



TEACHER RESOURCE GUIDE



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Teacher Resource Guide





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USING THE *ONE OCEAN* LEARNING RESOURCES

Activities: An Overview

The activities in this Teacher Resource Guide have been designed to provide specific opportunities for learning at the grades 8 – 12 level.

Activity 1 and Activity 2 for all episodes are designed to support curriculum at grades 8 – 10, and Activity 3 for all episodes is appropriate for grades 11 – 12.

As with most audio-visual and teacher-support materials, the grade levels indicated are suggestions only. Teachers will apply their own knowledge of the level of student understanding about the topic to make decisions concerning the use of the video content and activities in this guide.

V Video Chapter Titles

Each 44-minute *One Ocean* video is divided into four chapters, which coincide with natural breaks in the documentary storyline. The chapters provide a convenient “start-stop” point for teachers and students as they view the episodes. The Teacher Preparation and Materials Required section in each activity references the specific video chapter(s) required to effectively present and complete the activity, as indicated throughout the guide by **V**.

Episode 1: Birth of an Ocean

Chapters

- 1 – The Ocean is Born
- 2 – Oasis of the Deep
- 3 – Living Fossils
- 4 – From Water to Land (*Tiktaalik*)

Episode 2: Footprints in the Sand

Chapters

- 1 – Crisis Beneath the Waves
- 2 – Marine Deserts
- 3 – Coastal Zone Ecosystems
- 4 – Restoring Marine Ecosystems

Episode 3: Mysteries of the Deep

Chapters

- 1 – The Pacific Ring of Fire
- 2 – Bioluminescence
- 3 – Deep Sea Resources
- 4 – Beyond the Terrestrial View

Episode 4: The Changing Sea

Chapters

- 1 – Strange Days in the Global Sea
- 2 – The Arrhythmic Ocean
- 3 – Ocean Acidification
- 4 – Our Future Ocean

W The *One Ocean* Website: cbc.ca/oneocean

The *One Ocean* website is an integral component of the *One Ocean* experience. The site is student-friendly (teacher-friendly, too!) and increases awareness, fosters greater understanding and promotes positive change in both attitudes and actions. A sitemap is provided on page iii to assist in locating the features referenced in the lesson plans and activities in this guide.

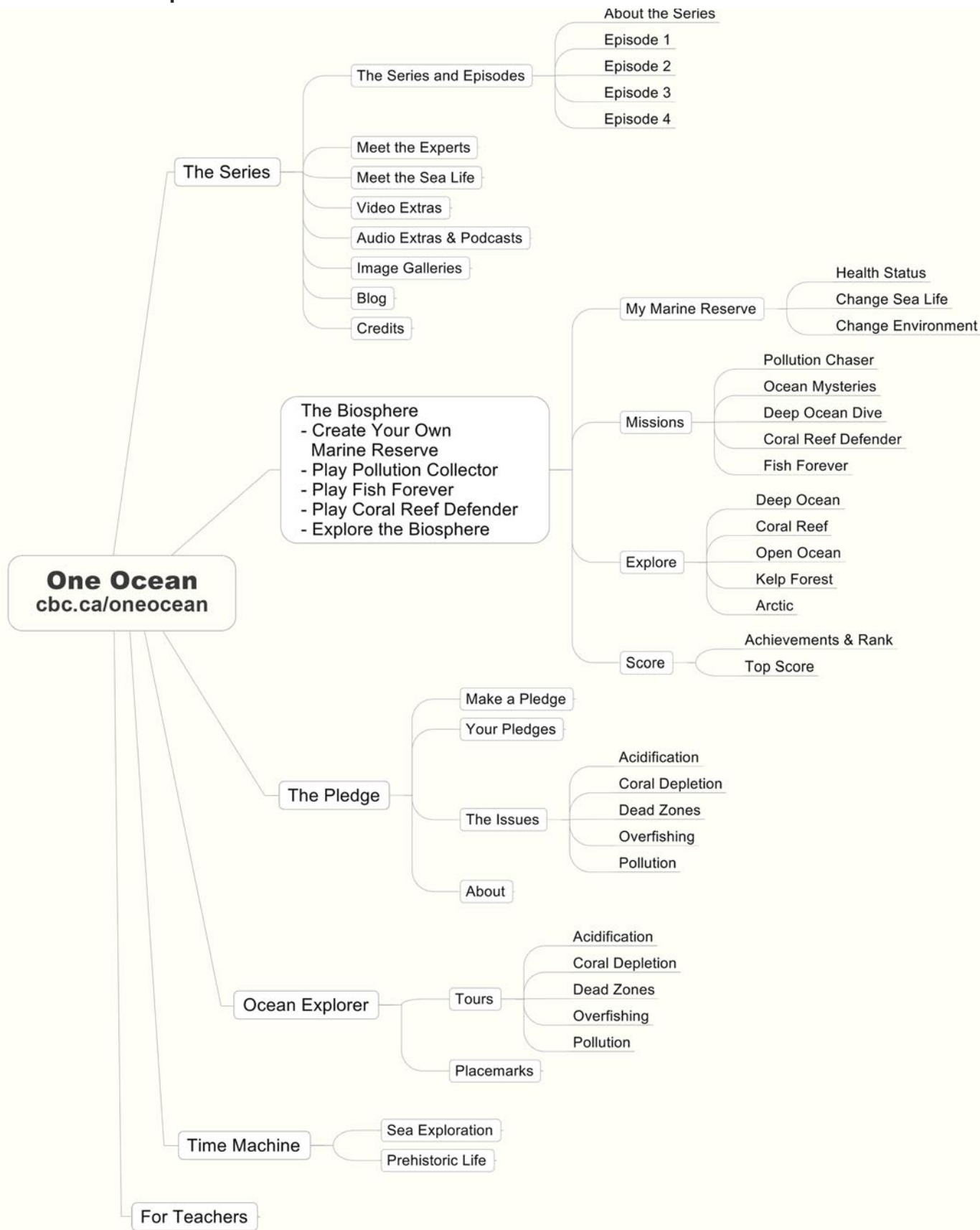
The website provides numerous opportunities for teacher presentation and student learning. It informs students about the issues facing our ocean and challenges them to change the ways in which they think—and act—about our natural resource heritage, especially the oceans. The tools employed on the website include visually rich images and educationally sound interactive games, teacher resource materials, podcasts and additional video, and challenge

students to question the status quo. The *One Ocean* Pledge feature is a call-to-action campaign that encourages students—and adults—to change thinking and behaviour. Social media connections are used in ways that are comfortable for today’s students.

Key Features of the Website

- The website provides students with an opportunity to meet the experts involved in the series, view video extras and listen to interviews with the experts featured in each of the episodes and subscribe to podcasts.
- In **The Biosphere** students can interact with other users, customizing ecosystems that they create and working collaboratively with others. Five games include: creating a marine reserve, cleaning up the ocean, strategic fishing management, defending coral reefs and exploring the biosphere.
- The **One Ocean Pledge** focuses on the five key issues—acidification, coral depletion, dead zones, over-fishing and pollution—and invites students to interact with friends to make meaningful changes to the way in which they view our natural resource base, particularly water.
- **Ocean Explorer** is an exploration of the ocean using leading-edge Google Ocean technology. This component also allows students to collaborate with friends to uncover the ocean’s mysteries.
- **Time Machine** offers a rich rendering of prehistoric life associated with the oceans and the history of underwater exploration and discovery.
- These website features are integrated into many of the activities presented in this guide. The specific feature is referenced in the Teacher Preparation and Materials Required section of each activity, as indicated throughout the guide by **W**.

One Ocean Sitemap



Organization of the Activities

The same format has been used for all of the activities in this guide. In some instances, a section may *not* be included if it was deemed not required for that particular activity.

SECTION	DESCRIPTION
Curriculum Expectations	The curriculum expectations have been placed “up front” to emphasize the importance of these links for the classroom teacher. The expectations may be modified slightly from those in specific provinces, but they generally follow the intent of the curriculum in that specific area across the country.
Activity Overview	A short outline of what the teacher can expect in the activity
Background Information	Often teachers require some insights into the content being addressed in the student activities; this information is provided in this teacher-oriented section.
Teacher Preparation and Materials Required	<p>It is assumed for all activities that teachers will have the <i>One Ocean</i> videos and will have access to the <i>One Ocean</i> website. Other preparations and materials required for the lesson plans are outlined to assist teachers with the development of the lesson plan.</p> <p>This section may not be included for all activities, depending on the content of the activity.</p>
Pre-viewing Activities	These activities take several different forms: reflection on the part of the student, acquiring key information about the topic from the video and from a variety of other sources, or accessing the <i>One Ocean</i> website.
Lesson Plan	The actual lesson plan is written as it might be directed toward the students involved, with occasional instructions directed at the teacher. The questions asked are those that can be the basis for the lesson plan and which can be directly asked to students.
Extension Suggestions	Although the lesson plan is a self-contained unit, teachers may wish to have the class, groups of students, or individual students go beyond the information and approaches presented in the video and on the website. These suggestions are more open-ended and will lead to more reflection and understanding for the students.
Assessment Suggestions	Assessment should be the domain of the teacher; however, this guide does provide some suggestions that the teacher can modify for student use.



CURRICULUM CONNECTIONS

The activities in this guide have been developed to match the curriculum across Canada in Science, Environmental Studies, Earth Science and Geography. Although the area of the curriculum in which the expectations are placed may vary by province, the focus in each province is on the importance of the Earth as a closed system that needs to be nurtured and preserved. Some of the unit titles found in provincial curricula across the country that have direct application to the *One Ocean* episodes are:

- Water Systems on Earth
- Earth Forces
- Earth Sciences
- Planet Earth
- Freshwater and Saltwater Systems
- Quality of Life – Effects of Oceans on Human Populations
- The Water All Around

The specific curriculum connections addressed by the activities include:

Grades 8 – 10

- Develop a chronological time scale of major events in Earth’s history.
- Appreciate the length of time within which evolution occurs and the importance of the oceans as the nursery of life.
- Assess data to elaborate conclusions on ocean characteristics.
- Describe the processes that lead to the development of ocean basins.
- Analyze factors that affect productivity and species distribution in marine environments.
- Understand the concept of “system” as it applies to oceans.
- Describe the interactions of the ocean currents, winds and regional climates.
- Design an experiment to compare the density and buoyancy of fresh water and sea water.
- Identify positive and negative effects of specific scientific or technological advances and explain how different groups perceive such developments.
- Assess the impact on global water systems of a scientific discovery or technological innovation.
- Provide examples of Canadian contributions to science and technology and how technologies have improved over time.
- Describe examples of how scientific knowledge has evolved in light of new evidence.
- Describe how the existing marine reserves have contributed to better understanding of the complexities and integration of ocean ecosystems.
- Use a range of resources to communicate the answer to a chosen question based on information presented in the episode.
- Identify the four issues causing the depletion of the ocean’s resources and how their integration compounds the problem.
- Identify the connection between the land and the ocean and understand the importance of coastal waters, wetlands and mangroves

(For Grades 11-12, see next page)

Grades 11 – 12

- Describe various kinds of evidence that life forms have changed over time, including evidence of mass extinctions.
- Investigate geological evidence of major changes that have occurred during Earth's history and of the various processes that have contributed to these changes.
- Describe evidence for the evolution of life through the Proterozoic, Paleozoic, Mesozoic, and Cenozoic eras using important groups of fossils that date from each era.
- Evaluate the environmental, economic and social implications of resource dependency for the various individuals or groups.
- Predict the social, economic and environmental effects of the extraction and depletion of selected resources.
- Identify positive and negative effects of specific scientific or technological advances and explain how different groups perceive such developments.
- Assess the impact on global water systems of a scientific discovery or technological innovation.
- Provide examples of Canadian contributions to science and technology and how technologies have improved over time.
- Explain how key ecological processes contribute to ecosystem health and analyze how various factors contribute to the fragility and/or resilience of selected ecosystems.
- Evaluate the impact of economic, social, political and technological change on natural and human systems.



EPISODE 1: BIRTH OF AN OCEAN

UNIT OVERVIEW

Episode Summary

In “Birth of an Ocean” we travel back to ancient time, telling the story of the ocean’s turbulent beginnings and its successive incarnations. It’s a journey that introduces the enormity of the ocean over space and time—at four billion years old the ocean is nearly as old as the planet itself. In a remote part of Western Australia, we venture to the stunning, crystal blue waters that harbour the descendants of the first life on Earth. These formations once covered the ancient seabed, and today they give scientists a remarkable window back in time. Travelling forward, we discover that almost 99.9 per cent of species that ever lived on this planet are now extinct. On the lush and diverse Osprey Reef, we swim alongside scientists to learn why one remarkable creature—the nautilus—has survived for millions of years. In “Birth of an Ocean” we trace our own profound connections to the ocean with *Tiktaalik*, the “fish-a-pod” that scientists believe may be the missing link between the ocean and all limbed creatures, including us.

Activities

Grades 8–10

1.1 An Ocean/Earth Timeline

Students will research and document the major events in the history of the ocean and develop a scale model of Earth’s timeline.

1.2 Hydrothermal Vents: Extreme Environments in the Ocean

Students will investigate hydrothermal vents that occur in the oceans and design a food web for that environment.

Grades 11–12

1.3 The Fossil Record: Survival, Extinctions and the Link to Humankind

Students will consider three aspects of life in the oceans and examine the causes and consequences associated with extinctions.



EPISODE 1: BIRTH OF AN OCEAN

Vocabulary

Useful abbreviations:

- by: billion years
- my: million years

Did you know?

Life has existed on land for only 9% of Earth's history, but it has existed in the oceans for ~80% of Earth's history.

The evolution of all animal groups took place in the last 560 my — i.e., in the last 12% of Earth's history.

ACTIVITY 1.1 • AN OCEAN/EARTH TIMELINE

Curriculum Expectations (Grades 8–10)

- Develop a chronological time scale of major events in Earth's history.
- Appreciate the length of time within which evolution occurs and the importance of the oceans as the nursery of life.

