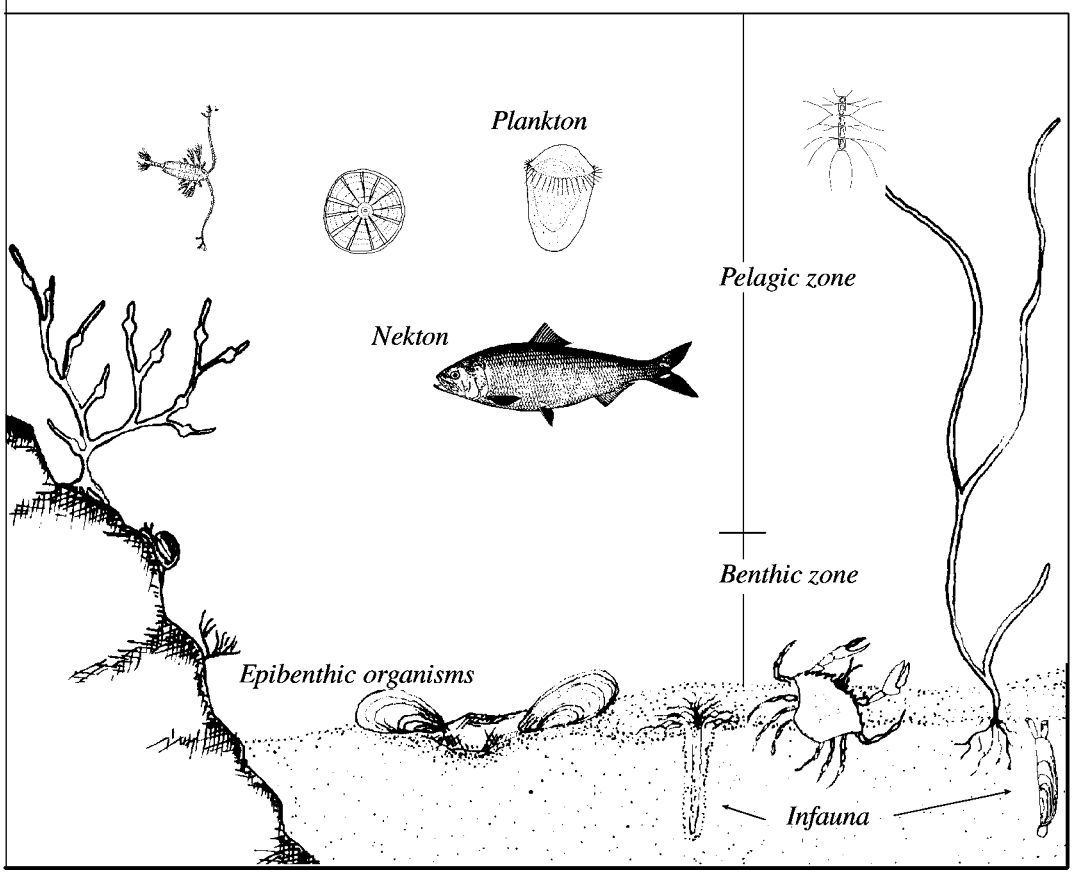


Who Lives Where?

Zonation

To Settle Down or to Roam

The ocean is separated into two basic environments. The benthic environment is the bottom of the ocean. Organisms that live in or on the bottom, such as seaweed, anemones, or worms, are known as benthos. Creatures that live in the substrate are called infauna whereas the ones on top of the substrate are called epifauna. The pelagic environment encompasses the waters of the ocean from the surface to the most profound depths. In the pelagic environment, marine biologists classify organisms as either plankton (wanderers) or nekton (swimmers).



Euphotic and Disphotic Zone

Despite constantly changing boundaries in the water column marine biologists have identified two zones. The euphotic zone extends from the surface down to the maximum depth at which photosynthetic plants can grow. Below this lies the disphotic zone where there is still light penetration, but not enough for photosynthesis. For example, if a diatom, a single-celled plant, sinks below the euphotic zone the loss of material from respiration will exceed that produced from photosynthesis and it will die. The disphotic zone can be loosely compared with the dimly lit floor of the forest.

Phytoplankton, which like all plants require light, are concentrated in the euphotic zone. Zooplankton, which feed on phytoplankton, may move between the euphotic and disphotic zone. The nekton, with its greater mobility, moves freely through the water column and back and forth from the nearshore zone to deeper waters.

Overall, the pelagic realm is a fluid environment and zonation is not such a distinctive feature as it is, for example, on a rocky shore.

Factors affecting lower limit of euphotic zone

Many factors affect the depth to which light will penetrate. These include the time of day, the time of year, cloud cover, and the clarity of the water. In Maritime waters, the euphotic zone rarely extends deeper than 30 m. (This depth roughly defines the outer boundary of the nearshore zone.)

In estuaries the discharge of sediment and other material from a river will reduce the penetration of light. In the upper Bay of Fundy the strong tides churn up the mud, increasing the turbidity of the water and blocking the light.

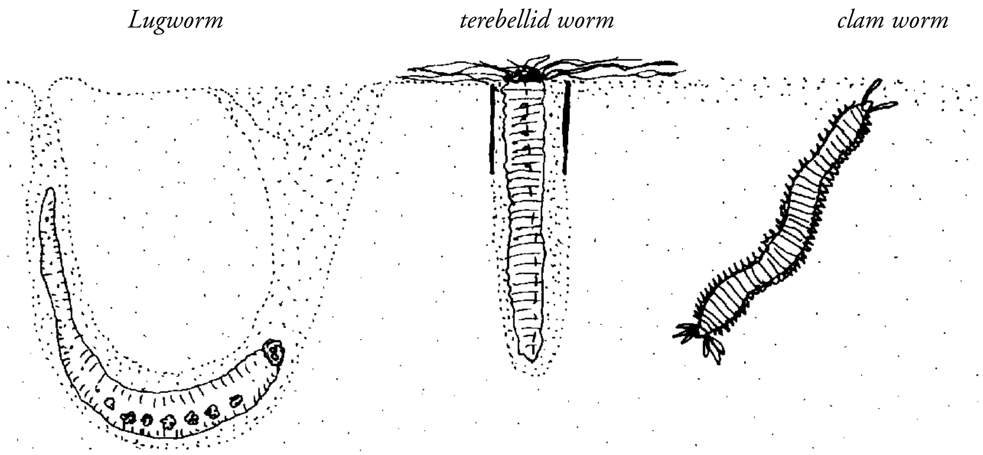
Skimming the surface

In some places a thin scum of organic material covers the surface. On a calm day look for an oily film on the water. Bacteria and protozoans feed on the material that concentrates here and in turn are fed upon by zooplankton from below. Birds, such as the petrels and shearwaters, have bills especially adapted for feeding on the organisms that collect at the surface.

Zonation on Sandy and Muddy Bottoms

Where the sea floor is soft, the presence of plants and animals changes with the type of sediment. Some species prefer to live in or on fine mud, while others require clean sand, pebbles, or larger cobbles.

Worms in a muddy substrate



In wave-washed shallows, bottom sediments may be coarse sand, pebbles, and/ or cobblestones. Muddy bottoms are found in sheltered embayments and deeper reaches undisturbed by wave action.

Soft bottoms are arranged in layers that differ in grain size and availability of oxygen. In surface layers, oxygen is plentiful and benthic animals may burrow actively. Below the surface are layers containing various microbes that break down organic matter and recycle nutrients for use in the water column. Lower layers of sediment that lack oxygen support more specialized microbes.

Patterns of Zonation on Rocky Bottoms

Bands of seaweed, like those seen in the intertidal zone, run parallel to the coast in nearshore waters. This is because each species of marine plant responds a little bit differently to any given environmental condition. Conditions change moving down from the wave-swept shallows to calmer, cooler, and darker depths. The depth at which each band of vegetation occurs can vary from one stretch of coast to another. This reflects geographical differences in tidal regime, geology, and ice scour.

Inhabitants

Planktonic Soup

At certain times of the year the water becomes thick with planktonic organisms. Many of these, such as bacteria, diatoms, dinoflagellates, protozoans, and the larvae of many marine species, can only be seen with a microscope. Think of all the life that may be in the next mouthful of sea-water you swallow!

see activities 9, 25, 26, 27

Along with being classified as either phytoplankton or zooplankton, plankton are further divided as part-time or full-time members.

For further information on plankton please refer to module 1: Introductory module, and module 13: Activities.

Full-time Plankton

Organisms that are planktonic throughout their life cycle are called holoplankton. Diatoms, dinoflagellates, protozoans, comb jellies, copepods, and euphausiids are some of the full-time members of the phytoplankton. You will meet these organisms on the following pages.

Diatoms

Diatoms are single-celled plants that range in size from 15 microns to 1 mm. (There are 1,000 microns in a millimetre.) There are two basic cell shapes: centric and pennate. Centric diatoms, the most common ones, may be square, round, or triangular, while pennate diatoms are boat-shaped and more benthic. All diatoms are composed of two tightly fitting valves, which make the centric diatoms look like pill boxes under the microscope.

Tube-dwelling Diatoms

Diatoms are single-celled plants usually found floating in the water column. However, some species live in tubes attached to the sea floor or to other plants. These colonial diatoms may fool you - they look like branched brown seaweed.

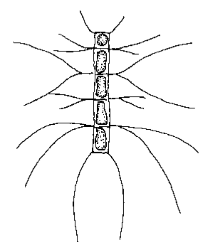
Dinoflagellates

In a plankton sample from Maritime coastal waters diatoms will usually be more abundant than dinoflagellates. However, localized blooms of dinoflagellates can occur. Despite their patchy abundance, marine scientists pay considerable attention to dinoflagellates because they are responsible for the production of toxins that can accumulate in shellfish, and for 'red tides.'

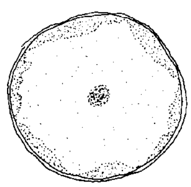
Some dinoflagellates are photosynthetic, and some, like animals, must obtain their food externally, and still others do both. All dinoflagellates are single-celled organisms with two whip-like flagella - hence their name dinoflagellate. The flagella give them some mobility, which they use most effectively to move up and down in the water.

Some diatoms and dinoflagellates

Chaetoceros sp.



Chaetoceros sp. are colonial, centric diatoms, and form chains of cells. The chain combined with the spines protruding from each cell may slow their sinking.

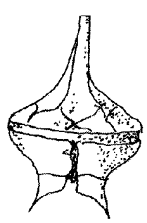


Coscinodiscus sp.

Coscinodiscus sp. are large centric diatoms that look like flying saucers under the microscope.

Gonyaulax sp.

Gonyaulax sp. is one of the dinoflagellate groups that is responsible for p aralytic shellfish poisoning. When very abundant, the pigment from these organisms turns the colour of the water red, hence the term red tide.



Peridinium sp.

Peridinium sp. are a common genus of dinoflagellate in coastal waters. Note the flagella lying along the horizontal and vertical girdles.

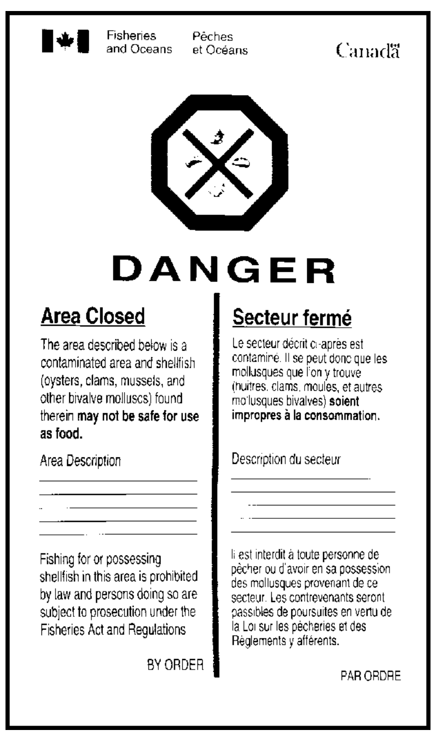
Toxins from plankton

Conditions are favourable in Maritime waters for the explosive increase in the numbers of diatoms and dinoflagellates each spring and fall. These events are called phytoplankton blooms and provide an abundant food source for many animals such as clams, mussels, and scallops. They strain the water of phytoplankton and other microscopic food items and are known as filter feeders.

Some phytoplankton produce substances that are extremely toxic to humans. Molluscs concentrate these toxins as they feed, but are usually not affected by them.

There are at least two types of shellfish poisoning now known to occur in the Maritimes. Paralytic shellfish poisoning (PSP) is caused by a dinoflagellate that produces a substance 10,000 times more toxic than cyanide. Symptoms of intoxication include numbness in the lips and fingers followed by paralysis and an inability to breathe. This kind of poisoning is curable. Amnesic shellfish poisoning (ASP) is linked to a diatom known to produce domoic acid. Poisoning symptoms include vomiting followed by memory loss and disorientation, and damage caused by this type of poisoning can be permanent. In severe cases both poisonings can result in death. Government officials monitor mollusc growing areas and close the areas and post signs if shellfish poisoning is detected. Check with your local fishery officer before you dig.

Nutrient run-off from human activities may increase the severity of toxic blooms.



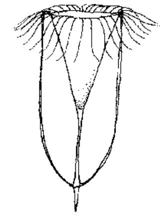
Other full-time plankton

Protozoans

Protozoans are one-celled animals usually no larger than a millimetre. (There are 1,000 millimetres in a metre.) They feed on diatoms, detritus, and other small protozoans, and in turn are eaten by larger zooplankton.

Tintinnids

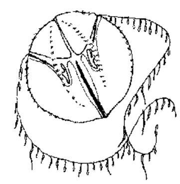
Tintinnids are a common group of protozoans in coastal waters. They have a vase-like shell crowned with microscopic hairs (cilia) which they use to capture food. Although tintinnids are small they are heavy feeders and may consume between four and 60% of phytoplankton production. Parafavella species are common in maritime plankton and feed on diatoms.



tintinnid

Ctenophores

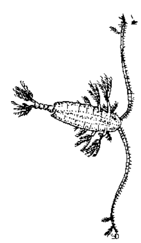
Ctenophores are jelly-like, but are not jellyfish. They're round and look like a plum or gooseberry with tentacles. With their two sticky tentacles, they capture zooplankton, such as copepods (see below), and fish larvae. When numerous they can clean the water of zooplankton including the larvae of commercially important fish species. They move by the beating of eight longitudinal rows of iridescent cilia, which often gives their presence away. The Sea Gooseberry looks very much like a large gooseberry with tentacles.



