Endeavour Hydrothermal Vents:
Canada's First Marine Protected Area.

Marine Conservation
Unique Environments
Adaptations
Biomes
Grades 4 – 11

Materials

Activity I, II, and III
Backgrounder pages
Colouring Page
Curriculum connections page
Diversity page
Glossary
Chemosynthesis vs. photosynthesis page
Interesting Facts
Visualization pages #1 and #2

Overview

Through class discussions, research, and activities, students in Grades 4 to 11, will learn about the ocean biome, hydrothermal vents, and more specifically about Canada's Endeavour Hydrothermal vent site and it's designation as a Marine Protected Area. Students will become acquainted with the Endeavour hydrothermal vents area and its residents and their adaptations for existence in this harsh environment.
A basic understanding of the Earth's tectonic plates is necessary prior to this lesson; a basic definition is given in the glossary.
Secondary grade students can take this lesson plan to the next level, using planning and investigation to look at theory of evolution and adaptation, photosynthesis versus chemosynthesis, speciation, and cause and effect relationships.

Objectives

Going through the three activities and class discussions students will –

- Meet grade appropriate curriculum connections (see separate curriculum connections page)
- Learn what a Marine Protected Area is and why we need them. (see backgrounder pages)
- Understand terminology (see glossary)

- Discover the residents of the hydrothermal vents and the challenges of exploring the marine abyss biome.

Activities

There are three activities for students on Marine Protected Areas and the Endeavour Hydrothermal Vents.

Activity I– Becoming a Researcher introduces students to features of hydrothermal vents, terms and names, and the vent ecosystem.
Students research and present within groups and then to whole class so that all the class is introduced to terminology and gains an understanding of Hydrothermal Vents and Marine Protected Areas.

Activity II – Special Places is designed to encourage students to analyze what makes a place special to them. Leading from this discussion, they will then look at the Endeavour Hydrothermal Vents, and discuss the reasons why this area was chosen (is it unique, threatened, vulnerable to human activity?) for a Marine Protected Area.

Activity III – A Product of My Environment (may be split into 2 lessons)
Beginning with an introduction to zones of the earth, then of the ocean, students are taken to the zone of the Endeavour Hydrothermal vents, the abyss, and look at adaptations that the local residents have made to survive in this environment. Using guided imagery, (visualization #1) student's imagination is challenged to create a creature that could survive well in the described fantasy habitat.
The next step is a guided imagery of what the hydrothermal vents habitat would be like, (visualization #2) and the students are then challenged to create or describe a creature that would be well adapted to survive there.

Estimate of time required

- Number of lessons: 3 or 4
- Time required for each lesson: 30-90 minutes
- Can be done: anytime
- Natural Area Required: None. An open area or outdoor area where students can form a circle to present is recommended.

Adaptations

As these are complex topics, with much information and many concepts for students to grasp, the materials have been divided into segments that can be presented to students in a sequence that the teacher feels will work best for the grade level they are working with. Part or all of the materials can be used.
The backgrounder has a short answer, followed by a more detailed explanation.

Evaluation

Evaluation suggestions have been given with each of the three activities.

Key questions that students should be able to answer at the end of this unit:

1. What is a Marine Protected Area?
2. What are Hydrothermal vents?
3. What makes the Endeavour Site unique?
4. For older grades, the following terms can be defined
    - what is endemism?
    - what is gigantism?
    - what is photosynthesis?
    - what is chemosynthesis?
    - what is symbiosis?

Other Resources

Web page links are provided when relevant to subject matter.
Key words are listed in the Becoming a Researcher activity to enable students to do their own web search.

Related lesson plans and Resources:

Video highlights – vents playlist -
https://www.youtube.com/playlist?list=PL84B4C76ABEFABB07

http://oceanexplorer.noaa.gov

http://education.nationalgeographic.org/activity/resources-in-the-deep-sea/

Curriculum connections - Endeavour Hydrothermal Vents Activities I, II, III

Grade 4 – Science -Communication, Creative thinking, Critical thinking

- all life is interdependent on its environment
- energy comes in a variety of forms that can be transferred from one object to another.
- the way organisms in ecosystems sense and respond to their environment.
- energy has various forms and is conserved
- features of biomes

Grade 5- Science - Communication, Creative and Critical thinking, Social Responsibility

- humans use earth materials as natural resources.
- multicellular organisms have organ systems that enable them to survive and interact within their environment.
- sustainable practices
- basic structures and functions of body systems
- the nature of sustainable practices around BC's living and non-living resources.

Grade 6 –Science - Creative and critical thinking

- multicellular organisms rely on internal systems to survive, reproduce, and interact with their environment.
- force of gravity
- extreme environments exist on earth and in the solar system.

Social Studies

- social responsibility - The pursuit of valuable natural resources has played a key role in changing the land, people, and communities of Canada.

Grade 7 – Science - Communication, creative thinking, critical thinking, social responsibility.

- the theory of evolution by natural selection provides an explanation for the diversity and survival of living things.
- natural selection, survival needs and interactions between organisms
- evidence of climate change over geological time and the recent impact of humans.

English Language Arts

- access information and ideas for diverse purposes and from a variety of sources and evaluate their relevance, accuracy, and reliability.

Grade 8 – Science – Communication, creative and critical thinking.

