A Newsletter from the Public Education Program of the Bamfield Marine Station

OCEAN News

Issue 5: Marine Biodiversity

Biodiversity: What is it all about?

Life is all around you. From the microbes in your gut and the insects crawling in your garden soil to the largest organisms on earth -the blue whales. Biodiversity refers to all life on earth. "Bio" means life and "diversity" means variety.

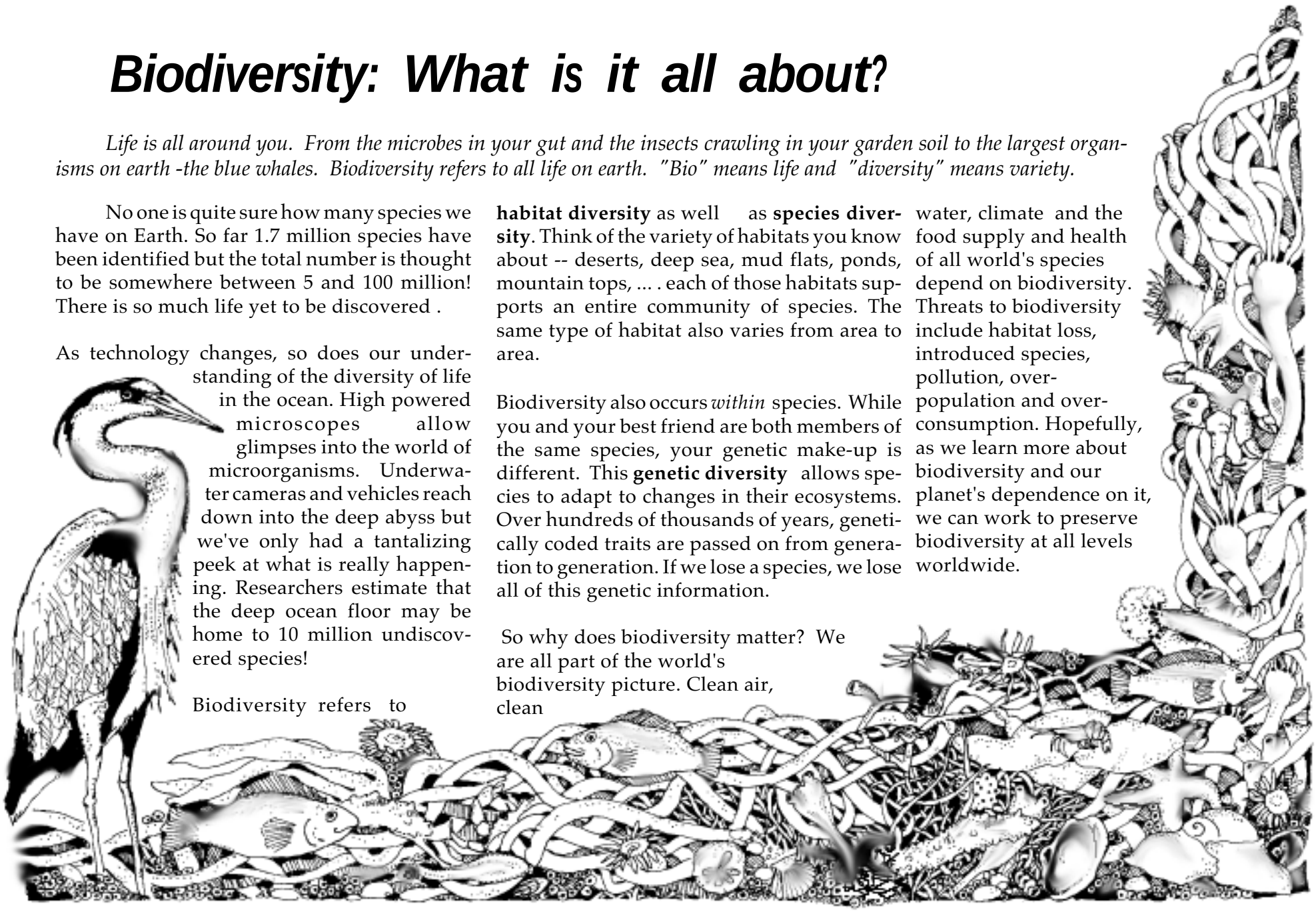
No one is quite sure how many species we have on Earth. So far 1.7 million species have been identified but the total number is thought to be somewhere between 5 and 100 million! There is so much life yet to be discovered .

As technology changes, so does our understanding of the diversity of life in the ocean. High powered microscopes allow glimpses into the world of microorganisms. Underwater cameras and vehicles reach down into the deep abyss but we've only had a tantalizing peek at what is really happening. Researchers estimate that the deep ocean floor may be home to 10 million undiscovered species!

Biodiversity refers to **habitat diversity** as well as **species diversity**. Think of the variety of habitats you know about -- deserts, deep sea, mud flats, ponds, mountain tops, ... each of those habitats supports an entire community of species. The same type of habitat also varies from area to area.

Biodiversity also occurs *within* species. While you and your best friend are both members of the same species, your genetic make-up is different. This **genetic diversity** allows species to adapt to changes in their ecosystems. Over hundreds of thousands of years, genetically coded traits are passed on from generation to generation. If we lose a species, we lose all of this genetic information.

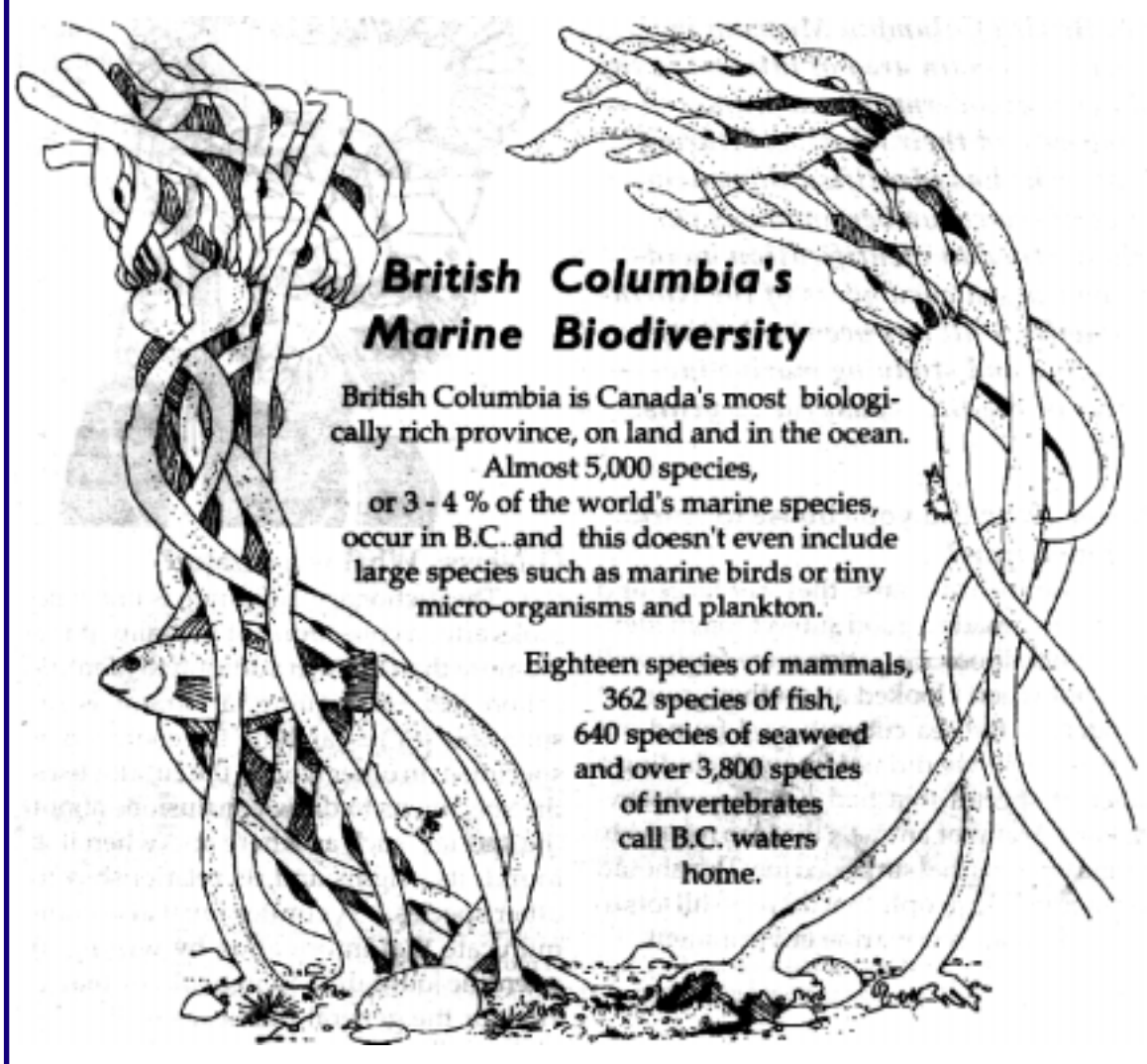
So why does biodiversity matter? We are all part of the world's biodiversity picture. Clean air, clean water, climate and the food supply and health of all world's species depend on biodiversity. Threats to biodiversity include habitat loss, introduced species, pollution, over-population and over-consumption. Hopefully, as we learn more about biodiversity and our planet's dependence on it, we can work to preserve biodiversity at all levels worldwide.



