

Ocean Literacy Guide

Principle #1

Francesca ALVISI

*Institute of Marine Sciences
Italian National Research Council*

1 Earth has one big ocean with many features.



THE OCEAN FROM SPACE. This infrared image from the GOES-11 satellite shows the Pacific Ocean. Photo: NASA

- A** The ocean is the defining 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, Southern, and Arctic.
- B** Ocean basins are composed of the seafloor and all of its geological features (such as islands, trenches, mid-ocean ridges, and rift valleys) and vary in size, shape, and features due to the movement of Earth's crust (lithosphere). Earth's highest peaks, deepest valleys, and flattest plains are all in the ocean.
- C** Throughout the ocean there is one interconnected circulation system powered by wind, tides, the force of 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. This "global ocean conveyor belt" moves water throughout all of the ocean basins, transporting energy (heat), matter, and organisms around the ocean. Changes in ocean circulation have a large impact on the climate and cause changes in ecosystems.
- 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 salty, 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. Balance of pH is vital for the health of marine ecosystems and important in controlling the rate at which the ocean will absorb and buffer changes in atmospheric carbon dioxide.
- F** The ocean is an integral part of the water cycle and is connected to all of 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 coastal estuaries and to the ocean.
- H** Although the ocean is large, it is finite, and resources are limited.

#1 – Earth has one big ocean with many features

□ Geological features

Ocean floor
Plate tectonics

□ Ocean water properties

Salinity
Temperature
pH

□ Circulation of the oceans

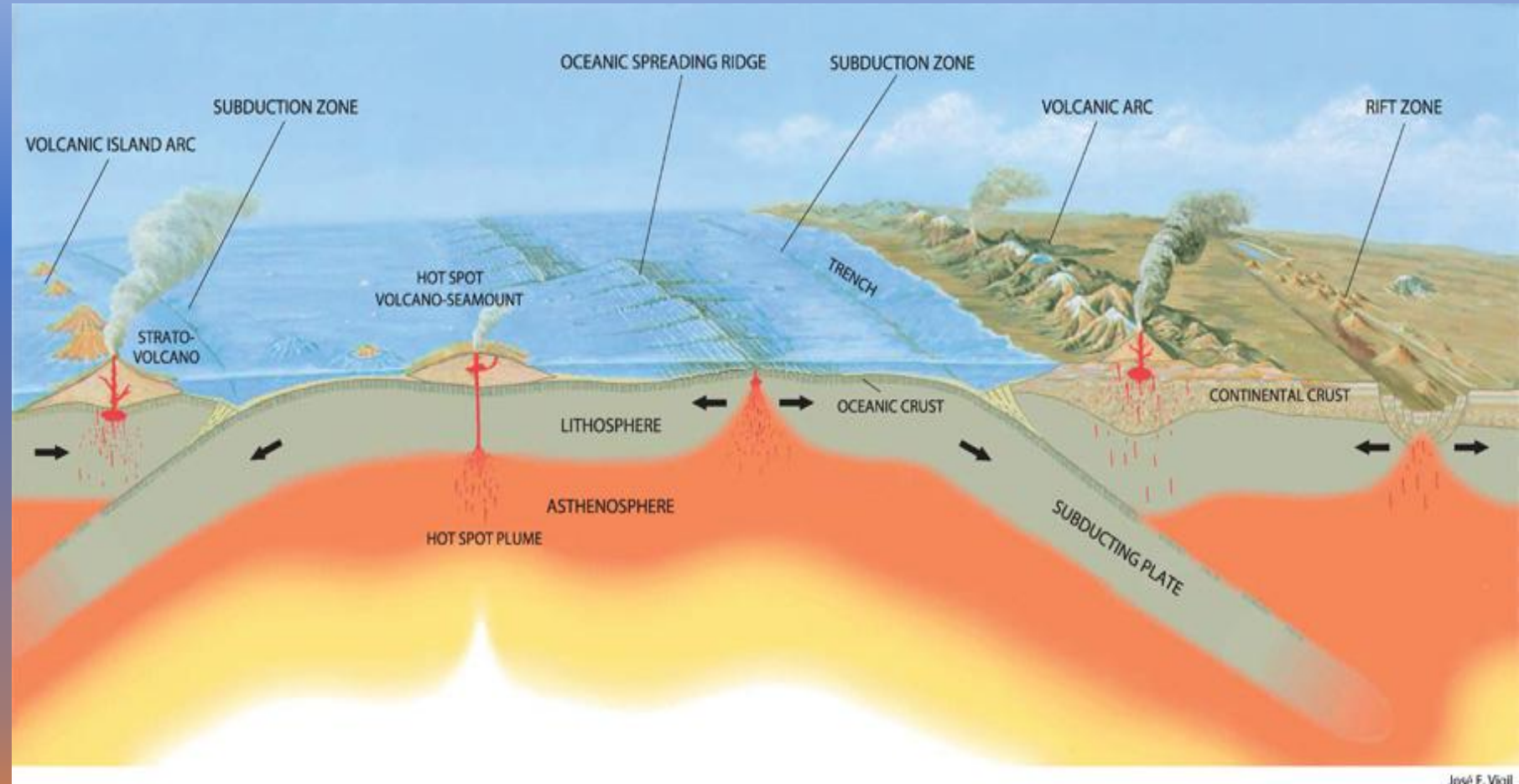
Water cycle
Currents
Waves
Tides

□ Sea level

Reference level
Oscillations

#1 – Geologic features

- The ocean is the defining physical feature on our planet Earth covering approximately 70% of the planet's surface
- There is one ocean with many ocean basins
- Plate tectonics
 - The **shape or morphology** of the ocean floor is very irregular
 - The distribution of sea depths is indicated on **bathymetric maps** where **isobaths** are plotted

