Didactic proposal for scholars

LIFE BLUE NATURA

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(LIFE2014/CCM/ES000957)

Blue Carbon in Andalusia and its role in the mitigation of climate change

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TITLE

The blue carbon in Andalusia and its role in climate change mitigation

Information. Classroom level awareness

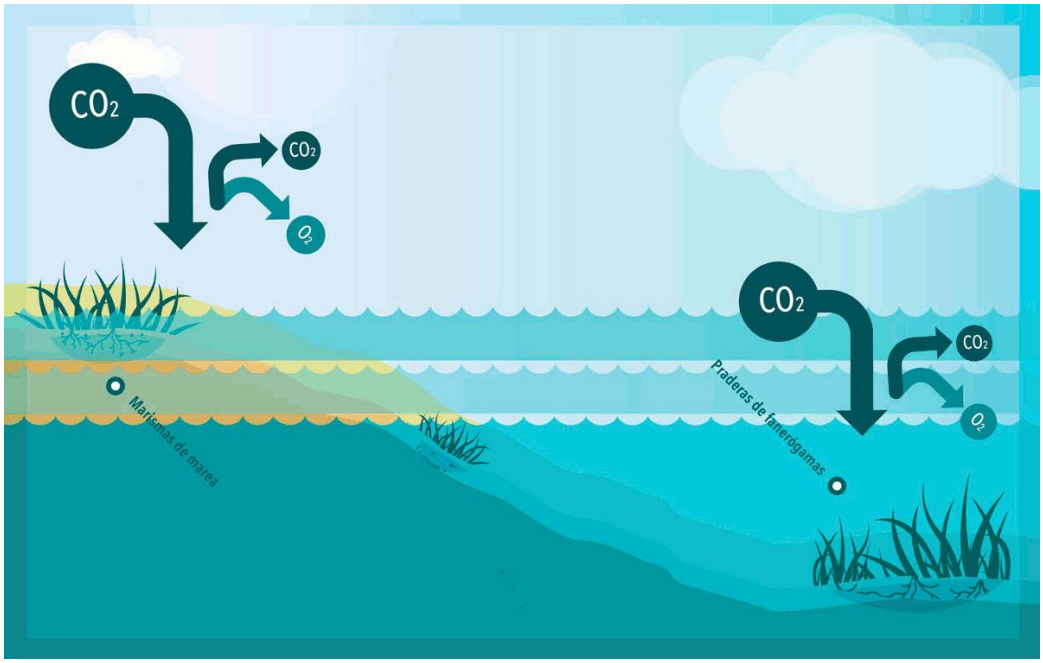
EDUCATIONAL LEVEL

Compulsory secondary education/Bachelor

DESCRIPTION

The activity consists of well-differentiated theoretical and practical parts. The basic contents are:

- Photosynthesis review: Plants in the marine environment: algae and higher plants;
- Blue and green carbon: accountable for their development, with special emphasis on the species present in Andalusia;
- *Posidonia oceanica* as a standard in the Mediterranean;
- Locations: Where to find areas with these species;
- Sinks, temporary accumulation, stock. Concept and integration of temporality and the reserve as a value to preserve;
- Impacts that cause sink degradation: effects (biodiversity, environmental quality and climate);
- Review / familiarity of different CO_2 emission rates and their relationship with the problem of climate change (video, list of broadcasting activities, etc.). Self-discovery of anthropogenic origin;
- Review of the sequestration rates of various species and different blue carbon sinks;
- Integrated recreational activity the blue carbon concept.



GENERAL APPROACH

When working with environmental problems looking for solutions from the educational level the effective interpretation and understanding of the problem and the active search for solutions including direct intervention action in favor of the environment is one of the best tools to motivate a more favorable change of attitude towards our environment. To intervene directly in favor of the climate is to know the causes that are modifying it. Reduce and balance our emissions of greenhouse gases, especially the gas that we emit the most, CO2, and to conserve the resources and ecosystems that support better environmental quality and help reducing emissions.

This activity aims to reinforce knowledge and awareness on climate change issues, informing and sensitizing school communities about blue carbon sinks and working on real interpretation measures of mitigation rates that are occurring (after calculating what we emit) as well as generating attitudes of reduction, day by day. Thus, it seeks to create conservation awareness and self-discovery attitudes that promote self-criticism and initiatives that favor and preserve them, so that they continue to absorb atmospheric CO2 and mitigate climate change.

CONCEPTS TO REINFORCE*

Photosynthesis and carbon incorporation. Photosynthetic organisms (algae and plants) present in the oceans, coastal zones, and terrestrial ecosystems obtaining CO_2 from the atmosphere to make photosynthesis. They separate carbon and oxygen: part of this carbon is used to create its roots, trunk and leaves, and expel oxygen to the environment.

