INVESTIGATING CARBON

student workbook

clouds over the Atlantic Ocean
Tiago Fioreze, CC-BY-SA-3.0

When we think of carbon and climate change we often think about the atmosphere and importance of trees. Indeed, plants do take carbon dioxide out of the atmosphere and are important in reducing effects of extra carbon dioxide produced by burning fossil fuels. However, we seldom think about ocean plants, which are also important. In these activities you will learn about ocean plants, the ocean environment and how it deals with carbon dioxide.

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Explore physical and biological properties of the ocean through ten practical activities. You may do them in any order.

Activity 1: Water density and salinity

Activity 2: Water density and temperature

Activity 3: Water temperature

Activity 4: Water acidity

Activity 5: Phytoplankton from space

Activity 6: Phytoplankton under the microscope

Activity 7: Phytoplankton rap

Activity 8: Plan a phytoplankton investigation

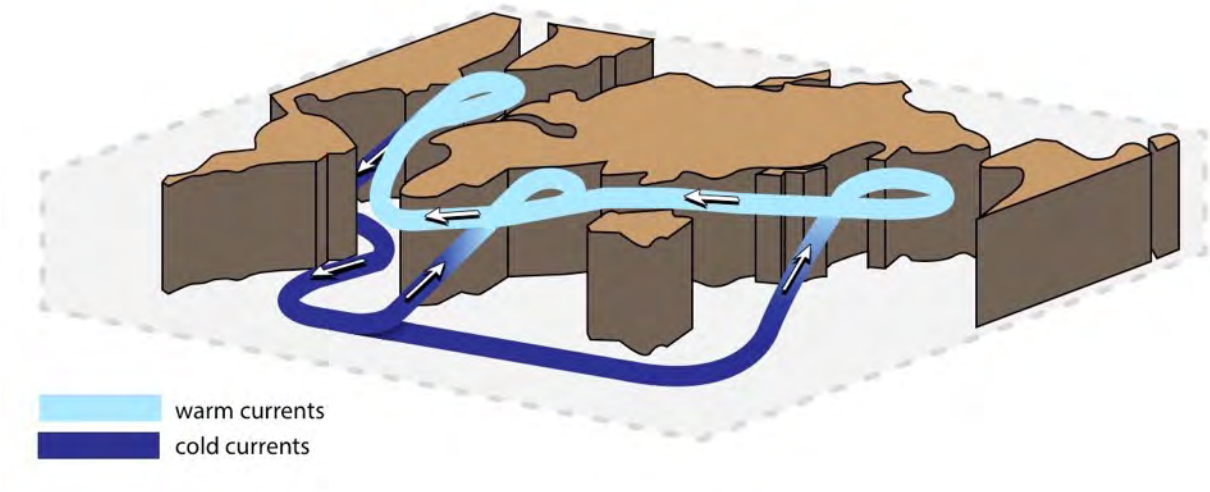
Activity 9: Sea grass services

Activity 10: Drawing the carbon cycle

Introduction

Carbon occurs in oceans as part of chemical compounds in water, plants and animals. Physical and biological properties of oceans affect how much carbon dioxide can be absorbed, dissolved and stored.

Like other molecules, carbon flows with moving water. Warm surface currents are connected to cold deep currents, circulating carbon from the surface to the deep and back.



Two pumps drive the flow of carbon in the ocean: the solubility pump and biological pump.

- The solubility pump describes physical (abiotic) factors that influence carbon storage in the ocean. These include water density, ocean temperature and acidity (pH).
- The biological pump describes how, like on land, photosynthesis by plants fixes carbon into biomass and is an important driver of the carbon cycle. Phytoplankton is the general name for floating plants found in vast numbers in the ocean, but too tiny to see individually. Other ocean plants include mangroves and sea grasses that grow in shallow water close to the edge.

Activity 1: Water density and salinity

The concentration of salt in seawater affects its density. As density changes, seawater either rises or sinks, creating currents that cause it to mix and flow.

Aim

To investigate how salinity changes density of water.