Sea Gooseberry

Copepods

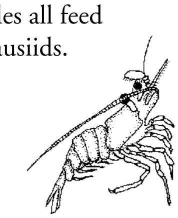
Take a close look at a plankton sample and you will see mysterious dots zipping around. Under the microscope some of these dots will turn out to be copepods. Copepods are crustaceans that look like miniature shrimp with an outstretched tail. They feed on diatoms and smaller zooplankton and in turn are fed on by many animals including the largest in the world, the baleen whales.



copepod

Euphausiids (or krill)

Euphausiids are shrimp-like crustaceans and most grow to about 1.5 to 2 cm in length. Like copepods, they're abundant in the plankton and fish, birds, and whales all feed on them. In the Bay of Fundy, Fin Whales feed on dense patches of euphausiids. Fishers may know them as red feed.



euphausiid

not to scale

Part-time Plankton

Organisms that reside in the plankton for only part of their life cycle, usually the larval stage, are called meroplankton. Below are just some of the benthic and nektonic organisms that have a planktonic stage: Sponges, sea anemones, hydroids, annelid worms, periwinkles, clams, scallops, crab, lobsters, barnacles, sea stars, brittle stars, sea cucumbers, sea urchins, tunicates, flounder, herring, Lumpfish, cod, tuna and many, many more.

Jellyfish

Jellyfish can be considered meroplankton, because many have a benthic phase in their life cycle. In the spring minute jellyfish bud or pinch off from the attached benthic body and begin a life of drifting.

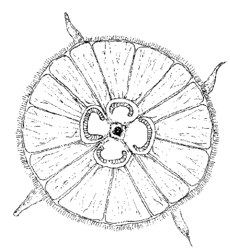
Do the jellyfish in Maritime waters sting?

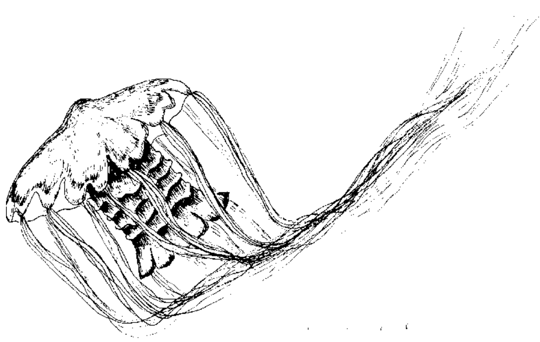
Most jellyfish use their tentacles to capture prey. Ranging along the tentacles are many little coiled darts which, when triggered, sting or stick to prey. The mouth of the jellyfish is found on the underside of the animal and leads to a dead-end digestive tract.

Moon Jellies, which become extremely abundant in the nearshore zone in early summer, produce a weak sting, largely undetectable by humans. The Lion's Mane, as perhaps the name suggests, produces a more powerful, but short-lived sting. The sting can however be very dangerous to people that have a sensitivity.

Moon Jelly

Moon Jellies have four pink oval-shaped gonads, which can be easily seen through the almost transparent body.





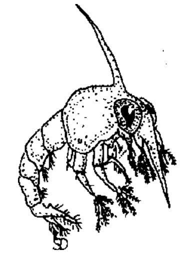
Lion's Mane

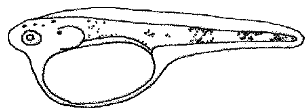
Lion's Mane can grow to a metre or more in diameter and has tentacles that reach down 20 m or deeper.

not to scale

crab larva

After hatching from eggs carried around on the abdomen
of the female, the crab larvae enter the plankton for 2 to 6 months.





cod larva

Cod begin life as a buoyant egg that hatches in the water column. The larvae move with the current until they reach lengths of between 2 and 5 cm at which time they descend to the bottom.

Seaweed on the Sea Floor

The Reds, Browns, and Greens

Marine plants, called seaweed, add colour and shape to the sea floor. Seaweed is important as food for animals. It also provides three-dimensional space where animals shelter, breed, and deposit eggs.

Seaweed is divided into three main groups on the basis of colour, i.e., red, brown, and green. There are more than 350 species in Eastern Canada, with the reds and browns being the most numerous. Some species are tough enough to tolerate periodic drying out. These are found in the intertidal zone. The vast majority need to be continually submerged in water. These plants live below the low tide mark or in tidal pools.

rockweed (brown)

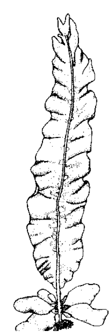
Rockweed with its air-filled bladders reaches up to the light, providing nooks and crannies to shelter shallow water animals.

leaf weeds (red)

Phyllophoras are lower shore to deep water plants with translu cent rosy blades at the tips of wiry stems.

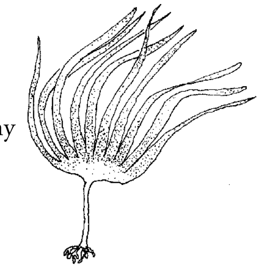
Edible Kelp (brown)

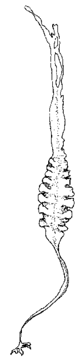
To gather the Edible Kelp you need to be quick and work at the lowest spring tides. It is found only in very wave-exposed locations.



Horsetail Kelp (brown)

This kelp is also good to eat. Try adding it to soup for a healthy dose of minerals and vitamins.



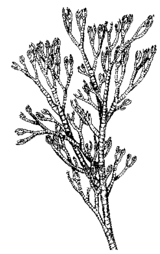


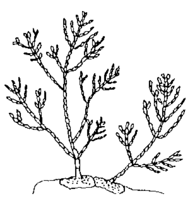
Sugar Kelp (brown)

This broad, frilly kelp is good to eat. As it dries, a white powder often comes to the surface. Taste it. It's a mixture of sea salt and the sugar mannitol.

Banded Weed (red)

You will often find this small bushy seaweed attached to larger plants. The bands on every branch can be seen with a hand lens. Look also for the inward-curving forked tips.



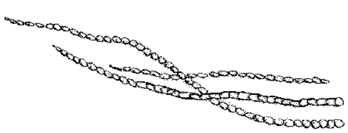


Encrusting Coralline Algae/Coral Weed (red)

These 'living rocks' have limestone in their cell walls.

Bootlaces (brown)

Bootlaces dried in the sun and heated to a crisp in the oven are a delicious snack. This flexible, slender seaweed grows attached to tiny pebbles and sessile animals as well as current-swept bedrock.



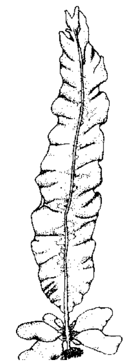
Green Thread Algae (green)

Even without a hand lens you can see the emerald green, bead-like cells of this simple filamentous seaweed.

Which seaweed lives where?

The colour and intensity of light, effective day length, temperature regime, timing of nutrient availability, wave stress, type of rock available for attachment, and the frequency and timing of disturbance all influence where a plant can grow.

Moving out to sea on rocky shores of the outer coast and Bay of Fundy, you find small red, green, and brown seaweed over-arched by a canopy of large brown kelp.



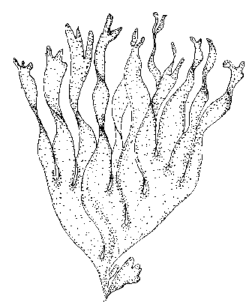
kelp

In the southern Gulf of St. Lawrence, however, kelp can't be seen from the low tide mark. The friable sandstone bottom doesn't provide a secure anchorage for large plants in wave-swept shallows. Another factor is ice, which covers the Gulf for months in winter and scrapes the bottom bare where it touches. Instead of being covered in kelp forests, these shallow, disturbed sandstone bottoms are often dominated by a dense turf of red seaweed to depths of 10 to 15 metres. A relatively sparse kelp forest occurs in deeper water.

Beyond the inshore kelp forests, hard bottoms are often occupied by scattered deep-water kelp called Sea Colander and various kinds of red seaweed including the leaf weeds.

Sea Colander

Slow-growing red seaweed dwells in the deepest reaches of the nearshore zone, often deeper than 20 m. Their red pigments are particularly sensitive to the dim blue light that penetrates to that depth.



Dulse

The seaward extent of vegetation may be limited by lack of light. Often, however, the lower limit for seaweed is determined by the presence of sand or by the activity of plant-eating sea urchins.

Seaweed design

Seaweed may be microscopic filaments, delicate branching tufts, leafy blades, fleshy crusts, or stony lumps. The bodies of plants growing in shallow water must either be flexible and resilient or very tough and pressed to the bottom to cope with the impact of waves and the force of underwater currents.

Compared to land plants, seaweed look simple. Their blades are often no more than a few layers of colourless internal cells flanked by a row of outer, coloured cells. In many cases, their bodies are made up of filaments stuck together rather than of three-dimensional tissues.

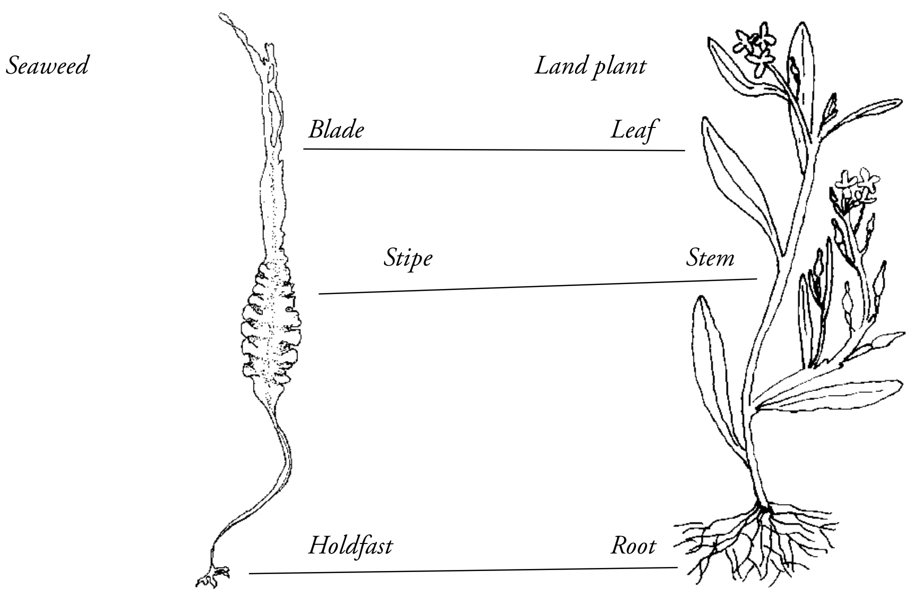
Seaweed have few specialized organs. Some have air-filled bladders to buoy them up in the water column and expose their blades to light. Others use stiff stems to hold up their blades.

Seaweed are attached to the bottom by branching or disc-shaped holdfasts but, unlike land plants, these are not designed to absorb nutrients. Most seaweed holdfasts need stable bedrock to cling to. Others make do with pebbles, sessile animals, or other seaweed. Some have hooks on their branches to help them catch hold.

A few kinds of seaweed can grow unattached, but these are either restricted to sheltered embayments or stay far out to sea. Seaweed drifting in active nearshore waters is frequently cast up on shore to dry and perish.

Nutrients are taken up through the entire plant surface. Only the large kelp have anything resembling the vascular tissue of land plants, and this tissue is used to move minerals and carbohydrates between the blades and the stem.

For more information about and activities with seaweed please refer to module 13: Activities.



Seaweed Colours

All algae contain chlorophyll, which is the pigment that is directly involved in the transformation of light energy into chemical energy. If light energy is to be used, it must first be absorbed by a pigment, which is any substance that absorbs light. The types of pigments present determine the depth at which the seaweed can live in the ocean. Less than two per cent of the ocean floor is shallow and solid enough for plants to attach to it and receive enough light energy for photosynthesis to occur. The different colours in algae are the result of the pigments present in different combinations with the chlorophylls.

Different species of algae can occur at varying depths because the different colours in their pigmentation allow for absorption of light at different depths.

Most of the algae in the world are red algae; there are more than 4,000 species identified. They grow attached to rocks and on to other algae (epiphytic). They have been found 175 metres below the surface of the ocean.

Red algae contain green, orange, and red pigments that combine to give them their distinctive red colour. This colour allows them to absorb the blue light that can penetrate deep water, and thus allow them to grow in deeper water than algae with other pigmentation.

Brown algae contain green and different orange pigments. They are often large in size and are found along rocky coasts. With the red algae, they make up the principal groups of large seaweed. They're found in shallow depths or with fronds floating near the surface connected to the holdfast by a long stipe. Fifteen hundred species have been identified.

Green algae contain green and some orange pigments. More than 7,000 species occur in this group. Some are marine, but most are freshwater species. They are very common in tropical marine systems.

How does seaweed reproduce?

Seaweed reproduction is extraordinary to anyone familiar with land plants. In kelp, for instance, the plants we see are just one manifestation of a complex cycle that includes microscopic male and female plants. Females produce attractive chemicals which, when released into the water, guide the swimming male sex cells to the waiting egg. A fertilized egg grows into the large kelp plant. Mature kelp produce millions of special swimming cells called spores. These are found in raised patches found on the blade. The spores are released from the blade and swim to the bottom, where they use their light-sensitive pigment to find a well-lit settling place. Each spore then grows into either a male plant or a female.

Red seaweed is the most complex. They have male, female, and spore-forming plants as well as a parasitic stage. Each stage and sex may have a different physical form.

Many species of seaweed can also reproduce vegetatively, either by casting off specialized bodies or by simple fragmentation.

Animals on the Sea Floor

By far the most common of the bottom-dwelling animals are invertebrates; that is, animals lacking an internal, bony skeleton. Invertebrates have a wide array of body types, and include soft-bodied worms and anemones, delicate hydroids and bryozoa, leathery sea squirts, sponges supported by glass or lime spicules, echinoderms with limestone deposits in their skin, hard-shelled molluscs and armoured arthropods. Some of these animals are active and mobile; others are sessile and attached permanently to the bottom. A few may be mobile or sessile at different stages in their life.

The arthropods and worms are related to the insects and worms found on land. However, most of the other animals resemble nothing that is found on land; indeed, they are members of families that have no terrestrial members.

On the next couple of pages we will look at these creatures of the bottom.

Molluscs

Molluscs include widely different body types, from crawling snails to sessile, filter-feeding clams to swimming octopuses.

For further information on molluscs please refer to module 1: Introductory module, and module 13: Activities.