** Likewise, photosynthetic organisms expel CO_2(but to a lesser extent than they retain) in their breathing process..*

Photo. Antonio Gómez Ferrer (CMAOT)

Sinks and mitigation. In some cases, some of these structures (roots, rhizomes, dead leaves) are "trapped" for many years, under the soil or sediments, along with a large amount of organic matter that has been deposited, constituting what are called sinks. The sink is therefore a "warehouse" of carbon, withdrawn for thousands of years in some cases, and which helps us to mitigate (reduce-compensate) the emissions that are generated. This sink is only maintained if no impacts occur that causes a release of carbon into the atmosphere. That is why the living part of the ecosystems that we are dealing with here is the "plug" that seals the drain..*

** Although by "sink" we can understand something related to sewer, drain or dump, usually different types of waste, in the terminology of climate change this concept expresses the opposite, something desirable to promote and protect, and that "keeps" excessive CO_2 in the atmosphere in the form of carbon, after the photosynthetic process.*

**The "mitigation" concept , associated with calming, softening or diminishing should not make us think of a problem (that of climate change in this case) without solution, but must be addressed as the action of braking, with expressed conviction that presents the term. Thus, all derivative uses like "mitigation rate" could be well explained as "reduction rate".*

**The term "trapping" would be an adapted synonym for the "sequester" concept that is commonly used in texts about climate change and which implies ambiguous interpretations about the desire for it to happen.*

Photo: Agustín Barrajón/Diego Moreno (AMAYA)

Conservation. Keeping the "living part" in good condition is essential so that it continues fixing not releasing the carbon that has been retained.

** Up to 1/3 of annual atmospheric emissions come from ecosystem degradation.*

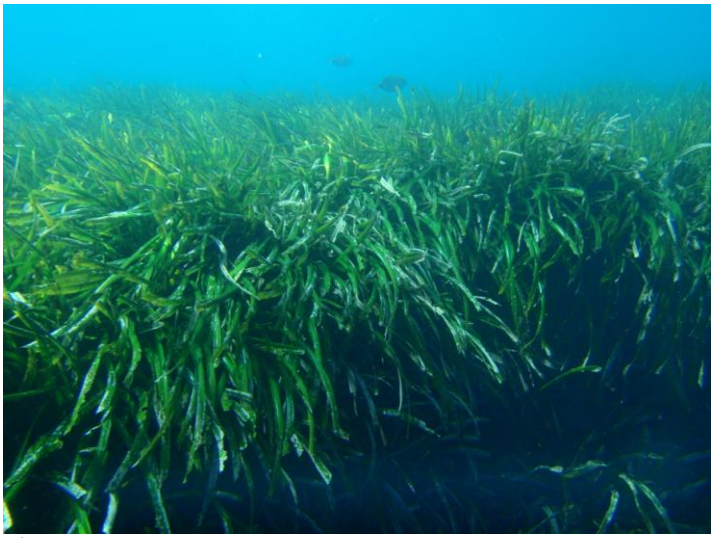


Photo: Juanmi Requena

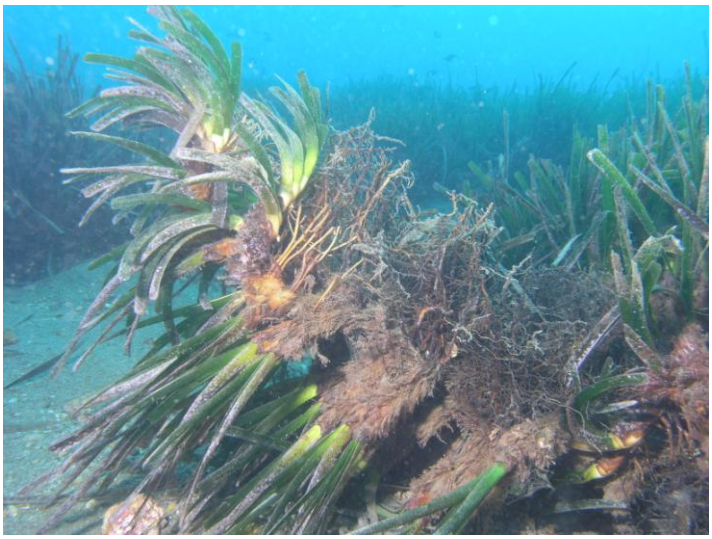


Photo: Asociación Hombre y Territorio (HyT)

Blue carbon. Some coastal and marine ecosystems have that capacity: the carbon they fix is called "blue", compared to the "green" of terrestrial vegetation. Therefore, the sinks they create it are called blue carbon sinks.

Mangroves, tidal marshes and seagrass meadows are the main accountable for this blue carbon on Earth. In Andalusia there are representatives of the last two.

** It is recommended to consult previously recommended websites and references (resources).*

OBJECTIVES

- Establish relationships between our actions and the environmental consequences of them.
- To get to know the importance of CO2 sinks, especially marine and coastal ecosystems, for the equilibrium of greenhouse gases in the atmosphere.
- Reinforce the concept and effects of the destruction of sinks (by physical or chemical impacts, short, medium or long term), and the loss at different levels (vegetation cover, associated biodiversity, CO2 release by oxidation of retained carbon).
- Introduce or reinforce a responsible consumption consciousness, through the integration of "carbon footprint", not only from an individual's point of view but also from the derivative of our actions and consumption.
- Intervene favorably in the environment, by proposing viable and realistic solutions.

SCHEDULING

The activity can be accomplished over the course of one month by considering the activity and carrying all practical activities out, taking advantage of the classes or a part of them to make progress in the subject.

PRINCIPAL CORE COMPETENCIES

- Linguistic proficiency.
- Mathematical and basic skills in science and technology.
- Sense of the initiative and entrepreneurial spirit
- Social and communal competencies.

RELATION TO OTHER SUBJECTS

- Natural Sciences.
- Language and literature.
- Mathematics.
- Geography.

