

Our Ocean Planet

A TEACHER'S MANUAL FOR OCEAN SCIENCE

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INTRODUCTION

OCEAN LITERACY

The ocean covers most of our planet, is the source of most life on Earth, regulates our weather and climate, provides most of our oxygen, and feeds much of the human population. Yet ocean and aquatic sciences are among the most underrepresented disciplines in K–12 educational curricula. Concepts about the ocean and the coasts infrequently appear in K–12 curriculum materials, textbooks, assessments or standards, and are rarely taught at any level.

In order to address this, several organizations, including the National Oceanographic & Atmospheric Administration (NOAA) and National Geographic Society (NGS), along with many scientists and science educators collaborated to define ocean literacy and produce a set of essential principles and fundamental concepts.

OCEAN LITERACY DEFINITION

Ocean literacy is an understanding of the ocean’s influence on you and your influence on the ocean. An ocean-literate person:

- understands the Essential Principles and Fundamental Concepts about the functioning of the ocean;
- can communicate about the ocean in a meaningful way;
- is able to make informed and responsible decisions regarding the ocean and its resources.

OCEAN LITERACY ESSENTIAL PRINCIPLES

Ocean Literacy is defined by seven Essential Principles:

1. The Earth has one big ocean with many features
2. The ocean & life in the ocean shape the features of the Earth
3. The ocean is a major influence on weather and climate
4. The ocean makes Earth habitable
5. The ocean supports a great diversity of life and ecosystems
6. The ocean and humans are inextricably interconnected
7. The ocean is largely unexplored

Each Essential Principle is supported by multiple detailed Fundamental Concepts which are presented in the next section. It is a work in progress and reflects efforts to date defining ocean literacy and identifying the Essential Principles and Fundamental Concepts of ocean science that should be included in K–12 curricula.

REFERENCES & FURTHER READING

- <http://www.coexploration.org/oceanliteracy>
- <http://www.ngsednet.org/oceans>
- <http://www.marine-ed.org>
- <http://www.cosee.net>
- <http://www.education.noaa.gov>



Ocean Literacy

Ocean Literacy is an understanding of the ocean’s influence on you and your influence on the ocean.

Essential Principles

1. The Earth has one big ocean with many features
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ESSENTIAL PRINCIPLES & FUNDAMENTAL CONCEPTS

PRINCIPLE 1 – THE EARTH HAS ONE BIG OCEAN WITH MANY FEATURES

- (a) The ocean is the dominant physical feature on our planet Earth—covering approximately 70% of the planet's surface. There is one ocean with many ocean basins, such as the North Pacific, South Pacific, North Atlantic, South Atlantic, Indian and Arctic.
- (b) An ocean basin's size, shape and features (islands, trenches, mid-ocean ridges, rift valleys) vary due to the movement of Earth's lithospheric plates. Earth's highest peaks, deepest valleys and flattest vast plains are all in the ocean.
- (c) Throughout the ocean there is one interconnected circulation system powered by wind, tides, the force of the Earth's rotation (Coriolis effect), the Sun, and water density differences. The shape of ocean basins and adjacent land masses influence the path of circulation.
- (d) Sea level is the average height of the ocean relative to the land, taking into account the differences caused by tides. Sea level changes as plate tectonics cause the volume of ocean basins and the height of the land to change. It changes as ice caps on land melt or grow. It also changes as sea water expands and contracts when ocean water warms and cools.
- (e) Most of Earth's water (97%) is in the ocean. Seawater has unique properties: it is saline, its freezing point is slightly lower than fresh water, its density is slightly higher, its electrical conductivity is much higher, and it is slightly basic. The salt in seawater comes from eroding land, volcanic emissions, reactions at the seafloor, and atmospheric deposition.
- (f) The ocean is an integral part of the water cycle and is connected to all of the earth's water reservoirs via evaporation and precipitation processes.
- (g) The ocean is connected to major lakes, watersheds and waterways because all major watersheds on Earth drain to the ocean. Rivers and streams transport nutrients, salts, sediments and pollutants from watersheds to estuaries and to the ocean.
- (h) Although the ocean is large, it is finite and resources are limited.