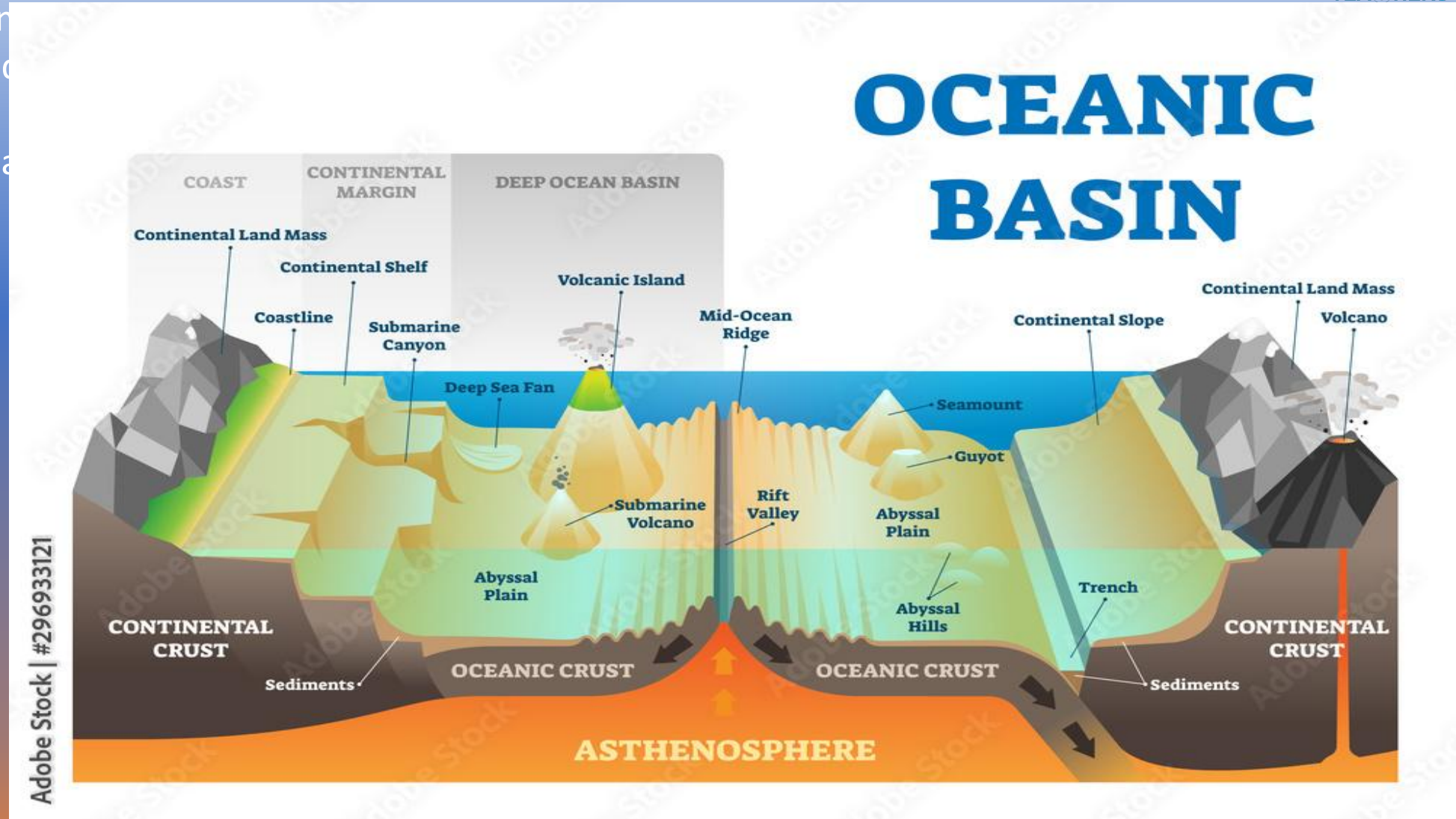


José F. Vigil

#1 – Geologic features

- Ocean basins are composed of mid-ocean ridges and deep-sea trenches.
- They vary in size, shape, and depth.

- Ocean floor
- The slopes are **gentler** than on land-based mountain ranges
- Earth's **highest** peaks, **deepest** valleys and **flattest** vast plains are all in the ocean