Photo: Antonio Gómez Ferrer (CMAOT)

STRUCTURE

- The first theoretical part of the activity and previous review of the concepts of photosynthesis is intended to teach what the concept of blue carbon refers to as a differentiator in the coastal and marine environment. Thus, the main ecosystems or responsible habitats are explained and taught, and the way of some of them forming sinks. These living habitats are essential to continue the fixation process, and also ensure a "seal" and maintenance of the sink.

    - *Resources can be used as support*

- The second theoretical part focuses on learning the values of CO_2 emissions that are derived from daily activities at different scales (person, class, school, town, city, country). Then reveal the average values of atmospheric carbon fixation of organisms responsible for blue carbon.
  The proven assimilation of emitters-accumulators allows us to initially internalize our effects and the tools of nature to mitigate them.

    - *Resources can be used as support*

- From this data, and in a practical way, it is proposed to establish a series of measures as realistic as possible how these systems reduce and have reduced the amount of emitted CO2. Cross-reference extension data of each ecosystem in Andalusia with its average fixation data (mitigation concept) help us to obtain annual fixation rates; calculating the estimated value of the stock by area we attain the "reservoir".

  Likewise, it can be used to take the opportunity to reflect on different types of emissions: direct, derivative or secondary, in relation to our consumption habits. In this way we can introduce the reflection about our "carbon footprint" and how we can reduce it through our consumption habits.

  ** Not the same carbon is emitted (by the cost of processing, transport, cold chain, etc, when consuming fresh products from the area or imported).*

    - *Resources can be used as support*

- With these results, it is proposed to carry out an exercise to suggest actions that they achieve not only mitigating, but compensating the calculated emissions, always presenting this action as a complement to mitigation. These proposals are perfectly valuable in ecosystem management policies, reaching the standard of the Climate Change Law of Andalusia in the process of elaboration *.

  ** The offset of CO_2 emissions should not be shown as an alternative to reduction, but as a complement to it and once measures have been taken to reduce emissions. This aspect is important from an educational point of view, since it is not about giving the feeling that we can emit as much as we want then compensate.*

- As a practical complement, a playful outdoor activity is exposed to strengthen the carbon sink concepts, mitigation and conservation of blue carbon- forming ecosystems

DEVELOPMENT

- After presenting the activity, we justify our involvement in the solution to climate change. To do this, it is proposed to watch the video of the program KiotoEduca (Resource 1) which specifies what climate change is, its causes, its consequences and some of the mitigation measures. This can be used to strengthen the concepts of emissions, greenhouse gases and climate change.

- Once the audiovisual is projected, students are asked to think in groups, of daily activities that generate CO_2. The contributions of the groups are commented and a common list with issuing activities is completed. Activities will be as commuting to the center, plugging in an electrical device or turning on the light. It can deepen in other cases, such as the use of fossil fuels in industrial production (basic examples like generating plastic materials that they use in their daily life), generation of fuels, transportation of food and materials and the degradation of ecosystems as deforestation, etc.

- Later the concepts of photosynthesis are reviewed: who are responsible for photosynthesis? What do they need to do it? What do they expel? What do they get? Students are asked if they know where these organisms are, seeking their self-discovery towards terrestrial, coastal and marine systems.

- After securing and recognizing the role of coastal and marine plants, the differences between green and blue carbon are explained. Later we explain the accountable of blue carbon in Andalusia, who and where they are. After this, a small emphasis is placed on *Posidonia oceanica* as a priority and important habitat. The documentation of Resource 7 can be consulted as support.

- Now we turn to the sink concept: how do tidal marshes and sea phanerogams to catch carbon? How old can a meadow or a marsh be? How much carbon can be there beneath? Where does that carbon come from? It is proposed to watch the videos about blue carbon (Resource 2 and Resource 3), in which all these concepts are explained in a simple and very visual way.

- Afterwards, a comprehension and calculation work will be done about the amount of CO_2 that is emitted in different acts of our life and the amount of carbon that blue carbon-forming organisms absorb.

- Estimated values of stock (amount retained in the sink) will be shown. It is proposed to perform calculations around an equal and known distance (100 km). To convert the kilometers of each means of transport into emissions several tools can be used (Resources 4 and file).

- With the resulting data the emissions are completed (file). It is important to work after on what these emissions imply, so that we can establish a link between our actions and their consequences. Students must understand that our emissions contribute to increase the greenhouse effect and that increase generates a rise in the average temperature of the planet which results variations in the climates on the Earth.

- After a process of self-discovery of the enormous potential and value of these systems as mitigators of climate change. It is proposed to hold a round table or debate where possible actions for the reduction of emissions and the conservation of these habitats are extracted. What can we do to minimize our environmental impact as a consequence of transportation? The answer goes to understanding the problem and its effects, reducing and balancing our CO_2 emissions. Informing and sensitizing others about what is known and conserving the systems that help us to mitigate global warming. Each and everyone set up a list of measures to help us reducing; riding a bike or sharing a car can be some of them. The list will be displayed in the classroom, open to be expanded by the students when new actions occur.

- Finally, to strengthen the concepts and to carry out a dynamic activity, it is proposed to finish in the courtyard with practical activity.

Photo: Asociación Hombre y Territorio (HyT)

The Blue Carbon Game

The class or group is divided into two teams, the carbon and the plant team.

Each team will be responsible for representing one of the components of the system (very simple): the plant team represents the marine phanerogams (or tidal marsh plants), and the carbon team will be free CO2 molecules or retained carbon (according to their state).