Activity Overview

Students will model the Earth's timeline, research the major events in the history of the Earth, oceans and life on the planet, and develop a timeline of Earth's history. This will lead to an understanding of the development of the planet, the oceans and how life evolved.

Background Information

This activity will facilitate student conceptualization of the immensity of geological time and the major events in the long history of the planet, including the oceans. Activity 1.1 also provides a framework for Activity 1.3: The Fossil Record: Survival, Extinctions and the Link to Humankind.

Teacher Preparation and Materials Required

View Episode 1: "Birth of an Ocean" and identify the major events and their timing (e.g., birth of the ocean four billion years ago). Teachers may wish to show the episode in two segments, with questions and time for reflection at the end of each segment.

This activity requires a five-metre rope or wallpaper roll, measuring tape or metre ruler, clothes pegs or tape, markers, index cards and access to the Time Machine feature of the *One Ocean* website (cbc.ca/oneocean).

Pre-viewing Activities

Elicit students' existing understanding of Earth history and evolution of life forms by brainstorming based on the following questions:

- How old is Earth?
- How old is the ocean?
- What were the earliest life forms?
- What life forms developed after the earliest life forms?
- What were the major steps in the evolution of life to the present?
- How long have humans existed?

1. Pin a 4.6 metre length of string to a wall to represent the duration of Earth's history.
2. Using the students' responses as a guide, label index cards with each event and life form identified. Place the cards on the string to indicate where students THINK the event or first appearance of a life form occurred.
3. Identify any events that were hard to place on the timeline.



EPISODE 1: BIRTH OF AN OCEAN

LESSON PLAN

- V** 1. Watch Episode 1: “Birth of an Ocean” and record the important events that relate to the history of the planet and the ocean, including the appearances of life forms. Note the timing of each event (e.g., formation of the planet at 4.6 billion years ago, or 4.6 by).
2. Describe what it might have felt like being there in each time frame mentioned in the video (e.g., recap the conditions that existed on early Earth as a planet of lava as described by Nick Eyles).
3. Make a master list of the events from the video. The list might look like Table 1 on page 1-5.
4. What other events are important in the development of the planet and life on it (see Table 2 for suggestions)? Add these or others to the list.
- W** 5. Individually or in small groups, research an important event in the history of the Earth (and oceans) using the Time Machine feature of the *One Ocean* website (cbc.ca/oneocean) as a starting point. For each important event indicate the name and location (ocean or land) and include a sketch or picture related to the event. Put this information on cards, and on the back write additional details about the event (e.g., where the fossils were discovered, what the organisms were like).
6. Use a 4.6 metre roll of wallpaper or rope to represent the 4.6 billion years of Earth history. Make a mark at the right-hand end of the paper and label it TODAY. Measure back 4.6 metres and mark this AGE OF THE EARTH. Mark off the metres in between—each metre represents one billion years of Earth history. Mark off the centimetres.
- What does each 1 cm equal in terms of years?
- Label the years at every tenth marking — e.g., 500 my, 600 my.
7. Attach the student event information cards at the correct place on the timeline (the centre of each card should be pegged or taped at the time of the event on the wallpaper or rope).
8. Starting at the origin of the planet at 4.6 by, name your event, provide an interesting fact and indicate whether the researched event occurred in the ocean or on land.
- W** 9. Take a tour on the Time Machine. Choose a time period and suggest a possible food chain for the time period chosen. Include primary producers (autotrophs) and herbivores and carnivores (heterotrophs). Which organisms might have been at the top of the food chain? Compare the results for different eras in Earth history.

Timeline Scale

1 cm will equal
10 million years.

Use the following questions to develop a picture—in written format—of the history of Earth’s journey.



EPISODE 1: BIRTH OF AN OCEAN

- What do you notice about the distribution of events in Earth history?
- What is different about the placing of events in the pre-viewing activity compared with the placing on the timeline based on the Time Machine?
- In terms of evolution of other life forms that followed, discuss the importance of the *Tiktaalik* fossil discovered in the Canadian Arctic.
- Which organisms have been on Earth the longest?
- Which organisms on the timeline have existed for the shortest amount of time?
- Why do you think there is such a concentration of events in the last 600 my of Earth history?
- Where has life existed for most of Earth history?
- Why do you think earlier life forms lived in the ocean and not on land?

Extension Suggestions

1. Research the way that Earth history is subdivided into eras and periods. Mark these subdivisions onto the timeline constructed by the class. Why do you think these divisions of Earth history were chosen? Hint: *zoic* means life.
- W** 2. Using the Time Machine feature of the website, determine the characteristic life forms during each of the time periods above. What organisms occur in many of the time periods? Show this information in graphic format.

Assessment Suggestions

1. Choose an analogy for Earth's timeline (e.g., the length of a football or soccer field, basketball court, bobsleigh run, distance across Canada, length of the school, distance to home, a year or a 12-hour clock). Scale the Earth's 4.6-billion-year history onto the chosen analogue. Calculate where five major events from "Birth of an Ocean" will be located on the timeline.
2. Write a "newspaper article" to address the question "In what ways did the ocean transform the planet?" which was posed in "Birth of an Ocean."



EPISODE 1: BIRTH OF AN OCEAN

Table 1: Important Developments in the History of Life on Earth

Formation of the planet	4.6 by
Birth of the ocean	4 by
First cell (life)	~4 by
Early bacteria (prokaryotic — i.e., no nucleus)	3.5 by
Stromatolites	3.5 by - 0.5 by
Major extinctions	five in last 560 my
First multicelled animals	600 my
Nautilus	500 my
Sharks	500 my
Horseshoe crabs	500 my
Devonian reef corals	460 my
<i>Tiktaalik</i> (first vertebrate animal on land)	375 my
Turtles	215 my
First fossils of genus <i>Homo</i>	2 my

Table 2: Additional Important Developments in the Evolution of Life

Additional important developments might include:

First cells with a nucleus	1.5 by
First animals with hard parts (e.g., trilobites)	545 my
First fish	426 my
First plants on land	420 my
First insects	350 my
First reptiles	325 my
First dinosaurs	225 my
First mammals	220 my
First birds	150 my
First flowering plants	130 my



EPISODE 1: BIRTH OF AN OCEAN

ACTIVITY 1.2 • HYDROTHERMAL VENTS: EXTREME ENVIRONMENTS IN THE OCEAN

Curriculum Expectations (Grades 8–10)

- Describe the processes that lead to the development of ocean basins.
- Analyze factors that affect productivity and species distribution in marine environments.

Activity Overview

Using hydrothermal vents as a starting point, students learn their location and association with mid-ocean ridges, the environmental conditions and the adaptations of the organisms to this extreme environment. Food webs around a vent ecosystem will be compared with a food web for a more typical ocean environment. This will lead to an understanding of the differences between chemosynthetic primary producers and photosynthetic primary producers.

Background Information

If the students have not yet studied plate tectonics, it would be useful to introduce plates and the nature of plate boundaries—convergent, divergent, and transform—prior to the activity.

Teachers may find CBC Learning’s series *Geologic Journey* to be of assistance in understanding some of the concepts here. Episode 2: “The Rockies,” Chapter 1 – Plate Tectonics, and Episode 4: “The Appalachians,” Chapter 2 – Colliding Plates, Making Mountains provide excellent footage on the topic.

Hydrothermal vents produce a unique environment for life. This environment is based on bacteria that use chemosynthesis—energy derived from chemical reactions to produce food—as opposed to photosynthesis—energy derived from solar radiation.

Teacher Preparation and Materials Required

In addition to Episode 1, Chapter 2 – Oasis of the Deep, and the Ocean Explorer and Biosphere features on the website, students will need index cards and coloured pencils.

Pre-viewing Activities

Brainstorm a list of the conditions that organisms typically need for life.

1. Where might you find the most productive environments on the planet? Similarly, what are some less productive environments?
2. Think about the Earth’s most extreme environments (e.g., polar-ice-covered regions, mountains, deserts, tropical jungles). How do the conditions in these places affect the types of life and productivity in these areas? Where would you expect NOT to find life?
3. Use your imagination to concoct a very weird organism. Then, describe the environment in which it lives, its eating habits and its neighbours (i.e., what else lives with it). Draw a picture of it and explain the conditions under which it lives.

Water, oxygen, sunlight, energy or food



EPISODE 1: BIRTH OF AN OCEAN

LESSON PLAN

Part I: Hydrothermal Vents

- V** 1. Use the following questions as a guide when viewing Episode 1, Chapter 2 – Oasis of the Deep, which tours the Endeavour Ridge off the coast of British Columbia with ocean scientist Verena Tunnicliffe.
- When were these hydrothermal vents first discovered?
 - How did the researchers reach this “alien quiet world”?
 - Why do you think the vents were not discovered before this?
2. Imagine yourself on a submersible. Write a postcard home from the submersible explaining what you see and feel as you approach the first hydrothermal vent. How does this area contrast with the surrounding deep ocean?
3. List the characteristics of the hydrothermal vent environment mentioned or shown in the video.
4. Using the comments of David Suzuki as a guide, describe what happens to form the vents, and draw a diagram to show these processes and the features they produce. Why do you think these vents were named hydrothermal vents?
5. Hypothesize where other hydrothermal vents might exist in the oceans. Research the locations of other hydrothermal vents that have been discovered. Is there a pattern to the distribution? Do they occur in every ocean? Is there a particular environment or ocean feature with which they are always associated?
- W** 6. Use the Ocean Explorer feature on the website to locate the mid-ocean ridges. What happens at a mid-ocean ridge? How is this important for the growth of ocean basins? Do all oceans have mid-ocean ridges?

All of the ocean crust is formed at mid-ocean ridges.

Mid-ocean ridges are the longest mountain chains on the planet.

The majority of the Earth’s volcanic activity occurs at mid-ocean ridges.

Most ocean crust will be recycled back into the mantle at subduction zones.

Part II: Organism Adaptation in an Extreme Environment

7. Why was it such a surprise for Verena Tunnicliffe to find the hydrothermal vent oasis “with animals all over the place”? Why would you not expect to find much life in deep ocean regions?
8. List the organisms at the hydrothermal vents in the video (bacteria, tube worms, clams, crabs, fish, shrimp, mussels) and assign one organism each to small groups of students. Additional organisms found at other vent sites may also be used. Each group will research the following:
- Where at the vents their organism lives (close to vent flow, farther away)
 - What each organism does to survive (how it gathers energy/feeds)
 - Whether the organism is a primary producer or consumer (and if so what does it consume)
 - How it has adapted to deal with the extreme conditions (heat, acidity)
 - Whether it can move around—e.g., to graze or to escape from falling pieces of lava or vent rock



EPISODE 1: BIRTH OF AN OCEAN

9. The findings will be shared by each group with the class to form the basis of the next part of the activity: making a food web for the hydrothermal vent environment and comparing it with a more typical food web.

Part III: Food Webs in a Hydrothermal Vent Environment

10. As a class, use the information provided by each group on the hydrothermal vent environment to produce a food web or pyramid. Include producers, consumers and top consumers.
11. How many organisms might be found within each of these levels. Why are there fewer consumers and very few top consumers?
12. Design a food web for a different part of the ocean and compare it with the hydrothermal one. Identify the differences and similarities between the two food webs.

Extension Suggestions

1. Are all hydrothermal vent environments the same? Research other hydrothermal vents in the Pacific and Atlantic oceans. Which organisms are the same? What are the differences (different species, different abundances of certain organisms)? What are the conditions at each of the sites (e.g., vent water temperature)? How might this relate to differences in organisms observed? Do you think organisms migrate between sites?
2. Think about why vent communities in different parts of the oceans might have the same types of organisms but different species.
3. What is a typical life span for a hydrothermal vent? What would happen when a vent stops? Would you expect that the organisms vary depending on whether a vent is active or not? What organisms might be plentiful when a vent stops?
- W** 4. Use the Biosphere feature of the website and construct a food web of the “marine reserve” you have created.
5. If new crust is being formed at mid-ocean ridges, does this mean that the Earth is getting bigger? Use the Ocean Explorer feature to find locations where ocean crust is being subducted (deep sea trenches and subduction zones) into the mantle.
6. How might the conditions around a hydrothermal vent mimic those where life may have first developed?
7. As Peter Ward mentioned: “All life on Earth came from one first cell somewhere.” Research the ideas that scientists have for how life might have first developed on the planet. How closely do the vent environments fit with these ideas?

Assessment Suggestion

Propose a new organism for the hydrothermal vent environment. Explain how it is adapted to the conditions in this environment and where it fits into the food web.



EPISODE 1: BIRTH OF AN OCEAN

ACTIVITY 1.3 • THE FOSSIL RECORD: SURVIVAL, EXTINCTIONS AND THE LINK TO HUMANKIND

Curriculum Expectations (Grades 11–12)

- Describe various kinds of evidence that life forms have changed over time, including evidence of mass extinctions.
- Investigate geological evidence of major changes that have occurred during Earth's history and of the various processes that have contributed to these changes.
- Describe evidence for the evolution of life through the Proterozoic, Paleozoic, Mesozoic and Cenozoic eras using important groups of fossils that date from each era.

Activity Overview

Students will consider how we know the characteristics of life that existed in our distant past. They will examine the nature of fossils and what kinds of organisms (or parts of organisms) are most likely to be preserved as fossils (or not). One focus will be on why extinctions happen and the factors that determine whether or not organisms die out or survive.

Students will understand the evolution of vertebrates and study the human link to the *Tiktaalik* fossil.

Background Information

The majority of the evidence for the history of life on planet Earth comes from fossils. Fossil evidence allows us to examine the kinds of life forms that existed at different times in the oceans, when extinctions occurred and how life has evolved over time. The fossil record is also the key to an understanding of our own origins. Only a very small proportion of the entire spectrum of life at any stage in Earth history is likely to be preserved, and the type of preservation is critical to the amount of information fossils will provide.

