Exploring the Ocean currents in circular bioeconomy

Co-funded by
the European Union

BioBeo

Information

BioBeo Bioeconomy Definition:

"Bioeconomy is a systems-based approach that seeks to replace fossil resources in a sustainable manner with renewable biological resources from terrestrial and marine ecosystems – such as forests, crops, animals, fish, microorganisms, organic waste, and agricultural side streams, to produce food, feed, fibres, energy, bio-based products, and services within a circular economy framework designed to optimise resource use based on a cascading hierarchy of utilisation options. A sustainable and circular bioeconomy requires the application of education and training programmes, scientific research, technology, and innovation with the aim of not only creating economic value, but also regenerating and expanding ecosystems and biodiversity as well as improving the health and the well-being of society. By addressing these systemic changes in the economy, environment, and society, the bioeconomy contributes to achieving a better and more sustainable future where no one is left behind."

Organisation: **E3STEM**

Country: **GREECE**

Topic: Exploring the Ocean currents

Narrative: The oceans are increasingly affected by human activity, including acidification, plastic waste, over-fishing, and oil/gas extraction. Ocean currents absorb heat from the atmosphere, but this absorption depends on the motion of ocean currents and scientists consider that the continuously warming climate will affect this motion. The decrease in ocean circulation could have wide-reaching impacts on sea levels and fish populations and adversely affect the global climate (from https://learn.microsoft.com/en-us/training/educator-center/instructor-materials/explore-ocean-currents).

Methodology/ies: Active Learning, Guided Discovery, Inquiry Based Teaching and Learning

SDG: 12 (Responsible Consumption and Production), 13 (Climate Action)

Age group: Secondary Education (age 12 – 18)

Curriculum integration: Environmental Sciences, Geography, Biology, Chemistry, Physics

The following themes are addressed by this Material:

	Interconnectedness ☒	**Interconnectedness** reflects the role of the biosphere and natural environments in human well-being and holistic health and the undisputed ecological interconnectedness of all living things.
	Outdoor learning ☐	**Outdoor learning** is active learning in the outdoors where participants learn through what they do, through what they encounter and through what they discover.
	Food Loop ☐	**Food Loop** encompasses farming, hospitality, retail, and energy production sectors. In terms of the circular economy, it focuses on the efficient use of by-products, and the overall reduction of food waste.
	Forestry ☐	Whilst **forestry** products are increasingly attractive in terms of sustainability, and are a major part of the circular economy, there are massive global disparities in the governance of forestry activity.
	Life Below Water ☒	**Life below water** refers to the conservation and sustainable use of all water bodies (like oceans, and marine resources but also rivers and lakes) for sustainable development.

Learning outcomes

Lesson 1

1. To understand the impact of salinity and temperature on the density and stratification of water bodies.
2. Understand how density differences lead to stratification in the ocean.
3. Apply this knowledge to real-world phenomena such as ocean stratification, nutrient exchange, and the effects on marine life.
4. To gain a greater awareness of environmental issues related to oceanography and the importance of understanding physical processes in the ocean for predicting and mitigating the effects of climate change in the context of circular bioeconomy.

Learning outcomes

Lesson 2

1. Understand the formation of ocean currents and how they are influenced by temperature changes.
2. Understand the formation of ocean currents using simple materials.
3. Understand how altered ocean currents lead to changes in connectivity and temperature regimes that contribute to lack of food for corals and hampers dispersal of coral larvae. Ocean acidification (a result of increased CO2) causes a reduction in pH levels which decreases coral growth and structural integrity.
4. Understand that when the current is stronger, it carries more cool water to the surface, and when it's weaker, water on the surface is warmer. As the corals sit on the reef, building their skeletons, they record changes in water temperature caused by current shifts.
5. Develop critical thinking skills to understand the challenges associated with the changes in ocean currents and how these affect living organisms and the circular bioeconomy.

Learning outcomes

Lesson 3

1. To be able to explain the concept of convection and how it occurs under ice.
2. Students will enhance their observational skills, keenly noting the changes and patterns in water movement beneath the ice surface.
3. To gain a greater awareness of environmental issues related to oceanography and the importance of understanding physical processes in the ocean for predicting and mitigating the effects of climate change in the context of circular bioeconomy.

Lesson Plan 1

Subject(s): Environmental Sciences, Geography, Biology, Chemistry, Physics	**Title of Lesson:** Exploring the Ocean currents in circular bioeconomy - Effects of salinity and temperature on density and stratification **No. of Lesson** 1 of 3	
Date: Autumn term 2023	**Class:** Secondary Education (ages 16 – 18)	**Time:** 10.00 am – 2.00 pm **Duration:** 4 hours
BioBeo Theme: Life Below Water, Interconnectedness	**Keywords/Phrases:** ocean currents, movement of water, salinity, pH, living organisms	

Learning Outcomes:

1. To understand the impact of salinity and temperature on the density and stratification of water bodies.
2. Understand how density differences lead to stratification in the ocean.
3. Apply this knowledge to real-world phenomena such as ocean stratification, nutrient exchange, and the effects on marine life.
4. To gain a greater awareness of environmental issues related to oceanography and the importance of understanding physical processes in the ocean for predicting and mitigating the effects of climate change in the context of circular bioeconomy.

Resources/Materials/Equipment:

- Rectangular tank with a divider
- Bottle containing pre-made salt solution (approximately 75 g salt dissolved in 1 L water)
- Food coloring (two different colors)
- Ice
- Beakers

Introduction:

This activity demonstrates that fluids arrange into layers according to their densities. In the ocean, this stratification forms an effective barrier for the exchange of nutrients and dissolved gases between the top, illuminated surface layer where phytoplankton can thrive, and the deep, nutrient-rich waters. This has important implications for biological and biogeochemical processes in the ocean. For example, periods of increased ocean stratification have been associated with decreases in surface phytoplankton biomass. In coastal waters, prolonged periods of stratification can lead to hypoxia (low oxygen), causing mortality of fish, crabs, and other marine organisms.

