2023

# Watching Seagrass Breathe

Alyson Hall
*Virginia Institute of Marine Science*

# WATCHING SEAGRASS BREATHE

**Alyson Hall**
Virginia Institute of Marine Science

**Grade Level**
7th Grade / High School

**Subject Area**
Life Science / Biology

*VA SEA is a collaborative project between the Chesapeake Bay National Estuarine Research Reserve, the Virginia Institute of Marine Science's Marine Advisory Program, and Virginia Sea Grant. The VA SEA project is made possible through funding from the National Estuarine Research Reserve System Science Collaborative, which supports collaborative research that addresses coastal management problems important to the reserves. The Science Collaborative is funded by the National Oceanic and Atmospheric Administration and managed by the University of Michigan Water Center.*

**Title: Watching Seagrass Breathe**

**Focus:** Investigating how seagrasses act as primary producers in the ocean, why we care about them, and how scientists measure their rates of primary production and respiration.

**Grade Level:** 7th Grade Life Sciences or High School Biology

**VA Science Standards:**

*Lesson without Additional Worksheet*:

LS.1 The student will demonstrate an understanding of scientific and engineering practices by

c) Interpreting, analyzing, and evaluating data

- identify, interpret, and evaluate patterns in data
- construct, analyze, and interpret graphical displays of data
- compare and contrast data collected by different groups and discuss similarities and differences in their findings

LS.4 The student will investigate and understand that there are chemical processes of energy transfer that are important for life. Key ideas include

a) photosynthesis is the foundation of virtually all food webs; and

b) photosynthesis and cellular respiration support life processes.

LS.8 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time. Key ideas include

a) organisms respond to daily, seasonal, and long-term changes;

b) changes in the environment may increase or decrease population size; and

c) large-scale changes such as eutrophication, climate changes, and catastrophic disturbances affect ecosystems.

*With Scaling Up to High School with additional Worksheet:*

BIO.1 The student will demonstrate an understanding of scientific and engineering practices by

a) asking questions and defining problems

- ask questions that arise from careful observation of phenomena and/or organisms, from examining models and theories, and/or to seek additional Information

- determine which questions can be investigated within the scope of the school laboratory or field to determine relationships between independent and dependent variables
- generate hypotheses based on research and scientific principles
- make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated

c) interpreting, analyzing, and evaluating data

- construct and interpret data tables showing independent and dependent variables, repeated trials, and means
- construct, analyze, and interpret graphical displays of data
- use data in building and revising models, supporting an explanation for phenomena,
- or testing solutions to problems analyze data using tools, technologies, and/or models to make valid and reliable scientific claims or determine an optimal design solution

d) constructing and critiquing conclusions and explanations

- make quantitative and/or qualitative claims regarding the relationship between dependent and independent variables
- construct and revise explanations based on valid and reliable evidence obtained from a variety of sources including students' own investigations, models, theories, simulations, and peer review
- apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and design solutions

BIO.2 The student will investigate and understand that chemical and biochemical processes are essential for life. Key ideas include

e) the processes of photosynthesis and respiration include the capture, storage, transformation, and flow of energy

BIO.8 The student will investigate and understand that there are dynamic equilibria within populations, communities, and ecosystems. Key ideas include

c) ecosystems have succession patterns; and

d) natural events and human activities influence local and global ecosystems and may affect the flora and fauna of Virginia.

**Learning Objectives:**

1. Students will be able to describe seagrasses and their role in the environment in the Chesapeake Bay.
2. Students will be able to describe primary production as net primary production and gross primary production and contrast this with respiration.
3. Students will demonstrate the ability to calculate rates of change for primary production in terms of dissolved oxygen.
4. Students compare and contrast rates of primary production for different species.
5. Students will expand on their knowledge of seagrass primary production to scale up and make estimates about the Chesapeake Bay and how it has changed through time.

**Total Time Needed:** 1 hour

**Key Words:**

Seagrass: marine flowering plants

Photosynthesis: the process by which carbon dioxide, water, and minerals are transformed into sugars and oxygen in the presence of light

Incubation: the time in which the benthic chambers are running and actively sampling

Net Primary Production: The primary production of a habitat after respiration of the plants have been subtracted.

Gross Primary Production: The total primary production of a habitat before the respiration of the plants has been subtracted.

Respiration: The cellular process in which sugars are broken down in the presence of oxygen to usable energy.

**Background Information:**

Seagrasses are the only marine flowering plants that evolved from terrestrial coastal plants (Hemminga & Duarte, 2000). These plants grow in shallow waters along coastlines to form seagrass meadows, literally underwater prairies that are critically important to marine life and provide other important ecosystem services. Ecosystem services are the processes or benefits of a habitat that we as humans value. Some of these services in meadows include providing homes and food for a variety of animals including bay scallops and other shellfish, juvenile game fish and crabs, rays and sharks, manatees, and sea turtles. The meadows also sequester carbon, improve water clarity through sediment trapping, protect shorelines, cycle nutrients, and oxygenate the water (Hemming and Duarte 2000; Duarte et al., 2010). Seagrass meadows are globally distributed, found on the coastline of all continents except Antarctica (Duarte et al., 2008). Despite their nearly global expanse, seagrasses are quickly disappearing due to local, regional, and global effects from human impact such as habitat destruction, deteriorating water quality, and increasing sea surface temperatures (Orth et al., 2006).

Virginia has two species of seagrasses that are present in the Chesapeake Bay and the Eastern Shore's coastal bays: *Zostera marina* (Eelgrass), and *Ruppia maritima* (Widgeon grass). In the Chesapeake Bay, we have seen devastating losses of submerged aquatic vegetation (SAV), with a majority of SAV losses coming from seagrass decline since the 1990s (Lefcheck et al., 2017). In the lower Chesapeake Bay, Zostera has historically been the dominant seagrass species, once making up 50% of SAV in the Bay; however, due to the increased frequency of summer heat waves, eelgrass coverage has been declining over the past 20 years, and now only makes up 20% of total SAV. During this time, widgeon grass has become the dominant species for mid and lower Chesapeake Bay seagrass coverage. The impacts of this species shift are not yet fully known and add a layer of complexity to understanding the ecosystem service of seagrasses in Virginia.

**Materials:**

- Calculator
- Worksheets
- Print out of incubations OR 5 computers/tablets for videos (1 per group)

**Classroom Set-Up:**

This activity is recommended for 5 groups, but 10 groups or students working individually can be accommodated with either some of the incubations being repeated or with groups working on one incubation only per worksheet. If in groups, students should be able to sit with their group members to look over the videos or printouts. Each group (or student, if working individually) will need a printed worksheet, including the photos of the incubations. The photos can be laminated and used over and over again. Alternatively, each group can use a computer or tablet to watch the incubations occur via the videos in replacement of the printouts. If working virtually, students can watch the videos as groups in break-out rooms or as a class.

There is an additional worksheet for scaling up the lesson to meet high school learning standards. This worksheet is not required, but will introduce students to how scientists use this data to look at primary production for an entire estuary.

**Procedure:**

1. **Prepare Materials**

   The instructor will pass out the worksheets and either the videos or printouts of the incubations, assign groups (if desired), and set up the PowerPoint slides. The printouts of the incubations can be laminated for future use.

2. **Introduction**

   The instructor will introduce the lesson and activity using the provided PowerPoint. Throughout the PowerPoint, students will be exposed to the Seagrasses of the Chesapeake Bay, the process of photosynthesis and respiration, and the importance of primary producers in ecosystems. They will also learn ways in which scientists measure primary production.

3. **Activity/Assessment**

   The instructor should pause the PowerPoint and allow students to complete the worksheet sections and questions in order (Noted in PowerPoint slides). Worksheets can be completed using one per group to save on paper. Throughout the activity, students will record differences in dissolved oxygen at the start and end of incubations, and calculate rates of respiration. net primary production, and gross primary production.

   While dissolved oxygen cannot be seen as bubbles when measuring production and respiration, the students are acting as dissolved oxygen sensors scientists use, which does count the amount of dissolved oxygen. Students will use the starting and ending dissolved oxygen concentrations to calculate the rate of change using this equation:

$$Rate\ of\ change\ = \frac{(Ending\ concentration)\ - (Starting\ concentration)}{(Time\ Passed)}$$

   If the rate of change is negative, the dominating process is respiration, while if the rate of change is positive, the dominating process is photosynthesis! From the difference between the rate of respiration and the rate of net primary production, the rate of gross primary production is calculated. Students will compare rates between species and show this comparison graphically through bar charts.

As a note: You may choose to have students watch videos of the incubations (either from video files you send them or the prepared PowerPoint that compiles videos by group number), or have them count the before and after (provided as a pdf).

Finally, students will scale up their rates of GPP per species from one hour to a whole day. The end of the worksheet include discussion questions about what their rates mean for seagrass ecosystems as a whole in the Chesapeake bay.

*Additional Worksheet:*

Students will use their rates to calculate the gross primary production of the lower Chesapeake Bay for one day as scientists do by scaling up their rates to a relevant spatial scale and compare over two time points. Throughout they will answer questions on the worksheets to recap what they have found and think about those findings in terms of ecosystems.

4. **Discussion/Reflection**

Students are asked discussion questions at the end of each worksheet. Students may complete discussions on their own or can be led by the teacher. Present the questions: “Explain seagrasses' role in the Chesapeake Bay”. How might species identity impact the primary production of seagrass meadows? Following all activities, students should discuss what their findings mean in a broader context: how seagrasses' role in the Chesapeake Bay will change depending on the species. This will be expanded upon in Worksheet 2 if used.

**References:**

Duarte, C. M., Marbà, N., Gacia, E., Fourqurean, J. W., Beggins, J., Barrón, C., & Apostolaki, E. T. (2010). Seagrass community metabolism: Assessing the carbon sink capacity of seagrass meadows. *Global Biogeochemical Cycles*, *24*(4). https://doi.org/10.1029/2010GB003793

Hemminga, M. A., & Duarte, C. M. (2000). *Seagrass Ecology*. Cambridge University Press.

Lefcheck, J. S., Wilcox, D. J., Murphy, R. R., Marion, S. R., & Orth, R. J. (2017). Multiple stressors threaten the imperiled coastal foundation species eelgrass (Zostera marina) in Chesapeake Bay, USA. *Global Change Biology*, *23*(9), 3474–3483. https://doi.org/10.1111/gcb.13623

Orth, R. J., Carruthers, T. J. B., Dennison, W. C., Duarte, C. M., Fourqurean, J. W., Heck, K. L., Hughes, A. R., Kendrick, G. A., Kenworthy, W. J., Olyarnik, S., Short, F. T., Waycott, M.,

& Williams, S. L. (2006). A Global Crisis for Seagrass Ecosystems. *BioScience*, *56*(12), 987–996. https://doi.org/10.1641/0006-3568(2006)56[987:AGCFSE]2.0.CO;2

**Appendices:**

Worksheet 1

Worksheet 2

Worksheet 3 with Unit Conversion

Worksheet 3 without Unit Conversion

Worksheet 1 Answers

Worksheet 2 Answers

Worksheet 3 Answers with Unit Conversion

Worksheet 3 Answers without Unit Conversion

**Seagrass Metabolism - Worksheet 1**

**Name(s) ___________________**

**Date_____________________**

Section A

**Introduction**

You are working with a group of marine scientists to measure the Gross Primary Production (GPP) of seagrasses in the Chesapeake Bay. Seagrasses are underwater plants that live in marine, salty, water. Like all plants, they use photosynthesis to use carbon dioxide to produce sugars and release oxygen, but they also respire and use oxygen and release carbon dioxide. You know that to measure GPP, you must first measure the Net Primary Production (NPP) and Respiration of the seagrass meadow.

**Answer the following questions before beginning**

1) Will the amount of dissolved oxygen increase or decrease with respiration? What about photosynthesis?

2) What equation will you need to calculate GPP from NPP and respiration?

**Form a hypothesis**

1) Write your hypotheses below
    a) Do you think the seagrasses will have a higher rate of respiration or NPP? Why?

b) Do you think the seagrasses will have a positive or negative rate of GPP? Why?

**Record the rates of Respiration and NPP in the data tables**

Look at the 1-hour incubations (light and dark) for your group and write down the replicate number. Count the number of bubbles at the start and end of your two incubations and record the starting and ending number of bubbles in your data table. Get the counts for bubbles from the other groups and record them as well. ]Calculate the average rate of change for each replicate. Finally, calculate the average rate of change.

Eelgrass Dark Incubations

| Replicate | Starting Oxygen Bubbles | Ending Oxygen Bubbles | Rate of Change |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | Average: |

Eelgrass Light Incubations

| Replicate | Starting Oxygen Bubbles | Ending Oxygen Bubbles | Rate of Change |
|---|---|---|---|
| | 0 | | |
| | 0 | | |
| | 0 | | |

| | | | |
|---|---|---|---|
| | 0 | | |
| | 0 | | |
| | | | Average: |

**Complete the following questions after filling in the tables.**

1) Which type of incubation is measuring respiration? NPP?

2) Which (respiration or NPP) has a higher rate of change? Does this match your hypothesis? Does this make sense?

<u>Section B</u>

**Not all seagrass species have the same rates of NPP and R**. In the Chesapeake Bay, we have two seagrass species: Eelgrass (*Zostera marina*) and Widgeon Grass (*Ruppia maritima*). These species differ in shape and size with Eelgrass having bigger and taller leaves while Widgeon Grass is typically shorter with thinner, round leaves.

**Answer the following questions before beginning**

1) Why might species have different rates of NPP and R?

**Form a hypothesis**

Which species (Eelgrass or Widgeon Grass) do you think will have the higher rate of NPP? Why? *Remember to write your hypothesis as an if-then statement.*

**Record the rates of Respiration and NPP of your second species in the data tables**

Look at the Widgeon Grass incubations (light and dark) for your group and write down the replicate number in the same way as with Eelgrass! Calculate the rate of change as you did with Eelgrass.

Widgeon Grass Dark Incubations

| Replicate | Starting Oxygen Bubbles | Ending Oxygen Bubbles | Rate of Change |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | Average: |

Widgeon Grass Light Incubations

| Replicate | Starting Oxygen Bubbles | Ending Oxygen Bubbles | Rate of Change |
|---|---|---|---|
| | 0 | | |
| | 0 | | |
| | 0 | | |

| | | | |
|---|---|---|---|
| | 0 | | |
| | 0 | | |
| | | | Average: |

**Answer the following questions after calculating**

1) Which species had a larger rate of respiration? Rate of NPP?

*Challenge Question:*

2) Why might these species differ?

**Calculate the Gross Primary Production (GPP) from the average rates of NPP and respiration.**

GPP is a measure of energy or biomass produced, but we are using oxygen as a way to indirectly measure this. Calculate the GPP of the seagrass meadow using the average rates of Eelgrass and Widegon Grass NPP and R from above. *Remember we calculate GPP by subtracting the Light - Dark Incubations:*

*(Oxygen rate from Photosynthesis) - (Oxygen rate from Respiration).*

<u>Eelgrass Rate of GPP</u>

| Average Rate of NPP | Average Rate of Respiration | Rate of GPP |
|---|---|---|
| | | |

Widgeon Grass rate of GPP

| Average Rate of NPP | Average Rate of Respiration | Rate of GPP |
|---|---|---|
| | | |

**Graph the rates of respiration, NPP, and GPP for each species as a bar plot.**

*Don't forget to add axis labels and a legend if needed!*


**Answer the following questions after graphing**

1) Is your rates of GPP positive or negative? Are they bigger or smaller than the average rate of NPP? Why does this make sense?

2) Does this mean seagrasses net add oxygen or remove oxygen from the water in the Chesapeake Bay?

Section C

**The incubations marine scientists run only show a snapshot in time.** In the incubations, you only measured the change in dissolved oxygen for 1 hour in the morning. Scientists often need to scale up their measurements both in time (for example: calculating GPP for a day, month, or year) and by space (for example GPP of all the seagrasses in the Chesapeake Bay).

**Answer the following questions**

1) Why would scientists want to know the rate of GPP for longer periods of time?

2) Why don't scientists measure the grass for that whole time?

**Calculate the GPP for a day for each of the species.**

In order to calculate the GPP for different time periods, we have to multiply our rate by the amount of time we want to estimate. *How many hours are our incubations for? How many hours in a day?*

| Species | Rate of GPP per hour | Rate of GPP per day |
|---|---|---|
| | | |

| | | |
|---|---|---|
| | | |
| | | |

**Final Reflections**

3) Are seagrass meadows net autotrophic or heterotrophic?

4) Which species had the larger rate of GPP per day? What does this mean for a meadow of Eelgrass vs a meadow of Widgeon Grass?

5) What would happen if a meadow that had Eelgrass switched to one with Widgeon Grass? How would the animals living in seagrass meadows be affected?

**Seagrass Metabolism - Worksheet 2**

**Name(s) ___________________**

**Date_____________________**

**Scaling Up in Space**

Seagrass coverage in the Chesapeake Bay changes yearly. Scientists at the Virginia Institute of Marine Science use annual aerial images taken from planes to map how much seagrass there is per year. Use some of these values to see how rates of GPP change over time depending on coverage and species identity.

**2020**

In 2020 Scientists found that there were 55,000 square meters of Eelgrass and 80,000 square meters of Widgeon Grass in the Chesapeake Bay. Our benthic chambers measured 1 square foot. How can we make the units match? We can multiply our rate by the same number of square meters in a square foot, which is equal to 0.9!

$$\frac{Oxygen\ per\ week}{per\ square\ foot} X \frac{Square\ foot}{Square\ meter} = \frac{Oxygen\ per\ week}{Square\ meter}$$

Calculate the GPP of each species and for all Seagrasses in the Chesapeake Bay for one day in 2020 using the coverage in square meters of each species and their rates of GPP per day (calculated in Worksheet 1 C).

GPP in 2020

| Species | Rate of GPP per day per Square Foot | Rate of GPP per day per Square Meter | Area of Species is 2020 | Rate of GPP for one day in the Chesapeake Bay |
|---|---|---|---|---|
| | | | | |

| | | | | |
|---|---|---|---|---|
| | | | | |
| | | | | Total GPP for seagrasses in the Chesapeake Bay for one day: |

**1990**

In 1990 the area of species of seagrass in the Chesapeake was different: Eelgrass covered 1,010,000 square meters and Widgeon Grass covered 71,000 square meters. Calculate the GPP of each species and for all Seagrasses in the Chesapeake Bay for one day in 1990. *Which rate should you use from the first part to get GPP for one day?*

<u>GPP in 1990</u>

| Species | Rate of GPP per day per Square <u>Meter</u> | Area of Species is 1990 | Rate of GPP for one day in the Chesapeake Bay per square meter |
|---|---|---|---|
| | | | |
| | | | |
| | | | Total GPP for seagrasses in the Chesapeake Bay in one day: |

**Final Reflections**

1) Was the rate of gross primary production higher in 2020 or in 1990? What is causing this?

2) Why would doing these calculations every year be helpful to scientists?

3) What do you think the differences between 2020 and 1990 mean for the ecosystems in the Chesapeake Bay?

4) What would cause changes in the amount of seagrass year to year?

5) Why might some species resond differently to changes in the environment?

**Seagrass Metabolism - Worksheet 1 ANSWERS**

**Name(s) ____________________**

**Date______________________**

Section A

**Introduction**

You are working with a group of marine scientists to measure the Gross Primary Production (GPP) of seagrasses in the Chesapeake Bay. Seagrasses are underwater plants that live in marine, salty, water. Like all plants, they use photosynthesis to use carbon dioxide to produce sugars and release oxygen, but they also respire and use oxygen and release carbon dioxide. You know that to measure GPP, you must first measure the Net Primary Production (NPP) and Respiration of the seagrass meadow.

**Answer the following questions before beginning**

1) Will the amount of dissolved oxygen increase or decrease with respiration? What about photosynthesis?

Decrease with respiration, increase with photosynthesis

2) What equation will you need to calculate GPP from NPP and respiration?

GPP = NPP - Respiration. (Respiration is negative so the - turns into a +!)

**Form a hypothesis**

3) Write your hypotheses below

a) Do you think the seagrasses will have a higher rate of respiration or NPP? Why?

Seagrasses will have a higher rate of NPP because they are primary producers for the whole ecosystem.

b) Do you think the seagrasses will have a positive or negative rate of GPP? Why?

Seagrasses will have a positive rate of GPP because oxygen is being produced, not used!

**Record the rates of Respiration and NPP in the data tables**

Look at the 1-hour incubations (light and dark) for your group and write down the replicate number. Count the number of bubbles at the start and end of your two incubations and record the starting and ending number of bubbles in your data table. Get the counts for bubbles from the other groups and record them as well. ]Calculate the average rate of change for each replicate. Finally, calculate the average rate of change.