#1 – Ocean water properties

□ Most of Earth's water (97%) is in the ocean

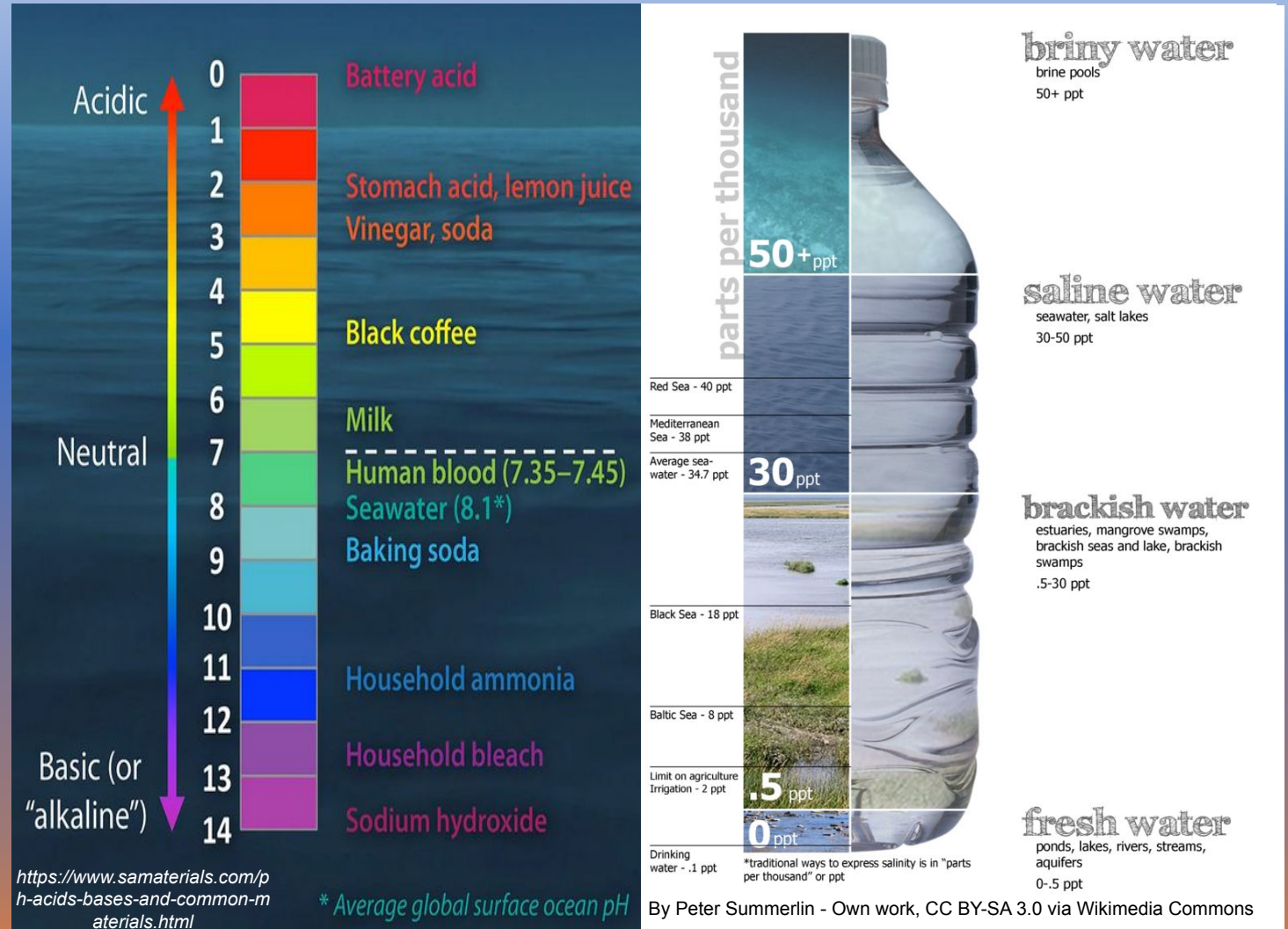
□ Seawater has unique properties

□ Salinity

It is salty, 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

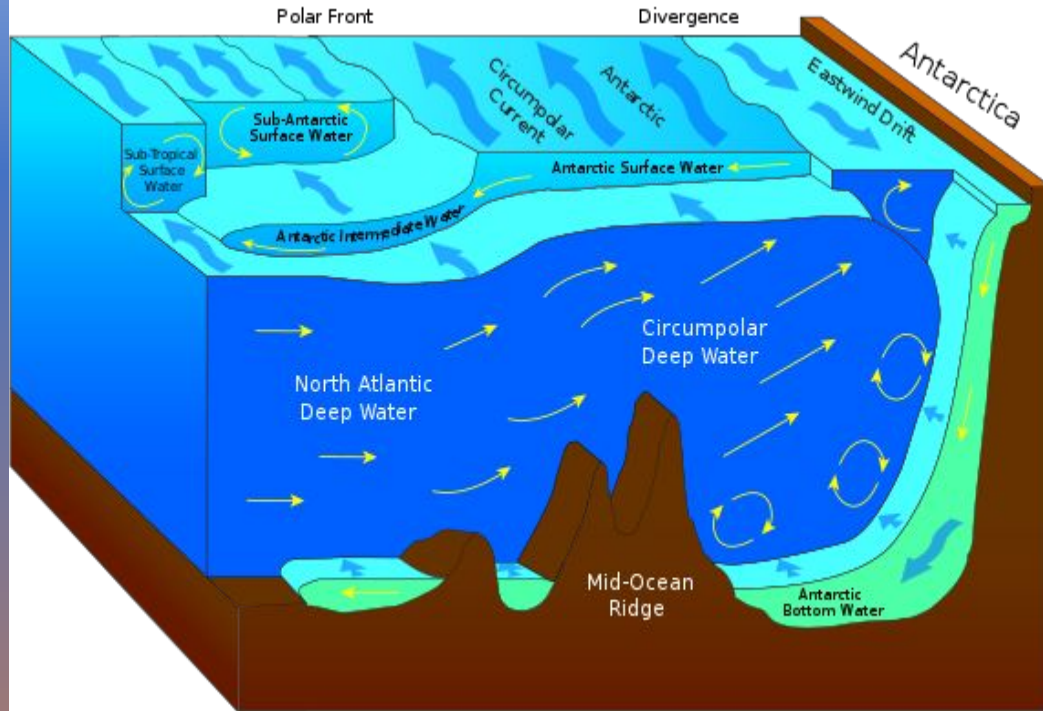
□ Ph

Balance of pH is vital for the health of marine ecosystems, and important in controlling the rate at which the ocean will absorb and buffer changes in atmospheric carbon dioxide

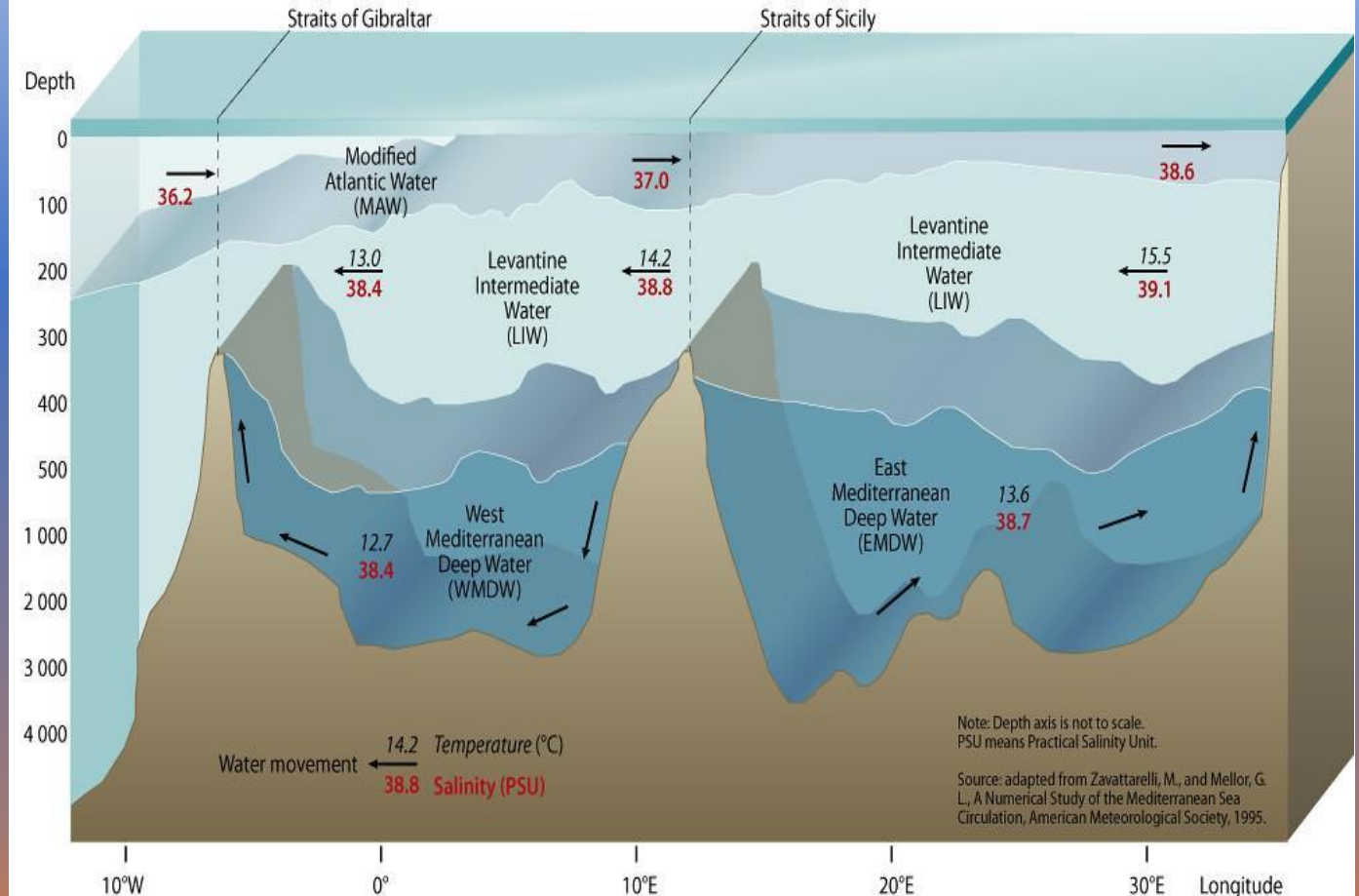


#1 – Circulation of the Ocean

By Fred the Oyster, CC BY-SA 4.0,
<https://commons.wikimedia.org/w/index.php?curid=35204554>



Mediterranean Sea water masses: vertical distribution



#1 –Circulation of the Ocean

- The ocean is an integral part of the water cycle and is connected to all of Earth's water reservoirs via evaporation and precipitation processes
- 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



#1 –Circulation of the Ocean

□ Currents

A continuous, directed movement of seawater generated by wind, the Coriolis effect, breaking waves, and temperature and salinity differences

Depth contours, shoreline configurations, and interactions with other currents influence a current's direction and strength