Canada's Role in Biodiversity

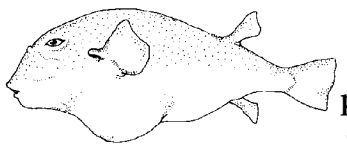
Over 160 nations signed the United Nation's Convention on Biological Diversity after the Earth Summit in Rio de Janeiro, Brazil in 1992. Canada was the first industrialized nation to sign. The document provides a framework for nations to work together to conserve biodiversity, to use their resources in a sustainable way, and to share the resulting benefits from genetic resources in a fair way. (This last point prevents developed countries from using less-developed countries as a source of valuable resources for their own profit. Under the agreement, resources must be used in a sustainable way with a sharing of equity).

Since signing the agreement, Canada has developed a Biodiversity Strategy which outlines how we will meet the objectives of the Convention of Biological Diversity agreement.

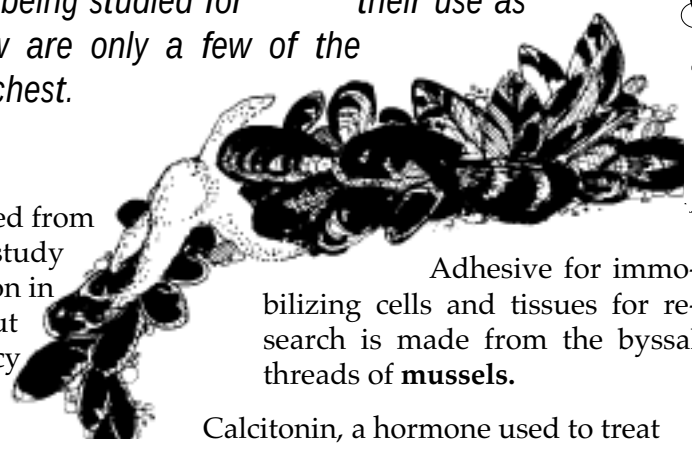


Marine Medicine Chest

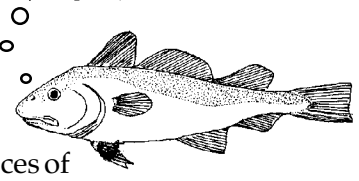
Many marine plants and animals are being studied for their use as medicines and in medical research. Below are only a few of the discoveries made in the marine medicine chest.



A chemical collected from **puffer fish** is used to study cellular communication in nerves. Pufferfish are highly toxic to humans but specially trained chefs in Japan create a delicacy called fugu for some daring diners.

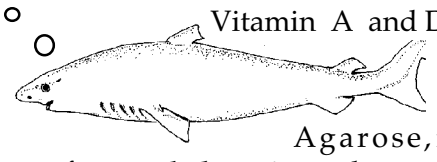


Adhesive for immobilizing cells and tissues for research is made from the byssal threads of **mussels.**

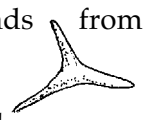


Cod and **shark** liver oils are used as sources of Vitamin A and D.

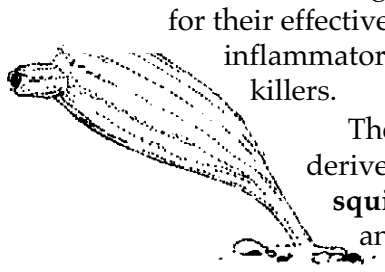
Bryostatin from the **bryozoan** *Bugula neritina* is being studied as an anti-tumour agent.



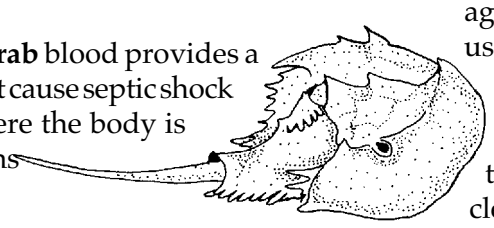
Calcitonin, a hormone used to treat bone disorders and slow bone breakdown, was modeled after a protein found in **coho salmon.**



A variety of compounds from many **sponges** have been derived to treat ailments such as herpes, asthma and cancer. Some are also being investigated for their effectiveness as anti-inflammatories and pain-killers.

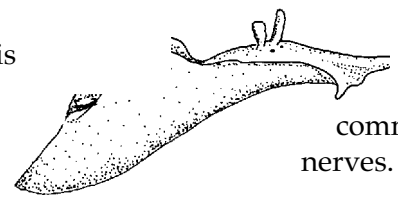


The compound didemnin is derived from a tunicate (**sea squirt**) and has potential as an anti-cancer agent.

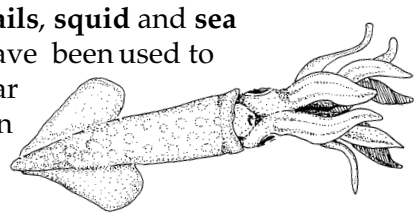


Horseshoe crab blood provides a test for toxins that cause septic shock (a condition where the body is overrun by toxins and bacteria).

Corals are used to replace bone grafts to help human bones heal quickly and cleanly.



Cone snails, **squid** and **sea hares** all have been used to study cellular communication in nerves.



Some wound dressings are made from calcium alginate, derived from **seaweeds**.

The Ocean In Your Home

See where the sea is at home -- Search through your house for some of these things that have their origin in the world's oceans.

