THE SEAGRASS IS GREENER ON THE OTHER SIDE

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Grade Level
High School

Subject area
Biology

Title: The Seagrass is Greener on the Other Side

Focus: Students will collect data about animals in a seagrass meadow, learn how seagrass density affects species abundance and diversity, and calculate a biodiversity index

Grade Level: High School Biology

VA Science Standards:

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
  - generate hypotheses based on research and scientific principles

- 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

- d) constructing and critiquing conclusions and explanations

  - construct explanations that include qualitative or quantitative relationships between variables
  - construct scientific explanations based on valid and reliable evidence obtained from sources (including the students' own investigations)

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

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:

- ✓ Students will count animals collected in a seagrass epifauna sample, and graph their data
- ✓ Students will identify if high, medium, or low seagrass cover attracts the most diversity and abundance of animals
- ✓ Students will compare and contrast their results to those from other groups members
- ✓ Students will calculate Simpson's Diversity Index
- ✓ Students will use data to develop a hypothesis about how climate change will affect diversity and abundance in seagrass meadows

Total Length of Time Required for the Lesson:

Initial advance preparation of lab materials – 45 to 60 minutes

Lesson and activity – 60 to 80 minutes

Lab setup – 5 minutes, Introduction – 15 minutes, Activity – 30 to 45 minutes,

Discussion – 10 minutes, Clean-up – 5 minutes.

Key Words:

- **Abundance:** the number of individual animals in a sample
- **Amphipod:** a type of crustacean whose Latin name means "different-footed" because they have multiple types of legs; in seagrass meadows they are important because they keep seagrass clean by eating the algae growing on the grass
- **Angiosperms**: flowering plants
- **Biodiversity:** the diversity of plants and animals that make up a particular ecosystem
- **Diversity:** the different variety and amount of species
- **Ecology**: the study of how organisms interact with one another and with their environment
- **Ecosystem**: a group of organisms that interact with each other within their environment
- **Ecosystem services:** the ways in which an ecosystem helps humans
- **Epifauna**: aquatic animals, such as amphipods, that live on the surface of the sediment or on the surface of a substrate, like rocks or plants
- **Photosynthesis:** the process by which plants convert light energy and carbon dioxide into sugar and oxygen
- **Population**: a group of individuals of the same species living in an area
- **Rhizomes:** the horizontal underground plant stem which seagrasses use to absorb and store nutrients as well as to anchor themselves in the sediment
- **Seagrass**: flowering plants, or angiosperms, that form underwater meadows and grow in shallow coastal waters
- **Simpson's Diversity Index**: a measure of biodiversity which considers the number of species present and the abundance of each species. Values range between 0 and 1 and a value of 1 represents infinite diversity while a value of 0 indicates no diversity.
- **Species**: a group of organisms that can reproduce with one another

Background information:

Seagrasses have a global distribution and can be found in the shallow coastal waters of all continents except Antarctica. Seagrasses are **angiosperms** that over time adapted to live underwater. They use their roots and **rhizomes** to absorb and store nutrients and to anchor themselves in the sediments. Just like land plants, seagrasses also perform **photosynthesis** and use light energy to convert carbon dioxide and water into sugar and oxygen. Seagrasses exchange oxygen and carbon dioxide through their thin leaves.

Unfortunately, seagrasses are at risk. Globally we are losing the equivalent of two football fields of seagrass meadows every hour. Threats to seagrass meadows include: climate change, poor water quality from pollution, as well as boating and destructive fishing methods. It is necessary to protect and study seagrass meadows, because they are an important marine **ecosystem** for a variety of reasons. For example, seagrasses absorb the carbon dioxide that is dissolved in the ocean and store it in their tissues or in the sediment. They also protect the coasts from the impacts of storms by stopping coastal erosion. Additionally, seagrass meadows have high **biodiversity** and are a vital source of food and habitat for many marine animals, especially juveniles. Seagrass meadows can be home to many fishes that humans eat and to other **species** like seahorses, manatees, and sea turtles. Higher percent cover of seagrass has also been shown to correlate with increases in diversity and density of **epifauna**. Epifauna, such as **amphipods**, are vital to the maintenance of seagrass ecosystems. These aquatic animals remove fouling algae which would otherwise overgrow the seagrass, preventing the plants from effectively carrying out photosynthesis. They also act as an important link between primary producers and animals higher up the food chain. These key roles mean that sampling the epifauna community is an important part of understanding the health and function of seagrass meadows. Measures of biodiversity like **Simpson's Diversity Index**, which considers the number of species present and the **abundance** of each species, can be used to quantify this high diversity.

