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TeachBlue: Teachers' Curriculum and Handbook

Marine and Ocean Literacy for Early Childhood Education

Edited by
Theodoros Kevrekidis
Democritus University of Thrace

Alexandroupolis, Greece 2025

<https://teachblue.eu/>



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TeachBlue: Teacher's Curriculum and Handbook

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EU programme for education, training, youth and sport

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Project coordinator:

University of Environmental and Life Sciences in Wrocław, Poland



WROCLAW UNIVERSITY
OF ENVIRONMENTAL
AND LIFE SCIENCES

Project partners:

Democritus University of Thrace, Greece



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TeachBlue



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Preface

The ocean is the defining physical feature on our planet. Marine photosynthetic organisms are a major source of atmospheric oxygen. The ocean regulates climate and weather, slows climate change and hosts some of the planet's most diverse ecosystems. The ocean is vital to human health and well-being. However, the ocean is under threat due to human activities. In this context, it is the responsibility of our generation to restore the health of the ocean for ourselves, for our children, and for future generations.

The promotion of Ocean literacy, namely of the understanding of the ocean's influence on us and our influence on the ocean, is widely recognized as a significant contributor to achieve the goal of conservation and sustainable use of the oceans, seas, and marine resources. However, unfortunately, ocean literacy has not been well integrated in educational curricula worldwide.

TeachBlue is an Erasmus+ project which aims to fill the existing gap in knowledge and education in ocean literacy, focusing on early childhood education. Six organisations from four European countries collaborated to build an innovative future-oriented Toolkit targeting giving early education teachers all the knowledge, skills, and key competences needed to teach students from a very early age about ocean literacy. This Toolkit includes a Teacher's Curriculum & Handbook, a Teacher's Educational Activities Guide, a Board Game, and 360° underwater videos.

The present educational material, the TeachBlue Teacher's Curriculum & Handbook, aims to briefly inform early education teachers about the need for ocean conservation and the sustainable use of the ocean and its resources, the important current international initiatives that have been undertaken to this end point, the Ocean Literacy movement and framework, as well as to provide an early education teacher's Curriculum about ocean literacy in a comprehensive way.

I would like to thank all the partners in the TeachBlue project for their contribution to the development of the present educational material. I would like to thank, in particular, my collaborator Theodora Boubonari, Democritus University of Thrace, and Helena Barracosa, Centro de Ciencias do Mar do Algarve for their contribution to the writing of this handbook, Konstantinos Lekkas and his collaborators in Dracon Rules Design Studio, especially Cristina Morar for artwork and layout, and my collaborator Chrisa Apostoloumi, Democritus University of Thrace for artwork.

The great variety of individual topics and the attempt to simplify concepts is expected to have inevitably led to omissions and oversights, which is another reason why well-intentioned criticism of the present educational material is always welcome.

Theodoros Kevrekidis
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Introduction



The Earth's surface is dominated by a vast ocean. Marine photosynthetic organisms are a major source of atmospheric oxygen. The ocean regulates climate and weather, slows climate change and hosts some of the planet's most diverse ecosystems. The ocean supports the economies of countries around the world and is vital to human health and well-being. However, despite its vast size, the ocean is under threat owing to human activities.

Ocean conservation and the sustainable use of the oceans, seas and marine resources is crucial. In 2015, the declaration of the **17 Sustainable Development Goals** (SDGs, 2030 Agenda for Sustainable Development) of the United Nations (UN) included the SDG 14 ("Life below water"), aiming at the conservation and sustainable use of the oceans, seas, and marine resources. Simultaneously, UN declared the **Decade of Ocean Science for Sustainable Development (2021-2030)**.

The vision of the Ocean Decade is "the science we need for the ocean we want". Both declarations prioritize research, education and development in **Ocean Literacy**.

Furthermore, Ocean Literacy is a prerequisite for the European Union (EU) to address its priorities concerning the sustainable blue economy. The **Ocean Literacy movement** aims to create an ocean literate society able to make informed and responsible decisions regarding the ocean and its resources.

However, research has shown that Ocean Literacy has not been well implanted in educational curricula worldwide. This especially applies to early childhood education which consists of a significant contributor to Education for Sustainable Development, since it is at that age range that children's fundamental attitudes towards the environment, fairness, and social justice are formed.





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About TeachBlue

TeachBlue is an **Erasmus+ project** which aims to fill the existing gap in knowledge and education in Ocean Literacy, focusing on early childhood education.

Six organizations from four different countries from **diverse EU sea regions** (Portugal - Atlantic, Poland - Baltic, Greece and Cyprus - Ionian & Aegean, Levantine), each one contributing from their own point of expertise, collaborated to build an innovative future-oriented Toolkit to support the professional development of **Early Childhood Education and Care (ECEC)** teachers (student teachers and in-service teachers) through informal and non-formal educational processes to lay the foundations for young students to become ocean literate.

The TeachBlue Toolkit consists of:





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The **Toolkit** is organized in an **educational package** including all the materials (Curriculum/Handbook, Activities Guide, Board Game and underwater videos). An electronic format of the Toolkit and its components has been produced to increase transferability potential to a wider audience in the EU through electronic means (eToolkit).

The TeachBlue Toolkit **aims** to foster national, European, and international recognition since it has been translated into the partners' four languages and in English to be made available and easily accessible for all interested parties.

The Teacher's Curriculum & Handbook consists of two major sections:

01

The first section (**Theoretical Framework**) aims to briefly inform the reader about issues such as the need for ocean conservation and the sustainable use of the ocean and its resources, the important current international initiatives that have been undertaken in this direction, the genesis and development of the Ocean Literacy movement, and the Ocean Literacy framework.

02

In the second major section (**TeachBlue Curriculum**), the Teacher's Curriculum is analyzed in a comprehensive way (aim, objectives, pedagogical approaches, assessment tools, thematic modules).

Seven thematic modules were arisen by combining and evaluating the data collected by the desk and field research, which were conducted in the framework of the TeachBlue project.

To organize these data into modules, **the Ocean Literacy essential Principles and fundamental Concepts** were also taken into account. As a result, each of these thematic modules corresponds to one of the seven essential Principles of Ocean Literacy.

In each module, the respective **conceptual flow diagram of the Ocean Literacy Scope and Sequence for Grades K–2** is presented, accompanied by synoptic texts providing the necessarily content knowledge.





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A | THEORETICAL FRAMEWORK





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A1. Ocean conservation and sustainable use

The **Ocean** is the planet's main physical feature. The ocean and ocean life shape the Earth's features. The ocean influences weather and climate, and makes the Earth habitable. The ocean supports a great diversity of life and ecosystems.



The **ocean** has high value to humans. The ocean is vital to human health and well-being. It provides food for billions of people, livelihoods for millions. The ocean supports the economies of countries around the world. It is the source of many essential medicines. It has cultural value.

However, the Ocean is threatened by human activity. Climate change has caused an increase in sea surface temperature, a rise in sea level, an increase in the frequency and intensity of extreme weather events and ocean acidification.

Fish stocks are declining, Ocean pollution has negative impacts on marine ecosystems, dredging, towed fishing and oil drilling threaten the seabed.

It has been repeatedly stated that it is the responsibility of our generation to restore the health of the ocean for ourselves, for our children, and for future generations. Initiatives have been developed in this direction.





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SUSTAINABLE DEVELOPMENT GOALS



In 2015, the **UN General Assembly established 17 SDGs** as a global call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity by 2030 (**2030 Agenda for Sustainable Development**).

In particular, the **SDG 14 states** “Conserve and sustainably use the oceans, seas, and marine resources for sustainable development”.



The UN General Assembly also declared the **Decade of Ocean Science for Sustainable Development (2021-2030)**. The vision of the Ocean Decade is “the science we need for the ocean we want”. The Decade’s Objectives are three, each of which includes sub-objectives. A sub-objective of the third Objective is to promote formal and non-formal education, including the promotion of **Ocean Literacy**.



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Intergovernmental
Oceanographic
Commission



**2021
2030** United Nations Decade
of Ocean Science
for Sustainable Development





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A2. The Ocean Literacy Movement

Previous research, conducted in various countries, showed that **citizens have a limited understanding** of issues related to the sea. This finding motivated scientists and educators in the US to make Ocean Sciences a central part of Science Education and Environmental Education.

The **Ocean Literacy movement** is a broad effort by scientists and educators that began in the US in 2002, with the aim of including Ocean Sciences in school curricula. The knowledge that citizens must acquire by the end of high school (Grade 12) in the US was identified so that they would be considered ocean literate, and the “**Ocean Literacy Framework**” was developed.

The Ocean Literacy Framework includes the “**Ocean Literacy Guide**” and the complementary “**Ocean Literacy Scope and Sequence for Grades K-12**”.

Ocean Literacy has now become globally accepted. The “Ocean Literacy Guide” has had a significant impact on both the scientific and educational communities. The Ocean Literacy movement has spread worldwide through the development of Marine Science educators’ associations.

Some countries, such as Portugal, have adopted the Ocean Literacy Principles and developed new approaches adapted to their realities. Museums, aquariums and science centers have restructured their programs, exhibitions and activities to incorporate Ocean Literacy guidelines.

A valuable research effort has also been developed on Ocean Literacy issues and related educational programs have been developed and implemented. In addition, as mentioned above, **Ocean Literacy has been recognized by the U.N.**

Finally, efforts have been made to regionally adapt and thematically specialize the **Essential Principles and Fundamental Concepts of Ocean Literacy**. In particular, the following have been developed: Great Lakes Literacy, Mediterranean Sea Literacy, Estuarine Principles and Concepts, and Principles and Concepts about Seagrasses.





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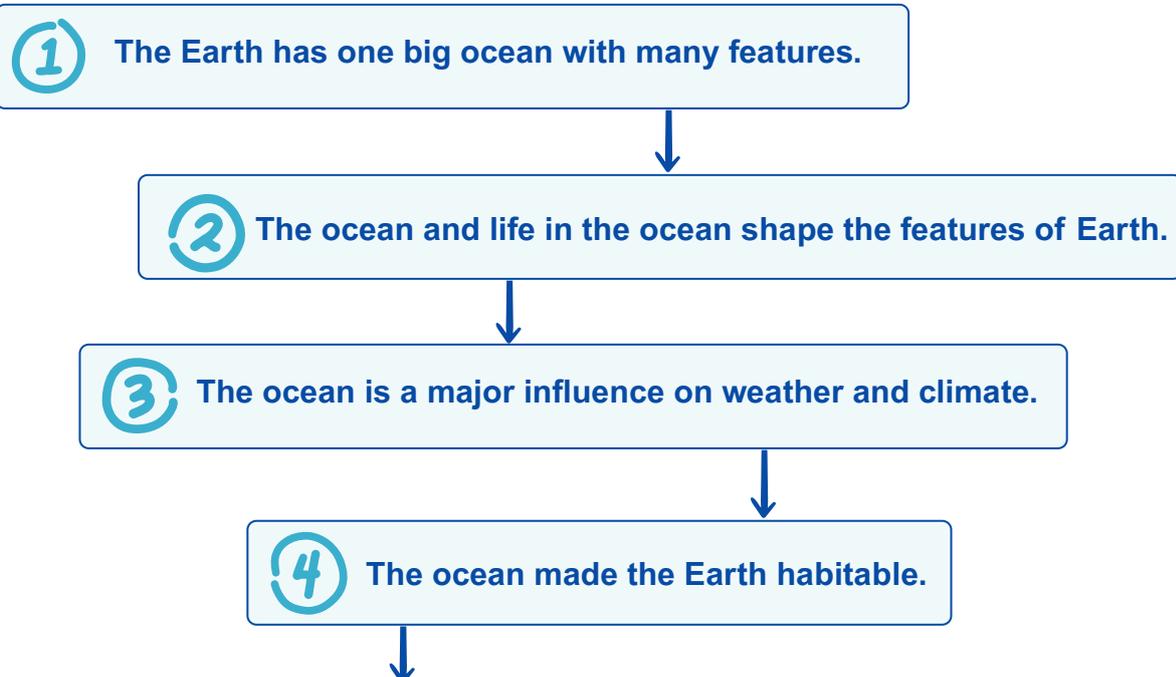
A3. Ocean Literacy Framework

As mentioned previously, the **Ocean Literacy Framework** includes the “**Ocean Literacy Guide**” and the complementary “**Ocean Literacy Scope and Sequence for Grades K-12**”.