1. Brainstorming / Discuss the formation of ocean currents
   [20 minutes]

Method: Brainstorming

Use a video as a trigger to introduce the formation of ocean currents.

https://www.youtube.com/watch?v=ygI1B7h2j_0&ab_channel=OfficersIASAcademy-India%27sOnlyIASAcademy

and https://www.youtube.com/watch?v=f2evaLaDvCI&ab_channel=BeSmart

Development:

1. **Engage** – Students read the article-use of resource "How does climate change affect coral reefs?" And watch three videos to realize the interrelationship between ocean currents and fish population. Engagement in Sustainability
   [40 minutes]

   Method: Inquiry based learning

   Use this article https://oceanservice.noaa.gov/facts/coralreef-climate.html#:~:text=Altered%20ocean%20currents%3A%20leads%20to,coral%20growth%20and%20structural%20integrity ,

   and the videos
   https://climatekids.nasa.gov/ocean/#:~:text=As%20Earth's%20climate%20warms%2C%20the,or%20stop%20in%20some%20places

   https://coastalscience.noaa.gov/project/ocean-currents-connect-coral-reefs/

   https://www.fisheries.noaa.gov/topic/sustainable-seafood

   as a catalyst to engage the students in the concept of how the climate change is affecting the ocean currents and how these changes dramatically affect coral reef ecosystems and fish resources

2. **Explore** - Students in groups conduct an unplugged experiment to see the effect of salinity and temperature in ocean currents.
   [45 minutes]

   Method: Inquiry based learning
   Scientific question: How might the effects of climate change, such as warming and melting of sea ice, affect the vertical structure of the water column?

   The teacher divides the class into groups of 3 or 4 students. Each group reads the article "Teaching Physical Concepts in Oceanography An Inquiry-Based Approach" teaching_phys_concepts.pdf (tos.org) and makes a presentation of the outcomes of the experiments. Students discuss scientific questions in their group.

3. **Explain** - Students explain the results of the unplugged experiments.
   [45 minutes]

   Method: Inquiry based learning

Each group use presentations to explain their findings (per group).

4. **Elaborate** - Students study the Current strength sheet in the Ocean currents workbook. This workbook utilizes real-world data to show how the Atlantic Meridional Overturning Circulation (AMOC), a system of currents in the Atlantic Ocean that is part of the great ocean "conveyor belt," has changed over time(From https://learn.microsoft.com/en-us/training/educator-center/instructor-materials/explore-ocean-currents)
   [90 minutes]

   Method: Inquiry based learning

   Each group makes a presentation for the data related to salinity and temperature.

Experimental Procedure

1. Fill a beaker with tap water.
2. Place water from the beaker in one compartment of the tank and water from the salt-solution bottle in the other. Add a few drops of one food coloring to one compartment and a few drops of the other food coloring to the other compartment. Students are asked to predict the outcome when they remove the divider between the compartments and explain their reasoning.
3. Measure the densities of the room-temperature tap water and the salt solution.
4. Test your prediction by removing the tank divider. What happens? Are your observations consistent with the densities you measured?
5. Empty the tank and fill one beaker with hot tap water and one beaker with ice-cold water and repeat the steps (instead of the tap and salt water). After removing the divider and observing the new equilibrium in the tank, place your fingertips on top of the fluid surface and slowly move your hand down toward the bottom of the tank. Students should feel the temperature change.

Outcome of the Experiment

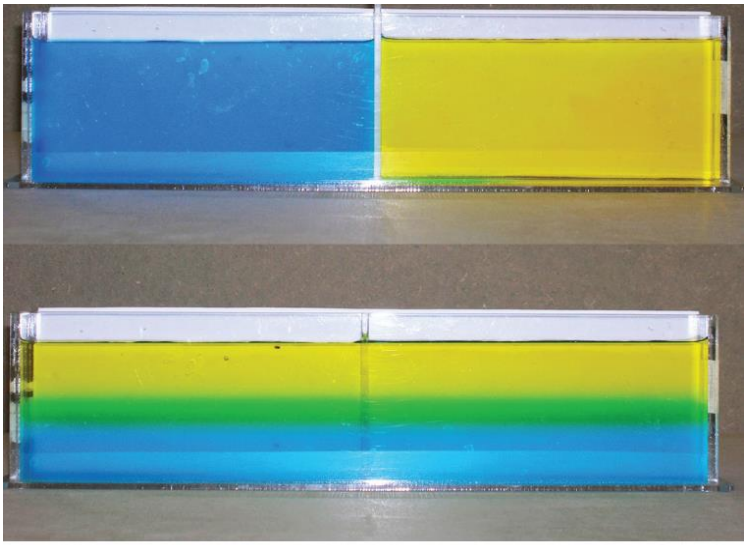

Figure 1 - The outcome of the experiment. Salt(hot) corresponds to the blue color. From Karp-Boss, Lee; Boss, Emmanuel; Weller, Herman; Loftin, James; and Albright, Jennifer, "Teaching Physical Concepts in Oceanography: An Inquiry-Based Approach" (2009). Marine Sciences Faculty Scholarship.195

Conclusion:

The lessons conclude with gathering the class to summarize the learning points and key findings of the activity. Furthermore, the class needs to discuss the ecological implications of the observed relationships between salinity, temperature, density, and stratification and how the observed phenomena relate to real-world ocean stratification, its effects on marine life and on circular bioeconomy.

Reflection on Teaching & Learning:

- Ask students to reflect on what they learned during the lesson.
- Discuss the effectiveness of the activities in enhancing understanding.
- Consider student engagement, understanding and participation.
- Reflect on the process and seek improvements.
- Encourage students to share any challenges faced and propose improvements.

Assessment for Learning:

Evaluate - Students create a video that describes the whole process followed and its impact to some living organisms, like for example Zooxanthellae.
[45 minutes]

Method: Inquiry based learning

The assessment of student understanding can be done also through a mix of formative and summative assessments.

- Evaluate students based on their participation as well as use quizzes on the material.
- Group discussions and reflections as informal assessments to gauge individual understanding.
- Assign projects where students research and present on the topic.