It is recommended that you identify in some way (color of the T-shirt, a bib number) to each team, although the design of the activity allows not having to do so.
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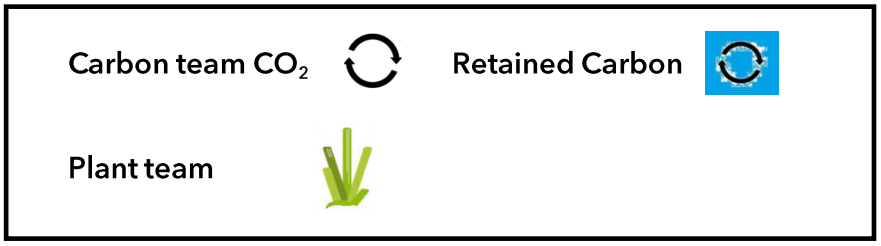
As the carbon team can be in two different states, you can differentiate between CO2 molecule and retained carbon with some badge that must carry all the components of the carbon team (for example a blue paper to reinforce the concept of blue carbon) and that are placed or removed according to their state.



First we explain to the students that they are going to perform a simulation of how blue carbon sink formation system works: therefore and at least there must be 2 components (although there are really many more). You can use this moment to ask them to identify what elements are needed.

The game is designed for a number between 30 and 35 students. Anyway the ratios are exposed to be able to adapt to the particular circumstance of the class:

5 units of marsh plants or seagrass meadow;
10 units of initial CO_2, derived from the Earth's metabolism (without distinction);
20 units of CO_2 that will enter later, derived from human activity (without distinction).

Ratio: 1-2-3 (example of 20 students: 3/6/12).

The game is divided into stages, marked by notable "changes" in the system.

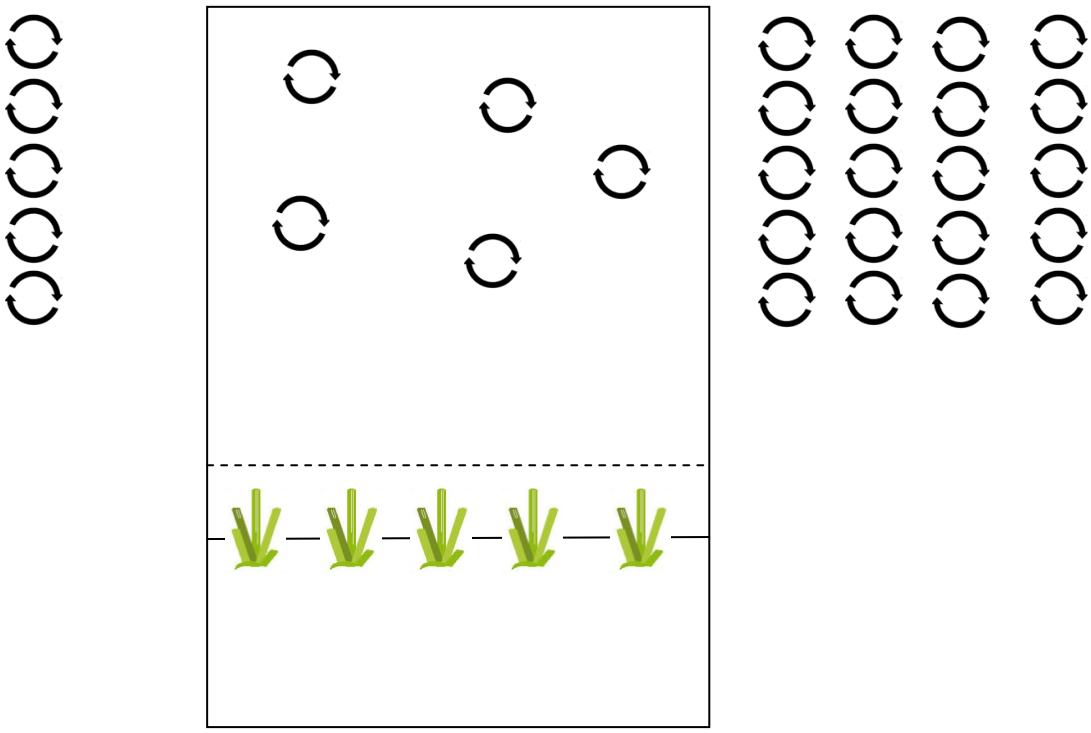
1. It is part of an initial situation in which there is a balance between the system (i.e., there is no excess emissions).
2. In the second stage the balance of natural inputs and outputs is maintained and anthropogenic inputs are included, but at a low rate.
3. The third stage would resemble a current situation, in which there is a high rate of emissions from human activities.
4. The fourth stage resembles an impact on the sink system to check its effects.
5. The fifth stage simulates a habitat recovery performance.

Each system change takes place every 2 minutes (which can be assimilated to years or decades). You can make "photos" of certain moments (the game is stopped and the situation is discussed).

Start

After separating and identifying each group, the activity is explained: the "study area" is defined, **an about 25m long and 15m wide rectangle**, which is divided into three parts, simulating a cross section of the Earth*. In the line that separates the last part are vegetation units, which have a limited space of "movement" (its CO_2 catchment area): behind them (below) is the sediment. The units of CO_2 are placed on the sides of the rectangle, in the highest part, separating on each side the derivatives of the Earth's metabolism derived from human activities.