- characteristics of life
- the theory of plate tectonics is the unifying theory that explains Earth's geological processes.
- plate tectonic movement

- layers in earth
- the relationship of micro-organisms with living things
- photosynthesis (vs. chemosynthesis)

English Language Arts

- Create and communicate – presentation techniques

Grade 9 Science

- The biosphere, geosphere, hydrosphere, and atmosphere are interconnected, as matter cycles and energy flows through them.
- matter cycles within biotic and abiotic components of ecosystems

Processing and analyzing data and information

- Experience and interpret the local environment.
- Use knowledge of scientific concepts to draw conclusions that are consistent with evidence.
- Analyze cause-and-effect relationships.

Grade 10 Science

Genes are the foundation for the diversity of living things.
Energy is conserved and its transformation can affect living things and the environment.

- mechanisms for the diversity of life: mutation and its impact on evolution — natural and artificial selection
- adaptive radiation
- selection pressure (e.g., adaptation and extinction, invasive species)
- adaptations
- extinctions
- Experience and interpret the local environment
- Use knowledge of scientific concepts to draw conclusions that are consistent with evidence
- Analyze cause-and-effect relationships

Questioning and predicting

- Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal interest
- Make observations aimed at identifying their own questions, including increasingly complex ones, about the natural world
- Formulate multiple hypotheses and predict multiple outcomes

Grade 11 Environmental Science

Diversity in Local Ecosystems

- Local environments contain diverse ecosystems with many roles and relationships.
- Content - abiotic and edaphic factors
- biodiversity:
- species and their ecological roles

- relationships and interactions in ecosystems

Processes and Changes in Local Ecosystems
- Interconnected systems sustain healthy ecosystems.
- Ecosystem stability is an important result of sustainability
- Content - energy flow
- matter cycles
- population dynamics and landscape structure
- change and stability in ecosystems

Sustainability in Local Ecosystems
- Human practices affect the sustainability of ecosystems.
- benefits of healthy ecosystems
- humans as agents of change: First Peoples and other traditional ecological knowledge
- unsustainable and sustainable ecosystem practices

Conservation and Restoration of Ecosystems
- Humans can play a role in conservation and restoration of ecosystems.
- Content- • environmental stressors challenge ecosystem integrity, health, and sustainability
- ecological restoration principles and practices

Life Science

Characteristics of Living Things
- All living things have common characteristics.
- What characteristics allow organisms to live on land?
- What unique characteristics allow organisms to live in extreme environments?

Process of Evolution
- Living things evolve over time.
- What is the role of DNA in evolution and biodiversity?
- What characteristics allow organisms to live in unique environments?

Curricular Competencies – Elaborations

Questioning and predicting:
- sustained intellectual curiosity:
- What conditions are needed for life by different organisms?
- How do changing climates such as desertification of biomes affect the organisms that live there?
- Make observations aimed at identifying their own questions: Consider a collection of pieces that are evidence for the theory of evolution to develop a series of questions and predict/infer the answers.
- Formulate multiple hypotheses and predict:
- Hypothesize why local organisms (e.g., snow geese) exhibit behavioural and/or migratory changes.

Endeavour Hydrothermal Vents: Canada's First Marine Protected Area

Activity I

Becoming a Researcher

Time
1 hour plus discussion time

Grades 4-11

Grades 4 and 5 use Glossary, Backgrounder, reference books, interesting facts page, illustration page on chemo and photosynthesis, and older students could also do web research in order to gain an understanding of the Endeavour hydrothermal vents and Marine Protected Areas.

Materials
Backgrounder
Glossary of terms
Interesting facts page
Photosynthesis vs. chemosynthesis page
Resources and key words.

Lesson Overview
Students are being introduced to hydrothermal vents and Marine Protected areas, and come to understand what these places are, how they are formed, who lives there, (and some of their unique characteristics), and how we try to protect them. Many new terms will need to be discussed and explained. This lesson is the first step in students' understanding of these unique areas.

Becoming a Researcher – the Activity

Teacher reads out backgrounder to class.

Discussion
How did these unique areas form, and why did Canada decide to protect some of them? Where do these areas exist and why?

Give students page on chemosynthesis vs. photosynthesis and discuss.
Then hand out the glossary of terms and interesting facts. * make sure to discuss tectonic plates, pick this term out of the glossary.

Students are given a list of research topics, (see below) and assigned to groups of 3 or 4, and are given a half hour to find 3-4 interesting facts about their topic. (Make sure that each group has a different topic)
Groups research items and gain basic knowledge of their chosen topic.
Groups present their results to the class, making sure to leave time for questions so that class becomes familiar with hydrothermal vents, marine protected areas, and deep sea research.
Class discussion of harsh environments and Endeavour Hydrothermal Vents, how life has adapted to survive there, how humans explore these areas, and why we need to protect them.

Research suggestions:

a. Marine Biomes – the Abyss Zone of the Ocean
b. Tectonic Plates – Juan de Fuca
c. What is a hydrothermal vent– specifically Endeavour
d. Marine Protected Areas
e. Endemism and hydrothermal vent inhabitants
f. Photosynthesis vs. Chemosynthesis
g. Deep Sea Exploration.

Evaluation

Ask each group for their 3-4 interesting facts about their topic.

What did they find interesting about their facts?

What did they find interesting about the other groups presentations?

How many students knew about hydrothermal vents?

Did they know hydrothermal vents exist off Vancouver Island?

Extensions

Students pick their own area of interest in the deep sea to explore further.

Students draw some of the creatures they have discovered that live in the Endeavour HTV area.

Students can find out what other types of places are Marine Protected Areas or are under consideration to become MPAs.

Students write a story about discovering something new on the earth.