Each group creates a video for the impact of the salinity and temperature of ocean currents to living organisms like Zooxanthellae.

Supportive Materials

Parental engagement before implementation

Set clear goals

Before embarking on the exploration of ocean currents and their effects on salinity, temperature, density, and stratification, the teacher initiates a collaborative goal-setting session with parents. The teacher provides an overview of the theoretical and practical aspects of exploring ocean currents, emphasizing their impact on marine ecosystems. Some parents who may be familiar with ocean-related activities or have local knowledge are encouraged to contribute insights on engaging and effective learning methods. Together, parents and the teacher discuss and formulate specific learning goals for the activity, such as understanding the role of ocean currents in nutrient distribution and their influence on marine life. At this stage, parents are invited to express any concerns they may have regarding the implementation of the activity, such as environmental issues or potential challenges.

Organise an Ocean Exploration Excursion or a Visit to an Oceanographic Center

A visit to a local coastal area or an Oceanographic Center could serve as the first step for the exploration of ocean currents, salinity, temperature, density, and stratification. To enhance this experience, an expert in oceanography or marine sciences might accompany parents and children, shedding light on the impact of ocean currents on marine ecosystems and the correlation between salinity and temperature. Discussions may revolve around the consequences of disruptions in density and stratification and the importance of understanding these phenomena for sustainable marine practices. Together, parents and children can delve into the fascinating world of different ocean currents, marine life, and ongoing conservation efforts.

Ocean Current Exploration - Innovative Stratification Model Design

To further enrich the exploration of ocean currents, salinity, temperature, density, and stratification, parents with their children could participate in a hands-on activity, where they collaborate to design models that illustrate the effects of salinity and temperature on oceanic density and stratification.

Parental engagement during implementation

Watch Videos / Brainstorming

By watching selected videos, families can delve into the complexities of oceanographic concepts, and subsequently, discuss their observations and thoughts on how these phenomena impact marine environments.

Role-Playing Expedition

At the exploration stage of the learning process, parents and their children can immerse themselves in a dynamic role-playing game centered around the subject. In this interactive activity, participants will be grouped and assigned various roles representing stakeholders in the oceanography field. Roles may include oceanographers, marine biologists, or environmental advocates, each with unique abilities or goals. While engaged in the game, parents and their children can delve into discussions about the challenges posed by ocean currents, salinity, temperature, density, and stratification, aiming to make informed and responsible choices for the preservation of marine ecosystems.

Educational Displays

At the last stage of implementing the activity (Evaluation stage), parents can help children evaluate the diverse aspects of oceanography. This includes understanding the effects of ocean currents on marine ecosystems, variations in salinity and temperature, and their impacts on density and stratification. Parents and children collaborate to create educational displays or presentations that showcase their insights into the intricate relationships within ocean environments.

Parental engagement after implementation

Engage in Open Science Projects:

By joining in real-world data collection initiatives related to ocean currents, salinity, temperature, density, and stratification will allow parents and children to actively contribute to scientific research. This immersive experience not only reinforces theoretical concepts but also instills a sense of responsibility and connection to ongoing efforts in understanding and preserving the dynamics of ocean environments.

Questionnaire for Parents

Dear parents, thank you for taking the time to complete this questionnaire. We are interested in hearing your feedback on the "Exploring the Ocean currents - Effects of salinity and temperature on density and stratification" educational scenario. Your responses will help us to improve the activity for future students and parents. The questionnaire should take approximately 10 minutes to complete. All your responses will be anonymous and will be used for improvement. Here is the questionnaire:

Activity Feedback

1. Did you like the activity? (Multiple choice: Yes/No/Not sure)
2. Did you find the activity engaging?
   (Likert scale: Strongly agree/Agree/Neutral/Disagree/Strongly disagree)
3. Would you recommend this activity to other parents?
   (Multiple choice: Yes/No/Not sure)
4. How well did the activity incorporate videos and brainstorming?
   (Likert scale: Strongly agree/Agree/Neutral/Disagree/Strongly disagree)
5. How well did the activity incorporate role-playing games?
   (Likert scale: Strongly agree/Agree/Neutral/Disagree/Strongly disagree)
6. How well did the activity incorporate creating educational displays?
   (Likert scale: Strongly agree/Agree/Neutral/Disagree/Strongly disagree)

Further Use of Knowledge

7. Has this activity changed your understanding of the effects of salinity and temperature on density and stratification? (Multiple choice: Yes/No/Not sure)
8. Has this activity influenced your perspective on environmental issues?
   (Multiple choice: Yes/No/Not sure)
9. If so, in what way? (Open-ended question)
10. What kind of learning do you think happened during this activity?
    (Multiple choice: Academic learning, social learning, emotional learning, all of the above)
11. How can we apply this learning in real-world scenarios? (Open-ended question)

Additional Questions

12. What did you like most about this activity? (Open-ended question)
13. What did you like least about this activity? (Open-ended question)
14. Do you have any suggestions for how we can improve this activity in the future? (Open-ended question)
15. How much time did you spend participating in the activity with your child? (Multiple choice: Less than 30 minutes/30-60 minutes/More than 60 minutes)
16. Did you learn anything new from the activity? (Multiple choice: Yes/No)
17. Do you feel more confident in your understanding of the effects of salinity and temperature on density and stratification as a result of this activity?
    (Multiple choice: Yes/No/Not sure)
18. Did you enjoy participating in the activity with your child?
    (Multiple choice: Yes/No/Not sure)
19. Would you be interested in participating in other similar activities with your child in the future?
    (Multiple choice: Yes/No/Not sure)
20. Do you have any suggestions for how we can improve this activity in the future? (Open-ended question)

Literature and links

European Resource Efficiency Knowledge Centre. https://www.resourceefficient.eu/en

European Commission, "Good practice in energy efficiency", COM (2016), 761 final

Franks, P.J.S., and S.E.R. Franks. (2009). Mix it up, mix it down: Intriguing implications of ocean layering. Oceanography 22(1):228–233. Available online at: https://tos.org/hands-on-oceanography (accessed April 23, 2021)

https://learn.microsoft.com/en-us/training/educator-center/instructor-materials/explore-ocean-currents.