Materials

1 golf ball

food colouring

1500 mL beaker

salt

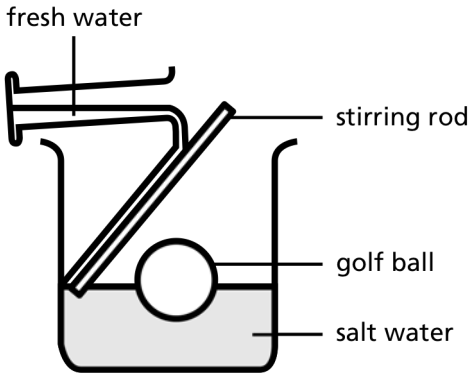
teaspoon

water

1 stirring rod

100 mL measuring cylinder

safety glasses and safety mat



Method

1. **Add** 200 mL of tap water to beaker.
2. **Add** 10 teaspoons of salt and stir to dissolve. As the salt won't dissolve entirely the solution remains cloudy.
3. **Lower** golf ball gently into beaker – it floats.
4. Using measuring cylinder, carefully pour 200 mL of fresh tap water down stirring rod into beaker, so that with minimal mixing it sits on top of the salt water.
5. **Drop** two drops of food colouring into beaker.
6. **Observe** what happens to food colouring.

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Questions

1.1 Draw beaker showing the position of: salt water, fresh water, golf ball and food colouring.

1.2 Which water has higher density: salt or fresh? How do you know?

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1.3 Describe where in the ocean you may find salt and fresh water. How is fresh water added to the ocean?

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Activity 2: Water density and temperature

The temperature of water affects its density. As density changes, water either rises or sinks, creating currents that cause it to mix and flow.

Aim

To investigate the relationship between temperature and density.

Materials

1 pneumatic trough

1 x 500 mL beaker

3 blue ice cubes

100 mL of hot or boiling water

red food colouring

Method

1. Add room-temperature water to the pneumatic trough so it's two thirds full.
2. Add five drops of food colouring to hot water, and mix.
3. Add ice cubes to water in trough and observe what happens.
4. Record your observations in the table below.
5. Tip hot water gently into water in trough and observe what happens.
6. Wait a few minutes then record your observations again.

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Questions

3.1 Summarise what happened in this experiment.

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3.2 How does this experiment relate to the ocean? Predict where around the world more or less CO_2 may be absorbed into the ocean?

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3.3 What do you think might happen to the ocean's ability to absorb and dissolve carbon dioxide as ocean surface temperature warms?

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Activity 4: Water acidity

Carbon dioxide from air enters seawater at the surface, and dissolves in top layers before being cycled into deep currents. The ocean can store carbon dioxide because carbon dioxide reacts with components of seawater to form carbonic acid and hydrogen carbonate ions. Over 90% of carbon in the ocean is stored as hydrogen carbonate ions. These compounds change pH of the ocean. This is a measure of acidity that needs to be fairly constant for sea life to exist.

Aim

To observe how pH of water changes when carbon dioxide gas (present in your breath) is bubbled through it.

Materials

100 mL seawater

100 mL tap water

universal indicator

indicator card

2 x 250 mL beakers

waste beaker

depression tile

eyedropper

straw

Method

1. **Place** 100 mL of tap water into one beaker and 100 mL of seawater into the other.
2. **Use** eyedropper to remove tap water, putting two drops into one hole in the depression tile.
3. **Measure** pH of tap water by adding two drops of universal indicator.
4. **Compare** colour with indicator card.
5. **Record** your reading at zero time, in table below.
6. **Using straw, blow** into tap water for five seconds.
7. **Remove** two drops of tap water and place in empty hole in depression tile.
8. **Test and record** pH.
9. **Using straw, blow** into tap water for another five seconds.
10. **Test and record** pH.
11. **Repeat** until pH of tap water changes.
12. **Repeat** steps 2 to 11 for seawater.

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Results

Complete the following table.

TIME (sec)	TAP WATER pH	SEAWATER pH
0		
5		
10		
15		
20		
25		
30		
35		

Questions

4.1 Did tap water or seawater change pH when carbon dioxide (in your breath) was bubbled in?

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4.2 Explain why pH has changed.

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Activity 5: Phytoplankton from space

Aim

To see the extent of phytoplankton and photosynthesis in the ocean.