<u>Eelgrass Dark Incubations</u>

| Replicate | Starting Oxygen Bubbles | Ending Oxygen Bubbles | Rate of Change |
|---|---|---|---|
| 1 | 9 | 5 | -4 |
| 2 | 10 | 7 | -3 |
| 3 | 13 | 9 | -4 |
| 4 | 11 | 10 | -1 |
| 5 | 14 | 12 | -2 |
| | | | Average: -2.8 |

Eelgrass Light Incubations

| Replicate | Starting Oxygen Bubbles | Ending Oxygen Bubbles | Rate of Change |
|---|---|---|---|
| 1 | 0 | 15 | 15 |
| 2 | 0 | 12 | 12 |
| 3 | 0 | 11 | 11 |
| 4 | 0 | 13 | 13 |
| 5 | 0 | 7 | 7 |
| | | | Average: 11.6 |

**Complete the following questions after filling in the tables.**

1) Which type of incubation is measuring respiration? NPP?

   The dark incubation measures R while the light bag measures NPP!

2) Which (respiration or NPP) has a higher rate of change? Does this match your hypothesis? Does this make sense?

   NPP! See if it matches and reasoning for this.

Section B

**Not all seagrass species have the same rates of NPP and R**. In the Chesapeake Bay, we have two seagrass species: Eelgrass (*Zostera marina*) and Widgeon Grass (*Ruppia maritima*). These species differ in shape and size with Eelgrass having bigger and taller leaves while Widgeon Grass is typically shorter with thinner, round leaves.

**Answer the following questions before beginning**

1) Why might species have different rates of NPP and R?

If they have different rates of photosynthesis or respiration they will have different rates of GPP. The environment can also impact both primary production and respiration.

**Form a hypothesis**

Which species (Eelgrass or Widgeon Grass) do you think will have the higher rate of NPP? Why? *Remember to write your hypothesis as an if-then statement.*

Either is right, it is just a hypothesis as long as they give a reason.

Example: If Eelgrass has a higher rate of NPP then it will have a higher rate of GPP.

**Record the rates of Respiration and NPP of your second species in the data tables**

Look at the Widgeon Grass incubations (light and dark) for your group and write down the replicate number in the same way as with Eelgrass! Calculate the rate of change as you did with Eelgrass.

Widgeon Grass Dark Incubations

| Replicate | Starting Oxygen Bubbles | Ending Oxygen Bubbles | Rate of Change |
|---|---|---|---|
| 1 | 13 | 5 | -8 |
| 2 | 18 | 6 | -12 |
| 3 | 15 | 10 | -5 |
| 4 | 9 | 5 | -4 |
| 5 | 6 | 3 | -3 |
| | | | Average: -6.4 |

Widgeon Grass Light Incubations

| Replicate | Starting Oxygen Bubbles | Ending Oxygen Bubbles | Rate of Change |
|---|---|---|---|
| 1 | 0 | 22 | 22 |
| 2 | 0 | 19 | 19 |

| | | | |
|---|---|---|---|
| 3 | 0 | 15 | 15 |
| 4 | 0 | 14 | 14 |
| 5 | 0 | 13 | 13 |
| | | | Average: 16.6 |

**Answer the following questions after calculating**

1) Which species had a larger rate of respiration? Rate of NPP?

Widgeon Grass has a higher rate of NPP and respiration!

*Challenge Question:*

2) Why might these species differ?

They might take up carbon dioxide, water, or light at different rates which causes a difference in rates if NPP and R. The environment can also impact both primary production and respiration (amount of light, depth of water, temperature) and these species could grow in different places. .

**Calculate the Gross Primary Production (GPP) from the average rates of NPP and respiration.**

GPP is a measure of energy or biomass produced, but we are using oxygen as a way to indirectly measure this. Calculate the GPP of the seagrass meadow using the average rates of Eelgrass and Widegon Grass NPP and R from above. *Remember we calculate GPP by subtracting the Light - Dark Incubations:*

*(Oxygen rate from Photosynthesis) - (Oxygen rate from Respiration).*

Eelgrass Rate of GPP

| Average Rate of NPP | Average Rate of Respiration | Rate of GPP |
|---|---|---|

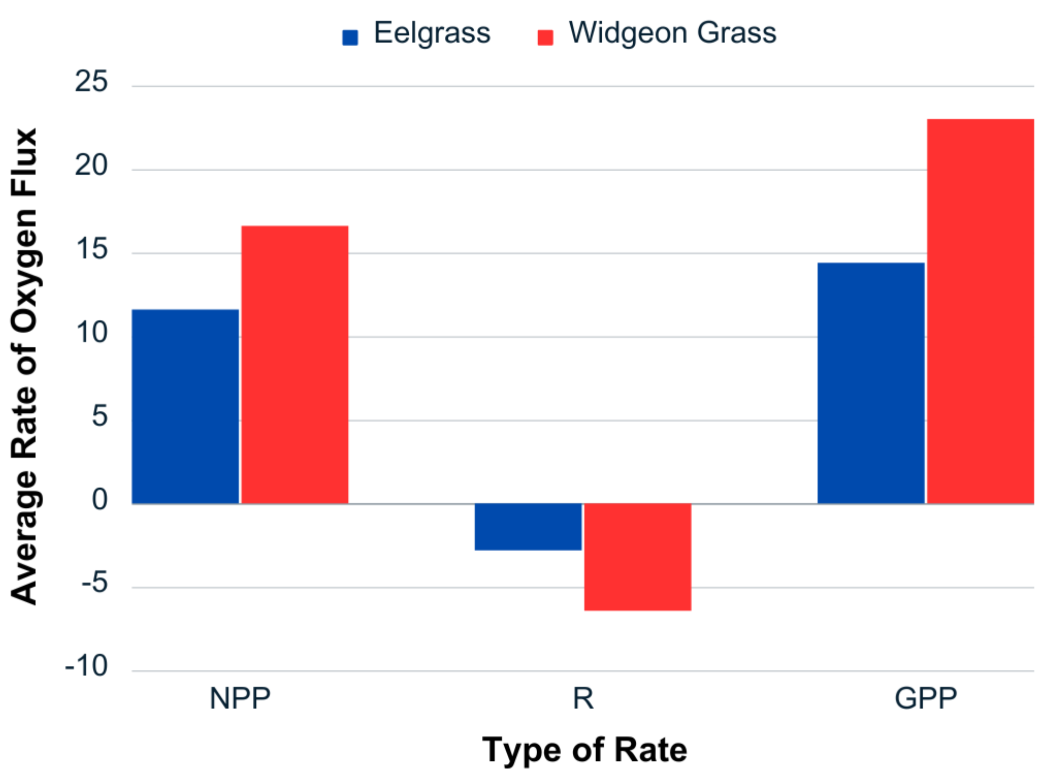
| | | |
|---|---|---|
| 11.6 | -2.8 | 14.4 |

<u>Widgeon Grass rate of GPP</u>

| Average Rate of NPP | Average Rate of Respiration | Rate of GPP |
|---|---|---|
| 16.6 | -6.4 | 23 |

**Graph the rates of respiration, NPP, and GPP for each species as a bar plot.**

*Don't forget to add axis labels and a legend if needed!*




**Answer the following questions after graphing**

1) Is your rates of GPP positive or negative? Are they bigger or smaller than the average rate of NPP? Why does this make sense?

The rate of GPP is positive and is bigger than the average rate of NPP. This makes sense because the plants have higher rates fo primary production than respiration. Extra answers could include primary producers are the base of many foodwebs, which means GPP for those ecosystems.

2) Does this mean seagrasses net add oxygen or remove oxygen from the water in the Chesapeake Bay?

They net add oxygen and energy to the Chesapeake Bay!

Section C

**The incubations marine scientists run only show a snapshot in time.** In the incubations, you only measured the change in dissolved oxygen for 1 hour in the morning. Scientists often need to scale up their measurements both in time (for example: calculating GPP for a day, month, or year) and by space (for example GPP of all the seagrasses in the Chesapeake Bay).

**Answer the following questions**

1) Why would scientists want to know the rate of GPP for longer periods of time?

So that they can estimate how oxygen levels change over time or for a full season.

2) Why don't scientists measure the grass for that whole time?

It would be heard to have sensors out for a whole day or even a whole year! Taking measurements takes time and effort and scientists work on many different things!

**Calculate the GPP for a day for each of the species.**

In order to calculate the GPP for different time periods, we have to multiply our rate by the amount of time we want to estimate. *How many hours are our incubations for? How many hours in a day?*

| Species | Rate of GPP per hour | Rate of GPP per day |
|---|---|---|
| Widgeon Grass | 23 | 23x24 hours = 552 |
| Eelgrass | 14.4 | 345.6 |

**Final Reflections**

1) Are seagrass meadows net autotrophic or heterotrophic?

Seagrass meadows are both sources of energy and oxygen to the Chesapeake Bay meaning they are net autotrophic! This is important to the ecosystem because they are a good base of the food web and help keep the water oxygenated!

2) Which species had the larger rate of GPP per day? What does this mean for a meadow of Eelgrass vs a meadow of Widgeon Grass?

Widgeon Grass has the largest rate of GPP! Meadows of Widgeon Grass should have higher rates and produce more energy and oxygen than meadows of Eelgrass per day. This could mean that meadows with Widegon grass will have higher concentrations of oxygen during the day which may bring more animals. Bonus answers for changing pH (more photosynthesis = less carbon dioxide = less acidic water), or higher rates of respiration in widgeon grass meaodows mean less oxygen at nightime for animals.

3) What would happen if a meadow that had Eelgrass switched to one with Widgeon Grass? How would the animals living in seagrass meadows be affected?

The animals may experience more oxygen than when it was dominated by eelgrass. BONUS: The shapes of eelgrass and widgeon grass differ so they may have less canopy space than they did with eelgrass.

**Seagrass Metabolism - Worksheet 2 ANSWERS**

**Name(s) ___________________**

**Date_____________________**

**Scaling Up in Space**

Seagrass coverage in the Chesapeake Bay changes yearly. Scientists at the Virginia Institute of Marine Science use annual aerial images taken from planes to map how much seagrass there is per year. Use some of these values to see how rates of GPP change over time depending on coverage and species identity.

**Answer the following questions before beginning**

1) What would cause changes in the amount of seagrass yera to year?

Changes in the environment: light, water quality, nutrients, animal grazing, climate change, human impacts (boating, aquaculture, etc.). Students should show evidence of brainstorming what might be impacting seagrass growth

**2020**

In 2020 Scientists found that there were 55,000 square meters of Eelgrass and 80,000 square meters of Widgeon Grass in the Chesapeake Bay. Our benthic chambers measured 1 square foot.

How can we make the units match? We can multiply our rate by the same number of square meters in a square foot, which is equal to 0.9!

$$\frac{Oxygen\ per\ week}{per\ square\ foot} X \frac{Square\ foot}{Square\ meter} = \frac{Oxygen\ per\ week}{Square\ meter}$$

Calculate the GPP of each species and for all Seagrasses in the Chesapeake Bay for one day in 2020 using the coverage in square meters of each species and their rates of GPP per day (calculated in Worksheet 1 C).

<u>GPP in 2020</u>

| Species | Rate of GPP per day per Square Foot | Rate of GPP per day per Square Meter | Area of Species is 2020 | Rate of GPP for one day in the Chesapeake Bay |
|---|---|---|---|---|
| Widgeon Grass | 552 | 552x0.09 = 49.68 | 80,000 square meters | 80,000x49.68= 3,974,400 |
| Eelgrass | 345.6 | 31.104 | 55,000 square meters | 1,710,720 |
| | | | | Total GPP for seagrasses in the Chesapeake Bay for one day: 5,685,120 |

**1990**

In 1990 the area of species of seagrass in the Chesapeake was different: Eelgrass covered 1,010,000 square meters and Widgeon Grass covered 71,000 square meters. Calculate the GPP of each species and for all Seagrasses in the Chesapeake Bay for one day in 1990. *Which rate should you use from the first part to get GPP for one day?*

GPP in 1990

| Species | Rate of GPP per day per Square Meter | Area of Species is 1990 | Rate of GPP for one day in the Chesapeake Bay per square meter |
|---|---|---|---|
| Widgeon Grass | 49.68 | 71,000 square m | 3,527,280 |
| Eelgrass | 31.104 | 1,010,000 square m | 31,415,040 |
| | | | Total GPP for seagrasses in the Chesapeake Bay: 34,942,320 |

**Final Reflections**

1) Was the rate of gross primary production higher in 2020 or in 1990? What is causing this?

The rate of GPP was higher in 1990! This is because there was more seagrass in 1990 than in 2020, the seagrass area is going down in the Chesapeake Bay!

2) Why would doing these calculations every year be helpful to scientists?

Scientists do these calculations every year so that they can track changes in the GPP of seagrasses for the whole Bay every year!

3) What do you think the differences between 2020 and 1990 mean for the ecosystems in the Chesapeake Bay?

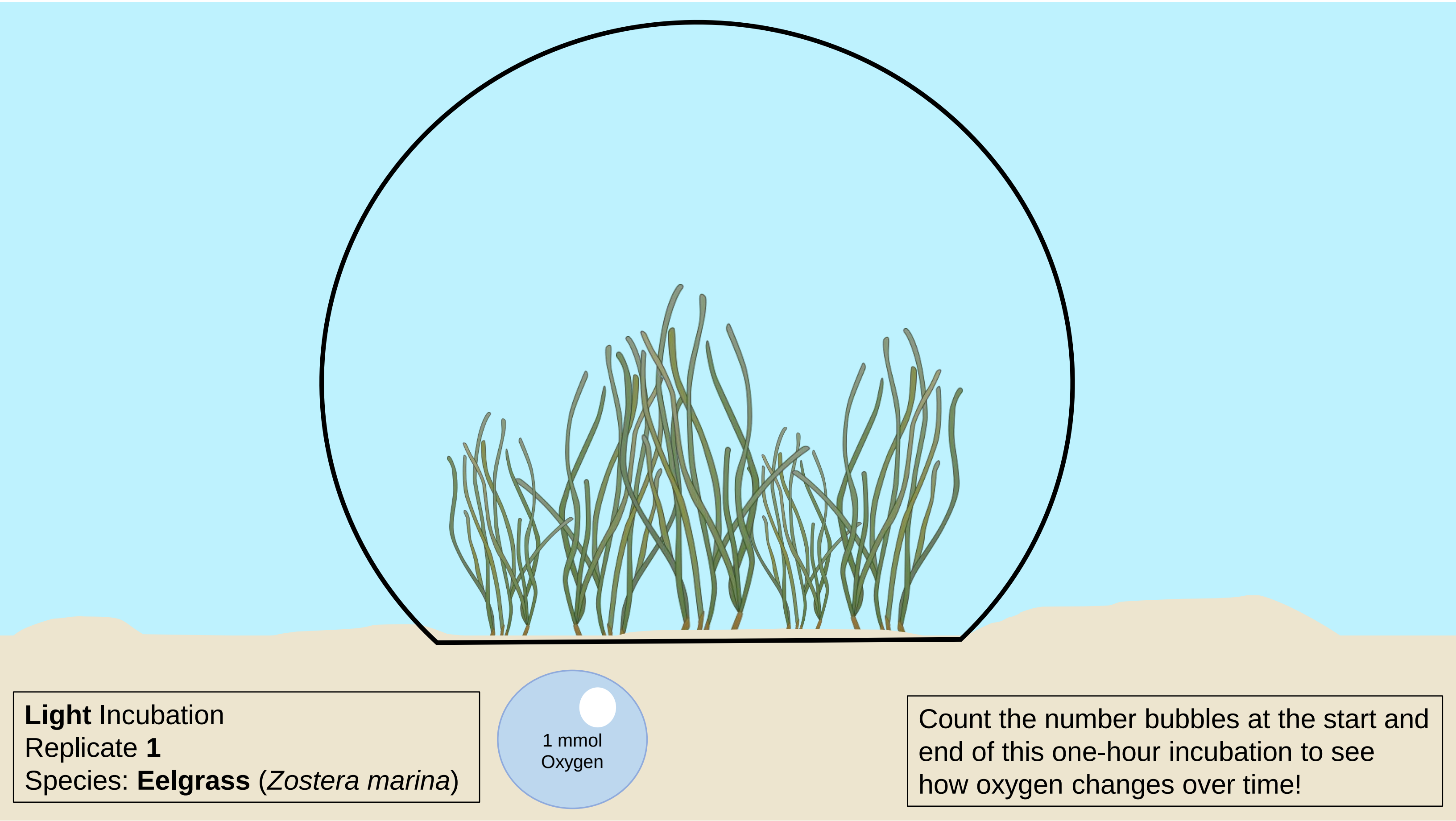
There is less seagrass which may mean less habitat for animals. There is also less energy and oxygen being produced by seagrasses which may mean less energy for food webs and oxygen for the animals that live in the water.

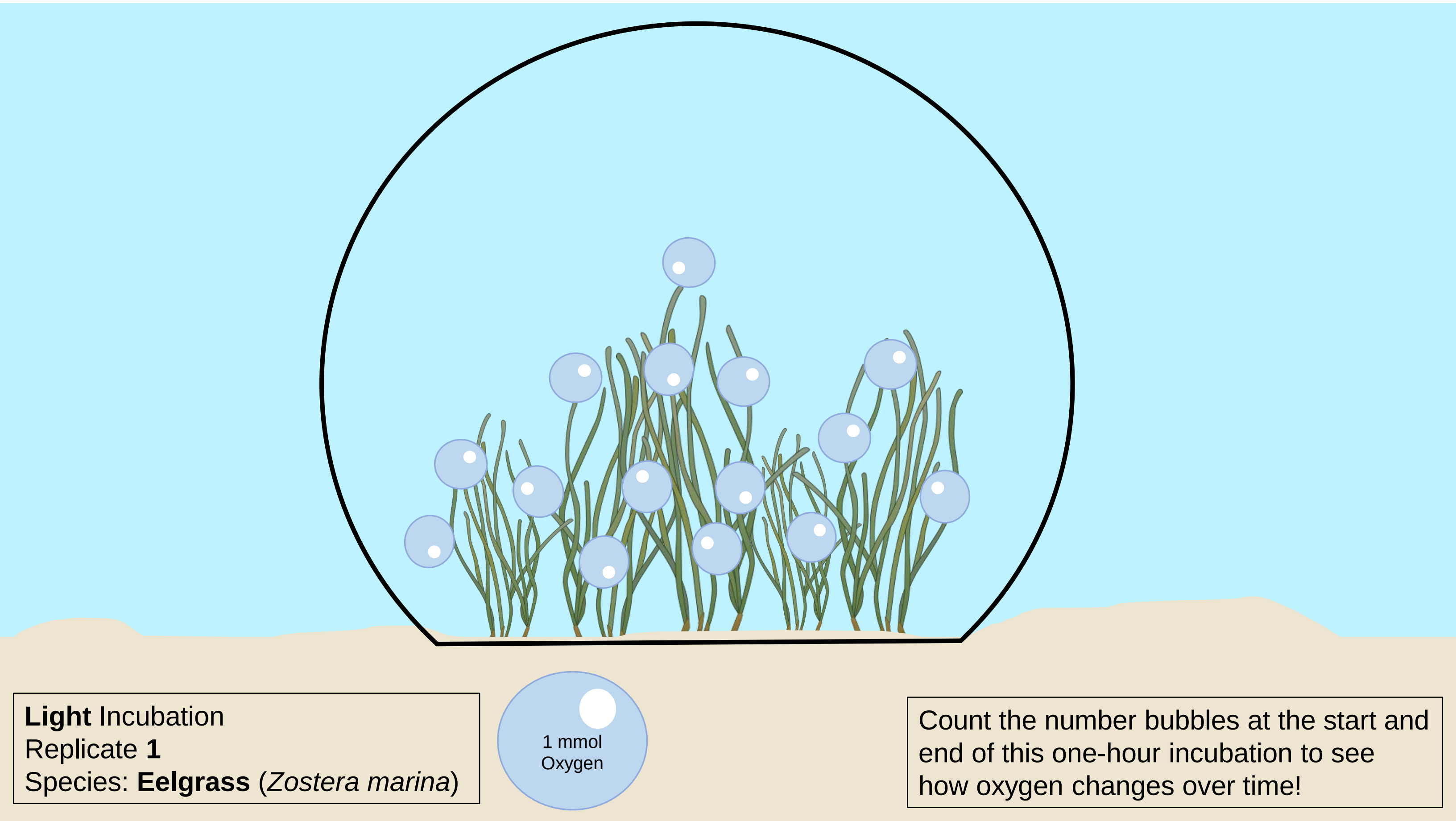
4) What would cause changes in the amount of seagrass year to year?