How do ocean currents affect on coral reefs.
https://oceanservice.noaa.gov/facts/coralreef-climate.html#:~:text=Altered%20ocean%20currents%3A%20leads%20to,coral%20growth%20and%20structural%20integrity

Karp-Boss, Lee; Boss, Emmanuel; Weller, Herman; Loftin, James; and Albright, Jennifer, "Teaching Physical Concepts in Oceanography: An Inquiry-Based Approach" (2009). *Marine Sciences Faculty Scholarship*.195.

Lesson Plan 2

Subject(s): Environmental Sciences, Geography, Biology, Chemistry, Physics	**Title of Lesson:** Exploring the Ocean currents in circular bioeconomy - Effect of stratification on Mixing **No. of Lesson** 2 of 3	
Date: Autumn term 2023	**Class:** Secondary Education (ages 16 – 18)	**Time:** 10.00 am – 2.00 pm **Duration:** 4 hours
BioBeo Theme: Life Below Water, Interconnectedness	**Keywords/Phrases:** ocean currents, movement of water, salinity, pH, living organisms	

Learning Outcomes:

1. To understand stratification in the context of oceanography and explain how it is caused by differences in temperature and salinity.
2. To understand the impact of stratification on the mixing of water in the ocean. They will be able to explain how changes in temperature and salinity can disrupt or enhance this mixing process.
3. To gain hands-on experience in creating a stratified system and observing the effects of different variables on mixing. This will enhance their understanding of the theoretical concepts discussed in the lesson.
4. Apply this knowledge to real-world phenomena such as ocean stratification, nutrient exchange, and the effects on marine life.
5. To gain a greater awareness of environmental issues related to oceanography and the importance of understanding physical processes in the ocean for predicting and mitigating the effects of climate change in the context of circular bioeconomy.

Resources/Materials/Equipment:

- Tank containing stratified fluid (developed though the previous activity)
- Hair dryer
- Food coloring (two different colors)
- Long pipettes
- Tank containing tap water

Introduction:

Welcome to our activity on the "Effect of Stratification on Mixing." This hands-on experiment will help us explore how temperature and salinity can create different layers in the ocean, and how this stratification affects the mixing of these layers in the context of circular bioeconomy. By the end of this activity, we will have a better understanding of the fascinating dynamics at play beneath the ocean's surface.

Brainstorming / Discuss the formation of ocean currents
[20 minutes]

Method: Brainstorming

Use a video as a trigger to introduce the formation of ocean currents.

https://www.youtube.com/watch?v=ygI1B7h2j_0&ab_channel=OfficersIASAcademy-India%27sOnlyIASAcademy

and https://www.youtube.com/watch?v=f2evaLaDvCI&ab_channel=BeSmart

Development:

1. **Engage** – Students read the article-use of resource "How does climate change affect coral reefs?" And watch three videos to realize the interrelationship between ocean currents and fish population. Engagement in Sustainability
   [40 minutes]

   Method: Inquiry based learning

   Use this article https://oceanservice.noaa.gov/facts/coralreef-climate.html#:~:text=Altered%20ocean%20currents%3A%20leads%20to,coral%20growth%20and%20structural%20integrity ,

   and the videos
   https://climatekids.nasa.gov/ocean/#:~:text=As%20Earth's%20climate%20warms%2C%20the,or%20stop%20in%20some%20places

   https://coastalscience.noaa.gov/project/ocean-currents-connect-coral-reefs/

   https://www.fisheries.noaa.gov/topic/sustainable-seafood

   as a trigger to engage the students in the concept of how the climate change is affecting the ocean currents and how these changes dramatically affect coral reef ecosystems and fish resources

2. **Explore** - Students in groups conduct an unplugged experiment to see the effect of salinity and temperature in ocean currents.
   [45 minutes]

   Method: Inquiry based learning
   Scientific question: How might the effects of climate change, such as warming and melting of sea ice, affect the vertical structure of the water column?

   The teacher divides the class into groups of 3 or 4 students. Each group reads the article "Teaching Physical Concepts in Oceanography An Inquiry-Based Approach" teaching_phys_concepts.pdf (tos.org) and makes a presentation of the outcomes of the experiments. Students discuss scientific questions in their group.

3. **Explain** - Students explain the results of the unplugged experiments.
   [45 minutes]

   Method: Inquiry based learning
   Each group use presentations to explain their findings (per group).

4. **Elaborate** - Students study the Current strength sheet in the Ocean currents workbook. This workbook utilizes real-world data to show how the Atlantic Meridional Overturning Circulation (AMOC), a system of currents in the Atlantic Ocean that is part of the great ocean "conveyor belt," has changed over time(From https://learn.microsoft.com/en-us/training/educator-center/instructor-materials/explore-ocean-currents)
   [90 minutes]

   Method: Inquiry based learning

   Each group makes a presentation for the data related to salinity and temperature.

Experimental Procedure

1. In the tank with the non-stratified water column, use a long pipette to carefully inject a few drops of food coloring at the water's surface. Using the hair dryer, generate "wind". Flowing roughly parallel to the fluid's surface and observe how the dye mixes.
2. With the tank containing the two-layer fluid, use the long pipette to carefully inject a few drops of food coloring at the water's surface and a few drops of a different food coloring at the bottom of the tank. Using the hair dryer, generate a wind similar to the one you generated in the previous step.
3. Compare your observations to what you saw happen in the non-stratified tank.