View animation/video, *SeaWiFS Biosphere Data over Australia* (see media provided). This animation is taken from data, collected over ten years, by the SeaWiFS instrument on Seastar satellite. The instrument monitors the colour of reflected light from the earth.

5.1 Which colours, and their coverage, change in the animation?

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5.2 What do you think these changes represent?

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View the animation/video: *Chlorophyll 2007-2010* (see media provided).
This animation is of chlorophyll concentration in a colour scale from dark blue (low) to yellow (high) in the ocean over three years. Chlorophyll is the chemical in plants that colour them green and is involved in photosynthesis. So the animation shows the concentration of green plants.

5.3 What do you observe in this animation?

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5.4 What do you infer from this observation?

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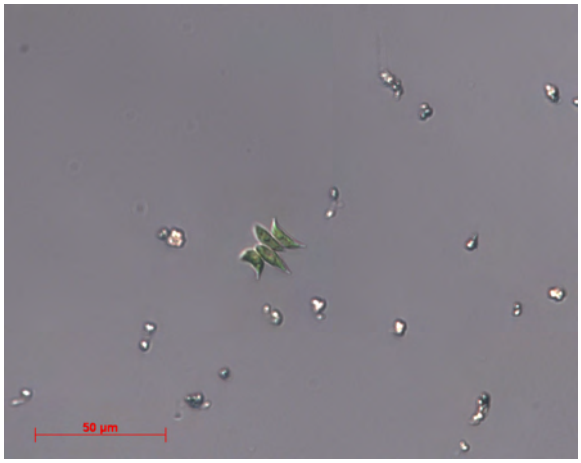
Activity 6: Phytoplankton under the microscope

Phytoplankton refers to a wide variety of microscopic organisms found in a watery environment. They include bacteria and protists, but most are single-celled plants. They all photosynthesise.



phytoplankton found in water from a fish tank

phytoplankton found in water from the Swan River

phytoplankton found in seawater

microscope images by John Murphy (Centre for Microscopy, Characterisation and Analysis, UWA)

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Aim

To see phytoplankton.

Materials

seawater or pond water

microscope

depression slide

cover slip

pipette

plain paper and pencil

Method

1. Obtain a sample of seawater or pond water.
2. Pipette small amount of water into depression slide well, and cover with cover slip.
3. Look at water through microscope.
4. Draw anything you think is phytoplankton, in the space below.
5. Repeat steps 1 to 4 with different water samples.

Activity 7: Phytoplankton rap

Aim

To appreciate the vital role of phytoplankton to life on Earth.

Method

Listen to and watch the rap (here's a guide to the lyrics).

You look at us
What do you see
Teeny-tiny things
In the huge sea
Well look again
Well look again

We are producers
We are sequesters
We are essential
We're phytoplankton
And we are cool huh
Yes really cool huh

Let us tell you
How it is us
That is real big
And how it's you
That is real small
See we woz here
Millenniums 'fore you
We made O2
So you could live
And you could move
And you could think
Plus we took down
Carbon dioxide
From atmosphere
To make it cool
Yeah cool
Otherwise
You woulda fried

We are producers
We are sequesters
We are the coolers
We're phytoplankton
And we are cool huh
Yes really cool huh

How'd we do it?
Well we are plants
So we make food
From sun'n CO_2 in the air
Which means we make
O2 as well
We may get eat'n
By zoo plankton
Who poo bits out
And if we're not
All gobbled up
We end up dead
And then we sink
With the zoo poo
As marine snow
Down to the depths
Where we stay put
Locking away
Bits of carbon
And 'cos there's tons
Of us and we
Been here for a
Very long time
That's lotsa carbon lock'd away
We mean a real
Big stasha carbon
Much bigger than
Anywhere else right

We are producers
We are sequesters
We are the coolers
We are the biological pumpers
We're phytoplankton
And we are cool huh
Yes really cool huh

But then in time
We became fuel
And you found that
And you burnt that
So the carb's back
And the whole earth
That had balance
Cannot hack that
So now we've got
Too much carb in
The atmosphere
Makin' the earth hot
That we made cool