The start of the game would be this way (still static):



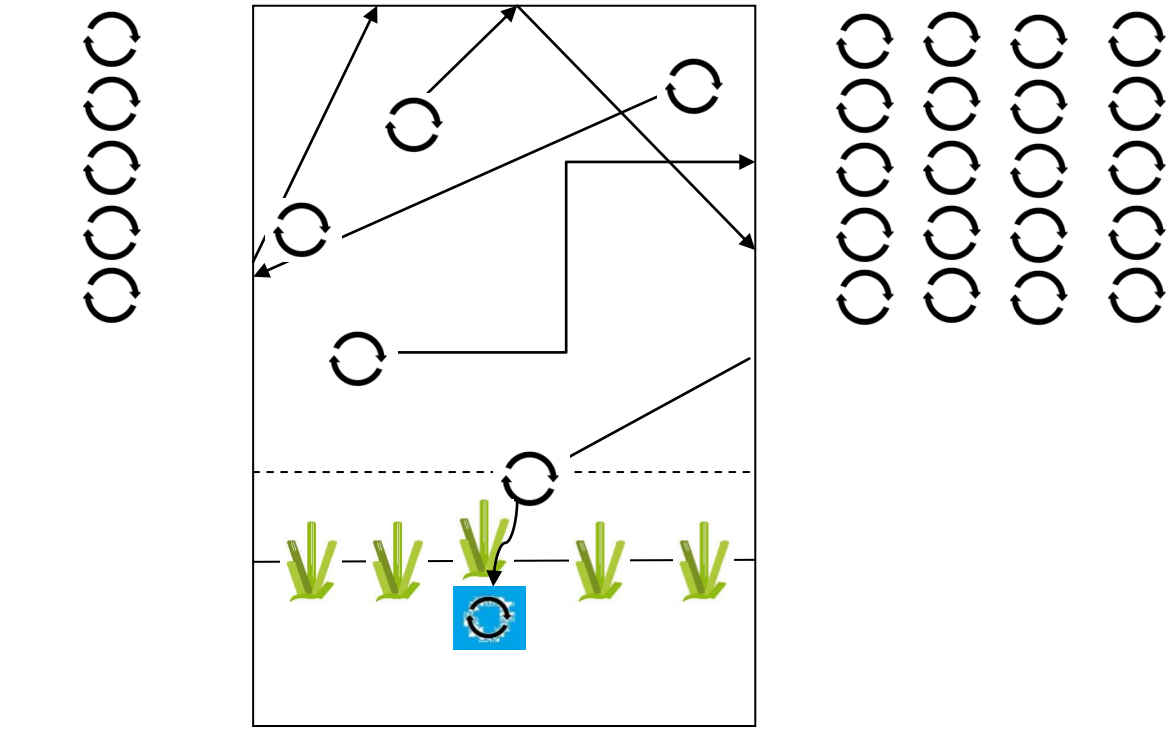
** Remember as reference the formation scheme of a sink (page 2).*

Step 1

Time starts running: 5 units of CO_2 derived from the Earth's metabolism enter the cycle. Their movement is unpredictable (for this they cover their eyes and move through the free space or mark a series of concrete steps and a change of direction).

When a plant intercepts one of them (i.e. when it enters its "catchment" zone), it assimilates it and becomes carbon that accumulates under the plant (the oxygen and CO_2 resulting from the metabolism of the plants is not considered in this reaction).

Stage 1 would be this way at some point: "Photo" *



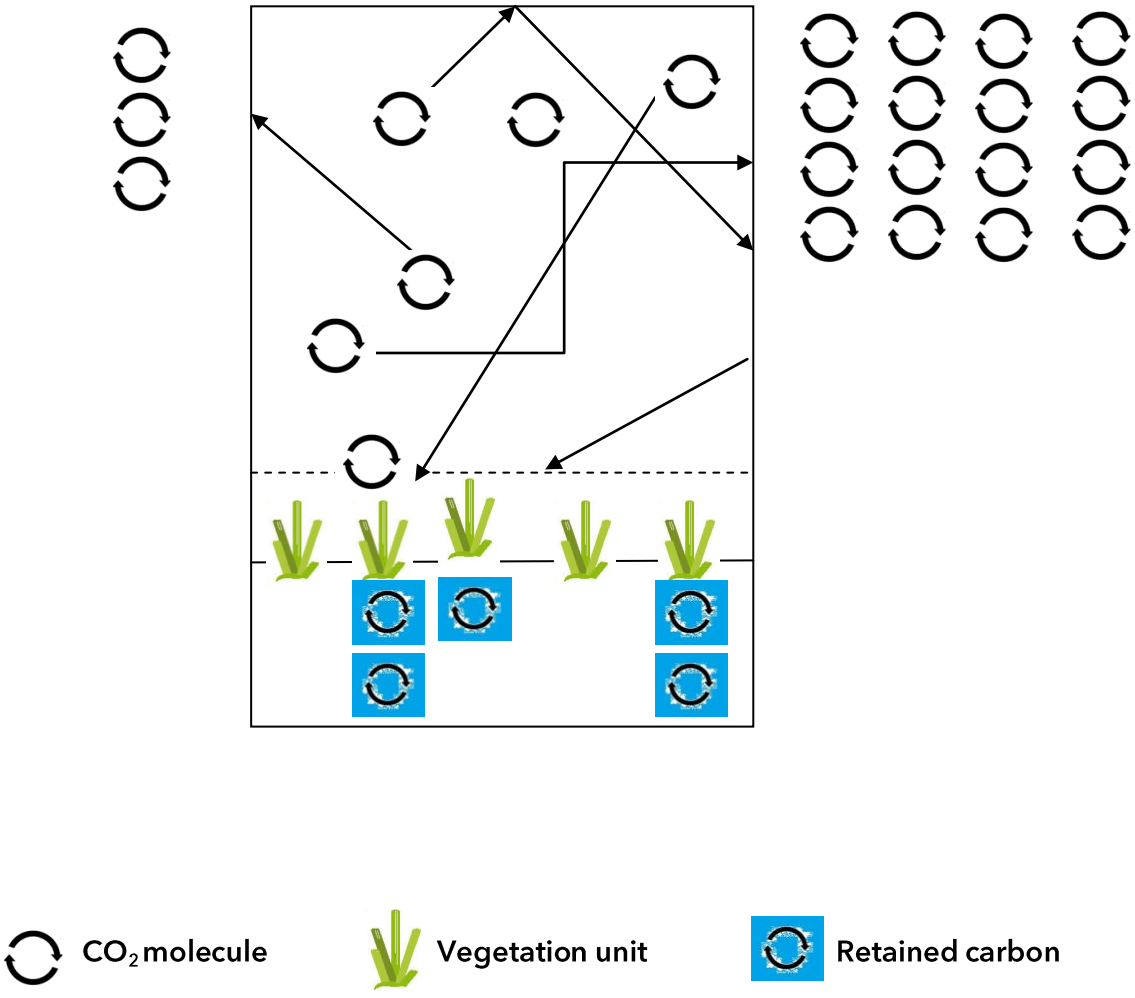
** This "photo" can be treated as a normal operating state*