Outcome of the Experiment

Figure 2 - The outcome of the experiment. Red color corresponds to tap water (before and after the injection of drops) and the right hand side corresponds to the stratified liquid. From Karp-Boss, Lee; Boss, Emmanuel; Weller, Herman; Loftin, James; and Albright, Jennifer, "Teaching Physical Concepts in Oceanography: An Inquiry-Based Approach" (2009). Marine Sciences Faculty Scholarship.195

Explanation

In the non-stratified water column (Figure 2, left panel), red dye added at the fluid's surface initially sinks because its density is slightly higher than that of the water (Figure 2, top left). After a short time of exposure to a stress on the surface ("wind" generated by a hair dryer), the dye mixes throughout the water column (Figure 2 bottom left). In the stratified tank (right panel), the pycnocline, the region of sharp density change between the layers, forms an effective barrier to mixing (Figure 2, top right). More energy is required to mix the two layers, and the "wind" generated by the hair dryer is no longer sufficient to mix the entire water column. As a result, the red dye mixes only within the upper layer, analogous to the upper mixed layer in oceans and lakes (Figure 2, bottom right)

Conclusion:

The lessons conclude with gathering the class to summarize the learning points and key findings of the activity. Furthermore, the class needs to discuss the ecological implications, how this stratification affects the mixing of these layers and how the observed phenomena relate to real-world ocean stratification, its effects on marine life and on the circular bioeconomy.

Reflection on Teaching & Learning:

- Ask students to reflect on what they learned during the lesson.
- Discuss the effectiveness of the activities in enhancing understanding.
- Consider student engagement, understanding and participation.
- Reflect on the process and seek improvements.
- Encourage students to share any challenges faced and propose improvements.

Assessment for Learning:

Evaluate - Students create a video that describes the whole process followed and its impact to some living organisms, like for example Zooxanthellae.
[45 minutes]

Method: Inquiry based learning

Each group creates a video for the impact of the salinity and temperature of ocean currents to living organisms like Zooxanthellae.

The assessment of student understanding can be done through a mix of formative and summative assessments.

- Evaluate students based on their participation as well as use quizzes on the material.
- Group discussions and reflections as informal assessments to gauge individual understanding.
- Assign projects where students research and present on the topic.

Supportive Materials

Parental engagement before implementation

Set clear goals

Before embarking on the exploration of ocean currents and their effects on salinity, temperature, density, and stratification, the teacher initiates a collaborative goal-setting session with parents. The teacher provides an overview of the theoretical and practical aspects of exploring ocean currents, emphasizing their impact on marine ecosystems. Some parents who may be familiar with ocean-related activities or have local knowledge are encouraged to contribute insights on engaging and effective learning methods. Together, parents and the teacher discuss and formulate specific learning goals for the activity, such as understanding the role of ocean currents in nutrient distribution and their influence on marine life. At this stage, parents are invited to express any concerns they may have regarding the implementation of the activity, such as environmental issues or potential challenges.

Organize an Ocean Exploration Excursion or a Visit to an Oceanographic Center

Embarking on a visit to a local coastal area or an Oceanographic Center marks the initial step in exploring ocean currents, with a specific focus on the effect of stratification on mixing. To enrich this experience, the company of an expert in oceanography or marine sciences is suggested, providing valuable insights into the impact of ocean currents on marine ecosystems and the intricate relationship between salinity, temperature, and stratification. Engaging discussions may center around the consequences of disruptions in density and the role of stratification in mixing processes, emphasizing the significance of understanding these phenomena for sustainable marine practices. Collaboratively, parents and children have the opportunity to immerse themselves in the captivating world of diverse ocean currents, marine life, and the ongoing initiatives dedicated to studying and conserving the delicate balance of marine environments.

Ocean Current Exploration - Innovative Stratification Model Design

To further enrich the exploration of ocean currents, salinity, temperature, density, and the effect of stratification on mixing, parents with their children could participate in a hands-on activity, where they collaborate to better comprehend the complexities of how stratification influences mixing processes within marine environments.

Parental engagement during implementation

Watch Videos / Brainstorming

By watching selected videos, families can delve into the complexities of oceanographic concepts, and subsequently, discuss their observations and thoughts on how these phenomena impact marine environments.

Role-Playing Expedition

At the exploration stage of the learning process, parents and their children can immerse themselves in a dynamic role-playing game centered around the subject. In this interactive activity, participants will be grouped and assigned various roles representing stakeholders in the oceanography field. Roles may include oceanographers, marine biologists, or environmental advocates, each with unique abilities or goals. While engaged in the game, parents and their children can delve into discussions about the challenges posed by ocean currents, salinity, temperature, density, and the impact of stratification on

mixing processes, aiming to make informed and responsible choices for the preservation of marine ecosystems.

Educational Displays

At the last stage of implementing the activity (Evaluation stage), parents can help children evaluate the diverse aspects of oceanography. This includes understanding the effects of ocean currents on marine ecosystems, variations in salinity and temperature, and the impact of stratification on mixing processes. Parents and children collaborate to create educational displays or presentations that showcase their insights into the intricate relationships within ocean environments.

Parental engagement after implementation

Engage in open science Projects:

By joining in real-world data collection initiatives related to ocean currents, salinity, temperature, density, and the impact of stratification on mixing processes will allow parents and children to actively contribute to scientific research. This immersive experience not only reinforces theoretical concepts but also instills a sense of responsibility and connection to ongoing efforts in understanding and preserving the dynamics of ocean environments.

Questionnaire for Parents

Dear parents, thank you for taking the time to complete this questionnaire. We are interested in hearing your feedback on the "Exploring the Ocean currents - Effect of stratification on Mixing" educational scenario. Your responses will help us to improve the activity for future students and parents. The questionnaire should take approximately 10 minutes to complete. All your responses will be anonymous and will be used for improvement.