Resources and key words

Canada's Marine Protected Areas

Deep Sea Mining - http://www.pbs.org/wgbh/nova/next/earth/deep-sea-mining/

Tectonic Plates

The Marine Biome

The Deep sea and Ocean Exploration

Oceans Act – Endeavour Hydrothermal Vents Marine Protected Area Regulations - Designation, Prohibitions, and Coming into Force
http://laws-lois.justice.gc.ca/eng/regulations/SOR-2003-87/page-1.html#docCont

Endeavour Hydrothermal Vents: Canada's First MPA

Glossary of Terms

1. abyssal zone - The deep ocean is the *abyssal zone*. The water in this region is very cold (around 3° C), highly pressured, high in oxygen content, but low in nutritional content. The abyssal zone supports many species of invertebrates and fishes. Mid-ocean ridges (spreading zones between tectonic plates), often with hydrothermal vents, are found in the abyssal zones along the ocean floors.

2. bacterivores – microscopic organisms which obtain energy and nutrients primarily or entirely from the consumption of bacteria.

3. biome – Biomes are defined as the world's major communities, classified according to the predominant vegetation and characterized by adaptations of organisms to that particular environment. World biomes are freshwater, marine, tundra, desert, forest, and grassland.

4. chemosynthesis - is the use of energy released by inorganic chemical reactions to produce food. Chemosynthesis is at the heart of deep-sea communities, sustaining life in absolute darkness, where sunlight does not penetrate.

5. chemoautotrophic – literally means chemical self nourishment. Chemoautotrophs use inorganic energy sources, such as hydrogen sulphide or elemental iron to obtain energy from chemical reactions. Most are bacteria or archaea that live in hostile environments such as deep sea vents and are the primary producers in such ecosystems.

6. community – a group of organisms or a social group interacting in a specific region under similar environmental conditions.

7. conservation – preserving and carefully managing natural resources so that they can be used by present and future generations.

8. ecosystem – a community and the interactions of living and nonliving things in an area. Different areas of the ocean can be classified as different types of marine ecosystems.

9. ecozones - To understand the diversity of life it is helpful to consider how natural boundaries, which exist now and in the geological past, have restricted movement and how different climates have lead to different environmental pressures. Both geographical isolation and differing environmental pressures have resulted in diversification through natural selection. Different groups of species, and different types of solutions have

evolved in different parts of the world, and these areas are called ecozones. British Columbia has the Pacific Marine ecozone which begins at the BC Coast and is defined by cold Arctic waters to the north.

10. endemic – found no where else on earth. Unique or limited to one place or habitat type on earth.

11. environmental impact – the effect, usually negative, of human activity or presence on an area.

12. extraction – removing rock or minerals from the earth.

13. extremophile – an organism that lives in extreme environments such as super heated water or toxic-laden environments.

14. habitat - A place where something lives is its habitat. It is a place where it can find food, shelter, space, and protection.

15. hydrothermal – of or related to hot water.

16. hydrothermal vents- Hydrothermal vents are the areas where ocean water is heated up by the molten magma under the earth's crust, and vent like structures are formed. "Deep sea geysers".

17. local environment – all the influences and conditions in which organisms live. (weather, temperature, etc.)

18. natural resources - *Natural resources* occur within environments that exist relatively undisturbed by humanity, in a *natural* form. A natural resource is often characterized by the amount of biodiversity that exists in various ecosystems. Natural resources are derived from the environment.

19. non-renewable - Something that cannot be replaced once it is used or that may take many hundreds of years to be replaced.

20. photosynthesis - occurs in plants and some bacteria, wherever there is sufficient sunlight – on land, in shallow water, even inside and below clear ice. All photosynthetic organisms use solar energy to turn carbon dioxide and water into sugar and oxygen.

21. renewable resources - Natural resources that can be renewed or replaced by nature within 100 years.

22. species - a group of living organisms consisting of similar individuals capable of exchanging genes or interbreeding.

23. symbiosis (or symbiotic relationship) is a close and often long-term interaction between two different biological species, usually to the benefit of both.

24. tectonic plates – Earth's outside layer (lithosphere) is made up of what is called the crust and the uppermost mantle, which is the hard, rigid layer on the outside of the earth. A good example to use for the layers of the earth is a soft-boiled egg, cut in half with the shell on. The shell is the crust and the white of the egg the mantle, and the yolk, which is runny, is the core of the earth.
    The crust of the Earth is divided into tectonic plates. The movement of the plates toward each other forms mountains, and away from each other, (divergent) allows for hot magma to lie close to the Earth's surface, enabling ocean water to be superheated - the creation of hydrothermal vents.

25. unique – specific to a certain place.

Sources

Earth and Space Science: Renewable and Non-renewable Resources (p. 100, Science K to 7)

Salmonids in the Classroom, Intermediate, Fisheries and Oceans Canada, Appendix 3, Glossary.

http://www.ucmp.berkeley.edu/exhibits/biomes/marine.php

http://oceanexplorer.noaa.gov/facts/photochemo.html

Wikipedia

Interesting Facts on Ecosystems, the Abyssal Zone, and Hydrothermal Vents
(supplement to Become a Researcher Activity)

- Different areas of the ocean can be classified as different types of marine ecosystems. An *ecosystem* is defined as a community and the interactions of living and nonliving things in an area.

- Many parts of the ocean remain unexplored and much still remains to be learned about marine ecosystems.

- Marine ecosystems have distinct organisms, with distinct characteristics that result from the unique combination of physical factors that create them.