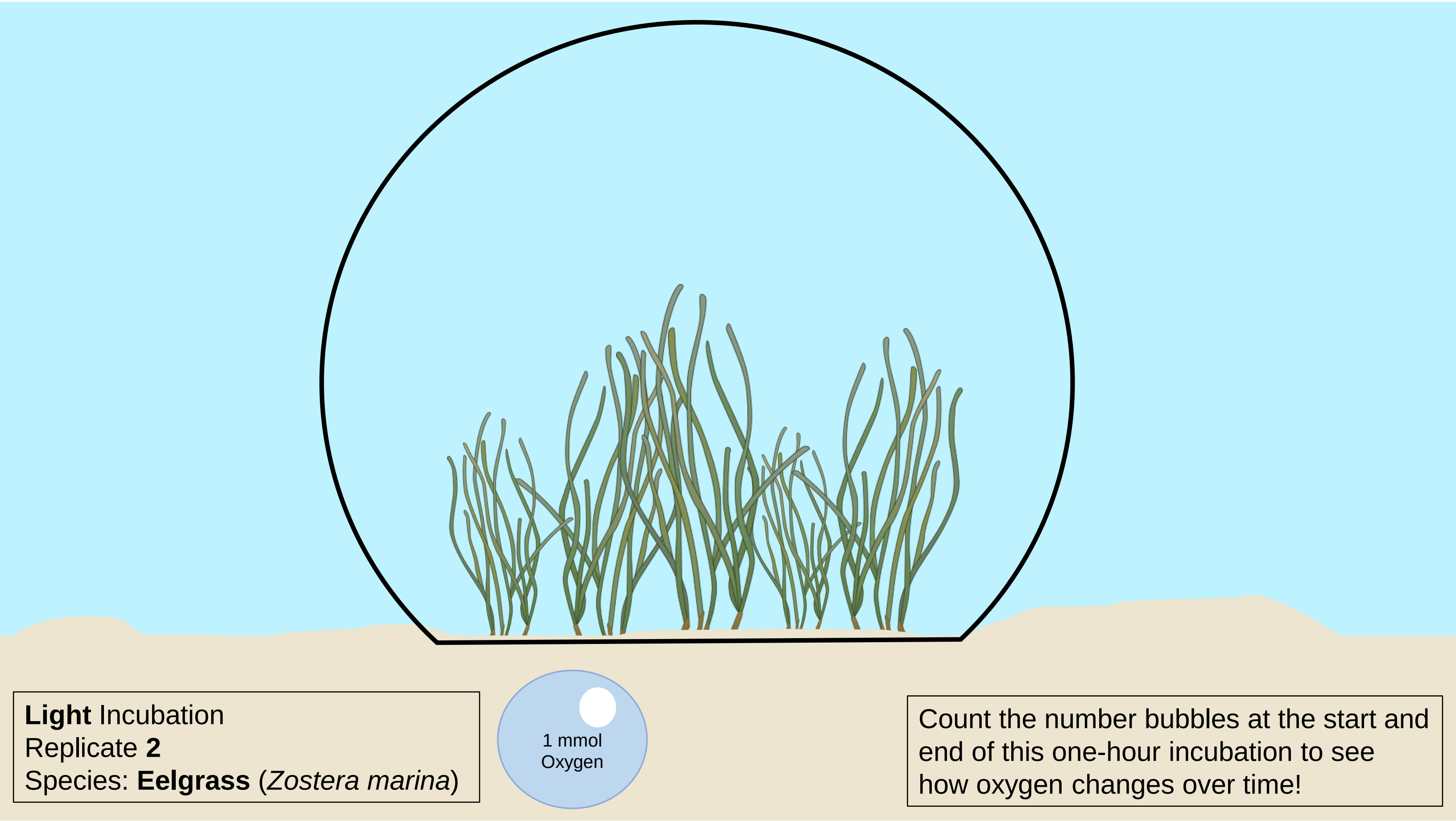
Changes in the environment: light, water quality, nutrients, animal grazing, climate change, human impacts (boating, aquaculture, etc.). Students should show evidence of brainstorming what might be impacting seagrass growth

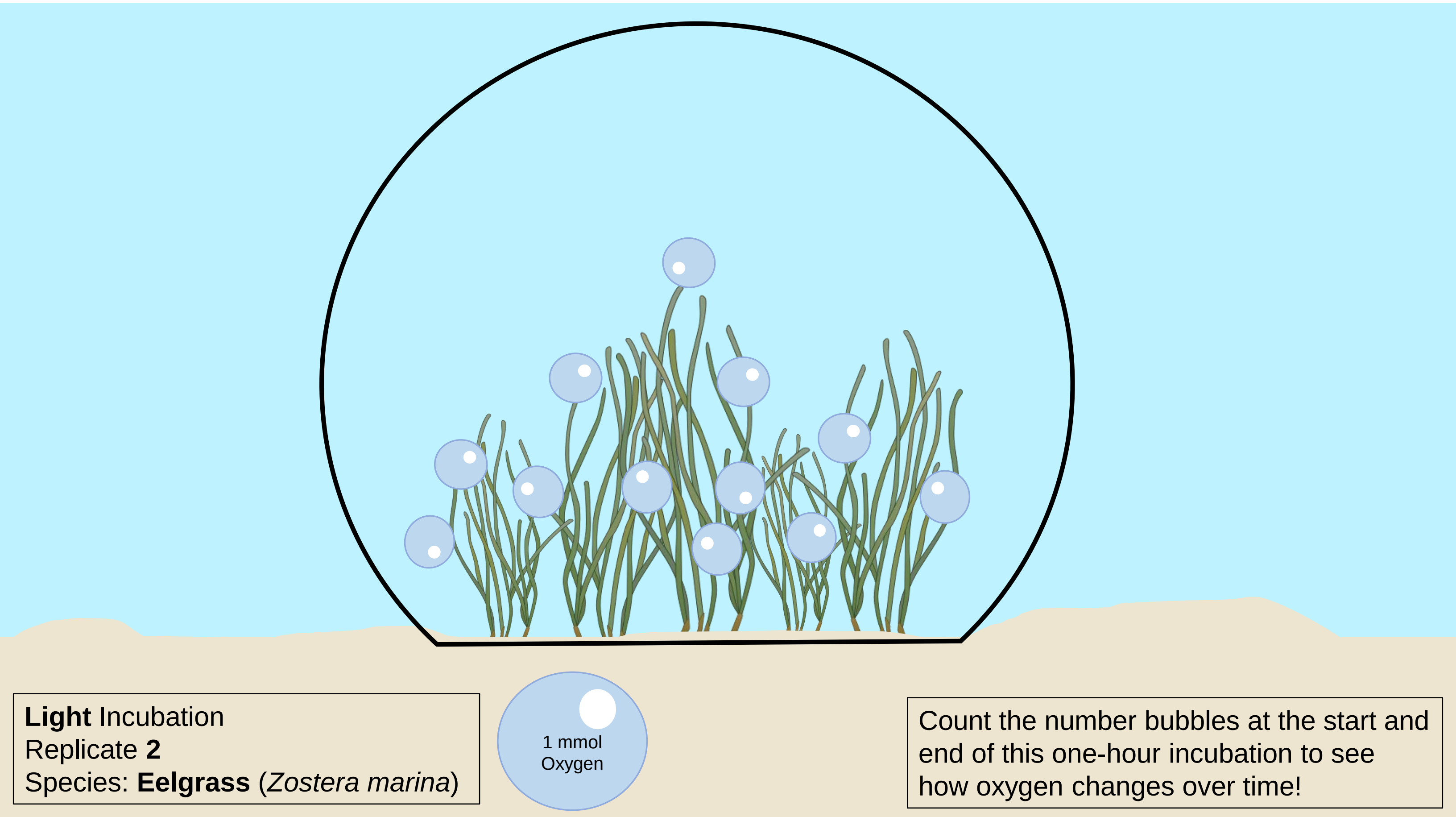
5) Why might some species resond differently to changes in the environment?

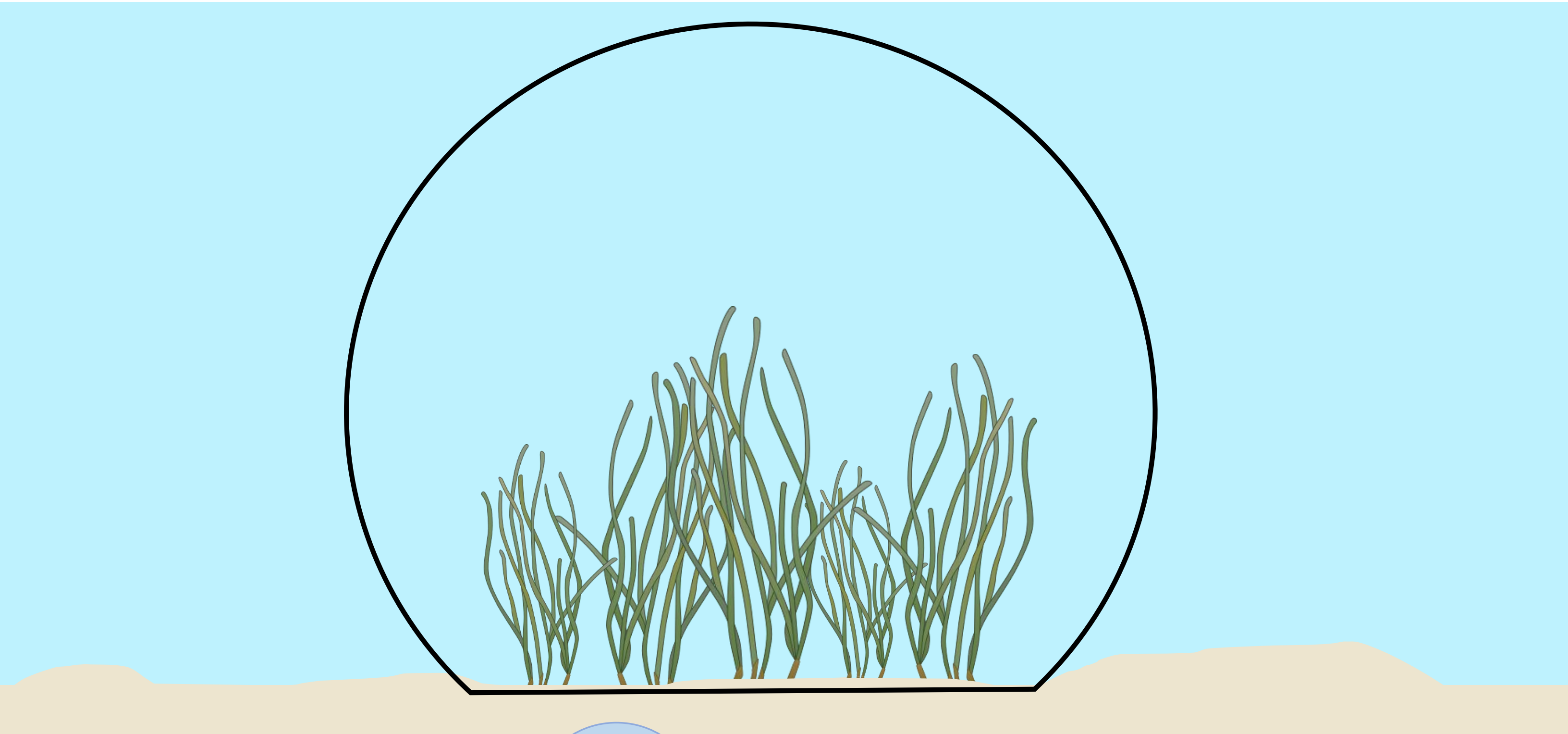
Some species have higher tolerances for less light, higher temperatures, or more nutrients so they will compete, outperform, or die-off as compared to other species.


**Light** Incubation
Replicate **1**
Species: **Eelgrass** (*Zostera marina*)
1 mmol Oxygen
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!


**Light** Incubation
Replicate **1**
Species: **Eelgrass** (*Zostera marina*)
1 mmol Oxygen
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!


**Light** Incubation
Replicate **2**
Species: **Eelgrass** (*Zostera marina*)
1 mmol Oxygen
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!

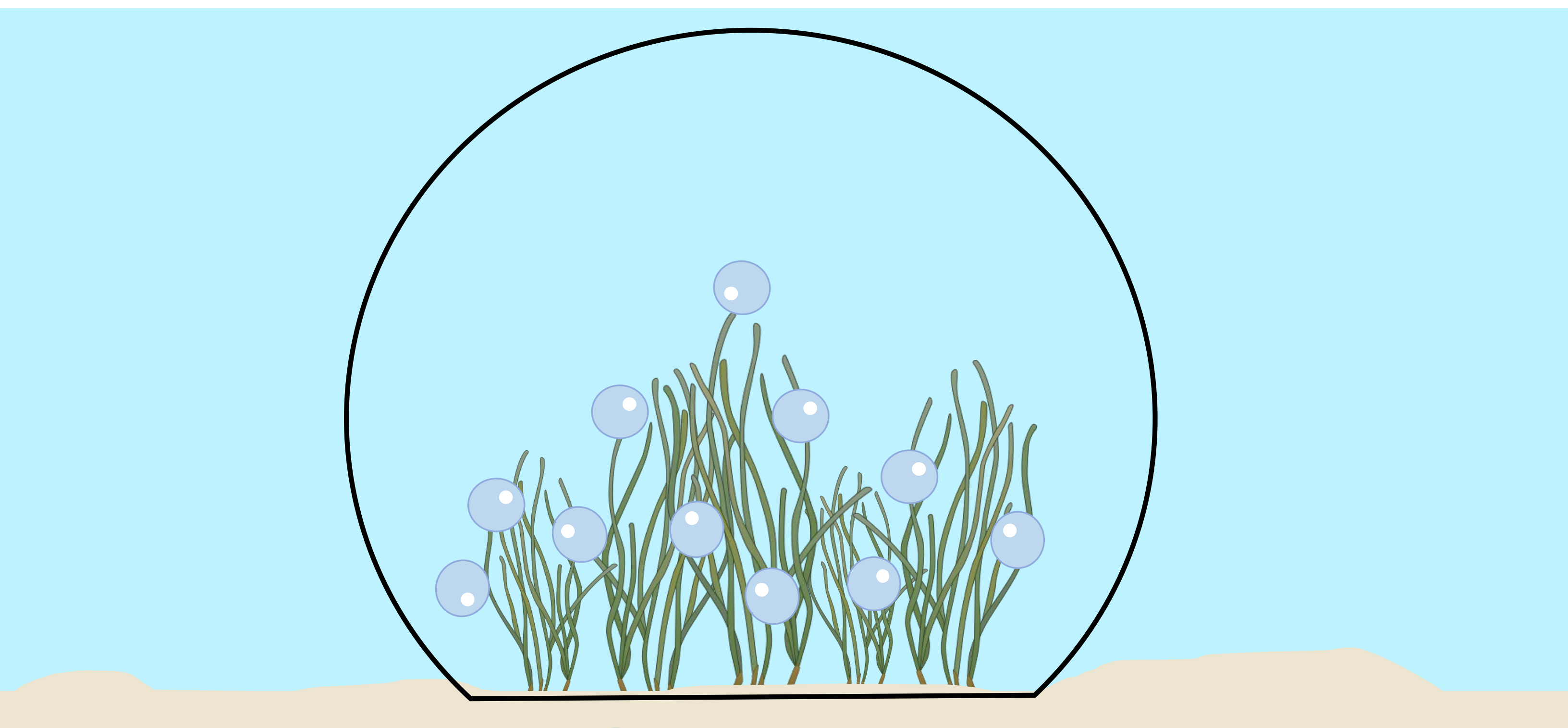

**Light** Incubation
Replicate **2**
Species: **Eelgrass** (*Zostera marina*)
1 mmol Oxygen
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



**Light** Incubation
Replicate **3**
Species: **Eelgrass** (*Zostera marina*)

1 mmol Oxygen

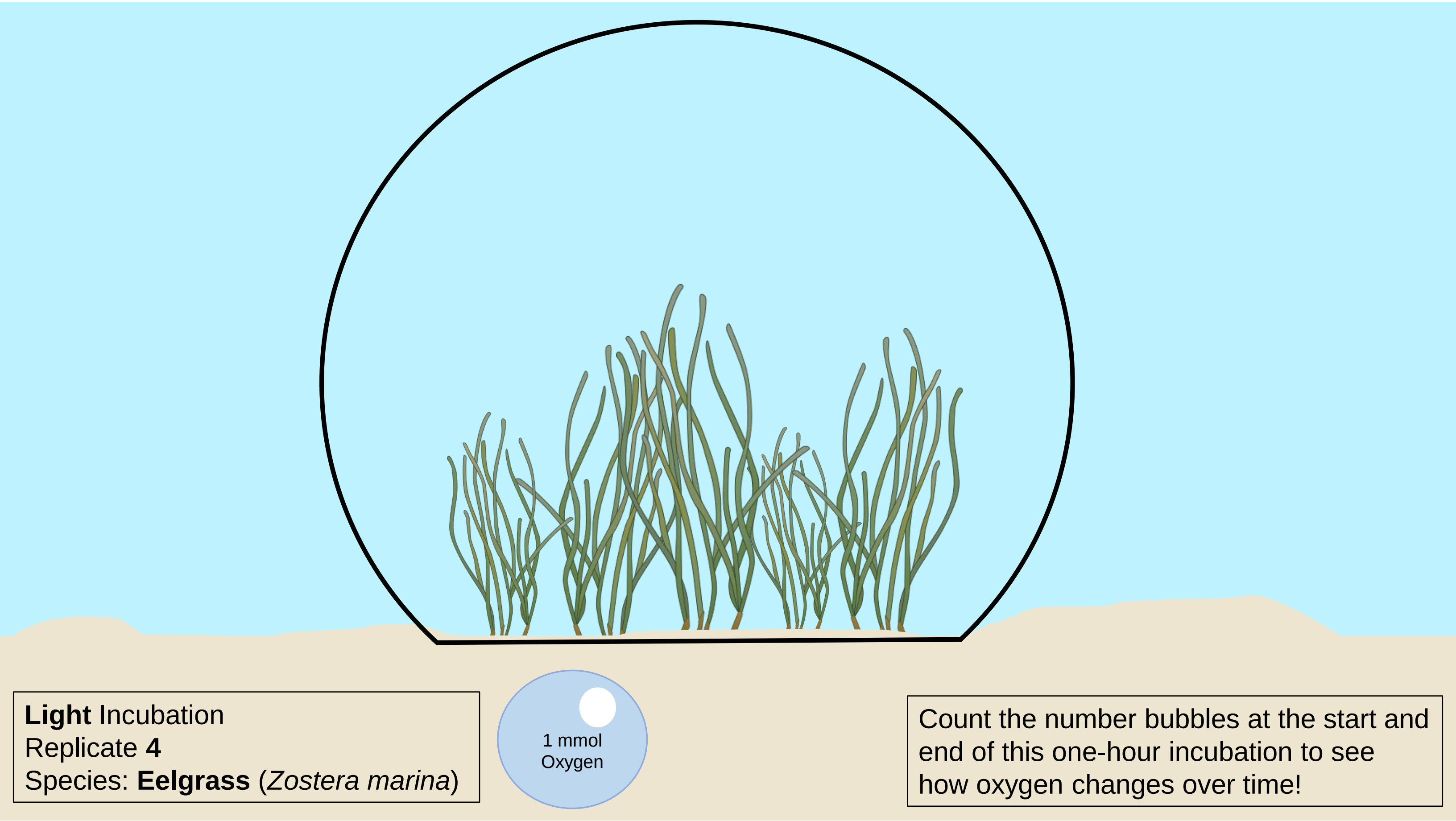
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!

