OCEAN CURRENTS AND CLIMATE

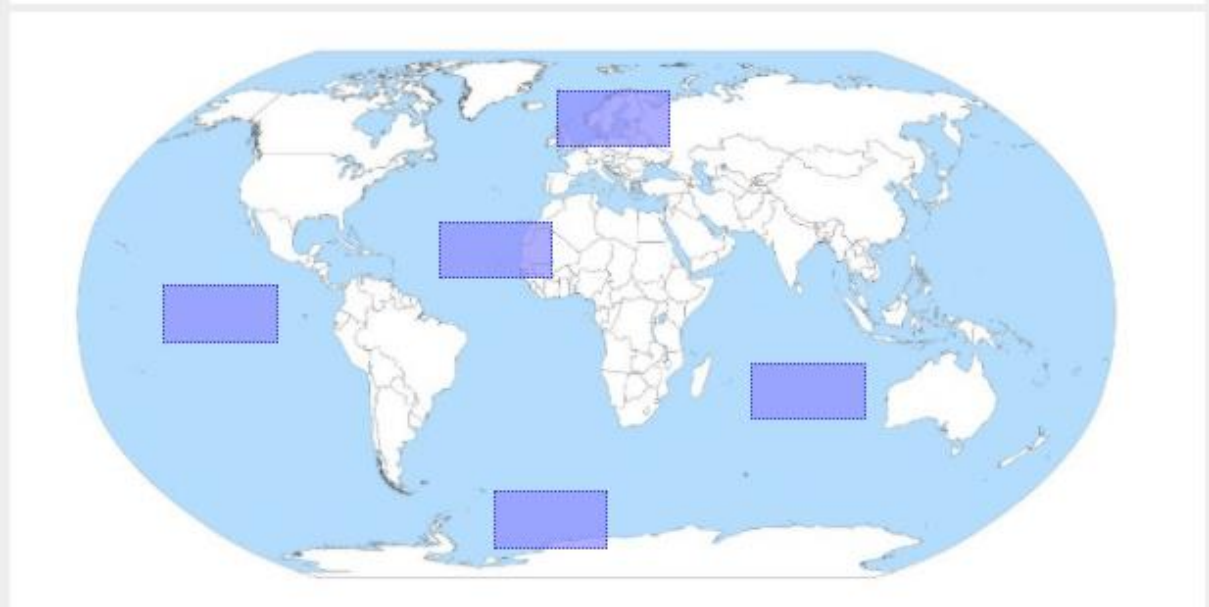
Learn all bout the most spectacular dance of water on our planet. No matter where you live: they affect your life every day!

Introduction

Oceans may seem calm, but they are not like bowl of soup: water is on the move, affecting your climate and your local ecosystem. Ocean currents, abiotic features of the environment, are continuous and directed movements of ocean water. These currents are on the ocean's surface and in its depths, flowing both locally and globally.
Do you know all the oceans?
While there is only one global ocean, the vast body of water that covers 71% of the Earth is geographically divided into distinct named regions. The boundaries between these regions have evolved over time for a variety of historical, cultural, geographical, and scientific reasons.

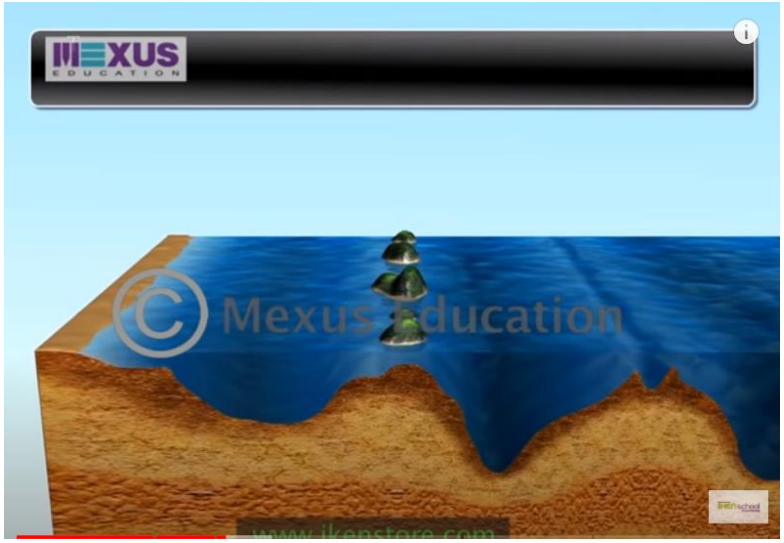
Historically, there are four named ocean basins: the Atlantic, Pacific, Indian, and Arctic. However, most countries - including the United States - now recognize the Southern (Antarctic) as the fifth ocean basin. The Pacific, Atlantic, and Indian are the most commonly known.
The Southern Ocean is the 'newest' named ocean basin. The boundaries of this ocean were proposed to the International Hydrographic Organization in 2000.

TASK: Sign put the names of the oceans in the right places on the map



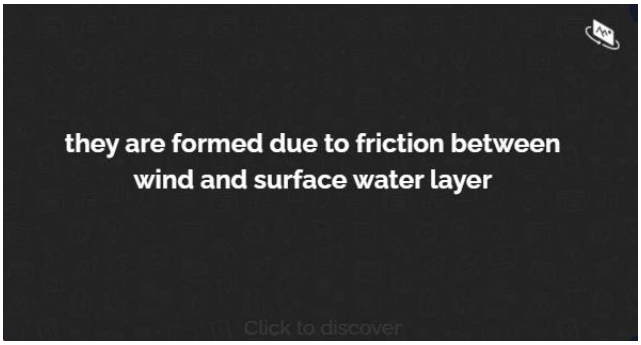
EDU-ARCTIC 2: from polar research to scientific passion – innovative nature education in Poland and Norway receives a grant of ca. 240 000 EUR received from Iceland, Liechtenstein and Norway under EEA funds. The purpose of the EDU-ARCTIC 2 project is to: enhance the knowledge about nature, geography, natural resources, political specificities concerning polar regions and increase awareness of environmental issues and climate change, increase of interest in pursuing STEM education and careers due to enhancement of knowledge about scientific research, and their place in the modern world, familiarizing young people with scientific career opportunities; introduce innovative tools by way of an e-learning portal and effective methods of teaching science in schools

[VIDEO MATERIAL: Learn about Tides, Ocean Currents and Waves]



LINK TO THE VIDEO: https://youtu.be/l1WF8b6HZLM

The movements that occur in oceans are categorized as: waves, tides and currents. You also may have heard of tsunamis. Check if you recognize differences between them.