The “**Ocean Literacy Guide**” describes the definition of Ocean Literacy (“the understanding of the ocean’s impact on us and our impact on the ocean”), the definition of an **ocean literate person** (“a person who understands the basic principles and fundamental concepts about the ocean, can communicate about the ocean in a meaningful way, and is able to make informed and responsible decisions about the ocean and its resources”) and the **7 Essential Principles** and **45 Fundamental Concepts of Ocean Literacy** that all students in the U.S. should understand by the end of high school.

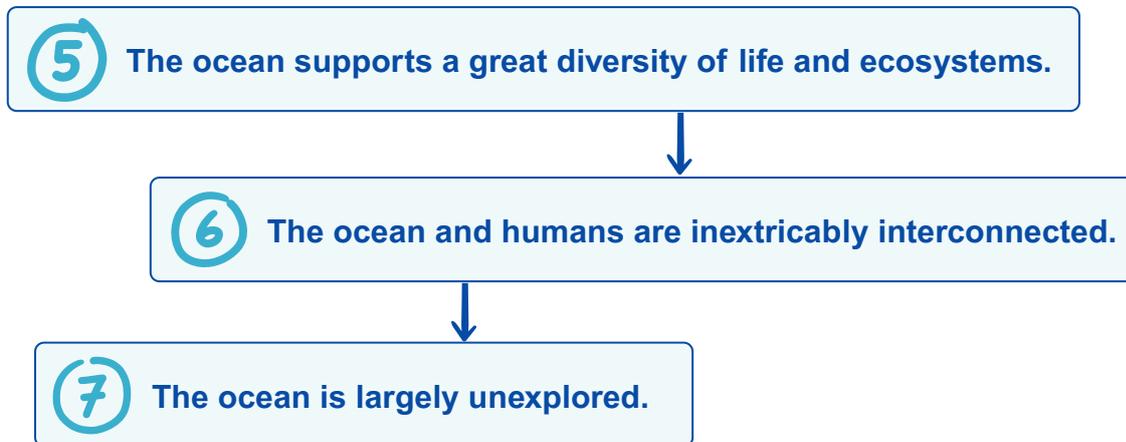
The **45 Fundamental Concepts of Ocean Literacy** specialize the **7 Essential Principles**. The 7 Essential Principles of Ocean Literacy are presented below, while the 45 Fundamental Concepts of Ocean Literacy can be obtained from the website <https://oceanliteracy.wp2.coexploration.org/ocean-literacy-framework/>.

The 7 Essential Principles of Ocean Literacy are:





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The complementary “**Ocean Literacy Scope and Sequence for Grades K-12**” shows, graphically,

- the **science concepts** underlying the Principles and how they are connected;
- **developmental appropriateness** - what students need to know to help them understand the higher-level concepts; and
- how **instruction** of the concepts might “flow”.

In particular, the Ocean Literacy Scope and Sequence is comprised of **28 conceptual flow diagrams**. There is one conceptual flow diagram for each principle for each grade band (**K-2, 3-5, 6-8, and 9-12**).

Each **flow** represents one possible way of breaking down and organizing the major concepts and supporting ideas for each principle for a grade band. They can be used as a suggested instructional sequence, organizer of ideas, and/or indicator of learning progression.

The “**Ocean Literacy Scope and Sequence for Grades K-12**” can be obtained from the website <https://oceanliteracy.wp2.coexploration.org/ocean-literacy-framework/>.

In the second section of the present handbook, the **conceptual flow diagrams for the grade band K-2** are presented, accompanied by synoptic texts providing the necessarily content knowledge.





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B | TEACHBLUE CURRICULUM





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B1. Aim and objectives

The TeachBlue project aims to enhance **Ocean Literacy in Early Childhood Education and Care (ECEC)** by providing a structured **curriculum** and innovative **teaching tools**. It seeks to equip teachers with **pedagogical strategies and resources** to foster young learners' understanding of the ocean's role in sustaining life and human well-being.

Objectives:

01

Develop a structured curriculum aligned with the Ocean Literacy Framework and its seven Essential Principles.

02

Provide effective pedagogical approaches, including digital tools, experiential learning, and inquiry-based methods.

03

Support teacher training with the **TeachBlue Toolkit** (Handbook, Activities Guide, Board Game, and 360° videos).

04

Promote cross-curricular learning by integrating ocean topics into various subjects.

05

Ensure accessibility and adaptability, making resources available in digital and physical formats for EU sea regions.

06

Encourage student engagement through interactive activities and structured learning sequences.

07

Contribute to global Ocean Literacy goals, aligning with SDG 14 and the UN Decade of Ocean Science.



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B2. Pedagogical Approaches

In the ocean literacy literature, the six following **pedagogical approaches** are applied in teaching interventions in early childhood and primary education, in the following order of decreasing appearance: digital learning activities, excursions, classroom/laboratory inquiry-learning activities, marine science projects, teacher-led learning and lectures by experts.

Specifically, the **digital learning activities** have the potential to support learning about the ocean as, virtually, they can take learners into the depths of the ocean and help them visualize complex interactions between different factors over time and space, allowing engagement with and manipulation of the abstract features of the ocean. These activities provide a field of action where children can experiment, make mistakes, get feedback and try again.

Excursions to the aquariums and **field trips** allow the observation and identification of living marine organisms and their environments, and the development of notions on their ecological importance. Overall, these activities arouse a sentiment of protection toward the animals living in the ocean in the students, and such feelings may promote changes in long-term attitudes toward the conservation of the sea.

The **classroom / laboratory inquiry-learning activities** are important to develop scientific and research skills, since they help learners to actively construct new understanding, to adopt the prospect of inquiry as a way of learning by making assumptions, and testing them, encouraging collaboration, discussion, and reflection in the group, thus facilitating deep understanding.

Marine science projects, which encompass classroom-based inquiry into coastal ecosystems, field work involving observations, measurements, and sample collection, as well as rough organism identification in a biology laboratory setting, followed by thorough discussions on marine environment-human interconnections, can significantly enhance students' knowledge of coastal ecosystems, their value, and conservation. However, these projects are the most demanding in terms of time, organization and teachers involved and, therefore, are not so often applied.

Lectures by experts promote the interaction of students with scientists and motivate their learning. **Teacher-led learning** in ocean literacy, although it is not a widely-proposed approach is still served in classes.





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B3. Competencies and Assessment

Competencies in ocean literacy for early childhood education focus on fostering a foundational understanding of the ocean and its ecosystems in young learners. The following key competencies are suitable for this age group:

01 Awareness of the Ocean

Helping children recognize that the **ocean exists and there is only one**, understand its significance, and identify its basic features (e.g., waves, beach, marine life).

02 Exploration and Discovery

Encouraging curiosity about the ocean through **hands-on activities**, such as experiments, beach walks, water play, and observations of marine animals (like fish, crabs, and sea turtles).

03 Connection to Nature

Fostering a sense of **wonder and appreciation for nature**, teaching children to observe and respect the ocean, as well as other marine ecosystems, and its inhabitants.

04 Basic Ecosystem Understanding

Introducing simple concepts about marine life and ecosystems, such as **food chains and the roles of different organisms** (e.g., plants, fish, and mammals).

05 Human Impact Awareness

Teaching young children about how **human actions can affect the ocean**, such as pollution and littering, in an age-appropriate manner.

06 Cultural Significance

Sharing **stories and traditions** related to the ocean from various cultures, emphasizing the **ocean's role** in different **communities**.





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07 Creative Expression

Encouraging children to **express** their understanding of the ocean through **art, music, and storytelling**, helping them to connect emotionally with the topic.

08 Environmental Stewardship

Instilling **values of caring** for the environment, promoting actions like **recycling** and **respecting nature**, even at a young age.

These competencies can be integrated into **play-based learning**, allowing children to engage with ocean-related themes through exploration, creativity, and inquiry.

Assessing ocean literacy in early childhood education can be approached through the following tools and methods that are engaging and appropriate for young learners:

01 Observation Checklists

Educators can use **checklists** to observe children's interactions with ocean-related activities, noting their curiosity, engagement, and understanding of concepts related to the ocean.

02 Portfolios

Collecting **children's work** overtime, such as **drawings, crafts, and written reflections** about the ocean, can provide insights into their learning and development in ocean literacy.

03 Storytelling and Role Play

Encouraging children to **tell stories** or engage in **role play** related to ocean themes allows educators to assess their understanding and ability to express ocean concepts creatively.





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04 Interactive Games

Utilizing **games** that incorporate ocean themes, such as matching marine animals to their habitats or sorting waste to understand recycling, can be both fun and informative for assessing knowledge.

05 Art Projects

Assessing children's **art projects** inspired by ocean themes can reveal their understanding of marine life and ecosystems, as well as their creativity and expression.

06 Group Discussions

Facilitating **group discussions** or circle time where children share what they know about the ocean can help educators gauge their understanding and ability to articulate their thoughts.

07 Questionnaires or Surveys

Simple, **illustrated questionnaires** can be designed for young children to express what they've learned about the ocean, using pictures or symbols to represent their ideas.

These **tools** can be adapted to fit the specific context and age group, ensuring that assessments are meaningful and supportive of children's ongoing development in ocean literacy.





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B4. Thematic modules

B4.1. Principle 1

1. Conceptual flow diagram

Ocean Literacy **Principle 1** and the **conceptual flow diagram** for Grades K–2 for this principle are given below.