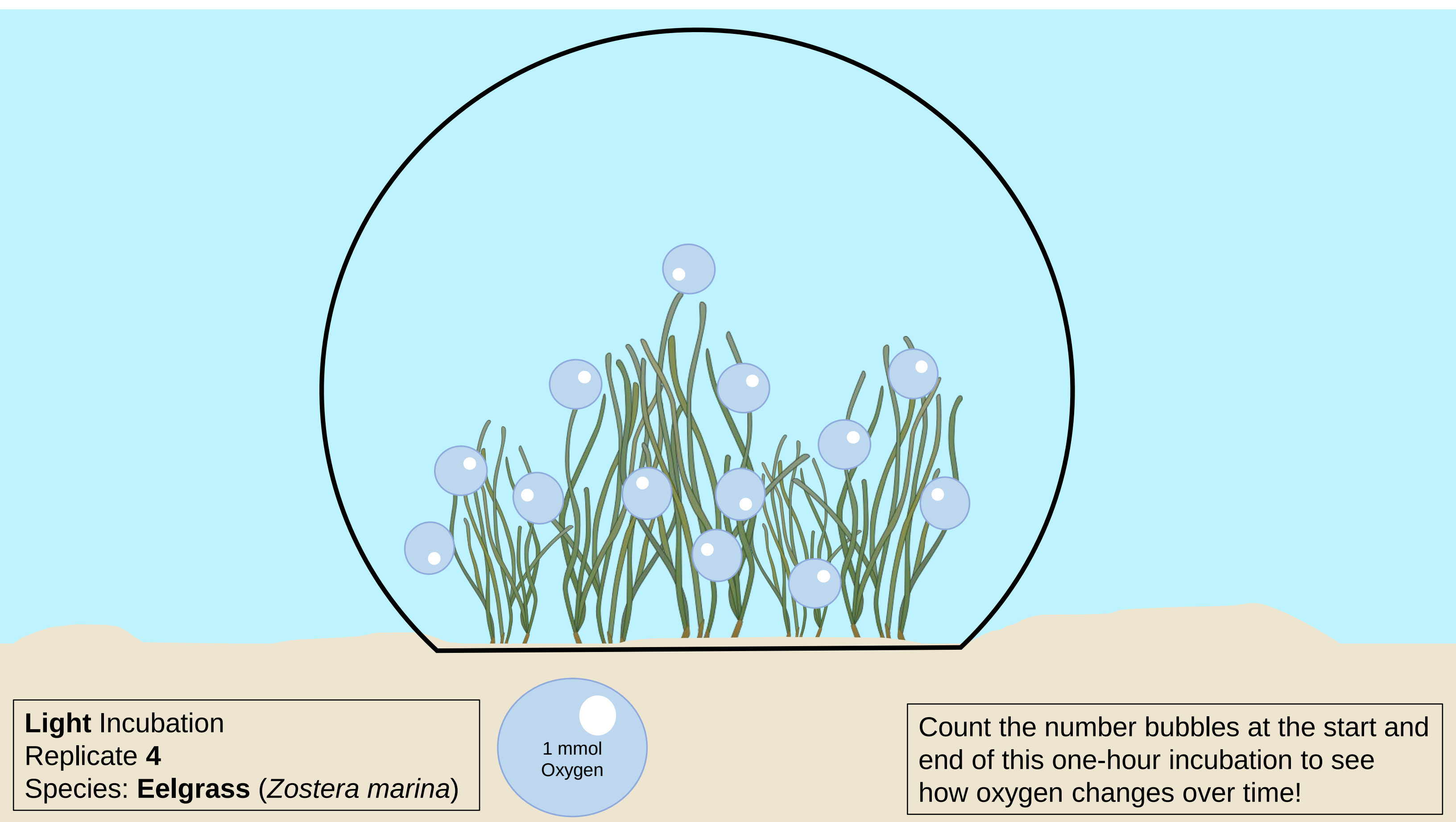


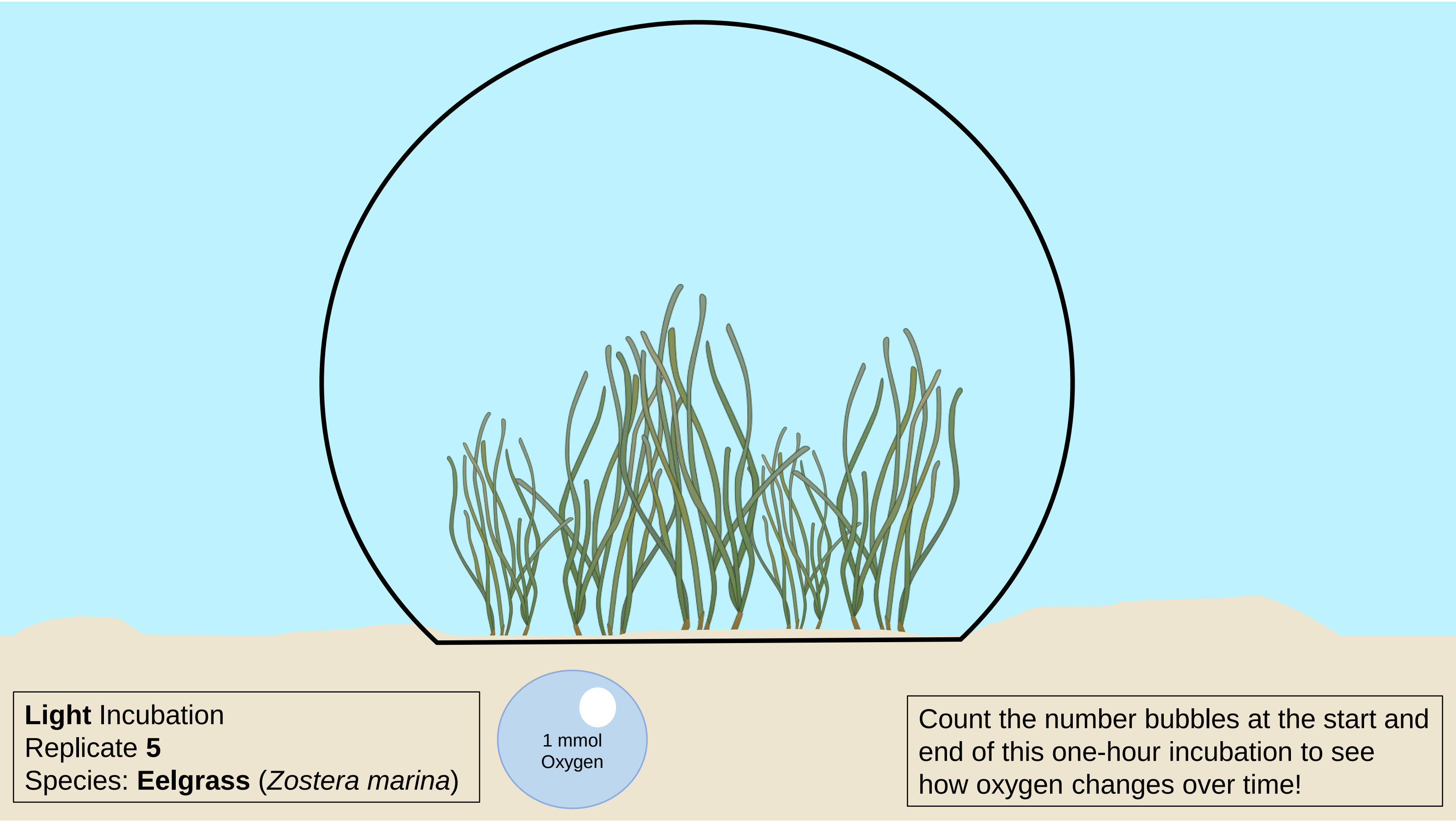
**Light** Incubation
Replicate **3**
Species: **Eelgrass** (*Zostera marina*)

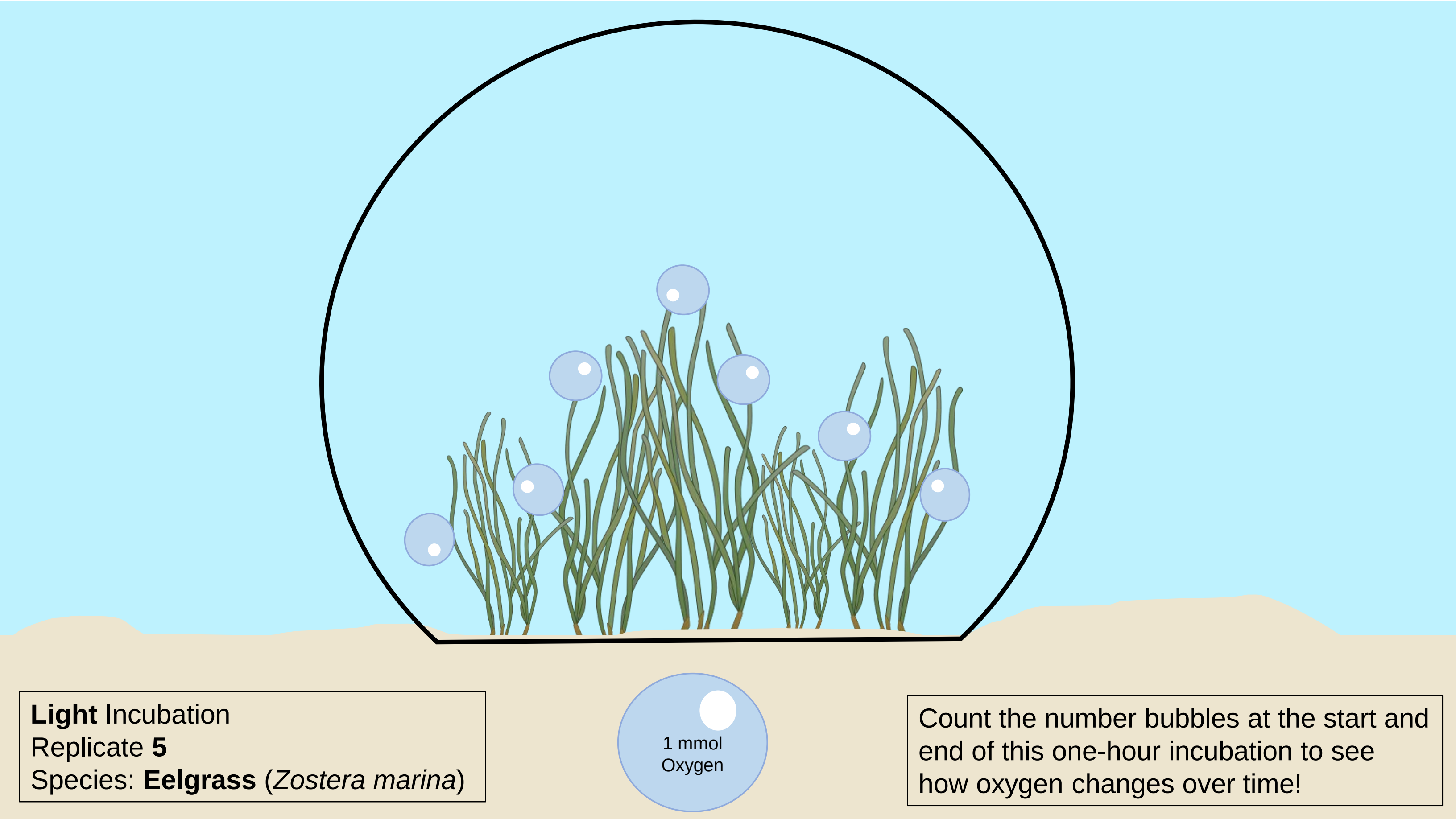
1 mmol Oxygen

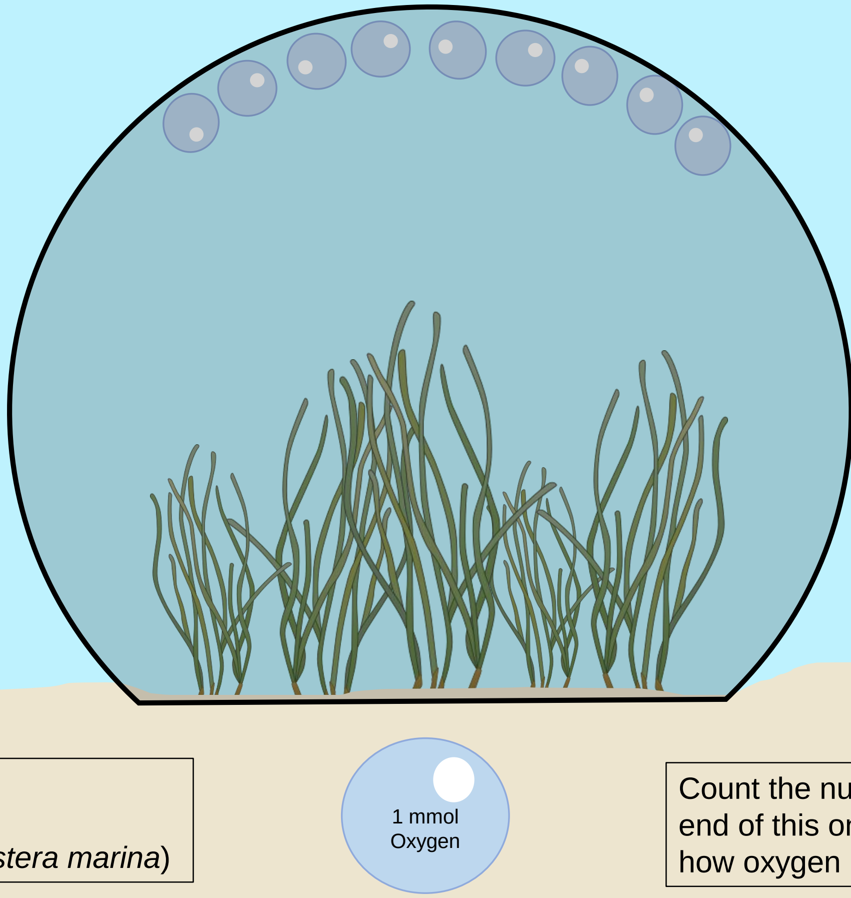
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!


**Light** Incubation
Replicate **4**
Species: **Eelgrass** (*Zostera marina*)
1 mmol Oxygen
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!


**Light** Incubation
Replicate **4**
Species: **Eelgrass** (*Zostera marina*)
1 mmol Oxygen
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!

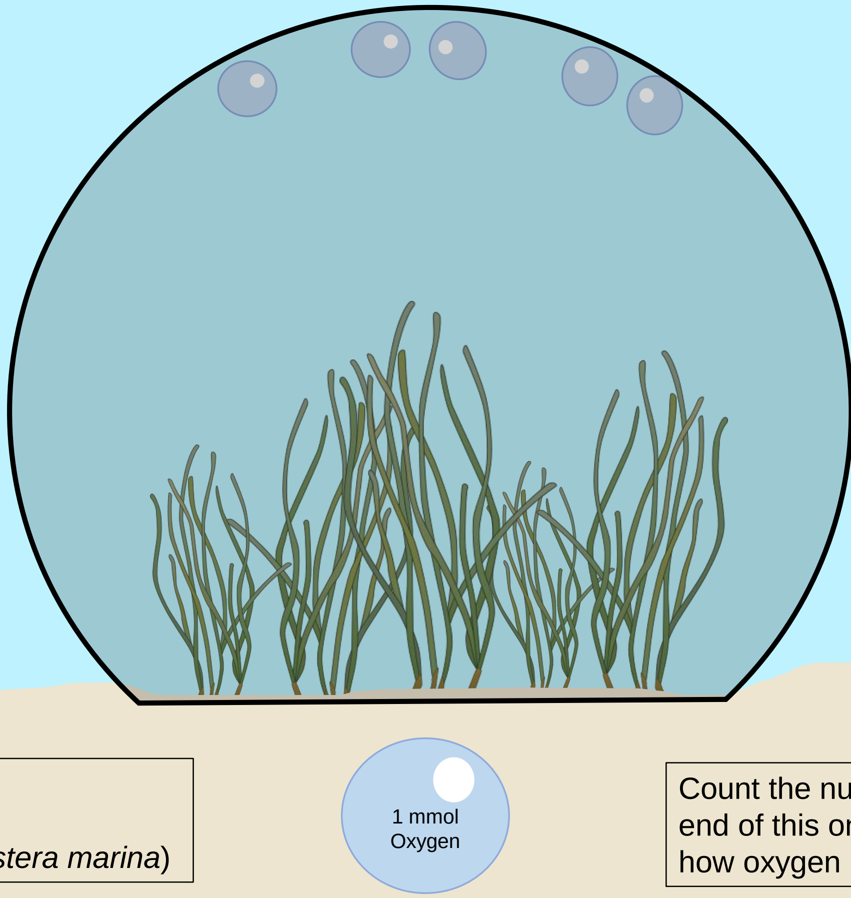

**Light** Incubation
Replicate **5**
Species: **Eelgrass** (*Zostera marina*)
1 mmol Oxygen
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!


**Light** Incubation
Replicate **5**
Species: **Eelgrass** (*Zostera marina*)
1 mmol Oxygen
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



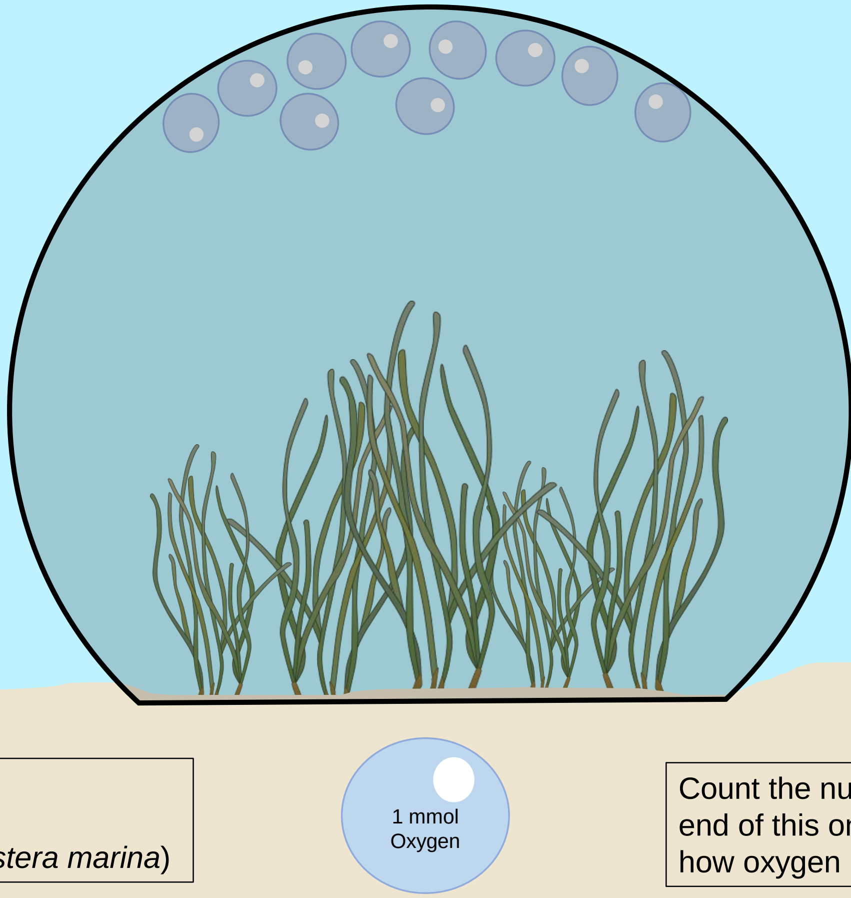

**Dark** Incubation
Replicate **1**
Species: **Eelgrass** (*Zostera marina*)

Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



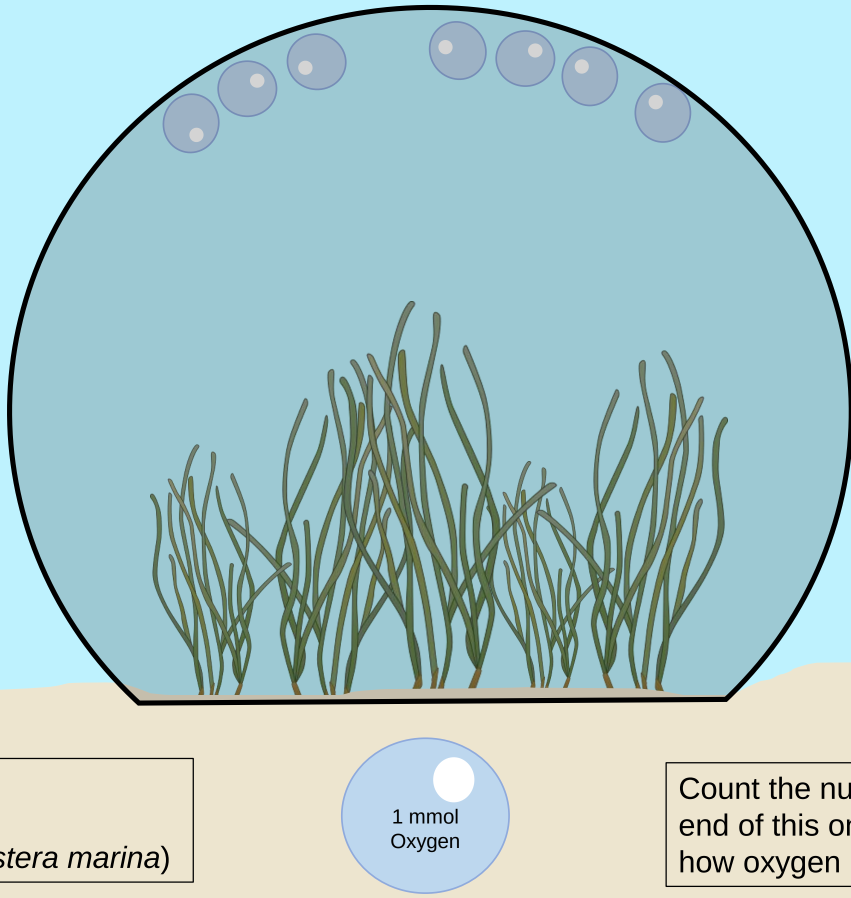

**Dark** Incubation
Replicate **1**
Species: **Eelgrass** (*Zostera marina*)

Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



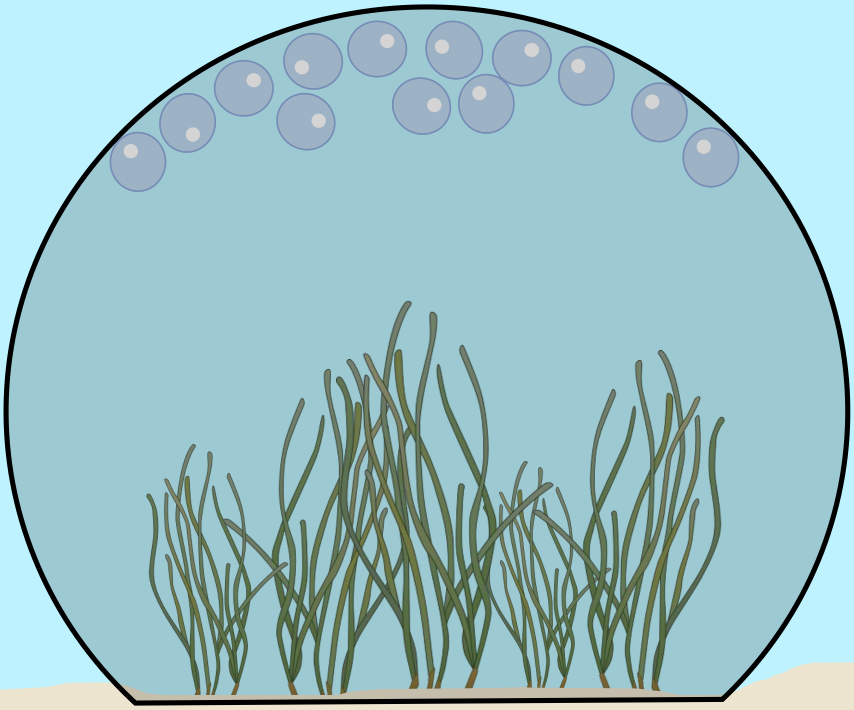

**Dark** Incubation
Replicate **2**
Species: **Eelgrass** (*Zostera marina*)

Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!