WAVES

they are a temporary rise in level of the water body due to the gravitational pull of Moon and the Sun

TIDES

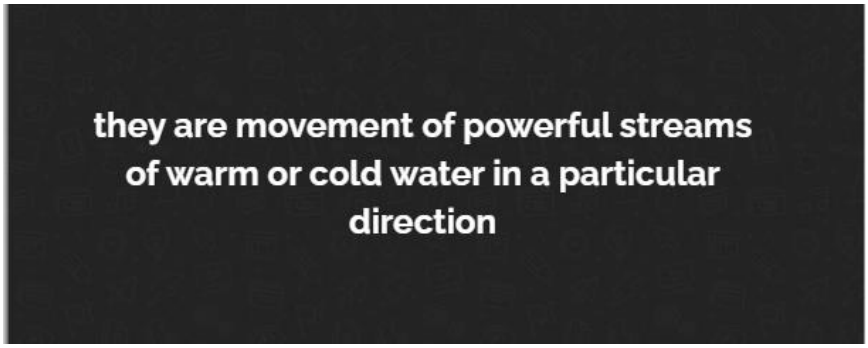
they die out quickly on reaching the shore or shallow waters

WAVES

they are caused by displacement of large masses of water

TSUNAMIS

TSUNAMIS



OCEAN CURRENTS

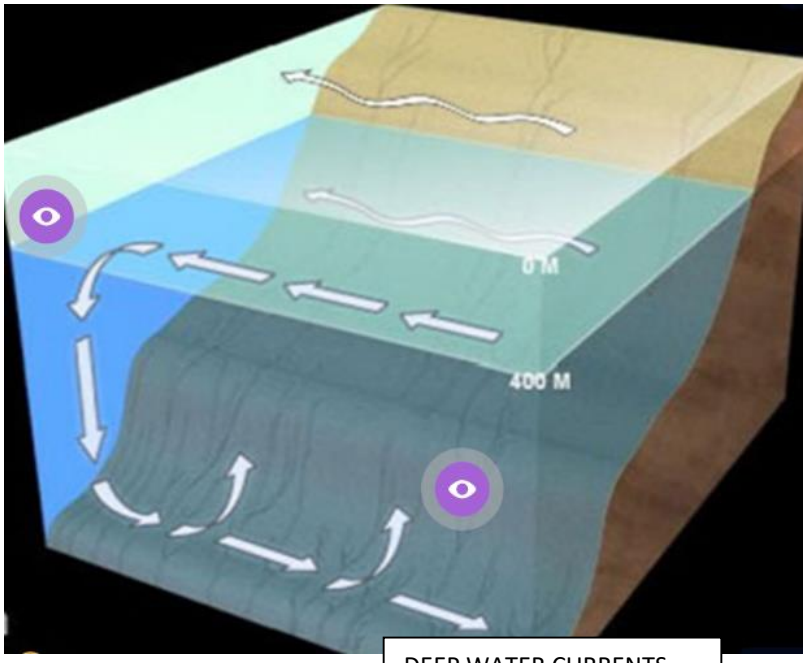
LINK TO FLASHCARDS:
https://view.genial.ly/5f33cc3a9a67350d7bac4b09/game-action-water-movements

INQUIRY

Learn:
*how currents are formed, *how do they work, where are they, *what is their role, *how they influence our lives and what is their relation with climate.

What makes water move: Meet the forces the influence ocean currents.
Check out the presentation (pdf).

SURFACE CURRENTS



DEEP WATER CURRENTS

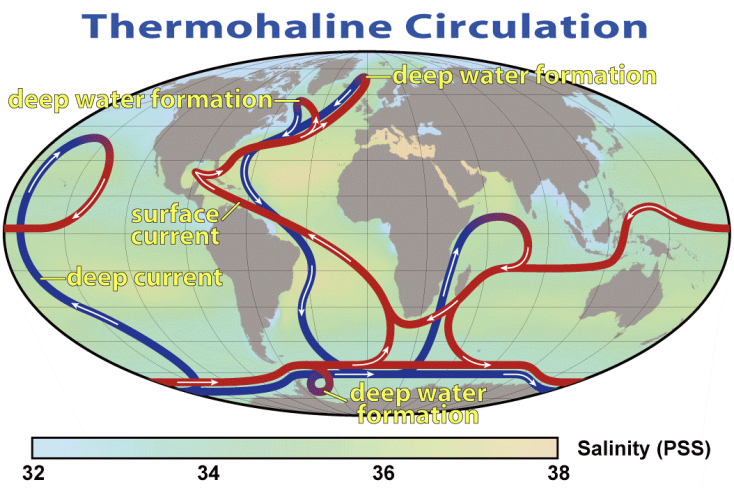
Surface currents refer to movement of the top layer of ocean water – the upper 400 m – primarily driven by wind. The large-scale circulation of these surface currents roughly mirrors the large-scale circulation of air, which most simply derives from unequal heating of the planet's surface by the sun. Currents form rotating systems in the middle of major ocean systems called gyres. Like the winds controlling them, these surface currents help redistribute heat at a planetary scale: Generally speaking warm water flows toward the poles and cold water flows toward the equator.

Deep-water currents describe water movement patterns far below the ocean's surface and the influence of the wind. Instead of airflow, these currents primarily arise from variations in the density of seawater, controlled by its temperature and salt content (salinity). Their movement forms thermohaline circulation ("thermo" meaning temperature, "haline" meaning salinity) which crosses ocean basins and links to surface currents in what's called the "global conveyor belt."