Kitchen

- seafood products - fish, shellfish, seaweeds
- infant formula - carrageenan*
- ice cream - beta carotene* (adds the cream colouring) and carrageenan
- whipped toppings - alginate* (mixes fats evenly and keeps the topping fluffy)
- pancake syrup - carrageenan (keeps the flow of syrup smooth)
- cheddar cheese - beta carotene (colouring)
- peanut butter - carrageenan (improves spreading and prevents oil separation)
- sea salt - sodium chloride from evaporated sea water
- salad dressings - alginates (thickener)
- beer - alginates keep the "head" (foam) on beer
- pasta - carrageenan (makes a uniform dough that's easier to handle)
- tomato sauce - carrageenan (keeps bottled sauces thick and well-mixed)
- canned meat - agar* (gels watery solutions)
- fruit juices - alginate (preserves pulp concentrates)
- chocolate milk/evaporated milk - carrageenan
- cottage cheese - carrageenan
- margarine/mayonnaise - beta carotene
- pet food - carrageenan

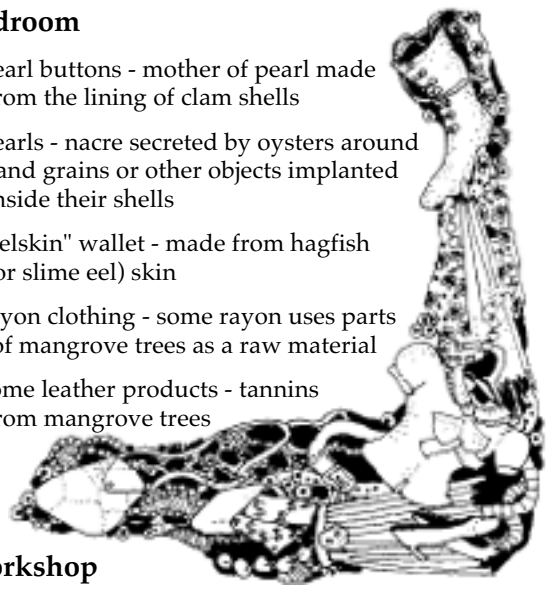
Bathroom

- nail polish/eye shadow - pearl essence made from herring scales
- diaper rash ointment - fish liver oil made from cod or halibut livers; treats irritation with vitamins A and D
- calcium supplement - made from crushed oyster shells; dietary supplement to build bones and teeth.
- antacids - magnesium from sea water; neutralizes stomach acid
- toothpaste - diatom shells act as abrasive cleaners to help brighten teeth; carageenan thickens toothpaste
- air freshener gels - carrageenan (stabilizes the gels so that odours are released gradually

- lipstick - alginates (allows for easier application)
- natural sponges - skeletal remains of sponge colonies
- skin creams - chitosan derived from chitin, the key component of the shells of crabs, lobsters and shrimp; retains moisture

Bedroom

- pearl buttons - mother of pearl made from the lining of clam shells
- pearls - nacre secreted by oysters around sand grains or other objects implanted inside their shells
- "eelskin" wallet - made from hagfish (or slime eel) skin
- rayon clothing - some rayon uses parts of mangrove trees as a raw material
- some leather products - tannins from mangrove trees



Workshop

- paint - alginates
- fertilizers - guano, the feces of seabirds; enriches nitrogen and phosphorous in soil
- plastics and waxes - petroleum (sea-floor deposits yield one quarter of oil used today)
- paper finishes - alginates even application of coatings onto paper
- cuttlebone - internal shells of cuttlefish; source of calcium in diets of pet birds
- aquarium fish - pet fish from tropical coral reefs
- cat food - fish scraps
- photographic film developers - sodium and potassium bromide from bromine extracted from sea water; fixes images onto photographic paper
- swimming pool filters - diatom shells catch and trap impurities
- pet litter - remains of diatoms
- textiles with prints - alginates can thicken print paste to control the application of dyes

*Red, green and brown algae all provide ingredients used in the manufacture of many food products. Carrageenans are extracted from red algae and form a medium-soft gel used to stabilize and gel food, cosmetics, pharmaceuticals and some industrial products. Agar is also extracted from red algae and makes a harder gel used in food such as jellied candies. Alginates are derived from brown algae and make products thicker, creamier and more stable. Beta-carotene is a reddish-orange pigment found in green algae and is used as a food colourant.

(Parts of this list were adaped from the Smithsonian Institute's Ocean Planet exhibit, SEAcrets)

Looking at Species Biodiversity

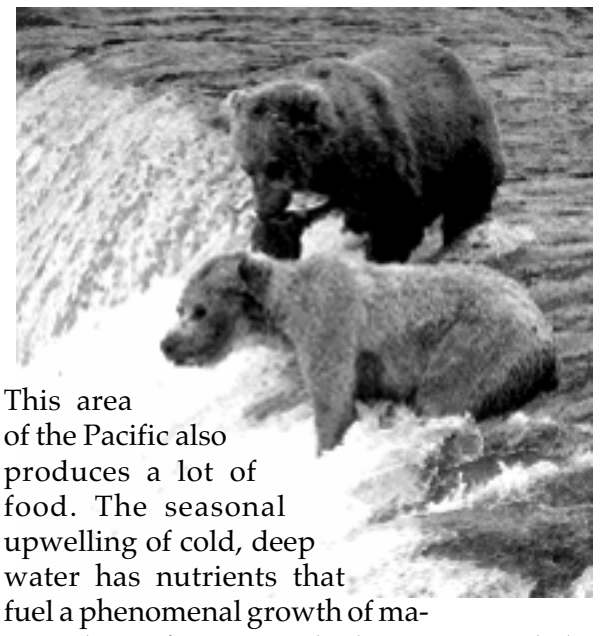
A species is a group of plants, animals or micro-organisms that are so similar they are able to breed and produce fertile offspring. To date almost 1.7 million species have been described worldwide and the estimates for the total number of species on Earth varies from 5 million to nearly 100 million!

Oceans are very rich biologically. There is a good reason for that. Marine evolution has had a 2.7 billion year head start on terrestrial environments. There are about 40 phyla (major groups of animals) in the ocean and at least 15 of these groups are found only in the ocean. Compared to terrestial habitats though, little investigation has gone on in the ocean. Insects and microorganisms are the two groups containing the most described species. It is estimated that 10 million species (yet undiscovered) could live in the deep sea!

Recent advances in the way scientists examine species has increased the possibility of discovering new species. The common blue mussel, *Mytilus edulis*, is now known to actually be three distinct species. A common worm in muddy areas was found to be 15 different species! These differences were found using advanced, molecular techniques.

Species diversity is not simply a measure of the number of living things in a given area. A good measure of species diversity, combines both the number of species (richness) and the distribution of the total number between the species. A species with just a few members might be more important from a biological point of view, than a species with large numbers.

One of the best places to see a rich species diversity is along the Pacific coast of Canada. Here there is a spectacular variety of marine life that can be matched in few other places in the world. The high diversity of habitats in this region leads naturally to a rich diversity of species. Quiet mudflats, sandy beaches, cobble and boulder beaches, wave-exposed rocky headlands all make up British Columbia's 17,000 km of coastline.



This area of the Pacific also produces a lot of food. The seasonal upwelling of cold, deep water has nutrients that fuel a phenomenal growth of marine plants, from tiny plankton to giant kelps. The large number of major rivers flowing into the ocean also contribute to this high productivity. These rivers deposit tonnes of nutrient-rich sediments into coastal waters. The rich growth of plant life provides food directly or indirectly for all of the animals in the coastal ecosystem.

With all of these things working together, it is small wonder that biologists, SCUBA divers and wildlife viewers flock to the Pacific northwest from all over the world, to observe the rich diversity of marine life on our coast.

Bizarre Worlds Beneath the Beach

Picture a beautiful sandy beach on a hot summer day. Imagine blue sky, beach blankets, sunglasses, the smell of sun cream, the sound of ocean waves and the cry of gulls. Can you believe that within a few centimetres of your body is a world teeming with animals so amazing they almost seem like creatures from outer space?

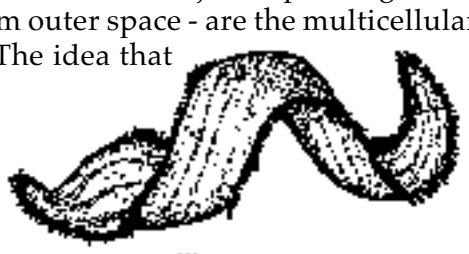
The tiny spaces around every sand grain are wet and where there is water, there is life. Creatures living in beach sand are very diverse. Bacteria coat the surfaces of sand grains and like yoghurt popsicles, they are excellent food for any animal able to lick the sand grains clean. Bacteria play a vital role by recycling wasteproducts.

Small plants called diatoms live in the spaces between sand grains. Enough light filters down to power up these tiny cells a few centimetres below the surface.They use the sun's energy to make food molecules. Diatoms are protected from being crushed by their outer shell made of glass.