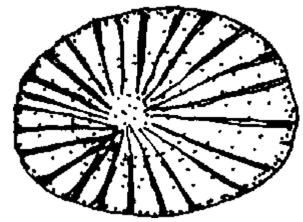
Preferences of gastropods

Different gastropods prefer different types of bottom surfaces. For instance the Chink Shell, like the Tortoiseshell Limpet, can be found scraping the surface of large seaweed and Eelgrass. The large white Moon Snail is common on soft bottoms where it plods through the sand in search of clams, its favourite food. Dogwinkles and whelks move across rocky substrates in search of prey, such as periwinkles and mussels.

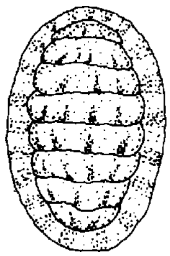
Some like it warm

Some invertebrates require relatively warm summer temperatures for growth and reproduction and are common only in the southern Gulf of St. Lawrence. These include the American Oyster. Such warm-water animals, together with plants that are otherwise restricted to shores south of Cape Cod, are remnants of the fauna and flora that occupied our nearshore approximately 7,000 years ago when the coastal waters were relatively shallow and warm.

Tortoiseshell Limpet



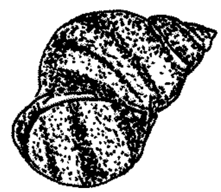
Common simple, flattened cone inside and out; rounded to oblong-oval with checked border. On rocks, kelp, and Eelgrass. 2.5 cm.



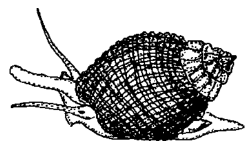
Red Chiton

Red Chitons look like limpets, but instead of one shell, they have a shell made up of eight plates. This gives them more flexibility and when pried from a rock they can curl up like a pill bug. The chiton wears a shell made up of eight sections, or valves, in a row. 2.5 cm.

Chink Shell



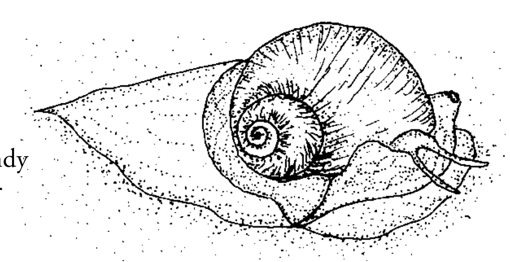
The Chink Shell is periwinkle-like, often delicately banded. Found subtidally but also on Eelgrass. 1.2 cm.



Dogwinkle

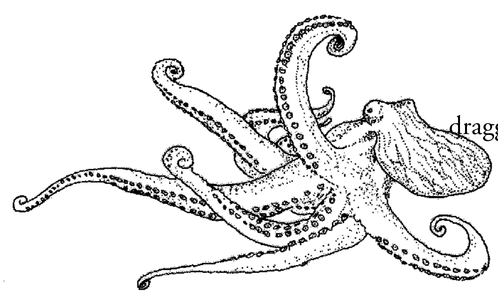
The predatory Dogwinkle feasts on other molluscs. 2 cm.

Moon Snail/Common Northern Moon Shell



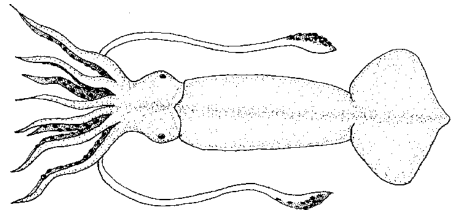
The large white Moon Snail with its unusual collar-shaped egg case is common on open sandy and muddy bottoms. This snail preys on other molluscs. 10 cm.

Offshore Octopus

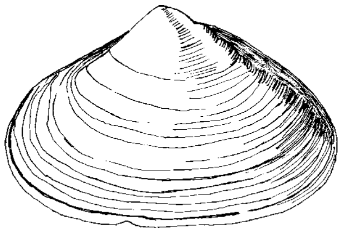


Among the most highly evolved of the molluscs is the Offshore Octopus. This octopus is two feet long, rough and warty. It’s often caught in bottom-dragging fish trawls. 60 cm.

Short-finned Squid



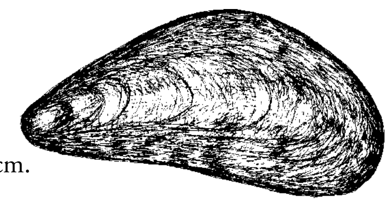
The Short-finned Squid feeds on young herring, mackerel, and krill. A relative of the octopus, it's known for squirting black ink to confuse pursuers. Squid has been used for many years as bait in the cod fishery. 22.5 cm.



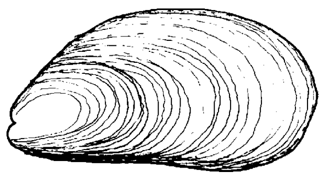
Surf Clam

The somewhat triangular Surf Clams burrow in soft, sandy bottom sediments. Surf Clams occur in the surf zones of beaches. 17 to 20 cm.

Blue Mussel

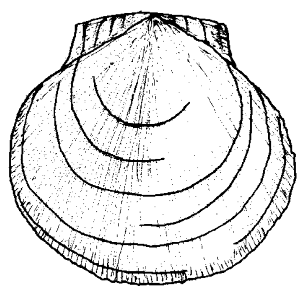


The edible Blue Mussels attach themselves by extremely tough threads to any solid surface - including other mussels and the bottom of boats. 10 cm.



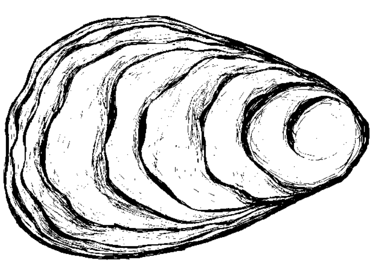
Horse Mussel

The large brown Horse Mussel may carpet broad areas of the bottom and is not edible. 15 cm.



Sea Scallop

Sea Scallops, unlike their sedentary relatives, can clap their finely ribbed shells and 'swim.' They occur in deep water. 20 cm.



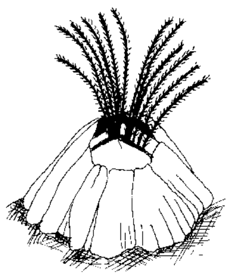
American Oyster

The American Oyster does not tolerate either high or too low salinity in the water. It grows in the intertidal and subtidal areas. This famous bivalve has a massive, rough shell that is extremely variable in shape. The oyster is susceptible to various diseases and to pollution. Oyster culture is practiced in some locations in Atlantic Canada. To 25 cm.

Crustaceans

These invertebrates encased in jointed external skeletons include the popular, edible lobster, shrimp and Snow Crab. Lesser known arthropods are the sea spiders, isopods, amphipods, marine insects and mites.

Although isopods and amphipods are small, often only a few millimetres in length, they are abundant and play important roles as food for fish. Some species assist seaweed by eating the epiphytes that threaten to compete for light and nutrients. Other species scavenge bits of dead fish, crabs, and the like. The Gribbles bore through wood. A few species build tubular shelters and live in sand or mud.



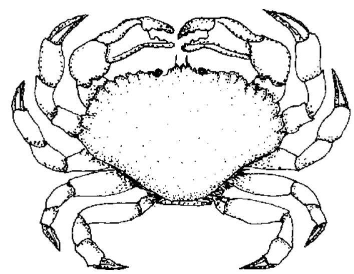
barnacle

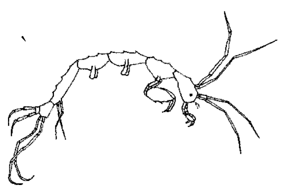
see activity 34

Barnacles do not look like crustaceans. They attach themselves to rocks, wharves, boat hulls, and other solid surfaces. 2.5 cm. For more information on barnacles please refer to module 7: Rocky Shores, and module 13: Activities.

Rock Crab

Rock Crabs are often caught in the same area as lobsters. Also found under rocks in tide pools. 13.1 cm.



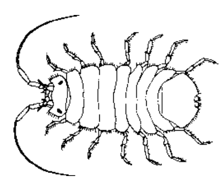


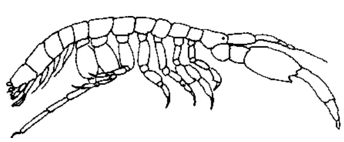
skeleton shrimp

This shrimp resembles a praying mantis. This curious creature may be found hiding in tufts of seaweed or floating with the flotsam at the sea's surface. 1.9 to 5 cm.

isopod

Isopods resemble the pillbugs found in rotting wood on land. You can attract them easily to a bit of rotting bait but be careful - they may nip your finger too. They remove decaying material and are found swimming and crawling in crevices, on wood pilings, and burried in the mud. Around 3 mm.

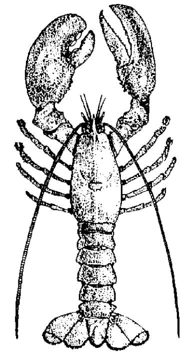




tube-building amphipod

The amphipods can be identified by their unique side-swimming style. Tube-building amphipods shelter in tubes that they build in fine sand, mud, and debris. To 8 mm.

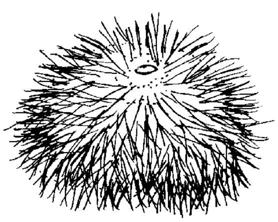
American Lobster



Lobsters usually hide in kelp forests and red seaweed turfs or under rocks. However, at times they can be found marching across open sand and may travel hundreds of miles in their lifetime. The American Lobster casts off and replaces its shell at intervals in order to grow. These moults occur more frequently where the water is warm, which is why lobsters grow more rapidly in the Gulf of St. Lawrence than they do on the colder outer coast. To 90 cm.

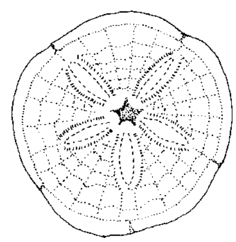
Echinoderms

Echinodermata translates from Latin as spiny skin and most species in this phylum (large group of animals) are prickly. The exception is the sea cucumbers, which are more slippery than spiny. The structure of the echinoderms reflects a five-part symmetry. You can see this in the five arms of the sea stars, the five-part design on a sand dollar's shell or test, or the five rows of tube feet on the sea cucumber.



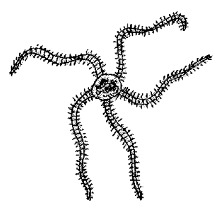
Green Sea Urchin, Common Sand Dollar

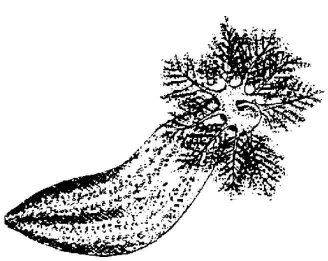
Prickly sea urchins (7.5 cm) and disk-like sand dollars (7.5 cm) wear skeletons of close-fitting limestone plates adorned with spines. They move about on a multitude of tiny tube feet. When they lack food, sea urchins actually grow smaller.



Dwarf Brittle Star

The skeletal plates of the sea stars are deeply embedded. These creatures have a remarkable ability to regenerate lost arms. Disk 0.5 cm, arms 5 times longer.



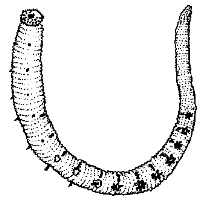


Orange-footed Cucumber

In contrast to the other echinoderms, which have a well-defined radial form, the Sea Cucumber looks like a fat worm and changes its shape easily. It has only minor deposits of lime deeply embedded in its leathery skin. To 25 cm.

Worms

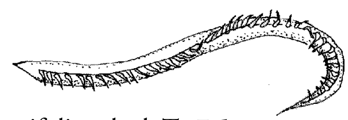
A wide variety of marine worms are found on and in sandy and muddy bottoms, or hiding in seaweed turfs and kelp holdfasts on rocky bottoms.
We are used to earthworms that eat dirt. Some marine worms do the same while others are parasites, scavengers, filter-feeders, or active hunters.



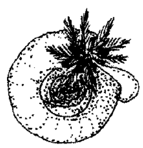
Lugworm

Lugworms spend their life at home in u-shaped burrows in soft sediment. They do not move. 30 cm.

opheliid worm



Clean sand attracts some spindle-shaped opheliid worms, while other species prefer to burrow in muck, and will move if disturbed. To 7.5 cm.



tube worm

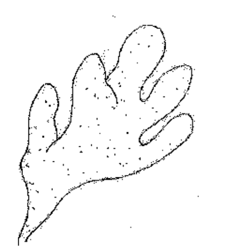
Tube worms build tightly coiled white, calcareous tubes around themselves that make it easy to spot them. 5 mm.

Other invertebrates

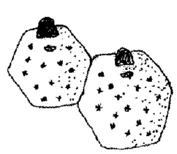
Bryozoans (animals that look like plants)

The bryozoa are tiny animals that live together in colonies attached to a variety of surfaces, living and non-living. Some grow into microscopic tendrils, others form flat crusts or upright bushy fronds resembling seaweed.

Leafy Bryozoan



This animal looks like a seaweed but look again! On close inspection you can see that it's a colony made up of multitudes of tiny animals, each encased in its own delicate house.

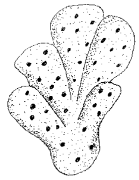


Micropore Crust

Glassy white crusts on the surface of seaweed become increasingly common as summer progresses.

Other invertebrates

Sponges



Palmate Sponge

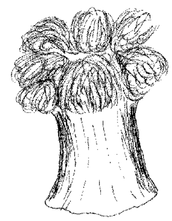
Sponges are widely distributed and never move. Some species can live for decades, often without growing visibly from year to year.

Cnidarians

Decorating inshore rocky bottoms, and especially on shaded walls, flower-like anemones nestle amid brightly coloured sponges and bulbous sea squirts.

Frilled Anemone

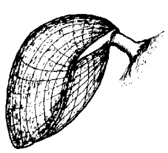
The anemones look like harmless plants, but they are hunters with tentacles armed with stingers to poison small animals. They can reproduce by budding off tiny offspring from the base of their body.



Garland Hydroid

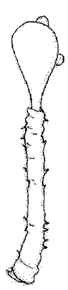
Hydroids come in a confusing variety of shapes and sizes. Many spend part of their life as an attached, vine-like, colonial animal and the rest of the time floating in the water in the shape of a tiny jellyfish. Others are exclusively attached or exclusively floating. Hydroids are often found together with bryozoans and tube worms, decorating the surface of kelp and other seaweed.