Materials Required

Episode 1: "Birth of an Ocean" and the *One Ocean* Pledge and Time Machine features of the website (cbc.ca/oneocean)

Samples of fossils or pictures of fossils will greatly assist with the activity.

Examples should illustrate as many types of preservation as possible including:

- body fossils
 - complete preservation — e.g., insects in amber
 - hard parts preserved — e.g., bivalve shells
 - hard parts replaced — e.g., corals or bones replaced by another mineral
- moulds or casts
- trace fossils — e.g., footprints or tracks older than 10 000 years

Samples of modern life such as acorns, shells



EPISODE 1: BIRTH OF AN OCEAN

Samples of sedimentary rock with features such as ripple marks

An alternative would involve a fieldtrip to a local geology or natural history museum to view fossil samples (most provincial museums have fossil collections that may be accessed on request).

Pre-viewing Activity

W Take a trip back in time with the *One Ocean* Time Machine feature to discover some of the amazing life forms that existed in the oceans in the past.

Review the major subdivisions of the geological time scale. What does *zoic* mean? What do the terms *proto*, *paleo*, *meso*, and *ceno* stand for?

If Activity 1: An Ocean/Earth Timeline (see lesson plan on page 1-3) has not already been carried out, make a scaled timeline for Earth history using a length of wallpaper. Mark off the major subdivisions (Archaean, Proterozoic, Phanerozoic, Paleozoic, Mesozoic and Cenozoic) and indicate 4.6 by as the origin of Earth and 0 as the present day. Have each metre represent 1 billion years (by) and each centimetre represent 10 million years (my).



EPISODE 1: BIRTH OF AN OCEAN

LESSON PLAN

400 my old coral reefs
mass extinctions
evolution of nautilus
500 my ago
early vertebrates —
e.g., *Tiktaalik*

A fossil is any
preserved sign of past
life more than 10 000
years old.

Fossils (and the rocks
they occur in) are our
main evidence for
understanding how
life has developed on
Earth.

Part I: Fossils

- V** 1. View Episode 1, Chapter 3 – Living Fossils and Chapter 4 – From Water to Land (*Tiktaalik*) and document the references that paleontologists Peter Ward and Ted Daeschler make to life that existed in the past and how life has changed.
2. What is the basis of the evidence regarding our knowledge of life in the Earth's past?
3. Use the samples or pictures identified in "Materials Required" (different kinds of fossils, an acorn, modern beach shells, a rock containing footprints and a sedimentary rock with ripple marks).

Which of these are fossils? What types of preservation are represented in the fossils? Which kinds of preservation provide us with the most information about the life form that lived so long ago?

4. As a class, brainstorm and list the major groups of organisms present in the modern ocean.

Individually or in small groups, consider one or more of the organisms and hypothesize whether or not that organism is likely to be preserved as a fossil. Draw a sketch of each life form and its likely fossil equivalent—e.g., the most likely part of a shark to be fossilized would be its teeth.

In small groups and then as a full class, conclude which life forms (or parts thereof) are likely to end up in the fossil record and which are unlikely to be preserved. Suggest reasons for the different scenarios.

5. Do you think the fossil record gives us the full picture of life at any time in Earth's history?

Part II: Extinctions

6. From Chapter 3 – Living Fossils identify the causes of mass extinctions and the effects (extinction or survival of organisms). What constitutes a mass extinction?
7. For each of the two major causes of mass extinctions draw a flow chart to show the sequence of events and conditions that led to the extinctions of such large proportions of organisms. Specify the cause stages and provide details regarding which organisms are impacted the most, which are not, which actually thrive, and why. Brainstorm the types of evidence, including physical evidence in the rocks, and which each type of extinction might leave behind.
- W** 8. Peter Ward notes that there have been five major extinctions in the last 540 my. Use the Time Machine feature of the website (cbc.ca/oneocean)



EPISODE 1: BIRTH OF AN OCEAN

as a starting point for researching these mass extinction events to find out:

- when each major extinction occurred
- the major types of organisms extinguished
- the percentage of life (genera) that became extinct
- evidence for the possible causes of each extinction

What was the likely cause for each of these mass extinctions?

Plot each major extinction on the 4.6 metre timeline.

9. When the first two mass extinctions occurred most life existed in the oceans. Later, life existed abundantly in both the ocean and on land. Identify the organisms more affected and less affected during the last three mass extinctions. What factors seem to be responsible for the differences?
10. In small groups, identify “survivor” organisms that were present both before and after one (or several) of the major extinctions (e.g., nautilus, sharks). Research these organisms to determine the range of adaptations that facilitated their survival.

Part III: *Tiktaalik* and the Evolution of Vertebrates

- V 11. From Chapter 4 – From Water to Land (*Tiktaalik*) note the physical features that identify *Tiktaalik* as a transitional form that is half fish and half four-footed animal.
12. Identify the major groups of vertebrates that exist today (including fish, amphibians, reptiles, birds, mammals) and indicate the date of their evolution—as well as the age of *Tiktaalik*—on the timeline.
13. Choose a representative organism/species from each group of vertebrates identified in question 12 (e.g., plesiosaurs [marine reptiles] featured in the Time Machine feature or whales [marine mammals]) and research their skeletal structures and other distinguishing characteristics. What do the vertebrates have in common? What are the differences? Are there any differences in reptiles or mammals depending on whether they are marine- or land-based creatures?
14. What does Ted Daeschler tell us about the characteristics we humans share with *Tiktaalik* ?

Extension Suggestions

- W 1. As a class consolidate your ideas regarding what could be done to help stop extinctions. Identify one action that would be implementable by the class and make a *One Ocean* Pledge on the website.
2. Given that there have been five mass extinctions in the past 560 my, predict whether (or not) the current changes in biodiversity represent the beginning of a sixth mass extinction.



EPISODE 1: BIRTH OF AN OCEAN

3. Use the extinction cause-consequence flow charts (question 7) to construct a cartoon strip for one or more of the mass extinctions that have affected life on Earth.
- W** 4. Go to the *One Ocean* website/The Series/Audio Extras. Listen to one of the two interviews associated with Episode 1: “Birth of an Ocean”: Nick Eyles or Ted Daeschler. First, indicate why you chose to listen to your particular scientist and then summarize the new information you have learned from the interview.

Assessment Suggestions

1. Imagine that immigrants are arriving from another planet in the solar system. Make an Extinction Survival Handbook (based on question 10 of this activity) to help the new inhabitants consider adaptation strategies to deal with both types of mass extinctions. Suggest which parts of the planet would be most suitable for survival during extinctions.
2. Write an essay on how life can modify the environment in which it exists.



EPISODE 2: FOOTPRINTS IN THE SAND

UNIT OVERVIEW

Episode Summary

In Episode 2: “Footprints in the Sand” we take measure of humanity’s impact on the sea since we first settled along its coasts over 150 000 years ago. We travel to the Mediterranean Sea with local Spanish fishers in search of the magnificent bluefin tuna, the most prized fish in the ocean. It’s also one of the most over-fished. As fishers try to maintain their centuries-old method of fishing, conservation scientists are desperate to find hard evidence to support their side in the heated debate over quotas and to save the species. Human activity through history—first over-fishing, then over-development of the world’s coastlines and the continuing pollution that we pour into the sea—have had unexpected consequences. But as the episode reveals, protected marine areas can have a significant impact on an ecosystem’s ability to recover. Zanzibar is a place where the people have always depended on fish for their survival. There, local fishers are finding ways to live in balance with the ocean by using more sustainable approaches to their harvests and also by creating a sense of communal ownership and stewardship. In New Zealand we discover that ocean areas that are now protected have experienced an extraordinary turnaround: where once sea urchins had taken over and destroyed the reefs and kelp forests, top predators have returned and the stunning reef has been restored to its full glory.

Activities

Grades 8–10

2.1 Depletion of the Ocean’s Resources

Students will learn how four issues—pollution, dead zones/global warming, over-fishing, and coral depletion—contribute to the depletion of the ocean’s resources and create a map to show the changes in the number of dead zones throughout the world’s oceans.

2.2 Marine Reserves: Build Them and They Will Come

This activity engages students in discovering the importance of marine reserves throughout the ocean. Students will design their own marine reserve and note the changes to the marine ecosystem/food webs.

Grades 11–12

2.3 Sustainable Management: “We need to manage ourselves!”

Students will respond to the question “How can we make humans more aware of sustainable approaches?” and as a class will examine the different perspectives related to the management of resources on a local scale.



EPISODE 2: FOOTPRINTS IN THE SAND

ACTIVITY 2.1 • DEPLETION OF THE OCEAN’S RESOURCES

Curriculum Expectations (Grades 8–10)

- Identify the four issues causing the depletion of the ocean’s resources and how their integration compounds the problem.
- Identify the connection between the land and the ocean and understand the importance of coastal waters, wetlands and mangroves.

Activity Overview

Our oceans face several problems (which are explored on the *One Ocean* website (cbc.ca/oneocean)—acidification, coral depletion, deadzones, over-fishing and pollution. This episode focuses on four of these issues and how they are integrated. Students will create a map to show the changes (locations and size) in the number of dead zones throughout the world’s oceans. Students will understand the connection between the land and the ocean and the importance of coastal waters, wetlands and mangroves.

Background Information

Industrial waste and agricultural run-off continue to be problems throughout the world’s coastal areas. The run-off contains nutrients (nitrates and phosphates) that result in rapid algae growth called an “algal bloom.” When the algae are alive, they can have positive effects on the ocean. They produce oxygen through photosynthesis and are eaten by other organisms in the ocean. However, the rapid growth associated with the addition of nutrients causes the algae to crowd themselves out of food and space, and then die in masses. Bacteria feed on the dead algae and use up oxygen through the process of cellular respiration. This consumes oxygen that fish and other organisms need to survive.

Like all gases, oxygen is soluble in cold water; cold water contains more oxygen than warm water. As the ocean temperature increases due to global warming, overall ocean oxygen decreases.

Coastal waters like lagoons, wetlands and mangroves act as filters and sponges for the ocean. They slow down the flow of run-off into the ocean and reduce erosion. They filter out nutrients (nitrates and phosphates), cleaning both water and air.

Teacher Preparation and Materials Required

View Episode 2: “Footprints in the Sand” before sharing with the class. Prepare copies of Appendix 2.1.1 – Mind Map for the students. Appendix 2.1.2 – World Map is also included.

Pre-viewing Activity

A map of the world, or a globe representing Earth, will illustrate the five

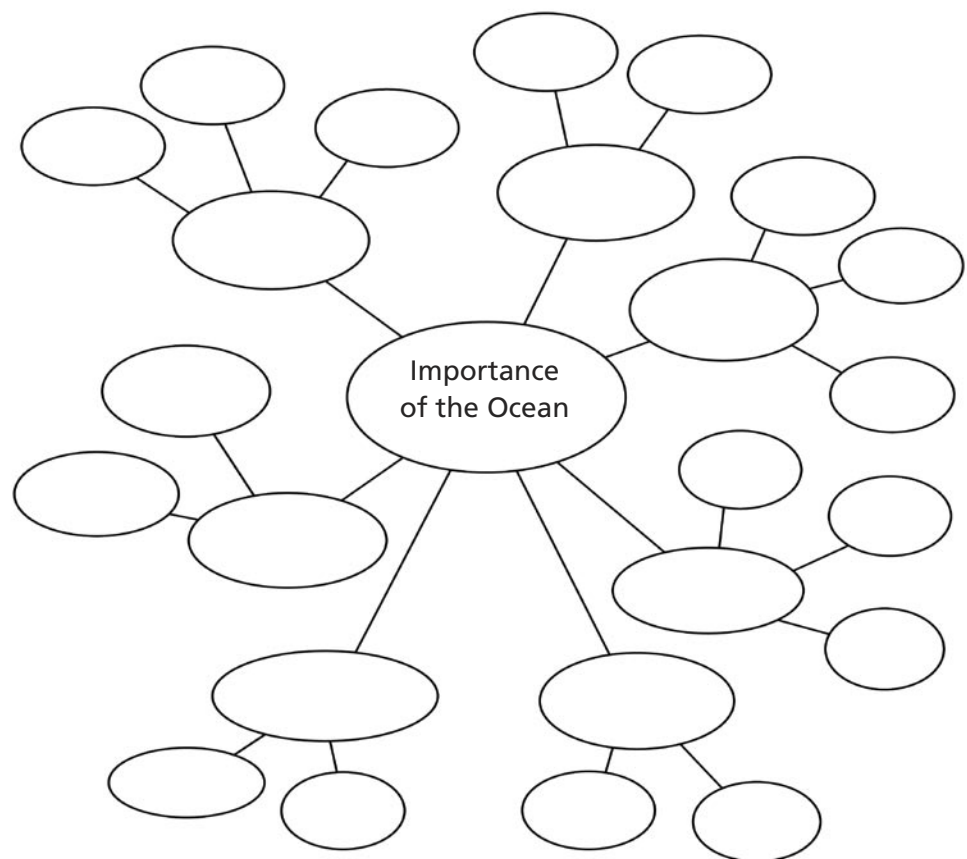


EPISODE 2: FOOTPRINTS IN THE SAND

oceans: Atlantic, Pacific, Indian, Arctic and Antarctic. Because they are all connected, only one ocean actually exists over Earth's surface. The seven continents appear as islands—some connected, like North and South America—in this huge body of water that occupies approximately 70 per cent of the surface of Earth.

In small groups and using a piece of chart paper, record the issue "Importance of the Ocean" in the centre of a mind map. Your diagram will look like the sample below.

Appendix 2.1.1 – Mind Map



Identify and record reasons why the ocean is important to both the natural world and to humans.

Study the graphic organizer your group has produced. Which reasons are short term in nature? Which reasons are ones that have long-term consequences for the ocean environment?