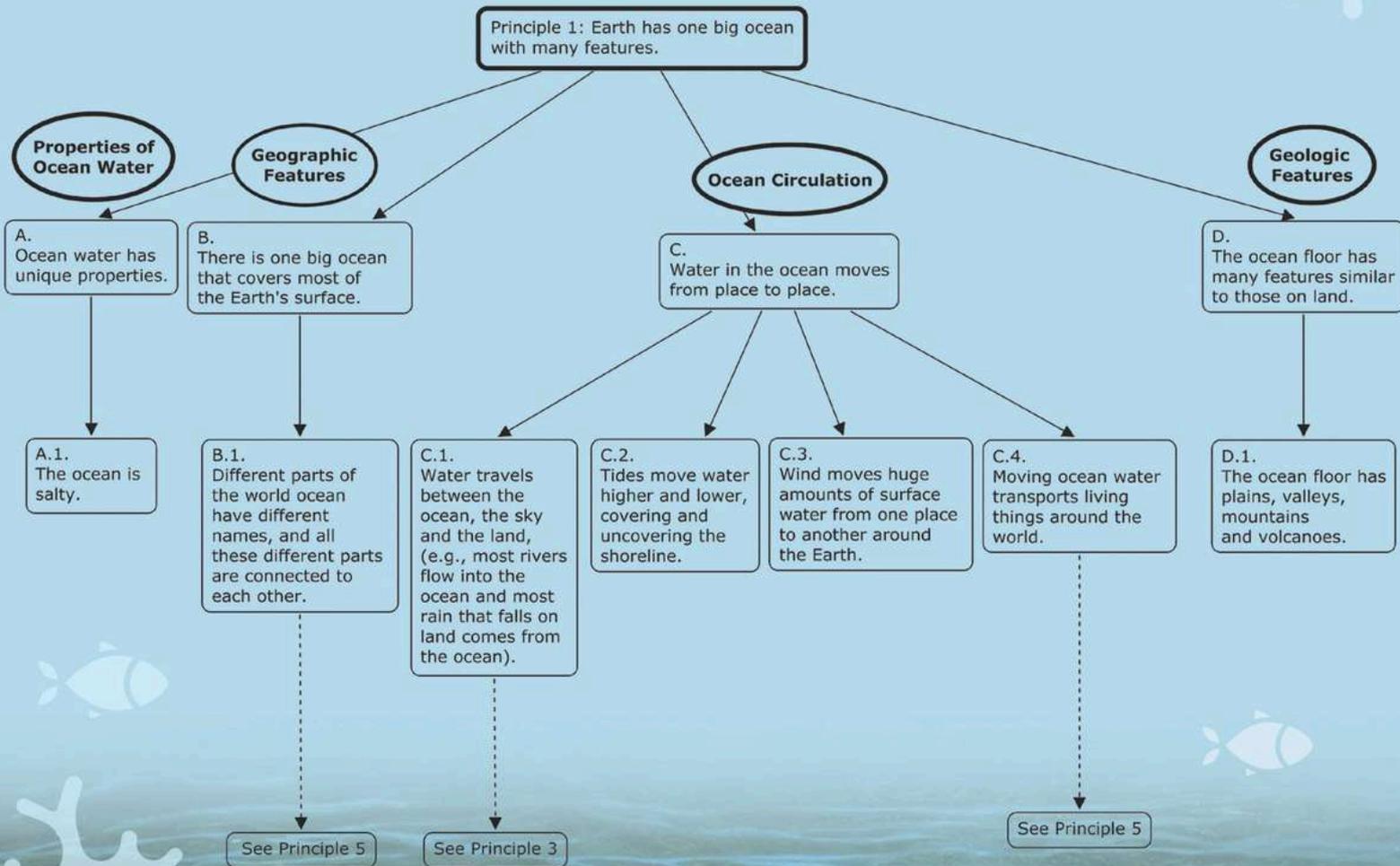
Ocean Literacy Principle 1:

The Earth has one big ocean with many features



PRINCIPLE 1

GRADES K-2





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2. Content Knowledge

2.1. Properties of ocean water

An estimated 97 percent of the world's water is found in the ocean. **Seawater** has unique properties. Seawater is pure water in which a variety of solids and gases are dissolved. A 1000 g sample of seawater will contain about 35 g of dissolved compounds, collectively called salts. The total amount of dissolved material is termed the **salinity**. If a typical seawater sample has 35 g of dissolved compounds in 1000 g, it has a salinity of 35.

Dissolved substances include inorganic salts, organic compounds derived from living organisms, and dissolved gases. The greatest fraction of the dissolved material is composed of inorganic salts present as ions. The **six most abundant ions** of seawater are **chloride** (Cl^-), **sodium** (Na^+), **sulfate** (SO_4^{2-}), **magnesium** (Mg^{2+}), **calcium** (Ca^{2+}) and **potassium** (K^+). The salt in seawater comes from eroding land, volcanic emissions, reactions at the seafloor, and atmospheric deposition.

The salinity of various parts of the open ocean away from coastal areas varies within a narrow range, usually from 34 to 37. The differences in salinity are due to differences in **evaporation** and **precipitation**. In inshore areas and partially enclosed seas, the salinity is more variable and may be near 0 where large rivers discharge freshwater, to near 40 in the Red Sea and Persian Gulf.

2.2. Ocean Geography

The ocean is a huge body of saltwater that covers about 71 percent of Earth's surface. **Ocean basins** are the large areas of the Earth's surface that are filled with saltwater and separated from the continents. They are interconnected to form the "**world ocean**". The world ocean is divided into the **North and South Pacific, North and South Atlantic, Indian, and Arctic Oceans**.

Marine scientists also recognize the **Southern Ocean**, which encircles Antarctica and includes the southernmost parts of the Pacific, Atlantic, and Indian Oceans. Projecting from, or partially cut off from, these larger oceans are smaller marginal seas as the Mediterranean, Caribbean, Baltic, Bering, South China, and Okhotsk. The locations of the major oceans and seas are given in Fig. 1.





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Figure 1. Major oceans and seas (modified from J.W. Nybakken, *Marine Biology: An Ecological approach*, 5th Ed., Benjamin Cummings).

2.3. Ocean circulation

The Water Cycle

Water moves from its main reservoir—the ocean—into the air, falls as rain and snow, and flows back to the ocean (Fig. 2).

Solar energy drives **evaporation** of water from the **ocean** and from **freshwater reservoirs**. Water that enters the **lower atmosphere** spends some time aloft as vapor, clouds, and ice crystals. By the process of **precipitation**, water falls from the atmosphere mainly as rain and snow. Precipitation that falls on land mostly seeps into soil or joins surface runoff toward streams. Some soil water is taken up by plants, which then release most of it by **transpiration-evaporation** from their leaves (Fig. 2).





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Figure 2. The water cycle.

Tides

The periodic rise and fall of the **level of the sea** over a given time interval is called **tide**. **High tide** is when water advances to its furthest extent onto the shoreline. **Low tide** is when it recedes to its furthest extent.

Most shore areas of the world experience tides. The Mediterranean Sea and the Baltic Sea are the only major seas that virtually lack tidal action.

Tides occur due to the interaction between the **gravitational attraction** of the sun and the moon on the earth and the **centrifugal force** generated by the rotating earth and moon system (see Fig. 3). **Gravitational force** is much stronger than centrifugal force on the side of the earth facing the moon than on the side opposite. As a result, the side facing the moon has the water pulled into a bulge (high tide).

On the opposite side of the earth, the **gravitational force of the moon** will be the least, and the stronger centrifugal force will pull water into a bulge away from earth (another high tide). Thus, we have the **two high tides**. These then circle the earth following the **position of the moon** as the earth revolves on its axis once every twenty-four hours. Low tides are about halfway between the high tides.

The **above system** would give two high tides and two low tides of equal magnitude each day. However, all **seashores** do not experience the same type of tide, or the same tidal range, due to the **interaction of the tide-generating forces**, the sun and moon, the rotation of the earth, the geomorphology of the ocean basins, and the natural oscillations of the various ocean basins.





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The **effect of the sun** is seen in spring and neap tides. **Spring tides** are tides that show the greatest range (both high and low) and result when the moon and sun are directly aligned so these forces are combined. Such tides occur all year round, about once every two weeks. Specifically, this happens during the new moon and the full moon. **Neap tides** are tides showing minimum range and result when sun and moon are at right angles to each other and thus counteract each other. Neap tides occur when the moon is in its first and third quarters.

Most shorelines, such as the east coast of North America and most of Europe and Africa, experience two high and two low tides within a twenty-four-hour period (**semidiurnal tides**). Some areas have a single low and high per day (**diurnal tides**). This occurs in the Gulf of Mexico, along the coast of Antarctica and in some parts of the Pacific Ocean. Also, some other areas have **mixed tides**, i.e. with two complete tides but of different heights. Mixed tides are characteristic of most of the west coast of the US and Canada.

A coastline's physical features, such as a **wide sandy beach** or a **rocky cove**, along with the depth of the water just offshore, **affect** the height of the tides.

Tide is the **most important environmental factor** influencing life in the **intertidal zone**, i.e. the area between high and low tide.

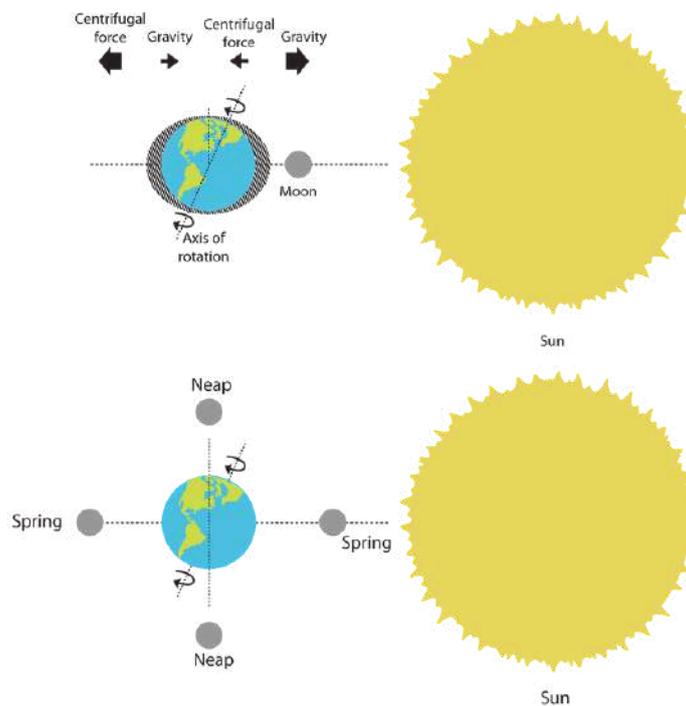


Figure 3. Origin of tides (modified from J.W. Nybakken, *Marine Biology: An Ecological approach*, 5th Ed., Benjamin Cummings).





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Wind-driven Ocean currents

The upper water mass of the oceans is in constant motion. The motion is produced primarily by the action of winds blowing across the surface of the water. These winds produce **waves** and **currents**.

Currents are water movements which result in the horizontal transport of water masses. The major ocean current systems are produced by a few major **wind belts** which succeed each other latitudinally around the world.

The main wind belts of the earth and their prevailing direction of motion are shown in Fig. 4. The ocean currents do not flow parallel to wind direction. They are deflected into roughly circular **gyres** which move clockwise in the Northern Hemisphere and anticlockwise in the Southern Hemisphere.

The deflections and gyres are the result of the **Coriolis force**.

The Coriolis force, in turn, is the result of the rotation of the earth on its axis.

The **shape** of ocean basins and adjacent land masses influence the path of circulation.

There are **five major gyres**: the **North Atlantic**, the **South Atlantic**, the **North Pacific**, the **South Pacific** and the **Indian Ocean Gyre**. The **Antarctic Circumpolar Current** is situated in the Southern Ocean and constantly circles around Antarctica.