THERMOHALINE CIRCULATION

What is the mechanism of THERMOHALINE circulation? Temperature and salinity independently affect water's density. The colder and saltier the water, the denser it becomes. As water becomes denser, it sinks.

Fun fact: Global thermohaline circulation is a relatively slow process. Radiocarbon measurements show that deep water in the ocean is replaced by new bottom water only every 600 years!



Link to video presentation explaining how global conveyor belt works: https://view.genial.ly/5f2806055270ea0d99cd2b96/video-presentation-global-conveyor-belt-in-a-nutshell

EXPLAIN MECHANISM OF THERMOHALINE CIRCULATION

Watch a video presentation and use the tool below to explain physical mechanism of thermohaline circulation, an engine to global conveyor belt. Example of a sentence: WHEN the temperature gets higher, THEN we use more electricity for air conditioning.

Parts of sentences to build from:

WHEN:

the water gets very cold
the water sinks
the water gets colder and saltier
the water is denser
sea ice is formed

THEN:

it freezes
water around gets saltier
it gets denser
it sinks
it is replaced by warmer water from the south

WHEN ……., THEN ……
WHEN ……., THEN ……
WHEN ……., THEN ……
WHEN ……., THEN ……

WHEN ……., THEN ……

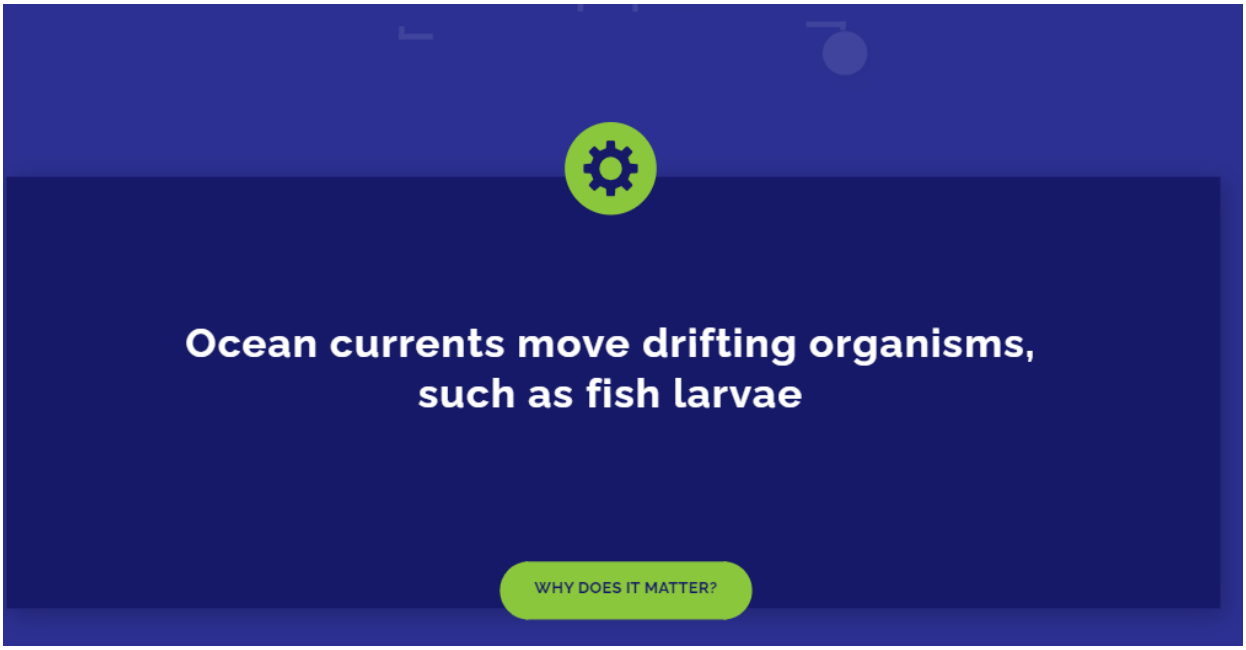
BUILDING A CONCEPT MAP-THERMOHALINE CIRCULATION AND ITS IMPORTANCE

Why is thermohaline circulation so important?. Used predefined concepts (different phenomena, their causes and results) and show links between them, by creating a CONCEPT MAP. Can you identify any LOOPS? You can add your own concepts.

CONCEPTS TO USE:

global warming	**Gulfstream weakened**	**transport of nutrients disrupted**	**less primary production**	**changes in fishery**	**weakened climate lag**
less sea ice	**colder winters**	**world's food chain disrupted**	**less salty water in the north**	**slowed transport of eggs or larvae**	**global heat transport disrupted**
circulation slowing	**hot summers**	**sea ice melting**	**warmer water in the north**	**less carbon fixation**	……

DISCOVER ROLE OF OCEAN CURRENTS IN GLOBAL ECOSYSTEM

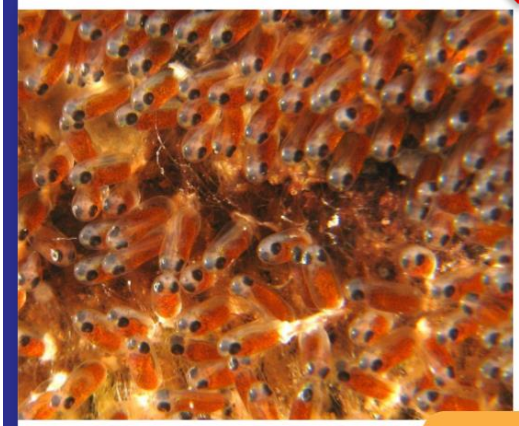


When hatched, the larvae have a large yolk-sac and cannot swim very well. Thus during their early stages the larvae may be passively carried by the water currents
Examples: eel, salmon

WHAT ELSE?

Ocean currents enable external fertilization

WHY DOES IT MATTER?