- Marine ecosystems include: the abyssal plain (areas like deep sea coral, whale falls, and brine pools), polar regions such as the Antarctic and Arctic, coral reefs, the deep sea (such as the community found in the abyssal water column), hydrothermal vents, kelp forests, mangroves, the open ocean, rocky shores, salt marshes and mudflats, and sandy shores.

- The average depth of the ocean is 4000m (about 2.5 miles), making the Abyssal Zone the largest living environment on Earth. It covers over 300,000,000 square km (115,000,000 miles)–about 83% of the ocean's total area and 60% of Earth's surface. http://www.untamedscience.com/biology/biomes/deep-sea-biome/

- The deeper you go in the ocean, the more intense the pressure. At the surface, there is one atmosphere of pressure; for every ten meters you go underwater, the pressure increases by one atmosphere.

- One way some animals have adapted to this pressure is that they have no air spaces in their body. (for example no swim bladder)

- The deep sea has extremely low temperatures. In fact, the beginning of the Abyssal Zone is conveniently defined as the area where water drops to 4 degrees Celsius. At the ocean's average depth of 4000m, the average temperature is 2 degrees Celsius. http://www.untamedscience.com/biology/biomes/deep-sea-biome/

- The abyssal plain at the bottom of the ocean contains pockets of life that are spread far apart from one another. Some marine ecosystems, like the deep sea, are in constant darkness where photosynthesis cannot occur. Other ecosystems, like rocky shores, go through extreme changes in temperature, light availability, oxygen levels, and other factors on a daily basis. The organisms that inhabit various marine ecosystems are as diverse as the ecosystems themselves. They must be highly adapted to the physical conditions of the ecosystem in which they

live. For example, organisms that live in the deep sea have adapted to the darkness by creating their own light source—photophores are cells on their bodies that light up to attract prey or potential mates.

- Animals here must withstand pressures of up to 11,000 psi. They tend to be grey or black (for camouflage) and unstreamlined (for energy conservation). Many are blind, and they are thought to reproduce very slowly. Some examples of deep sea life here are the tripod fish, anglerfish and giant squid.

- Hydrothermal vents are fissures, or openings in the ocean floor that release hot, mineral rich water. They are found in both the Pacific and Atlantic Oceans at a depth of about 2,100 meters. (7000 feet).

- There are two known types of hydrothermal vents – black smokers and white smokers.

- Black smokers are the hottest of the vents. Black smokers spew a black smoke composed mainly of iron and sulphide.

- Giant tube worms, located in the hydrothermal vent ecosystem at 2,499 meters (8,200 feet) below the surface, have long, white bodies and no eyes, mouth, or stomach. The worms use a special part of their body, "the trophosome", to soak up chemicals from the hydrothermal vent to feed to the bacteria living inside them. In return, the bacteria make food for the tube worm. (Julie Brown, National Geographic Society)

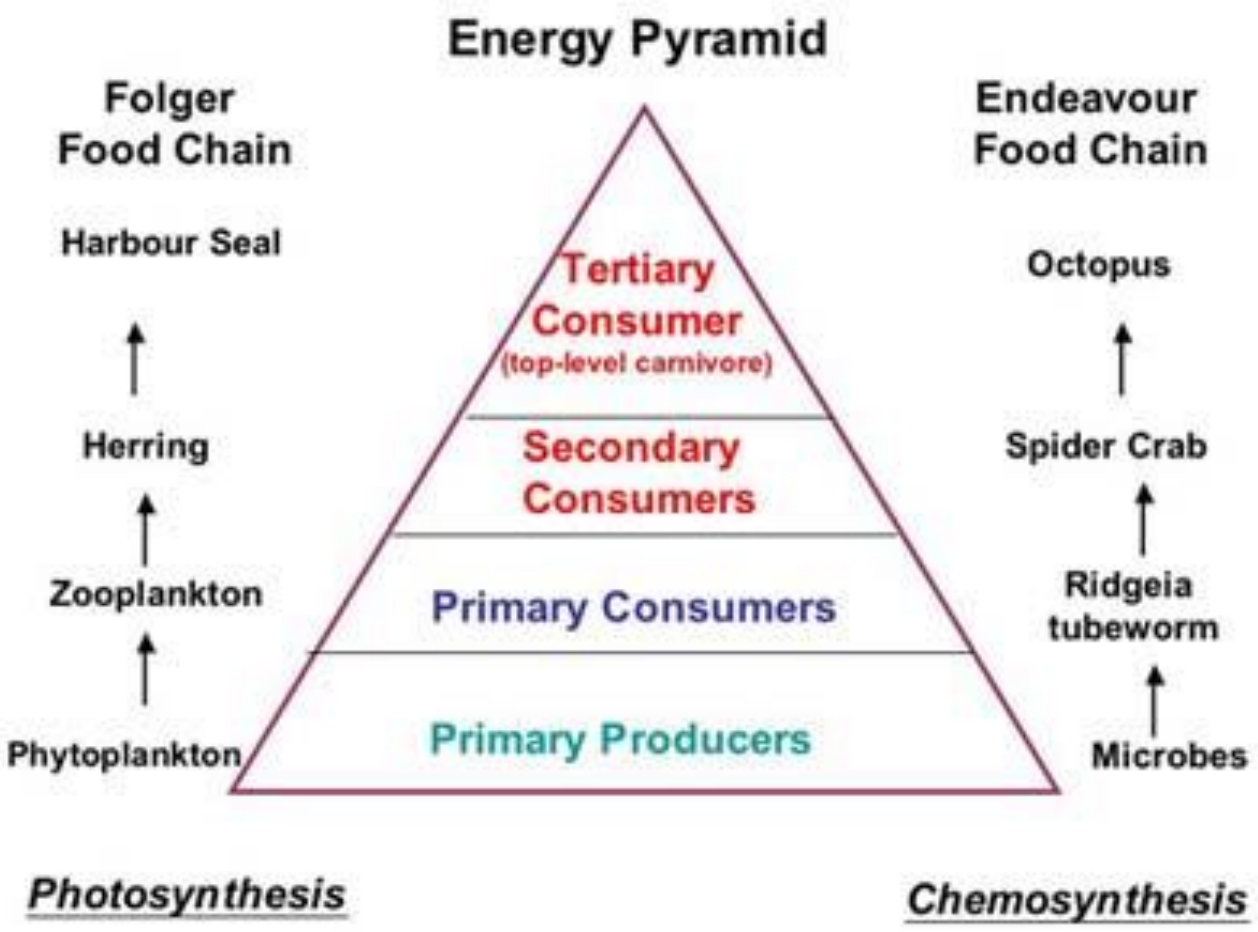
- The deep sea is a noisy place, recordings of sound in the deepest part of the ocean included whale and dolphin sounds, as well as motor sounds and far off earthquakes.
- http://www.noaa.gov/media-release/seven-miles-deep-ocean-is-still-noisy-place