Brachiopods



The brachiopods, commonly called lamp shells, are ancient lifeforms that flourished 400 million years ago. Only a few species remain. They have a pair of shells but are not bivalves. They're attached to the bottom by fleshy stalks.

Tunicates



sea squirt

Sea squirts, like sponges, pump water through their bodies, filtering out bits of food.

not to scale

Fish

The abundant supply of plankton in coastal waters - the euphausiids, copepods, and ctenophores, etc.- supports large schools of small pelagic fish. Fishers refer to these schools of herring, mackerel, Capelin, and other small pelagics as bait or baitfish. Indeed, they use the fish to bait their lobster and crab traps, and long-line hooks.

Moreover, the term baitfish or foodfish is also ecologically appropriate because larger fishes feed on these small pelagics. In Atlantic Canada many of these larger fishes are commercially important, such as the Atlantic Cod, Pollock, Atlantic Halibut, Bluefin Tuna, Winter Flounder, Striped Bass, and several species of shark.

The small pelagics are also food for birds, whales, seals, and humans. In the case of Capelin, 10 fish species, five species of marine mammals, and nine marine bird species are known to forage extensively on this small, but abundant fish.

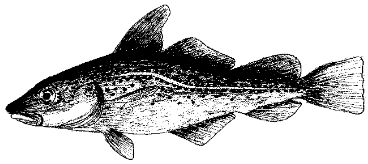
Prey and predators of adult fishes

The following table provides a rough, but clear picture of the importance of small pelagic fish such as Herring to coastal food webs and to the fishing industry.

Fish	Prey	Predators
herring	zooplankton	fish, birds, whales, humans
Mackerel	zooplankton	fish, birds, whales, humans
Capelin	zooplankton	fish, birds, whales, humans
Smelt	zooplankton	fish, birds, seals, humans
cod	Capelin, etc.	seals, whales, humans
Pollock	herring, etc.	fish, seals, humans
Salmon	Capelin, etc.	fish (tuna), seals, humans
Porbeagle Shark	herring, etc.	humans

Fish grammar

Did you know that when you refer to more than one species of fish you say fishes? For example, if you had a sample that contained 20 cod you would say 20 fish. If you had a sample that contained 10 Cod and 10 Haddock you would say 20 fishes.

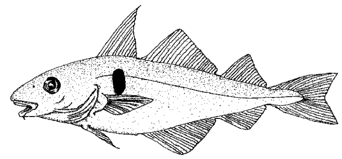


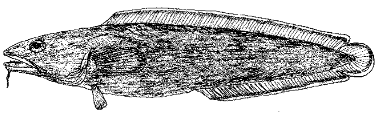
Atlantic Cod

Cod belong to the dominant and commercially important family Gadidae, which includes Haddock, Pollock, Cusk, and the hakes. 50 to 60 cm.

Haddock

Haddock, a relative of the cod, can be distinguished by the dark 'thumb print' above the pectoral fin. Around 50 cm.



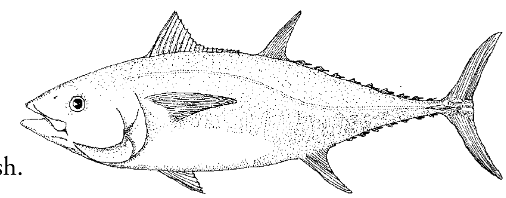


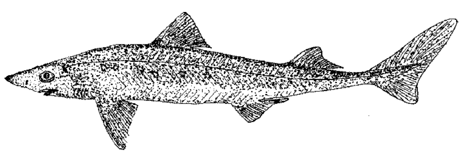
Cusk

Cusk are a mottled brown fish. Like most members of the cod family, they have a sensory appendage or barbel on the lower jaw that helps locate food on the bottom. 55 to 65 cm.

Bluefin Tuna

Bluefin Tuna are powerful, fast-swimming fish that can weigh up to 680 kg. This summer visitor can be seen porpoising through water in pursuit of small fish. Over 250 cm.



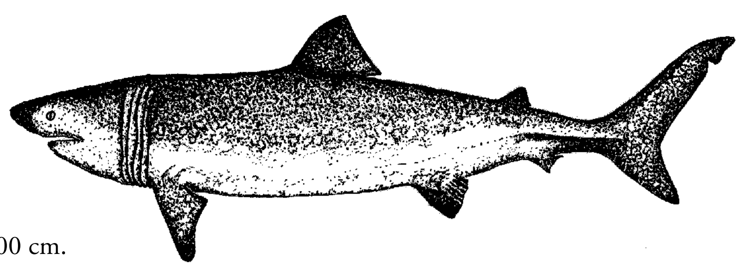


Spiny Dogfish

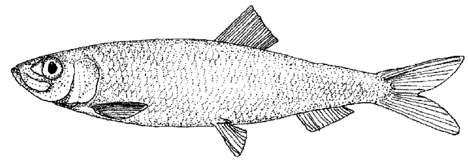
The Spiny Dogfish is a small shark that grows to a maximum length of one metre. It gives birth to live young after a 22-month gestation period. They are common in all waters. To 120 cm.

Basking Shark

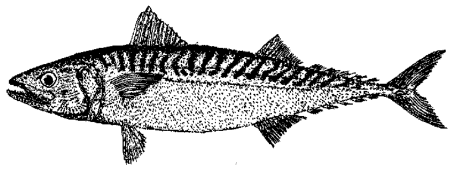
The Basking Shark is a slow-swimming, friendly giant that feeds on plankton. It appears in Maritime waters during the summer. 500 to 700 cm.



Atlantic Herring



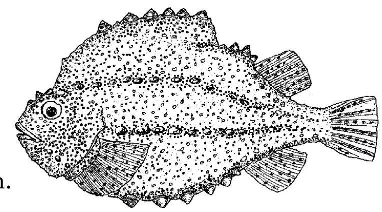
Atlantic Herring school in large numbers and often spawn in shallow water. Sardines are young Herring. To 37 cm.



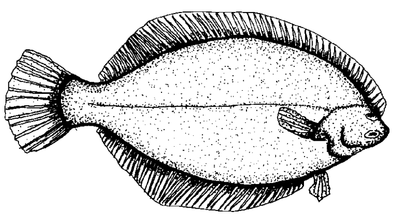
Atlantic Mackerel

Atlantic Mackerel, like most fish, are countershaded - dark back, light underneath - which makes them less visible to predators from either above or below. To 39 cm.

Lumpfish



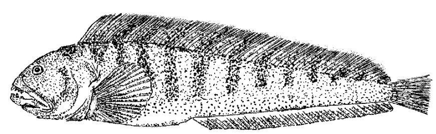
Lumpfish are rotund, stout fish with a round adhesive disc on the underside. In the spring, young Lumpfish are sometimes found sticking to lobster buoys. To 46 cm.



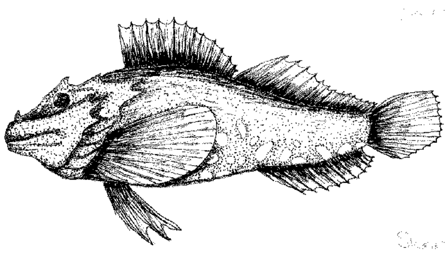
Winter Flounder

Winter Flounder are a laterally compressed fish that lie on their left side. 50 cm.

Atlantic Wolffish



Atlantic Wolffish have strong teeth and jaws and are capable of snapping a broom handle. To 77 cm.



Shorthorn Sculpin

Shorthorn and Longhorn Sculpins are common in the nearshore - watch out for the spines. They exhibit a wide range of beautiful, mottled colour patterns. 42 to 50 cm.

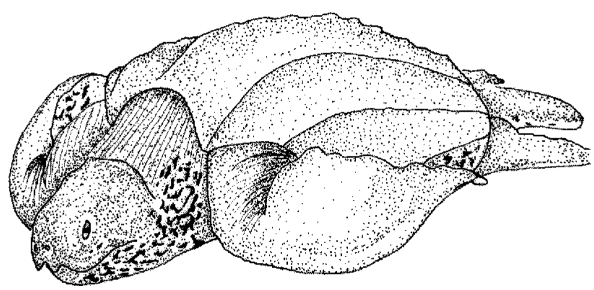
Reptiles

What animal may weigh over 500 kg and eat jellyfish?

Believe it or not large sea turtles from the tropics appear in Maritime waters in the late summer. The most common visitor is the Leatherback Turtle, probably because it can better tolerate cooler water than other species of sea turtles.

Like all marine turtles, the Leatherback is endangered. In the Maritimes it is often only discovered after washing up on the shore dead. The primary cause of mortality appears to be fishing gear (mackerel traps), in which the turtles become entangled. Turtles also die from swallowing plastic bags, which they mistake for jellyfish, their favourite food.

The Leatherback is most common along the Atlantic coast of Nova Scotia, but it also has been sighted in the Bay of Fundy and Northumberland Strait. It enters the nearshore zone when the water warms up in the summer.



Leatherback Turtle

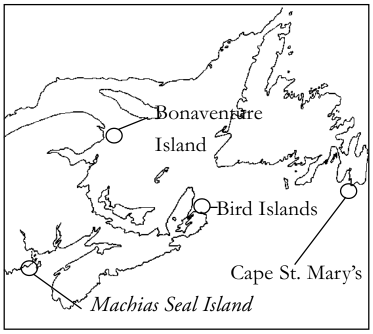
The endangered Leatherback Turtle's shell is unlike the bony shell or carapace of most turtles and is black and leathery with ridges that run from head to tail.

Birds

Seabirds nest in large colonies on offshore islands and on the rocky ledges of coastal cliffs. These sites provide seabirds, which are ungainly on land, with protection from terrestrial predators. Seabirds make efficient use of the limited nesting space that islands offer. Puffins and petrels dig burrows, gulls nest on flat grassy areas, guillemots and murres on ledges, gannets on rocky outcrops, and terns on sandy beaches.

For detailed information on seabirds and seabird colonies please refer to module 8: Coastal Islands and Cliffs.

European settlers exploited these vulnerable colonies, collecting the eggs for food and the young for fish bait, and shooting the adults for their feathers. As a result, a number of colonies were completely wiped out. Older residents describe Gannet Rock off southwestern Nova Scotia as being white with Gannets at one time. Today none nest there.



The most breathtaking colonies of seabirds in Atlantic Canada are found on the Bird Islands off Sydney, Nova Scotia, off Cape St. Mary's, New foundland, and Bonaventure Island off the Gaspé Peninsula. Puffins, Black-legged Kittiwakes, Guillemots and Northern Gannets can be ob served.

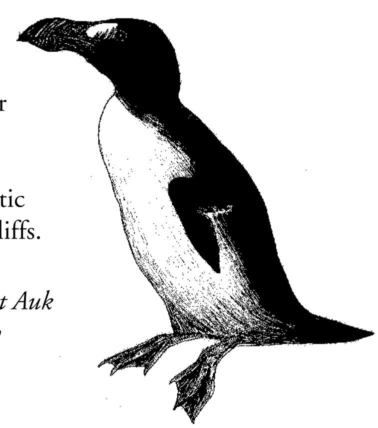
Gulls are nature's garbage collectors. They are one of the few seabirds that have benefited from human activities, as their numbers have increased in the last two decades. As scavengers they frequent public dumps and feed on wastes from the fishing industry. They also prey on the young of other seabirds.

Declining bird numbers

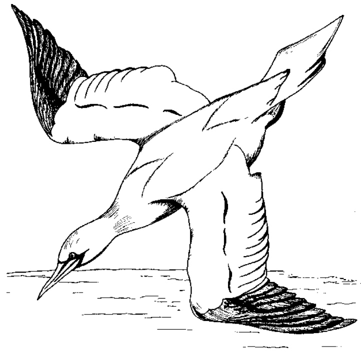
Many shorebirds were heavily hunted both commercially and for sport until the early part of this century. Barrels of plovers, sandpipers, and curlews were shipped to city markets. Birds such as terns were hunted for their feathers, which were used in the fashion business. Birds such as cormorants and gannets were shot because they were considered pests. Old-timers tell of shooting cormorants, also known as shags, until the barrels of their guns were too hot to touch. As a result several species, such as the Great Auk, the Labrador Duck, and Eskimo Curlew, became extinct in Atlantic Canada; others declined greatly in numbers and never rebounded.

Today, only ducks, geese and cormorants can be legally hunted in season (please check with your local natural resource offices and the Canadian Wildlife Service for more details). Many of these species nest in the Arctic or inland and overwinter on the ice-free parts of the coast.

For more information on seabirds and colonies in Atlantic Canada please refer to module 8: Coastal Islands and Cliffs.



Great Auk (now extinct)

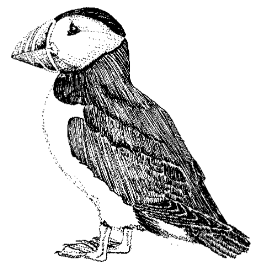


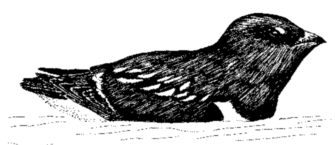
Northern Gannet

Northern Gannets breed in large colonies on the rocky ledges of islands such as Bonaventure Island off the Gaspé Peninsula. Adult Gannets are white with black wing tips and have a dusting of tawny brown on the head. They are spectacular divers and plummet from 30 m or more straight into the ocean, usually swallowing their prey underwater. 95 cm.

Puffin

These birds are a well-known member of the alcids, a group of birds that includes the murres, Guillemots, Razorbills, and the small Dovekie. They nest in colonies in Newfoundland and feed on Capelin and other small fish. 30 cm.



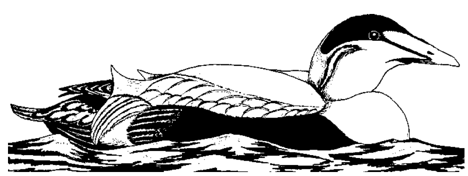


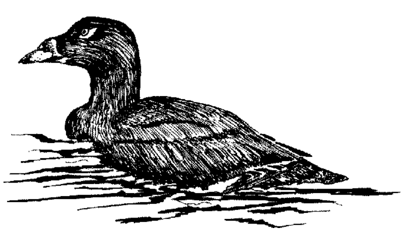
Dovekie

The smallest alcid, the Dovekie is a robin-sized bird with 'no neck.' It's sometimes blown ashore during winter storms and needs to be returned to the water before it can take off. 19 to 23 cm.