Be prepared to share your group's responses with the class.



EPISODE 2: FOOTPRINTS IN THE SAND

LESSON PLAN

- ✓ View Episode 2: “Footprints in the Sand,” Chapter 1 – Crisis Beneath the Waves, Chapter 2 – Marine Deserts and Chapter 3 – Coastal Zones Ecosystems and answer the following questions:
1. Coastal waters occupy only a small portion of the world’s oceans (10 per cent), yet they support 90 per cent of sea life. Fifty per cent of the human population is located in areas adjacent to these coastal waters. How does an increase in population in areas adjacent to the world’s coastal waters increase pollution and decrease the role that coastal waters play?
 2. How does the melting of the polar ice caps affect the coastal waters of the world’s oceans?
 3. Use a world map to show the dead zones of the ocean (show locations and size). Refer to the graphic “Dead zones around the world” in Episode 2, Chapter 2 – Marine Deserts.
 4. Refer to graphics “Algae growth and decomposition” and “Dead zones in the Gulf of Mexico” in Chapter 2 – Marine Deserts of this episode. Explain why dead zones throughout the ocean have increased and why some have gone from temporary dead zones to permanent ones.
 5. What effects do low levels of oxygen have on the reproductive processes of fish?
 6. At the bottom of some dead zones no oxygen is present. Explain why areas like this have no living organisms.
 7. Not all organisms in dead zones die, but they still affect the ecosystem. Explain. Use the references to the Mediterranean Sea, Gulf of Mexico and Indian Ocean near Zanzibar.
 8. What has happened to the ocean’s harvest as the demand for protein from the sea has increased?
 9. Most countries have quotas for the fish that can be harvested off their shores. Are quotas sustainable? What would be the consequences of a moratorium on specific species?
 10. How do traditional methods of fishing compare with the large fishing fleets that use high-tech equipment?
 11. Coral reefs are the most threatened ecosystems of the ocean. Why are they called the ocean’s gem?
 12. What is causing the destruction of the coral reefs?
 13. Create a coral reef ecosystem to show the diversity of food webs within it.



EPISODE 2: FOOTPRINTS IN THE SAND

Extension Suggestions

- W** 1. Go to the Ocean Explorer feature of the *One Ocean* website and take a guided interactive tour exploring one of the five critical issues threatening the ocean.
- Be prepared to share your example with the class. A chart with the issues could be posted in the classroom. Students could add their examples to the chart.
- W** 2. Click “Make a Pledge” and select one or two from those presented. Compare the impact rating, eco-credit and related issues for each of your pledges.
- A chart with the three headings could be posted in the classroom, giving students the opportunity to share their pledges.

Assessment Suggestion

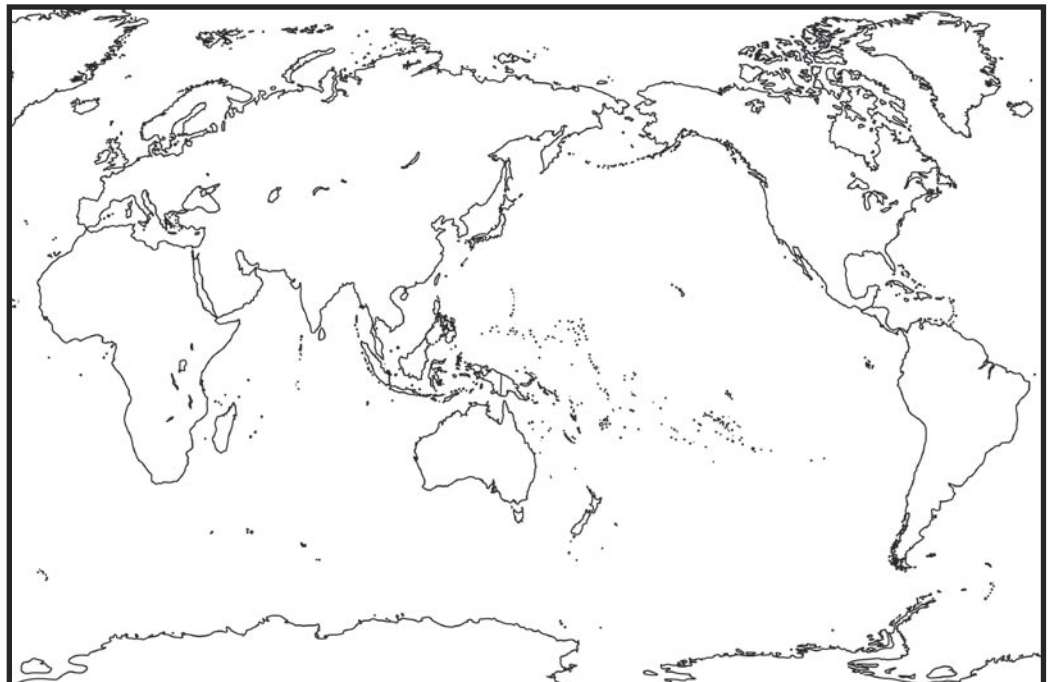
Events do not occur in isolation; they are caused by multiple factors. Record the problem “Depletion of the Ocean’s Resources” in a graphic organizer/ mind map. Around the circle record the four issues that cause depletion of the ocean’s resources.

Identify and record the causes that contribute to the issues.

Study the organizer and write three paragraphs to respond to the following:

- How are the causes integrated?
- Why must the issues be dealt with together in an integrated manner?
- How can human activity affect all forms of life in the ocean?

Appendix 2.1.2 – World Map





EPISODE 2: FOOTPRINTS IN THE SAND

Vocabulary

autotroph, heterotroph, herbivore, carnivore

ACTIVITY 2.2 • MARINE RESERVES: BUILD THEM AND THEY WILL COME

Curriculum Expectations (Grades 8–10)

- Describe examples of how scientific knowledge has evolved in light of new evidence.
- Describe how the existing marine reserves have contributed to better understanding of the complexities and integration of ocean ecosystems.

Activity Overview

This activity engages students in discovering the importance of marine reserves throughout the ocean. We may have many land reserves, but very few “no-take” marine reserves. Students will learn the basics of a “no-take or nothing” philosophy with regard to sea life and how it will lead to massive population increases of sea life, and that the recovery rate is not linear but exponential. Students will design their own marine reserve and note the changes to the marine ecosystem/food webs. They will also note the changes to the waters adjacent to the marine reserve.

Background Information

All ecosystems have feeding levels called producers, consumers and decomposers. They interact to form food chains and food webs. In the open ocean the dominant producers are diatoms and dinoflagellates. The herbivores that feed on these are mainly crustaceans. Herring, other small fish, squid and many other carnivores feed on the crustaceans. Tuna and other larger fish feed on the smaller fish. Decomposers break down dead plant and animal matter and return valuable nutrients back to the ecosystem.

When an ecosystem is balanced, energy flow through the system supports all the feeding levels. This results in an ideal pyramid of numbers. This means that there are enough producers to support first-order consumers (herbivores) and enough first-order consumers to support second-order consumers. This continues up the feeding levels. However, if an ecosystem becomes unbalanced from over-fishing or other outside influences, the support system will fail to operate effectively.

Teacher Preparation and Materials Required

A review of the concept of an ecosystem will greatly enhance this activity.

Episode 2: “Footprints in the Sand”

Access to the *One Ocean* website (cbc.ca/oneocean)

Pre-viewing Activities

1. Review the components of feeding the trophic levels within food webs of any ecosystem.



EPISODE 2: FOOTPRINTS IN THE SAND

- What is the role of a producer in an ecosystem? Give examples of marine producers.
 - What is the role of a consumer in an ecosystem? Give examples of marine consumers.
 - What is the role of a decomposer in an ecosystem? Give examples of marine decomposers.
 - Define the term *autotroph*. How does it relate to producers?
 - Define the terms *heterotroph*, *herbivore* and *carnivore*. How do they relate to consumers?
 - What is the direction of energy through food chains?
 - What happens to total energy from the sun as it goes through the food chain?
 - List the different types of marine ecosystems (e.g., open ocean, coral reef, coastal waters).
 - Draw a simple food chain that would represent one element of a marine ecosystem.
 - Visit the Ocean Oasis website (www.oceanoasis.org)—specifically lesson 10 in the Teacher Guide—and develop a food chain using the diagrams involved.
2. Develop a food web for a different environment—such as forest or grassland—and establish the common features to illustrate the concept of a food web.



EPISODE 2: FOOTPRINTS IN THE SAND

LESSON PLAN

- V** View Episode 2: “Footprints in the Sand” and answer the following questions.
1. What happened to marine life in the coastal waters of Zanzibar when “no-take-zone” conservation projects were implemented?
 2. What happened to the people of the four villages and their attitude toward conservation when the no-take zones were implemented?
 3. In 1965 the coral reef off the coast of New Zealand was distressed and out of balance. What evidence was present to prove this was true? What happened to the producers and the different levels of consumers?
 4. New Zealand was one of the first countries to set up a marine reserve with a no-take zone for commercial fishing; it included 5 km of protected marine ecosystem that still allowed recreational fishing. What happened to the marine life in the reserve?
 5. What happened 17 years later when recreational fishing was also banned and the philosophy “no take or nothing” was adopted?
 6. What changes occurred to the waters adjacent to the marine reserves? Why?
 7. Trial and error is a common method of dealing with a scientific problem. Why do you think this method was used by conservationists and scientists in the development of the successful marine reserve?
 8. Draw a graph to show the population growth rate in a no-take zone over a given period of time. Compare this exponential growth rate to a linear growth rate.

Extension Suggestions

- W** 1. Use the *One Ocean* website (cbc.ca/oneocean) to create your own marine reserve and interact with the different marine life.
- W** 2. Play Pollution Chaser or Coral Reef Defender on the *One Ocean* website and report on your experiences to a partner. What did you learn about the oceans from this video game? How might you apply what you have learned to your real-life experiences? Make a pledge to reduce consumption and waste and improve the quality of Earth’s ocean. Explore the different ocean ecosystems, from deep ocean trenches to coral reefs.
3. If you did *not* complete the pre-viewing activity related to food webs on land, apply what students have learned about marine food webs to a different environment.
 4. If you *did* complete the pre-viewing activity related to food webs on land, update your original activity based on the new information that you have learned about food webs from this lesson.



EPISODE 2: FOOTPRINTS IN THE SAND

- W** 5. In the Ocean Explorer feature of the website, create a unique placemark presenting a location on the globe that practises a sustainable system. Provide a description of that system and, if possible, include a photo.
6. Compare a no-take zone in a marine environment to a natural park or environmentally protected area on land. What are the similarities and differences? How is a no-take zone more difficult to manage?

Assessment Suggestion

Divide the class into groups. Each group will design a marine reserve to show the feeding levels (food webs) within a marine ecosystem. Each group will use a different scenario to illustrate what will happen to the feeding levels in their marine ecosystem when it becomes distressed. The factor causing the distress could be as a result of:

- the top carnivores are over-fished
- the producers are killed when a dead zone expands into your marine ecosystem
- pollution decreases the reproductive rate of small fish



EPISODE 2: FOOTPRINTS IN THE SAND

ACTIVITY 2.3 • SUSTAINABLE MANAGEMENT: “WE NEED TO MANAGE OURSELVES”

Curriculum Expectations (Grades 11–12)

- Evaluate the environmental, economic and social implications of resource dependency for the various individuals or groups.
- Predict the social, economic and environmental effects of the extraction and depletion of selected resources.

Activity Overview

Humans need to live in balance with the ocean by using more sustainable approaches. Students will note the various approaches to sustainability and respond to the question: “How can we make humans more aware of sustainable approaches?” As well as awareness, humans need to create a sense of communal ownership and stewardship, especially for local communities. As a class, students will examine the different perspectives related to the management of resources on a local scale. Humans need to understand the issues and relationships between ocean and communities. Awareness and then an understanding of the issue will lead to behavioural change. However, it is hardly a simple one-two-three process. Many impediments will block the way between understanding and actual change. For example, conservation is a difficult concept to understand and act upon when one’s stomach is empty. By comparing case studies, students will determine the complex relationships that evolve and how they impact local communities and entire countries.

Background Information

As humans we need to change our attitudes toward the ocean’s resources. As a stewardship responsibility issue, we need to teach our students to become aware that the ocean and all its living organisms are integrated in complex relationships and at the same time represent a very delicate system.

The ocean affects the terrestrial Earth, including humans. It needs to be protected and managed—or, as said in Episode 2: “We need to be managed.” However, telling people that they need to change their attitude about an issue does not lead to positive and long-lasting results. Humans need a reason to change their attitudes; this is certainly true when it comes to conservation of the oceans. The reasons will vary depending upon one’s “attachment” to the oceans and the ocean environment. The reasons could vary from simple survival to source of income to recreational interests or basic appreciation of the oceans as an ecosystem.

We need to provide students (and all humanity) with the tools to appreciate and understand the issue before we can expect a change in attitude or behaviour.



EPISODE 2: FOOTPRINTS IN THE SAND

Teacher Preparation and Materials Required

Episode 2: "Footprints in the Sand"

Access to the *One Ocean* website (cbc.ca/oneocean)

Pre-viewing Activity

Humans need a reason to conserve the ocean's resources. They need to understand that both humans and the environment will benefit. Sustainable management of the ocean's resources will affect both the environment and humans in different ways. The ocean's ecosystems will be affected. The economies of local fishers and entire countries will be affected, and people's way of life and livelihood will be affected.

Use Appendix 2.3.1 – Sustainable Management of the Ocean's Resources

The "consequences" of sustainable management of the ocean's reserves have been categorized into three areas: environmental, economic and social/cultural. In each column, identify and record items that may be affected by sustainable management. Indicate, using symbols, whether each item that you have recorded will be: Positive or negative / Long-term or short-term.

Be prepared to share your responses with your class.

Analyze your results to establish the implications and relationships, discern causes and effects and locate new problems that need to be solved.