It is an eastward-flowing current driven by the dominant western winds at this latitude. The **major currents** of the world's oceans are shown in Fig. 5.

The horizontally moving currents transport huge volume of water across vast distances in the oceans, thus transporting heat and matter, and influencing the distribution of marine organisms.

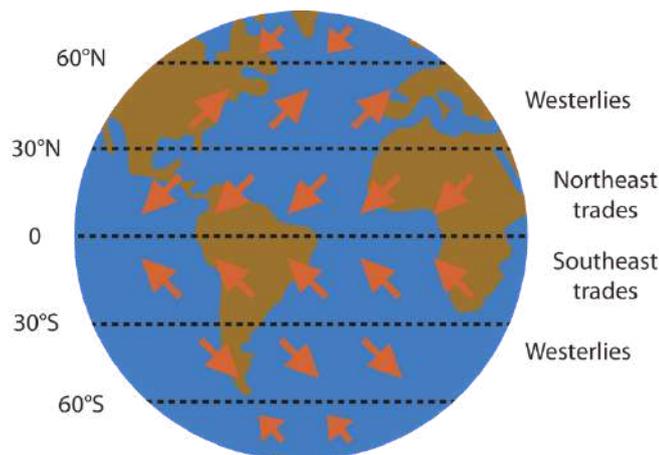


Figure 4. The main wind belts of the earth and their prevailing direction of motion (modified from J.W. Nybakken, *Marine Biology: An Ecological approach*, 5th Ed., Benjamin Cummings).





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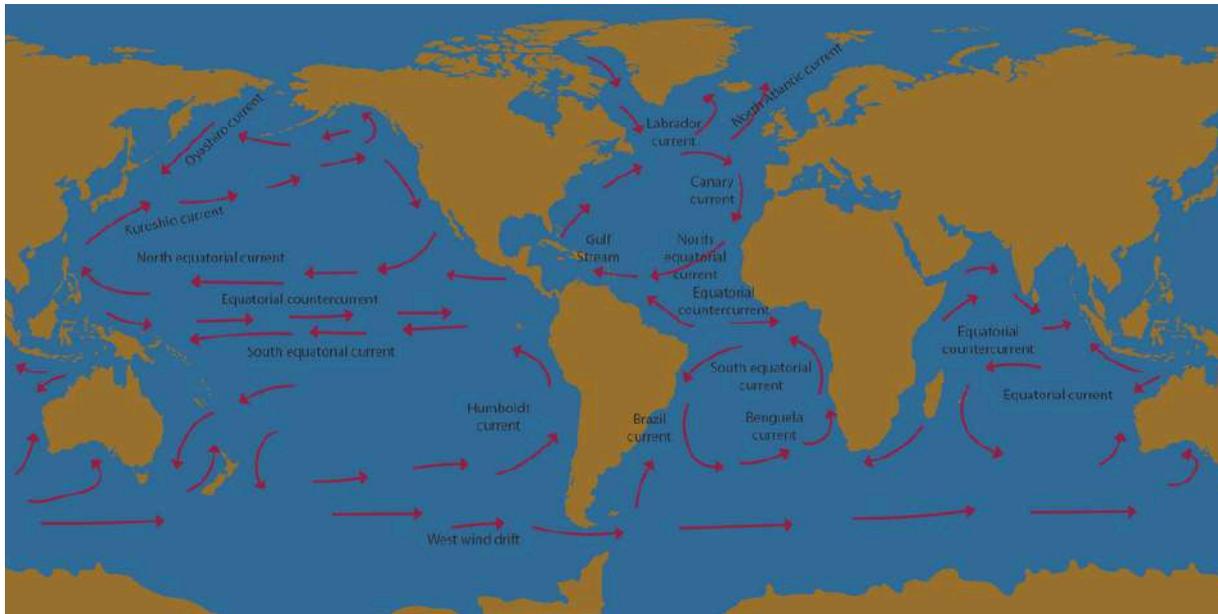


Figure 5. The major ocean surface current systems (modified from J.W. Nybakken, *Marine Biology: An Ecological approach*, 5th Ed., Benjamin Cummings).

2.4. Geomorphology of the Ocean

Ocean basins are composed of the **seafloor** and all of its **geological features** and vary in size, shape and features due to the movement of Earth's crust.

On the margins of the major land masses, the ocean is very shallow, overlying an underwater extension of the continent called the **continental shelf** (Fig. 6). Forming only 7-8 percent of the total ocean area, the continental shelf slopes gently from shore to a depth of 200 m.

At the outer edge of the shelf, there is an abrupt steepening of the bottom to become the **continental slope**. The continental slope descends precipitously to depths of 3 to 5 km. At these depths, the bottom becomes the flat, sediment-covered **abyssal plain**. Abyssal plains cover the floors of vast areas of the oceans at depths between 3 and 5 km.

Abyssal plains are broken in several places by various **submarine ridges**. The ridges are extensive, contiguous submarine mountain chains. Occasionally, the ridges break the surface to form islands.





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In certain areas, the abyssal plains are cut by deep, narrow troughs called **trenches**. Most of trenches lie in an arc bordering the islands and continents in the Pacific Ocean. The trenches have depths from 7,000 to more than 11,000 m. The deepest area known is the 11,022 m Challenger Deep in the Marianas Trench.

In addition, there may be isolated **islands** and submarine **sea mounts** (Fig. 6) formed by isolated volcanic action. Such mountains, as opposed to the ridges, rise individually from the abyssal plain.

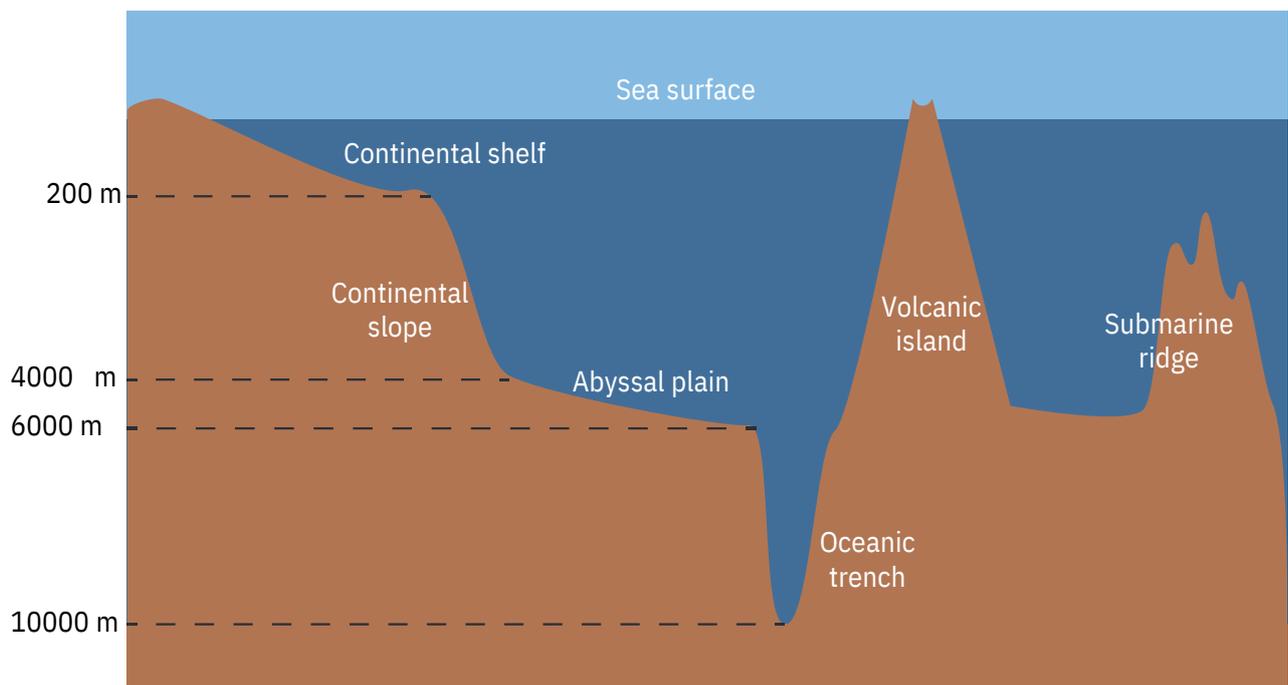


Figure 6. Diagrammatic cross section of an ocean basin showing the various geographic features (not to scale, modified from J.W. Nybakken, *Marine Biology: An Ecological approach*, 5th Ed., Benjamin Cummings).





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B4. Thematic modules

B4.2. Principle 2

1. Conceptual flow diagram

Ocean Literacy **Principle 2** and the **conceptual flow diagram** for Grades K–2 for this principle are given below.

Ocean Literacy Principle 2:

The ocean and life in the ocean shape the features of Earth



Conceptual flow diagram for Grades K–2 for Principle 2:

PRINCIPLE 2 GRADES K-2

Principle 2: The ocean and life in the ocean shape the features of the Earth.

Erosion and Changing Coastlines

A. Moving water can cause coastal build up and erosion, carrying Earth materials from one place to another and shaping the shoreline.

A.1. Shorelines are built up by Earth materials brought to the shore by rivers and waves.

A.2. Some Earth materials from the ocean, such as sand, shells, corals and rocks, are carried to the shore by waves.

A.3. Some Earth materials from the land, such as rocks, sand and soils, are carried to the shore by rivers.

A.4. Erosion is the wearing away of rocks, soil, shells and other Earth materials and features.

A.5. Waves can break down and wear away cliffs, beaches and materials brought to the shore, changing the shape of the shoreline.

A.6. Rocks, shells, corals, plants and other materials can be broken down into sand.

See Principle 1

See Principle 5

2. Content Knowledge

2.1. Coastal landforms

The **coastal environment** is made up of a wide variety of **landforms** manifested in a spectrum of sizes and shapes ranging from gently sloping beaches to high cliffs. However, coastal landforms are best considered in two broad categories: **erosional** and **depositional**.

Erosional coasts (Fig. 7) are created in conditions of high wave energy, which is combined with a lack of sediments available for deposition. Often, erosional shores are small in extent and occur on resistant rocky shores exposed to high-energy waves, while erosional materials are quantitatively few.

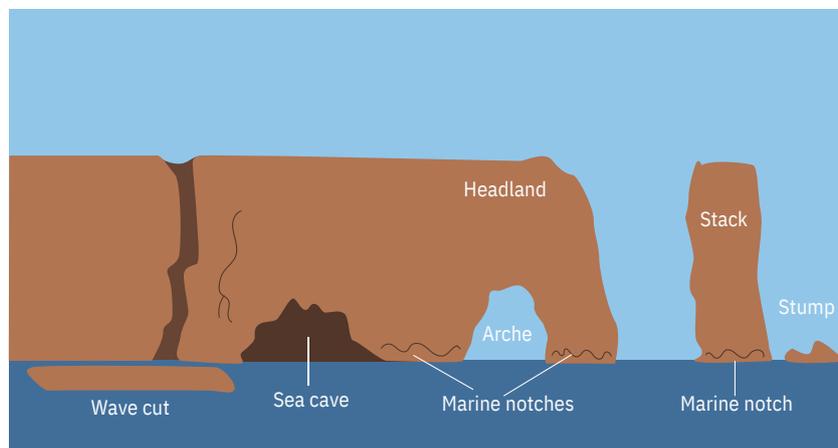


Figure 7. Characteristic coastal erosional landforms (modified from S. E. Poulos, Introduction to Oceanography or Oceanology, Disigma publications).