Ocean currents are primarily horizontal water movements

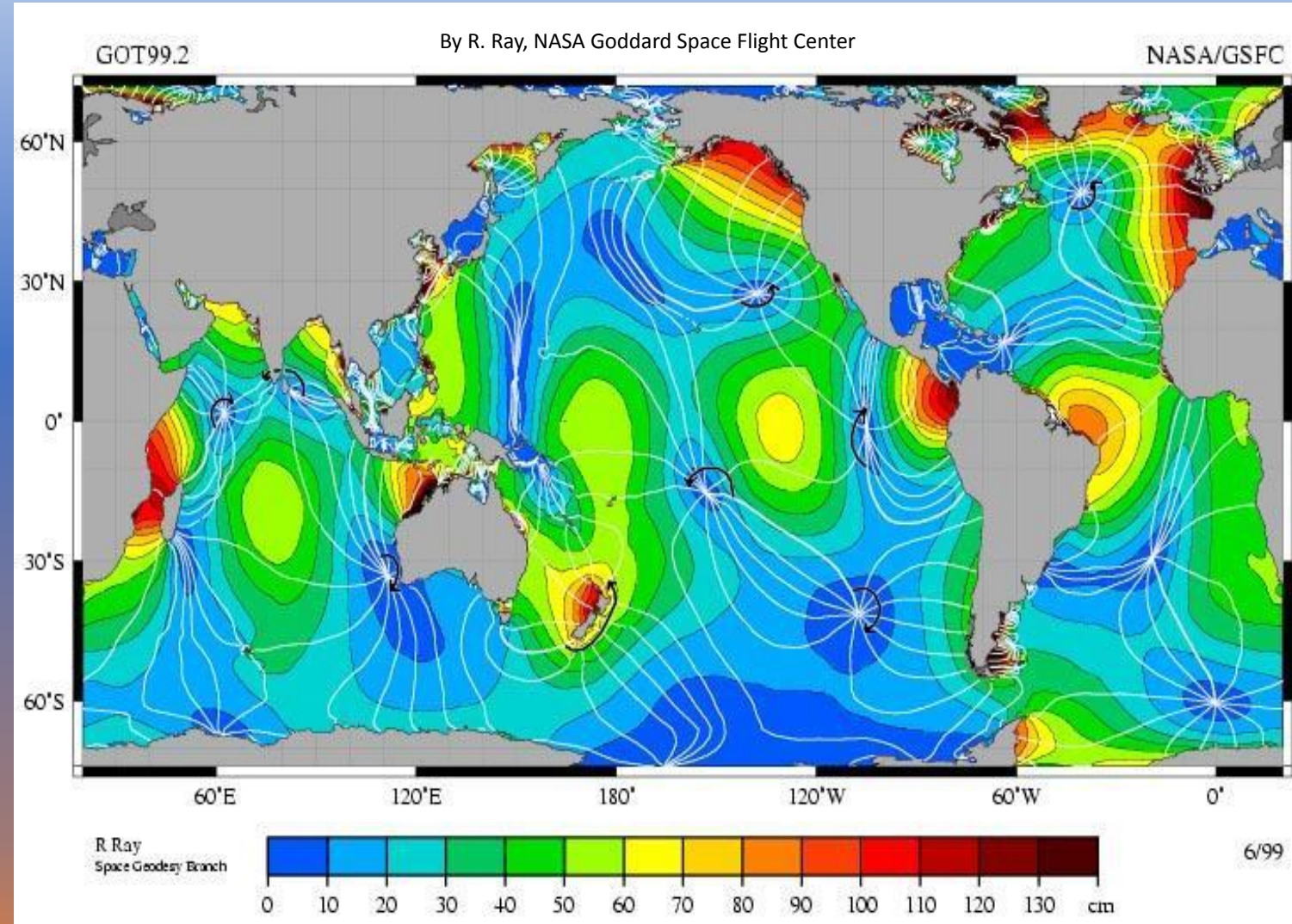
□ Waves

A special case of gravity waves, i.e. waves propagating at the interface of two fluids with different densities (in this case water and air)

One of the main causes of sea waves is the action of the wind that can be felt, in the open sea, up to a maximum depth of 150 metres

□ Tides

Tides are the rise and fall of sea levels caused by the combined effects of the gravitational forces exerted by the Moon (and to a much lesser extent, the Sun) and are also caused by the Earth and Moon orbiting one another



#1 – Sea level

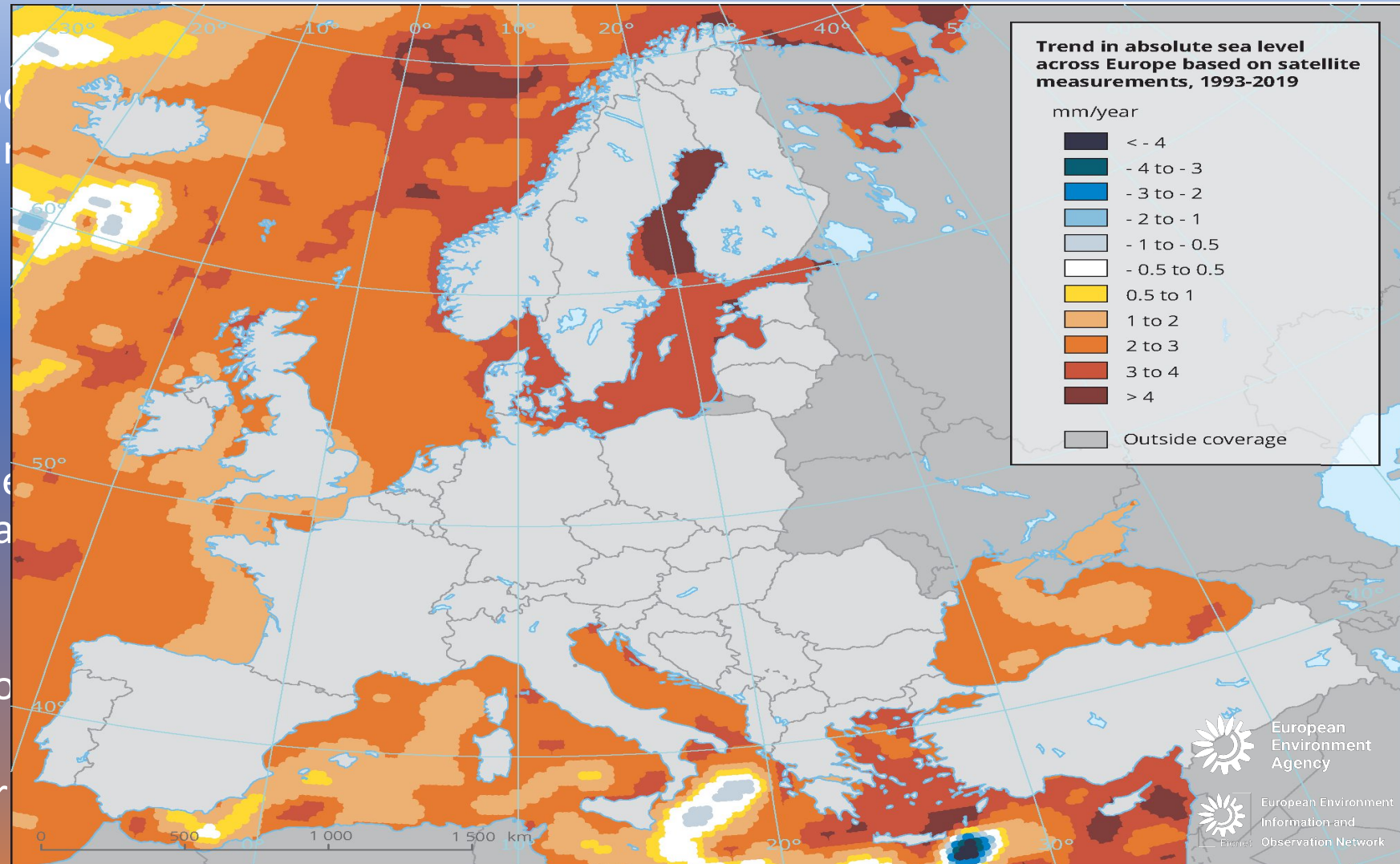
Reference level

The average height of the ocean relative to the land, taking into account differences caused by tides