Appendix 2.3.1 - Sustainable Management of the Ocean's Resources

Consequences of a More Sustainable Management Scheme		
Environmental	Economic	Social/Cultural



EPISODE 2: FOOTPRINTS IN THE SAND

LESSON PLAN

- V**
1. View Episode 2: “Footprints in the Sand.”
 2. List the various approaches to sustainability of the ocean’s resources found in the episode.
 3. Describe how each of these approaches helps improve and manage the ocean’s resources.
 4. Humans need to be convinced to conserve and manage the ocean’s resources. What are the short-term and/or long-term problems associated with the implementation of the sustainable approaches that are suggested?
 5. With a partner, debate the notion that a moratorium on fishing specific species is a sustainable approach. Try to reach consensus with your partner on the issue and share your common areas of agreement and your areas of difference with the rest of the class.
 6. In a chart format, list the pros and cons of managing resources locally.
 7. What resources may not be able to be managed at a local level?
 8. Study the following scenarios and compare how a sustainable approach may affect them—both positively and negatively:
 - You are an Aboriginal Canadian living off the coast of British Columbia. Fishing is a way of life for you and you are asked to set up a no-take zone in your area.
 - You are a commercial fisher from Nova Scotia, not far from U.S. territorial waters. You are asked to fish with more traditional boats and equipment.
 - You are a conservationist and are asked to set up 10 km of marine reserve to protect a coral reef.
 - You are a fisher living in a coastal village in an impoverished part of the world and are asked to set up a no-take zone.

Extension Suggestions

- W**
1. Using the *One Ocean* website, click on Meet the Sealife. Select one of the following categories: invertebrates, fish or mammals. Select up to 10 different species under your category. In a table format like the sample below, record for each species: its habitat, threats on the species and whether the species is protected. If is protected, indicate the type of protection provided.

Species	Habitat	Threats	Protection (Yes/No) If yes, type of protection



EPISODE 2: FOOTPRINTS IN THE SAND

- W** 2. Go to the One Ocean website/The Series/Audio Extras. Listen to one of the two interviews associated with Episode 2: “Footprints in the Sand”: Nancy Rabalais or Wade Doak. First, indicate why you chose to listen to your particular scientist and then summarize the new information you have learned from the interview.

Assessment Suggestion

You are a scientist working for the Federal Oceans and Fisheries Department. One of your tasks is to create a policy document to improve the environment and add new fishing regulations that will help the Canadian fishing industry achieve sustainable management of the ocean. As you decide on these regulations keep two things in mind from the “Footprints in the Sand” video.

1. “We need to be managed.”
2. Humans need a reason to change their attitude toward the ocean, and the reasons will vary depending on one’s attachment.

In the document include your regulations. Why did you choose these regulations? Explain how you would justify your decisions to the different people or groups affected.



EPISODE 3: MYSTERIES OF THE DEEP

UNIT OVERVIEW

Episode Summary

“Mysteries of the Deep” identifies some of the surprises and mysteries about Earth’s one ocean. Asking questions is the focus. What’s down here? What’s its nature? What secrets are hidden beneath the surface? How do the interconnected elements of the oceans work together?

Exploring the open ocean’s and deep ocean’s large, majestic creatures, scientists use their discipline-related knowledge and skills and new technologies to reveal the once-invisible behaviour of marine animals. A shift in attitude from distant observer to participant in the deep sea allows scientists to sample, collect and measure to record exciting discoveries and stories that are critical to how human beings interact with the ocean. Research of animals (such as turtles, tuna and giant sharks) and of seamounts will help to explain and elaborate on the ocean’s life and chemistry. The world of wonder and motion that technology reveals, even if it fuels ocean exploitation, is explored.

“Mysteries of the Deep” introduces the “wow” factor to the study of the planet’s oceanic body and helps students to question their role and the role of society in the life of the oceans in the 21st century. As well as new facts about this engaging environment, the episode and its associated content on the *One Ocean* website raise many questions for consideration.

- Why is it important to study the oceans *now*?
- How is the study of the oceans different from that of other environments?
- How do we know we are asking the right questions?
- How must our attitudes change to make the study of the oceans a viable and worthwhile experience?

Activities

Grades 8–10

3.1 The Deep Sea: What’s down there?

Students will answer questions about the ocean, particularly as they relate to the perception of the world’s oceans as a single entity or “one ocean.”

3.2 Ocean Exploration and Exploitation: The Effects of Technology

By focusing on the technology associated with the oceans, students will learn more about the advances that have been made in both explorative and exploitive technology.

Grades 11–12

3.3 Future Relationships

Students will investigate the concepts associated with “one ocean” relationships and explain problems and theories, conduct analysis and create plans of action.



EPISODE 3: MYSTERIES OF THE DEEP

Vocabulary

chemosynthetic bacteria, bioluminescence, microbes, biodiversity, adaptations, dead zones, coastal zones, Ring of Fire, gelatinous forms, pollution, coral depletion, acidification, over-fishing

ACTIVITY 3.1 • THE DEEP SEA: WHAT'S DOWN THERE?

Curriculum Expectations (Grades 8–10)

- Understand the concept of *system* as it applies to oceans.
- Assess data to develop conclusions on ocean characteristics.

Activity Overview

Students will answer the following questions about the ocean, particularly as they relate to the perception of the world's oceans as a single entity or "one ocean": What are the basic characteristics of the Earth's oceans? What secrets are "hidden" beneath the surface of the ocean?

Students are introduced to a variety of new terms in Episode 3. These will be defined and explained. The concept of a *system*, with evidence to support the concept, will be explored by the students and teacher. Working in groups, students will discuss and report on their findings. Each group should have a reporter, recorder, materials person, and leader whose role is to keep the group on task. The observations and conclusions established by each group will be recorded. The method used for recording is left to the teacher—from simple chart paper to Powerpoint presentation to blog. The *One Ocean* website (cbc.ca/oneocean) provides opportunities for the students to share their experiences with other students across the country.

Background Information

Throughout our education, we have been taught that the Earth has five oceans: Atlantic, Pacific, Arctic, Indian and Antarctic. Three of these oceans have contact with Canada. Earth, basically an ocean planet, can be perceived as having a single ocean. This is most evident when the Earth is viewed in the traditional way, with the North Pole at the "top," the South Pole at the "bottom" and the Earth's axis tilted at 23.5 degrees. However, when the globe is rotated to view the poles horizontally and the equator is viewed on the vertical, the perception changes; the oceans can be easily perceived as a single connecting body of water.

A system is a set of interacting or interdependent relationships that form an integrated whole. Systems have structure, defined by parts and their composition. They have behaviour, which involves inputs, processing, and outputs of material, energy or information. They have interconnectivity.

The world's oceans—one ocean—are an incredible body of water, covering nearly 70 per cent of the surface of the Earth. They are one of the last areas



EPISODE 3: MYSTERIES OF THE DEEP

to be explored by scientists. Here, scientists encounter different species of fish and other creatures at great depths as well as along the mid-oceanic ridges, often called seamounts. The mystery of the deep sea is enough to be intriguing to most students.

Teacher Preparation and Materials Required

Teachers should view Episode 3: “Mysteries of the Deep” before proceeding to the pre-viewing activity and the lesson plan that follows. A brief look at student awareness of the concept of *ecosystem* may put the lesson plan in perspective.

A globe or satellite image of Earth

Chart paper or access to computers to record information

Pre-viewing Activity

Use a globe (or satellite image of Earth) to introduce the students to the concept of “one ocean.” Tilt the globe so the poles are horizontal in order to emphasize the connectivity of the oceans.

- What observations can be made about the world’s oceans?
- How are the oceans connected?
- How does this view of the world support the title of the series as *One Ocean*?
- From a visual perspective, what are some of the characteristics of the oceans?
- Estimate how much of the surface of the Earth the ocean covers.



EPISODE 3: MYSTERIES OF THE DEEP

LESSON PLAN

1. View Episode 3: “Mysteries of the Deep.” In Chapter 1 – The Pacific Ring of Fire, one of the scientists indicates that “everything is new.” What are some of the new terms you identified while watching the episode?
2. Working in groups, record answers to the following questions: What are the basic characteristics of the Earth’s oceans? What are some of the secrets “hidden” beneath the surface of the ocean that you did not know?
3. In Chapter 1 – The Pacific Ring of Fire, the life around the sulphur vents was a surprise to the scientists who viewed it. How is life around the sulphur vents connected to the vents? What role do the vents play in the life of the flatfish? How can this be described as a *system* that works together?
4. The life around the sulphur vents is a small version of an ecosystem. How might the ocean be described as a *system*? What might be the characteristics of an ecosystem?
5. Write a definition of a system as it relates to the ocean and give examples to support your definition.
6. In Chapter 2 – Bioluminescence, one scientist says: “We are still in search of the right questions.” Why do you think questions are important to ask? Are questions about the preservation of a system like the ocean important? Explain.
7. The interconnectivity of an ecosystem is emphasized in Chapter 3 – Deep Sea Resources. What story is the ocean telling us about how it works and how everything is connected? How is this illustrated in Chapter 3? How is the commercial fishing of orange roughy in various parts of the world connected?

Extension Suggestions

1. Episode 3: “Mysteries of the Deep” provides us with new information about the oceans and also raises questions about the oceans and our relationship with the oceans. Identify three questions that the episode raised in your mind concerning the mysteries found in the oceans.
2. What are the problems associated with studying an ecosystem such as the ocean that would not be present in the study of an ecosystem like a forest or desert?
3. In Chapter 4 – Beyond the Terrestrial View, it is stated that there needs to be a change in attitude toward the deep seas from distant observer to direct participant. What do you think this means for the study of the oceans?



EPISODE 3: MYSTERIES OF THE DEEP

4. When discussing elevation, we use the terminology *above sea level*. Of course, this really means above the level of the oceans. How does this terminology add relevance to the concept of “one ocean”?
5. When travelling through the Panama Canal, ships are raised 26 metres from the Atlantic Ocean to Gatun Lake. Then ships go through the locks down to the Pacific Ocean (or vice-versa). How does this illustrate the concept of “one global ocean”?

Assessment Suggestions

1. How does bioluminescence work for animals in the ocean? Give an example.
2. What is a system? How does this work in the ocean?
3. Does biodiversity happen in the deep seas? Give an example.
4. Are there different ways to observe what happens in the deep seas? Give an example of an effective, non-harmful way that was demonstrated in the video.



EPISODE 3: MYSTERIES OF THE DEEP

Vocabulary

exploration, exploitation, havoc, trench, seamounts, Ring of Fire, Mariana Arc, orange roughy, Monterey Bay, Super Falcon, barreleye fish, giant praya

ACTIVITY 3.2 • OCEAN EXPLORATION AND EXPLOITATION: THE EFFECTS OF TECHNOLOGY

Curriculum Expectations (Grades 8–10)

- Identify positive and negative effects of specific scientific or technological advances and explain how different groups perceive such developments.
- Assess the impact on global water systems of a scientific discovery or technological innovation.
- Provide examples of Canadian contributions to science and technology and how technologies have improved over time.

Activity Overview

By focusing on the technology associated with the oceans, students will learn more about the advances that have been made in both explorative and exploitive technology. The *One Ocean* website (cbc.ca/oneocean) is used as a starting point to focus on the different levels of technology over time. Case studies within the episode will be examined in detail as examples of the effects of technology on the study and utilization of the ocean's resources. A discussion about deep-sea exploration and exploitation will include references that connect science, technology, society and the environment.

Background Information

As we improve our technological prowess, we venture deeper into the planet's last frontier. A team of scientists, ranging from biologists to volcanologists, on an international expedition as they return to the Mariana Arc on the Pacific Rim of Fire use their submersible remote operated vehicle (ROV) to peer into extreme environments, making discoveries about myriad deep-sea dwellers. At the heart of the matter is a key question: Can cutting-edge technologies allow us to truly experience, for the first time, the three-dimensional world of the ocean?

Teacher Preparation and Materials Required

Episode 3: "Mysteries of the Deep" and access to the *One Ocean* website

Appendix 3.2.1 – KWL (Know ... Want to know ... Learned) Chart

Appendix 3.2.2 – Cause and Consequence Worksheet

Pre-viewing Activity

Before visiting the website or viewing Episode 3, divide the students into two groups—one to focus on the exploration of the ocean depths and the other to focus on the exploitation of the ocean depths. Use Appendix 3.2.1 – KWL (Know ... Want to know ... Learned) Chart and have the students fill in as much of the first two columns as possible. They can track their "what I have learned about exploration/exploitation" after the following pre-viewing activity and the viewing of the video.



EPISODE 3: MYSTERIES OF THE DEEP

Appendix 3.2.1 – KWL (Know ... Want to know ... Learned) Chart

KNOW What do I already know about the exploration/exploitation of the ocean depths and seamounts?	WANT TO KNOW What questions do I have about the exploration/exploitation of the ocean depths and seamounts?	LEARNED What have I learned about the exploration/exploitation of the ocean depths and seamounts?
The <i>One Ocean</i> website was useful to me because it provided me with . . .		Episode 3: “Mysteries of the Deep” was useful to me because it provided me with . . .

W Use the Time Machine feature on the *One Ocean* website (cbc.ca/oneocean) and focus on the journey through the History of Sea Exploration. In groups, students will identify the 17 vessels, and for each vessel, identify the following aspects (where available):

- piloted or non-piloted
- time in history
- construction
- accomplishments and contributions to research or other areas
- a small sketch of each of the vessels

Students should organize their information in a manner that can be shared with other groups later in the lesson plan (e.g., in chart form with a fully labelled sketch).