Student Handouts:

- Seagrass Survey – Epifauna Data Sheet
- Seagrass Survey – Biodiversity Worksheet

Materials & Supplies:

- Computer and projector for accompanying PowerPoint
- Three (3) 'seagrass' samples, one for each site (samples correspond to low, medium, and high amounts of seagrass) for each group. Each sample will need:
  - A plastic sandwich bag
  - Site labels (Site 1, Site 2, or Site 3)
  - Epifauna collected in the sample:
    - 4 bead colors, one for each juvenile blue crab, white amphipod, Hippolyte shrimp, and Bittium snail
  - Green pipe cleaners to represent seagrass
- Colored pencils / markers / etc. for graphing
- Calculator to calculate Simpson's Diversity Index

Teacher Preparation & Classroom Setup:

Students will be divided into groups of three.

For Part I of the activity, each student should receive a copy of the epifauna data worksheet. For Part II of the activity, each student should receive a copy of the biodiversity index worksheet.

Each 'seagrass' sample should be labeled with the site name. (Amount of seagrass should not be on the label so that it is a secret to the students.) Each sample should be filled with the four epifauna species (beads) and corresponding amount of 'seagrass' (pipe cleaners) according to the following chart.

Site Name	Amount of Seagrass		Juvenile Blue Crab	White Amphipod	Hippolyte Shrimp	Bittium Snail	TOTAL
Site 1	Low	10	0	18	0	25	43
Site 2	High	20	2	40	3	48	93
Site 3	Medium	15	0	32	1	37	70
		TOTAL	2	90	4	110	206

Procedure:

I. Lesson Introduction:

- Teachers should load the accompanying PowerPoint presentation and review slides #1-9 with the students. (Suggested talking points and discussion questions are included in the comments section of each slide.)

II. Activity:

Part 1: Examine the Epifauna Data

- Teachers should fill in slide #10 with their chosen bead colors and have the slide up during this part of the lesson so that students may refer to it.
- Students should first answer questions #1-2 on the Epifauna Data Sheet.
  - If time allows, instructors should ask students to share their predictions and hypotheses.
- Students should be divided into groups of three. Each group will receive three (3) 'seagrass' samples corresponding with low, medium, and high seagrass density. Samples should include labels (Site 1, Site 2, Site 3). Amount of 'seagrass' (low, medium, high) should be kept secret from the students.
- Each group member will then receive a single 'seagrass' sample. Students in a group can either work individually or work together to sort and count the number of epifauna caught in each sample.
  - Each student could be responsible for counting all the species in one of the 'seagrass' samples, or one student could record while the other group members sort and count species. The 'recorder' and 'counters' can then switch roles between samples.

- When sorting and counting is complete, students should complete the graphing exercise on the Epifauna Data Sheet.
- Students should answer questions #3-5 on the Epifauna Data Sheet.
- When all groups are finished, ask students to share their observations with their classmates.

Part 2: Calculate Simpson's Diversity Index

- Teachers should review slides #11-14 with students in order to demonstrate an example of how Simpson's Diversity Index is calculated.
- Students should continue working in groups of three and answer questions #1-2 on the Biodiversity Worksheet after the demonstration.
- Next, each group member should calculate the Simpson's Diversity Index for one of the three 'seagrass' samples. Students should then share answers within their group and record the Simpson's Diversity Index for each site in the data table provided on the Biodiversity Worksheet.
  - Depending on individual ability, additional time for writing out the steps of the math problem or partnering with a classmate who is stronger in math might be needed.
- Students should answer questions #3-5 on the Biodiversity Worksheet.
- When all groups are finished, ask students to share their observations with their classmates.