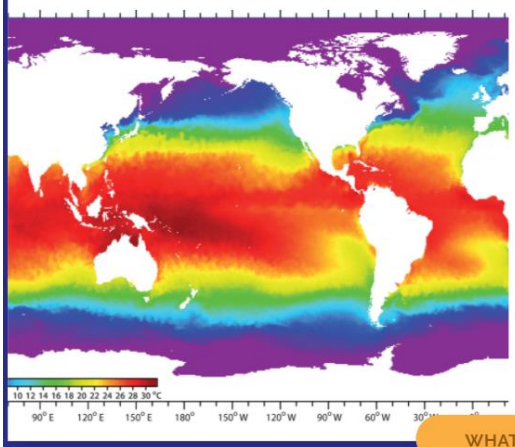


External fertilization is a mode of reproduction in which a male organism's sperm fertilizes a female organism's egg outside of the female's body. Water movements carry sperm/eggs.

WHAT ELSE?

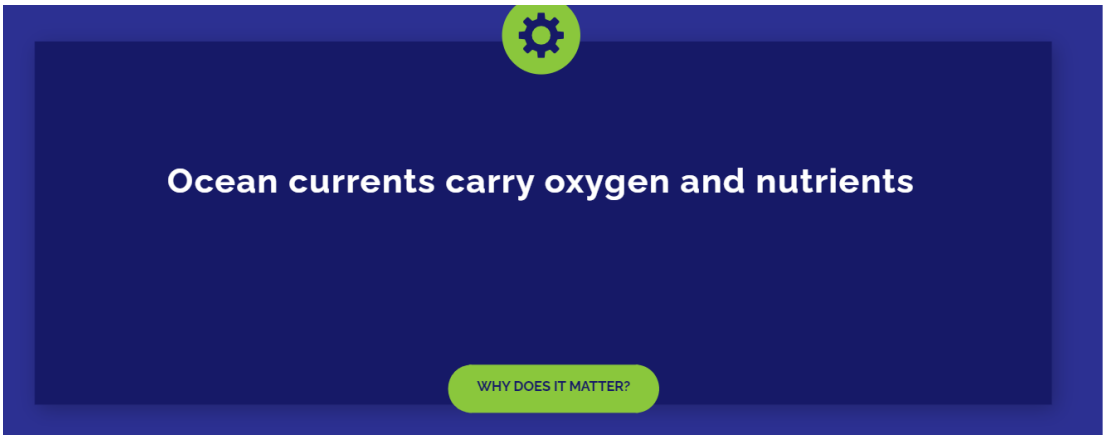
Ocean currents transport heat

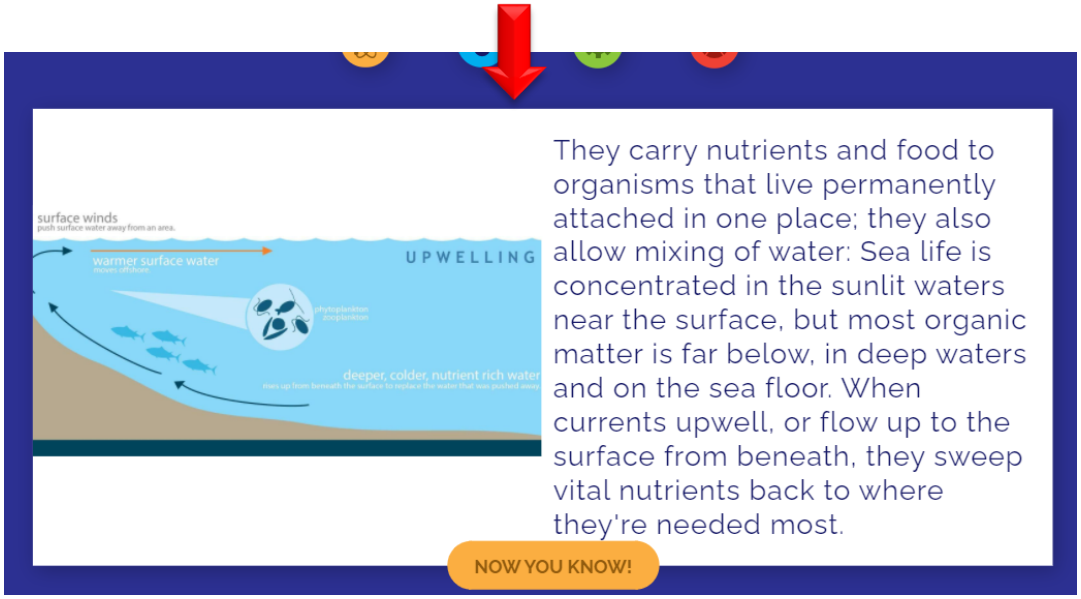
WHY DOES IT MATTER?



Currents account for about 40% of global heat transport. Currentt transport heat from equator towards the poles, regulating Earth's climate

WHAT ELSE?





LINK TO ONLINE FLASHCARDS: https://view.genial.ly/5f314628e948420d8267a520/game-action-why-are-ocean-currents-important

How does climate change affect ocean currents? The global conveyor belt is a strong, but easily disrupted process. Research suggests that the conveyor belt may be affected by climate change. If global warming results in increased rainfall in the North Atlantic, and the melting of glaciers and sea ice, the influx of warm freshwater onto the sea surface could block the formation of sea ice, disrupting the sinking of cold, salty water. This sequence of events could slow or even stop the conveyor belt, which could result in potentially drastic temperature changes in Europe.