We are producers
We are sequesters
We are the coolers
We are bio pumpers
We are your fuellers
We're phytoplankton
And we are cool huh
Yes really cool huh

We'll do our bit
To cool it down
But you must help
It tooka long time
To store the carbon
And we don't like
Acidic seas
Or gettin' warm
So quit your burnin'
And love all us
Photosynthsizing plants huh
However small
On land and sea

We are producers
We are sequesters
We are the coolers
We are the fuellers
We are biopumpers
We are essential
We're teeny tiny
But there's lotsa us
We're phytoplankton
And we are cool huh
Yes really cool huh

Questions

7.1 What does ‘we are producers’ mean?

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7.2 How do phytoplankton make food?

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7.3 What’s the name of the process that causes dead phytoplankton and bits of phytoplankton to end up in the deep ocean?

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7.4 What is ‘marine snow’?

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7.5 What does ‘we are sequesters’ mean?

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Activity 8: Plan a phytoplankton investigation

Phytoplankton, like all plants, need certain things to survive. Brainstorm what factors (variables) are most likely to affect how phytoplankton grow and reproduce.

Aim

To plan an investigation that tests how phytoplankton respond to changes in their living environment.

Planning

1. Which variable(s) are you going to investigate? Why?
2. Predict what might happen in the investigation.
3. What equipment will you need to carry out your investigation?
4. Draw a diagram of your equipment.
5. How will you carry out your investigation?
6. How will you measure phytoplankton growth?
7. How will you record your observations about phytoplankton growth? E g Draw a table if you're collecting data.

Discuss

1. Which factor did you test?
2. Why is this factor essential for phytoplankton to survive?
3. What did your test show?
4. Can you explain what happened?
5. Phytoplankton are an important carbon store in the ocean. Relate observations from your investigation to the wider issue of carbon in our atmosphere?

Interesting notes about phytoplankton

Experiments are underway to see if phytoplankton can be 'farmed' to provide a sustainable form of bio-fuel.

It's been suggested that phytoplankton played a significant role in causing the last ice age when initial cooling caused nutrient-rich dust to blow into the ocean and levels of phytoplankton increased, pulling more carbon dioxide out of the atmosphere and subsequently cooling the planet further. (reference Martinez-Garcia, 2011)

Activity 9: Seagrass services

Aim

To find out how seagrasses support the near shore environment, and how they're involved in the carbon cycle.

Method

Watch the media about a seagrass transplanting project with UWA scientist John Statton, and South Fremantle Senior High School marine studies students.

Answer the following questions.

Questions

9.1 What are some services that seagrasses provide to the coastal environment?

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9.2 Why is it useful for these students to experiment to find the best way to replant and restore seagrass beds?

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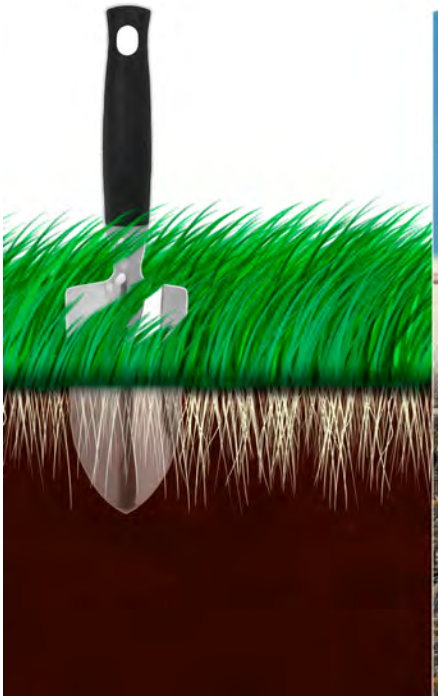
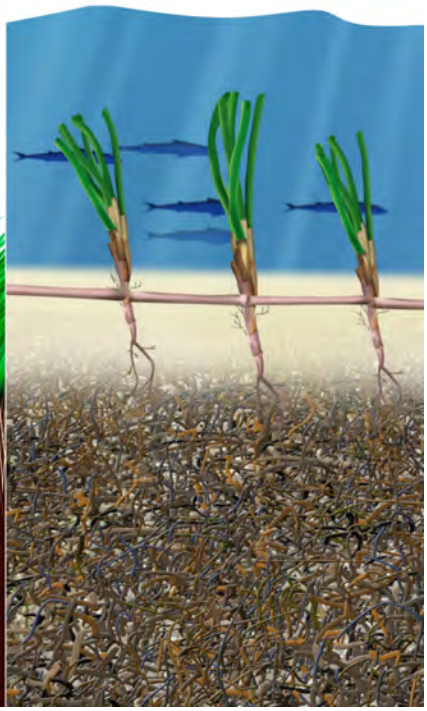
9.3 Label the following diagram with places/way(s) that grass and seagrasses sequester (store away) carbon. Place a star next to the best place.