**Dark** Incubation
Replicate **2**
Species: **Eelgrass** (*Zostera marina*)

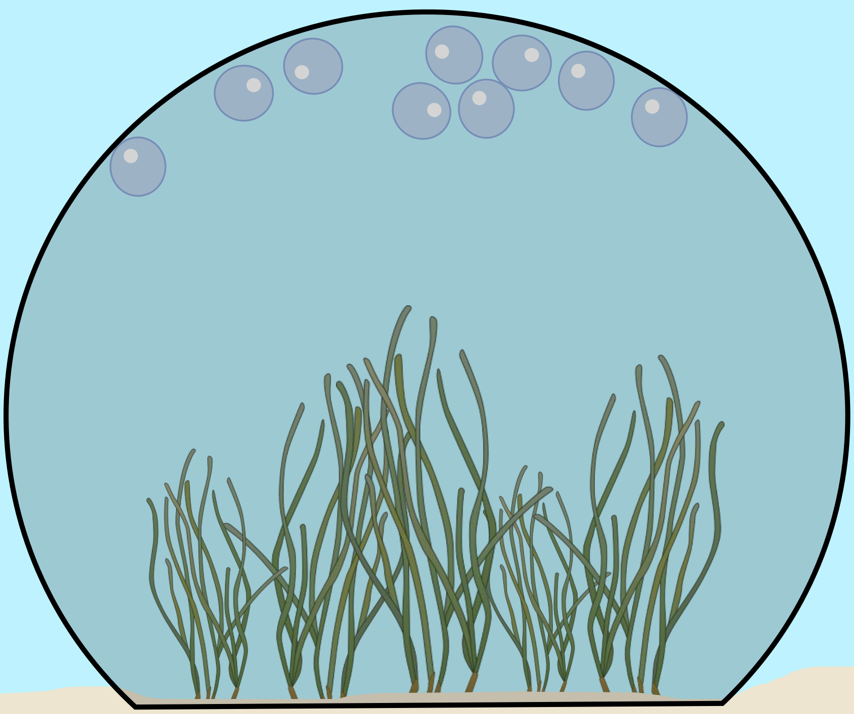
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



**Dark** Incubation
Replicate **3**
Species: **Eelgrass** (*Zostera marina*)

1 mmol
Oxygen

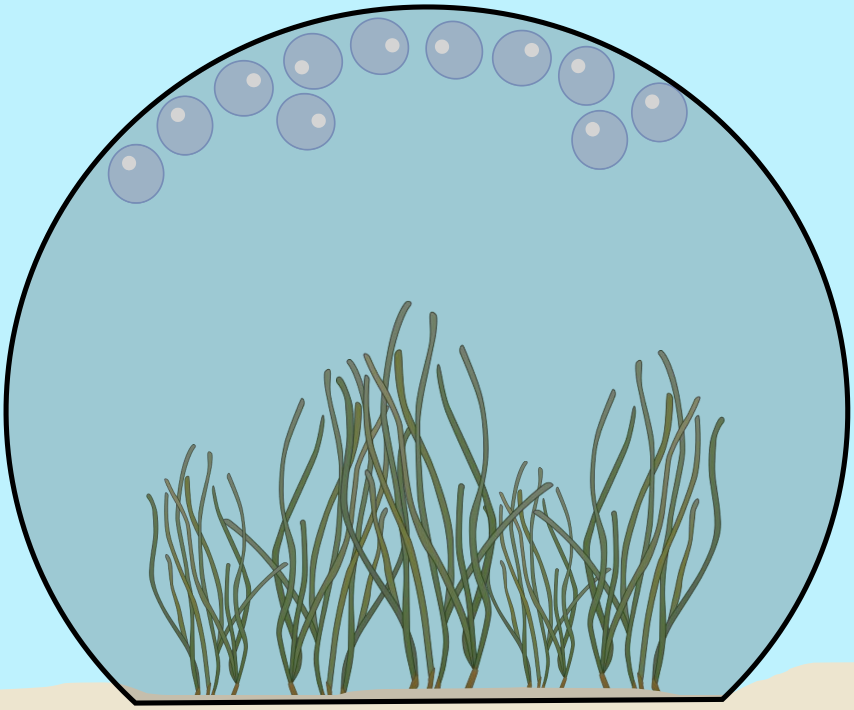
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



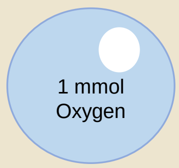
**Dark** Incubation
Replicate **3**
Species: **Eelgrass** (*Zostera marina*)

1 mmol
Oxygen

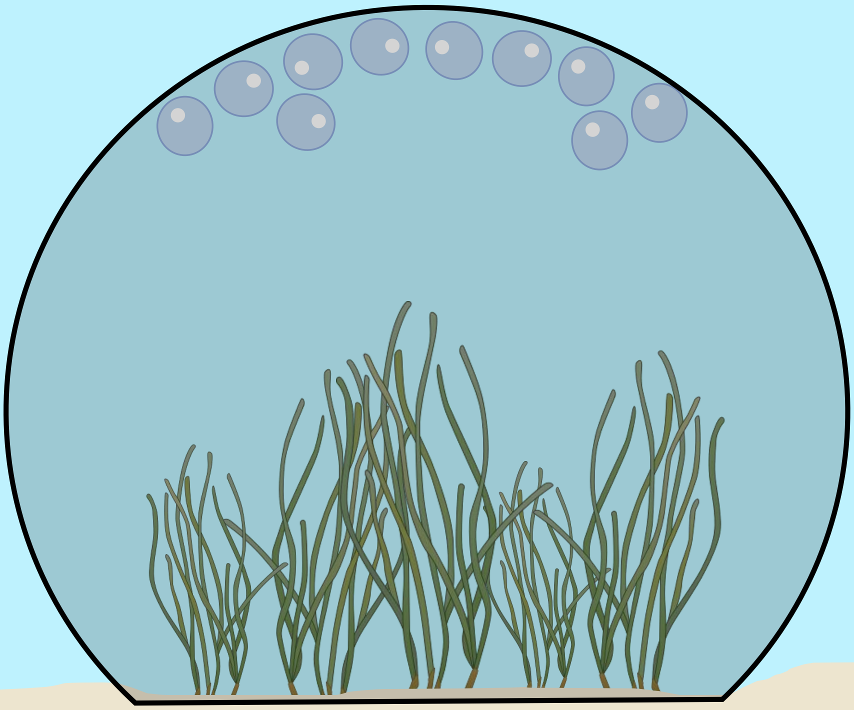
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



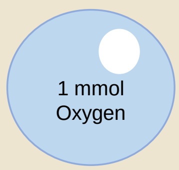
**Dark** Incubation
Replicate **4**
Species: **Eelgrass** (*Zostera marina*)



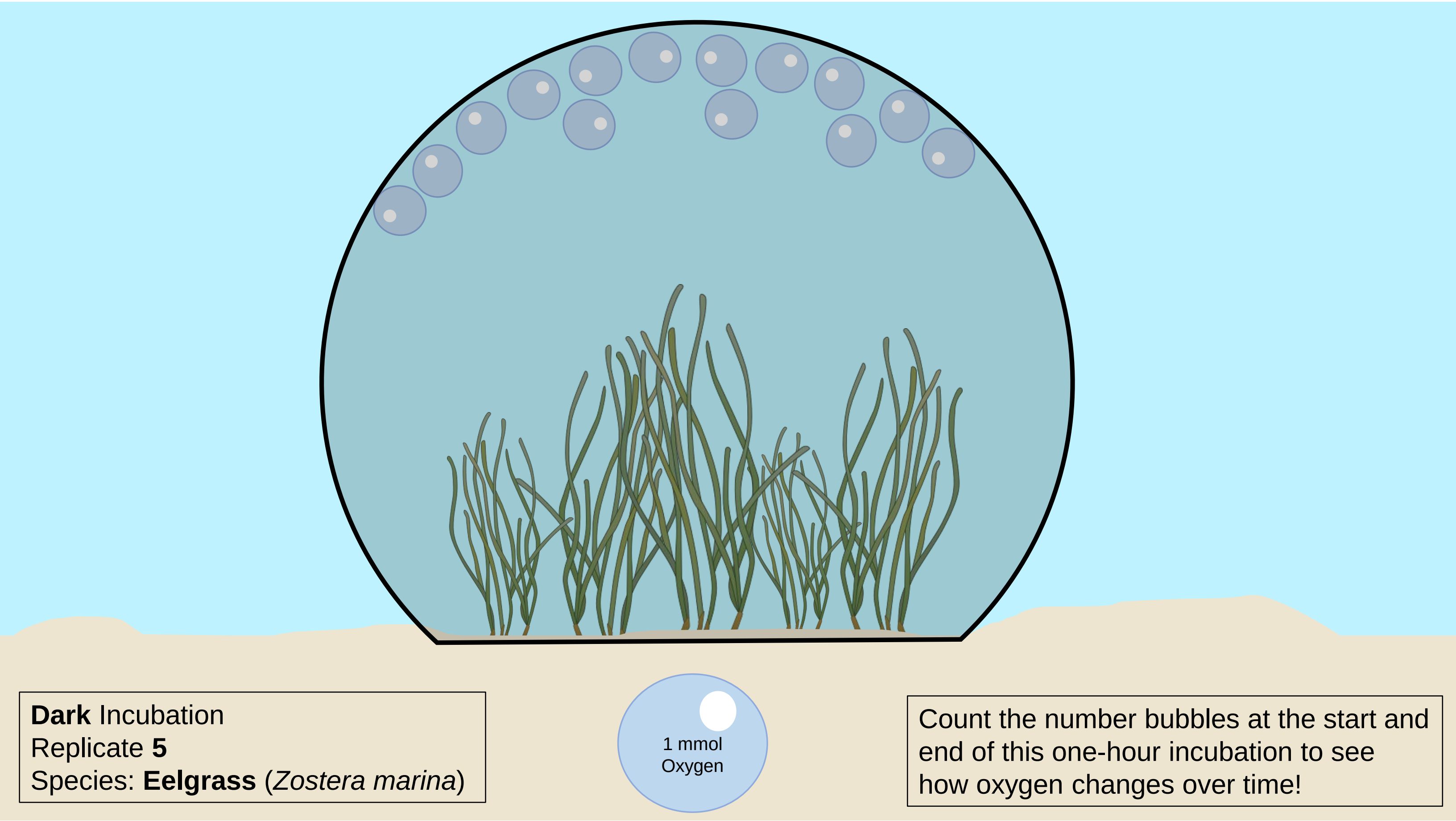

Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!

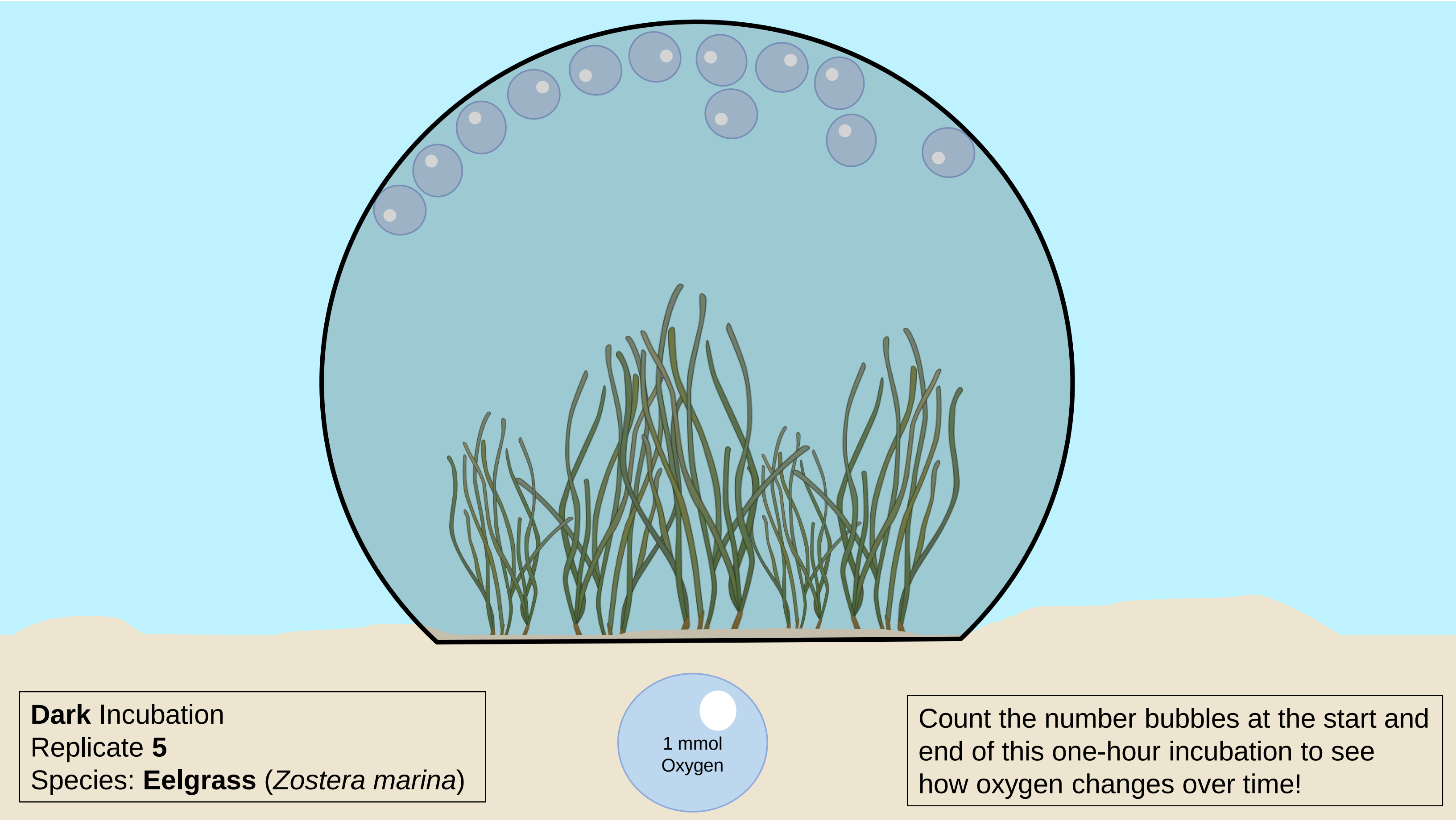


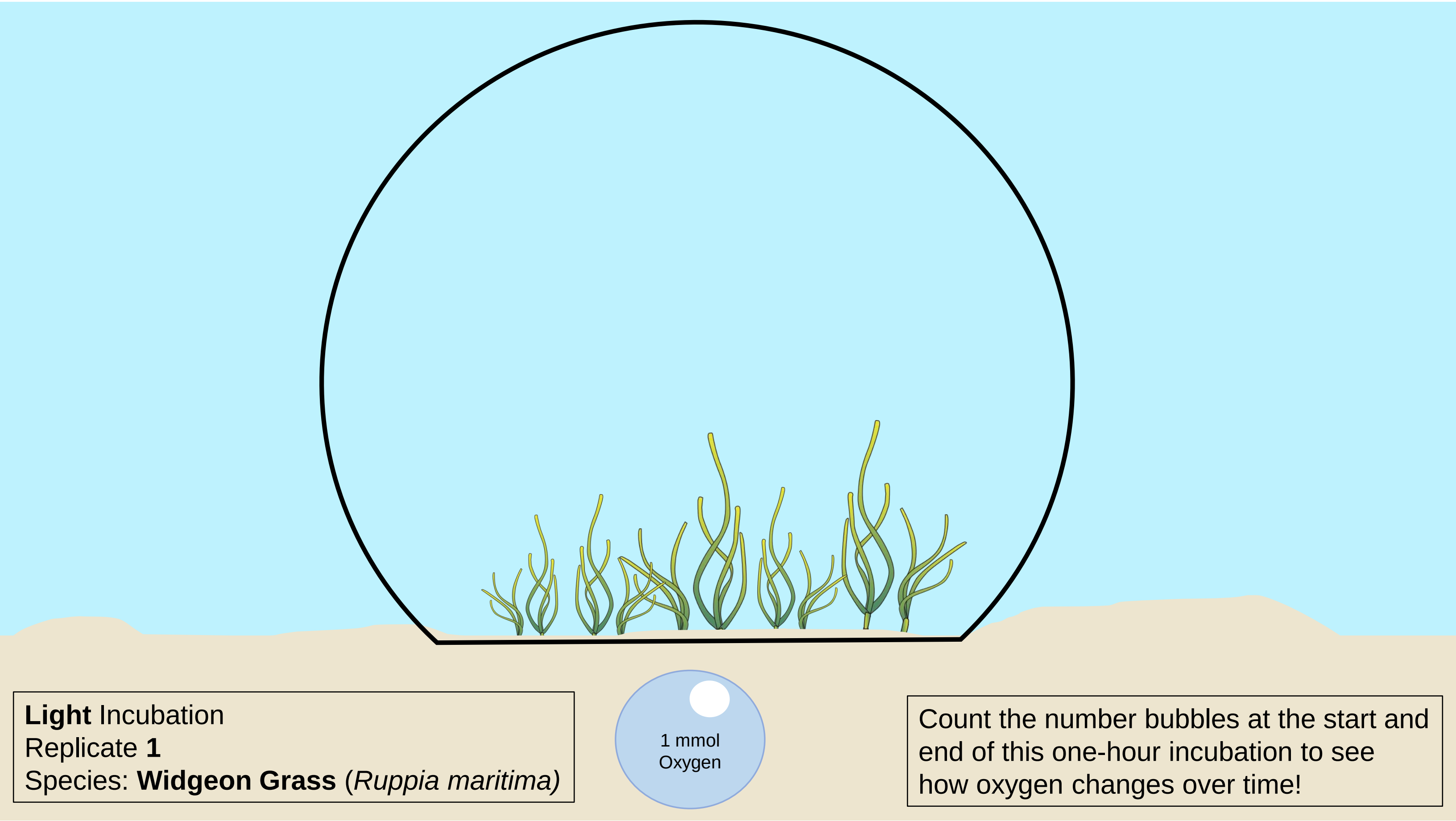
**Dark** Incubation
Replicate **4**
Species: **Eelgrass** (*Zostera marina*)