Here is the questionnaire:

Activity Feedback

21. Did you like the activity? (Multiple choice: Yes/No/Not sure)
22. Did you find the activity engaging?
    (Likert scale: Strongly agree/Agree/Neutral/Disagree/Strongly disagree)
23. Would you recommend this activity to other parents?
    (Multiple choice: Yes/No/Not sure)
24. How well did the activity incorporate videos and brainstorming?
    (Likert scale: Strongly agree/Agree/Neutral/Disagree/Strongly disagree)
25. How well did the activity incorporate role-playing games?
    (Likert scale: Strongly agree/Agree/Neutral/Disagree/Strongly disagree)
26. How well did the activity incorporate creating educational displays?
    (Likert scale: Strongly agree/Agree/Neutral/Disagree/Strongly disagree)

Further Use of Knowledge

27. Has this activity changed your understanding of the effects of stratification on mixing? (Multiple choice: Yes/No/Not sure)
28. Has this activity influenced your perspective on environmental issues?
    (Multiple choice: Yes/No/Not sure)
29. If so, in what way? (Open-ended question)

30. What kind of learning do you think happened during this activity?
    (Multiple choice: Academic learning, social learning, emotional learning, all of the above)
31. How can we apply this learning in real-world scenarios? (Open-ended question)

Additional Questions

32. What did you like most about this activity? (Open-ended question)
33. What did you like least about this activity? (Open-ended question)
34. Do you have any suggestions for how we can improve this activity in the future? (Open-ended question)
35. How much time did you spend participating in the activity with your child? (Multiple choice: Less than 30 minutes/30-60 minutes/More than 60 minutes)
36. Did you learn anything new from the activity? (Multiple choice: Yes/No)
37. Do you feel more confident in your understanding of the effects of stratification on mixing as a result of this activity?
    (Multiple choice: Yes/No/Not sure)
38. Did you enjoy participating in the activity with your child?
    (Multiple choice: Yes/No/Not sure)
39. Would you be interested in participating in other similar activities with your child in the future?
    (Multiple choice: Yes/No/Not sure)
40. Do you have any suggestions for how we can improve this activity in the future? (Open-ended question)

Literature and links

European Resource Efficiency Knowledge Centre. https://www.resourceefficient.eu/en

European Commission, “Good practice in energy efficiency”, COM (2016), 761 final

Franks, P.J.S., and S.E.R. Franks. (2009). Mix it up, mix it down: Intriguing implications of ocean layering. Oceanography 22(1):228–233. Available online at: https://tos.org/hands-on-oceanography (accessed April 23, 2021)

https://learn.microsoft.com/en-us/training/educator-center/instructor-materials/explore-ocean-currents.

How do ocean currents affect on coral reefs.
https://oceanservice.noaa.gov/facts/coralreef-climate.html#:~:text=Altered%20ocean%20currents%3A%20leads%20to,coral%20growth%20and%20structural%20integrity

Karp-Boss, Lee; Boss, Emmanuel; Weller, Herman; Loftin, James; and Albright, Jennifer, "Teaching Physical Concepts in Oceanography: An Inquiry-Based Approach" (2009). *Marine Sciences Faculty Scholarship*.195.

Lesson Plan 3

Subject(s): Environmental Sciences, Geography, Biology, Chemistry, Physics	**Title of Lesson:** Exploring the Ocean currents in the context of circular bioeconomy - Convection under ice **No. of Lesson** 3 of 3	
Date: Autumn Term 2023	**Class:** Secondary Education (ages 16 – 18)	**Time:** 10.00 am – 2.00 pm **Duration:** 4 hours
BioBeo Theme: Life Below Water, Interconnectedness	**Keywords/Phrases:** ocean currents, movement of water, salinity, pH, living organisms, circular bioeconomy	

Learning Outcomes:

1. To be able to explain the concept of convection and how it occurs under ice.
2. Students will enhance their observational skills, keenly noting the changes and patterns in water movement beneath the ice surface.
3. To gain a greater awareness of environmental issues related to oceanography and the importance of understanding physical processes in the ocean for predicting and mitigating the effects of climate change in the context of circular bioeconomy.

Resources/Materials/Equipment:

- At least four blocks of colored ice (add food coloring to water, then freeze in food-storage containers)
- Two large transparent containers—one filled with tap water, and one filled with saltwater (both at room temperature)

Introduction:

In this activity, we will delve into the fascinating world of ocean science and explore the concept of convection, a process that plays a crucial role in the Earth's climate system and in circular bioeconomy. Using simple materials, we will create a model to observe how convection occurs under ice. By the end of this activity, you will have a deeper understanding of this important natural phenomenon and its impact on our planet. So, let's dive in and start exploring!

Brainstorming / Discuss the formation of ocean currents
[20 minutes]

Method: Brainstorming

Use a video as a trigger to introduce the formation of ocean currents.

https://www.youtube.com/watch?v=ygI1B7h2j_0&ab_channel=OfficersIASAcademy-India%27sOnlyIASAcademy

and https://www.youtube.com/watch?v=f2evaLaDvCI&ab_channel=BeSmart

Development:

1. **Engage** – Students read the article-use of resource "How does climate change affect coral reefs?" And watch three videos to realize the interrelationship between ocean currents and fish population. Engagement in Sustainability
   [40 minutes]

   Method: Inquiry based learning

   Use this article https://oceanservice.noaa.gov/facts/coralreef-climate.html#:~:text=Altered%20ocean%20currents%3A%20leads%20to,coral%20growth%20and%20structural%20integrity ,

   and the videos
   https://climatekids.nasa.gov/ocean/#:~:text=As%20Earth's%20climate%20warms%2C%20the,or%20stop%20in%20some%20places

   https://coastalscience.noaa.gov/project/ocean-currents-connect-coral-reefs/

   https://www.fisheries.noaa.gov/topic/sustainable-seafood

   as a trigger to engage the students in the concept of how the climate change is affecting the ocean currents and how these changes dramatically affect coral reef ecosystems and fish resources

2. **Explore** - Students in groups conduct an unplugged experiment to see the effect of salinity and temperature in ocean currents.
   [45 minutes]

   Method: Inquiry based learning
   Scientific question: How might the effects of climate change, such as warming and melting of sea ice, affect the vertical structure of the water column?

   The teacher divides the class into groups of 3 or 4 students. Each group reads the article "Teaching Physical Concepts in Oceanography An Inquiry-Based Approach" teaching_phys_concepts.pdf (tos.org) and makes a presentation of the outcomes of the experiments. Students discuss scientific questions in their group.

3. **Explain** - Students explain the results of the unplugged experiments.
   [45 minutes]

   Method: Inquiry based learning
   Each group use presentations to explain their findings (per group).