The animals that live bet ween sand grains are called **meiofauna** which means 'smaller (meio) animals (fauna)'. One meiofauna group includes the single-celled creatures known as ciliates. Usually less than one-fifth of a millimetre long, ciliates are covered with small hair-like structures known as cilia that beat like a coordinated mob of miniature paddles causing the ciliate to move around with surprising speed. Little is known about the meiofauna ciliates, except that they eat bacteria. There are likely to be thousands of different species in the sandy sediments of the world.

Rotifers sweep through the sand grain spaces like miniture street sweepers.

Perhaps the most fascinating sand dwellers - the ones that conjure up thoughts of aliens from outer space - are the multicellular animals. The idea that small animals live between sand grains may seem odd to many people, but even more amazing is their diversity.



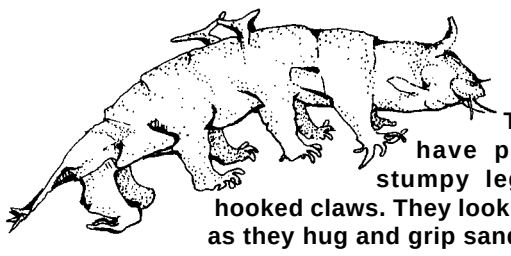
ciliate

The animal kingdom consists of about 40 different major animal groupings, or phyla. At least 22 phyla, more that half of all basic animal types, are known to be members of the meiofauna of ocean sands and sediments. Perhaps the only other habitats in the entire world that can boast such a diversity of major groups are the tropical coral reefs of the South Pacific Ocean.

Although we know that animals representing many different phyla are present in the meiofauana, we know only a tiny fraction of the species by their scientific names. The vast majority have never been seen, and most that have been seen, and most that have been examined have not been studied enough to be given scientific names. Even if you are a beginning meiofauna explorer, it is possible you might find a new species of animal.

Even more exciting in the study of biology is the possibility of finding a previously unknown phylum of animals. Only three animal phyla have been discovered this century, and the latest was described in 1982. This phylum, the Loricifera, consists of animals that are unlike any other animals in the world - and all loriciferans now described have been found in meiofauna samples. Scientists speculate that if other phyla remain to be discovered, the habitats between sand grains are probably the most likely places to find them.

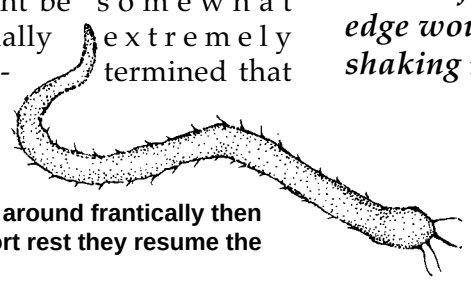
One might think that since so few are named, meiofauna might be somewhat rare, but they are actually extremely abundant. One study determined that a single handful of wet sand on a Florida beach contained over 10,000 of these animals.



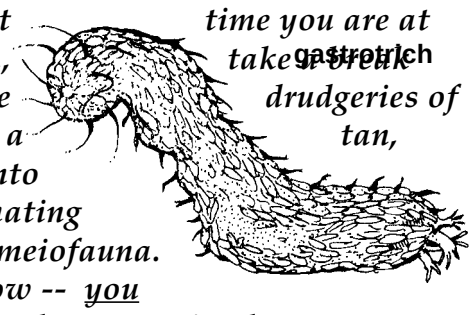
Tardigrades have plump bodies, stumpy legs and sharp hooked claws. They look quite bear-like as they hug and grip sand grains.

Meiofauna play a vital role in the world, as any beach lounger should appreciate. By scouring the sand grains, these animals continuously clean the beach. Without the meiofauna, beaches would become stinking masses of slimy bacteria-filled sediments!

We know very little about how human activities affect meiofauna survival. In one study at Santa Barbara, California, researchers discovered a distinct zone of hardened oil fragments about one-half metre below the beach surface. When meiofauna collections were taken at different levels, samples from the upper layers showed slightly below normal meiofauna collections, but samples from near the oil-particle level and below it showed almost no living meiofauna.



Gnathostomulids race around frantically then suddenly stop . After a short rest they resume the hectic race.



Next time you are at the beach, take a break from the drudgeries of getting a tan, and dig into the fascinating world of meiofauna. Yever know -- you might reveal a new animal, yet unknown to science!In the fascinating world of biology, that kind of knowledge would be sand-shaking and earth-shaking news.

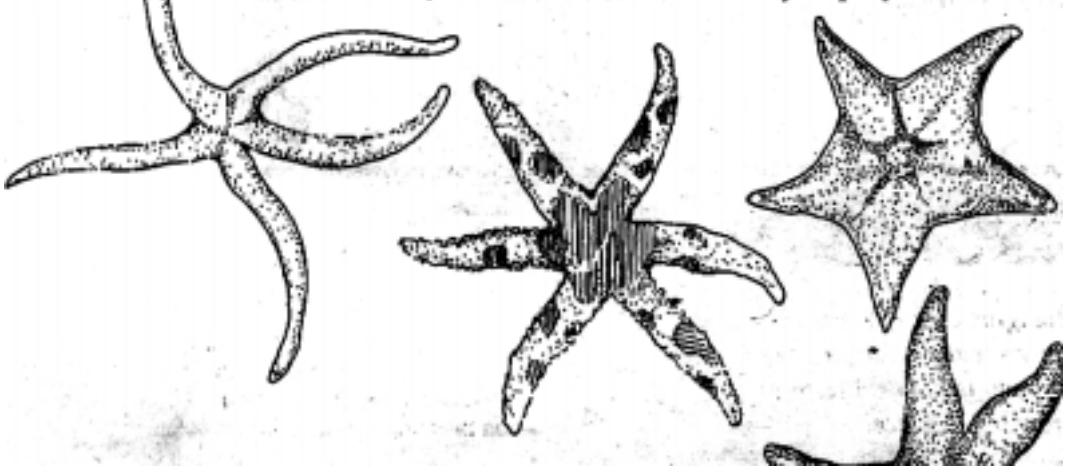
B.C. - Sea Star Capital of the World

Next time you visit a rocky Pacific shore try to find one of the bright orange or purple common shore stars. B.C.'s common shore star is easy to find on rocky beaches at low tide. Did you know that this species is just one of 2,000 seastar species found worldwide?

These carnivorous creatures are found in all the world's oceans, from beaches down to depths of over 7 kilometers. Nowhere else on earth do sea stars occur in such abundance and diversity as along the west coast of North America.

In B.C. alone, there are 68 different species many which are unique to this area. Even within a single ecosystem, there may be up to 20 different species co-existing.

Scientists have learned that when species diversity is high, each species has specific needs in terms of feeding, behaviour and reproduction. Some seastars have very specific diets, feeding exclusively on one favourite food, while others, like the huge sunflower star , will chase and eat a variety of prey.



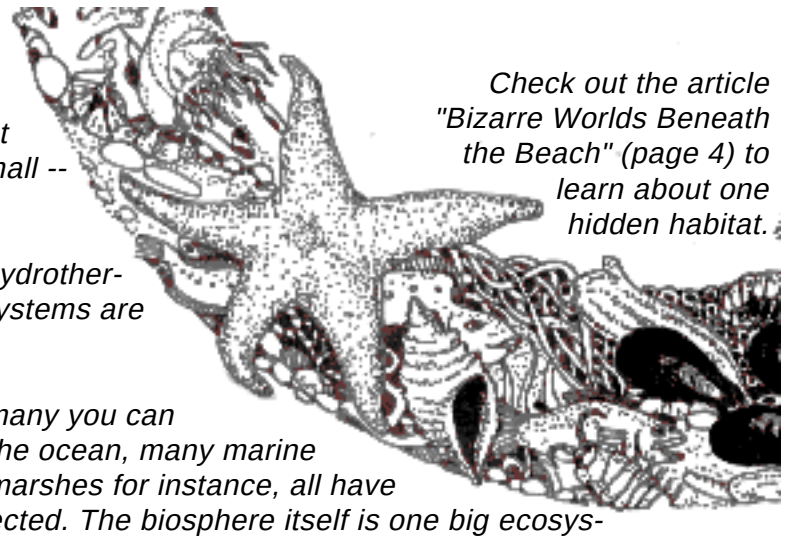
Count those kelp

Seaweeds- particularly large brown kelps and red algae- are also especially abundant and diverse on the B.C. Coast. In fact, marine plant life here is second only to New Zealand and Australia in terms of number of endemic species (those that are found nowhere else in the world). This abundance may have evolved in part due to the unusually low number of herbivores (plant-eaters) here. Compared to other parts of the world there are very few herbivorous fishes in B.C. waters. Because of the large number of unique kelp species found here, it is thought that this region may be where kelps originally evolved millions of years ago.