Common Eider

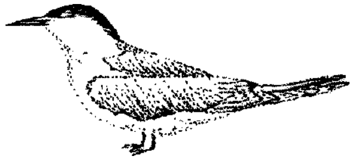
Common Eiders are handsome black and white ducks with strong bills. They form large rafts in fall and winter. 58 to 68 cm.





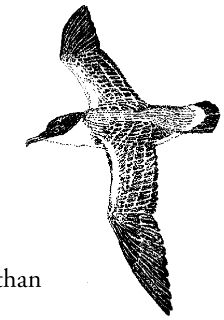
White-winged Scoter

The White-winged Scoter, like the Black Scoter and Surf Scoter, overwinters in Maritime coastal waters and nests in the interior and north of Canada. These three species are commonly referred to as coots. 53 cm.



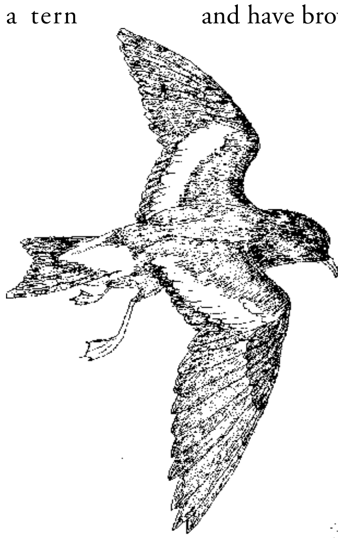
Roseate Tern

Like other, more common terns, the Roseate Tern looks like a small and agile gull. It is an endangered species. 35 to 43 cm.



Greater Shearwater

Greater Shearwaters breed at the other end of the world - off the southern tip of South America. Each summer, during the Southern Hemisphere's winter, the entire population migrates to the North Atlantic. These birds soar and glide so close to the water that it looks like they're shearing the crest off a wave. These birds are a little larger than a tern and have brown backs and white breasts. 48 cm.



Leach's Storm Petrel

Leach's Storm Petrels nest in large colonies such as the one on forested Kent Island in the Bay of Fundy. During the day the colony is silent, but at night the birds emerge from their burrows to feed, calling as they go. They look like large swallows with white rumps as they flit over the water in search of food. 20 cm.

Mammals

Whales

Scientists refer to whales as cetaceans and split them up into two groups: the toothed and baleen whales. Porpoises, dolphins, Orcas (Killer Whale), and Sperm Whales are toothed whales, what the Greeks referred to as sea monsters with teeth. They feed on squid and fish, with some species also feeding on benthic invertebrates.

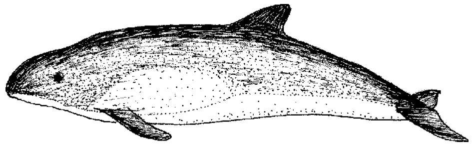
Baleen whales, instead of teeth, have long pliable rows of plates extending down from the roof of their mouth. These baleen look like a closely-spaced comb descending from the upper jaw. Baleen whales feed on zooplankton, such as copepods and euphausiids, and small fish. When feeding they take large mouthfuls of water and close their mouth, which forces the water out through the baleen, but traps the food. The Minke, Fin, and Humpback Whales are commonly seen in Maritime waters.

Can you see a whale from shore?

Only a few large mammals are regular visitors to the nearshore zone. Certainly for one species size may be a factor. An adult Blue Whale may be as long as 30 metres.

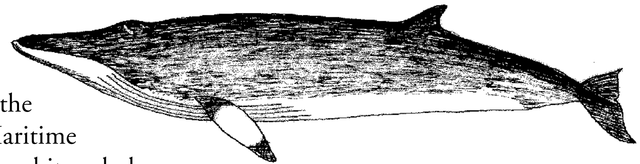
The best time to see whales from the shore is in summer and fall when their food is more abundant. You may also get a glance of a whale when taking one of the Maritime's many ferries. Whale watching cruises offer the best opportunity to see whales. Remember, boating activity can disturb whales, and federal guidelines state that boaters should keep 100 metres or more from whales. Furthermore, the Fisheries Act prohibits any attempts to pursue and harass whales.

Harbour Porpoises are common in the Bay of Fundy. Brier Island at the southwest tip of Nova Scotia is a good place to see porpoises and other whales. Pothead or Pilot Whales have a large bulbous 'forehead' and during the summer can be seen from lookouts in Cape Breton Highlands National Park. Humpback Whales can occasionally be seen from atop the cliffs of Grand Manan in the Bay of Fundy, and in Whitless Bay, Newfoundland. Minke and Fin Whales can be seen feeding on herring during the winter off Chebucto Head outside of Halifax.



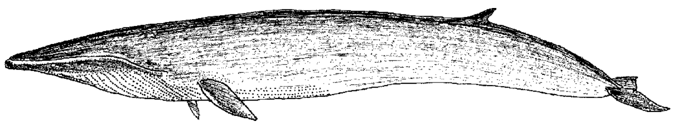
Harbour Porpoise

The Harbour Porpoise, a small, black, toothed whale, grows to almost two metres in length. To 1.8 m.



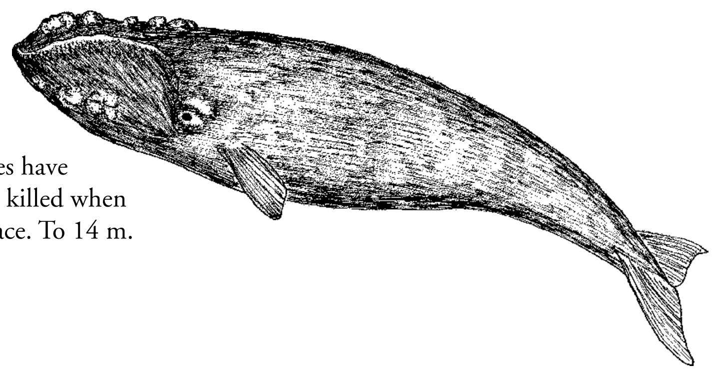
Minke Whale

Minke Whales are the smallest of the baleen whales that are found in Maritime waters. They can be identified by a white splash on their flippers. To 7 m.



Fin Whale

Fin Whales have a long back with a curved dorsal fin and usually feed alone. To 20 m.



Northern Right Whale

Right Whales are an endangered species. A number of these whales have been hit by ships and sometimes killed when feeding and breeding at the surface. To 14 m.

Seals

Populations of four seal species can be found around Atlantic Canada. Grey Seals breed off St. Georges Bay in Nova Scotia and off Sable Island. They give birth to pups from December to February. The pups are weaned after approximately two weeks and are then on their own. Shortly after, the female will mate with a dominant male.

Male and female Harbour Seals, unlike Grey Seals, spend most of the year together. They mate in the fall and the female gives birth in early spring. The greatest number of Harbour Seals is found on the east coast of Nova Scotia and on Sable Island.

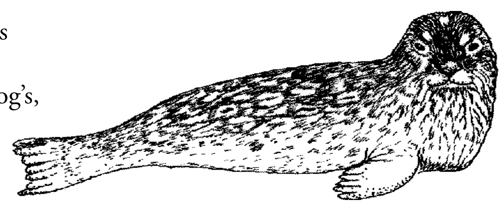
Ice in the Gulf also provides a breeding area for a large population of seals. Harp seals and Hooded Seals use the Gulf as their southernmost breeding area. Harp Seals are the most abundant seal in the Gulf of St. Lawrence. They are only present in the winter and spring. After the ice melts, they move north toward the Hudson Strait, Baffin Island, and Greenland.

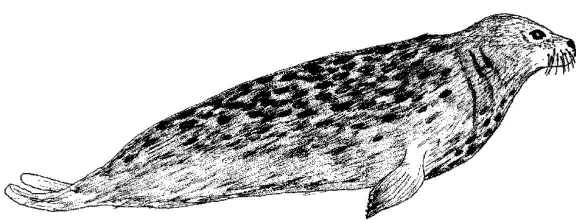
Hooded Seals are only present in the spring, and they will move toward Greenland in summer.

The presence of seals in winter and spring has created an opportunity for activities such as scientific research and ecotourism. Because of this some traditional fishing communities, such as those on the Iles de la Madeleine, have developed a winter tourism economy.

Harbour Seal

Harbour Seals can be seen hauled out on islands and rocky ledges along the coastline. The head of a Harbour Seal resembles a dog's, while the head of a Grey Seal resembles a horse's. To 150 cm.



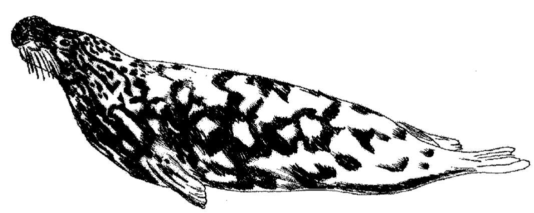


Grey Seal

The Grey Seal, locally called 'horse face,' is larger than the Harbour Seal and spends most of its time feeding in coastal waters. To 300 cm.

Hooded Seal

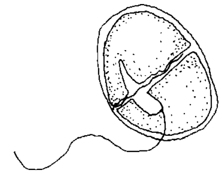
Hooded Seals, like the harps, breed on ice floes in the St. Lawrence and off Newfoundland and Labrador. The males have a strange, balloon-like nose from which they get their name. To 250 cm.



Harp Seal

Harp Seals get their name from the harp-shaped pattern on the backs of the males. The pups are born with a white coat, which they shed after about nine days. To 172 cm.

ECOLOGY



For an introduction to ecology please refer to module 1: Introductory module.

That Sinking Feeling - Adaptations in Water

Phytoplankton, like all plants, need light and must stay in the euphotic zone. However, diatoms and dinoflagellates are slightly denser than sea-water and have a tendency to sink. How do they stay up?

The shape and size of some diatoms may help. Features such as long spines, an elongated shape, and chains of cells create frictional drag and may slow the rate of sinking. Diatoms may also be able to regulate their buoyancy. Experiments have shown that dead cells sink twice as fast as live cells.

In contrast, dinoflagellates use two whip-like flagella to maintain their position in the water column. Currents also help to keep phytoplankton close to the surface.

The Ups and Downs of Zooplankton - Predator Avoidance

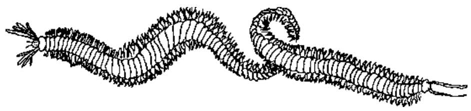
Zooplankton, such as copepods, feed on phytoplankton and therefore their distribution follows that of the phytoplankton, and numbers respond to phytoplankton blooms. But, unlike phytoplankton, zooplankton are not restricted to the euphotic zone. Scientists have noticed that many species of zooplankton descend to deeper, darker waters during the day and rise at night to feed. In offshore waters some species migrate 200 metres or more in one direction over a 24-hour period.

Zooplankton, by dropping below the euphotic zone during the day, are less visible and hence less vulnerable to predators. At night they rise to feed under the protection of darkness. Migration may also allow a copepod or other animal to change its position horizontally. At different depths currents may be going in different directions. This movement could be likened to getting on an elevator, switching to an escalator, and then getting back on an elevator.

Light and Dark - Adaptations

Light is fundamental to life in the nearshore. Marine plants, which transform light energy into living tissues, are the basis of marine food webs. The activity of marine plants changes according to the intensity and colour of the available light. Their reproduction often requires light of a specific colour or a particular combination of daylight and temperature.

The combination of spring low tide and full moon triggers light-stimulated reproduction in many animals as well as plants. Others respond to the blackness of a moonless night.



clam worm

Clam worms are richly coloured green and copper and live in burrows. These worms emerge and gather in vast swarms to breed in the water column at the time of the new moon in the spring.

The downs and outs of plankton

Some species, such as copepods, undertake seasonal migrations. They overwinter and reproduce in deeper water. In the spring, they move toward the surface to feed on developing blooms of phytoplankton.

Some phytoplankton produce a dormant stage and overwinter in the bottom sediment.

Why do so many benthic and nektonic species have a planktonic larval stage?

Many benthic and nektonic organisms have a larval stage that is planktonic for several months. The presence of the larval stage of crabs, mussels, sea stars, fish, and other animals in a plankton sample makes for fascinating viewing. Many of them are bizarre looking and bear little resemblance to the adults.

A planktonic larval stage allows the offspring to disperse and colonize new areas. Another advantage of being part of the plankton is the abundant supply of food present in the surface waters at certain times of the year.

Countershading

Many larval fish are virtually transparent. Many adult fish have a colour scheme adapted to underwater light. When viewed from below their silver underside blends in with the lit surface above. When viewed from above their dark backs blend in with unlit depths below. This makes it more difficult for a predator to see them. The occasional glint of a silver belly may be all that reveals the presence of a school of Mackerel in the water. This coloration is known as countershading.

There is Only So Much Room

Many bottom-dwelling animals and plants must attach themselves to a hard substrate. A rocky bottom is among the most desirable real estate for seaweed and sessile invertebrates. This space is under pressure from a continuous rain of potential settlers.

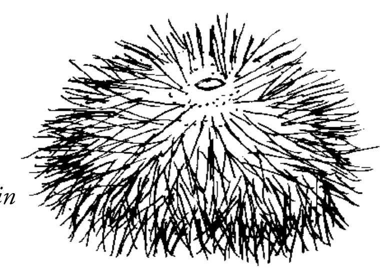
The outcome will vary depending upon which species are involved. A plant or animal that consistently wins against one species may be the loser when a different species is involved. The outcome may also be influenced by seasonal factors such as availability of light, nutrient levels, and water temperatures. Another important factor is the degree to which the space has been modified by previous occupants.

Erratic and seasonal physical forces can wipe out local winners and losers alike. The rocky bottom is at risk of being smothered by storm-driven sand and gravel or by sediment discharged from rivers. Large underwater boulders can be tossed and overturned during storms, crushing attached lifeforms and exposing clean surfaces for settlement. In winter, ice may scour large areas of shallows, or carve occasional furrows in deeper bottoms.

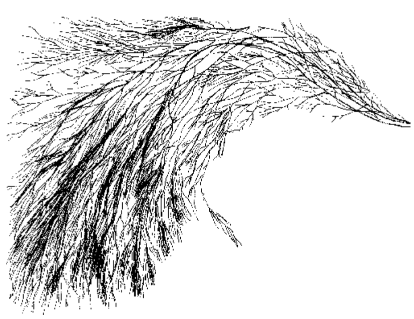
Precious space can also be reduced or its inhabitants disturbed and destroyed by human activities such as dredging, ocean dumping, bottom dragging for fish and shellfish, and marine construction.