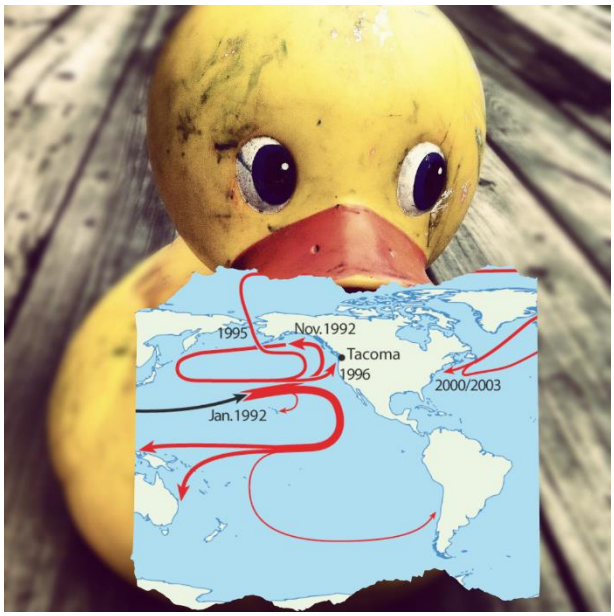
BECAUSE OF CLIMATE CHANGE

Research

Researchers study ocean currents for many reasons. They want to know how their patterns change, but sometimes there's an emergency that requires us to know what happens in the ocean. This became evident in 2010 during Deepwater Horizon Oil Spill when predicting how ocean currents would carry the spilled oil was critical to a fast clean-up. As the spill continued to grow, disaster response teams needed to know where the oil was going to end up. What kind of equipment do they use?

READ the article "Five methods of tracking the ocean" and fill in the table. (pdf version enclosed).
LINK TO THE ARTICLE ONLINE: https://ocean.si.edu/conservation/gulf-oil-spill/five-methods-tracking-oceans-motion

	What is it?	How does it work	What are the advantages?
GPS drifters			
Acoustic Doppler Current Profiler			
Planes			
Aerostat			
Drones			



Sometimes some incredible coincidences or seemingly unrelated events contribute to science. For ocean currents research, that was the case. On a stormy January night in 1992, out in the Pacific Ocean, 28,000 plastic yellow ducks, blue turtles and green frogs fell from a cargo ship from China and were lost at sea. The plastic animals then have proved most valuable for scientific research of great ocean currents - the so-called engine of the planet's climate.
Since the incident, the yellow ducks have moved halfway around the world. Some have washed up on the shores of Hawaii, Alaska, South America, Australia and the Pacific Northwest; others have been **found frozen in Arctic ice.**
The charismatic duckies have even been christened with a name, the "Friendly Floatees," by devoted followers who have tracked their progress over the years!

How do ocean currents work? Dive into the science of ocean currents (including the Global Conveyor Belt current), and find out how climate change affects them.
LINK TO VIDEO: https://youtu.be/p4pWafuvdrY

Scientists are trying a new, interactive way to understand ocean current data with the help of high-resolution global ocean simulations. In the part of the global visualization shown, the Gulf Stream features prominently. Surface water speeds are shown ranging from 0 meters per second (dark blue)

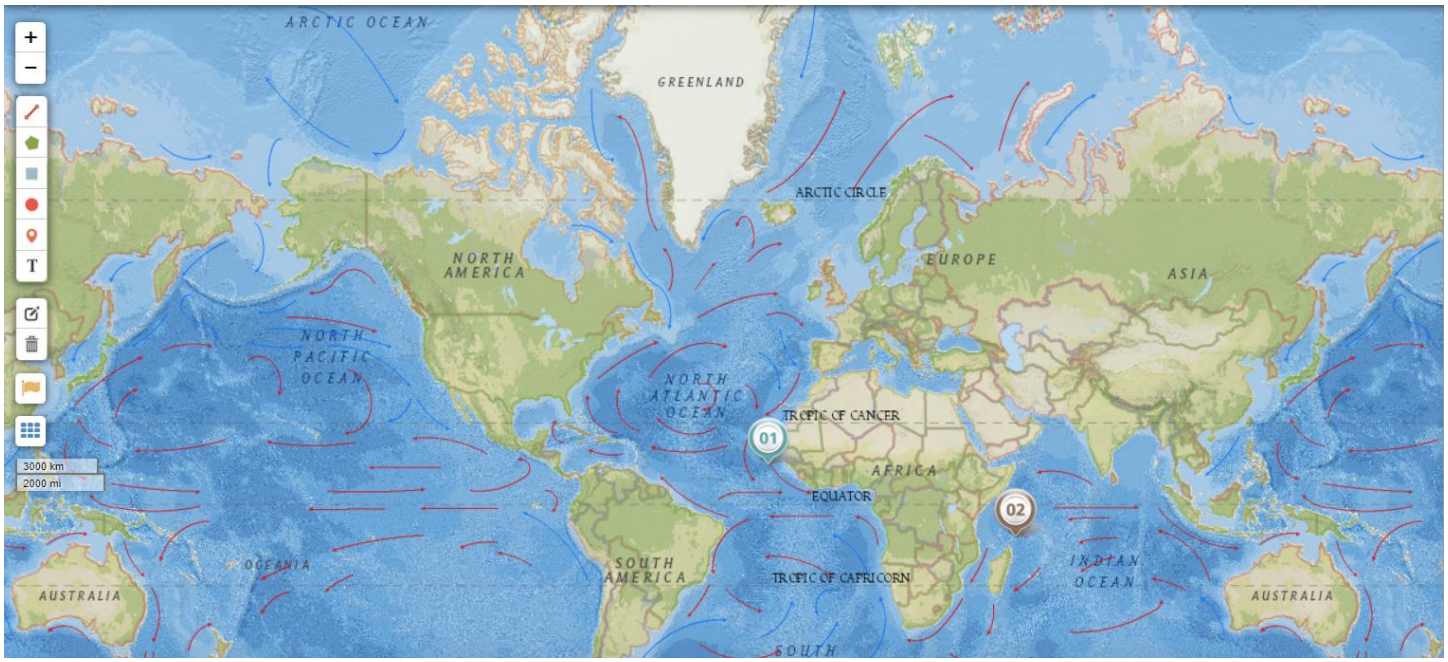
to 1.25 meters per second (cyan). The video is running at one simulation day per second. A team from the NASA Advanced Supercomputing (NAS) facility at Ames Research Center in Silicon Valley has developed a new visualization tool that is being used by researchers from the Estimating the Circulation and Climate of the Ocean project to study the behaviour of ocean currents. The new visualization tool provides high-resolution views of the entire globe at once, allowing the scientists to see new details that they had missed in previous analyses of their simulation, which was run on NASA's Pleiades supercomputer.