Habitat, or ecosystem, diversity is another level used to describe biodiversity. An ecosystem consists of all the living and non-living things in an area. Each ecosystem has unique combinations of animals, plants, microorganisms and a distinct set of physical characteristics that define that place. Ecosystems can be large or small -- and many exist where you'd never imagine.

Ecosystems are still being discovered. It wasn't that long ago that deep sea hydrothermal vents, with an entirely unique community of animals, were discovered. So ecosystems are important to protect for what we do, and even what we don't, know.

The poster on the next two pages illustrates a variety of marine habitats. See how many you can identify. Are any of these habitats found near your home? Even if you live far from the ocean, many marine ecosystems are closely linked to terrestrial ecosystems. Rivers, estuaries and salt marshes for instance, all have direct connections to the sea. Ultimately all of the world's ecosystems are all connected. The biosphere itself is one big ecosystem.



Check out the article "Bizarre Worlds Beneath the Beach" (page 4) to learn about one hidden habitat.

Kelp Forests:

Large, brown seaweeds -- the kelps -- dominate this habitat type which are found throughout the cold temperate regions of the world's oceans. An entire assemblage of animals, including fish and marine mammals, use the various levels in the forest (canopy, stipes, holdfasts, bottom substrate) for shelter, reproduction and feeding. Kelp forests of the northeast Pacific have the highest measured primary productivity of all ecosystems.

Eelgrass Beds:

Seagrasses such as surfgrass or eelgrass often cover shallow areas of sea bottom. These grasses are not seaweeds, but are actually flowering plants. Seagrass habitats are a major source of food and shelter for many organisms in near shore environments. They also help stabilize the soft bottoms of these habitats with their dense root systems.

Rocky shore:

Rocky shores have the great diversity of animal and plant species. They are densely populated with larger, more visible invertebrates including sea stars, mussels, barnacles, anemones, and a variety of intertidal seaweeds. The relatively high productivity of the area, contributes to its rich biodiversity. Organisms in intertidal zones must cope with changes in moisture levels, heat balance, temperature, and salinity as well as the mechanical stress from wave action.

Sandy beaches:

Sandy beaches appear to have few inhabitants but looks can be deceiving. Since the sand shifts with the movement of the tides, the few large animals that inhabit this ecosystem tend to anchor themselves by burying in the sand. Worms, clams and crustaceans are some of the larger animals living here but this habitat teems with other creatures.

Mudflats:

Muddy shores are usually associated with estuaries, where fresh water flows into the sea. These areas tend to have low wave action which allows for fine sediment nd organtic particles to accumulate. In spite of very low oxygen levels in the mud there are many inhabitants buried here. Bacteria are very abundant here and provide an important food source for many creatures in the mudflat.

Docks and Pilings

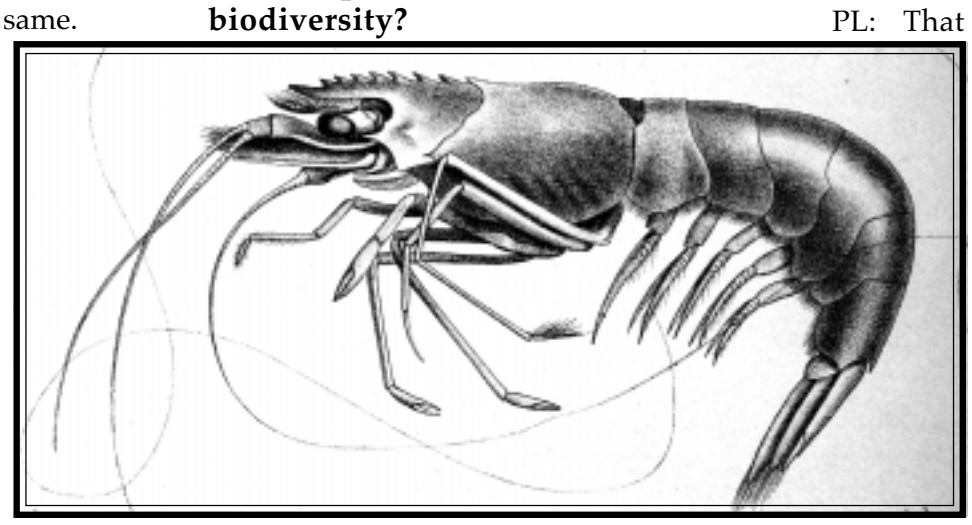
Certain man-made structures can also provide habitat for marine organisms. In areas where the water is relatively clean, docks support large communities of attached animals such as sponges, tube dwelling worms, anemones, barnacles and mussels. Motile animals including nudibranchs, sea stars, sea urchins and small fish also find food and shelter in this environment.

the molecular data. Traditional taxonomy is based on how things look but now we are finding that species can actually be very different in terms of DNA even though they may look the same.

O-News: How are museum collections used in environmental science?

PL: There have been a number of instances in which museum specimens have been analyzed to try and answer environmental questions. For example, a researcher requested specimens of clam shells collected prior to the testing of atomic bombs to try and establish a pretest baseline for radioactive molecules. This is important for improving accuracy of dating techniques. The effect of DDT was detected using the changes in the thickness of bird egg shells from museum collections prior to wide use of that chemical. Samples of lake bottoms are analyzed for pollen grains which can be identified to species. The species of trees that were common thousands of years ago tell us how the climate has changed over the years. DNA has also been extracted from museum specimens and compared with modern relatives.

O-News: How can museum collections help us understand marine biodiversity?



PL By keeping careful records, we get a picture of where a species lives including latitude, longitude and depth. Date and location will tell us about the timing of its' movements and development. Collection notes indicate habitat type. Careful dissection will tell us what it has been feeding on, when it reproduces and what parasites infect it.

O-News: Is marine biodiversity changing in Canadian waters and how does it affect us?

PL: That is a difficult question to answer because data is so fragmentary. Most data is for commercially important species. For example, we know that salmon and abalone populations are very low because of the reductions in the commercial catch. We might be able to determine if a species has disappeared from an area by checking a museum collection to see if that species was collected in that location previously. The long term effects of a loss of biodiversity are difficult to predict in such a complex system, because of this, most scientists recommend that we should take a conservative approach and try to maintain existing biodiversity.

Blueprints of Life - Genetic Diversity

If you look at five examples of the same species — sea stars, salmon, killer whales, or even people — you will notice slight differences. These variations are a result of genetic diversity. Genetic diversity arises because of gene and chromosome mutations and the geographic isolation of different populations. Genes carry the genetic code — a sort of blueprint for life — and are inherited from an organism's parents. This diversity causes differences between individuals of even the same species. In humans, genetic diversity may be visible as colour (skin, hair, eye) or size differences or behavioural differences. Other differences are not so obvious and are "hidden" inside our bodies. These genetic differences may affect the way we grow, think or combat disease for example.

Genetic diversity is like an insurance policy to deal with changing conditions in the environment. The characteristics of certain individuals may better equip them to deal with an unexpected change and thus pass on their genes. Since changes in our environment are inevitable, genetic diversity helps guarantee the ability of species to adapt to these changes. Genetic variation within species also provides the raw material from which new species can evolve over time.