Depositional coasts (Fig. 8) are characterized by a large deposition of sediments of terrestrial origin. They come either from the deposition of sediments of fluvial origin, or from the deposition of materials from the erosion of local and/or adjacent coastal formations which are ultimately deposited under the influence of waves, coastal currents and tidal currents, but also the influence of wind.

In the first coastal landforms' category the **retreat** of the coastline prevails, while in the second category its **advance**.



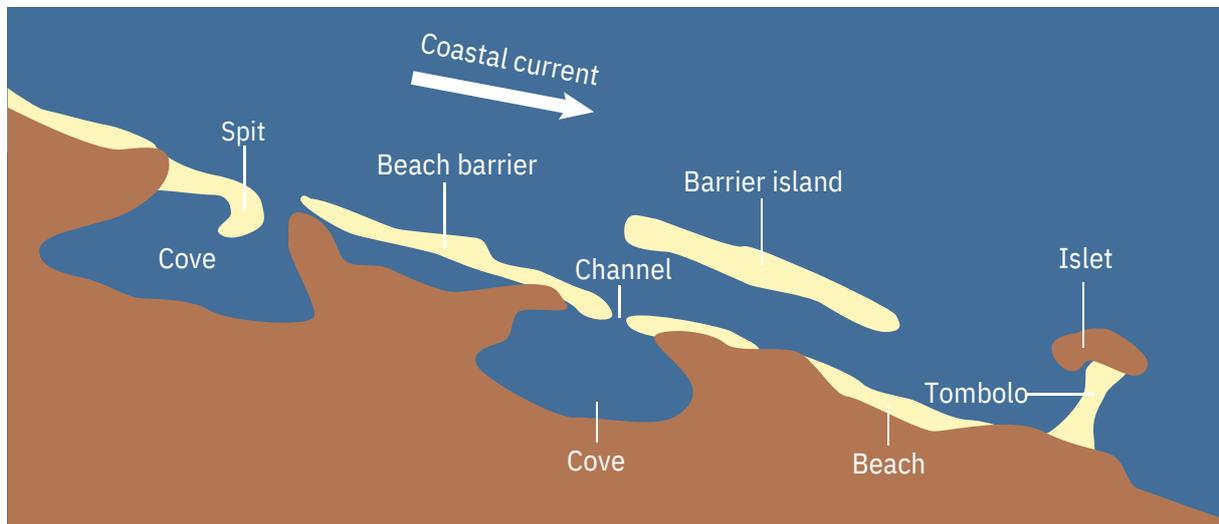


Figure 8. Characteristic coastal depositional landforms (modified from S. E. Poulos, Introduction to Oceanography or Oceanology, Disigma publications).

2.2. Marine sediments

Much of the ocean floor is covered by layers of **sediment**. **Sediment particles** come from the weathering of terrestrial rocks, from hard parts of organisms such as shells and skeletal fragments, from volcanic eruptions, from marine chemical processes, and from space.

The sediments show a wide variety of texture and composition. Depending on the size of their particles, the sediments are distinguished in order of size into **boulders** (256-1,024 mm), **cobbles** (64-256 mm), **pebbles** (4-64 mm), **granules** (2-4 mm), **sand** (0.062-2 mm), **silt** (0.004-0.062 mm) and **clay** (<0.004 mm).





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B4. Thematic modules

B4.3. Principle 3

1. Conceptual flow diagram

Ocean Literacy **Principle 3** and the **conceptual flow diagram** for Grades K–2 for this principle are given below.

Ocean Literacy Principle 3:

The ocean is a major influence on weather and climate



PRINCIPLE 3

GRADES K-2

Principle 3:
The ocean is a major influence on weather and climate.

Weather and
Water Cycle

A.
Local weather, including precipitation, fog and wind, can be caused by the ocean—no matter where you live.

A.1.
Most precipitation on Earth comes from water that evaporated from the ocean.

A.2.
When water evaporates and condenses, clouds form, which can lead to precipitation.

A.3.
Most of the water in lakes, ponds, rivers and the ground comes from water that evaporated from the ocean and fell to the land as precipitation.

A.4.
Most of the water from land and in the atmosphere eventually returns to the ocean as runoff from rivers, or precipitation.

See Principle 1: C1
See Principle 6: A6

See Principle 6: A3



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2. Content Knowledge

2.1. The water cycle

Water moves from its main reservoir-the ocean-into the air, falls as rain and snow, and flows back to the ocean (see Fig. 2).

Solar energy drives **evaporation** of water from the **ocean** and from **freshwater reservoirs**. Water that enters the **lower atmosphere** spends some time aloft as vapor, clouds, and ice crystals. By the process of **precipitation**, water falls from the atmosphere mainly as rain and snow.

Precipitation that falls on land mostly seeps into soil or joins surface runoff toward streams. Some soil water is taken up by plants, which then release most of it by **transpiration-evaporation** from their leaves (see Fig. 2).





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B4. Thematic modules

B4.4. Principle 4.

1. Conceptual flow diagram

Ocean Literacy **Principle 4** and the respective **conceptual flow diagram** for **Grades K–2** are presented below.

Ocean Literacy Principle 4:

The ocean made Earth habitable



PRINCIPLE 4

GRADES K-2

Principle 4: The ocean makes Earth habitable.

A.
Life as we know it does not exist without water.

B.
Almost all the water on Earth is in the ocean.

See Principle 3: A1

See Principle 1: B



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2. Content Knowledge

2.1. Life does not exist without water, almost all the water on Earth is in the Ocean

The **Earth's surface** is dominated by a vast ocean. The **ocean** covers more than 70% of the Earth's surface and contains 97% of the world's water. Most of the **oxygen** in the atmosphere originally came from the activities of **photosynthetic organisms** in the ocean. This accumulation of oxygen in Earth's atmosphere was necessary for life to develop and be sustained on land.

The ocean is the **cradle of life**; the earliest evidence of life is found in the ocean. The millions of different species of organisms on Earth today are related by descent from common ancestors that evolved in the ocean and continue to evolve today.

The **ocean** provided and continues to provide **water, oxygen** and **nutrients**, and **moderates the climate** needed for life to exist on Earth.





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B4. Thematic modules

B4.5. Principle 5

1. Conceptual flow diagram

Ocean Literacy **Principle 5** and the **conceptual flow diagram** for **Grades K–2** for this principle are given below.

Ocean Literacy Principle 5:

The ocean supports a great diversity of life and ecosystems





PRINCIPLE 5

GRADES K-2

Principle 5:
The ocean supports a great diversity of life and ecosystems.

Diversity of Life

A.
There is a great diversity of organisms in the ocean.

A.1.
More different kinds of organisms are found in the ocean than on land.

A.4.
Ocean organisms have a variety of different structures and behaviors that help them to survive in the ocean.

A.2.
Many groups of organisms exist only in the ocean.

A.3.
Ocean life ranges in size from the tiniest organisms to the largest animal on Earth.

Diversity of Ecosystem

B.
The ocean holds a great diversity of unique environments and habitats where organisms live.

B.1
There are distinct and unique ocean habitats throughout the ocean and on the coast, off shore, in the deep ocean and at the surface.

B.2.
Organisms living in different kinds of places in the ocean have different adaptations in structure and behavior, which help them to survive in their habitat, e.g., to find and capture prey.



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2. Content Knowledge

2.1. Diversity of life

In the **ocean** there is a **wide variety of organisms**. More than 250,000 marine species are known, a number that is constantly increasing due to the identification of new species. Marine organisms range in size from tiny bacteria to the blue whale, the largest animal to have ever lived on earth. Marine organisms are categorized according to their **way of life**.

Plankton includes organisms that live in the water column and have very limited abilities to move actively, so they are carried by currents. Plankton is subdivided into **phytoplankton**, which includes organisms that move passively in water and photosynthesize, and **zooplankton**, which includes a variety of animal organisms that also move passively.

Phytoplankton collected with conventional plankton nets consists of **diatoms** which are microscopic organisms enclosed in a two-part siliceous capsule and **dinoflagellates** which are microscopic organisms possessing two locomotory flagellae. Among the zooplankton organisms collected with plankton nets the most important are **copepods** which are small crustaceans.

Plankton also includes **bacterioplankton**, which includes autotrophic and heterotrophic bacteria and is very abundant. A schematic representation of some planktonic organisms is given in Fig. 9.

Nekton includes **animals** that live in the water column and have developed powers of locomotion so that they are not at the mercy of the ocean currents or wind-induced water motion.

The nekton consists of a wide variety of **bony fishes, sharks and rays**, and, to a lesser extent, **marine mammals** such as seals, sea lions, walruses, sea otters, sea cows, whales, dolphins and porpoises, **reptiles** such as sea turtles, and **birds** such as the penguins. Invertebrates that can be considered to belong to the nekton are the various **cephalopod mollusks**, such as squids.

A schematic representation of some nektonic organisms is given in Fig. 9.

Benthic organisms live on or are somehow related to the bottom of the sea. Some benthic organisms live attached to a site, while others can move around the bottom. More than 98% of the 250,000 known marine species are benthic organisms. Important categories of benthic organisms are benthic microorganisms, macroalgae, seagrasses and benthic invertebrates.

Benthic microorganisms include bacteria that are abundant in marine sediments, cyanobacteria that are microscopic photosynthetic prokaryotic organisms, benthic diatoms that are photosynthetic organisms, and fungi.





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Macroalgae are photosynthetic organisms that do not have shoots, leaves, roots, do not form seeds, fruits or flowers and are visible to the naked eye, while they can also have large size. The main categories of macroalgae are the **rhodophytes** (red algae), **phaeophytes** (brown algae) and **chlorophytes** (green algae). **Seagrasses** are flowering plants that live completely submerged and develop a root system. Seagrasses form extensive underwater meadows in coastal areas.

Benthic invertebrates are animal organisms that live either on the surface of the bottom (**epifauna**), such as on the surface of marine sediment or on a rocky bottom, or within the sediment (**infauna**). Benthic invertebrates are divided into categories according to their size. **Macrofauna** includes invertebrates larger than 0.5 mm in size, while **meiofauna** consists of organisms between 0.5 mm and 0.062 mm in size. Benthic invertebrates include organisms such as sponges, cnidaria (e.g. sea anemones), polychaete worms, mollusks, such as gastropods (e.g. limpets, abalone, mud snails), bivalves (e.g. mussels, oysters, clams) and cephalopods (e.g. octopuses), echinoderms, such as starfish and sea urchins, and crustaceans, such as crabs. Benthic organisms also include **fish** whose habits are more related to the bottom, such as plaices. A schematic representation of some benthic organisms is given in Fig. 9.