Step 2

2 units of CO_2 derived from the Earth's metabolism enter the cycle. In addition, 4 units of CO_2 derived from human activity enter the cycle. The movement of CO_2 units remains erratic and without fixed objective (they should not avoid being absorbed).

With this increase of CO_2 molecules in the middle there is a greater greenhouse effect but the plants continue to perform photosynthesis and "kidnapping" those molecules in their structures (and under them).

Stage 2 would be this way at some point: "Photo" *

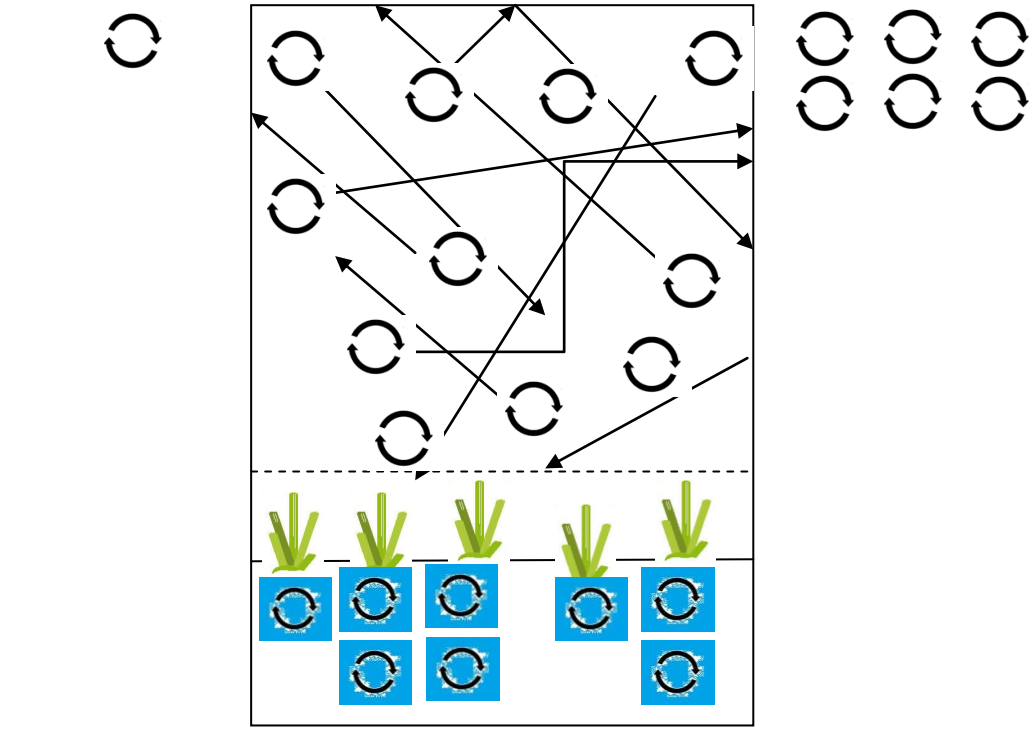


** This "photo" would show as before slight increases in CO2 (natural or anthropogenic). Ecosystems allow balancing them if they are in good condition. It also shows the formation of the sink.*

Step 3

2 units of CO_2 derived from the Earth's metabolism enter the cycle. In addition, 10 units of CO_2 derived from human activity enter the cycle (simulating a significant increase in emissions). The movement of CO_2 units remains erratic and without fixed objective (they should not avoid being absorbed). The sink continues to form.