Eating and Being Eaten - The Sea Urchin Story

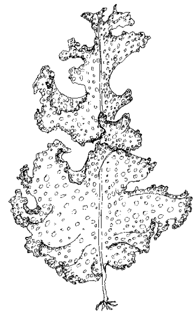
The endless drama of eating and being eaten may also change the look of the sea floor. Sea urchin populations are not always controlled by their usual predators, which include wolffish, lobsters, and crabs. The urchins may then concentrate on and consume vast kelp forests. They leave behind 'barrens' covered in coralline seaweed and dotted with other species.



Green Sea Urchin



Spiny Sour Weed is shunned by hungry sea urchins because the cells contain acid. If you collect this seaweed, keep it apart from other specimens, or the acid will dissolve them!



Agarum is commonly known as the Sea Colander, because of the many perforations in its broad blade. Sea urchins don't care for its tannin-rich blade, but they love to feast on other kelp.

Just a few sea urchins can maintain barrens and prevent recolonization by seaweed. The lack of cover makes the area poor habitat for lobsters, crabs, and other urchin predators.

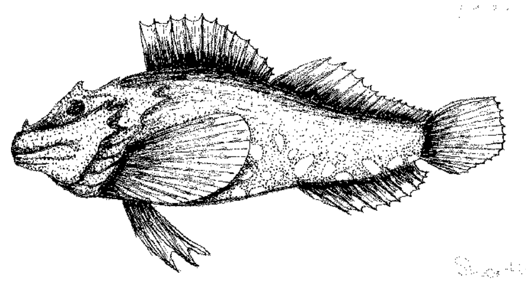
If the urchins die off or move away from an area, the seaweed beds may regenerate. The mix of perennial species that grows up depends in part upon the season of the year, as different plants reproduce in different months. In addition, there must be parent plants close by in some refuge not favourable to sea urchins, for instance wave-beaten shallows.

For more information on predator/prey relationships please refer to module 7: Rocky Shores.

Camouflaged

To avoid being eaten, or to hunt more successfully, some animals use camouflage. Flounder change colour to suit their background and become invisible to hungry predators. Sometimes individuals of the same species may be very different colours, perhaps because they live on different bottoms. Some Shorthorn Sculpins are bright orange, others are dark brown.

Shorthorn Sculpin



Producing Offspring - The Life of a Cod

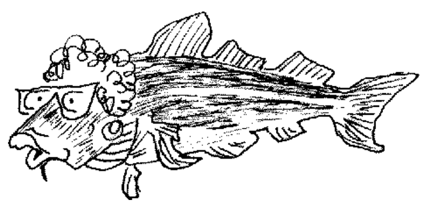
Atlantic Cod ranks as the most valuable commercial finfish species in Atlantic Canada, yet there is much we still don't know about cod, particularly its movements. Nonetheless, the life of an Atlantic Cod is not a complete mystery.

Would You Care to Dance?

Cod go through a courtship ritual before mating. (It may not always be easy to find a partner these days.) The male and female do an intimate dance moving from deeper water to the surface where they mate. To mate, the fish press bellies and release eggs and sperm into the water at the same time.

Cod spawn on offshore banks, such as Browns Bank, but smaller stocks or stocklets may possibly spawn closer to shore. Different stocks spawn at different times.

Grandma Cod



Recent Canadian research has shown that not only do larger cod lay more eggs, but their eggs have a better chance of survival. Here are some facts:

- a 51 cm cod may release 200,000 eggs while a 141 cm cod may release 12,000,000 eggs
- eggs from larger fish have larger yolks, which increase a larva's chance of survival
- larger fish release their eggs over a period of a couple of weeks, also increasing the odds for survival of the larvae

Odds Are One in a Million or Less

After the eggs hatch the larvae remain in the plankton until they reach a length of 2.5-5 cm at which time they drop to the bottom. On the bottom the juvenile cod are less visible to predators and continue to grow and feed.

The mortality rate of eggs and larvae is extremely high - millions die; if it wasn't, the oceans would be choked with cod. Two adult cod only need to have two surviving offspring for the population to remain stable.

Some years environmental conditions are more favourable and more young survive. As these fish grow and enter the fishery, fishers would likely see better catches for a time. Because cod lay millions of eggs, if the survival rate doubles from one in a million to two in a million, future catches might improve significantly.

Which Fish is Older?

Fish are cold-blooded animals and water temperature is one of the factors that regulate their growth. The warmer the water (up to a certain temperature) the faster a cod grows. A four-year-old cod from the warmer waters of Georges Bank may be twice as large as a four-year-old cod from the colder waters of Sydney Bight.

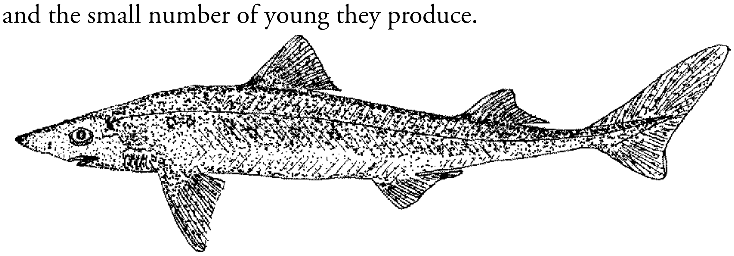
Two very different reproductive strategies

Groundfish, such as cod, Haddock, and Pollock, produce millions of eggs over a lifetime and nearly all of them die before reaching age one. At the other extreme, at least for fishes, are the sharks, which produce only a few young.

The Spiny Dogfish, a common shark in Maritime waters, has internal fertilization, that is, the young develop inside the mother. After a gestation period of 22 months, the longest for any vertebrate, she gives birth to from 2-15 live young. As individuals, these young sharks have a much better chance of survival than a cod larva. The odds for a dogfish are roughly one in fifteen while for cod it's roughly one in a million. The dogfish has adopted the strategy of producing a few young whose likelihood of survival is increased by a high level of parental care. The cod produces lots of eggs with very low chances of survival and will benefit when environmental conditions are favourable.

When overfished dogfish and other sharks may have difficulty bouncing back, because of the long gestation period and the small number of young they produce.

Spiny Dogfish



Productivity

The nearshore is both a nursery area for many species of invertebrates and fish and a nutrient pump. Nurseries are important because they help to sustain species.

Nutrients

Nutrients for plant growth are more available in nearshore waters than in the surface waters of the offshore. This is due in part to inputs from nutrient-enriched rivers. Nutrients in the water fluctuate seasonally. Stormy spring and autumn weather mixes the water column, bringing enriched bottom water to the surface. In summer, warm surface water forms a stable layer resistant to mixing. In winter, ice cover inhibits mixing in some areas.
At the mouth of the Bay of Fundy nutrients are pumped from the deep ocean to the surface year-round in a process called upwelling.

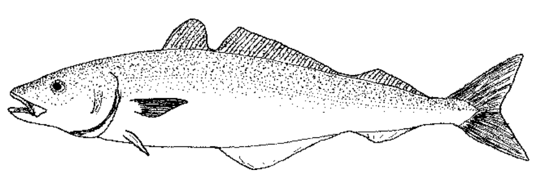
On a local scale, nutrients are recycled by animals, floating bacteria, and microbe-rich sediments.

For more information on nutrients and upwelling please refer to module 1: Introductory module.

The nursery zone

Pollock, also known as a Boston Bluefish in the supermarket, is one species that uses the nearshore as a nursery area. The 'harbour Pollock' caught off the end of the wharf and delicious pan-fried is not another species, just a young Pollock.

Juvenile Pollock move inshore and remain in coastal waters until approximately three years of age at which time they migrate to deeper waters. They may move into the nearshore zone to seek the cover of seaweed and other coastal features and thereby escape predation by larger fish.



Pollock

Blooming Waters

The floating plants or phytoplankton grow rapidly in spring and fall when nutrients are available at the same time as ample light for photosynthesis. During these plankton blooms the water can turn red, yellow, brown, or green, depending upon the type of phytoplankton dominating the growing population.

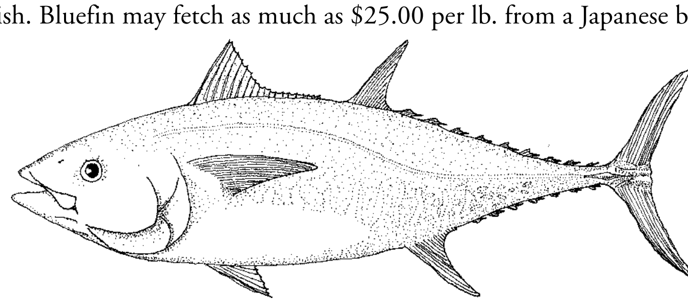
Organic matter produced by plankton blooms or swept out to sea from inshore seaweed beds rains down from the surface to sustain bottom-feeding animals in the gloomy deeps. Here, light is not sufficient for plant growth. As the rain of organic matter is broken down, nutrients are released back into the water column. As a result, deep ocean water is relatively enriched.
Most outer coast and Gulf of St. Lawrence waters are starved for nutrients in summer and seaweed have had to adapt. Some small, short-lived seaweed take advantage of brief pulses of nutrients derived from animal wastes. The long-lived kelp store nutrients in winter for use during the summer. Irish Moss switch from producing nitrogen-rich proteins to producing carbon-rich sugars and gums when nitrogen supplies are restricted.

The nearshore zone - a good place to dine

During the summer months fish, turtles, birds, and whales may visit coastal waters to take advantage of the abundant food supply. One of the most spectacular visitors is the Bluefin Tuna, which pursues mackerel, herring, and Capelin into the nearshore zone.

In certain years, Bluefin is a lucrative by-catch in the mackerel trap fishery along the Nova Scotia coast from Halifax to Lunenburg. The tuna enter the traps perhaps in pursuit of baitfish, and once in can't get out. In St. Margaret's Bay fishers have taken this one step further by keeping the fish alive and feeding them. The feeding increases their fat content and hence the price of the fish. Bluefin may fetch as much as $25.00 per lb. from a Japanese buyer.

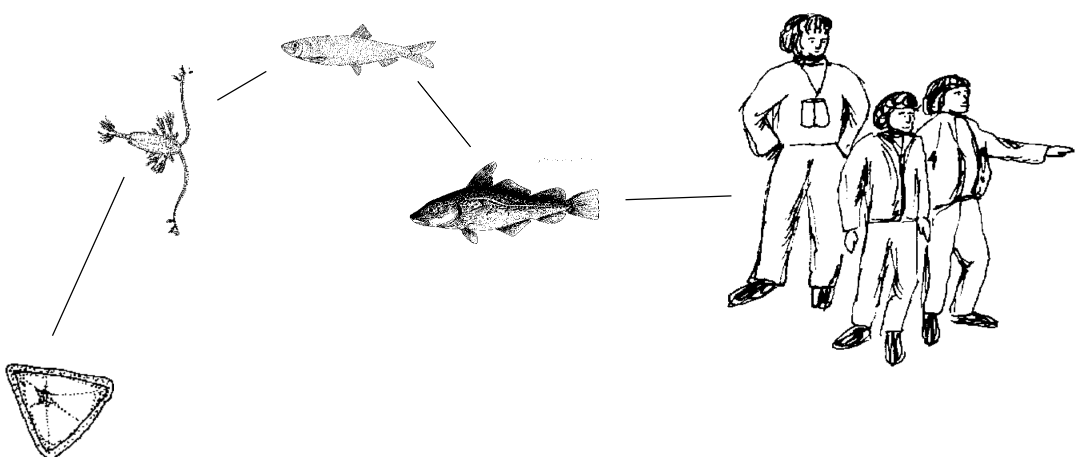
Bluefin Tuna



Food Chains and Food Webs

Ecologists talk of food chains and food webs to describe the array of feeding relationships that exist in the ocean. Recent research is suggesting that while useful concepts, their application is limited because of the complexity of marine ecosystems.

A food chain is the simplest representation of who eats whom. In Maritime waters, a typical pelagic food chain may have the following organisms in it: diatom, copepod, herring, cod, and human. This food chain has five trophic or feeding levels.

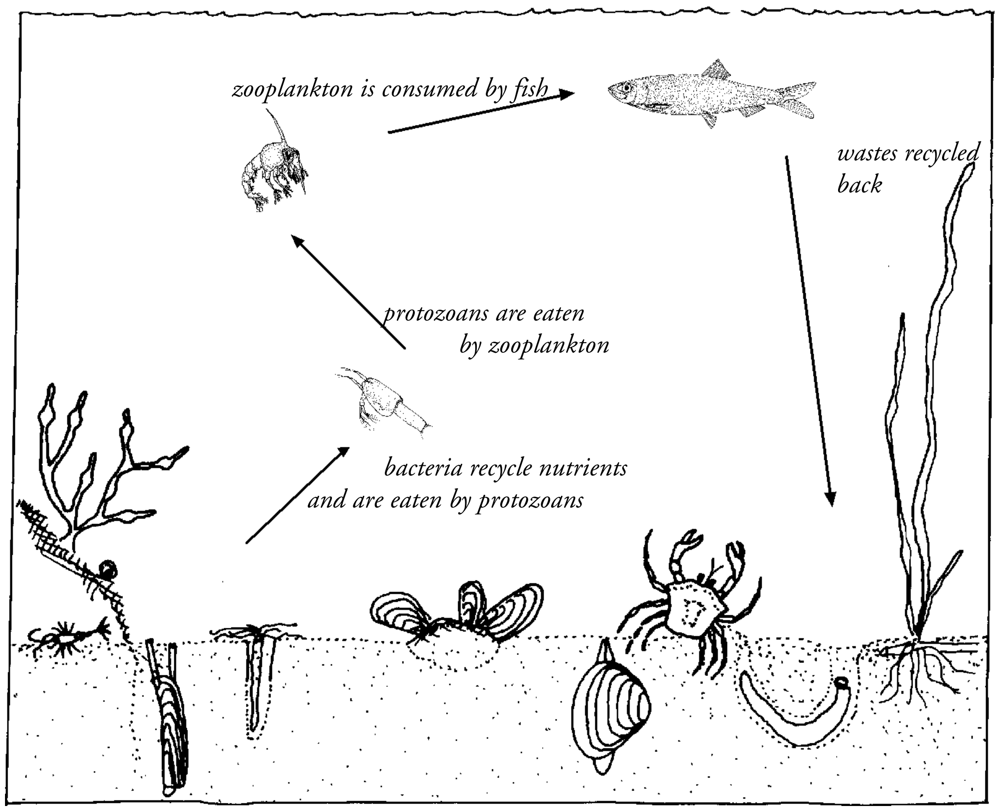


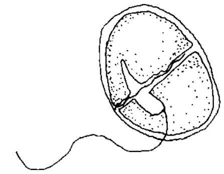
A food web shows the linkages between different food chains and as the name suggests, illustrates the web of feeding relationships that exist amongst all organisms.