Oscillations

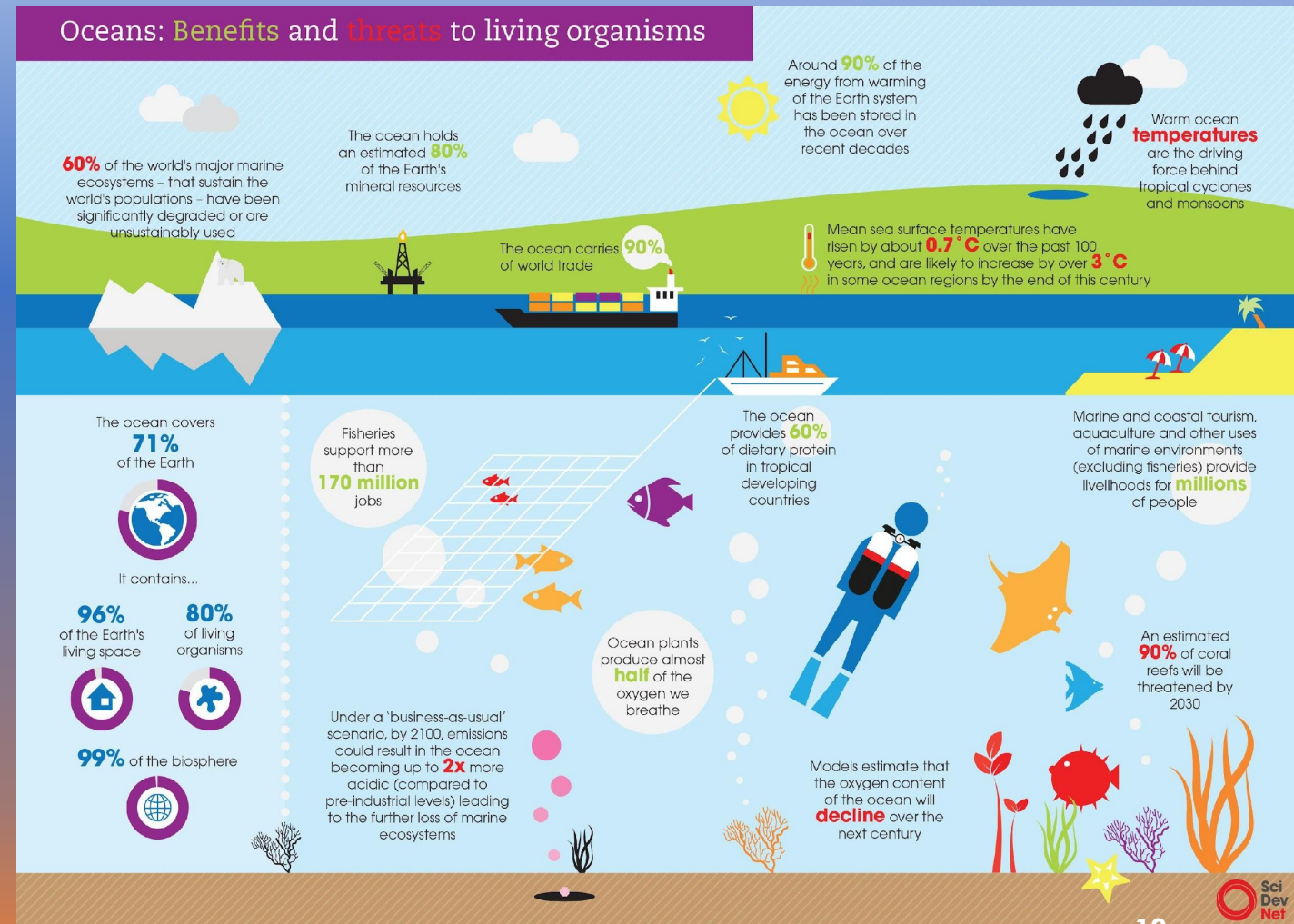
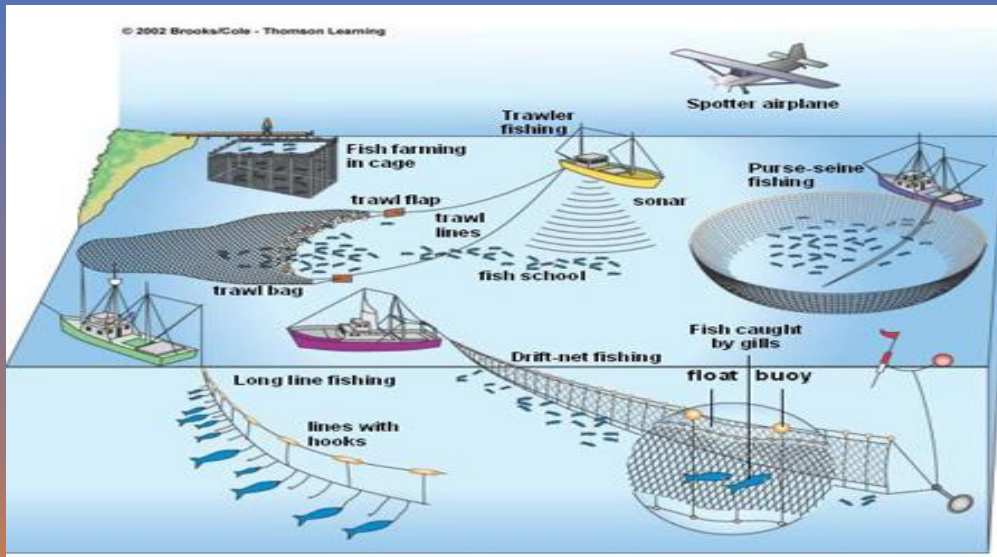
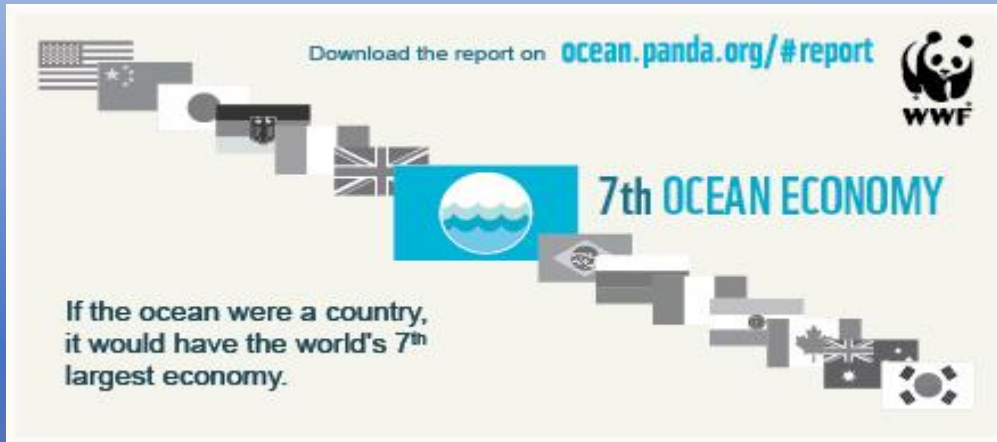
Sea level changes when:

- plate tectonics causes the volume of ocean basins and the height of the land to change
- polar ice caps melt or grow
- seawater expands and contracts as ocean water warms and cools



#1 – Big, but not infinite!

- Although the ocean is large, it is finite and resources are limited



GRADES 3 THROUGH 5

Principle 1



<https://www.marine-ed.org/ocean-literacy/scope-and-sequence>

Principle 1:
Earth has one big ocean with many features.

The ocean, which covers 70% of Earth's surface, is the defining feature of the planet.

Properties of Ocean Water

A.
97% of all water on Earth is salt water in the ocean.

A.1.
Only 3% of all water on Earth is fresh water stored in lakes, rivers, underground aquifers, glaciers, and other places.

A.2.
Most of all the fresh water in the world is stored in ice caps and glaciers.

A.3.
Fresh water melting from glaciers contributes to the ocean and can change its salinity and temperature and cause sea level to rise.

See Principle 3: B3

A.4.
Salinity and temperature vary throughout the ocean.

A.5.
The movement of ocean water as currents is partly driven by these differences in salinity and temperature.

Ocean Circulation

B.
The ocean is a single, huge, interconnected body of water that circulates through all the ocean basins and continents.

B.1.
The ocean, the largest reservoir of water on Earth, is integral to the water cycle.

B.2.
Water circulates from land to the ocean and back via watersheds and the water cycle.

B.3.
Lakes and glaciers are connected to the ocean via watersheds that are made up of rivers, streams, and groundwater.

B.4.
Watersheds drain water from inland to the ocean.