III. Evaluation

- Suggested wrap up questions and answers:
  - Were you surprised by any of your findings? Why?
  - What are some benefits that seagrasses provide?
    - Answer: Seagrass meadows have high biodiversity and are a vital source of food and habitat for many marine animals, especially juveniles. Seagrasses absorb the carbon dioxide that is dissolved in the ocean and store it in their tissues or in the sediment. They also protect the coasts from the impacts of storms by stopping coastal erosion.
  - How did the amount of seagrass impact the amount of epifauna in a sample? How did it affect diversity?
    - Answer: When there was more seagrass in a sample, there was more epifauna and higher diversity.
  - How is human activity impacting seagrass beds?
    - Answer: Boating and dredging can physically harm seagrass meadows by uprooting the plants from the sediment. Poor water quality due to pollution and excessive nutrients also harms seagrass meadows.
  - How might decreased epifauna abundance and diversity negatively impact seagrass ecosystems?
    - Answer: These invertebrates remove fouling algae from seagrasses and without them seagrass might become overgrown with algae. This could reduce the amount of light available to seagrasses decreasing their ability to photosynthesize and grow. Additionally, loss of epifauna species could mean a loss of food sources for species higher up in the food chain that forge in seagrass meadows.

IV. Assessment

Students will be assessed based on their performance on the data table, graphs, and follow up worksheet questions and based on contributions to group and class discussions. Teachers can also ask students to prepare a lab report if they so choose.

References and further reading:

Cullen-Unsworth L, Jones B, Lilley R and Unsworth R (2018). Secret Gardens Under the Sea: What are Seagrass Meadows and Why are They Important?. Front. Young Minds. 6:2. doi: 10.3389/frym.2018.00002

Duncan, Sarah & Lenhart, Suzanne & Sturner, Kelly. (2014). Measuring Biodiversity with Probability. Mathematics Teacher. 107. 10.5951/mathteacher.107.7.0547.

Orth, R. J., Heck, K. L., & van Montfrans, J. (1984). Faunal communities in seagrass beds: a review of the influence of plant structure and prey characteristics on predator-prey relationships. Estuaries, 7(4), 339-350. https://doi.org/10.2307/1351618

Waycott, M., Duarte, C. M., Carruthers, T. J. B., Orth, R. J., Dennison, W. C., Olyarnik, S., et al. (2009). Accelerating loss of seagrasses across the globe threatens coastal ecosystems. Proc. Natl. Acad. Sci. U.S.A. 106:12377–81. doi:10.1073/pnas.0905620106

Seagrass Survey – Epifauna Data Sheet

Name_____

Date_____

Introduction.

You are working with a group of marine scientists to study seagrass meadows in Clearwater Bay. Epifauna, or the small animals that live on seagrass, play an important part in understanding the health and function of seagrass meadows. You and your team decide to collect epifauna samples from three sites with low, medium, and high amounts of seagrass in order to count and identify the different epifauna species present.

Form a hypothesis.

1. Which seagrass amount (low, medium, or high) do you think will have the most amount of epifauna? Which one do you think will have the least amount of epifauna? Why?

2. Write your prediction from the previous question as a hypothesis using an if-then statement.

Record your epifauna count data in the data tables.

Open your 'seagrass' sample, record which site your sample came from (Site 1, Site 2, Site 3), and count how many seagrass blades your sample contains. Next, sort the epifauna by species. Count how many epifauna of each species were collected. If your sample did not contain some of the species, record a count of 0. Then, record the total number of all the epifauna in your sample. Get the epifauna count data for the other two sites from your other group members and record it as well.