grass



seagrass



Sequester

1.....

2.....

Sequester

1 .....

2 .....

3 .....

Activity 10: Drawing the carbon cycle

Aim

To recognise carbon sinks, their relative sizes and movement of carbon between them.

Method

Look closely at the two carbon cycle diagrams, and answer the questions.

Note: Carbon is measured in GtC (gigatonnes of carbon).

Questions

10.1 Which is the largest carbon sink (storage)?

.....

10.2 Which is the smallest carbon sink shown?

.....

10.3 How much carbon (GtC) is held in soil?

.....

10.4 How much carbon (GtC) is held in fossil fuels (oil, gas and coal)?

.....

10.5 Where is there a 'two-way' movement (flux) of carbon?

.....

10.6 Between which stores is the largest flux of carbon? How much carbon is involved?

.....

10.7 How much carbon goes into the atmosphere as a result of using fossil fuels and cement production (GtC/year)?

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10.8 Find two differences in information between cycles in these diagrams. Why do you think this is?

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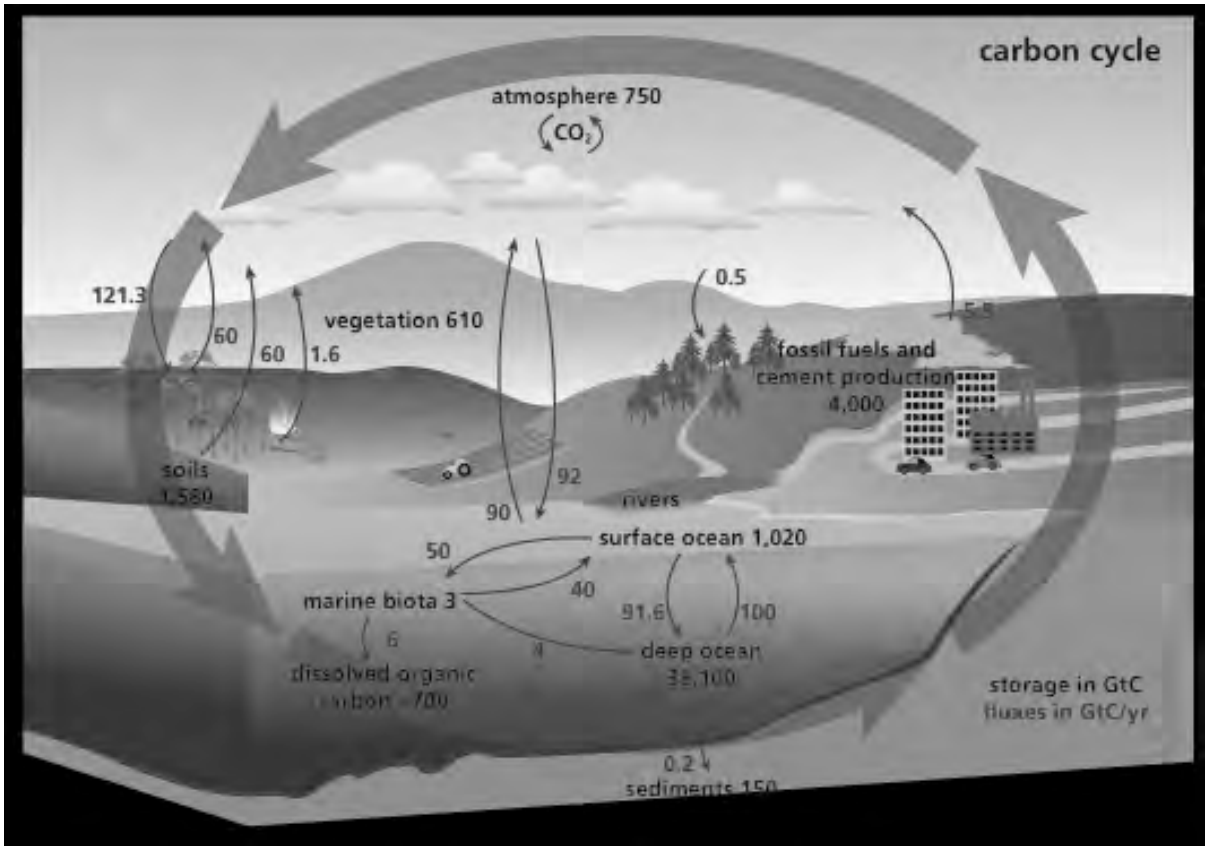
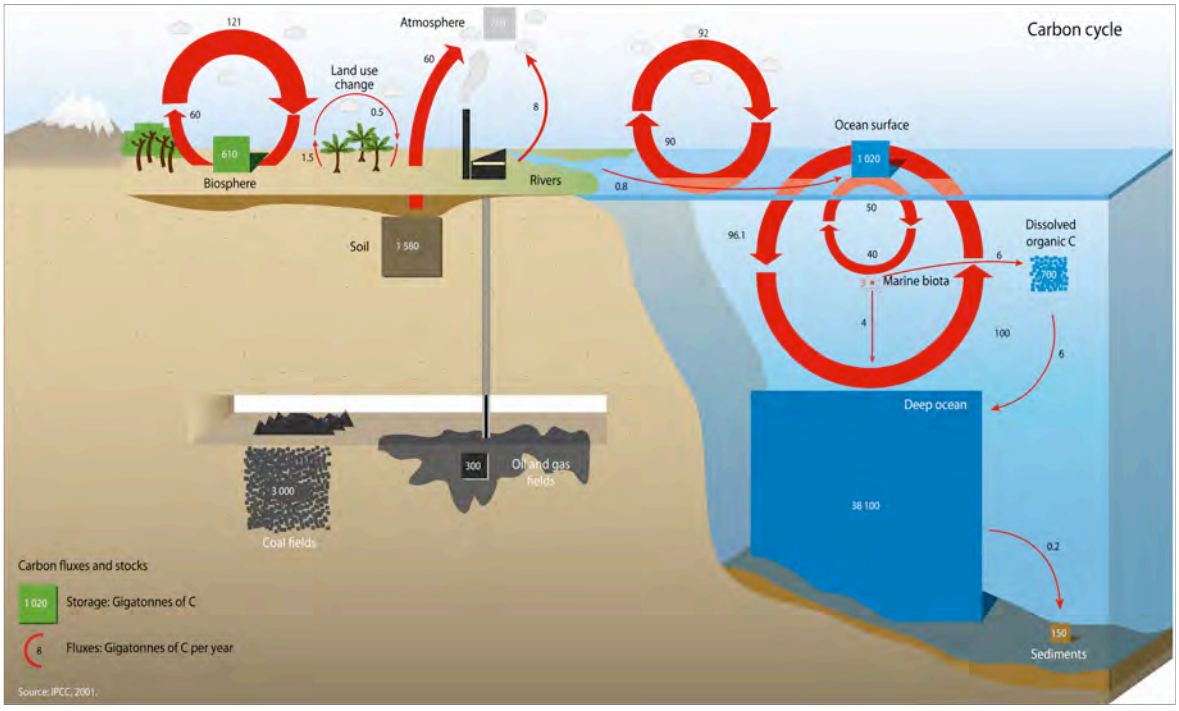


credit: NASA Earth Observatory



credit: Ricardo Pravettoni UNEP/GRID-Arendal

10.9 Use either the NASA or IPCC diagrams to complete the flow diagram below. It should represent the carbon sink and amounts in GtC (gigatonnes of carbon) and GtC/year (gigatonnes of carbon per year).