PRINCIPLE 2 – THE OCEAN & LIFE IN THE OCEAN SHAPE THE FEATURES OF THE EARTH

- (a) Many earth materials and geochemical cycles originate in the ocean. Many of the sedimentary rocks now exposed on land were formed in the ocean. Ocean life laid down the vast volume of siliceous and carbonate rocks.
- (b) Sea level changes over time have expanded and contracted continental shelves, created and destroyed inland seas, and shaped the surface of land.
- (c) Erosion—the wearing away of rock, soil and other biotic and abiotic earth materials—occurs in coastal areas as wind, waves, and currents in rivers and the ocean move sediments.
- (d) Sand consists of tiny bits of animals, plants, rocks and minerals. Most beach sand is eroded from land sources and carried to the coast by rivers, but sand is also eroded from coastal sources by surf. Sand is redistributed by waves and coastal currents seasonally.
- (e) Tectonic activity, sea level changes, and force of waves influence the physical structure and landforms of the coast.

PRINCIPLE 3 – THE OCEAN IS A MAJOR INFLUENCE ON WEATHER AND CLIMATE

- (a) The ocean controls weather and climate by dominating the Earth's energy, water and carbon systems.
- (b) The ocean absorbs much of the solar radiation reaching Earth. The ocean loses heat by evaporation. This heat loss drives atmospheric circulation when, after it is released into the atmosphere as water vapour, it condenses and forms rain. Condensation of water evaporated from warm seas provides the energy for hurricanes and cyclones.
- (c) The El Niño Southern Oscillation causes important changes in global weather patterns because it changes the way heat is released to the atmosphere in the Pacific.
- (d) Most rain that falls on land originally evaporated from the tropical ocean.
- (e) The ocean dominates the Earth's carbon cycle. Half the primary productivity on Earth takes place in the sunlit layers of the ocean and the ocean absorbs roughly half of all carbon dioxide added to the atmosphere.
- (f) The ocean has had, and will continue to have, a significant influence on climate change by absorbing, storing, and moving heat, carbon and water.
- (g) Changes in the ocean's circulation have produced large, abrupt changes in climate during the last 50,000 years.

PRINCIPLE 4 – THE OCEAN MAKES EARTH HABITABLE

- (a) Most of the oxygen in the atmosphere originally came from the activities of photosynthetic organisms in the ocean.
- (b) The first life is thought to have started in the ocean. The earliest evidence of life is found in the ocean.

PRINCIPLE 5 – THE OCEAN SUPPORTS A GREAT DIVERSITY OF LIFE AND ECOSYSTEMS

- (a) Ocean life ranges in size from the smallest virus to the largest animal that has lived on Earth, the blue whale.
- (b) Most life in the ocean exists as microbes. Microbes are the most important primary producers in the ocean. Not only are they the most abundant life form in the ocean, they have extremely fast growth rates and life cycles.
- (c) Some major groups are found exclusively in the ocean. The diversity of major groups of organisms is much greater in the ocean than on land.
- (d) Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.
- (e) The ocean is three-dimensional, offering vast living space and diverse habitats from the surface through the water column to the seafloor. Most of the living space on Earth is in the ocean.

- (f) Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is “patchy”. Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.
- (g) There are deep ocean ecosystems that are independent of energy from sunlight and photosynthetic organisms. Hydrothermal vents, submarine hot springs, methane cold seeps, and whale falls rely only on chemical energy and chemosynthetic organisms to support life.
- (h) Tides, waves and predation cause vertical zonation patterns along the shore, influencing the distribution and diversity of organisms.
- (i) Estuaries provide important and productive nursery areas for many marine and aquatic species.

PRINCIPLE 6 – THE OCEAN AND HUMANS ARE INEXTRICABLY INTERCONNECTED

- (a) The ocean affects every human life. It supplies freshwater (most rain comes from the ocean) and nearly all Earth’s oxygen. It moderates the Earth’s climate, influences our weather, and affects human health.
- (b) From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation’s economy, serves as a highway for transportation of goods and people, and plays a role in national security.
- (c) The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.
- (d) Much of the world’s population lives in coastal areas.
- (e) Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.
- (f) Coastal regions are susceptible to natural hazards (tsunamis, hurricanes, cyclones, sea level change, and storm surges).
- (g) Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

PRINCIPLE 7 – THE OCEAN IS LARGELY UNEXPLORED

- (a) The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation’s explorers and researchers, where they will find great opportunities for inquiry and investigation.
- (b) Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.

- (c) Over the last 40 years, use of ocean resources has increased significantly; therefore the future sustainability of ocean resources depends on our understanding of those resources and their potential and limitations.
- (d) New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.
- (e) Use of mathematical models is now an essential part of ocean sciences. Models help us understand the complexity of the ocean and of its interaction with Earth's climate. They process observations and help describe the interactions among systems.
- (f) Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, and physicists, and new ways of thinking

PURPOSE OF THIS MANUAL

While the Ocean Literacy Essential Principles and Fundamental Concepts are powerful statements, they are not sufficient for teaching purposes since they do not explain their points in any detail. This manual was written to illustrate these principles and concepts and to describe them in more detail. It is intended for educators who teach Key Stage 2 (9-11 year old) pupils.