Stage 3 would be this way at some point: "Photo" *

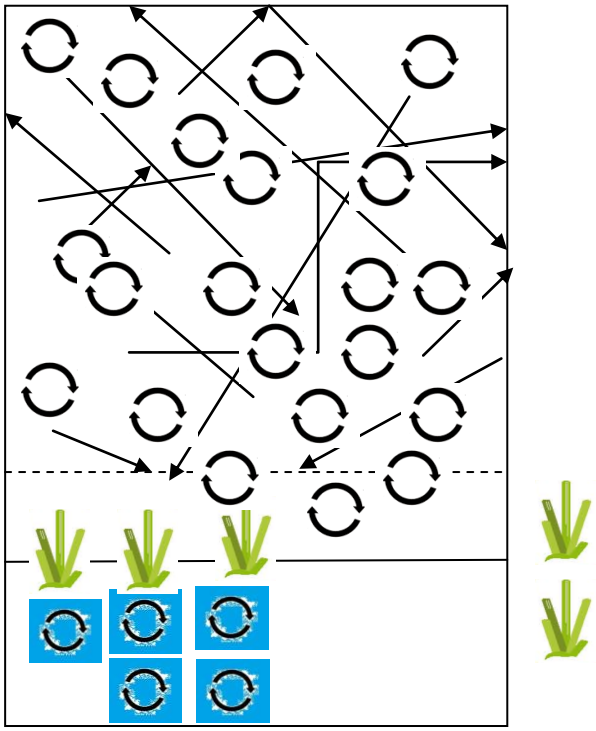


** "This "photo" would simulate the current state: Many emissions (with its climatic consequences), and the sinks with a high "stock" of accumulated carbon.*

Step 4

1 unit of CO_2 derived from the Earth's metabolism enters the cycle. In addition, 6 units of CO_2 derived from human activity enter the cycle. Finally, the teacher "impacts" the meadow or marsh by eliminating 2 of the vegetation units by eliminating 2 of the vegetation units: the retained carbon goes back to the cycle as CO_2.
The movement of the CO_2 units remains erratic and without fixed objective (they should not avoid being absorbed).

Stage 4 would be this way at some point: "Photo" *

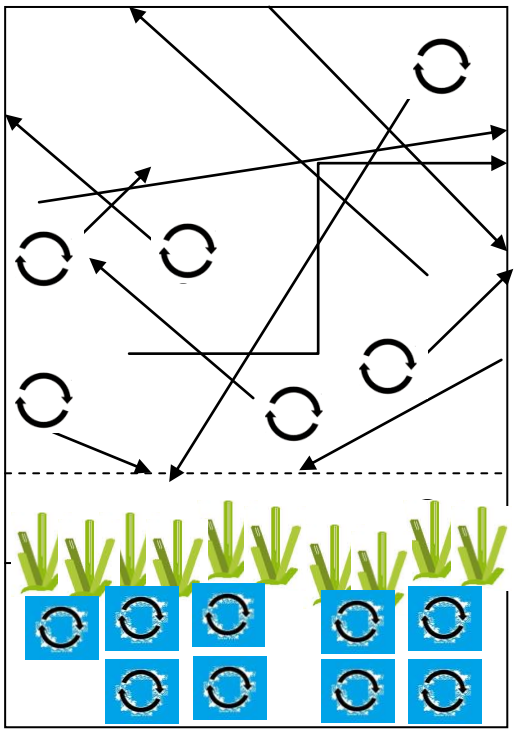


** Impacts on blue carbon sinks forming ecosystems have, in addition to the consequences of their disappearance, the release of retained carbon (with its climatic consequences).*

Step 5

With all the units in play, a recovery action of the ecosystem is carried out, increasing the number of these: for this, the role of plant is given to 5 more students (10 units of vegetation in total). The movement of CO_2 units remains erratic and without fixed objective (they should not avoid being absorbed).

Stage 5 would be this way at some point "photo"



** Mitigation actions include rehabilitation, restoration or recovery of sink-forming ecosystems. By increasing the number and density of these habitats, we are reducing the amount of CO2 in the atmosphere.*

In each of the "photos", or moment of stop and reflection can be used for each unit to explain what it is doing (to reinforce the concepts explained) and that among all are looking for interpretations of the moment and get answers to the effects that has each of the moments in the climate.

This way you can review and reinforce the concepts of climate change, greenhouse gases, sea meadows and tidal marshes, blue carbon, sink, stock, mitigation.

Some of these project concepts can be reinforced Life Blue Natura (sink, absorption, stock, blue carbon), as well as proposing and applying (in later modalities of the game) other conservation actions to minimize the current state.

COMPLEMENTARY ACTIVITIES

- Make a calculation at the time of the emissions that a person generates.
- Make posters or an awareness campaign to the nearby groups of each student regarding the topics covered.

AVAILABLE RESOURCES

- **Resource 1**. KiotoEduca Programa Vídeo: https://goo.gl/c6dZBA
  Web: KIOTO EDUCA:
  http://www.juntadeandalucia.es/educacion/webportal/web/educacion-ambiental/kiotoeduca/recursos-educativos

- **Resource 2**. Video "Two Minutes on Oceans w/ Jim Toomey: Blue Carbon". Educational video from the hand of a well-known American illustrator.
  https://www.youtube.com/watch?v=4fNW8spFS_o (UN Environment Programme)

- **Resource 3.** Vídeo: "El Mediterráneo de hace milenios". TV program where one of the largest Spanish experts in blue carbon explains in situ the objective of their work:
  http://www.rtve.es/alacarta/videos/lab24/lab24-reportaje/3215758/