- Scientists are just beginning to understand how animals and microorganisms have adapted to the extremely hot, toxic environment of the hydrothermal vents. This information may help them understand how life started on Earth, and whether life on other planets is possible.

- "Some biologists have gone so far as to suggest that a vent-like environment was the place where life on Earth likely got its start. And if such a miracle could have occurred here on Earth, why not on other planets that have the necessary ingredients, including heat, water, and the right mix of chemicals? In the end, there may indeed be a harsher place to live than hydrothermal vents. But again, it hasn't been found. Yet." from Life in the Abyss, by Peter Tyson: http://www.pbs.org/wgbh/nova/nature/life-in-the-abyss.html

Compare food webs:

Folger Passage vs. **Endeavour hydrothermal vent** communities.



Despite their unusual nature, animals based on chemosynthesis are tied together by food webs similar to those of better-known communities. The hydrothermal vent food web has four layers:

- **Primary producers** are the original source of food in the vent ecosystem, using chemical energy to create organic molecules. All other life depends on primary producers, and they have the greatest biomass (amount) in the community.
- **Primary consumers** get their energy directly from the primary producers by eating or living symbiotically with them.
- **First order carnivores** prey on the primary consumers and in turn are eaten by other animals.
- **Top order carnivores** eat other consumers and carnivores but are rarely hunted by other creatures. Because they are separated from the primary food production by several layers, top order carnivores have the smallest numbers in the food web.

Chemosynthesis vs Photosynthesis

Photosynthesis is the process of using sunlight to produce energy. All organisms need **energy**, **oxygen**, **water** and **shelter** to survive. In the shallow ocean environments, seaweeds harness the energy from the sun to produce carbohydrates (or sugars), just like plants on land.

In the deep ocean, the light does not reach the hydrothermal vent communities. The primary producers of these ecosystems are bacteria that use **chemosynthesis** to produce organic material and energy from the dissolved minerals that are plentiful in the vent waters.

At **Endeavour Ridge**, the food web is powered by chemosynthesis.

Chemicals such as **sulfides** (highly toxic to most organisms including humans) spewing out of the hot smoker chimneys and cracks in the sea floor are gobbled up by **microbes** as the **primary producers**. These sulfide suckers are generally of two types. First, some **chemosynthetic bacteria**, or microbes live in large mat-shaped mounds that are tasty treats for bacterivores like snails, crabs and shrimp that graze on these food piles and for filter feeders sorting food "crumbs" from the water. Second, some of these microbial producers live right inside the bodies of some animals in a **symbiotic** partnership (meaning that both organisms depend on each other for survival) These bacteria produce carbohydrates (sugars) from the sulfide that is pumped out of the vents and supports a large population of **chemoautotrophic** (chemical self nourishing) **bacteria**. These bacteria use sulfur compounds, particularly **hydrogen sulfide**, a chemical highly toxic to most known organisms,(including humans), to produce organic material through the process of **chemosynthesis.**
http://oceanlink.island.net/SOLE/vents/End_foodweb.html

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Activity II

Special Places

Timeline - 45 minutes to 1 hour.
Grade Levels 4-11

Materials and resources

Backgrounder pages
Chemosynthesis vs. Photosynthesis page
Glossary
Diversity document (optional)
Sticky notes (optional)

Overview – What makes a special place? To humans, a special place may be due to pleasant memories, good feelings or many other things, and to other living things it may be a place that provides the necessities of life. Sometimes there are unique adaptations that allow organisms to survive in their special places, such as heat and cold tolerance in intertidal organisms.
Pressures are often placed on special places that can threaten their very existence, creating the need for protection.

Special Places – the Activity

Read Backgrounder sections on:
(There are short answers for grades 4 and 5, optional)

1)What is a Marine Protected Area ?

2)Canada's Network of MPA's

3)Endeavour - Becoming an MPA and why?