LINK TO VIDEO: https://www.youtube.com/watch?v=0PiCPbrXmis&feature=youtu.be
Video credit: NASA/Ames Research Center/David Ellsworth

Now it's time to play with maps. Use National geographic MapMaker interactive.
LINK TO ONLINE VERSION: https://mapmaker.nationalgeographic.org/#/

First choose BASE MAP - OCEANS, then press Add Layer and choose "Ocean Surface Currents" layer (from "Water" group of layers). Then turn on coordinates and find two locations (mark them as 1 and 2) 1: 18N 22W, 2: 2S 52E. 1 is a place when a little rubber toy fell into t (choose "draw a polyline" option, taking surface currents into account. How long is your route [km]? Compare your routes with other students!

You can also perform this exercise offline. Here's the map with 2 locations marked. Look at the scale. Draw your route and calculate the distance.



Let's do some calculations!

The distance between the wave crests is 10 m. The speed of waves is 1 m/s. How many times will the wave touch your feet if you stand by the shore for 1 minute?

[REMINDER: $V=\lambda*f$, where V= wave velocity, f=frequency [Hz=1/s], λ=wave length

TIP: 1 minute=60 seconds

You need to find FREQUENCY (how many times per second will the wave hit the shore x60)

Wave length is the distance between the wave crests

$f=V/\lambda$ ....]

.....

Do you know names of all the currents?

Look at the map with marked currents. What happens to North Atlantic Drift when it passes northern Europe? Can you spot GYRES? If you want to remember some names of famous currents, solve the WORDSEARCH. Which of these currents are warm, which are cold and why?

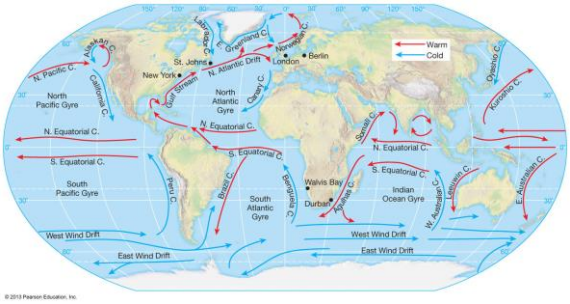
Remember: COLD currents are colder than surrounding water. WARM currents are warmer than surrounding water.

Ocean currents

A	A	B	E	N	G	U	E	L	A	L	U
R	C	B	F	U	L	F	C	B	S	E	C
R	I	L	A	B	R	A	D	O	R	G	A
A	T	N	D	T	N	N	A	N	A	U	L
L	N	M	L	O	T	U	L	L	S	S	I
A	A	S	A	S	L	N	A	I	A	H	F
S	L	D	U	E	C	F	O	L	O	N	O
K	T	A	T	S	R	R	B	F	C	N	R
A	A	R	B	I	O	T	B	T	I	I	N
F	H	A	A	R	C	R	S	O	L	R	I
A	T	A	I	F	A	L	T	F	B	T	A
R	R	A	T	Z	S	U	C	N	L	C	A
O	O	L	I	T	R	T	C	B	M	U	T
I	N	L	L	T	L	L	A	S	A	A	G

GULFSTREAM
LABRADOR
ALASKA
CALIFORNIA
NORTHATLANTIC
BRAZIL
BENGUELA

LINK TO ONLINE VERSION OF WORDSEARCH: https://thewordsearch.com/puzzle/1355077/ocean-currents/



Watch demonstration and do-it-yourself experiment about how hot and cold currents mix.
LINK TO VIDEO: https://youtu.be/A2nEh0Zlqo8

Now it's time for you to do some hands-on experiment. Check what you need and write down what you observe! Your task is to recreate GLOBAL CONVEYOR BELT. Use instructions from “Experiment scenario” file. Write down your observations:

……
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Play the fun game: GO WITH THE FLOW! In this ocean currents game, prepared by NASA, use heat and salt to float your sub to the treasure! Remember: Salt makes water heavier, so it sinks. Heat makes water lighter, so it rises.

LINK TO ONLINE GAME: https://spaceplace.nasa.gov/ocean-currents/en/

Check out how much you know about the currents and solve the quiz!

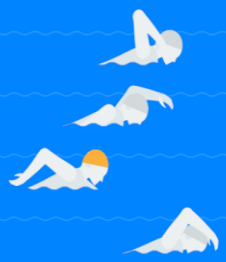
1. Surface currents are a result of

Global Wind Patterns | Density | Landscape

2. The Coriolis Effect is caused by

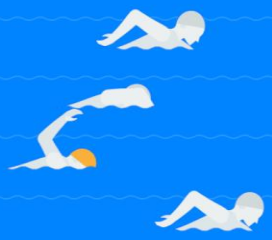
Earth rotating around the sun | Earth rotating on its axis | Gravity

3. Due to the Coriolis Effect, water in the northern hemisphere moves



clockwise | counter clockwise | towards equator

4. Ocean currents have an effect on



poles and equator | earthquakes | climate and weather

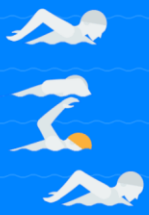
5. A strong surface current that runs along the east coast of the United States and carries warm water to Europe

Surface current | Conveyor belt | Gulf Stream

6. Why are surface currents at the surface of the ocean?

colder temperature & more salinity | warmer temperature & less salinity | because of ocean bottom landscape

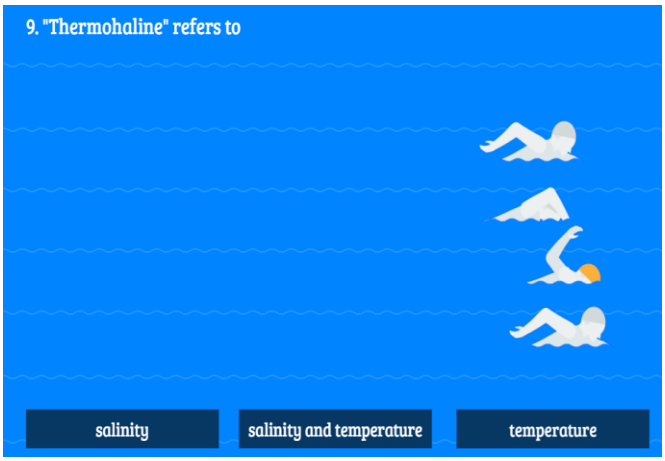
7. How much global heat do ocean currents transfer?