- **Resource 4**. Different websites and links to conversion and calculation tables for calculating carbon emissions:
  http://www.ceroco2.org/calculadoras/
  http://arboliza.es/compensar-co2/calculo-co2.html
  http://www.alimentoskilometricos.org/

- **Resource 5**. Different websites and links to international projects and institutions with special attention to blue carbon:
  https://greenteacher.com/
  http://oceanservice.noaa.gov/facts/bluecarbon.html
  http://thebluecarboninitiative.org/

- **Resource 6.** Website of Life Blue Natura, with infographics and texts:
  http://www.life-bluenatura.eu/

- **Resource 7.** Informative documents elaborated in Life Posidonia Andalucía:
  https://lifeposidoniandalucia.wordpress.com/material-divulgativo/

- **Available work sheets.**
  - **Ficha A. Emissions**
  - **Ficha B. Mitigation**

- **Resource 8.** Vídeo: "Jornadas técnicas". Interview with Miguel Ángel Mateo (CEAB-CSIC) regarding to the potential of hidden information in the sinks.
  https://goo.gl/b2rqDz

ACTIVITY SUPPORT TABLES

"Blue carbon, a coastal and marine ally against climate change"
"

TAB A: EMISSIONS*

Table. Emission calculation factors

Car	100 km	15 kg CO_2 (per vehicle)
Motorbike	100 km	3,5 kg CO_2 (per vehicle)
Bus	100 km	6,5 kg CO_2 (per person)
Train-metro	100 km	3,5 kg CO_2 (per person)

Curious facts to contribute

- One person CO_2 emissions:0.9 Kg CO_2 (per person and per day)

- If we are 6.6 billion people and emit about 0.9 Kg of CO_2 per day, the annual emission due to human respiration is between 1.362 10 ^ 9 and 2.168 10 ^ 9 tons/year. Comparing these values with those produced by the burning of fossil fuels by human activity about 24,126 10 ^ 9 tons per year we find that the emission of CO_2 due to respiration of all humanity is only between 5,65 and 9% of the CO_2 produced by the use of fossil fuels.

** These data are average estimates, unofficial; they should serve only as a reference for the calculations made by KiotoEduca. They have been developed taking into account the tables of the IDAE (Institute for the Diversification and Saving of Energy) and other sources. Therefore the data expressed in the tables on measures and values are indicative. In this activity, above the purely technical value, educational value prevails.*
Therefore, the data expressed in the tables on measures and values are indicative. In this activity, educational value prevails over the purely technical value.

Tab A: EMISSIONS*

Table for calculate the kilometres travelled*

NAME	KM TRAVELLED	TYPE OF TRANSPORT				
		TRAIN	BUS	BIKE	FOOT	CAR
TOTAL						

It can be filled in together by the entire class, assessing the total of, for example, a school year.

Tab A. EMISSIONS*

Table for the calculation of kilometers made and emissions produced*

SUMMARY		
Total km. carried out by the whole class (in a year).		
Total km. by car of the whole class (in a year).		
Total km. by train of the whole class (in a year).		
Total km. by bus of the whole class (in a year).		
Total km. by motorbike of the whole class (in a year).		
Means of transport used by more people (according to km).		
Annual emissions by car displacement (kg of CO_2).		
Annual emissions by train displacement (kg of CO_2).		
Annual emissions by bus displacement (kg of CO_2).		
Annual emissions by motorcycle displacement (kg of CO_2).		
Total annual emissions (kg of CO_2).		

Tab B. MITIGATION*

Table. CO_2 Capture by different ecosystems and blue carbon generating species

Average CO_2 capture of *Posidonia oceanica*: between 22 and 650 t CO_2/km^2/year
Average CO_2 capture of other marine phanerogams: between 1 and 4 tCO_2/km^2/year
Average CO_2 capture of marshes: about 500 t CO_2/km^2/year

The data of the file are extracted from: Mateo and Serrano 2012 IUCN (Data of Posidonia) Fourqurean et al 2012 (Global of Phanerogams), Blue Carbon Report (marshlands).

** The data expressed in the tables on measures and values are indicative. In this activity, educational value prevails over the purely technical value.*

Table. CO_2 Capture by different ecosystems and blue carbon generating species in Andalusia

HÁBITAT OR ECOSYSTEM	*Posidonia oceanica*	*Cymodocea nodosa*	*Zostera spp*	Marismas de marea
EXTENSION (Km^2)	69,18	66,65	10,03	176
RETAINED CARBON. STOCK (1 meter sediment potency)	15-250 kg CO_2/ m2	5 kg CO_2/ m2	5 kg CO_2/ m2	55 kg CO_2/ m2
DEPHT OF SINK	To be determined*	To be determined*	To be determined*	To be determined*
APPROXIMATE AGE	To be determined*	To be determined*	To be determined*	To be determined*
PROVINCES	AL, GR , MA	AL, GR, MA, CA	AL, CA, HU	CA, HU

Data of extension by provinces are extracted from "Atlas de las praderas marinas de España. IEO/IEL/UICN, Murcia-Alicante-Málaga, 681 pp. Ruiz, J.M., E. Guillén, A. Ramos Segura & M. Otero. 2015
http://www.ieo.es/atlas-praderas-marinas

Data of retained carbon are extracted from Mateo & Serrano 2012 (*Posidonia oceanica*); Fourqurean *et al* 2012 (all the seagrasses); Chmura *et al* 2003 (marshes)

**Values will be obtained as one of the results of the Project Life Blue Natura (www.life-bluenatura.eu)*