A marine food chain often has more trophic levels than a terrestrial food chain. Compare the above marine food chain with a typical terrestrial food chain, which may be represented by the following organisms: grass-rabbit-coyote. The greater number of trophic levels in a marine chain may be partly explained by the small size of the lower level organisms. Most fishes cannot feed on phytoplankton directly because the phytoplankton are too small; there must be an intermediate level: zooplankton.

Marine researchers now think that the role of bacteria may have been underestimated in food chains and webs. Bacteria may play an important role in recycling the wastes and carcasses of pelagic organisms.

Small protozoans feed on bacteria, which in turn are fed on by larger zooplankton. Because bacteria are consumed by animals in the pelagic food chain, the nutrients remain in the pelagic zone. Wastes that are not absorbed by bacteria sink to the bottom to fuel benthic food chains.





THE NEARSHORE AND US

The people of Atlantic Canada have always had a very close relationship with their nearshore zone. A way of live has developed that is based on the nearshore resources, be it fish or seaweed. In many cases these coastal communities not only have economic problems related to the decline in the fish stocks, but at the same time they suffer in their social and cultural identity. The health of the nearshore area and the coastal zone is crucial to the health of many coastal communities in Atlantic Canada.

Do You Eat Seaweed?

Rockweed, kelp, Irish Moss, and Furcellaria are marine plants that are commercially harvested in our nearshore waters. They provide valuable emulsifying, thickening, gelling, and stabilizing agents for the food processing, cosmetics, and pharmaceutical industries. We often eat these additives without knowing it - they're found in ice cream, processed cheese, diet foods, toothpaste, beer, and many other products.

see activity 44

Kelp and rockweed are also used as livestock feed and agricultural fertilizers. They're valued for their rich array of micronutrients and plant growth hormones.

Dulse is a red seaweed harvested in the Bay of Fundy and dried for direct human consumption. Several of the kelp are also prized as food in health food and Asian markets. The commercial potential of these resources is now being investigated.

Old MacDonald Had a Fish - Aquaculture

Aquaculture is a growing industry in our coastal zone. Salmon farming is important, particularly in the Bay of Fundy. Recently progress has been made in farming other fish species. Aquaculture of shellfish including mussels, quahogs, and scallops brings money into some coastal communities. Oyster culture is concentrated in the warm waters of the southern Gulf of St. Lawrence.

see activity 46

For more information on aquaculture please refer to module 3: Estuaries and module 13: Activities.

Would You Care for Some Sea Urchin Roe?

As fisheries based on traditional species collapse, the fishing industry is starting to exploit non-traditional species. Species being considered or already exploited include sea urchins, Moon Snails, whelks, sea cucumbers, Spiny Dogfish, worms and several species of crabs. The market for many of them is in Europe or Asia.

Mining the Sea

Oil and gas exploitation are starting to make an impact in the Atlantic economy, with the Hibernia oil fields and Sable Island gas developments being planned or in progress. Other smaller deposits of oil and gas have been considered for exploitation in the past and may be considered again in future.

We do not mine the seabed for minerals as yet, but dredging up marine sand and gravel for construction purposes has been considered.

Several of the coal mines in Cape Breton have shafts that run out under the floor of the sea.

Problems in the Ecosystem

The coastal zone of Atlantic Canada has been a focus for development for a long time. The first settlements developed close to the ocean, drawing on the resources that were available. Today there is very intense human activity in this area. Many of our activities impact directly or indirectly on the nearshore zone.

Coastal fisheries are both productive and accessible. They are vulnerable to overfishing. They are vulnerable because juvenile and spawning habitats are lost constantly, and because raw sewage and industrial discharge reduce the quality of the water and can contaminate species. Some species have been extirpated in the nearshore area, and others are under stress. Aquaculture developments have negative impacts on the marine ecosystems, and rockweed harvesting is an economy with many problems. Global warming has potential negative impacts on the nearshore zone.

The Government, the Fish, and the Fishers

Coastal stocks were the first to decline as new technologies were introduced and fishing efforts increased. Fishers in many Maritime communities remember when you only had to go a couple of kilometres to make a day's catch. Now fishers travel farther to catch less.

Up until recently, the government has assumed most of the responsibility for scientific assessment, management, and enforcement of fishing regulations.

Scientific Assessment

Scientists have to determine how many fish are in a particular area and how many can be safely caught each year. To do this, scientists plug data from research vessel surveys and the fishing industry into complex models. These models are used to establish catch quotas. This approach does not take into account all the factors that influence the health of any individual species.

Management

Managers take advice from the scientists and, in discussion with industry, set an overall quota for the following year. The Fisheries Resource Conservation Council (FRCC) has now taken on the role of reviewing all the scientific advice and making recommendations on quotas to the Minister. Department of Fisheries and Oceans managers continue to manage the fishery on a day-to-day basis.

Enforcement

Fishery officers are responsible for enforcing regulations and making sure the fishing industry does not exceed its quota.

What Went Wrong?

Most Maritimers, indeed most Canadians, know that the abundance of many groundfish species, such as cod, flatfish, and redfish, is at record low levels in some regions. Explanations of why so many stocks are depleted are many and often controversial:

- too many fishers and too few fish
- more sophisticated equipment and more efficient gear
- scientists cannot accurately count the number of fish in the ocean and cannot provide reliable enough advice

- catch quotas are set too high
- environmental factors can harm the resource (such as increased juvenile mortality)
- certain fishing technologies, like bottom-dragging, harm the habitat
- misreporting of the amount of fish landed
- destruction of spawning and juvenile fish habitat
- dumping of undersized and unwanted fish (see below).

Siltation

Human activities on land including agriculture, clearcut forestry, and road-building release silt into local rivers that is then washed into the sea, smothering bottom habitat. The silt carries nutrients as well as organic materials that consume oxygen.

By-catch and highgrading

On November 28, 1995, an article appeared in the Globe and Mail with the title 'Dumping aided decline of fishery, scientists say.' Here is an excerpt from this article: 'The Report provides the first statistical evidence of a problem that is widespread, but rarely publicly discussed in the Atlantic Fishery: Huge amounts of dead fish are thrown back because they are too small to meet the requirements of processing plants or they are not the species fishermen are licensed to catch.' The article indicates that the problem is most widespread in the dragger fleet.

Fish are also dumped because some species are worth more than others and large fish are worth more than small fish.

Eutrophication

Human communities also use the ocean as a dumping ground for sewage and food processing waste.

Many municipalities still discharge their wastes directly into the ocean. Saint John for example discharges 8.5 billion litres of raw sewage yearly. Halifax/ Dartmouth discharges 35.3 billion litres yearly.

Fecal contamination is the cause of many closures of beach areas. Eutrophication can cause the closure of shellfish areas.

Large additions of nutrients may trigger massive blooms of unwanted vegetation or alter the water chemistry to favour species that do not normally occur in the area. These unwanted plants include toxic plankton blooms, called 'red tides' or 'brown tides.' When eaten by cultivated shellfish, these toxic plankton render them poisonous and unfit for human consumption.

Since the late 1980s there have been blooms of a previously unknown toxic strain of the diatom Nitzschia pungens in the Gulf of St. Lawrence. This poses an expensive problem for shellfish aquaculture. Although the exact causes of toxic Nitzschia blooms are not known, nutrient imbalance is a reasonable hypothesis.

Poisons in the Sea

Most people identify major oil spills as a threat to the marine environment. However, this sort of catastrophe, such as occurred in Chedabucto Bay, Cape Breton Island, in 1970, contributes less than 2% of the annual input of oil into the world's oceans. Another approximately 15% is dumped directly from the bilges of ships, leaks from onshore oil refineries and ports, or leaks from offshore oil and gas wells. By far the greatest volume of oil enters the ocean via rivers and sewage outfalls, with the major component being used engine oil. The result is a steady and largely unseen attack on marine life.

By the early 1980s it was estimated that 10% of the world's ocean outside of ice-covered areas was covered with oil slicks. Such slicks are a particular threat to the neuston (small organisms that live in the surface layer of the water), including larvae of commercial fish species, that live in the surface layer of the sea. Reptiles, birds, and mammals are also at risk.

The slow but steady land-based inputs of oil, metals, and persistent toxins accumulate in marine waters and sediments. Analyses reveal low concentrations of a wide array of human-made toxins at every level of the marine food web. For example, levels of toxins that exceed human health standards have been found in fish from Georges Bank and in waters off Iceland.

Long-lived predators, particularly marine mammals, tuna, and Swordfish, are particularly at risk. St. Lawrence River Beluga Whales and Bay of Fundy Harbour Porpoise carry clinically dangerous levels of heavy metals and persistent organics (PCBs) in their tissues.

Oil spills and pollutants

Our lifestyles and activities on land can affect all marine systems. The increased use of energy creates a range of links to the nearshore environment. Increased energy use demands greater quantities of energy such as oil and electricity. Demands for oil will increase large oil tanker traffic in coastal waters. With the increase in traffic there is also a rise in the probability of oil spills. In the Bay of Fundy for example, increased oil tanker activity and shipping in general have prompted scientists and governments to predict that there will be a major oil spill at some time in this region! The Gulf of St. Lawrence and the shores of Newfoundland are also at risk.

Land-based industries release a variety of toxic chemicals into rivers flowing to the sea. Toxins also enter the ocean as fallout or precipitation from polluted air masses. Such atmospheric deposits may originate thousands of kilometres away. For instance, pesticides now banned in Canada are carried from southern countries where they are still in use and deposited in our northern ecosystems. Heavy metals are another class of pollutants causing serious concern. Aerosols and precipitates will be transported from terrestrial and other marine systems via wind. Acid aerosols and particulates can act as non-point sources of pollution. Pollutants can create problems within the nearshore system. An example is the immune system breakdown in whales, which makes them vulnerable to normally harmless viruses.

In addition, airborne pollutants may well affect adjacent terrestrial systems, killing vegetation or being deposited on soils. These in turn may eventually find their way into the nearshore via direct run-off or through estuarine inputs.

Marine Debris

Humans dump tonnes of solid waste into the sea every year. The most common items are plastic bags, bottles, ropes, and nets, some of which are fatal to marine animals when the animals eat them or become entangled in them. Nets and traps can continue catching species for a long time after they have been lost (ghost fishing).

Debris cast into Canadian waters not only pollutes our shores, but is carried across the Atlantic by the Gulf Stream and fetches up on European shores. Such debris poses a problem for tourism operators who wish to promote recreational use of beaches.

For more information on marine debris please refer to module 13: Activities.

Destruction of Habitat

Additions of nutrients at unnatural levels or in the wrong season can disrupt ocean life. On the other hand, the destruction or disturbance of marshes, estuaries, kelp beds, and marine sediments may reduce nutrient input and decrease productivity. These habitats are the natural sources of recycled nutrients to which marine ecosystems are adapted, and are crucial to the survival of many species.

Research shows that certain fishing methods have long-term effects on the nearshore system. Scallop dragging is one such process. Typically a scallop drag utilizes a large boom onto which are attached a number of heavy metal scallop drags. These are literally dragged along the bottom, picking up and depositing into the drag net anything from rocks to shellfish, urchins, and juvenile fish. The drag can also tear, rip, and crush animals and the bottom in its path. Some feel that repeated dragging has a detrimental effect on the capability of bottom life to maintain itself.

Extinctions

The Great Auk and the Labrador Duck were hunted to extinction very early in the history of European occupation on this continent. Walrus, once common in our waters, are now restricted to regions far to the north.

We know relatively little about benthic invertebrates. We do know that these organisms have, along with groundfish, been dragged up, killed, and discarded in the course of fishing activity. Every year bottom-dragging fishing boats rake over an unknown percentage of the world's continental shelf. This activity is focused on particularly productive bottom and fish spawning habitat.
It is possible that there have been local extinctions of invertebrates peculiar to such habitats. However, we cannot tell because we don't know what was there to begin with.

Ecotourism

The development and popularity of water-based ecotourism can also create user conflicts within the nearshore. Sea kayaking, whale watching, and other water-based tours, although seemingly benign, can have their own effects.

These activities increase the use of the coastal environment. Increased use can generate more conflict between fishers and ecotourists through greater boat traffic in the nearshore.

Water-based ecotourism may also stress the environment or elements of the environment that the industry relies on. What are the effects of increasing numbers of boats encircling large mammals, trying to get close for a good look? Will these activities affect reproduction rates? We don't know acceptable levels of stress for these animals. Examples from elsewhere in the world have shown us that ecotourism can, in fact, adversely affect those resources on which it depends for success.

Aquaculture: Opportunity or Threat?

Aquaculture can offer options for depleted stocks and it provides opportunities for economic development. This development also has costs.

Potential environmental problems from finfish culture include the accidental release of foreign, genetically altered or genetically restricted animals into wild populations; release of excess food, which depletes local oxygen supplies and smothers the bottom; introduction of diseases into wild populations; and the use of toxic insecticides and antibiotics required to maintain health in crowded cage cultures.

Shellfish aquaculture is less problematic, but where it is intensive there is a risk of depleting local waters of food needed by other types of filter feeders. There is also a risk of developing an unhealthy imbalance in nutrients.

Aquaculture is presently not practiced in Atlantic Canada on a large scale. However problems are already serious enough to merit research that is looking into its effects. In other areas, such as British Columbia where large-scale salmon aquaculture is common, there is a moratorium on new developments in place and presently an environmental impact assessment is looking at the impacts of aquaculture.

For further information on aquaculture please refer to module 3: Estuaries and module 13: Activities.

Conflicting activities

Although limited in the amount of water area used, aquaculture prohibits others from harvesting commercial species near cage sites. Scallop draggers cannot drag for their catch near aquaculture sites. Nor can lobster fishermen set traps. Similarly, herring weir owners contend that their potential catch, schools of herring coming inshore to feed, turns away when salmon aquaculture sites are sensed. Salmon prey upon herring and although the salmon are caged, their scent is enough to turn the herring away. Many aquaculture sites and herring weirs are within a few hundred metres of one another.