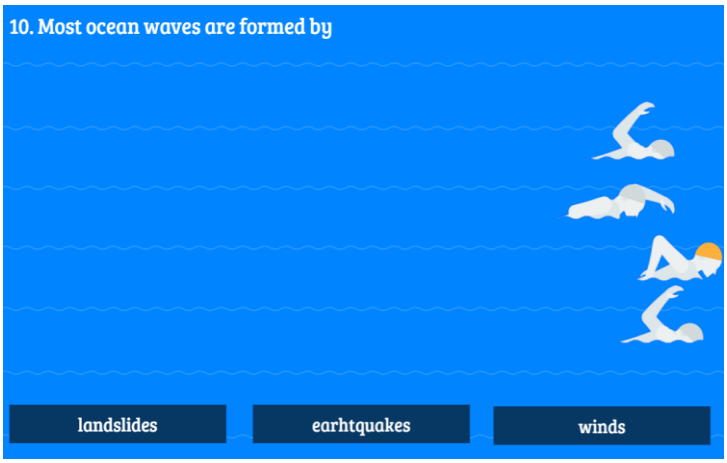


40% | 10% | 5%

8. What is the oceans' influence on climate

they make it dry | they moderate it | they make it more varied



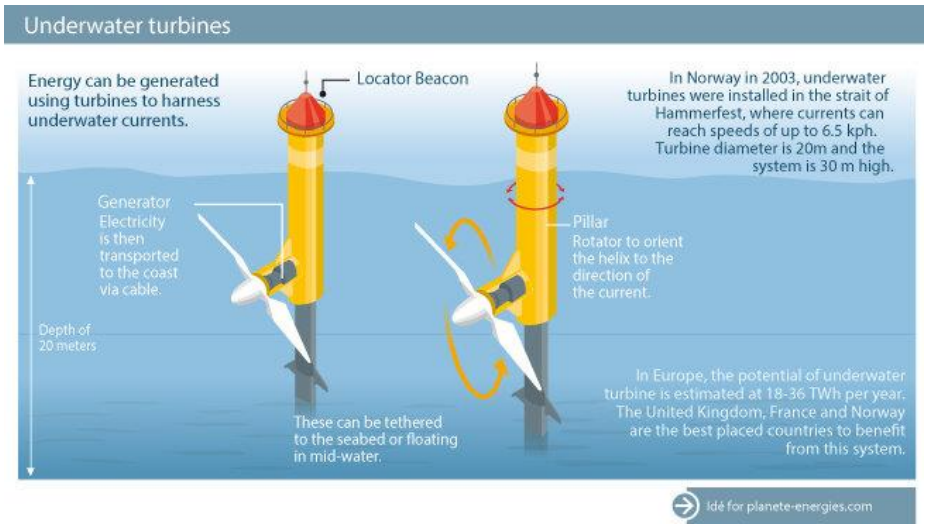


LINK TO ONLINE QUIZ: https://view.genial.ly/5f325f8de948420d8267aa54/game-ocean-currents

Ideas

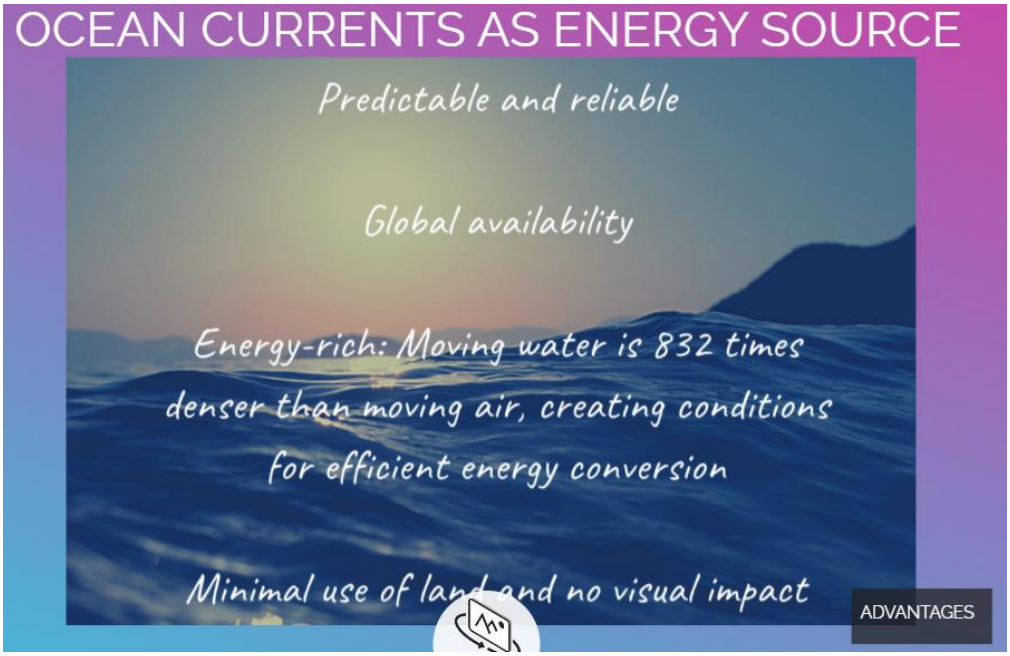
The relatively constant flow of ocean currents carries large amounts of water and energy across the earth's oceans. Would it be possible to harness and use this renewable energy? The total energy flux has been estimated at 280 trillion watt-hours. Preliminary surveys show a global potential of over 450,000 MW. Because of their link to winds and surface heating processes, the ocean currents are considered as indirect sources of solar energy. Relative to wind, wave, and tidal resources, the energy resource potential for ocean current power is the least understood, and its technology is the least mature and only experimental at that point. It is estimated that in Europe The United Kingdom, France and Norway are best placed to benefit from this type of energy.