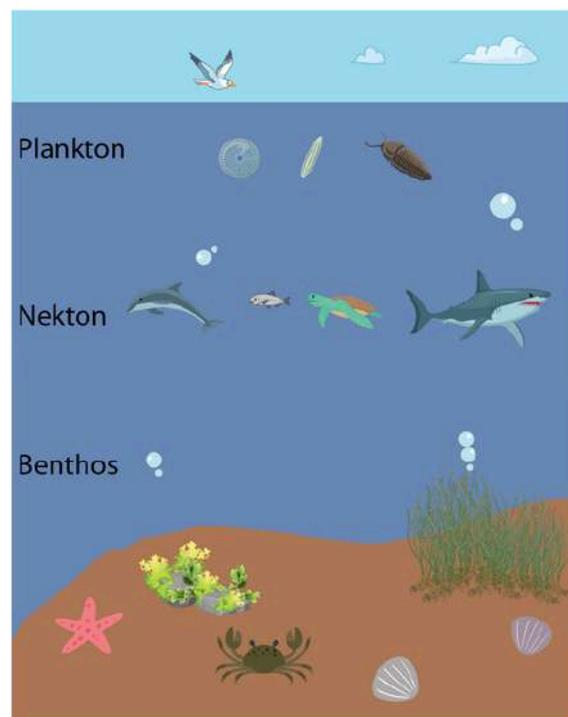


Figure 9. A schematic representation of some marine organisms categorized according to their way of life (plankton, nekton, benthic organisms) (not to scale).



2.2. Diversity of ecosystems

Ocean habitats

The **ocean** supports a great diversity of **ecosystems**. **Ocean habitats** are the result of a complex interplay between distance from shore, depth and climate zones. Ocean habitats can be divided to **pelagic and benthic** (or seafloor) **habitats**.

Pelagic habitats exist within the water column (Fig. 10). The area of the open water is termed the **pelagic realm**. The pelagic realm can be divided horizontally to the **neritic zone**, which includes the water mass that overlies the continental shelf, and **the oceanic zone**, which encompasses all other open waters. The pelagic realm can be divided vertically to three zones.

The **photic** (or **epipelagic**) **zone** is the part of the pelagic realm which is lighted. Its lower boundary generally is between 100-200 m. The **dysphotic** (or **mesopelagic**) **zone** extends from 200 to 1000 m. In this zone, the light penetration is minimal.

The **aphotic zone** is the permanently dark part of the pelagic zone below the dysphotic zone. The aphotic zone can be subdivided to the **bathypelagic zone**, lying generally between 1000 and 4000 m, the **abyssal pelagic zone**, overlying the plains of the major ocean basins (4000-6000 m), and the **hadalpelagic zone**, which is the open water of the deep oceanic trenches (6000-10000 m).

Benthic habitats comprise various ecosystems found at the bottom of the ocean (Fig. 10). The benthic realm refers to organisms and zones of the sea bottom. The benthic realm is divided to four zones. The **sublittoral zone** is the benthic zone underlying the neritic pelagic zone. It is lighted and supports diverse biotic communities, including seagrass meadows, coral reefs and kelp forests.

The **bathyal zone** is the benthic zone which includes the continental slope and down to about 4000 m, the **abyssal zone** is the benthic zone encompasses the abyssal plains of the ocean basins (4000-6000 m) and the **hadal zone** is the benthic zone of the oceanic trenches (6000-10000 m).

In addition, two **transitional zones** exist. The **intertidal** zone or **littoral** zone which is the shore area lying between the extremes of high and low tide and represents the transitional area between the marine and the terrestrial environment, and **estuaries** which represent the transitional area between marine and fresh water.

Examples of ocean habitats are shown in <https://encounteredu.com/cpd/subject-updates/all-about-ocean-habitats>.





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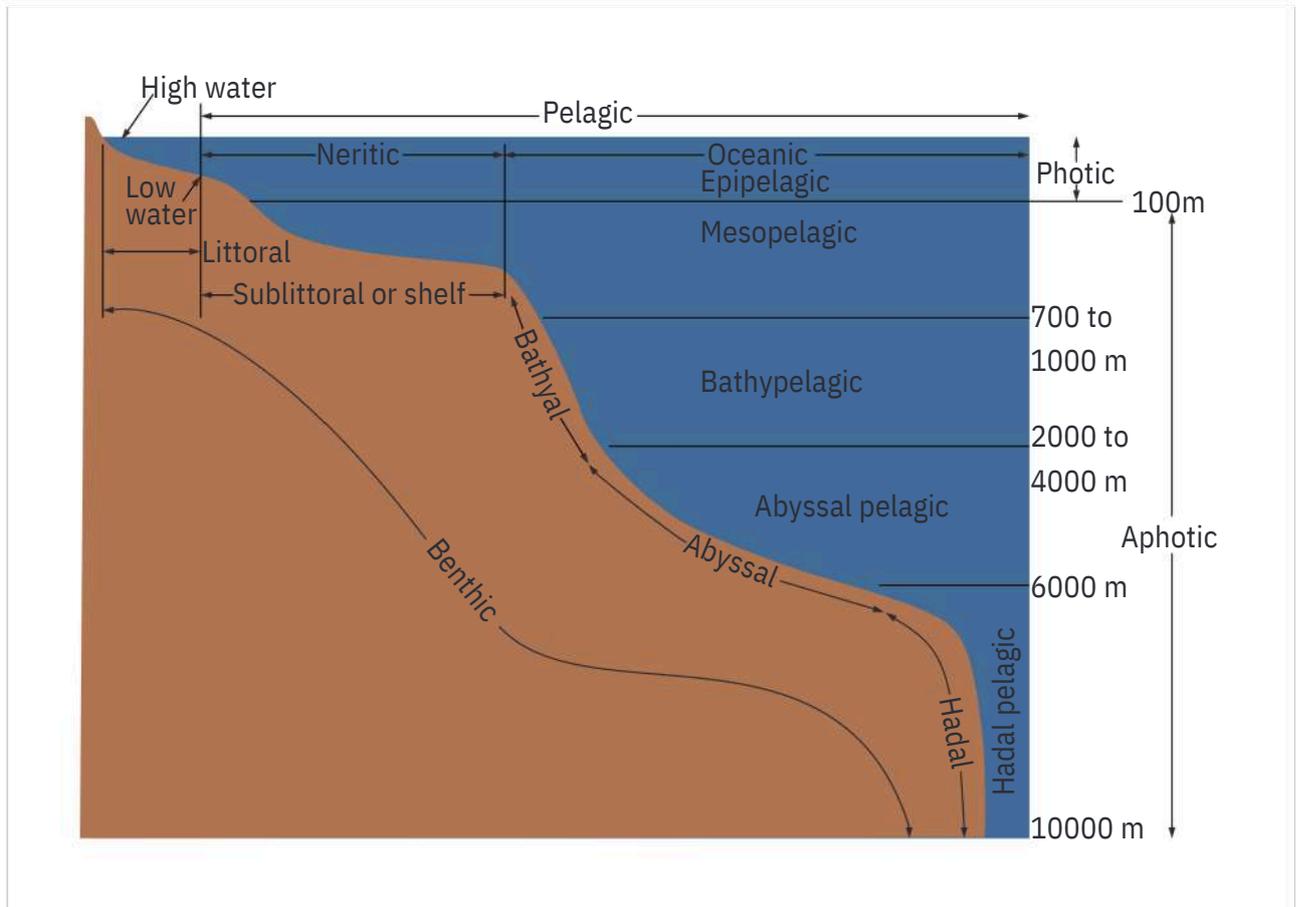


Figure 10. Major subdivisions of the world ocean (not to scale, modified from J.W. Nybakken, *Marine Biology: An Ecological approach*, 5th Ed., Benjamin Cummings).

Coastal habitats

A synoptic mention for some marine habitats, specifically for some coastal habitats that are easily accessible (intertidal habitats, coastal lagoons), is followed.

Intertidal habitats

The intertidal zone is the part of the seashore between the highest and lowest point reached by the water during the tidal cycle. In areas with a small tidal range such as the Mediterranean, this zone corresponds to the **midlittoral zone**. In the intertidal zone, marine organisms are often exposed to the air. The biotic communities of the intertidal zone are distinguished according to the type of bottom in communities of the **rocky substrate** and in communities of the **soft substrate**.



Rocky substrate communities

The **rocky substrate community** is divided into individual zones corresponding to different heights of the **intertidal zone**. A species is not found throughout the intertidal zone, but within a specific vertical range. Thus, on most rocky shores a **vertical zonation** of organisms is evident. Three main divisions of the intertidal zone have been suggested (Stephenson “Universal” scheme, Fig. 11). The upper limit of a zone is determined by abiotic factors, while the lower by biotic factors, mainly by competition, predation and grazing.

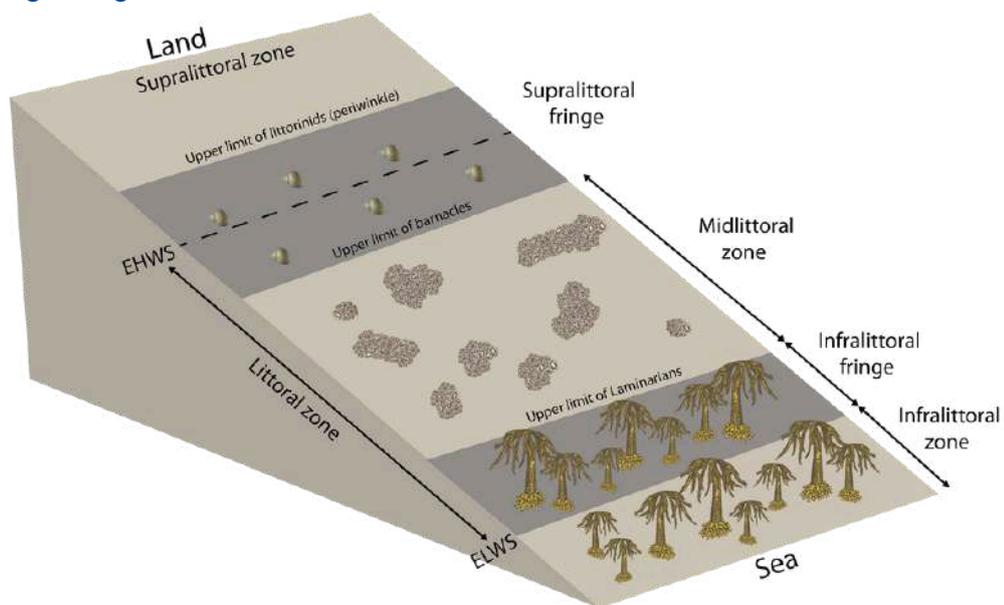


Figure 11. The Stephenson scheme of zonation for rocky shores (not to scale, modified from J.W. Nybakken, *Marine Biology: An Ecological approach*, 5th Ed., Benjamin Cummings).

The uppermost zone is the **supralittoral fringe**. The lower limit of this zone is the upper limit of barnacles, while it extends to the upper limit of snails of the genus *Littorina* (periwinkles). Part of this zone is reached by extreme high water of spring tides, but most of its water comes from wave splash. Thus, organisms in this zone are rarely submerged in water and are adapted to tolerate exposure to air. *Littorina* snails and black encrusting lichens are the dominant organisms of this zone. Above this zone is the **supralittoral zone**.

The **midlittoral zone** is the middle part of the intertidal zone. This zone is exposed to the air and submerged in seawater due to the tide at regular intervals. Its upper limit is coincident with the upper limit of **barnacles**, while its lower limit is the upper limit of large **phaeophytes** (brown algae). The upper part of the midlittoral zone is usually occupied by barnacles.