Similarly, many feel aquaculture has a long-term detrimental effect on nearshore bottom and sedimentary intertidal environments. Aquaculture operations add large quantities of organic material (waste feed and fish waste) to the bottom directly under cages. Some of this is also transferred into the adjacent water column. Long-term buildup of wastes under cages may have adverse effects. The organic material could be washed away to be deposited on mudflats, gently sloping beach areas, and embayments and may be having detrimental effects in these coastal habitats.

Seaweed: Habitat or Commodity?

The harvesting of seaweed as a commercial activity is often controversial because seaweed is much more than a potential commodity-it's also valued habitat, spawning grounds, nursery areas, and essential shelter. Seaweed beds alter the chemistry of the overlying water in ways that may be important to other organisms.

Dulse and Irish Moss harvesting have been found to be sustainable over the years. Rockweed harvesting however has been shown to have many problems.

Rockweed beds are extremely important habitat for many species. They provide shelter from predators and foraging space for fish like juvenile pollock or flounder; amphipods, whelks, periwinkles, and barnacles are some of the permanent residents of the rockweed 'forests.'

Seaweed significance

The use of adjacent ecosystems such as rocky intertidal areas or salt marshes can have an effect on nearshore systems as well. Rockweed harvesting on a large scale is an example.

Rockweed not only provides shelter and food for many animals, it also is a nutrient base. As it dies and decomposes it releases essential nutrients into coastal waters. There are still many unanswered questions about what significance this process plays in the establishment and maintenance of food webs in the nearshore. Large-scale harvesting may deplete an essential nutrient base.

It would also reduce the source of floating seaweed mats. These are utilized by whole communities of larval and juvenile species living in the nearshore. Similar arguments can be developed for the filling or draining of marshes.

For further information on the importance of rockweed please refer to module 13: Activities.

Future Shock - Our Changing Climate

We now know that human activities have resulted in increased levels of carbon dioxide and other 'greenhouse gases' in the atmosphere. This will inevitably change our climate, if allowed to continue.

Warming temperatures on a global scale are predicted to melt polar ice, raise sea-levels, increase the frequency and violence of storms, and change patterns of precipitation.

The thought of global warming may be tempting to those of us living in boreal regions. The reality of this process, however, will change not only temperatures but distributions of animals and plants, water levels, and large-scale climatic patterns. It won't necessarily create tropical regions where none are now, but rather extreme climatic conditions.

Our increased consumption of energy on land has been a primary reason for global warming. Increased use of fossil fuels and deforestation elevate the levels of carbon dioxide in the atmosphere. Increased CO2 acts like the glass in a greenhouse. It allows heat in but slows its release. This trapped heat upsets the way the planet works.

What link does it have to the nearshore? One link is the potential for sea-level rise and its implications. A rising sea-level would affect such things as the location of the nearshore, the shape of the coastline, the pattern of currents, and the tidal range. Climate change is expected to affect ocean currents and may interfere with the exchange of water between the sea surface and deep ocean. Predicted higher sea-levels and more intense storms will result in increased erosion and flooding of coastal land.

Releases of chlorinated and other ozone-destroying compounds have eroded the protective ozone layer in the upper atmosphere. Increased UV radiation is known to be damaging to many plants as well as to delicate eggs and larvae that float. Exposure to UV affects the immune system, so we can expect increased disease in, for instance, marine mammals. UV radiation is also expected to interact with heavy metal pollutants and persistent organic toxins, making them more dangerous.

These changing conditions will affect marine life in many ways that we cannot even predict. Local extinctions of species that fail to adapt to changing conditions are possible.

Large-scale change - tidal power

The issue of provision of electricity by tidal power generation will surface again in the future. Tidal power projects will require a huge restructuring of the intertidal and nearshore region, effecting extensive habitat change. The Bay of Fundy region has been a primary focal point for the development of tidal power. Studies have already shown that significant long-range and long-distance effects will be felt by an undertaking of this magnitude. Shorebird feeding areas will be reduced, fish feeding areas will disappear, a tidal barrage would change sedimentation patterns and currents in the upper bay, and tidal ranges would change throughout the bay and Gulf of Maine. However, as user demands increase the environment often takes second place.

Protection of the Ecosystem

The nearshore holds the promise of riches from an array of resources. However, we can't have them all, for the use of the nearshore for one type of activity often precludes another. There must be room and resources left for the wildlife. We also need to be careful not to disrupt functions such as nutrient cycling and ocean currents. Many nearshore ecosystems have already been seriously damaged and require work to restore them before their potential can be realized.

Resolving conflicts and promoting cooperation among potential users in ways that are both environmentally and socially responsible is a serious challenge. Proactive planning and integrated management are required to ensure a sustainable future. We also must adopt a precautionary approach. In other words, when we do not know the impacts of what we're doing, we should stop and take time to gather the information necessary for informed decision-making. Internationally, Canada has participated in the development of many conventions and agreements that seek to reduce oil pollution, ocean dumping, long-range atmospheric depositions, and offshore fishing pressures. The precautionary principle has been recognized in a number of these agreements.

When You Can't Build Fences: Marine Parks

Just as we have parks on land, some people are proposing parks or marine protected areas (Map's) for coastal waters. In these Map's some or all human activities would be excluded. Map's may be established to protect fish stocks for the benefit of the fishing industry, to provide an undisturbed area for scientific research, to provide an opportunity for recreation and education, and/or simply to leave a small part of the marine environment undisturbed.

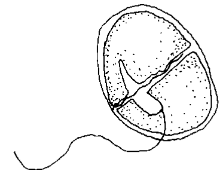
Both the provincial government and the Island Nature Trust in Prince Edward Island have begun to work toward establishing marine reserves in the nearshore of Prince Edward Island. The involvement of fishers in this endeavor has enhanced the ability of this group to create a protected area that will allow limited fishing activities and perhaps other sites will be established as 'no-take' zones.

In reality drawing lines on the ocean is difficult and, in part, symbolic. Whales, fish, and other animals can't be kept inside an MPA and pollutants cannot be kept out.

Co-management

Government and the fishing industry have called for increased involvement of fishers in the science and management of the fishery. This ranges from government consulting fishers more often, to shared management responsibilities, to fishers managing the fishery.

Certainly there are good reasons for fishers to be more involved. Fishers and scientists have complementary knowledge about fish movement and abundance. However, some fishers are concerned that they are now being handed management responsibilities when funds are low and stocks depleted.



SPECIES LISTS

The following lists are by no means a complete account of the organisms living in this ecosystem. They were chosen as representative species, ones that would most likely be observed when visiting the nearshore. There are also great regional and local variations, and we realize the difficulty in accommodating all of these.

Plants

Diatoms	
	Coscinodiscus sp.
	Chaetoceros sp.
Dinoflagellates	
	Gonyaulax sp.
	Peridinium sp.
Sea Lettuce	*Ulva lactuca*
Sea Colander	*Agarum cribosum*
Green Thread Algae	*Chaetomorpha melagonium*
hollow green weed	*Enteromorpha intestinalis*
Irish Moss	*Chondrus crispus*
Furcellaria	*Furcellaria lumbricalis*
Twig Weed	*Polyides rotundus*
Dulse	*Palmaria palmata*
leaf weeds	*Phyllophora sp.*
Banded Weed	*Ceramium rubrum*
Encrusting Corralline Algae	*Corallina officinalis*
Bootlaces/Smooth Cord Weed	*Chorda filum*
Spiny Sour Weed	*Desmarestia aculeata*
Sugar Kelp	*Laminaria saccharina*
Edible Kelp	*Alaria esculenta*
Horsetail Kelp	*Laminaria digitata*
Sea Colander	*Agarum cribosum*
rockweed	*Fucus sp.*

Molluscs

Red Chiton	*Ischnochiton ruber*
Tortoiseshell Limpet	*Acmaea testudinalis*
Red Gilled Nudibranch	*Coryphella sp.*
Common Northern Moon Shell/ Moon Snail	*Lunatia heros*
Dogwinkle	*Nucella lapillus*

Gould's Pandora	*Pandora gouldiana*
Common Periwinkle	*Littorina littorea*
Waved Whelk	*Buccinum undatum*
Ten-ridged Whelk	*Neptunea decemcostata*
Soft-shelled Clam	*Mya arenaria*
Ribbed Mussel	*Modiolus demissus*
Blue Mussel	*Mytilus edulis*
Horse Mussel	*Modiolus modiolus*
American Oyster	*Crassostrea virginica*
Bay Quahaug	*Mercenaria mercenaria*
Surf Clam	*Spisula solidissima*
Baltic Macoma	*Macoma baltica*
Chalky Macoma	*Macoma calcarea*
Razor Clam	*Ensis directus*
Sea Scallop	*Placopecten magellanicus*
Octopus	*Bathypolypus arcticus*
Short-finned Squid/Boreal Squid	*Illex illecebrosus*
Chink Shell	*Lacuna vincta*

Crustaceans

tubicolous amphipod	*Amphithoe sp.*
greedy isopod	*Cirolana borealis*
skeleton shrimp	*Caprella sp.*
copepods	*Calanus sp.*
barnacles	*Balanus sp.*
Green Crab	*C arcinus maenas*
Rock Crab	*Cancer irroratus*
American Lobster	*Homarus americanus*
Snow Crab	*Chionectes opilio*
Common Spider Crab	*Libinia emarginata*
Jonah Crab	*Cancer borealis*
toad crab	*Hyas sp.*
Acadian Hermit Crab	*Pagarus acadianus*

Echinoderms

Green Sea Urchin	*Strongylocentrotus droebachiensis*
Sand Dollar	*Echinarachnius parma*
asterias sea stars	*Asterias sp.*
Dwarf Brittle Star	*Axiognathus squamatus*
Basket Star	*Gorgonocephalus arcticus*
Orange-footed Cucumber	*Cucumaria frondosa*
Scarlet Psolus	*Psolus fabricii*

Worms

clam worm	*Nereis virens*
Lugworm	*Arenicola marina*
opheliid worm	*Ophelia acuminata*
terebellid worm	*Amphitrite johnstoni*
thread worm	*Capitella capitata*
Tube Worm	*Spirorbis borealis*
Sea Mouse	*Aphrodita hastata*
twelve-scaled worm	*Lepidonotus sp.*
Plankton Worm	*Tomopteris helgolandica*
arrow worm (planktonic)	*Sagitta sp.*

Sponges

Crumb of Bread Sponge	*Halichondria panicea*
Finger Sponge	*Haliclona oculata*
palmate sponge	*Isodictya sp.*

Bryozoans

Leafy Bryozoan	*Flustra foliacea*
Micropore Crust	*Microporella ciliata*

Cnidarians

garland hydroid	*Sertularia pumila*
Frilled Anemone	*Metridium senile*
Moon Jelly	*Aurelia aurita*
Lion's Mane/Red Jelly	*Cyanea capillata*

Ctenophores

Sea Gooseberry	*Pleurobrachia pileus*
Common Northern Comb Jelly	*Bolinopsis infundibulum*

Brachiopods

lamp shell	*Terebratulina septentionalis*

Tunicates

Sea Peach	*Halocynthia pyriformis*
Sea Potato/Stalked Sea Squirt	*Boltenia ovifera*

Fish

Shorthorn Sculpin	*Myoxocephalus scorpius*
Atlantic Hagfish	*Myxine glutinosa*
Little Skate	*Raja erinacea*
Spiny Dogfish	*Squalus acanthias*
Blue Shark	*Prionace glauca*
Porbeagle	*Lamna nasus*
Basking Shark	*Cetorhinus maximus*
Capelin	*Mallotus villosus*
Atlantic Silverside	*Menidia menidia*
Rock Gunnel	*Pholis gunnellus*
American Sand Lance	*Ammodytes americanus*
Atlantic Herring	*Clupea harengus harengus*
Atlantic Sturgeon	*Acipenser oxyrhynchus*
Ocean Pout	*Macrozoarces americanus*
Atlantic Tomcod	*Microgadus tomcod*
Pollock	*Pollachius virens*
Haddock	*Melanogrammus aeglefinus*
Atlantic Cod	*Gadus morhua*
Cusk	*Brosme brosme*
Atlantic Salmon	*Salmo salar*
Monkfish	*Lophius americanus*
Winter Flounder	*Pseudopleuronectes americanus*
Smooth Flounder	*Liopsetta putnami*
Witch Flounder	*Glyptocephalus cynoglossus*
Windowpane	*Scophthalmus aquosus*
Atlantic Halibut	*Hippoglossus hippoglossus*
Striped Bass	*Roccus saxatilis*
Gaspereau/Alewife	*Pomolobus pseudoharengus*
American Shad	*Alosa sapidissima*
Rainbow Smelt	*Osmerus mordax*
Atlantic Mackerel	*Scomber scombrus*
Bluefin Tuna	*Thunnus thynnus*
Atlantic Wolffish	*Anarhichas lupus*
Lumpfish	*Cyclopterus lumpus*

Reptiles

Leatherback Turtle	*Dermochelys coriacea*

Birds

Common Loon	*Gavia immer*
Double-crested Cormorant	*Phalacrocorax auritus*
Great Cormorant	*Phalacrocorax carbo*
Common Tern	*Sterna hirundo*
Arctic Tern	*Sterna paradisaea*
Roseate Tern	*Sterna dougallii*
Great Black-backed Gull	*Larus marinus*
Herring Gull	*Larus argentatus*
Bonaparte's Gull	*Larus philadelphia*
Common Eider	*Somateria mollissima*
White-winged Scoter	*Melanitta fusca*
Black Scoter	*Melanitta nigra*
Surf Scoter	*Melanitta perspicillata*
Northern Gannet	*Sula bassanus*
Common Murre	*Uria algae*
Thick-billed Murre	*Uria lomvia*
Black Guillemot	*Cepphus grylle*
Common Puffin	*Fratercula arctica*
Dovekie	*Alle alle*
Leach's Storm Petrel	*Oceanodroma leucorhoa*
Northern Fulmar	*Fulmarus glacialis*
Greater Shearwater	*Puffinus gravis*

Mammals

Harbour Seal	*Phoca vitulina*
Grey Seal	*Halichoerus grypus*
Harp Seal	*Pagophilus groenlandicus*
Hooded Seal	*Cystophora cristata*
Minke Whale	*Balaenoptera acutorostrata*
Fin Whale	*Balaenoptera physalus*
Humpback Whale	*Megaptera novaeangliae*
Northern Right Whale	*Eubalaena glacialis*
Beluga	*Delphinapterus leucas*
Harbour Porpoise	*Phocoena phocoena*
Common Dolphin	*Delphinus delphis*
Potheador Pilot Whale	*Globicephala malaena*
Human	Homo sapiens