4. **Elaborate** - Students study the Current strength sheet in the Ocean currents workbook. This workbook utilises real-world data to show how the Atlantic Meridional Overturning Circulation

(AMOC), a system of currents in the Atlantic Ocean that is part of the great ocean "conveyor belt," has changed over time(From https://learn.microsoft.com/en-us/training/educator-center/instructor-materials/explore-ocean-currents)
[90 minutes]

Method: Inquiry based learning

Each group makes a presentation for the data related to salinity and temperature.

5. **Evaluate** - Students create a video that describes the whole process followed and its impact to some living organisms, like for example Zooxanthellae.
[45 minutes]

Method: Inquiry based learning

Each group creates a video for the impact of the salinity and temperature of ocean currents to living organisms like Zooxanthellae.

Experimental Procedure

1. Place a block of colored ice in a container filled with tap water. As the ice melts, observe and explain the behavior of the fluids.
2. Place the other block of colored ice in the container filled with saltwater. As the ice melts, observe and explain the behavior of the fluids.
3. Compare these observations.

Outcome of the Experiment

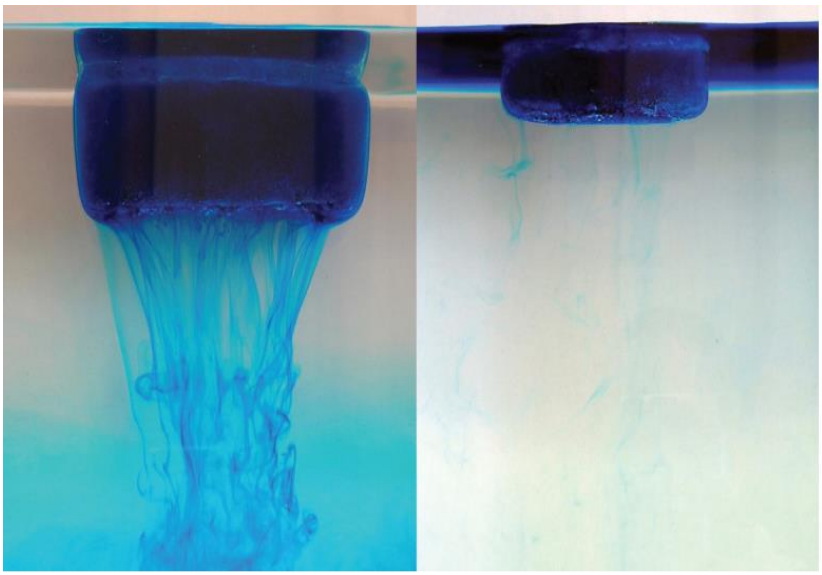

Figure 3 - Convection associated with melting of a colored ice block in tap water (left) and saltwater (right). From Karp-Boss, Lee; Boss, Emmanuel; Weller, Herman; Loftin, James; and Albright, Jennifer, "Teaching Physical Concepts in Oceanography: An Inquiry-Based Approach" (2009). Marine Sciences Faculty Scholarship.195

Explanation

Figure 3, left panel: In tap water, the ice block floats because the density of ice is lower than that of freshwater. As the ice melts, however, cold, colored meltwater sinks to the bottom because it is denser than tap water. Warmer water from the bottom is then displaced and upwells, resulting in a convective flow visible in the dye patterns. Ice melting in the center of the tank is analogous to a convection "chimney" formed in the open ocean, while ice melting at the tank's edge is analogous to a chimney on a continental shelf (near a land mass).

Conclusion:

The lessons conclude with gathering the class to summarize the learning points and key findings of the activity. Furthermore, the class needs to discuss the ecological implications, how the convection under ice, how the observed phenomena relate to real-world ocean stratification, its effects on marine life and on the circular bioeconomy.

Reflection on Teaching & Learning:

- Ask students to reflect on what they learned during the lesson.
- Discuss the effectiveness of the activities in enhancing understanding.
- Consider student engagement, understanding and participation.
- Reflect on the process and seek improvements.
- Encourage students to share any challenges faced and propose improvements.

Assessment for Learning:

The assessment of student understanding can be done through a mix of formative and summative assessments.

- Evaluate students based on their participation as well as use quizzes on the material.
- Group discussions and reflections as informal assessments to gauge individual understanding.
- Assign projects where students research and present on the topic.

Supportive Materials

Parental engagement before implementation

Set clear goals

Before embarking on the exploration of ocean currents and their effects on salinity, temperature, density, and stratification, the teacher initiates a collaborative goal-setting session with parents to understand convection under ice. The teacher provides an overview of the theoretical and practical aspects of exploring ocean currents, emphasizing their impact on marine ecosystems. Some parents who may be familiar with ocean-related activities or have local knowledge are encouraged to contribute insights on engaging and effective learning methods. Together, parents and the teacher collaboratively formulate specific learning goals for the activity, concentrating on comprehending the distinctive role of ocean currents in nutrient distribution, particularly beneath ice-covered surfaces, and their influence on marine life in such environments. At this stage, parents are invited to express any concerns they may have regarding the implementation of the activity, such as environmental issues or potential challenges.

Organise an Ocean Exploration Excursion or a Visit to an Oceanographic Center

Embarking on a visit to a local coastal area or an Oceanographic Center marks the initial step in exploring ocean currents, with a specific focus on convection under ice. To enrich this experience, the company of an expert in oceanography or marine sciences is suggested, providing valuable insights into the impact of ocean currents on marine ecosystems, particularly in icy environments. Engaging discussions may center around the consequences of disruptions in density and the role of convection under ice, emphasizing the significance of understanding these phenomena for sustainable marine practices. Collaboratively, parents and children have the opportunity to immerse themselves in the captivating world of diverse ocean currents, marine life, and the ongoing initiatives dedicated to studying and conserving the delicate balance of marine environments in icy conditions.

Ocean Current Exploration - Innovative Stratification Model Design

To further enrich the exploration of ocean currents, and specifically the effect of convection under ice, parents with their children could participate in a hands-on activity, where they collaborate to better comprehend the complexities of convection under ice.