Introduction

All living things have basic requirements to survive. Adaptations to the features of their environment enable organisms to live in their "special place". An example of a unique adaptation is chemosynthesis, a process to produce nourishment in a dark environment. Due to a complete lack of light, creatures of the abyssal zone use this process. Photosynthesis and chemosynthesis are both processes by which organisms produce food; photosynthesis is powered by sunlight while chemosynthesis runs on chemical energy. (see chemo vs. photosynthesis page)

Our knowledge of chemosynthetic communities is relatively new, brought to light by ocean exploration. The thriving communities associated with hydrothermal vents

shocked the scientific world when humans first observed a vent on the deep ocean floor in 1977.

The discovery of hydrothermal vents and cold-water methane seeps gave us a new vision of primary production in the deep sea. The irony is that once scientists knew what to look for, they went to other well-known ecosystems that were rich in hydrogen sulfides, such as salt marshes, and found the same mutualistic association of chemosynthetic bacteria and animals that had stunned them in the deep vents.

No one had ever thought to look for them, but these communities were there all along.

Marine Protected Areas have been created to protect such "special places", which are chosen for their uniqueness and vulnerability to human intervention.

Activity

Students brainstorm what a special place is to each of them, what makes it special, and then discuss their individual special places. (concept from Get Outdoors, Wild BC)
Examples of what makes a special place - Feeling safe, warm, comfortable, happy, content, loved. Scents, sounds, and aesthetics also can make a place special.

Have students close their eyes and imagine their special place. Ask them to observe what things make this a special place to them. Ask them to keep these thoughts as they will be asked to discuss.

Students get together in groups of 3-4 and share their special places and characteristics. (these can be jotted down on sticky notes) The groups then find the key items that are common in the group and present to rest of class.

Discussion – What things were in common to some of the groups? Were there any unique items?

What things make the Hydrothermal vents a 'Special Place" for it's residents? There are species that are endemic to the Endeavour hydrothermal vents (meaning they only exist there). Why wouldn't you find these same species in other areas of hydrothermal vents in the world?

Evaluation

Why do we try and protect special places?

What makes a special place for you?

If this place is the only environment that you could survive in, would that make you unique? (Endemism) Would it make you vulnerable?

What is a Marine Protected Area and why does Canada have them?

How does the MPA designation protect the Endeavour Hydrothermal Vents area?

Extension: (optional)

Read Diversity document to class and discuss how diversity plays a role in survival.

References

Chemosynthesis - http://oceanexplorer.noaa.gov/facts/photochemo.html

Get Outdoors, Wild BC publication - http://hctfeducation.ca/product-category/books-and-guides/

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Diversity

Generally, there are three main categories of biological diversity: genetic diversity, species diversity and ecosystem diversity.

(1) **An organism's genetic diversity** is the variation or difference in the amount of genetic information within and among individuals of a population, a species, a group, or a community. Genetic diversity is shown through the amount of similarities and differences in the genetic makeup of individuals, populations and species. These similarities and differences may evolve as a result of many different factors. (ie. heat, light, predation, etc.)
Even though genetic diversity is not always obvious, it is necessary so that organisms can evolve and adapt to changing environments in order to survive.

(2**) Species diversity** is the variation in the number and frequency of species in a biological group or community. The number of species of plants, animals, and microorganisms usually measures the biodiversity of a particular environment. This is why species diversity is the most commonly used synonym for biodiversity, where the number of species in a given habitat is used to measure its biodiversity. (more species = more biodiversity) The diversity of species is mainly important to the ecosystem functioning naturally; therefore, it is considered an indication of the health of an environment. It is estimated that the total number of species on earth is approximately 12.5 million, however the total number that could exist ranges from 50 to 100 million.

(3) **Ecosystem diversity** is the variation in the collection of groups, communities, and habitats within a region. An ecosystem is comprised of all living and non-living things in a particular area. Ecosystems include a combination of animals, plants, microorganism and physical characteristics that define the location. There are a number of new habitats that continue to be discovered and there may be more ecosystems waiting to be found.

In signing the Convention on Biological Diversity, signatory countries agreed to accept the responsibility to protect and understand the abundance of species, genetic materials, habitats, and ecosystems that make up the natural world; develop and maintain biological resources, to recognize each nation's authority over the biodiversity found in its territory, and to correct the imbalance between who benefits and who pays for protecting biodiversity.

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Activity III
(adapted from Project Wild, Fashion a Fish Activity, Canadian Wildlife Federation.)

A Product of My Environment

Timeline
Two - 45 minute lessons.
One lesson is to discuss terminology and background, one lesson is to hear visualizations and create creatures.
Grades 4 – 11

Materials and resources
Art materials,
paper
modeling clay
colouring page
glossary of terms (pick out relevant words)
visualizations #1 and #2

Objectives

1. Students will be able to define biomes, the abyssal zone, and describe adaptations of marine life to their environments.
2. Students will be able to describe how adaptations can help marine life survive in their habitat
3. Students will interpret the importance of adaptations in living organisms.

Curriculum connections

Grade 4 – (Science) Biomes –The abyssal biome (or zone) is where the Endeavour hydrothermal vents exist.
Grade 5 - (Science) Humans use earth materials as natural resources – Sustainable practices – MPA's .
Chemosynthesis vs photosynthesis - Multicellular organisms have organ systems that enable them to survive and interact within their environment.
Grade 6 - (Science) Multicellular organisms rely on internal systems to survive, reproduce and interact with their environment.
Grade 7 – (Science) Theory of evolution by natural selection provides an explanation for the diversity and survival of living things. Unique adaptations of vent inhabitants.
Grade 8 – **(Science)** – Communication, creative and critical thinking.
Characteristics of life

Theory of plate tectonics is the unifying theory that explains Earth's geological processes.
Relationship of micro-organisms with living things - photosynthesis vs. chemosynthesis.