MANUAL CONTENTS

The primary subject of this manual is the "ocean", its influence on us and our influence on it. As such, its scope is necessarily global and covers a wide variety of topics. The topics reflect the multiple disciplines that make up ocean sciences. The primary disciplines covered throughout the manual are Geography and Biology. However, there are also topics in Geology, Physics, Chemistry, History and even a small section on naval terms in the English Language. This manual is divided into 10 main sections and 1 supplemental section as follows:

SECTION 1 – OUR OCEAN PLANET

Section 1 discusses the ocean as a whole. Thus, it describes the ocean's features and the vast expanse of water that covers Earth. It also describes plate tectonics, the sea bed, and what the oceans looked like in the past. It also describes the nature of sea water and fresh water, where all the water originates, and the Water Cycle.

SECTION 2 – FORCES OF NATURE

Section 2 discusses natural forces such as the sun and moon and the effects of the Earth itself on the oceans. It then goes on to describe the tremendous effects of the ocean on our planet, including its influence on our weather and climate and the Carbon Cycle.

SECTION 3 – LIFE IN THE OCEANS

Section 3 discusses life in the oceans from a general perspective. It presents a timeline of life in the ocean from the beginning of life on Earth. It also discusses some extreme life forms in the ocean including the largest, smallest, oldest and most poisonous animals. It goes on to discuss important relationships that are found including food chains, and predator-prey and symbiotic relationships.

SECTION 4 – COASTS

Section 4 describes coastal areas where land and sea meet. Rocky coasts, sandy coasts, and muddy coasts (estuaries) are discussed in terms of where they found, how they are created and what life exists there.

SECTION 5 – TROPICAL SEAS

Section 5 describes tropical seas. Mangroves, sea grasses and coral reefs are described along with the life that exists in each ecosystem. It also describes the cnidarians (which include corals, sea anemones and jellyfish), Caribbean reef fishes and sea turtles in some detail.

SECTION 6 – TEMPERATE SEAS

Section 6 describes temperate seas. These are cool green waters that are immensely rich in plant and animal life. Kelp forests are described along with the life that lives in this ecosystem. It also describes horseshoe crabs, sturgeons and sea otters in some detail.

SECTION 7 – POLAR SEAS

Section 7 introduces polar seas. In the north, the Arctic Ocean is described along with life that inhabits this frozen sea. In the south, the Antarctic Ocean is described along with life that lives here. Pinnipeds (true seals, eared seals and walruses) are described in some detail along with one of Antarctica's most famous inhabitants – penguins.

SECTION 8 – OPEN OCEAN

Section 8 describes life in the vast open ocean. It describes both vertical migrations from the depths to the surface as well as migrations undertaken by certain animals across the ocean. Some of the most famous (or infamous) open ocean animals are also described – sharks and rays.

SECTION 9 – DEEP OCEAN

Section 9 describes the deep ocean and the extraordinary life that inhabits it. The deep ocean has hydrothermal vents and cold seeps that supports life that is very different to that found nearer the surface. It is one of the least known areas of our planet and one which this generation of explorers and scientists will be capable of exploring and studying.

SECTION 10 – HUMANS AND THE OCEAN

Humans have a mixed history with the ocean. This section presents a brief history of our interaction with the ocean. This is followed by a description of why we need the ocean and some of the problems we are causing. We also discuss some of the more practical things we might do to help conserve and protect the ocean.

SECTION 11 – CAYMAN ISLANDS AND THE SEA

This section discusses the ocean's influence on life in the Cayman Islands. We start with a brief history of the Cayman Islands and discuss its geography, history and natural resources. We then describe the rich resources the ocean provides the Cayman Islands including coral reefs, sea food, beaches and mangroves, and some of the effects humans have on these natural resources.

HOW TO USE THIS MANUAL

It is not necessary for teachers to know all the material in the manual. Instead, teachers should view the manual as a resource that can be referred to when information is needed and to provide source material for lesson planning. It is composed of multiple, modular sections, with each section consisting of various topics of interest. The material gives the teacher much more information than he/she needs but it is there for background should the teacher require the information without him/her having to do significant additional research. It is left to the discretion of the teacher as to how much information he/she wishes to impart about a particular topic. There are also references to additional information sources should the teacher require it. At the end of each section are "Activities". Activities consist of a variety of mental and physical tasks, such as drawing or making things, along with answering questions, taking part in discussions, and writing. These are intended to serve as a practical way of re-enforcing the topics of interest.

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