B.5.
Runoff from watersheds impacts the ocean.

See Principle 3: B
See Principle 6: A3

B.7.
Wind- and density-driven currents move ocean water around Earth.

B.8.
Organisms travel on currents.

See Principles 5: B7

B.6.
Water in the ocean is constantly moving and mixing vertically and horizontally.

B.9.
Tides move ocean water higher and lower, covering and uncovering the shoreline.

B.10.
Waves crash on the shore, moving and mixing the water.

See Principle 2: B
See Principle 3: A3

Geographic and Geologic Features

C.
The ocean floor has a variety of geological and geographical features comparable to those on land.

C.1.
The ocean has many basins. They are called the Pacific, Atlantic, Indian, Arctic, and Southern basins.

C.2.
The ocean floor has other features such as mountains, plains, valleys, volcanoes, canyons, trenches, and ridges.

C.3.
The highest mountain on Earth is in the ocean. It is called Hawaii, an island in the Pacific Ocean.

C.4.
The lowest point on Earth is in the ocean. It is called the Mariana Trench, and is located in the Pacific Ocean.

See Principle 2: A5

C.5.
The features of the ocean floor influence ocean circulation patterns.

SCOPE AND SEQUENCE CONCEPTUAL TABLE



Principle 1

GRADES 6 THROUGH 8

Principle 1: Earth has one big ocean with many features.

The ocean, which covers 70% of Earth's surface, is the defining feature of the planet.

Geologic Features — A				Properties of Ocean Water — B			Ocean Circulation — C						
The size and shape of the ocean has changed over geologic time and continues to move and change.				97% of all water on Earth is ocean water, which has unique chemical and physical properties.			The ocean is one interconnected body of water that is integral to the water cycle; and is in constant motion in a global circulation system.						
A1		A7		B1	B3		C1			C6		C9	
Motion along the margins of lithospheric plates creates physical features on the ocean floor and land.		During various times in Earth's geologic history, all of the continents have been joined into one supercontinent. A giant ocean circulated around the supercontinent.		Salts enter the ocean via erosion from land, volcanic emissions, reactions at the sea floor, and atmospheric deposition.	Density differences between masses of water can cause currents.		A global ocean circulation system is generated from tides and different types of currents moving the water.			Currents transport heat, nutrients, and organisms throughout the ocean.		All major watersheds, from the Amazon River to melting glaciers, mix fresh and salt water when they meet the ocean, which contributes to the density differences that set ocean currents in motion.	
A2		A8		B2	B4		C2	C3	C4	C7	C8	C10	C11
Many of the physical features on the ocean floor are the result of the constant motion of the lithospheric plates that make up Earth's crust.		The supercontinent broke apart along rift valleys to create new, smaller continents and ocean basins now known as the Pacific Ocean, Atlantic Ocean, etc.		The freezing point of ocean water decreases as salinity increases; the pH of ocean water is more basic than fresh water.	The density of ocean water increases as salinity (amount of dissolved salts) increases and as temperature decreases.		Deep ocean currents are driven by density differences between masses of ocean water.	The wind, combined with Earth's rotation (Coriolis effect), drives surface currents in circular gyres in each ocean basin; clockwise in the Northern Hemisphere and counter-clockwise in the Southern Hemisphere.	Tides are mainly caused by the gravitational interaction between Earth, the moon and the sun.	Upwelling, which occurs mostly on west coasts, brings nutrients from deep water to the sunlit surface zone where photosynthetic primary producers grow.	Currents are especially important in moving young organisms (larvae and juveniles) to populate new areas.	As water travels through the watersheds, it collects nutrients, salts, sediments and pollutants and carries them into the ocean.	Sea level rises as glaciers melt.
A3	A4	A5	A9		B5	B6	C5	C5	C5				
New lithospheric crust is generated at spreading centers while older, denser crust is recycled into the Earth's interior at subduction zones, creating various physical features.	Plate movement is primarily caused by the convection of hot fluids below Earth's crust.	Features on the ocean floor are highly varied, and include trenches, rift valleys, mid-ocean ridges, seamounts, islands, and continental shelves.	The continents are still in motion today.		The salinity of ocean water can change due to adding or removing water (e.g., evaporation, melting glaciers, or inflow from rivers, streams, and rainfall).	The temperature of ocean water can change due to warming and cooling (e.g., heat from the sun or contact with ice).	Ocean circulation is influenced by the position of basins, continents, and other geologic features.	Ocean circulation is influenced by the position of basins, continents, and other geologic features.	Ocean circulation is influenced by the position of basins, continents, and other geologic features.				

SCOPE AND SEQUENCE CHART

https://oceanliteracy.wp2.coexploration.org/?page_id=1641#ep1topics

Grade Band	Properties of Ocean Water	Geographic and Geologic Features	Ocean Circulation	Sea Level
K-2	a. The ocean is salty	a. Ocean basins b. Ocean floor features c. Only one ocean	a. Tides b. Transportation of living things c. Watersheds d. Wind-driven currents	

Topics and Subtopics of Principle 1

The charts list the major topics and subtopics in the conceptual flow diagrams of the Scope and Sequence

There is one chart for each principle

For each chart, the major branches of topics on the conceptual flow diagrams for that principle run horizontally across the top

The grade bands run vertically along the left column

9-12	a. Density b. Effect on life processes c. pH d. Salinity e. Temperature	a. Generation of Earth's crust b. Motion of lithospheric plates c. Ocean basins d. Ocean floor features e. Tectonic activities	a. Coriolis effect b. Currents c. Density-driven currents d. Eckman forces e. Effect on climate f. Gyres g. Prevailing winds h. Tides i. Transportation of living things j. Upwelling k. Water cycle l. Waves m. Wind-driven currents	a. Atmospheric pressure b. Change over time c. Effect on currents d. Global temperature change e. Movement of lithospheric plates f. Prevailing winds g. Regional differences
------	---	--	---	---

WHY DOES EARTH SCIENCE LITERACY MATTER?

EARTH SCIENCE LITERACY PRINCIPLES



The Big Ideas and Supporting Concepts of Earth Science

www.earthscienceliteracy.org

Why is Earth Science Literacy Important?

Earth is our home and we rely upon it for our existence in many different ways

Its resources feed us and provide the materials of our way of life

Even modest changes to Earth's systems have had profound influences on human societies and the course of civilization. Understanding these systems and how they interact with us is vital for our survival

Earth Science Literacy is especially important at this time in history. There are many challenges facing humanity—dwindling energy and mineral resources, changing climates, water shortages—directly relating to the Earth sciences

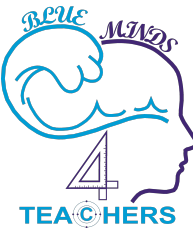
There are many difficult decisions that governments, local and national, will have to make concerning these issues, and how well humans survive the twenty-first century will depend upon the success of these decisions

We need governments that are Earth science literate

It will take a deep and subtle understanding of Earth's systems for future generations to be able to feed, clothe, house, and provide a meaningful existence for all humans

We need citizens and businesses that are Earth science literate

EARTH SCIENCE LITERACY PRINCIPLES



BIG IDEA 1. Earth scientists use repeatable observations and testable ideas to understand and explain our planet.

BIG IDEA 2. Earth is 4.6 billion years old.

BIG IDEA 3. Earth is a complex system of interacting rock, water, air, and life.

BIG IDEA 4. Earth is continuously changing.

BIG IDEA 5. Earth is the water planet.