EPISODE 3: MYSTERIES OF THE DEEP

LESSON PLAN

1. Review the basic information concerning the 17 exploratory vessels identified on the website and examined in the pre-viewing activity. Divide the vessels up and distribute to groups (give a specific group a different vessel than they had in the pre-viewing activity). In groups, identify the levels of technology used for each of the vessels.
2. How are the advances in technology illustrated in the pictures on the website and the sketches that have been drawn?
3. The focus on the timeline on the website is on the history of exploration of the ocean depths. However, technology has also had an effect on the human use of the oceans. List the positive and negative effects of current technology in deep-sea exploration and exploitation.
- V** 4. View Episode 3: “Mysteries of the Deep.”
5. In Chapter 1 – The Pacific Rim of Fire, scientists examine seamounts. What is a seamount? How did technology help the scientists to observe and analyze life around the seamounts? How is this information helpful to understanding the ocean?
6. How has technology helped scientists to explore the Ring of Fire and associated troughs such as the Mariana Trench?
7. Using the case study of the orange roughy in Chapter 3 – Deep Sea Resources, outline how advances in technology have been involved in the over-fishing and exploitation of the ocean’s resources. What has been the impact of this activity, locally and globally?
- W** 8. Ultimately, it is the scientists who invent and utilize new technology. Go to the *One Ocean* website (cbc.ca/oneocean) and meet the experts who have been highlighted in Episode 3: Chadwick, Worm, Robison, Costa, Hawkes, Clark, Dunn and Tunnicliffe. For each of these renowned scientists, identify the country in which they received their training, their areas of expertise and their role in ocean exploration and preservation.
9. How have advances in technology helped scientists to learn more about the importance of the oceans as a significant ecosystem? How does the information collected by scientists help them understand life in the deep sea? How have changes in society impacted on the exploration and exploitation of the deep sea? What has happened to the environment of the ocean as a result of exploration and the exploitation of the resources of the oceans?
10. What changes in technology need to occur to give us more in-depth information about the ocean?



EPISODE 3: MYSTERIES OF THE DEEP

Extension Suggestions

1. Draw a scale drawing of one of the vessels not previously studied and research how the name for the vessel was assigned.
2. The vessel NEMO can be piloted or can be operated robotically. Spell NEMO backwards. What does this mean? The book *20 000 Leagues under the Sea*, by Jules Verne, references a NEMO. Who is this?
- V** 3. From descriptive passages in the above book, illustrate one scene that was seen under the sea. Compare it with a scene from Episode 3: "Mysteries of the Deep."
4. Research a Canadian scientist, such as Ballard or McInnes, and list the contributions made by this individual to deep-sea explorations.
5. Research Canadian oceans facilities, such as the Bedford Institute of Oceanography, the Institute of Ocean Sciences in Victoria or Project NEPTUNE and list three contributions that have been made to technological innovations for deep-sea explorations.

Assessment Suggestions

1. Design a brochure to market one of the recent vessels for underwater exploration to other scientific organizations. Include a title, description and picture. Include a section on the technology involved and its impact on exploring the deep sea.
2. Assess student understanding by using Appendix 3.2.2 – Cause and Consequence Worksheet. In the triangle in the centre of the web, students write in the words "Ocean Exploitation" and then fill in the squares with information that they have gleaned from Episode 3 and the website. The analysis component can also be utilized.
3. Discuss the statement "Discovery is only the beginning of exploration" with reference to the vessels used to explore the deep sea.

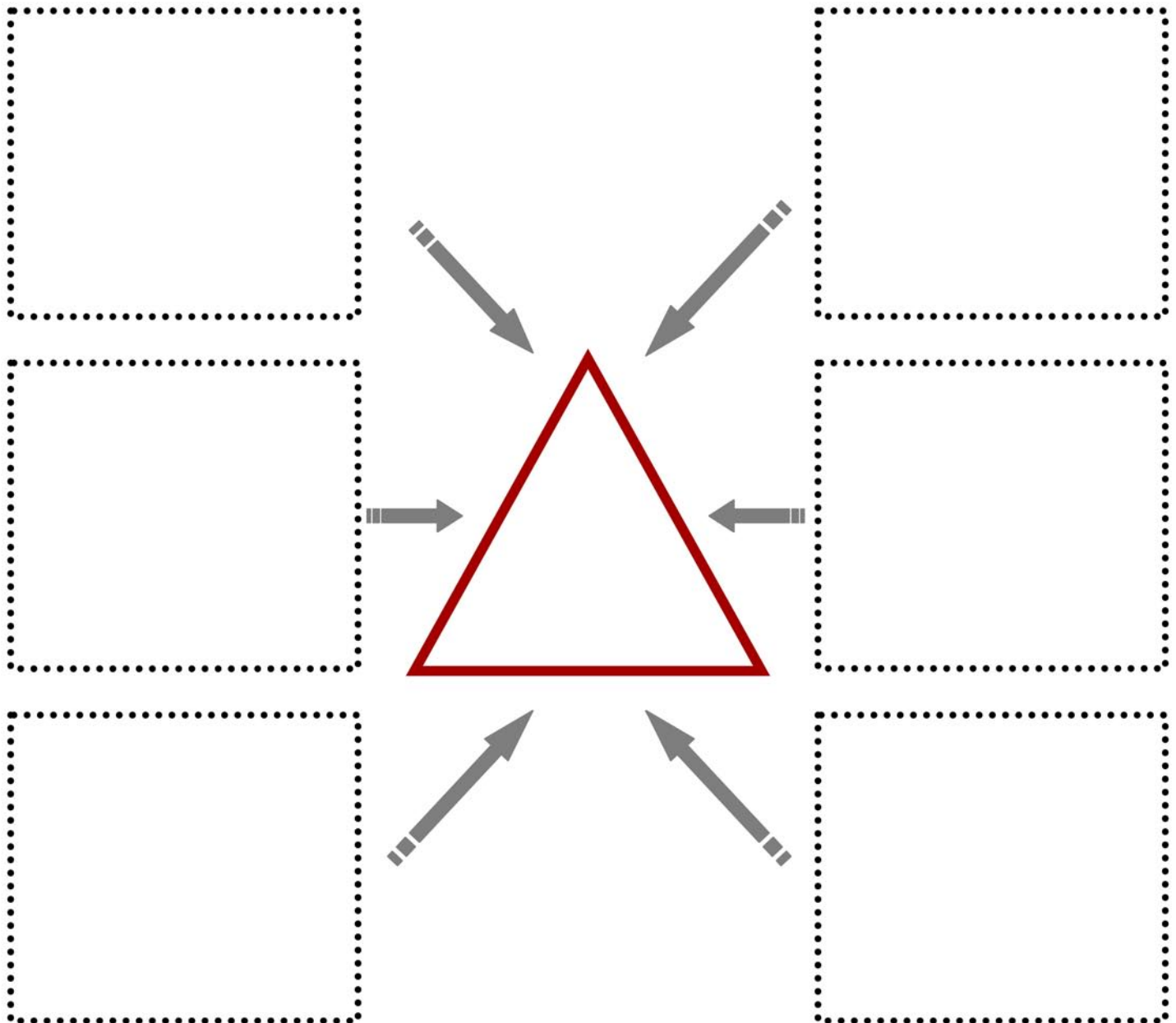


EPISODE 3: MYSTERIES OF THE DEEP

Appendix 3.2.2 – Cause and Consequence Worksheet

Instructions:

Record the event or issue you are analyzing in the centre triangle. Then identify and record all of the short-term and long-term causes that you believe contributed to the event.



Analysis:

1. Study the web and decide which of the causes could be considered: a) short-term, or b) long-term. Identify each of these categories by shading the boxes different colours.
2. Alternatively, you might want to determine which of the causes could be considered: a) economic, b) social and cultural, or c) political. Be prepared to share your responses with your classmates.



EPISODE 3: MYSTERIES OF THE DEEP

Vocabulary

bioluminescence,
exploration, exploitation

Quick Facts

Oceans cover approximately 70% of the Earth's surface.

The oceans have an influence on the ecology of the entire planet.

Oceans contain the largest number of species.

Oceans have the largest biomass on the planet.

Oceans have the largest number of individual organisms.

Most of the ocean-living animals survive in the deep oceans.

ACTIVITY 3.3: FUTURE RELATIONSHIPS

Curriculum Expectations (Grades 11–12)

- Identify the merits of specific scientific or technological endeavours in a societal context.
- Analyze the risks and benefits and propose alternative solutions to a practical problem (positive and negative elements) and select one as the basis for a plan.
- Explain how scientific knowledge evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised or replaced.
- Describe the rights and responsibilities of individuals with respect to protecting the environment for future generations.

Activity Overview

Students will investigate the concepts associated with one-ocean relationships through the scientists, the technology and the ocean itself. Students will explain and provide examples of a problem, explain theories investigated, analyze the pros and cons, write plans to explore the problem, and take action in a variety of ways.

Background Information

Chapter 4 – Beyond the Terrestrial View stresses the importance of new ways of thinking about our relationships with the ocean and advocates for a benign and productive interaction with this, the largest ecosystem on our planet. In addition to the acquisition of scientific knowledge, students will use critical thinking skills—engaging, exploring, explaining and extending—to lead them to a position where they can take action that is directive and effective.

Teacher Preparation and Materials Required

Teachers should review the concept of *ecosystem* with the students and establish some of the “known facts” about the oceans. Students should be made aware of the differences between *discovery* and *exploration*. Copies of Appendix 3.3.1 – Multiple Consequence Web Diagram should be available for use.

Pre-viewing Activity

1. What are the characteristics that make the ocean a hostile environment for humans?
2. Suggest why the oceans—as opposed to space—might be defined as “the last frontier.”
3. Discuss the statement that “science is still in search of the right questions” and how this might apply to studies of the world's oceans.



EPISODE 3: MYSTERIES OF THE DEEP

LESSON PLAN


- V** View Episode 3: Chapter 4 –Beyond the Terrestrial View, and respond to the following questions.
1. The oceans can be interpreted as either a hostile or hospitable environment. What are some of the aspects of both of these particular perspectives that are identified in Chapter 4? How does the exploration of a two-dimensional environment differ from that of a three-dimensional environment?
 2. How must our attitudes toward the deep ocean environment change (e.g., from distant observer to direct participant)? In what way has *your* attitude toward the ocean changed from your viewing of Episode 3: “Mysteries of the Deep.”
 3. How does the public expenditure of funds for research into the deep ocean compare with that for the space environment? Suggest reasons for the differences.
 4. If, indeed, “ours is the ocean planet” as is stated in Chapter 4, why has there been so little public interest in research in this area?
 5. In order to raise public awareness, interest, and understanding about the ocean environment, more must be done to promote the oceans as “a cause.” The series *One Ocean* and the accompanying website provide a starting point in this direction. The key issues associated with the oceans are found in the Pledge feature of the website. Choose ONE of the issues and identify possible methods of increasing societal involvement in this issue.
 6. In small groups, share your possible methods to increase societal involvement with others in the group. Choose one for further investigation.
 7. Develop a plan to implement your method. Your plan should include the following:
 - a clear statement of method chosen
 - a list of the actions that you propose to implement your idea
 - for each action, an evaluation of the problems that will be encountered in implementing the action
 - for each problem, how you propose to solve the problem
 - based on your evaluation of the problems and their ability to be solved, choose the best action and share your rationale with the other groups in the class
 - W** 8. Proceed to the *One Ocean* website and examine the Make a Pledge feature. Individually, as a small group or as a class, make a pledge that is implementable and that will reflect the method you have chosen.



EPISODE 3: MYSTERIES OF THE DEEP

9. Use Appendix 3.3.1 – Multiple Consequence Web Diagram to illustrate the consequences of increased societal awareness and understanding related to the ocean environment. At the centre of the web, write the words “Increased societal understanding of our ocean environment” and indicate the consequences of this result.
10. Your ideas for implementation of a plan to increase societal involvement in the issues surrounding our oceans have come to the attention of the media. Develop a brief but focused report based on your plan to be presented to the media. This can be in the form of a press release, newspaper article, Powerpoint presentation or oral presentation.

Extension Suggestions

1. The scientific community continues to need individuals with a passion for scientific research and people to support research in this area (e.g., technicians). Investigate a career choice that could involve research associated with the ocean environment. Outline the educational requirements, including where to obtain post-secondary training/ education for the specific career choice.
-  2. This episode is called “Mysteries of the Deep.” Identify, from the video, the mysteries that may not *be* a mystery in 25 years. What will be needed to change this from a puzzling event or situation to a known one?
3. In Chapter 2 – Bioluminescence, the phenomenon known as bioluminescence is described as the “most important communication form on Earth.” Evaluate this claim. If, indeed, it is true, what are the consequences of such a claim for us as humans living on this planet?
4. Go to the *One Ocean* website/The Series/Audio Extras. Listen to one of the two interviews associated with Episode 3: “Mysteries of the Deep”— Boris Worm or Verena Tunnicliffe. First, indicate why you chose to listen to your particular scientist and then summarize the new information you have learned from the interview.

Assessment Suggestions

1. Has scientific knowledge helped change how we look at the life in the oceans? Give examples.
2. “We are faced with vast problems and we have half-vast solutions.” Discuss this statement with respect to caring for the ocean.