Parental engagement during implementation

Watch Videos / Brainstorming

By watching selected videos, families can delve into the complexities of oceanographic concepts, and subsequently, discuss their observations and thoughts on how these phenomena impact marine environments.

Role-Playing Expedition

At the exploration stage of the learning process, parents and their children can immerse themselves in a dynamic role-playing game centered around the subject. In this interactive activity, participants will be grouped and assigned various roles representing stakeholders in the oceanography field. Roles may include oceanographers, marine biologists, or environmental advocates, each with unique abilities or goals. While engaged in the game, parents and their children can delve into discussions about the challenges posed by ocean currents, and specifically the effect of convection under ice, aiming to make informed and responsible choices for the preservation of marine ecosystems.

Educational Displays

At the last stage of implementing the activity (Evaluation stage), parents can help children evaluate the diverse aspects of oceanography. This includes understanding the effects of ocean currents on marine ecosystems, and specifically the effect of convection under ice. Parents and children collaborate to create educational displays or presentations that showcase their insights into the intricate relationships within ocean environments.

Parental engagement after implementation

Engage in Open Science Projects:

By joining in real-world data collection initiatives related to ocean currents, and specifically the effect of convection under ice will allow parents and children to actively contribute to scientific research. This immersive experience not only reinforces theoretical concepts but also instills a sense of responsibility and connection to ongoing efforts in understanding and preserving the dynamics of ocean environments.

Questionnaire for Parents

Dear parents,

Thank you for taking the time to complete this questionnaire. We are interested in hearing your feedback on the " Exploring the Ocean currents - Convection under ice" educational scenario. Your responses will help us to improve the activity for future students and parents. The questionnaire should take approximately 10 minutes to complete. All your responses will be anonymous and will be used for improvement.

Here is the questionnaire:

Activity Feedback

1. Did you like the activity? (Multiple choice: Yes/No/Not sure)
2. Did you find the activity engaging?
   (Likert scale: Strongly agree/Agree/Neutral/Disagree/Strongly disagree)
3. Would you recommend this activity to other parents?
   (Multiple choice: Yes/No/Not sure)
4. How well did the activity incorporate videos and brainstorming?
   (Likert scale: Strongly agree/Agree/Neutral/Disagree/Strongly disagree)
5. How well did the activity incorporate role-playing games?
   (Likert scale: Strongly agree/Agree/Neutral/Disagree/Strongly disagree)
6. How well did the activity incorporate creating educational displays?
   (Likert scale: Strongly agree/Agree/Neutral/Disagree/Strongly disagree)

Further Use of Knowledge

7. Has this activity changed your understanding of the effects of convection under ice? (Multiple choice: Yes/No/Not sure)
8. Has this activity influenced your perspective on environmental issues?
   (Multiple choice: Yes/No/Not sure)
9. If so, in what way? (Open-ended question)
10. What kind of learning do you think happened during this activity?
    (Multiple choice: Academic learning, social learning, emotional learning, all of the above)

11. How can we apply this learning in real-world scenarios? (Open-ended question)

Additional Questions

12. What did you like most about this activity? (Open-ended question)
13. What did you like least about this activity? (Open-ended question)
14. Do you have any suggestions for how we can improve this activity in the future? (Open-ended question)
15. How much time did you spend participating in the activity with your child? (Multiple choice: Less than 30 minutes/30-60 minutes/More than 60 minutes)
16. Did you learn anything new from the activity? (Multiple choice: Yes/No)
17. Do you feel more confident in your understanding of the effects of convection under ice as a result of this activity?
    (Multiple choice: Yes/No/Not sure)
18. Did you enjoy participating in the activity with your child?
    (Multiple choice: Yes/No/Not sure)
19. Would you be interested in participating in other similar activities with your child in the future?
    (Multiple choice: Yes/No/Not sure)
20. Do you have any suggestions for how we can improve this activity in the future? (Open-ended question)

Literature and links

European Resource Efficiency Knowledge Centre. https://www.resourceefficient.eu/en

European Commission, “Good practice in energy efficiency”, COM (2016), 761 final

Franks, P.J.S., and S.E.R. Franks. (2009). Mix it up, mix it down: Intriguing implications of ocean layering. Oceanography 22(1):228–233. Available online at: https://tos.org/hands-on-oceanography (accessed April 23, 2021)

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Karp-Boss, Lee; Boss, Emmanuel; Weller, Herman; Loftin, James; and Albright, Jennifer, "Teaching Physical Concepts in Oceanography: An Inquiry-Based Approach" (2009). *Marine Sciences Faculty Scholarship*.195.

National Curricula and Policy/SDG Connections:

The lesson is connected with the SDG 12 and 13. Goal 12 is about ensuring sustainable consumption and production patterns, which is key to sustain the livelihoods of current and future generations[1].

Goal 13 is about climate change. Climate change is caused by human activities and threatens life on earth as we know it. With rising greenhouse gas emissions, climate change is occurring at rates much faster than anticipated. Its impacts can be devastating and include extreme and changing weather patterns and rising sea levels[2].

The lesson can be applied to the Skills Labs module in Secondary Education (ages 12-15). The *Skills Labs* is a new, innovative school module which focuses on the cultivation of soft and digital skills. The *Skills Labs'* main goal is the cultivation of skills necessary for a rapidly changing world. These skills include both fundamental life skills related to health, safety, and social interactions, as well as more elaborate skills related to education and life-long learning. Particular emphasis is placed on the **4Cs of 21st century skills – communication, collaboration, critical thinking, and creativity – along with digital skills.** The *Skills Labs* is designed to promote and bring into effect the **UN Sustainable Development Goals, with particular emphasis to Goal 4.7** and has gathered significant attention from international bodies such as UNESCO. It was awarded the **Global Education Network Europe (GENE) Global Education Award (2020/2021)[3]**.

[1] https://www.un.org/sustainabledevelopment/sustainable-consumption-production/

[2] https://www.un.org/sustainabledevelopment/climate-change/

[3] https://eurydice.eacea.ec.europa.eu/news/greece-21st-century-skills-labs-ergastiria-dexiotiton