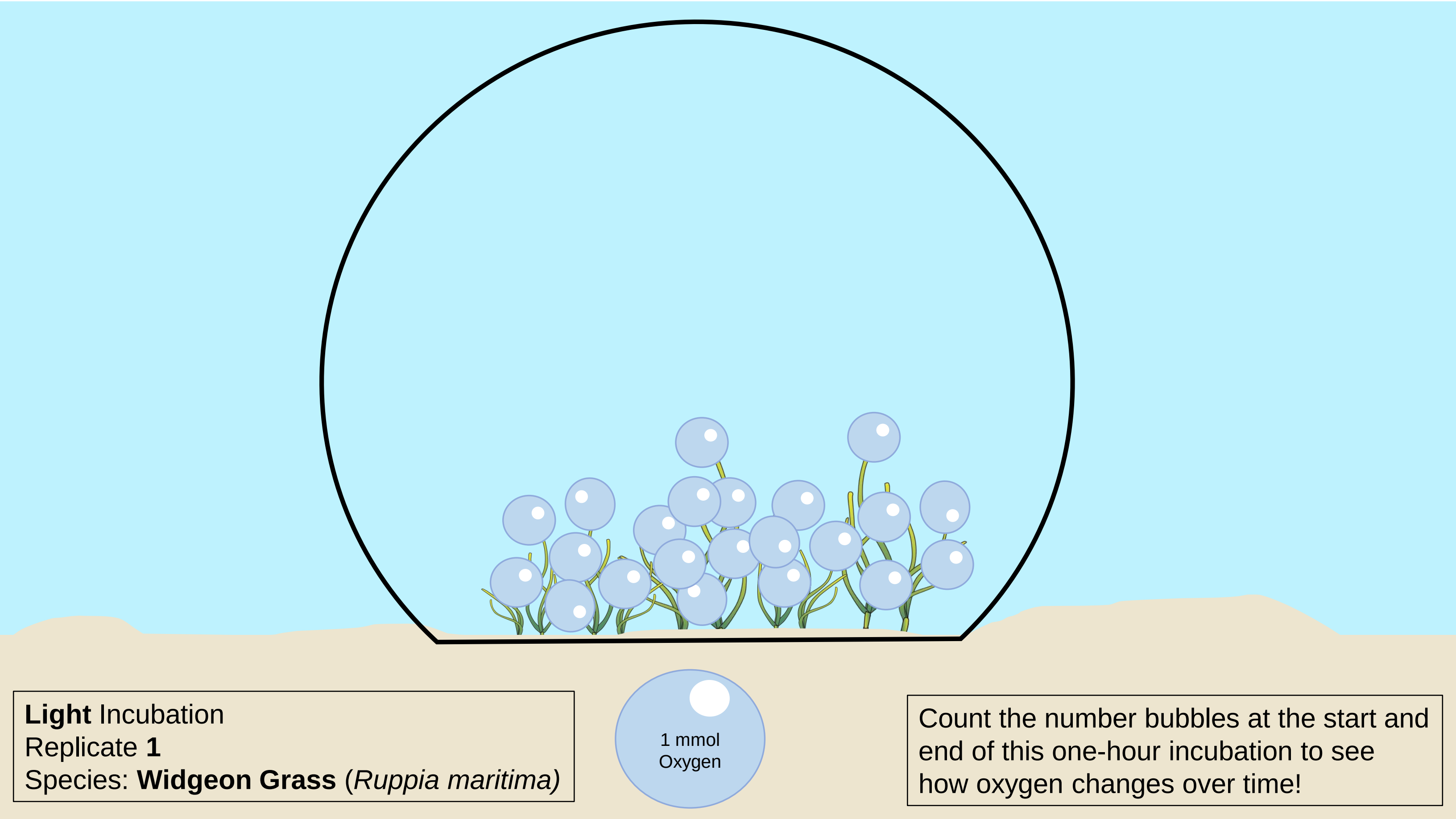


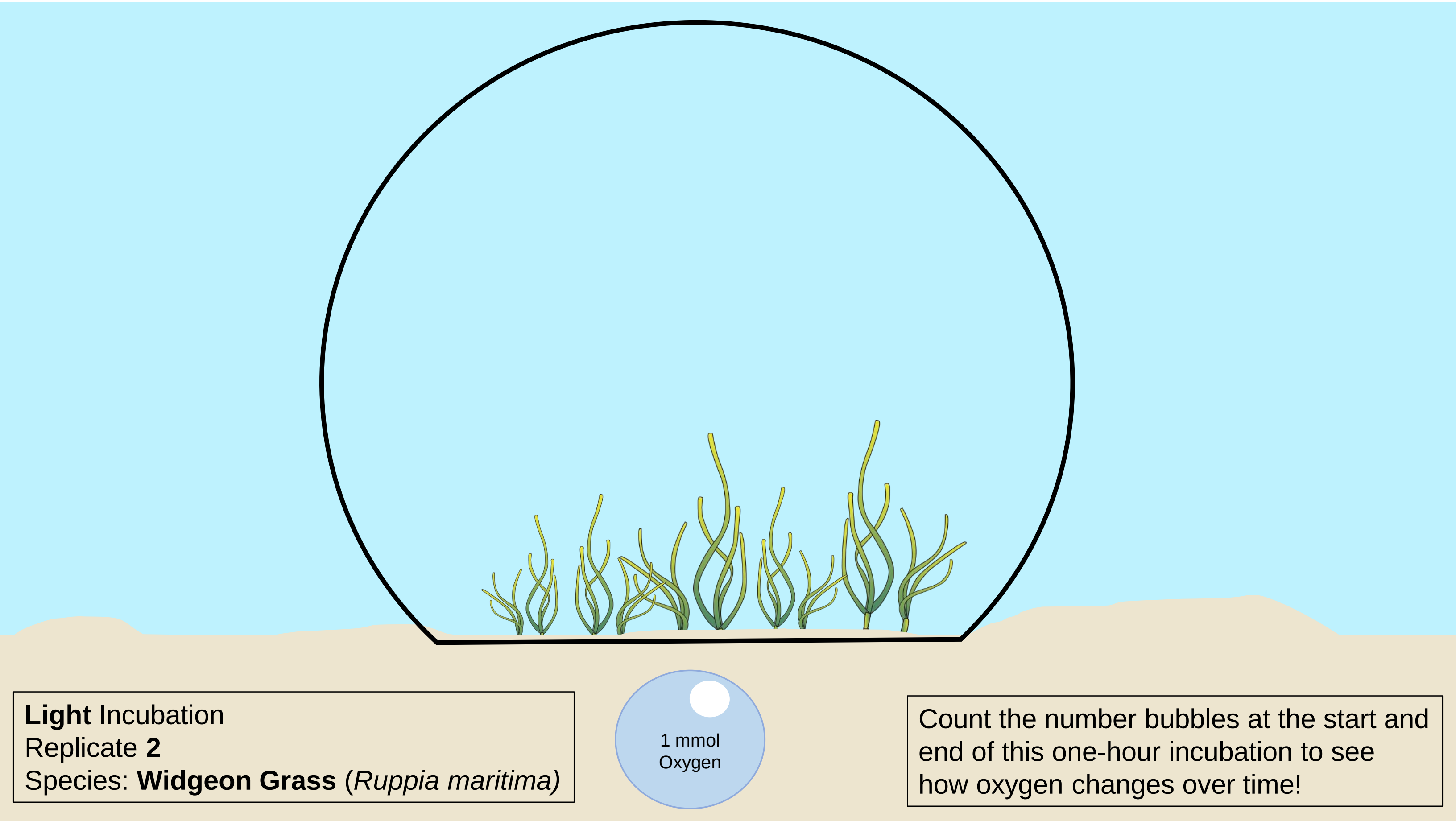

Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!

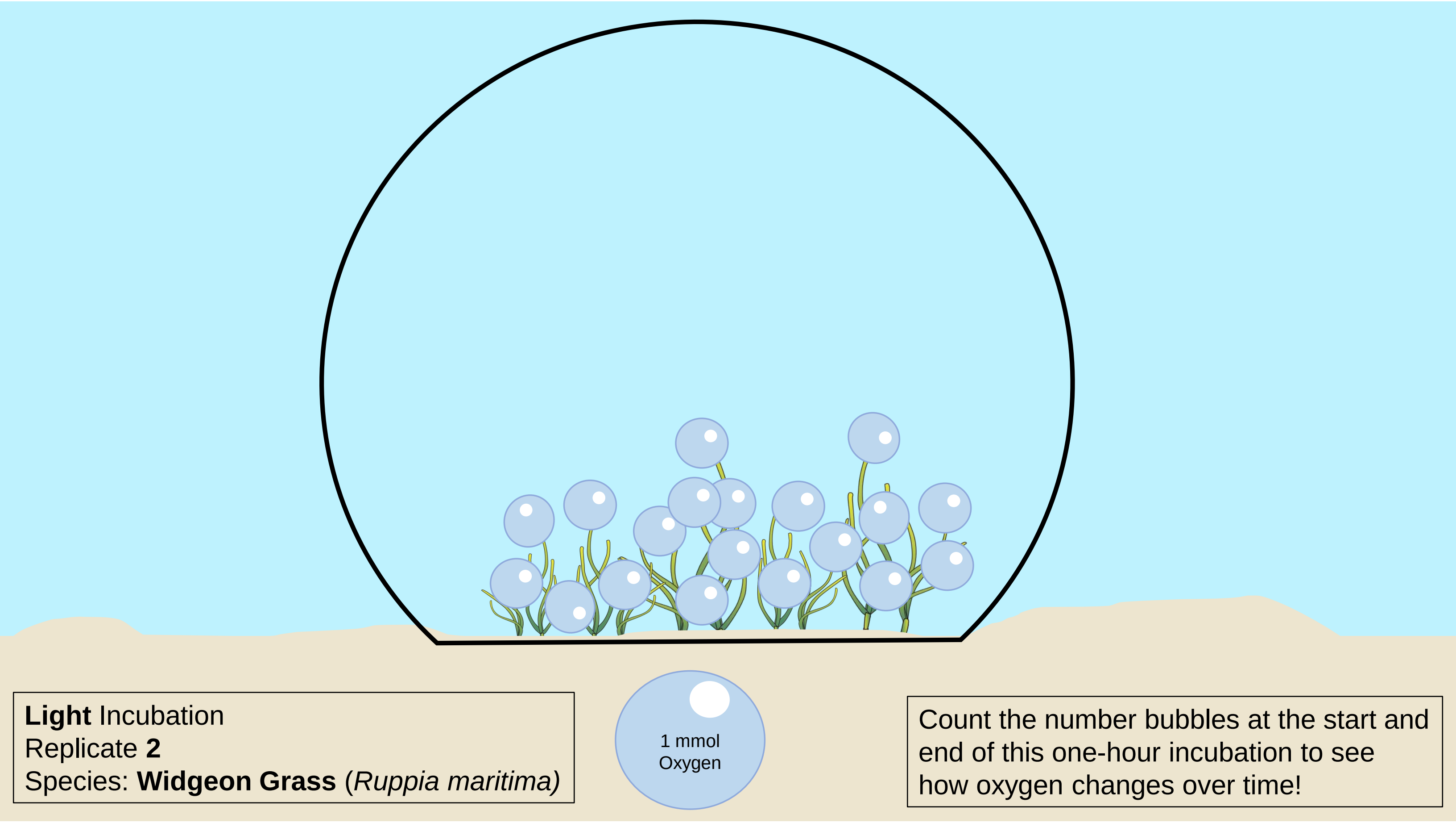

**Dark** Incubation
Replicate **5**
Species: **Eelgrass** (*Zostera marina*)
1 mmol
Oxygen
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!

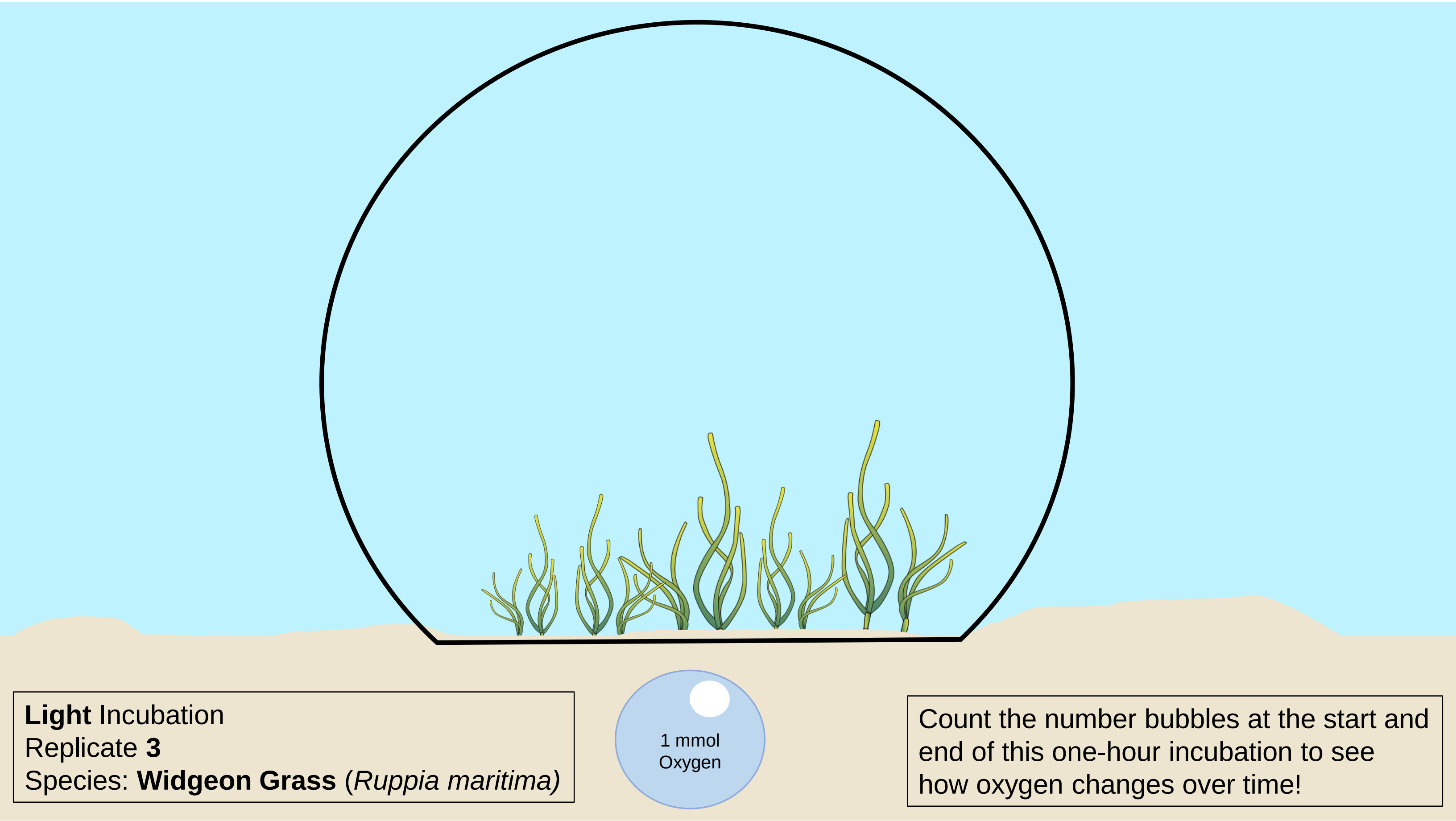

**Dark** Incubation
Replicate **5**
Species: **Eelgrass** (*Zostera marina*)
1 mmol
Oxygen
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!

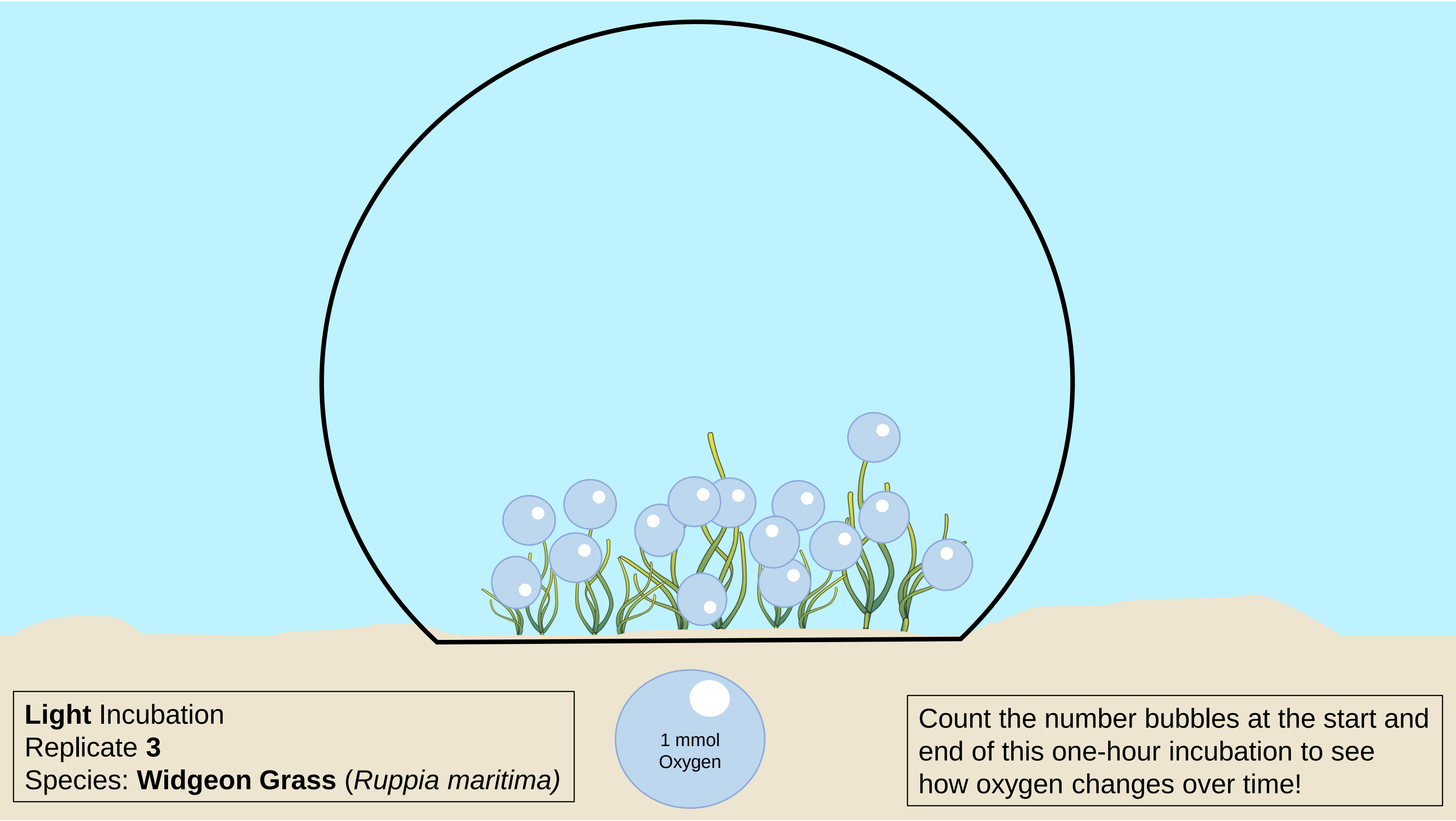

1 mmol Oxygen
**Light** Incubation
Replicate **1**
Species: **Widgeon Grass** (*Ruppia maritima)*
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!

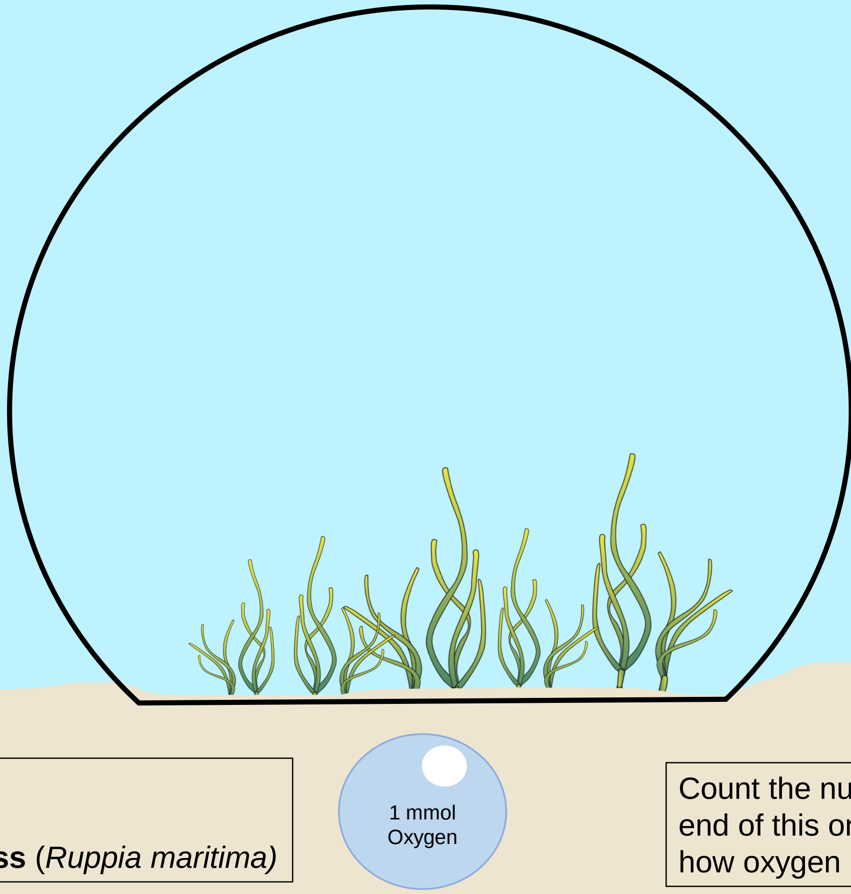

1 mmol Oxygen
**Light** Incubation
Replicate **1**
Species: **Widgeon Grass** (*Ruppia maritima)*
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!


**Light** Incubation
Replicate **2**
Species: **Widgeon Grass** (*Ruppia maritima)*
1 mmol
Oxygen
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!


**Light** Incubation
Replicate **2**
Species: **Widgeon Grass** (*Ruppia maritima)*
1 mmol
Oxygen
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!