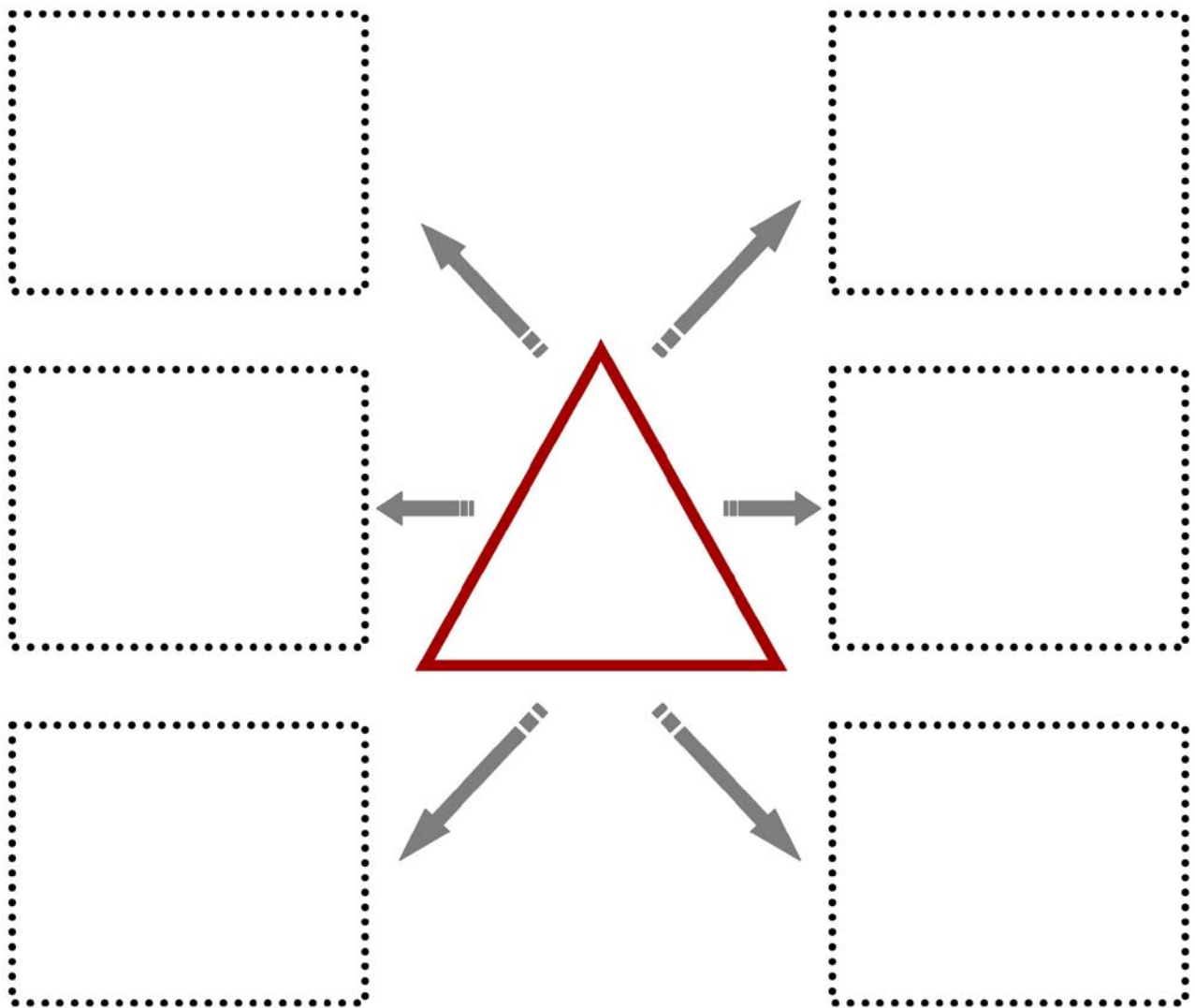
EPISODE 3: MYSTERIES OF THE DEEP

Appendix 3.3.1 – Multiple Consequence Web Diagram

Changing one element in a complex world will lead to myriad consequences. Some of the consequences will be part of the plan developed and, therefore, intentional. At the same time, some consequences will be unintentional. Some consequences will be positive, others negative. Some will only occur in the short term, but others will be long-lasting in nature.

Instructions:

Place the words "increased societal understanding of the ocean environment" in the triangle. In the boxes surrounding the triangle (and you may add more if needed, or add boxes to boxes, if one consequence leads to another consequence), record the consequences generated by this situation.



Analysis:

Using symbols or colour coding, classify each of the consequences as intentional or unintentional, short-term or long-term, positive or negative.

Write a paragraph to analyze the potential effects of the initial event (increased societal understanding of the ocean environment).



EPISODE 4: THE CHANGING SEA

UNIT OVERVIEW

Episode Summary

In the final episode, “The Changing Sea,” we discover that the ocean is sending us clear signals. Off the rugged and beautiful coast of California we meet scientists and fishers who are shocked at the recent arrival of a voracious new creature: the Humboldt squid. These monster-sized squid are native to the equatorial waters of Mexico, but they have moved north and ushered in a cascade of changes to the ecosystem. Their arrival is part of a disturbing pattern that is emerging through the tracking of species movement around the world. In “The Changing Sea” we illustrate how the ocean’s chemistry and systems are being compromised by increased acidity, less oxygen and warming temperatures. The changes to the timeless rhythms of birth and renewal are being felt everywhere—even on coral reefs. In the idyllic waters of the Bay of Naples, we get a glimpse of our future ocean, thanks to the mythic Mount Vesuvius. As scientists swim through lush green seagrass, collecting creatures whose shells are dissolving, we discover that this stunning location has a terrible secret. It has been naturally acidified for millennia—could this be our ocean’s future?

Activities

Grades 8–10

4.1 Biodiversity in Marine Environments

Students will pose a research question that will allow them to analyze factors that affect productivity and species distributions in marine environments.

4.2 Exploring Ocean Dead Zones

Students will explore scientific explanations for the formation of dead zones and their impact on aquatic ecosystems, and use their understanding to encourage others to make a difference.

Grades 11–12

4.3 Disappearing Coral Reefs

Students will analyze some of the ways that human-influenced global climate change is contributing to the loss of coral reefs in the world’s oceans.



EPISODE 4: THE CHANGING SEA

Vocabulary

hake, Humboldt squid, jigging, krill, arrhythmia, upwelling, phytoplankton, acidification, zooplankton

Factors

Lack of predation, warming periods, carbon dioxide from the burning of fossil fuels, hypoxia, temperature sensitivity, ocean acidification

ACTIVITY 4.1 • BIODIVERSITY IN MARINE ENVIRONMENTS

Curriculum Expectations (Grades 8–10)

- Analyze factors that affect productivity and species distributions in marine environments.
- Understand the concept of *system* as it applies to oceans.
- Use a range of resources to communicate the answer to a chosen question based on information presented in the episode.

Activity Overview

As they view Episode 4: “The Changing Sea,” students will record information about the factors that have an impact on marine ecosystems. They will indicate “What I discovered” and “I am wondering about ...” in a two-column format. Students will then identify two to four new factors that are having an impact on marine ecosystems. They choose one factor and come up with four to seven questions to answer about that factor. One place they must search for information is the *One Ocean* website. Students will summarize the answer to their questions.

Background Information

There is no question that human actions are having an impact on the world’s oceans. Marine ecosystems are relocating to cooler waters, becoming less inhabitable or disappearing altogether. Episode 4: “The Changing Sea” explores each of these issues and how human activity is contributing to each. Before watching the episode, students complete a pre-viewing activity to help activate prior knowledge and get them thinking critically about the topic of human-marine ecosystem interactions. The activity works to help the teacher identify any alternate conceptions students may have about the topic. These alternate conceptions can then be addressed and discussed prior to, or following, the viewing of the episode.

Teacher Preparation and Materials Required

The teacher should review the factors that are having an impact on marine ecosystems discussed in the episode by watching “The Changing Sea” before showing it to the students. This will help the teacher to assess whether a class discussion should occur after each chapter or at the conclusion of the episode. Teachers are also encouraged to explore the One Ocean website (cbc.ca/oneocean) to become familiar with its layout. The website provides a number of interactive features such as Ocean Explorer, Biosphere Game, *One Ocean* Pledge and content areas such as the The Series, which contains information about the episodes and a section in which students can “meet the expert.”



EPISODE 4: THE CHANGING SEA

Since this activity is group-based, review the basic expectations for working in groups (all members contribute, no put-downs, etc.). Review the concepts of ecosystems, food chains, food webs and trophic levels to get students thinking about some of the themes presented in this episode.

Pre-viewing Activity

In groups of four and using a large piece of chart paper, divide the paper equally by drawing four line segments from a centrally drawn square (or rectangle or circle) to the edge of the chart paper. List the different factors that affect populations and diversity in marine ecosystems. As a group, identify (rank order) the top three factors, listing these in the centre of the chart paper (in the square or rectangle or circle drawn). Be prepared to share the list and the reasons for the top three items.



EPISODE 4: THE CHANGING SEA

LESSON PLAN

1. Complete the pre-viewing activity (2-3 minutes to make individual list; 7-10 minutes to discuss and come up with a group list of three factors; 3-5 minutes to create a class list of factors and introduce the episode).

Summarize the factors and display them for class reference throughout the viewing of the episode and the remainder of the activity.

- V** 2. View Episode 4: “The Changing Sea” and record (individually) a summary of the information in two columns: “What I discovered” and “I am wondering about . . . ”
3. At the end of each chapter, stop the video and give students a chance to review what they have written, add to what they have written, and come up with one or two questions they have based on what they have written.
4. In groups, summarize what you have discovered and consolidate your questions where there is overlap in the direction of the questions.
5. At the completion of the episode and using your charts, develop a list of the factors that can and are affecting both the populations and diversity in marine ecosystems.
6. Select one factor from the list created after watching the episode and establish at least five questions you have about that factor.
7. Before beginning to research answers to the questions, get approval from the teacher about the selected factor and the questions about that factor.

It would be helpful for the teacher to provide anecdotal feedback to the students about their questions before they begin the research process.

- W** 8. Use the *One Ocean* Pledge feature on the website (cbc.ca/oneocean) to learn about the issues affecting the oceans as presented in the episode: acidification, coral depletion, dead zones, over-fishing, pollution. Other sources can be used to find information about specific questions that you have developed. Use a Web search engine to located more information about your specific question.
9. Submit the answers to the questions to the teacher for feedback. Summarize your findings in a short one-page article that could be submitted to a local newspaper or magazine.
- W** 10. Make a commitment to the preservation and enhancement of the oceans on the website by completing the *One Ocean* Pledge.

This could be done individually or as a class. If completed as a class, then the class could also challenge another class in the school, district, province/territory or country.



EPISODE 4: THE CHANGING SEA

Extension Suggestion

In Episode 4, Chapter 4 – Our Future Ocean, the scientists featured share their beliefs about what the oceans will look like in the future. Create a podcast/poem/song/public service announcement answering the question “What do you think the oceans will look like in 50 years?”

Assessment Suggestion

Anecdotal feedback can be provided at several stages in the activity and could be focused around the elements outlined in the lesson plan—the two-column chart, the questions about the factor chosen for research and the research answers to the chosen question. This will be helpful for students as they take the information they have gathered and use it to create a one-page article for submission to the local newspaper or magazine.

Formal assessment may be used to evaluate the student article. Areas of focus for the formal assessment could include knowledge and understanding of the issue, thinking and inquiry skills, written communication skills, and the development of a synthesis or conclusion in the article. In terms of knowledge and understanding, the focus should be on the understanding of the impact their chosen factor has on populations and diversity in marine ecosystems and the understanding of the concept of *systems* as it applies to oceans. Students should be informed in advance regarding the criteria for assessment.



EPISODE 4: THE CHANGING SEA

Vocabulary

algal bloom, arrhythmia, eutrophication, hypoxia, ocean breathing, phytoplankton, upwelling

ACTIVITY 4.2 • EXPLORING OCEAN DEAD ZONES

Curriculum Expectations (Grades 8–10)

- Describe the interactions of the ocean currents, winds and regional climates.
- Assess data to elaborate conclusions on ocean characteristics.
- Design an experiment to compare the density and buoyancy of fresh water and sea water.

Activity Overview

The activity will introduce students to the phenomenon of ocean dead zones, explore scientific explanations to the formation of these areas, explore their impact on aquatic ecosystems, and use their understanding to encourage others to make a difference by signing the *One Ocean* Pledge on the *One Ocean* website (cbc.ca/oneocean).

There are five stages to the activity: engagement, exploration, explanation, elaboration/extension and evaluation.

Background Information

Dead zones are regions in fresh and marine aquatic environments in which dissolved oxygen concentrations drop to extremely low levels. The condition of oxygen deprivation, known as *hypoxia*, results from a combination of biological, chemical and physical processes.

While such zones do develop naturally in some aquatic ecosystems, many dead zones have expanded and new ones have been formed. The expansion of dead zones can be traced back to human activities—population growth and associated sewage discharges, increased run-off of fertilizers from agricultural use, loss of wetlands and forests to urban development, and deposition of nitrogen from the burning of fossil fuels.

Dead zones currently occur in many aquatic ecosystems around the world, including Lake Erie, the northern Gulf of Mexico, Chesapeake Bay, Black Sea, Baltic Sea, in the coastal waters off South America, China, Japan and Australia, and Cape Perpetua off the Oregon coast.

Teacher Preparation and Materials Required

Preview Episode 4, Chapter 2 – The Arrhythmic Ocean, and the *One Ocean* website to become familiar with its layout. The website provides a number of interactive features such as Ocean Explorer, The Biosphere, *One Ocean* Pledge and other content (Episode Guide, About the Series).

Appendix 4.2.1 – Density Demonstration and Appendix 4.2.2 – Physical Characteristics of Dead Zones



EPISODE 4: THE CHANGING SEA

The Extension Suggestion requires viewing Episode 2: “Footprints in the Sand.”

Pre-viewing Activity

Two pre-viewing activities are recommended. The first is a simple demonstration illustrating the concept of *density* (see Appendix 4.2.1 – Density Demonstration); the second is an inquiry that offers a biological/physiological explanation of the connection between nutrient loading, phytoplankton blooms and dead zone formation. A complete description of this previewing activity can be found at: www1.coseecoastaltrends.net/modules/dead_zones/access_classroom_resources/. Click on Activity (Explore)/Dead Zone Model for a complete description.

Students should have an understanding of cellular respiration, photosynthesis and decomposition and be able to transfer that understanding to aquatic organisms.



EPISODE 4: THE CHANGING SEA

LESSON PLAN

- V** 1. Engage students in the topic of dead zones by viewing Chapter 2 – The Arrhythmic Ocean. While viewing, students should be aware of the following two questions, which will be investigated following the viewing:

- What did I discover about dead zones?
- What do I want to know about dead zones?