Their upper limit is determined by how high up the shore they can live without dehydrating, while their lower limit is determined by competition with other barnacles or **mussels**, or by predation by **gastropods** or **starfish**. The midlittoral zone contains a host of various organisms including **limpets** and mussels.

The **sublittoral fringe** is the lowermost zone of the intertidal zone. It extends from the lowest low tide up to the upper limit of the large **phaeophytes**. This zone is the part of the intertidal zone that is most often submerged. This fact facilitates the presence of predators such as **gastropods** and **starfish**, with the result that barnacles and mussels are rare. This zone is rich in organisms that can tolerate only limited exposure to air. In fact, this zone is an extension of the sublittoral zone.

A schematic representation of a typical pattern of rocky shore zonation is given in Fig. 12. The pattern may vary from area to area.

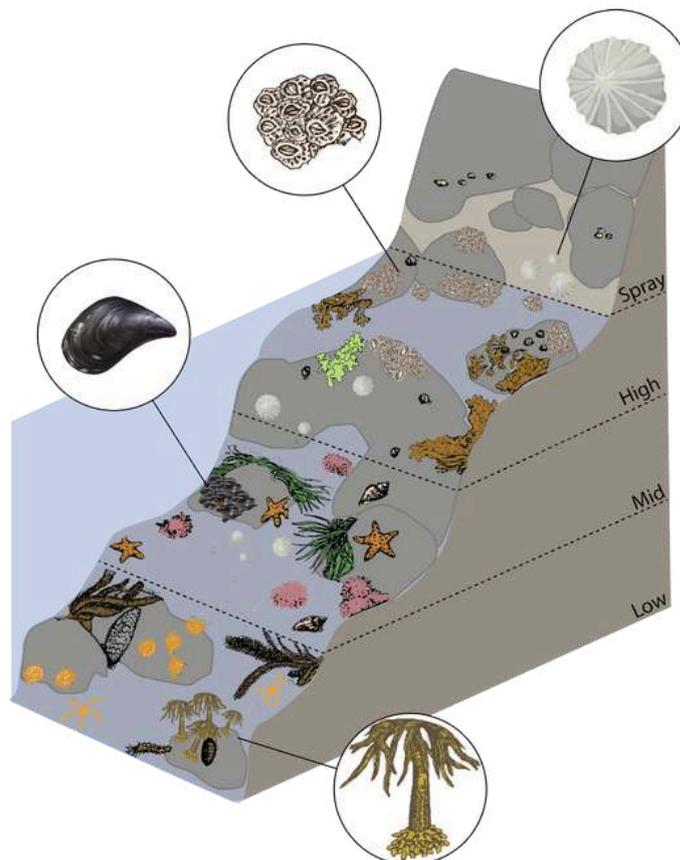


Figure 12. Schematic representation of a typical pattern of rocky shore zonation (modified from J. McCrae and L. Osis, *Plants and animals of Oregon's rocky intertidal habitat*, Oregon Department of Fish and Wildlife). The pattern may vary from area to area.



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Soft substrate communities

Soft substrate bottoms are the bottoms characterized by the presence of **sediment**. The type of sediment depends on its origin and the intensity of water movement. The terms **sand**, **silt**, and **clay** refer to sediments with specific **particle sizes**. Sand is coarser sediment than silt and silt than clay. The combination of silt and clay is referred to as **mud**. Most sediments are a mixture of particles of different sizes.

The term by which a sediment (e.g. sand) is characterized is determined by the most common size class of its particles. Sheltered coasts that are not exposed to strong waves and strong currents have muddy bottoms because the finer portions of the sediment settle out, while coasts that are exposed to strong waves and strong currents have coarse sediments. In turn, the type of shore sediment affects the composition of biotic communities.

Soft substrate organisms cannot attach to the substrate as the sediment is moved by wave action, tides and currents. Few **macroalgae** have adapted to soft substrates. Also, few **benthic invertebrates** live on the surface of the sediment (**epifauna**), while most burrow into the sediment to avoid being swept away by water movement (**infauna**).

On **sandy shores**, water quickly drains from the sand, and because the coast slopes, the upper part is drier than the lower part. This results in the distribution of benthic organisms in the **intertidal zone** of shores with sandy substrate creating a **zonation** (Fig. 13). But because the organisms live in the sediment and cannot be seen, this zonation is not as obvious as in the intertidal zone with a rocky substrate.

In the **upper part** of the intertidal zone of sandy shores live **isopod** and **amphipod crustaceans**. In warmer regions these small crustaceans are replaced by **crabs**. Lower in this zone live **polychaete worms**, **bivalves** and other **benthic invertebrate** (Fig. 13).

On **muddy shores** practically no zonation is created, as the bottom is almost flat, and the fine sediments hold water so that there is no a marked change of habitat between the upper and lower part of the intertidal zone.





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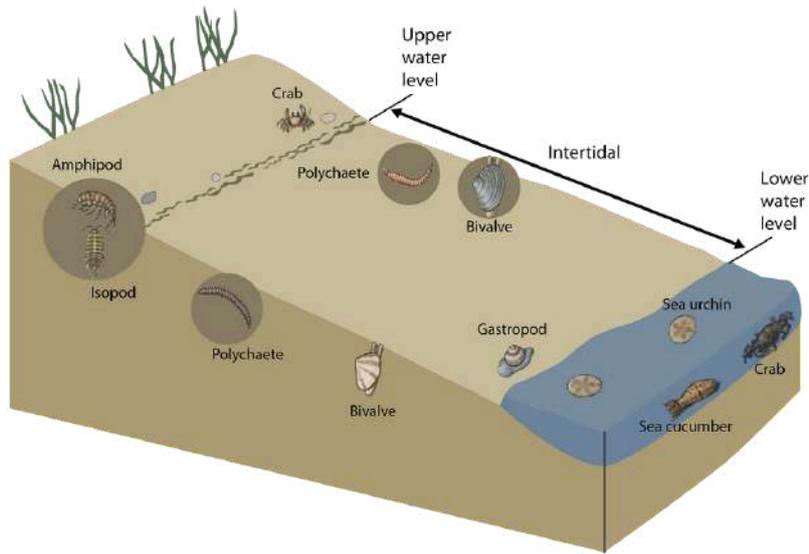


Figure 13. Pattern of sandy beach zonation (modified from P. Castro and M. Huber, Marine Biology, 11th Ed., McGraw-Hill Education).

Coastal lagoons

Coastal lagoons are a prevalent type of coastal environment, accounting for 13% of coastal areas globally. A coastal lagoon is defined as a shallow coastal water body separated from the sea by a barrier, intermittently connected to the sea through one or more restricted inlets, and generally oriented parallel to the shore (Fig. 14). Coastal lagoons are typically shallow, with an average depth seldom exceeding 2 m.



Figure 14. Types of coastal lagoons according the degree of water exchange with the adjacent sea (modified from T. Kevrekidis et al., Exploring the coastal lagoons, HFRI).





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Coastal lagoons are dynamic systems characterized by significant **environmental variability**. Environmental conditions differ among lagoons, within different areas of the same lagoon, seasonally, and even daily. For example, due to their relatively small water volume, the temperature of lagoon water quickly responds to changes in air temperature, both seasonally and daily.

Additionally, variations in freshwater input from runoff or precipitation, as well as changes in water exchange with the sea, lead to notable fluctuations in the salinity of coastal lagoon water.

Coastal lagoons harbor **high biodiversity**, providing a variety of habitat types for many organisms. They function as refugia, feeding grounds, and nursery areas for numerous marine species and autochthonous or migratory bird species. The organisms within coastal lagoon ecosystems are well-adapted to the environmental variability.

Coastal lagoons are characterized by high levels of **primary production**, which in turn support rich faunal communities. **Phytoplankton** does not have such a dominant role as in marine ecosystems. **Macroalgae** such the green alga *Ulva* and the red alga *Gracilaria*, and **submerged angiosperms** like the brackish-water angiosperm *Ruppia* are important primary producers in coastal lagoons (Fig. 15). In some coastal lagoons, **seagrasses**, such as *Zostera marina*, *Zostera noltii* and *Cymodocea nodosa* also occur. Seagrass beds provide a multitude of ecological

functions and services, including carbon sequestration and storage (Blue Carbon storage), and, thus, climate change mitigation.

The main food source for the primary consumer animals in the coastal lagoon is the large quantity of **detritus**, which is abundant both in the water column and on the bottom.

Detritus is come mainly from fragments of dead plant and animals from the land, from rivers, from the sea and from the coastal lagoon itself. Most of the primary consumers are benthic invertebrates such as **polychaete worms** (e.g. *Hediste*), **bivalve molluscs** (e.g. *Cerastoderma*, *Abra*) and **gastropod molluscs** (e.g. *Ecrobia*), and **crustacean amphipods** (e.g. *Corophium*) (Fig. 15).

The secondary consumers of coastal lagoons include **crabs** (e.g. *Carcinus*, *Callinectes*), **shrimps**, **fish** and **birds** (Fig. 15). **Fish populations** in coastal lagoons can be abundant. However, only a few fish species live in the coastal lagoon throughout the year (e.g. *Atherina*, *Aphanius*). Most fish are marine species which seasonally move into the coastal lagoon and then, move out to sea again (e.g. *Mugil*).

Large numbers of **birds**, especially **wildfowl**, **waders** and **gulls** are attracted to coastal lagoons as feeding areas. The birds mainly feed on the rich populations of molluscs, crustaceans and polychaete worms.





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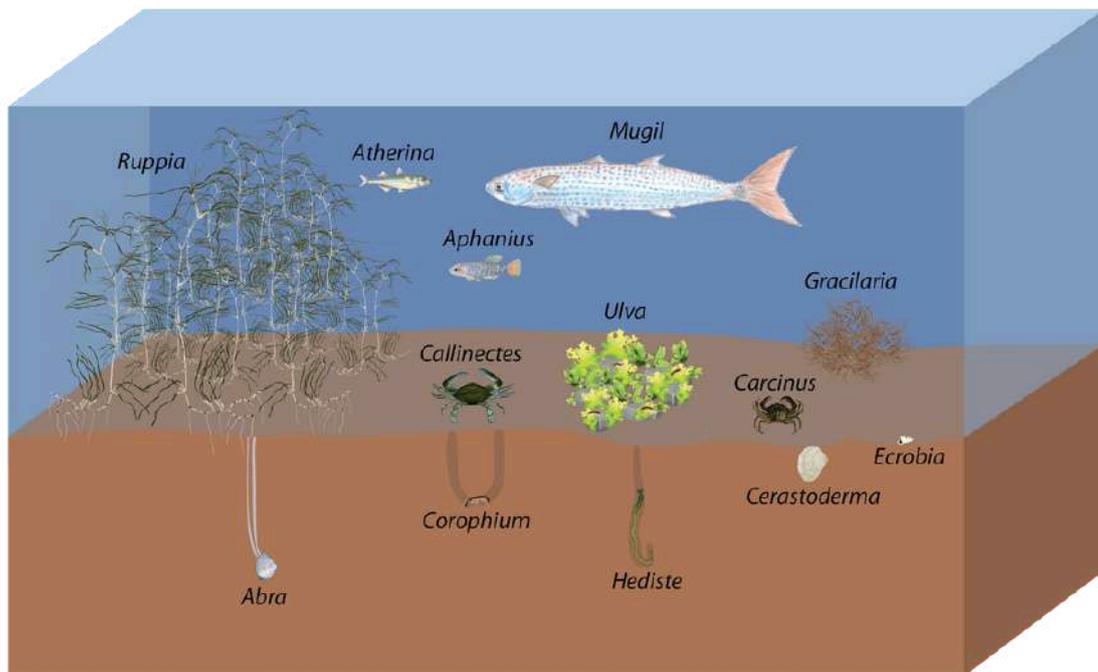


Figure 15. Representation of the coastal lagoon habitat (modified from T. Kevrekidis et al., Exploring the coastal lagoons, HFRI).