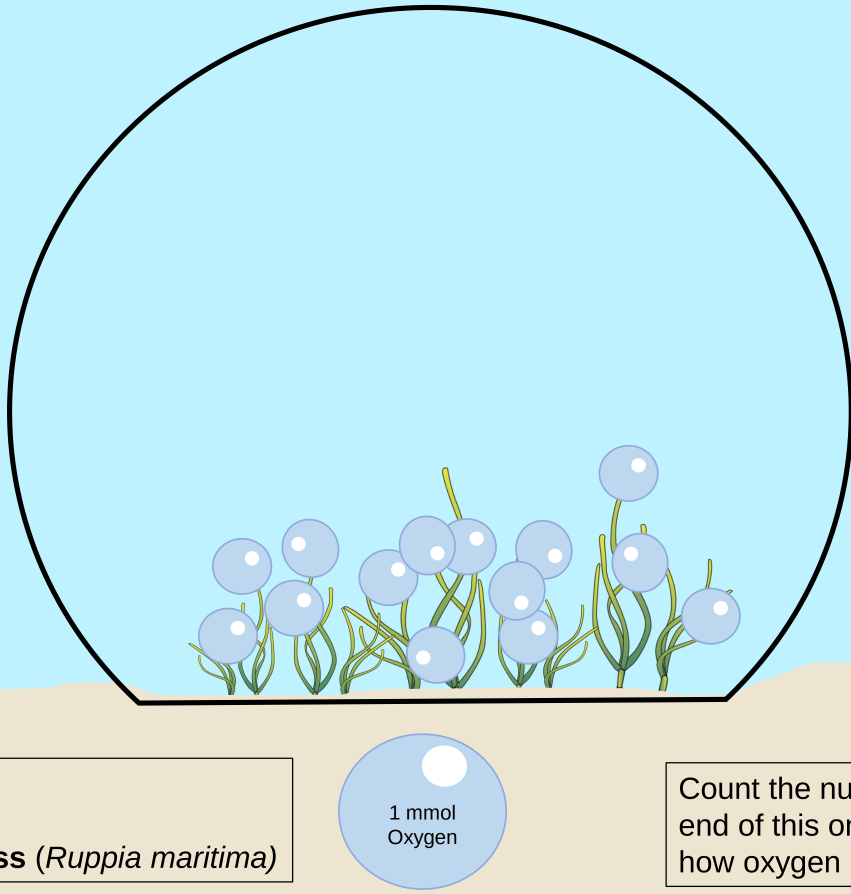

**Light** Incubation
Replicate **3**
Species: **Widgeon Grass** (*Ruppia maritima)*
1 mmol Oxygen
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!


**Light** Incubation
Replicate **3**
Species: **Widgeon Grass** (*Ruppia maritima)*
1 mmol Oxygen
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



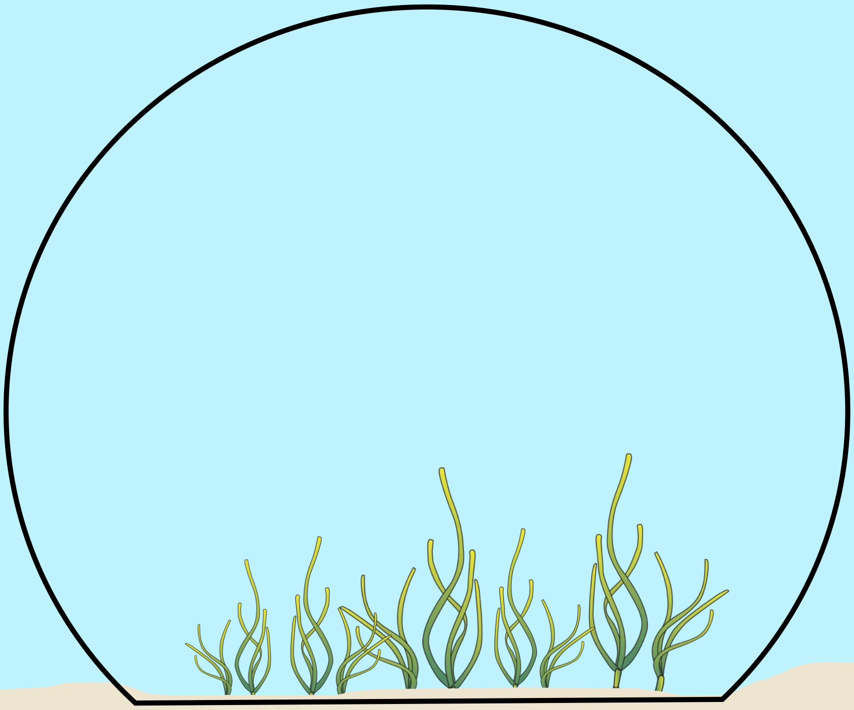

**Light** Incubation
Replicate **4**
Species: **Widgeon Grass** (*Ruppia maritima)*

Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!




**Light** Incubation
Replicate **4**
Species: **Widgeon Grass** (*Ruppia maritima)*

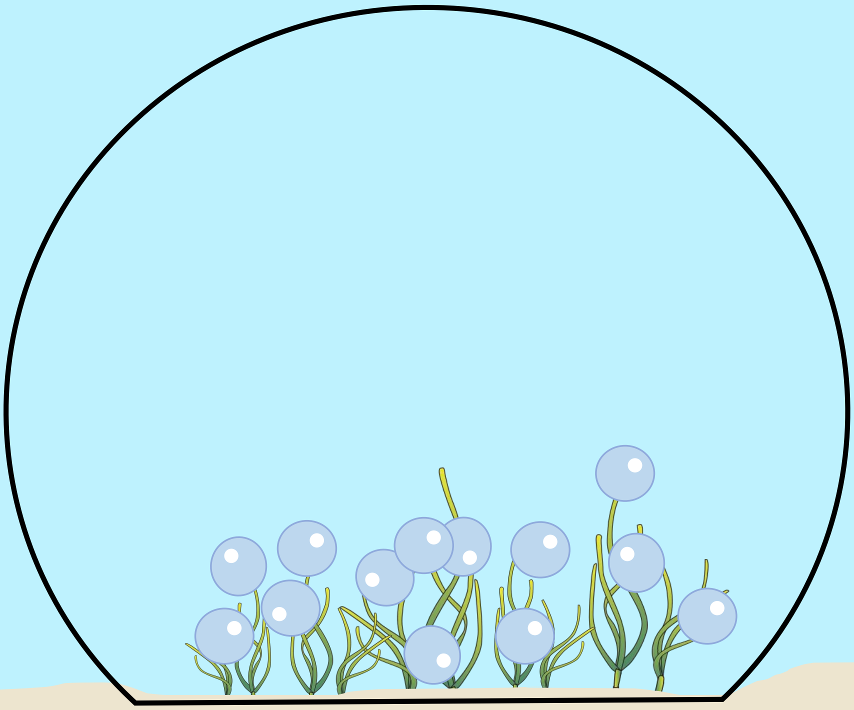
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



**Light** Incubation
Replicate **5**
Species: **Widgeon Grass** (*Ruppia maritima)*

1 mmol
Oxygen

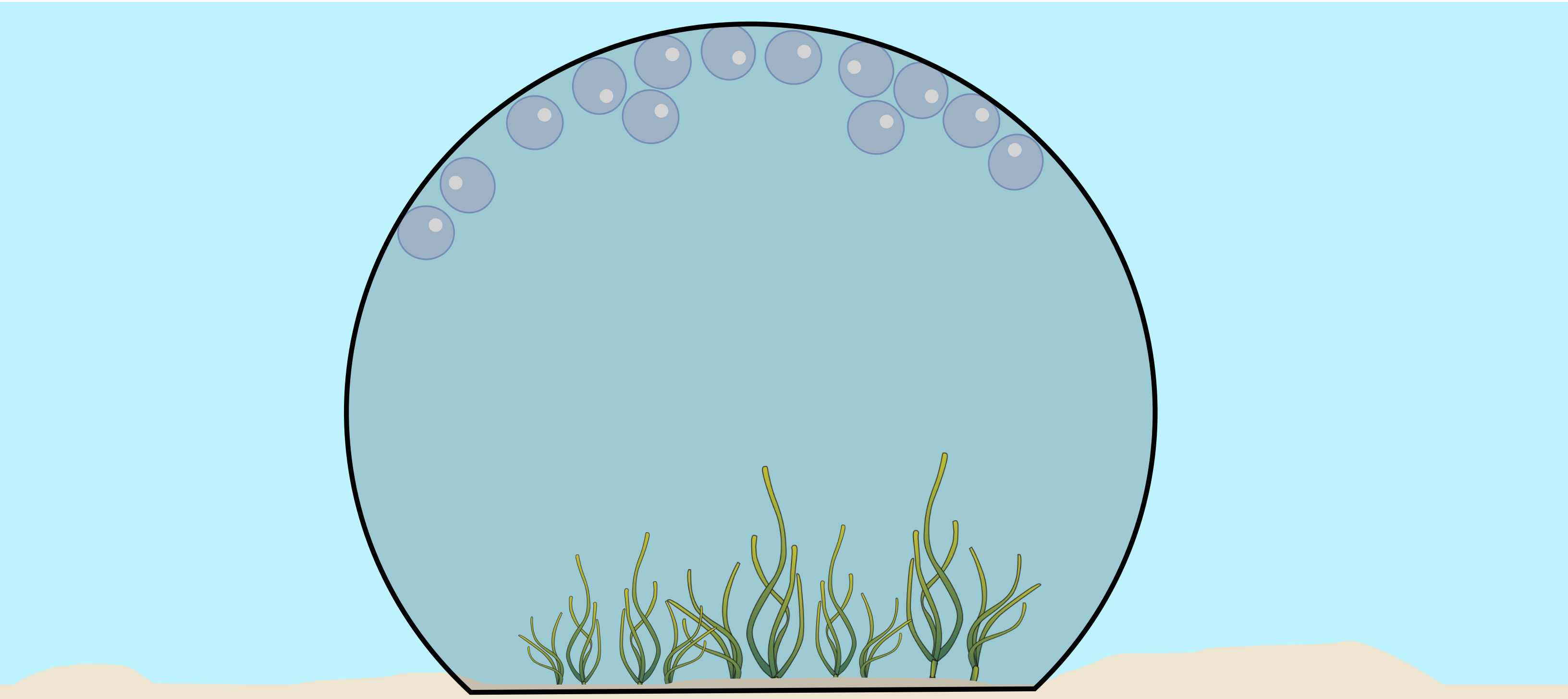
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



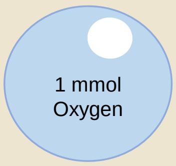
**Light** Incubation
Replicate **5**
Species: **Widgeon Grass** (*Ruppia maritima)*

1 mmol
Oxygen

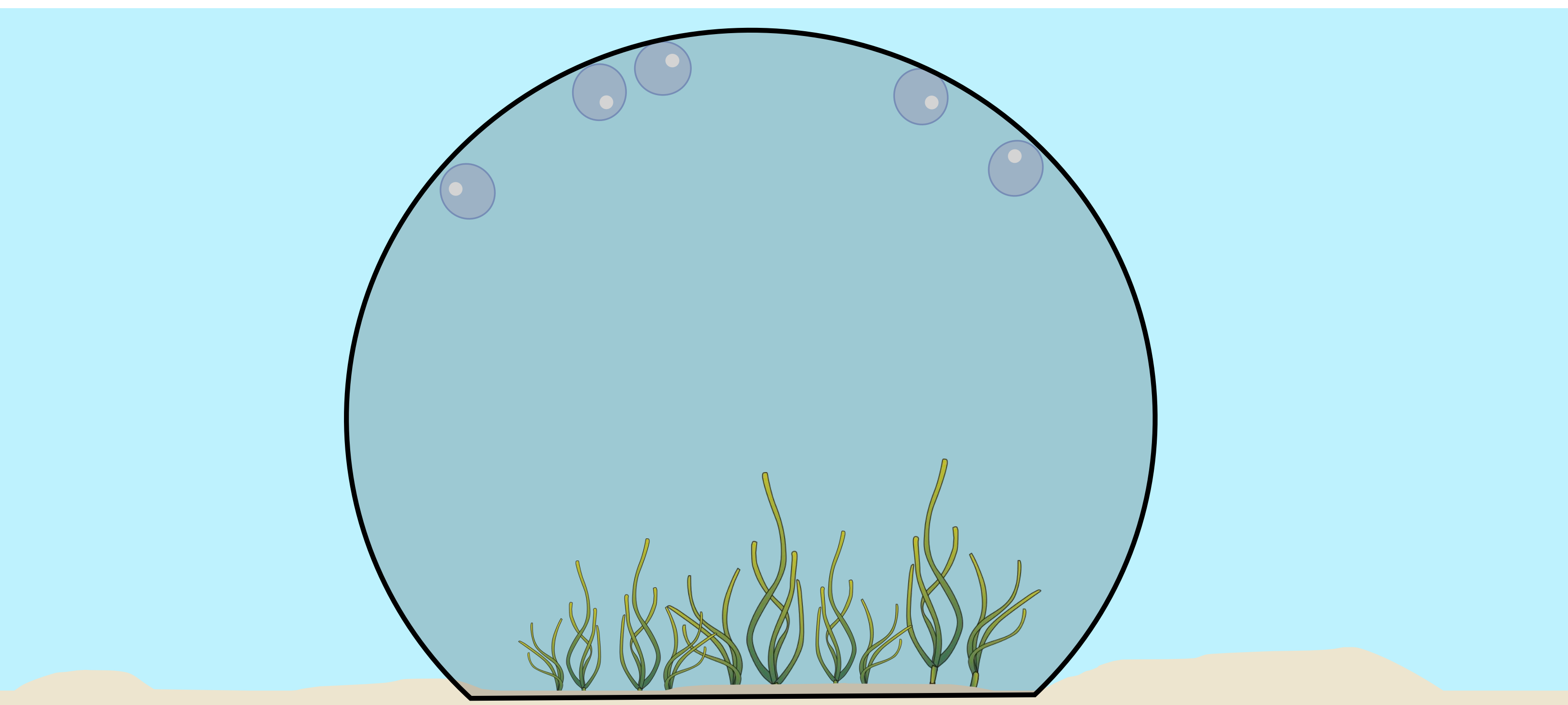
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



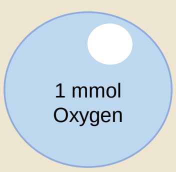
**Dark** Incubation
Replicate **1**
Species: **Widgeon Grass** (*Ruppia maritima)*