Grade 9 Science

The biosphere, geosphere, hydrosphere, and atmosphere are interconnected, as matter cycles and energy flows through them.
Matter cycles within biotic and abiotic components of ecosystems

Grade 10 Science

Genes are the foundation for the diversity of living things.
Energy is conserved and its transformation can affect living things and the environment.
Mechanisms for the diversity of life:

Grade 11 Environmental Science

Diversity in Local Ecosystems
Local environments contain diverse ecosystems with many roles and relationships.
Abiotic and edaphic factors
Biodiversity: species and their ecological roles.
Relationships and interactions in ecosystems.

Overview

In the first activity, a class discussion of biomes, the abyssal zone, and adaptation, students are asked for specific examples of adaptations for various biomes, and more specifically the abyssal zone where the Endeavour site is located.

In the second activity, through guided imagery, students are given traits of an imaginary marine environment and are asked to "design" marine creatures that will have the best chances for survival.
They are then given another guided imagery, where characteristics of the abyssal zone – then the Endeavour hydrothermal vents area are described, and students are asked to create a creature that is adapted to survive there.

Background

Our earth is divided into areas called **biomes,** areas of the earth with similar climatic conditions and species living there. **Biomes** are defined as "the world's major communities, classified according to the predominant vegetation and characterized by adaptations of organisms to that particular environment" (Campbell, 1996).

There are aquatic and terrestrial (land) biomes. Terrestrial biomes are – tundra, rainforest, savanna, taiga, temperate forest, temperate grassland, chaparral, alpine, and desert.
Each biome consists of many ecosystems whose communities have adapted to the small differences in climate and the environment inside the biome. All living things are closely related to their environment.

Aquatic biomes are freshwater and marine.
Within the marine biome there is the ocean, estuaries, and coral reefs.
The ocean is divided into layers according to depth and temperature, with the abyssal zone being the area where the Endeavour hydrothermal vents occur. This layer of the ocean ranges from approximately 2000 to 6000 meters deep, and is subject to extreme cold, intense pressure due to depth, and complete darkness.

The water in this region is very cold (around 3° C), highly pressured, high in oxygen content, but low in nutritional content. The abyssal zone supports many species of invertebrates and fishes. Mid-ocean ridges (spreading zones between tectonic plates), often with hydrothermal vents, are found in the abyssal zones along the ocean floors. Chemosynthetic bacteria thrive near these vents because of the large amounts of hydrogen sulfide and other minerals they emit. These bacteria are thus the start of the food web as they are eaten by invertebrates and fishes.

(Biomes Group of the Fall 96 Biology 1B class, section 115, at UC Berkeley
Editing by Stephanie Pullen, redesign by Kacey Ballard, April 2004.)

Activity

We will look at adaptation, and the adaptations the residents of the Endeavour Hydrothermal Vents have made to survive, and even flourish, in this harsh environment.

Introduction
Activity part 1 – 30 - 45 minutes
All life is the product of countless adaptations over long periods of time. What are the requirements for survival? (food, water, shelter) What are some adaptations to better survive? (body shape, mouth, colour - method of camouflage or hiding, reproduction or spawning, tolerance to temperature and temperature changes, tolerance to chemical compounds)

Have students draw or find a picture of a creature with specific adaptation.
Have students think about an adaptation that an animal has – ie. long legs and sharp bill of blue heron for standing in water and catching prey, ears of owl offset in their head to enable them to hear in more directions.

Have a class discussion of the value of different kinds of adaptation to living things. Ask students if they can think of an adaptation to an extreme environment.

Activity part 2 – 1 hour, plus discussion time.
Discuss with the class the different adaptations marine creatures have that enable them to survive. Next, discuss the creatures of the hydrothermal vents and their adaptations to survive in the extremes of this environment. (extreme heat at vent

sites, extreme cold away from vent sites, sulfur dioxide (rotten egg gas) and other metals, and complete dark)

Divide students into groups of 3 or 4, depending on class size. (this activity can also be done individually.)

Read students the "visualization story #1" and have them create a creature that would be best adapted to survive in the described environment. (This can be drawn, a modeling clay form, a written description)

Have groups present their creatures and tell what adaptations the creatures have (whether color, shape, reproduction, mouth, etc.) to best enable them to survive.

Students must be prepared to defend why their creature has the specific features they have given it.

Read students the "visualization story #2" (the characteristics of the abyss zone of the ocean) and have them create something that would be best adapted to survive this harsh environment. Make sure to stress that this does not have to be a creature like a fish – be creative!

Have students present these creatures and describe their adaptations and how they enable the creatures to survive.

Hand out colouring page on Endeavour Hydrothermal vents.

Have students look at the drawing page. Tell students to look for various adaptations that the various creatures have made to survive the high sulphur content of the water, the heat of the vents, the surrounding cold, the high pressure of the deep sea, and the complete lack of light.

How do these things feed, reproduce, avoid predation/predators?

End with discussion of unique adaptations of Endeavour HTV creatures and compare to adaptations of other creatures in various biomes on the earth.

Evaluation

Name two adaptations of creatures in hot areas - what is the advantage of these adaptations to the survival of the creature in the hot habitat?
What biome could a hot area be?

Name two adaptations of creatures in cold areas – what is the advantage of these adaptations to the survival of the creature in the cold?
What biome would this be?