Present your question(s) and answer(s) to the class for feedback. Revise your answers based on the feedback from the class and post your information for the rest of the class.

- W** Use the Meet the Sealife feature on the website to learn more about phytoplankton, Dungeness crab, halibut and sunflower sea star—marine organisms affected by the Cape Perpetua dead zone.
2. Explore a physical model of dead zones by designing an experiment to compare the density and buoyancy of fresh water and seawater (see Appendix 4.2.1 – Density Demonstration for a description of the activity). Use the information gathered from watching Chapter 2 of the episode to design an experiment and to reach conclusions from the experiment.
3. Summarize the conclusions reached from the density and buoyancy investigation. Use these conclusions, along with the conclusions reached from the second pre-viewing activity (a biological/physiological explanation for the formation of dead zones) to write a paragraph in response to the statement: “Too much phytoplankton can be too much of a good thing.”
4. Research one possible solution to the problem of human-influenced dead zone formations. Possible sources include: National Oceanic and Atmospheric Administration website: www.noaa.gov; Centre for Oceanic Science Educational Excellence’s Coastal Trends Modules website: www1.cosecoastaltrends.net/modules; Google search engine: www.google.ca. In groups of four, present a proposed solution and, using the criteria “Benefits and Drawbacks,” obtain feedback from the rest of the group. The student proposing a solution is responsible for recording their feedback from the group. This feedback and proposed solution will be submitted to the teacher for assessment. Each group comes to a consensus on which solution presented is the most realistic and presents that solution to the entire class. From the solutions presented, decide on the one solution that has the best chance of implementation.
- W** 5. Demonstrate an understanding of ocean dead zones by pledging to make a commitment to the ocean using the *One Ocean* Pledge on the website and by posting a comment to the Dead Zones issues page (Click The Issues tab on the *One Ocean* Pledge page followed by the Dead Zones link. Comments are posted after the description of dead zones). The posting should include the proposed solution and reflect the feedback from their group.



EPISODE 4: THE CHANGING SEA

Extension Suggestion

- ✓ The expansion and development of dead zones has been attributed to human activity—specifically to coastal development and the associated sewage discharges. View Episode 2: “Footprints in the Sand” to assess and analyze the cost of coastal development on marine ecosystems and the expansion of dead zones.

Assessment Suggestion

Anecdotal feedback can be provided at several stages in the activity: responses to the questions “What did I learn about dead zones?” and “What do I want know about dead zones?”, answers to the questions from the comparing the density and buoyancy of fresh and sea water experiment, and their proposed solution, with benefits and drawbacks, to human-influenced formation/ expansion of dead zones. This is helpful as students will take this information and use it for their *One Ocean* Pledge and comment posted to the *One Ocean* website.

Formal assessment may be used when evaluating each student’s *One Ocean* Pledge, comment posted to the website and paragraph response to the statement: “Too much phytoplankton can be too much of a good thing.” The Pledge, posted website comment and paragraph response should reflect student understanding of dead zones: what they are, how they form, possible solutions to mitigate the development/expansion of dead zones, and should correctly use the vocabulary introduced through the activities.



EPISODE 4: THE CHANGING SEA

Appendix 4.2.1 – Density Demonstration

Objective

Students will be challenged to think critically about a simple demonstration exploring the concept of density and hypothesize about various proposed outcomes of the demonstration.

Materials

Light corn syrup	Dawn dish soap (blue)	Graduated cylinder (1 L)
Water	Rubbing alcohol	Food colouring
Vegetable oil	Honey	200 mL beakers

Procedure

1. Measure 150 mL of each type of liquid into the 200 mL beakers. It is important that the volume of each liquid be the same, as this variable is being controlled throughout the demonstration. Food colouring needs to be added to those liquids that are colourless (water, rubbing alcohol, light corn syrup) to give a more dramatic effect when the liquids are added to the graduated cylinder. The vegetable oil and honey will not change colour.
2. Pour the honey into the graduated cylinder first. Make sure that the honey is poured in the centre and not down the insides of the vessel. Add the remaining liquids in the following order: light corn syrup, dish soap, water, vegetable oil, rubbing alcohol.
3. As you pour, the liquids will layer on top of one another due to the differences in density of the liquids. You now have a six-layered density column.

Students will respond to the following questions individually, and then share their findings with a partner. A full class discussion can bring together the responses.

1. Do you think the order in which the liquids are added to the graduated cylinder is important? Explain.
2. What do you think would happen if the rubbing alcohol was added to the graduated cylinder first and the honey was added last?
3. Given that the volume of each liquid was the same, what other measurable quantity could explain the behavior of the different liquids?



EPISODE 4: THE CHANGING SEA

Appendix 4.2.2 – Physical Characteristics of Dead Zones

The Roles

Chief researcher

makes sure the task is completed in the time allotted and that each member knows their assigned task.

Equipment manager

obtains the necessary equipment to complete the investigation and returns it to the required location.

Fact finder researches answers to questions the group may have about fresh water, seawater, density and buoyancy.

Communication

manager acts as liaison for any questions the group has to the teacher, helps the chief researcher as needed.

Objective

Students will design an experiment to answer the question: How can you compare the density and buoyancy of fresh water and sea water?

Materials

Use any or all of the following materials to complete your investigation:

Water	Graduate cylinder
Salt	Medicine droppers or pipettes
Food Colouring	Beakers
Balance	Rubber stopper

Procedure

Working in small groups design a procedure that would help your group compare the density and buoyancy of fresh water and seawater. Each member of the group has a role in task.

Your procedure must be approved by the teacher before beginning the investigation. Create a table, with appropriate headings, to summarize your findings.

Consolidating Your Findings

1. In a deep body of water, where would you find the warm water and the cold water during the summer? How might this be different in the winter?
2. Which has a greater density — fresh water or sea water?
3. Which has greater buoyancy — fresh water or sea water?
4. How does oxygen get into water?
5. Which would have a higher concentration of oxygen — cold water or warm water?
6. Why do you think a dead zone typically occurs in deep water?



EPISODE 4: THE CHANGING SEA

Vocabulary

acidification, plankton, pteropods, zooplankton, zooxanthellae

ACTIVITY 4.3 • DISAPPEARING CORAL REEFS

Curriculum Expectations (Grades 11–12)

- Explain how key ecological processes contribute to ecosystem health and analyze how various factors contribute to the fragility and/or resilience of selected ecosystems.
- Evaluate the impact of economic, social, political, and technological change on natural and human systems.

Activity Overview

Students analyze some of the ways that human-influenced global climate change is contributing to the loss of coral reefs in the world's oceans. Students will also understand how anthropogenic production of carbon dioxide is impacting coral ecosystems, what this impact means to ocean biodiversity and to humans, and propose simple behavioural changes they, as citizens of a global community, can make to alleviate some of the environmental stresses.

Background Information

The loss of the ocean's coral reefs will be devastating to numerous species, not only in the oceans, but in a variety of ecosystems—including our own as humans. Students need to be engaged in an analysis of these kinds of environmental crises so they can build the necessary skills and personal connections to the crisis. Through such connections students become environmentally literate, are able to critically analyze current actions and can propose solutions that are sustainable. Such actions will produce citizens who are environmentally aware, knowledgeable about the environment and willing to take action (behavioural change) to conserve and protect the environment.

Teacher Preparation and Materials Required

Preview Chapter 3 – Ocean Acidification, and the *One Ocean* website (cbc.ca/oneocean) to become familiar with its layout. The website provides a number of interactive features such as *One Ocean Explorer*, *Biosphere Game*, *One Ocean Pledge* and content-specific data (Episode Guide, About the Series). Students may need to review basic ecological concepts (such as autotrophs, producers, consumers, biotic factors, abiotic factors, predators, prey, symbiotic relationships, commensalism). It may be necessary to review their understanding of food chains and the consequences of the loss of a primary producer (autotrophs) such as zooplankton to other consumers, including humans. A review of pH, the pH scale and the mathematical relationship between acidic strength and pH values will add greatly to an understanding and appreciation of the lesson to follow.

Appendix 4.3.1 – Modelling Ocean Acidification

The Extension Suggestions requires viewing Episode 2: “Footprints in the Sand.”



EPISODE 4: THE CHANGING SEA

Pre-viewing Activity

Conduct a simple experiment to illustrate how carbon dioxide can turn neutral water acidic. Fill a beaker with tap water (or distilled water, if you have access to it). Add a few drops of an indicator solution (red cabbage juice is the safest to use and can be produced by boiling red cabbage and then draining the solution into a bottle for storage). Use a drinking straw to gently blow into the water until the indicator changes colour. For the red cabbage juice indicator the solution will change from red-purple to green, indicating that the solution is now acidic. The chemical equation illustrates to the students the reaction that has taken place: carbon dioxide + water = carbonic acid.



EPISODE 4: THE CHANGING SEA

LESSON PLAN

1. Investigate how solutions of differing pH affect seashells (see Appendix 4.3.1 – Modelling Ocean Acidification for a description of the investigation).
- V** 2. View Episode 3, Chapter 3 – Ocean Acidification.
3. Engage students in the topic of ocean acidification by viewing Chapter 3. While viewing, students should be aware of the following two questions, which will be investigated following the viewing:
 - What did I discover about ocean acidification?
 - What do I want to know about ocean acidification?

After viewing, pair up with a partner to share what you have discovered and what you would like to learn. Choose one item for further research based on your responses to the question “What do I want to know about ocean acidification”? Have your choice approved by the teacher. Note that if the choice involves investigation of a different factor on corals (e.g., temperature, salinity, nutrient load), you will need to design an experiment with appropriate materials, procedures and safety measures before proceeding.
- W** 4. Use the *One Ocean Explorer* and *Meet the Sea Life* features on the *One Ocean* website (cbc.ca/oneocean) as a starting point and create a list of key components of a coral reef ecosystem, including optimal conditions (temperature, pH, salinity) for survival. Research how different factors (temperature, nutrient load, pH, pollution, disease) are impacting the health of coral reefs and the sources of those factors.
5. Develop a presentation in response to the statement “Coral reefs are the nurseries of the oceans.” In your presentation, address the role of coral reefs factors impacting their continued survival, the significance of the coral reefs and how an individual can slow down or even reverse the loss. The presentation can be in the form of a Powerpoint presentation, podcast, video blog or public service announcement.
6. Present your final product to the class. Students provide feedback to the presenters on the benefits and drawbacks of their proposed solution to the acidification of the ocean.
7. Collate proposed solutions on a sheet of paper that will become the class’s pledge to the oceans. Have each student sign the pledge and place it prominently in the class.
- W** 8. Make a pledge to protect the oceans using the Pledge feature on the *One Ocean* website.



EPISODE 4: THE CHANGING SEA

Extension Suggestion

- V** 1. View Episode 2: “Footprints in the Sand” to explore the efforts of Bill Ballantine to protect coral reefs off the coast of New Zealand. Create a list of interview questions to ask Ballantine about his conservation efforts.
- W** 2. Alternatively, challenge students to play either the Coral Reef Defender or an Ocean Mysteries game in the Biosphere feature of the *One Ocean* website and see which student can get the highest number of eco-credits. Issue a challenge to friends from other schools.
- W** 3. Go to the *One Ocean* website/The Series/Audio Extras. Listen to one of the two interviews associated with Episode 4: “The Changing Sea”: Debby Lanson or Richard Feeley. First, indicate why you chose to listen to your particular scientist and then summarize the new information you have learned from the interview.

Assessment Suggestion

- 1. Anecdotal feedback can be provided at several stages in the activity—the answers to the questions, the notes students make while watching the video and the research notes that students make while researching what more they would like to know about coral reefs. Such feedback is helpful, as the teacher will be able to address any alternate conceptions with students about coral reefs. Further, the feedback can help students critically reflect on their research findings.
- 2. Formal assessment may be used when evaluating student presentations. The criteria for assessment may include: depth of understanding of the role of coral reefs in marine ecosystems, impact of anthropogenic factors on the health and survival of coral reefs, depth of understanding of what the loss of coral reefs would mean, clarity of the information presented and feasibility of the proposed solution.



EPISODE 4: THE CHANGING SEA

Appendix 4.3.1 – Modelling Ocean Acidification

Students will model the effect of various pH levels on carbonate shells and use this model to make predictions about the impact on coral reefs from ocean acidification.

Materials

3 solutions of different pH (neutral, slightly acidic, strongly acidic)
250 mL beakers
Seashells
pH paper

Procedure

1. Label three beakers “Neutral,” “Slightly Acidic,” “Acidic.”
2. To each beaker add a handful of seashells.
3. In the beaker labelled “Neutral,” cover the seashells with distilled water.
4. In the beaker labelled “Slightly Acidic,” cover the seashells with a 50:50 mixture of white vinegar and distilled water.
5. In the beaker labelled “Acidic,” cover the seashells with white vinegar.
6. Leave the beakers for two to three days.
7. Make observations about the seashells in each beaker.
8. Using pH paper, check the pH of the solution in each beaker.

Use your observations to respond to the following questions.

1. Summarize in chart form the changes (if any) to the seashells in each of the solutions.
2. What was the pH of each solution?
3. What is the composition of the seashells?
4. Seashells provide a protective exoskeleton for many marine organisms. If the oceans were to become more acidic, what would be the fate of such organisms?
5. Hard corals are made of a limestone skeleton. What is the chemical formula for limestone? What would happen to hard corals as a result of ocean acidification?
6. *As oceans become more acidic, the amount of carbonate ions will decline.* Design an experiment to test this statement. Why is carbonate so important to corals?



EPS 1 - BIRTH OF AN OCEAN



EPS 2 - FOOTPRINTS IN THE SAND



EPS 3 - MYSTERIES OF THE DEEP



EPS 4 - THE CHANGING SEA



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