Meet Captain Kelp and his Team

If you are a team player then a career in science may be for you. Scientists are working in teams more and more to try and answer difficult questions. Dr. Louis Druehl, also known as Captain Kelp, leads a team of kelp researchers at the Bamfield Marine Station.

The team is studying the biodiversity of kelp in the Broken Group Islands section of Pacific Rim National Park Reserve. Kelp forests are an extremely important part of near shore marine ecosystems and provide food and shelter for a multitude of other organisms. Catherine Elliott is coordinating the kelp surveys and gathers information which includes the abundance and variety of species as well as the number of juvenile and adult plants. She also photographs permanent study plots to produce a visual reference that the researchers can refer to as habitat conditions change over time. All of this data goes into a Geographical Information System (GIS) to create a baseline of information. This will help us understand such things as long term changes in kelp communities and ecosystems shifts which might include the effects of introduced species, oil pollution, global warming or the return of the sea otters.*

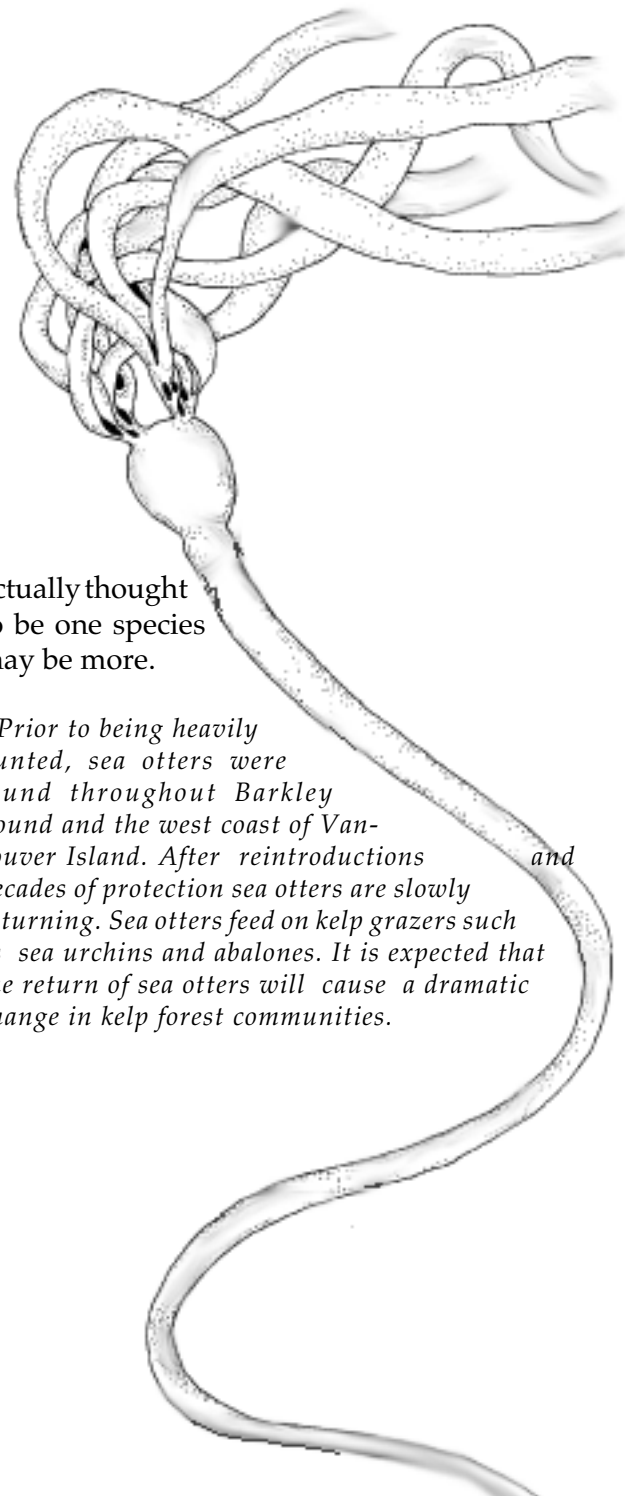
The team is also investigating kelp biodiversity at the genetic level. Mike Liptack (Ph.D. candidate) and Ian McKenzie (Masters candidate) need to be equally at home in their rain gear navigating through the fog in an open boat as they are in their lab coats mixing reagents in the Molecular Biology lab.

Mike uses DNA sequencing to try and understand how closely related populations of kelps are. The answer to this question would show how far kelp plants can disperse their young. He is studying two species, bull kelp (*Nereocystis luetkeana*) which has an air-filled float, and *Alaria marginata,* which has no float. Data shows that bull kelp plants from throughout Barkley Sound appear to be closely related. Mike is now busy sequencing DNA from *Alaria* and expects to see a different pattern with this species. Another team player, Handojo Kusumo is doing similar work on the giant kelp, *Macrocystis integrifolia.*

Ian is studying whether giant kelp plants which have different shapes are also different genetically. He makes measure-ments in the field and takes samples back to the lab where he extracts and analyzes the DNA and tries to relate shape diversity to genetic diversity.

Captain Kelp (Dr. Druehl) is also interested in the evolutionary relationships between different kelp species. He says that one reason that his team can do this type of study is because they are working with such a small number of species. There are only about twenty species of kelp in their study area (compared with about 350 species of red algae). Kelp is also a very recent group in evolutionary terms since it appeared only in the last 15 to 30 million years.

The detailed genetic studies that the kelp team is working on may prove that what was actually thought to be one species may be more.



** Prior to being heavily hunted, sea otters were found throughout Barkley Sound and the west coast of Vancouver Island. After reintroductions and decades of protection sea otters are slowly returning. Sea otters feed on kelp grazers such as sea urchins and abalones. It is expected that the return of sea otters will cause a dramatic change in kelp forest communities.*

Giving it the Gears

Trawling and dredging, where the bottom is scraped to capture ground-dwelling species, can have a big impact on ocean habitats. Fishing pressure can also cause irreversible changes to community structure. Georges Bank is a very productive Atlantic coast fishing bank which is shared by Canada and the U.S.. Over time the percentage of cod in the trawl catch has decreased while the percentage of skate and dogfish has increased. This new community structure is very stable so that even if fishing pressures are reduced or removed, it is not likely that the situation will reverse itself.

Fishing gear which is not selective, impacts marine diversity heavily because of the bycatch of non-targetted species. A bycatch of Pacific halibut of 7,000 metric tons is one of the more resounding issues of the North Pacific. Not all of these die when discarded but mortality rates can be as high as 80% in the trawl fishery for pollock, a member of the cod family.

How's that Habitat?

How habitat degradation affects a fished species is not always obvious since marine food webs are extremely complex. Different habitats are important at various stages in a species, life cycle. As well, a variety of age groups from the same species have distinct roles in food webs.

Different ecosystems are also connected in complex ways. There are many connections between land and sea for instance. Activities carried out upstream, on the shore or out at sea may all affect ocean habitat quality (See Ocean News Issue #4 on Marine Pollution for more information.) Dams which prevent salmon from reaching their spawning grounds have resulted in endangered and even extinct salmon stocks. Many small watersheds have been lost in the lower mainland of B.C.. Estuaries and eelgrass beds, which are important nurseries for young fish are often destroyed for marinas, mills and other development projects.

Protection and stewardship that ensure healthy habitat helps marine biodiversity.

Loss of genetic diversity

The greatest loss in genetic diversity as a result of modern fisheries occurs at the population level. This includes the extinction of wild, specialized stocks of herring, sardines, cod, salmon, halibut, abalone, urchins, sturgeon and tuna. Genetic diversity is nature's insurance system. A variety of different traits allows entire species to survive and deal with changes in the environment. Losses at the population level decrease the overall genetic diversity of the species.

The good news for marine biodiversity is that although there are many cases of fished species becoming commercially extinct there are no modern cases of biological extinction.

High "Tech", but What the Heck !