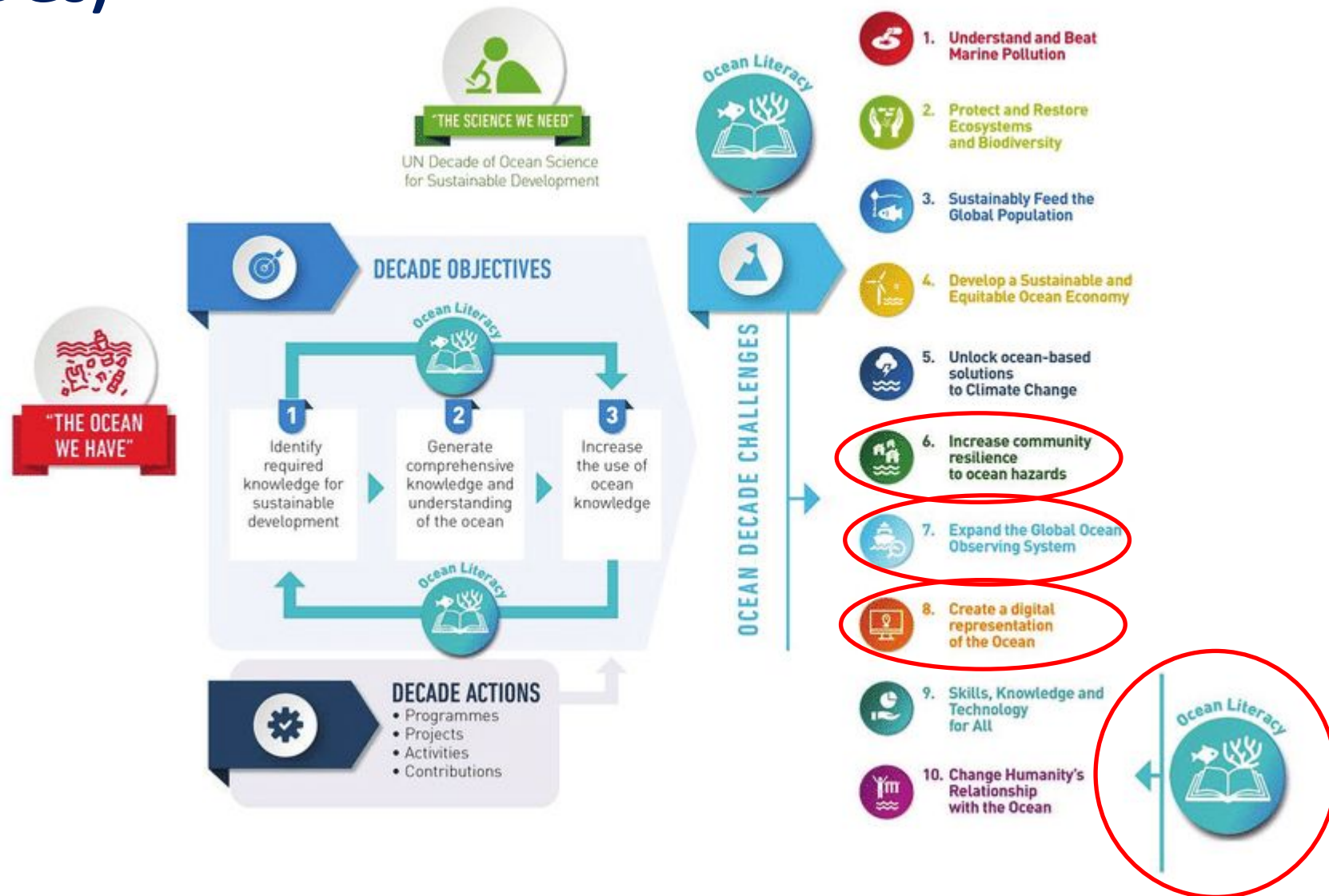
BIG IDEA 6. Life evolves on a dynamic Earth and continuously modifies Earth.

BIG IDEA 7. Humans depend on Earth for resources.

BIG IDEA 8. Natural hazards pose risks to humans.

BIG IDEA 9. Humans significantly alter the Earth.

The OCEAN flows through all 17 UN Sustainable Development Goals (SDGs)



EU MISSIONS

MISSION AREAS:

Soil health and food



Adaptation to climate change, including societal transformation



Climate-neutral and smart cities



Cancer



Healthy oceans, seas, coastal and inland waters



#HorizonEU



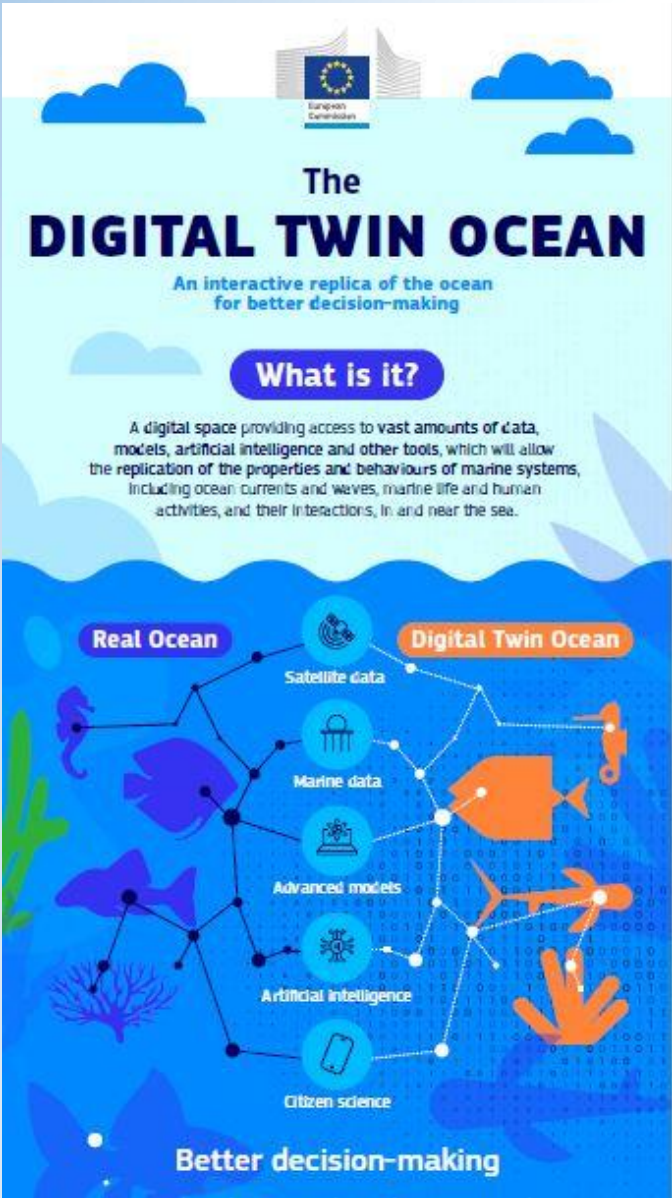
What are EU Missions?