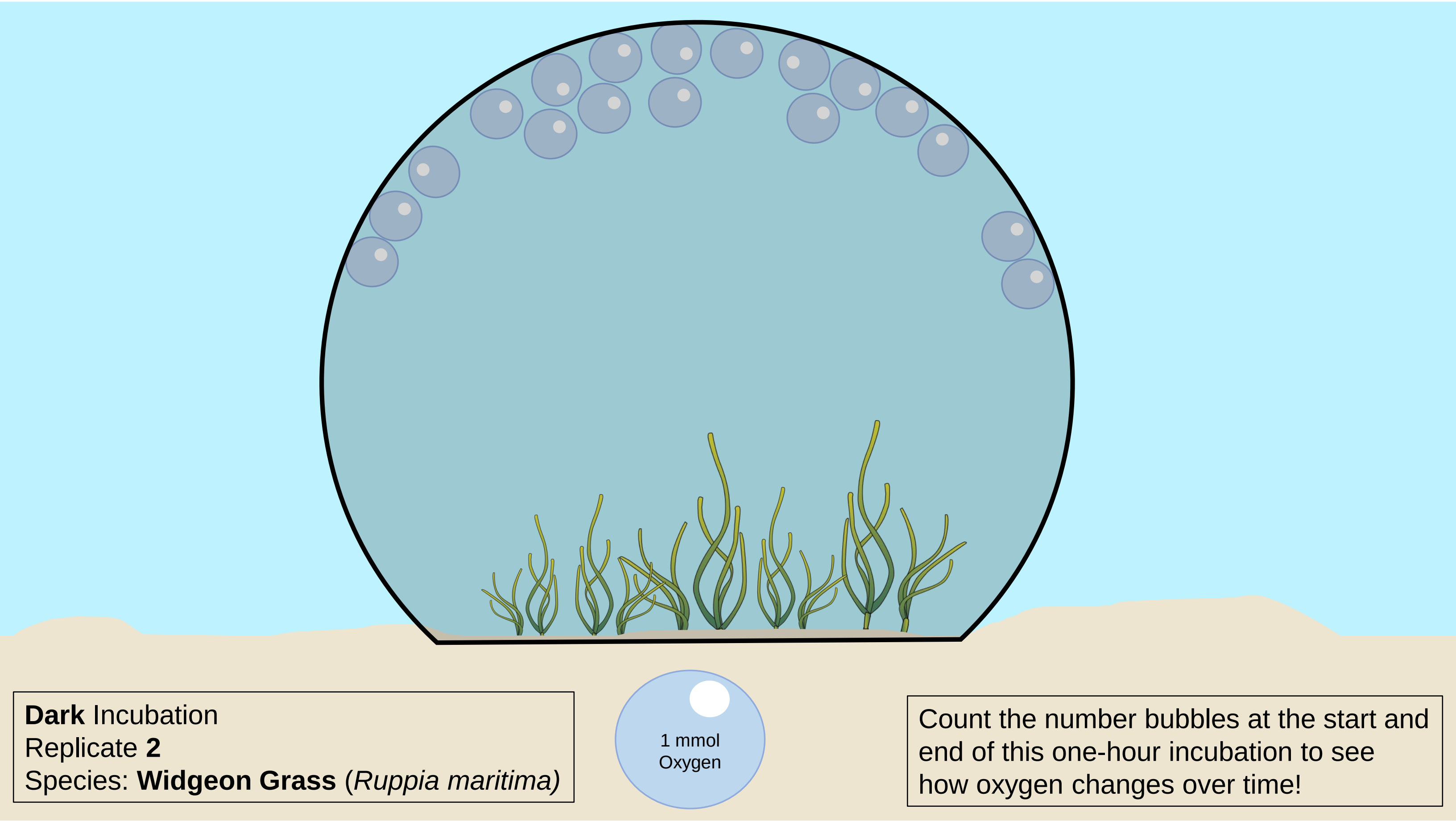

Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



**Dark** Incubation
Replicate **1**
Species: **Widgeon Grass** (*Ruppia maritima)*

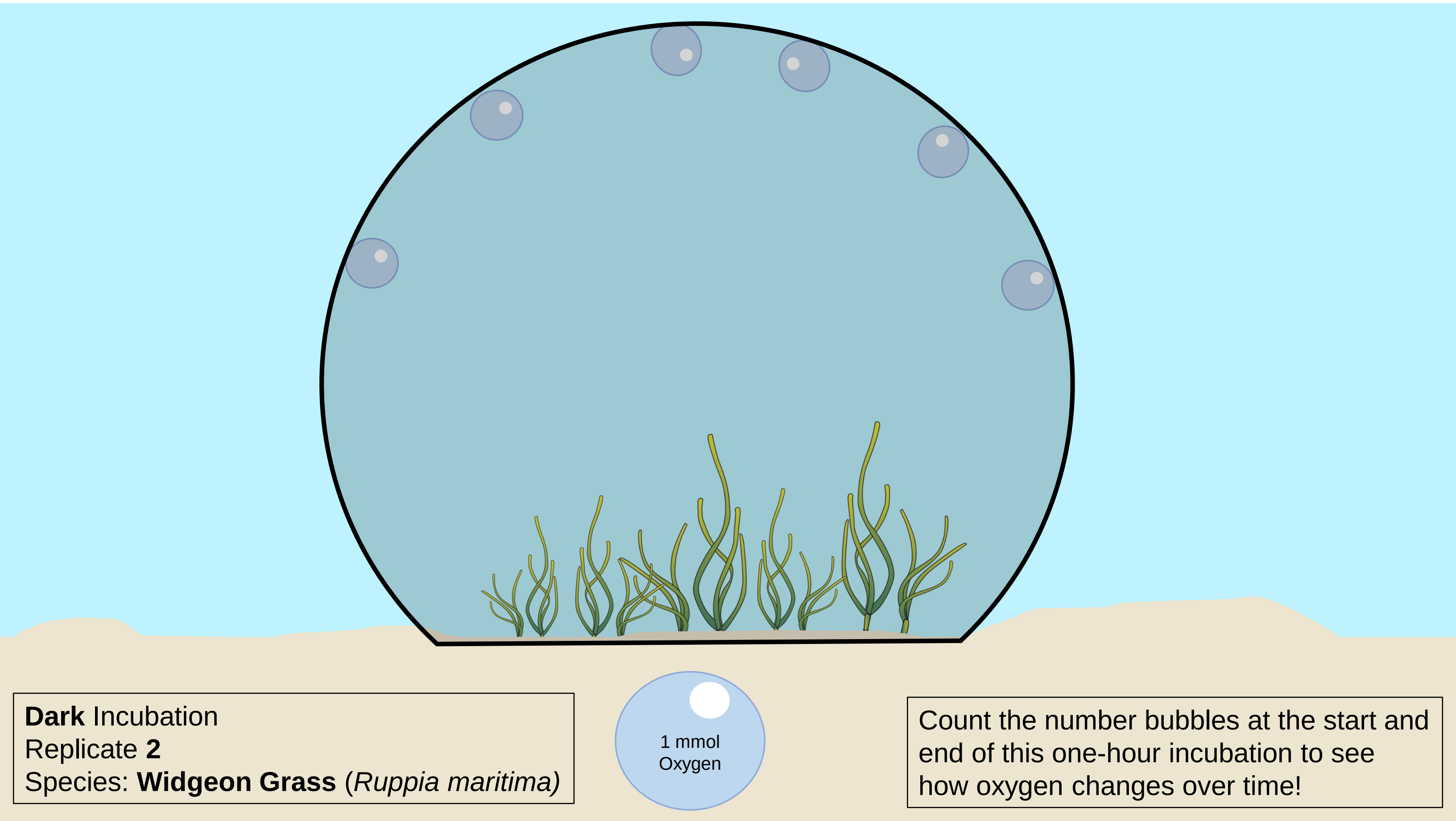



Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



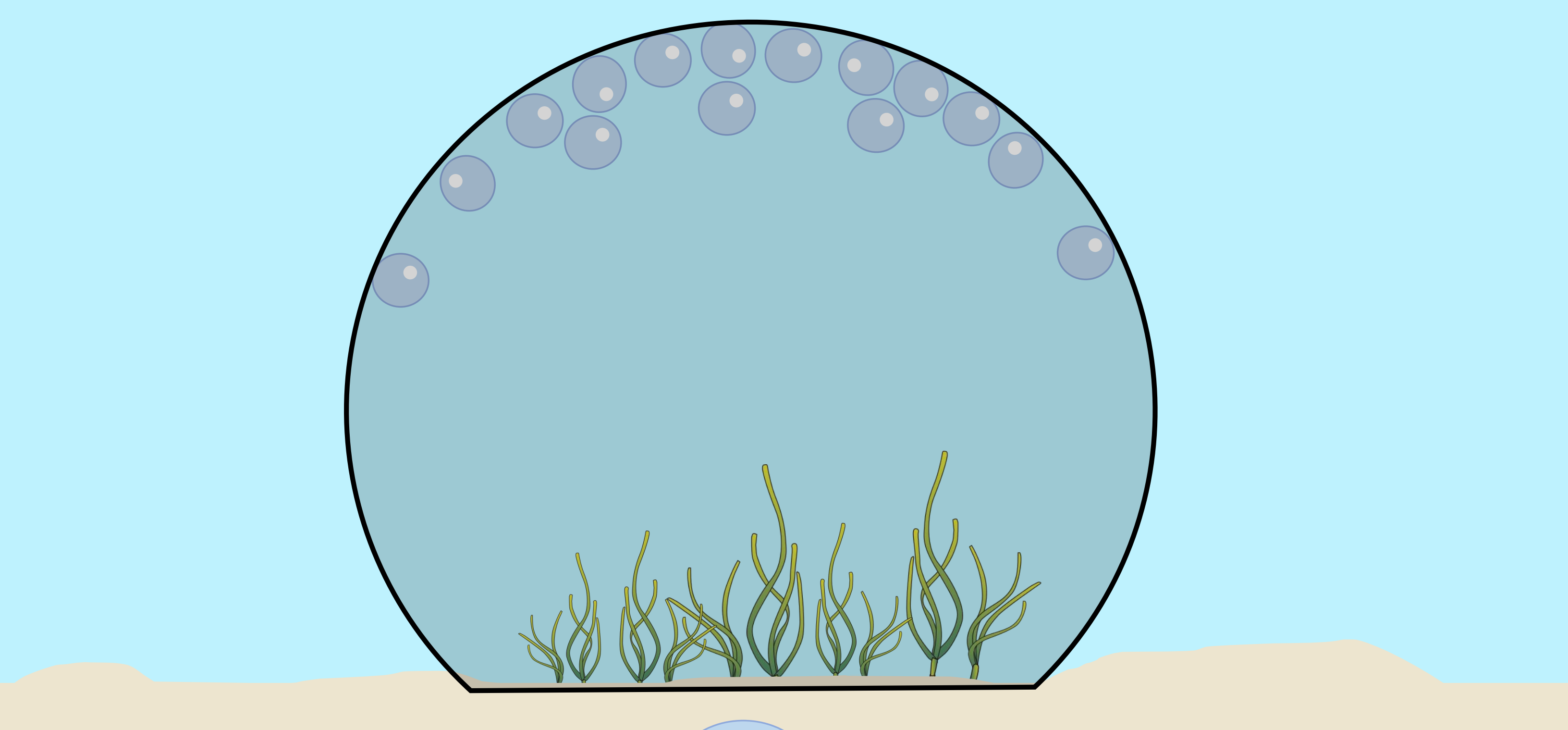

**Dark** Incubation
Replicate **2**
Species: **Widgeon Grass** (*Ruppia maritima)*

Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!

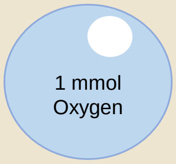



**Dark** Incubation
Replicate **2**
Species: **Widgeon Grass** (*Ruppia maritima)*

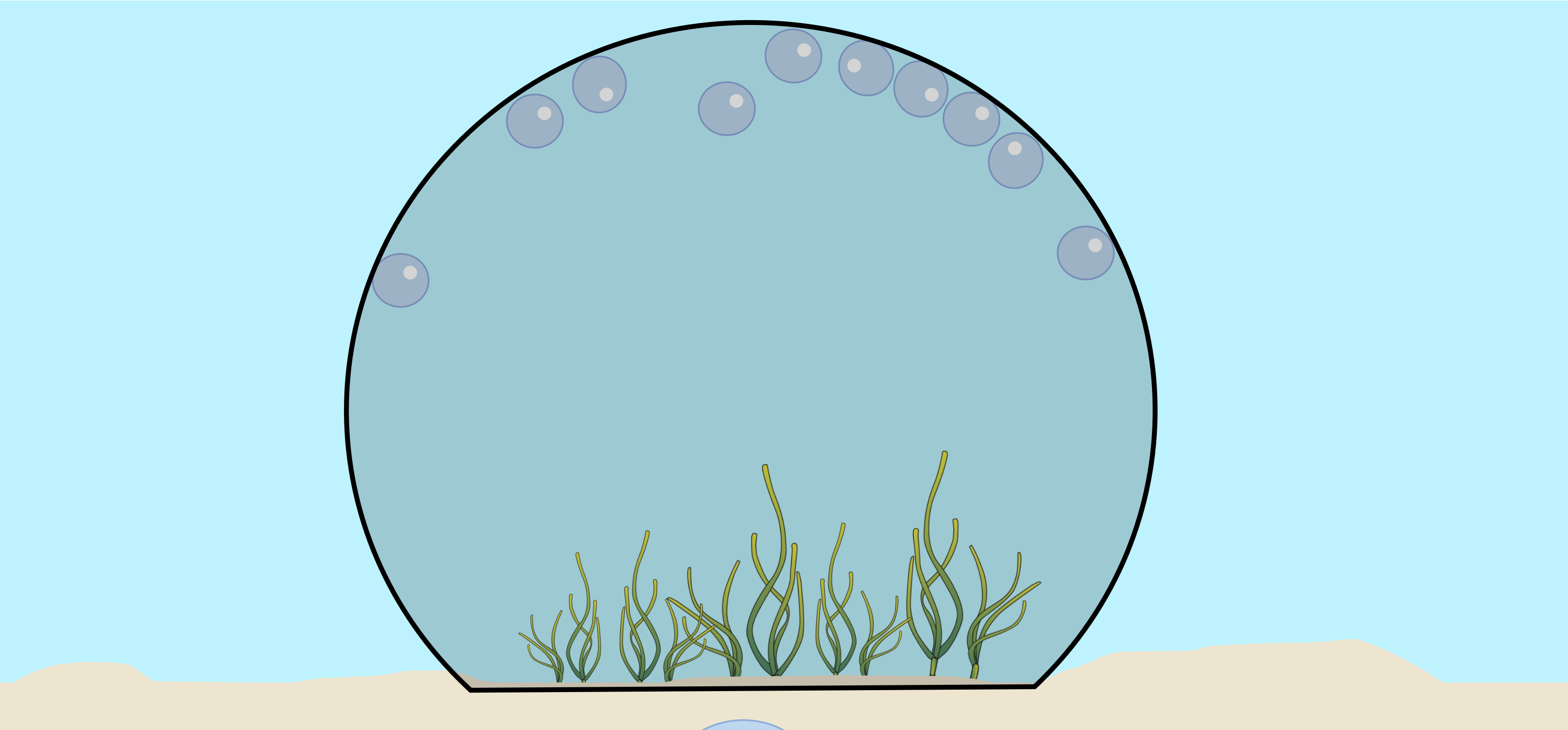
Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



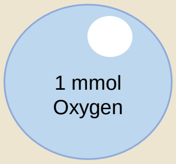
**Dark** Incubation
Replicate **3**
Species: **Widgeon Grass** (*Ruppia maritima)*



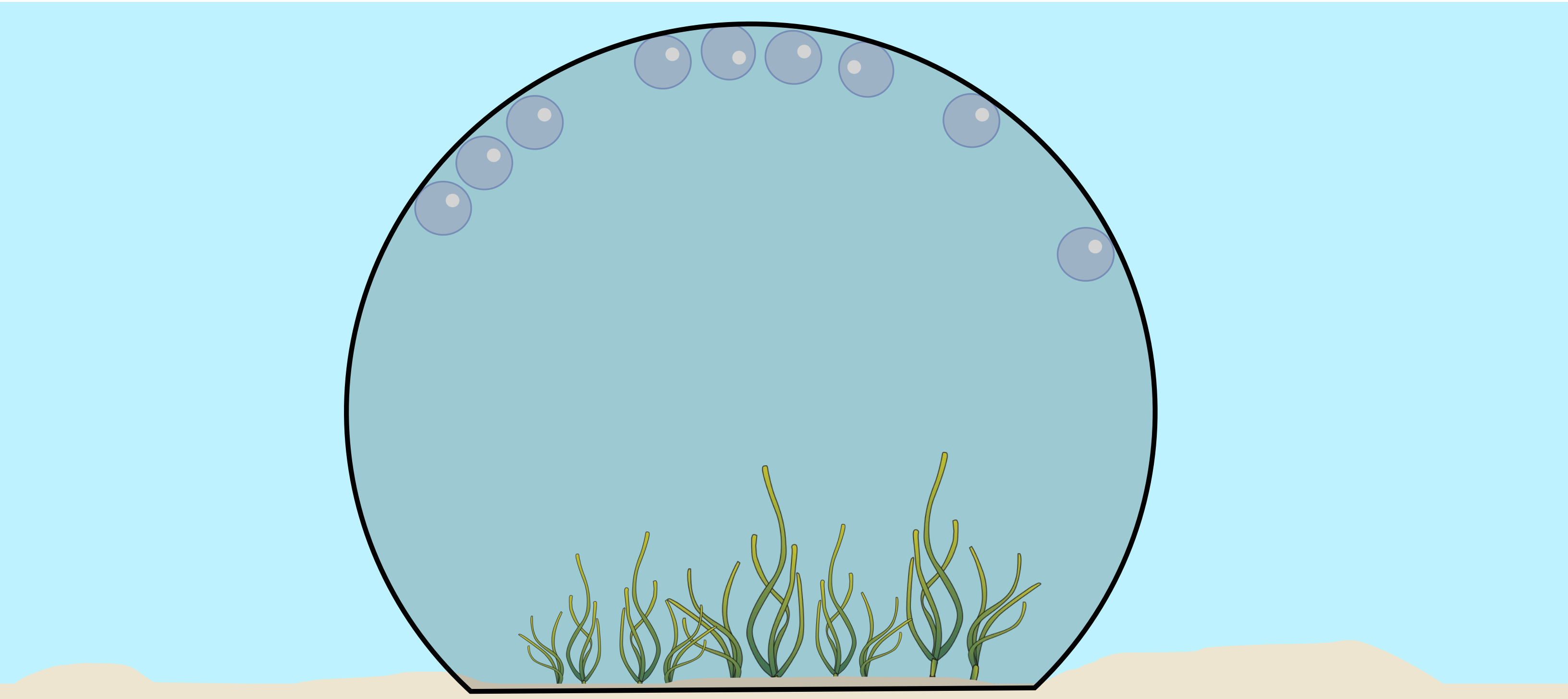

Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



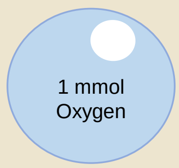
**Dark** Incubation
Replicate **3**
Species: **Widgeon Grass** (*Ruppia maritima)*



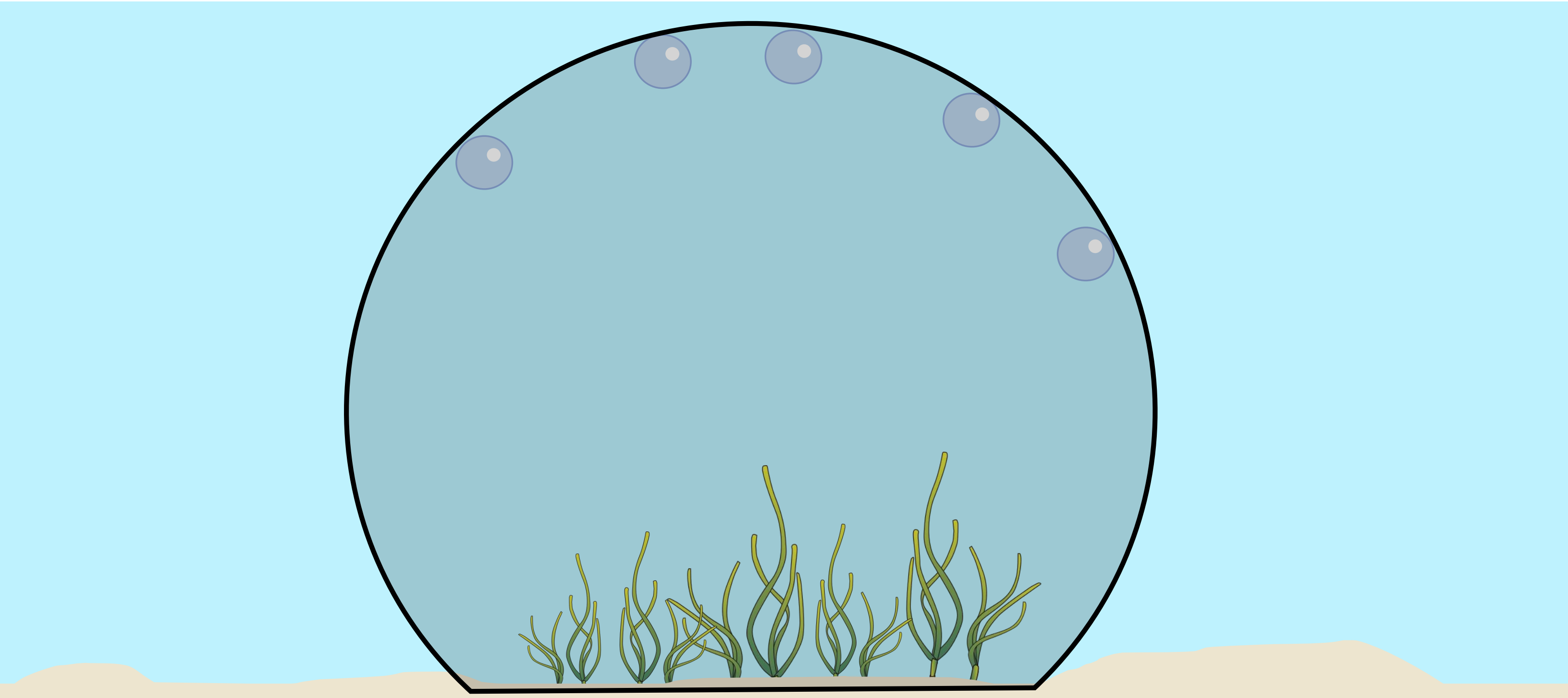

Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



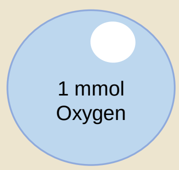
**Dark** Incubation
Replicate **4**
Species: **Widgeon Grass** (*Ruppia maritima)*



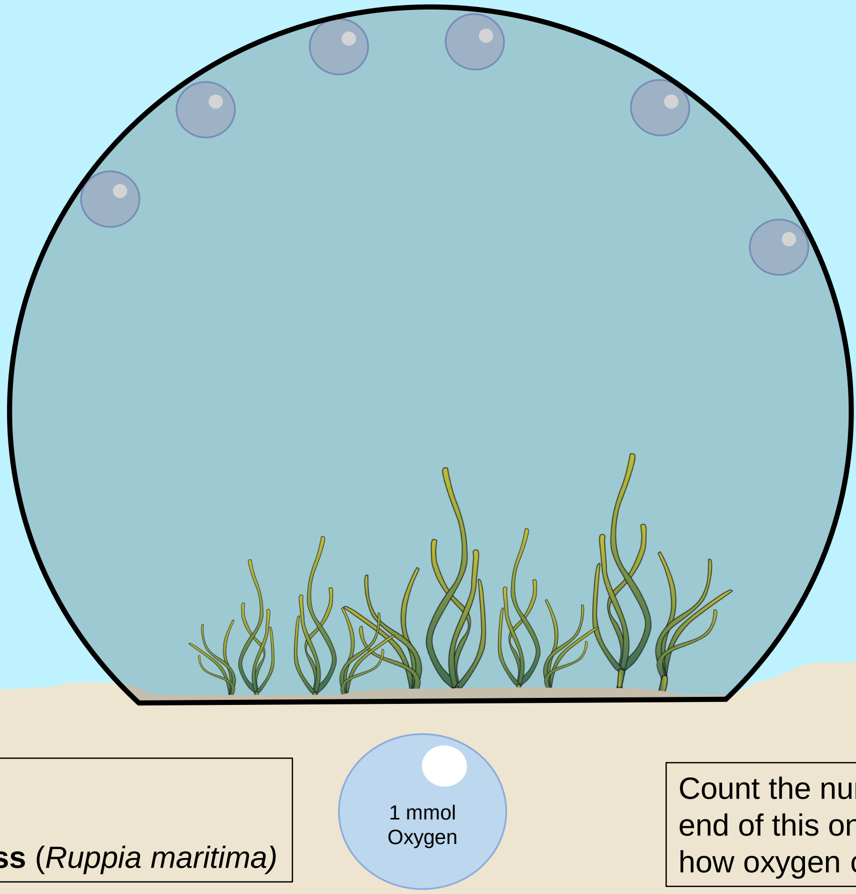

Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!



**Dark** Incubation
Replicate **4**
Species: **Widgeon Grass** (*Ruppia maritima)*




Count the number bubbles at the start and end of this one-hour incubation to see how oxygen changes over time!




**Dark** Incubation
Replicate **5**
Species: **Widgeon Grass** (*Ruppia maritima)*

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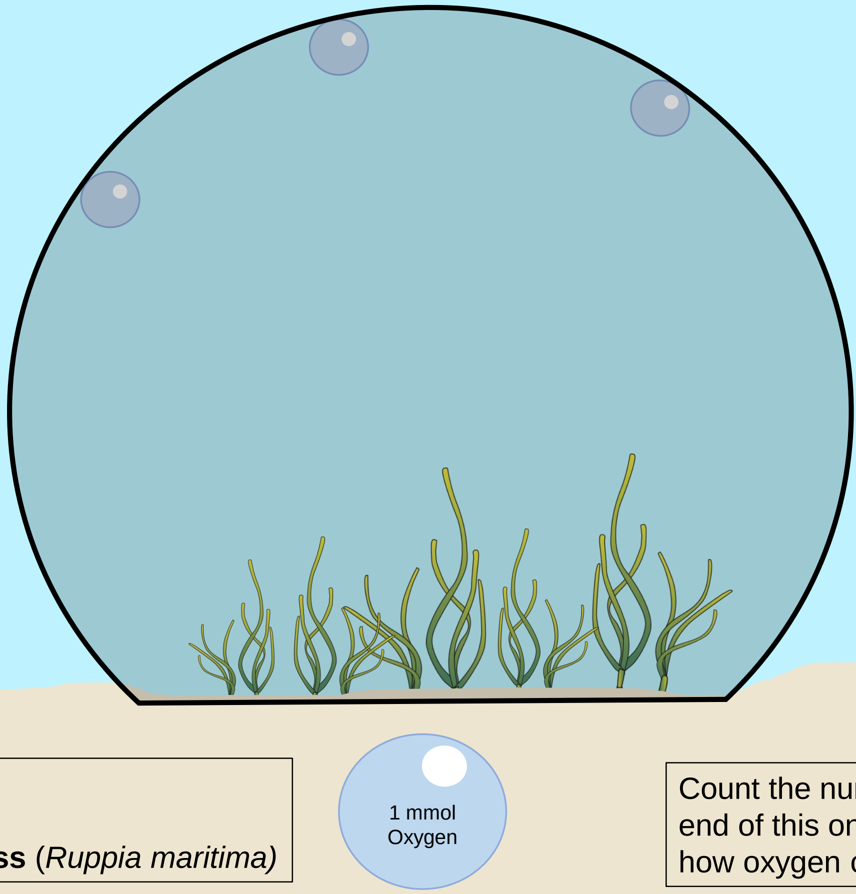


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