Describe how deep sea (abyssal dwellers) have adapted to survive in the complete dark.
Name three adaptations of Endeavour hydrothermal vent dwellers – (chemosynthesis to deal with lack of light and maintain ability to produce food, symbiotic relationships to deal with extreme chemical environment, limited range of habitat to take advantage of warmth of smokers, adaptation to large temperature range – hot close to vents, cold as you go away.)

Define endemic and name three endemic species. (Found only in a specific habitat or biome - tubeworms, clams, bacteria.)

What have scientists done to be able to study these hard to access, dark, hostile environments?

Extensions

Have students draw their interpretations of what the visualizations #1 and #2 habitats looked like.

Look at the colouring page and choose a creature or feature to explore further. Colour this creature or feature according to what you have found in your research.

Explore all of the earth's biomes and look at the differences.

Pick one of the ocean biomes, research and present to class.

Class discussion of how different areas of the earth are divided into biomes. How does this assist science?

Find another area of the earth than hydrothermal vents that harbor endemic species.

Deep sea biome :http://www.untamedscience.com/biology/biomes/deep-sea-biome/

World biomes :http://www.untamedscience.com/biology/biomes/

Photosynthesis/chemosynthesis:
http://oceanexplorer.noaa.gov/edu/learning/5_chemosynthesis/activities/chemovsphoto.html

Endeavour Hydrothermal Vents: Canada's First MPA

Activity III - A Product of My Environment

Home is where you are safe from weather, harm, have food to eat, water to drink, and air or water to breathe. (or could that be something else?)

Listen to the following, then draw, describe with words, or create with clay the creature you would think best suited to survive, and survive well, in this place. If you finish early, you can then draw or describe with words what the environment looked like in your mind.

Visualization # 1 (Fantasy habitat)

It's bright. Really, really bright. The sun streams down in distinct lines of yellow, orange and gold. The golden colours touch on the jagged edges of the glittering surface of huge caverns and wrinkled walls, making angular patterns of the golden colours. From there, the yellow, orange and gold refracts off the surfaces at an angle and down to play on the fuzzy edges of the dense jungle of vine like plants, making them appear as golden soft edged, rope-like forms.
At the base of these plants, the ground is a mass of crumbly, lumpy sand. It mimics the golden tones of the bright light that shines down. In the patches where the sand is exposed, there are tiny clumps of spiny needle-like plant forms.
But suddenly a blackness claps shut on the place, and there is nothingness. No light, nothing to see or be seen in the total blackness.
It is either bright or completely black with darkness in this place. There is no twilight, only bright, with a searing intensity of golden colours, or dark, coming like a blanket suddenly thrown over the landscape.
There are things here to watch out for. Things that have eyes that can see in the blackness, things that jump out of the brightness with huge needle-like teeth and ravenous appetites, and things that are not what they appear.
The textures of this place range from the sharpness of angles and the lumpy crumbly texture of the ground, to the curves and winds of the vines and tiny spikey plant forms that eke out an existence where the vines are absent.

What adaptations would your creature have to live in this place? How would your creature avoid predators, find a mate, reproduce? Would your creature live only in one specific area of this place? Where?

Draw your creature, ensuring it has the best possibility of survival. Be prepared to point out features and adaptations.

If time allows, describe this place.

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Activity III – A Product of My Environment

Visualization #2.

Home is where you are safe from weather, harm, have food to eat, water to drink, and air or water to breathe. (or could that be something else?)

Listen to the following, then draw, describe with words, or create with clay the creature you would think best suited to survive, and survive well, in this place. If you finish early, you can then draw or describe with words what the environment looked like in your mind.

Visualization #2 (Thermal Vent habitat)

It is a long journey to get to this place. Going from the brightness of the surface waters of the ocean, gradually dimming to absolute darkness, there are vast expanses of virtual nothingness except the snow-like continuous shower of organic debris from the upper reaches of the ocean. And then you arrive.
It is totally dark, there is no light that reaches this place. The pressure of the surrounding water is extreme, enough to crush your body if you were a human, or to squash metal.

Is there sound? In the distance there is the call of a whale, the sputter of a boat propeller or the rumble of a far-off earthquake. Finn whales are known to use this area.
There are tall forms that rise up out of the ocean floor, with black smoke coming out of them. They are jagged and volcanic looking, and there are things living on and around them. Many things.
Masses of straw shaped objects, called tubeworms, sway in the water currents and amongst those tubeworms many smaller beings, small snails, worms, elongated white fish, and long legged crabs.
This place is located at a join in the earths crust, where tectonic plates on the ocean floor are spreading by 6 centimeters each year.

It's hot, a hot place in a sea of cold. This heat is caused by the superheating of water that has been drawn down through cracks in the earth and taken close to the molten magma where it is near the earths crust. This hot water is then spewed out, but not before it has taken on a load of minerals and sulfides.

Things that live here have adapted to living on the edge of the cold – in the zone where the heat of the hydrothermal vents drives out the freezing cold. Very specific adaptations, since the cold settles in a short distance away from the super-heated vents.

Create your own creature that you feel would be well adapted to survive here. Think about what features would ensure good survival and incorporate them into this creature.

Present your creature to the rest of the class.

If time allows, the colouring sheet can be handed out, and students can look at some of the creatures that live by the hydrothermal vents. Are there any similarities with the creatures the students have created?

Take a look at the real habitat!
Link for live feed of video camera within the Grotto complex, Main Endeavour Field, in the MPA.
It can be dark because some of the species are sensitive to light.
http://www.oceannetworks.ca/sights-sounds/video/live-video/tempo-mini-vent-camera