Fill in:

- boxes representing sinks without names (3)
- sinks without carbon amounts (2)
- arrow lines without a directional arrowhead (2)
- arrows without flux amounts (3)

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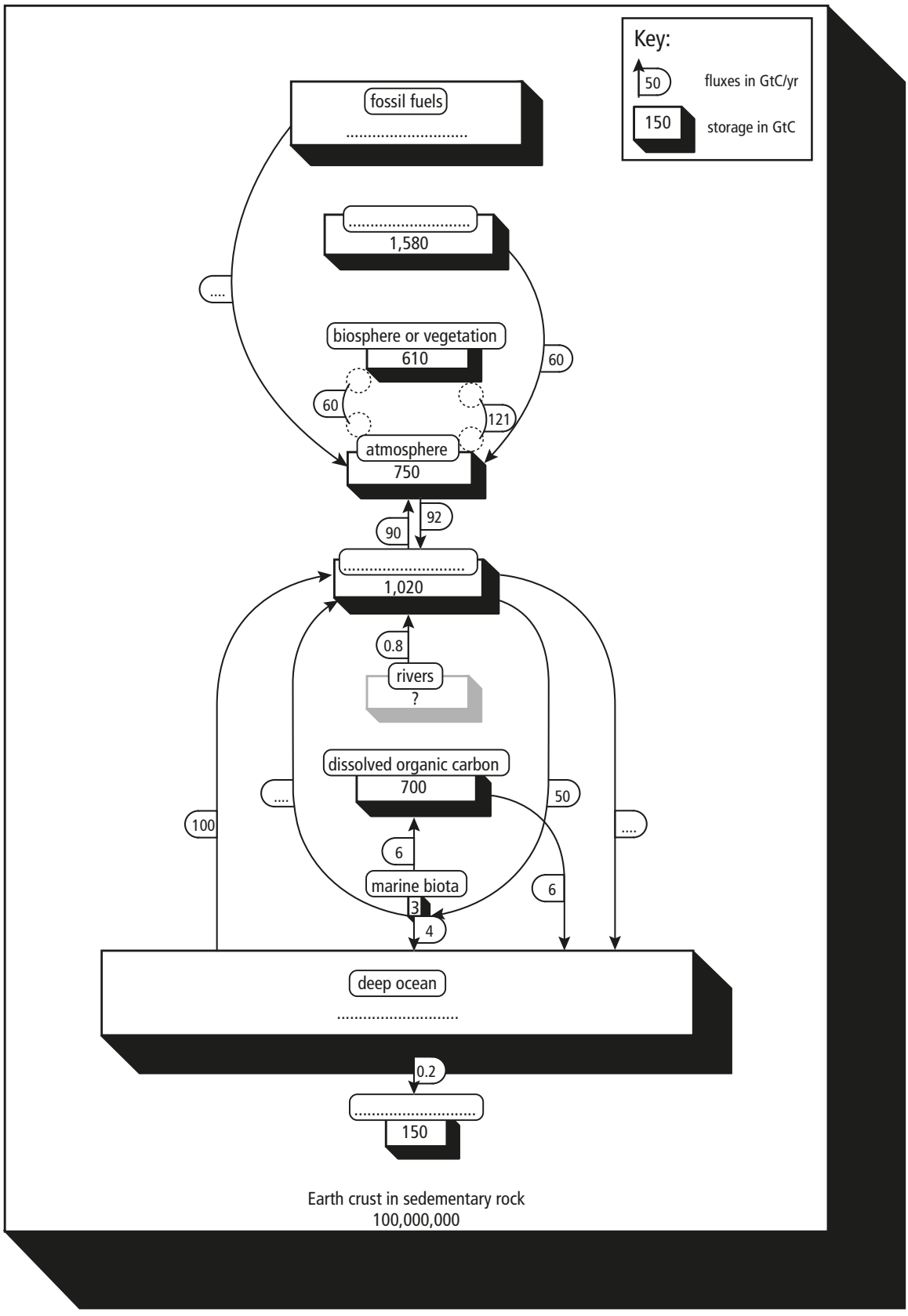

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