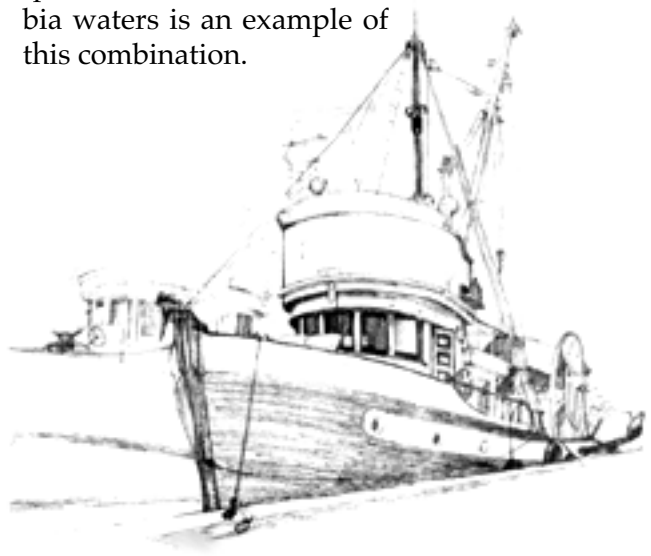
Even though we are fishing the oceans with more effort than ever, the global fish catch has not increased much since 1989. Despite technological and scientific advances, our skyrocketing human population and the need to feed the world,s people, has pushed our planet's fisheries beyond a sustainable level.

Eighty-five per cent of the world fish harvest is produced by natural ecosystems (as opposed to aquaculture). In Canada, the catch already requires 25 to 35% of the total primary production (plant production at the base of food chains). We do not have the ability to safely increase oceanic primary production and we cannot increase the percentage used for fishery production without starving other top predators such as marine birds and mammals.

Environmental Change

Small changes in seawater temperature can mean big changes in marine ecosystems. On Laperouse Bank off Barkley Sound, many fished species as well as seabirds and marine mammals including the endangered humpback whale all feed on herring and krill in the summer. Hake, a member of the cod family, are migratory and come from as far away as California to feed on the rich bank in the summer. The warmer the water is, the more hake come to the bank. This has a tremendous affect on herring and krill populations. It also has a big impact on the entire food web. Species such as mackerel will also move in during warmer than normal years and they may feed heavily on young salmon.

Environmental change such as global warming has a big impact on ocean ecosystems and in combination with over fishing is even more dramatic. The disappearance of Pacific sardine (pilchard) from British Columbia waters is an example of this combination.



"How much fish can a fisher fish and still have fish to fish?"

Fish do not recognize international boundaries and even though management of fish stocks within a country may be adequate, foreign fishers may over-fish the same stocks right up to natitional boundaries. On the Grand Banks, foreign fishing just outside of Canada's waters took sixteen times the quotas for cod, flounder and redfish. This disregard for regulations is in part what caused the collapse of the Northern Cod fishery off Canada's Atlantic coast.

Species that are most vulnerable to overfishing mature late and produce few young. Many of the marine mammals that were either fished to extinction or threatened with extinction -- Steller's sea cows, sea otters and baleen whales for example -- fit into this category.

In order to help the ocean feed more people and to protect the diversity of life in our oceans, we need to change the way we act and harvest marine resources. Let's see if Canada,s new Ocean Act is a step in the right direction. (See page 12 for more on the Oceans Act).

The Land and Sea Connection

Forests are important for regulating water flow and water temperatures and for holding soil. Forest removal affects the rivers, streams, lakes and estuaries which provide incubation and rearing environments for salmon. Problems such as siltation causing egg smothering, floods sweeping out redds ("nests" where fish spawn), fluctuating temperatures and water levels can occur after logging. These effects may also disrupt ocean herring spawning habitat which in turn may further effect salmon food webs at sea. The degradation of spawning habitat for the six species of Pacific salmon is beginning to be recognized. We need to leave enough plant cover to allow for soil stability, natural drainage patterns and natural stream flow rates.

Changes are needed in fisheries management, enforcement and international cooperation. Reducing waste and bycatch, fishing lower on the food chain and protecting habitats would all be favourable moves for marine biodiversity.

Traditional Ecological Knowledge

Traditional ecological knowledge embodies a deep relationship with the natural world; a relationship characterized by a sense of connectedness, respect and stewardship. The wisdom and knowledge embedded within First Nations, cultures continues to influence the world and modern society. We can learn a great deal from this knowledge to help sustainably manage the very complex ecological systems found in the oceans.

First Nations, languages and traditions are living expressions of dynamic cultures where humans are part of the natural world. This is reflected in distinctive world views. As George Erasmus, a Dene leader states, human knowledge of nature goes hand-in-hand with human obligations to maintain balances of nature. Other life forms are our "relatives" with whom we share the living landscape and the sacred planetary home.

In David Neel's book, *Our Chiefs and Elders: Words and Photographs of Native Leaders*, knowledge of respect is shared. "Respect is the foundation for all relationships: between individuals, with future and past generations, with the Earth, with animals, with our creator (use what name you will) and with ourselves." To understand this essence of respect and connectedness is a necessary lesson to learn as we move into the twenty-first century.

Meet Robert Dennis

Robert Dennis is Chief Councillor of the Huu ay aht First Nation. and a member of the Nuu chah nulth Tribal Council 's Treaty Negotiation team. The Bamfield Marine Station is located within Huu ay aht traditional territory in Barkley Sound. Here Mr. Dennis reflects on the important role of the ocean to his people.

The Huu ay aht people have always depended on the sea and were once leaders in the fishing industry. In the 1950s there were 61 commercial Huu ay aht fishermen, today there are only 14. One of the basic principles we respected was that you took only what you needed and never over-fished. When you have 1000 fishermen who all want more money, and the driving factor is making more money, you threaten the resource. When you do something to create an imbalance or disrupt nature, you are going to affect other areas.

We know our backyard. The land and the water cannot be separated, people can,t exist without the forest. The Sarita River was called the "river became so white with male spawn of salmon." Today people who have lived there all their life, who know the fish, the ducks, swans and deer have experienced this imbalance.

We were once dependent on the salmon and used to need 1600 fish per family for a winter. Now the total catch of the Huu ay aht community is 1,645 fish for 500 people. Previously we had 35 salmon-producing creeks, now we are left with four to nine. The imbalance occurred when the forest was being destroyed, gravel and dirt from the mountains washed down into the creeks. Where does the silt go? Onto the salmon eggs.

The Huu ay aht chiefs have always had responsibilities for looking after the land. We need the rivers restored. We need cooperative management which will benefit every one of us. We must all work together.
The Huu ay ahts were predominantly a whaling community, a whaling people. We took one whale at a time, shared and used all of it. The commercial whaling station at Sechart took 200 - 400 whales per season until there were not enough left. Fur seals were also very important. They also disappeared with commercial sealing.

Our people used to know that they would be able to eat herring spawn every spring. Now there is an unhealthy environmental balance involving the loss of kelp. Kelp that the herring used to spawn on has been harvested. Kelp Bay used to have herring spawn, so did Bamfield and Grappler Inlets. Now there are no herring there.

Shellfish have always been important food for the Huu ay aht. Urchins, chitons, clams, mussels and barnacles. Now lease-holders try to keep us from digging on our own beaches. Good beaches have been dug out. An Huu ay aht person would never see a beach destroyed. What can we do to restore the clam beds? What can we do so that foreshore leases don,t impinge on our freedom to dig clams?

What can we do to restore the whole nation? What can each of us do to bring back the rivers, clam beds, halibut banks, whaling and sealing grounds? We as a people almost lost our songs and dances. When we get together song is good medicine. Now we have people who are proud to say that they are Huu ay aht.

The ocean has always been very important to our community. This is what we are saying in our message. We no longer have this food source that was available on a daily basis. A people who depended on what was in the sea can no longer get to it.