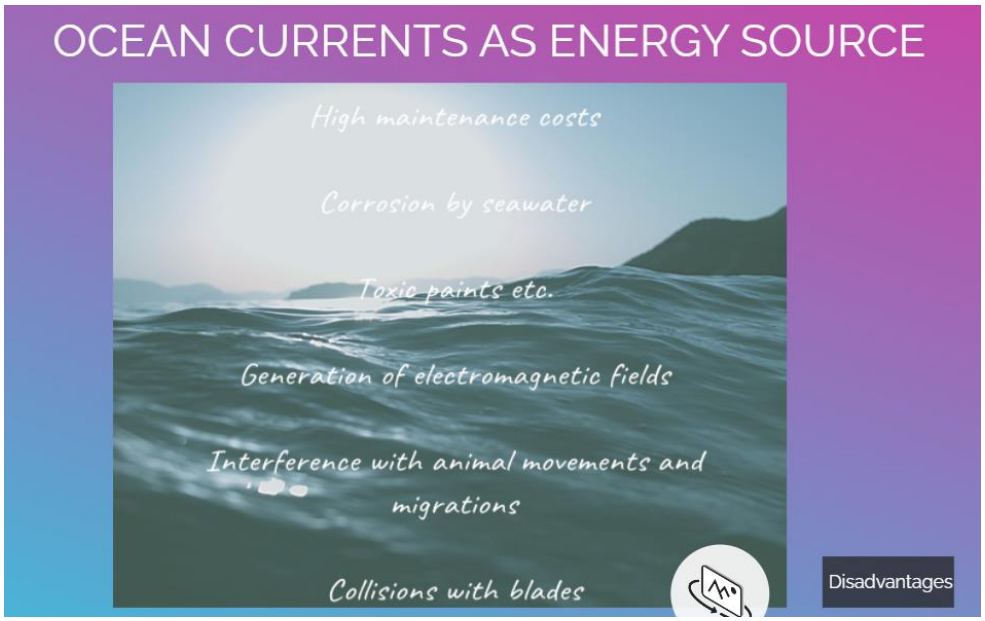
Look at underwater turbines:



Should we use ocean currents as energy source? PROs and CONs.

Check the images to learn about advantages and disadvantages of use of ocean currents as energy source. Do you governments should invest in such form of renewable energy? Discuss, using your own and given arguments.





Wrap up

Let's wrap-up: fill in the blanks to complete the sentences. Then read the full text.

An ocean current is any more or less permanent or continuous, _____ movement of ocean water that flows in one of the Earth's oceans.

The currents are generated from the _____ acting upon the water like the earth's _____, the wind, the temperature and _____ differences and the _____ of the moon.

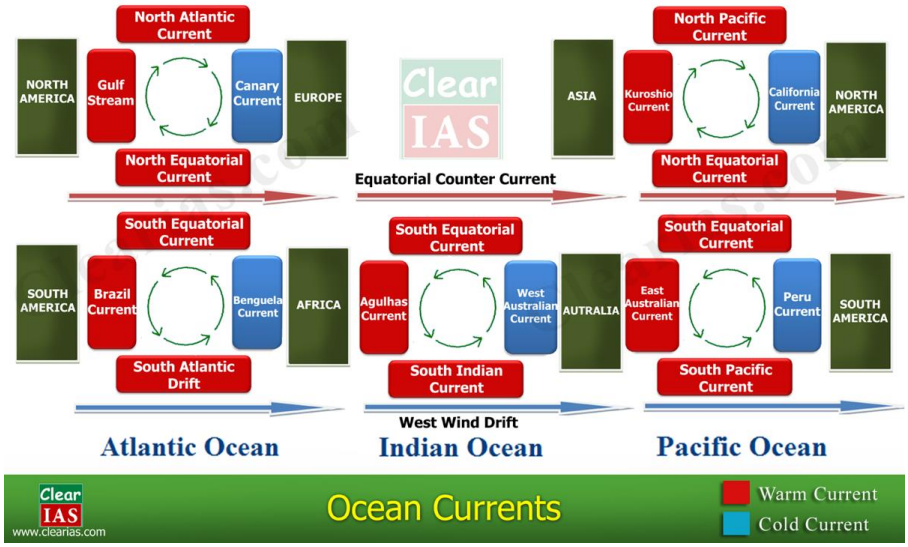
The depth contours, the shoreline and other currents influence the current's direction and strength.

Ocean currents can flow for thousands of kilometers.
They are very important in determining the _____ of the continents, especially those regions _____ on the ocean.
Perhaps the most striking example is the _____, which makes northwest Europe much more temperate than any other region at the same _____.
_____ ocean currents are driven by density and _____ gradients.
Thermohaline circulation, also known as the ocean's _____ belt, refers to the deep ocean density-driven ocean basin _____.

bordering	climates	currents	deep	directed	forces
Gulf Stream	latitude	rotation	salinity	temperature	gravitation

Can you recognize a current?

Look at the scheme of ocean currents system. Note the loops (gyres) and how they rotate in opposite directions in southern and northern hemispheres.



Can you spot if current's name fits the description? Use the scheme to help you solve the quiz:

I'm a warm current in southern hemipshere, in Atlantic Ocean. I am Agulhas Current.

TRUE FALSE

I am a current near North America. I originate in North Pacific, but then I got cold. I am California Current.

TRUE FALSE

I make south coast of North America warmer. I am Kuroshio current.

TRUE FALSE

What are 3 main things you'd like to carry with you after these activities? Imagine you are a representative of Earth during a Universe Council meeting. You have to convince the Council that ocean currents are very important. Write the arguments below.

……

……

……

……
……

Time to discuss

After all you've learned about, consider the following issues. You can discuss in group and/or insert your individual thoughts:

1. Why is ocean currents' energy considered form of solar energy?

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2. Why is it that rich fisheries often occur where different currents meet?

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3. What is the role of ocean currents in transporting pollutants? Does it influence the environment in a negative or positive way, or maybe both?

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