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B4. Thematic modules

B4.6. Principle 6.

1. Conceptual flow diagram

Ocean Literacy **Principle 6** and the respective **conceptual flow diagram** for **Grades K–2** are presented below.

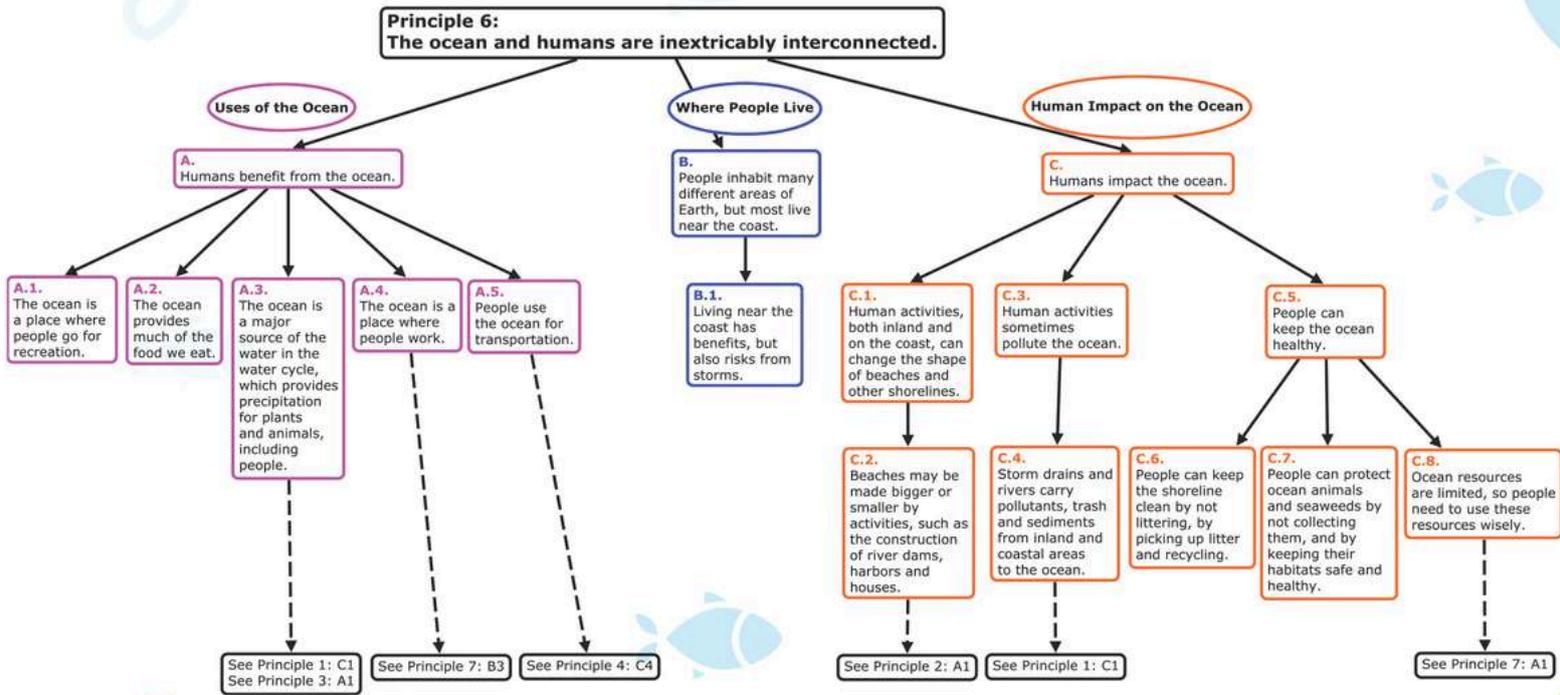
Ocean Literacy Principle 6:

**The ocean and humans are
inextricably interconnected**



PRINCIPLE 6

GRADES K-2





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2. Content Knowledge

2.1. Uses of the ocean - Where people live

The ocean is essential to **human health** and **well-being**. It supplies over 50% of the world's oxygen, and freshwater, since most rain comes from the ocean. It provides food to billions, livelihoods for millions and is the source of essential medicines, and mineral and energy. The ocean is a source of joy, beauty, peace and recreation, and has traditional cultural value. Approximately 40% of the world's population lives within 100 km of the coast.

The European Commission has introduced the concept of the **Blue Economy**. The Blue Economy includes all sectoral and cross-sectoral economic activities based on or directly related to the ocean, seas, coasts and seabed. The Blue Economy is an integral part of the overall economy of the European Union.

In terms of employment, the Blue Economy participated in 2018 by 2.2% in the total economy of the European Union. Among the member states of the European Union, this percentage ranged from 0.1% (Luxembourg) to 14% (Greece).

Blue Economy sectors are divided into established and emerging. **The established sectors** of the Blue Economy include marine living resources, marine non-living resources, marine renewable energy (offshore wind energy), port activities, shipbuilding and repair, maritime transport and coastal and maritime tourism.

Emerging sectors of the Blue Economy include among others ocean energy, blue biotechnology and desalination.

The **marine living resources sector** includes fisheries and aquaculture, the processing of fish products and the distribution of fish products. The European Union is the eighth largest producer of fishery and aquaculture products, covering around 2% of global production.

Maritime transport is essential to the global economy and comprises two main sectors, maritime and coastal passenger transport, and maritime and coastal freight transport.

Coastal and maritime tourism play an important role in the economies of many member states of the European Union.

Coastal tourism refers to tourism activities including swimming, surfing, sunbathing and other recreation activities taking place on the coast. Maritime tourism refers to sea-based activities such as boating, yachting, cruising, nautical sports.





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2.2. Humans impact the ocean

The **ocean** is vast. However, **ocean resources** are not limitless. Despite its vast size, the ocean is under **threat**. **Human activity** has been negatively impacting the ocean for decades. Most of the ocean is experiencing increasing cumulative impact due to climate change, fishing, land-based pollution, shipping, and other human activities. The cumulative impact of human activities often results in **ecosystem degradation or even collapse**. Coastal ecosystems, particularly coral reefs, seagrass meadows and mangroves are the most vulnerable to anthropogenic threats.

Ocean pollution is widespread, worsening and in most countries poorly controlled. Pollution of the ocean is a complex mixture of chemicals and biological materials, including plastic waste, petroleum hydrocarbons, toxic metals, industrial chemicals, pharmaceuticals, pesticides, human sewage, agricultural fertilizers and animal feedlot waste. More than 80% of ocean pollution arises from land-based sources. Pollutants enter the ocean through runoff, rivers, direct discharges and atmospheric deposition. Pollution is most severe in coastal areas and has negative impacts on marine ecosystems and human health.

Plastic pollution is the most visible category of ocean pollution. An estimated 10 million metric tons of plastic enter the ocean annually. Plastic pollution threatens fish, marine mammals and seabirds. It breaks down into microplastic and nanoplastic particles which can enter the human food chain.

According to the European Environment Agency, pollution by industrial chemicals, toxic metals and plastic wastes is at problem levels in 75% of the North-East Atlantic Ocean, 87% of the Mediterranean Sea, 91% of the Black Sea, and 96% of the Baltic Sea.

Human activities, such as **coastal development**, can modify coastal features and impact coastal processes and coastal ecosystems. Coastal development, including the construction of harbors, marinas, buildings, roads, or touristic infrastructure, can destabilize the substrate and result in increased erosion, causing the coastline to **retreat**.

In addition, the construction of coastal defense structures, such as seawalls, can disrupt coastal processes and result in changes in the position and shape of the coastline. On the other hand, some other human activities, such as the deposition of sediment derived from dredging, can result in the **advancement** of the coastline seaward.





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Sea level rise due to rising global temperature results in increased coastal flooding and erosion, causing coastlines retreat. Increased intensity and frequency of **extreme weather events** due to climate change can impact the coastline and result in further coastal retreat.

An understanding of how human activity negatively impacts the ocean is crucial for its **protection** and **conservation**. The next step is doing something about the ocean. Everyone is **responsible** for the health of the ocean. **Individual** and **collective actions** are required to effectively manage ocean resources for all.





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B4. Thematic modules

B4.7. Principle 7

1. Conceptual flow diagram

Ocean Literacy **Principle 7** and the respective **conceptual flow diagram** for **Grades K–2** are presented below.

Ocean Literacy Principle 7:

The ocean is largely unexplored





PRINCIPLE 7

GRADES K-2

Principle 7:
The ocean is largely unexplored.

Life on Earth Depends on the Ocean

A.
All living things depend on resources from the ocean, such as oxygen, food, water, energy, etc.

A.1.
Ocean resources are limited. People need to learn about these resources through exploration and scientific investigation.

See Principle 6: C8

People Explore the Ocean

B.
People have always been interested in the ocean. People explore the ocean to answer questions they have about it.

B.1.
People are still discovering new things about the ocean all the time.

B.2.
Ocean exploration helps us understand the health of the ocean and find new medicines, food for humans, and new sources of energy (e.g., oil, gas and wind).

B.3.
People explore the ocean through many different hobbies and careers: scientists, fishers, engineers, surfers, swimmers, photographers, filmmakers, artists and explorers all spend time exploring the ocean.

See Principle 6: A4

B.4.
People use creativity, curiosity, tools and technology to make better observations of the ocean.



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2. Content Knowledge

2.1. Life on Earth depends on the Ocean, people explore the Ocean

The **ocean** is the largest unexplored place on Earth - less than 20% of it has been mapped, observed, and explored. The next generation of explorers and researchers will find great opportunities for discovery, innovation and investigation.

Understanding the ocean is more than a matter of curiosity. **Exploration, experimentation, and discovery** are required to better understand ocean systems and processes.

Over the last 50 years, use of ocean resources has increased significantly, the **future sustainability** of ocean resources depends on our understanding of those resources and their potential.

New technologies, sensors and tools are expanding our ability to explore the ocean system. Scientists are relying more and more on satellites, drifters, buoys, subsea observatories and uncrewed submersibles.

Use of **mathematical models** is an essential part of the ocean systems. Models help us understand the complexity of the ocean and of its interaction with Earth's interior, atmosphere, climate and land masses.

Ocean exploration is truly **interdisciplinary**. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, physicists, animators and illustrators. And these interactions foster new ideas and new perspectives for inquiries.





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TeachBlue: Teachers' Curriculum and Handbook

Marine and Ocean Literacy for Early Childhood Education

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