Transcribed from Robert Dennis

Hesquiaht Traditional Ecological Knowledge

"In Hesquiaht territory we look at a point of land and we don,t see trees that will give us a million dollars. What we see is that maybe there is an eagle,s nest and maybe there are some of those ferns with the roots on that tree over there and maybe there are some sea urchins down below . That is the way we look at it. Not that it is a beautiful view, maybe I can build a resort there. We still view it the way my grandfather viewed it. We look at land as a source of food, other forms of life, not as dollar signs." - Steve Charleson

Hesquiaht territory supports a diversity of human and non-human life. It is a whole system. It is not the sum total of so many fish and so many birds and so much forest acreage, but rather a place that has sustained life for thousands of years. Hesquiaht people have long realized that in such a living system no single element is more important than any other element. Each species and each habitat has its role to play and, therefore, cannot be removed without consequences to the overall health of everything else.

Hesquiaht knowledge of their natural world, and themselves, has developed over the course of many generations living in intimate contact with their environment. The diversity of that environment has translated into a diversity of resources uses. Archaeological evidence, collected from three Hesquiaht Harbour sites, found the remains of 12 different land mammals, 11 different marine mammals including northern fur seals*, three types of whales and two types of porpoises, 40 species of fish including tuna*, 34 species of shellfish, and 63 varieties of birds, including albatross*.

** These are all offshore species.*

Though a number of these species are no longer found in Hesquiaht Harbour, the intricate pattern of resource use has continued to the present day. Knowledge of the best sites for different species and the best, or only, time of year to gather certain species, is still vital information we possess. The time of year herring arrive in Hesquiaht Harbour, the marine mammals that accompany them, the birds that grow fat on herring spawn, the spring salmon that feed off the herring ˆ this is the knowledge of the web of life in Hesquiaht Harbour that still governs our thoughts and actions.

Skills such as using mussel and clam shells as tools, or making containers for dog salmon roe out of seal bladders may no longer be common, but the ingenuity gained from centuries of contact with the life of the sea and land is not easily erased. The last time I went to Tsamata beach with a class of students, my brother-in-law made a doll out of bull kelp for one of the girls. The other children were quickly impressed he soon found himself making a kelp baby for each student. While making dolls out of kelp is not an ideal example of Hesquiaht traditional ecological knowledge, it does illustrate the very practical way in which Hesquiaht people continue to use the resources that their environment provides. A resource that appears valueless, in this case dead bull kelp, is readily pressed into service when it is needed.

As it has for generations, the diversity of our environment provides all that we need here.

written by Karen Charleson

Radar Man

Tommy Happynook, or Mexus is one of the hereditory chiefs of the Huu ay aht Fiirst Nation. His late Grandpa, Bill Happynook was trained in the old ways and was often a source of inspiration and awe to Tom as he was growing up.

It was the month of August. I was probably about 9 or 10 years old. The time was 4 am and I was awakened in the usual way by my grandpa leaning quietly over me and asking me if I would like to get up and go fishing with him. This particular morning I decided that it was a good idea. When I left the house to go down to the boat I found it to be a normal August morning, the fog was thicker than Chunky soup. I wondered how my grandpa even found the boat because I couldn't see it and it was only about 100 feet away. I found my way down the float and untied the lines, pushed the bow out and jumped aboard. We headed out towards Bamfield. We couldn't see a thing but because I had lived there all my life and was an experienced fisherman I knew it was normally in that direction... SOMEWHERE. We putted along at grandpa's normal speed, which was SLOW, through the gap between Burlo Island and the Ostroms and out of Bamfield harbour.

Eventually we arrived somewhere in the foggy mess and the order came from the captain of the vessel that "we are here so drop the gear." I looked around and wondered where "here" was and how the heck grandpa knew where we were. However, I felt safe in the experienced hands of my grandpa because he had started fishing at the age of 12. Every now and then grandpa would give me the old style foghorn and had to climb out on the bow and blow into it as hard as I could. I was sure this was the only thing that was saving us from crashing into another boat or being run over by a huge ship.

After many hours fishing on the high seas of the Pacific Ocean, the order came to "pull up, we are heading home." The next logical thought that came to my experienced mind was "WHERE IS HOME?" I pulled the gear up and grandpa came out and had a good look around. I was not sure what the heck he was looking for but had full trust in his capabilities as a seaman of the West Coast of Vancouver Island from Victoria to Cape Scott and points beyond. After plugging along for some time wondering when we were going to see land. what appears right before my eyes but Bamfield Point.

The whole experience was incredible. We had left many hours ago and spent all day out in the thick fog, without any modern technology aboard for navigating and now there we were right back where we started -- AMAZING!

Later, I asked my grandpa how he new where to go and how to get back. His answer was astounding. e said" To begin with, I have been fishing for 50 years but most imporantly we were taught to read the waves, read the wind, watch for the type of seabirds that you run into throughout the day and you listen to the noise the ocean makes, it tell you where you are and which way to go." I thought to myself, "WOW, GROOVY," (look, that's what we used to say in those days, OK?!)

If only the newcomers did not view us as inferior peoples, to be saved by their God and made to be what they considered to be civilized, but instead saw the knowledge and the skill that our forefathers and mothers had acquired over thousands and thousands of years. This knowledge kept us alive and living in harmony with nature, not to destroy Mother Earth, but to take care of each other as equals.

Giving biodiversity a boost

Many organizations and programs across Canada are working to preserve marine biodiversity. These are just a few of them.

B.C. Ecological Reserves

Ecological reserves are protected natural areas that preserve representative ecosystems, natural phenomena and plant and animal species throughout B.C.. Established to be used as outdoor laboratories and classrooms, ecological reserves help maintain and protect the outstanding biological diversity of B.C.

Ecological reserves are different from parks. They are *not* created for outdoor recreation. Most ecological reserves are, however, open to the public for non-consumptive uses — wildlife viewing, bird watching, scuba diving and photography. For other reserves, including seabird nesting colonies, access is restricted to researchers with valid permits. Groups also must obtain permits from B.C. Parks' district offices.

Of the 131 ecological reserves in B.C. many were established for the protection of marine biodiversity. Some examples include: several seabird breeding colonies; a sea lion colonies; areas rich in intertidal and subtidal marine life; prime sea otter habitats; prime killer whale habitats; and a pristine west coast estuary.

Are there any ecological reserves near your community? B.C. Parks publishes a map and key that identifies the locations of ecological reserves.

To obtain the map or for more information about the ecological reserve program contact: and your local B.C. Parks office or the main office at B.C. Parks, 2nd Floor, 800 Johnson St., Victoria, B.C., V8V 1X4. Friends of Ecological Reserves (Box 8477, Victoria, B.C., V8W 3S1) can also supply you with information.

Marine Life Sanctuaries Society

This volunteer organization is committed to creating a network of marine protected areas along the B.C. coast. These sanctuaries would protect representative ecosystems and areas of special value and fishing and harvesting of any sort would be prohibited.

Marine sanctuaries help marine biodiversity in many ways. They protect areas of special marine significance and also provide natural enhancement of stocks to neighboring areas where harvesting is still permitted. For example, the rockfish present in a marine sanctuary would help replenish rockfish populations in nearby areas.

So far the Marine Life Sanctuaries Society has been successful in the creation of Canadaís first marine protected area -- Whytecliff Park near Vancouver. The Society is gathering support for other marine sanctuaries in Gabriola Passage near Nanaimo and in Browning Passage and Hunt Rock near Port Hardy.

You can join the Marine Life Sanctuary Society if you write: P.O. Box 48299, Bentall Centre, Vancouver, B.C., V7X 1A1.

Canada's Oceans Act

Canada is a country with close connections to the ocean. Three oceans border our country and we have the World's longest coastline. A new Oceans Act will give Canada a stronger jurisdiction over the use and management of ocean areas and their resources. The Act defines an Exclusive Economic Zone that spans from the edge of the continent to 200 nautical miles offshore. In this zone, Canada will have jurisdiction over the exploration, exploitation and conservation of marine resources.

The new Act also gives Canada the authority to establish marine protected areas and entitles Canada's oceans to the same level of environmental protection as Canada's lands.

This Act is not in place yet however. It requires one more reading in Parliament before it finally becomes law.

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