- EU Missions are a new way to bring concrete solutions to some of our greatest challenges
- They have ambitious goals and will deliver concrete results by 2030

- They put research and innovation into a new role, combined with new forms of governance and collaboration, as well as by engaging citizens

<https://projects.research-and-innovation.ec.europa.eu/en/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-mission-s-horizon-europe/restore-our-ocean-and-waters/mission-ocean-and-waters-service-portal>

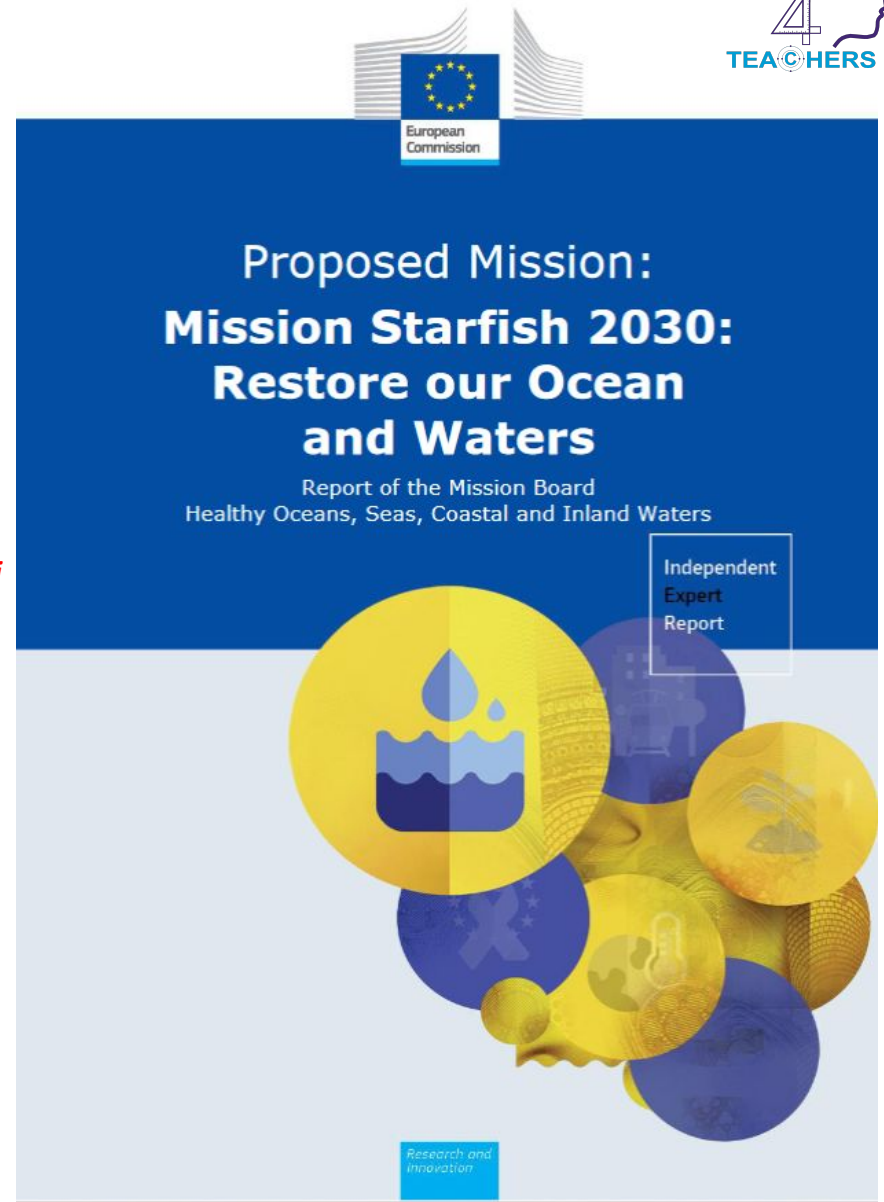
EU priorities for 2019-2024



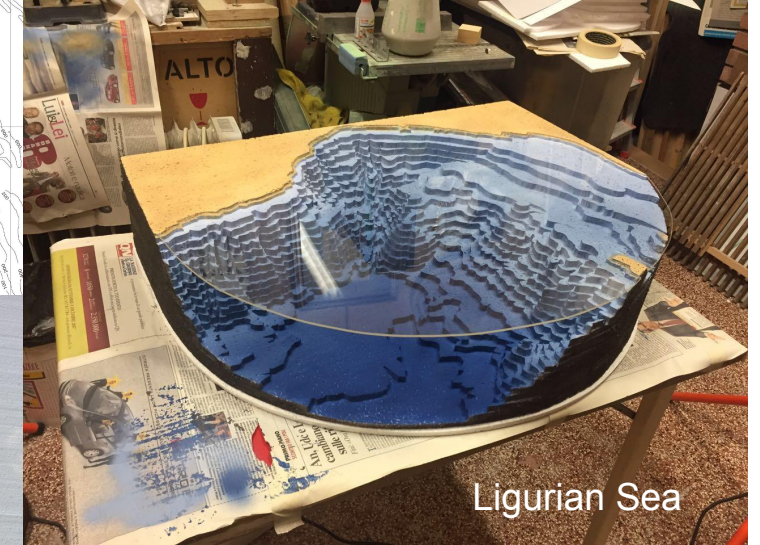
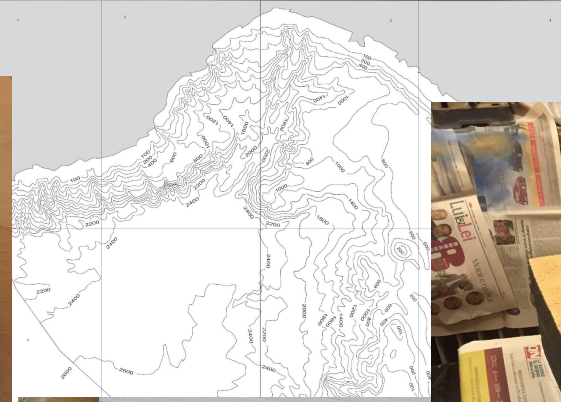
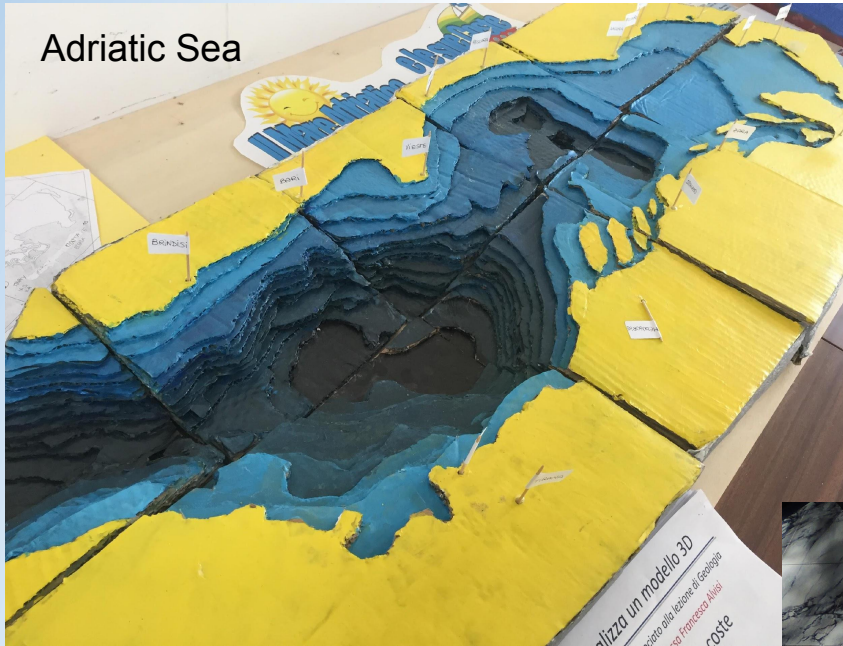
https://commission.europa.eu/strategy-and-policy/priorities-2019-2024_en

<file:///C:/Users/scarl/Downloads/the%20digital%20twin%20ocean-KI0622164ENN.pdf>

<file:///C:/Users/scarl/Downloads/mission%20starfish%202030-KI0220682ENN.pdf>



How Deep is the Sea? Let's discover shapes and sizes of your sea... and beyond!



ONE BIG OCEAN

- ☐ Ocean floor
- ☐ Plate tectonics
- ☐ Sea level
- ☐ Shape & Size