Site:
Seagrass blade count:

Species	Epifauna Count
Juvenile Blue Crab	
White Amphipod	
Hippolyte Shrimp	
Bittium Snail	
TOTAL	

Site:
Seagrass blade count:

Species	Epifauna Count
Juvenile Blue Crab	
White Amphipod	
Hippolyte Shrimp	
Bittium Snail	
TOTAL	

Site:
Seagrass blade count:

Species	Epifauna Count
Juvenile Blue Crab	
White Amphipod	
Hippolyte Shrimp	
Bittium Snail	
TOTAL	

Graph the data after you have finished filling out the data tables.

Fill in the X-axis with the different species observed at your site (low, medium, or high). Create a bar graph to demonstrate the abundance, or number, of each species that you collected. Be sure to label each of your axes and give the graph a title.

Site:
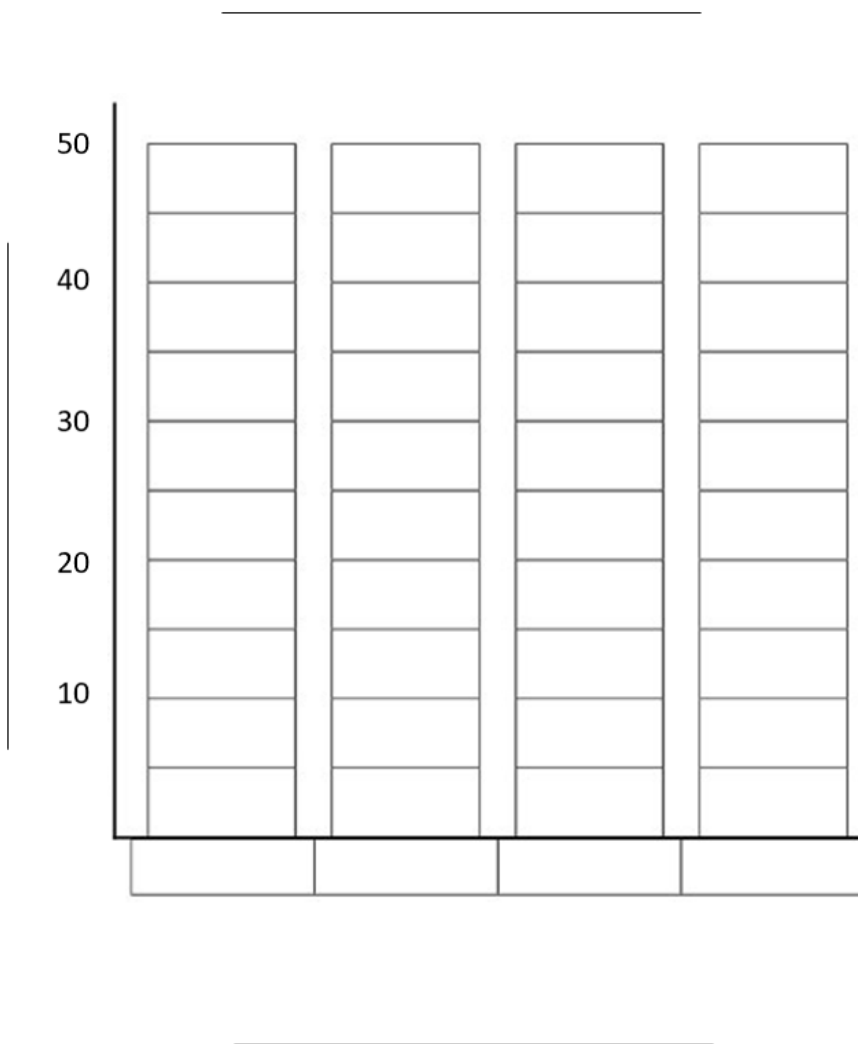
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Complete the following questions below after graphing.

3. Which site had a low amount of seagrass? Which one had a medium amount of seagrass? Which one had a high amount of seagrass?

4. Which site had the most amount of epifauna? Which one had the least amount of epifauna?

5. Why do you think the amount of seagrass affects the amount of epifauna present?

Seagrass Survey – Biodiversity Worksheet

Name_____

Date_____

Introduction.

Simpson's Diversity Index is a measure of biodiversity that considers the number of species present and the abundance of each species. The value of Simpson's Diversity Index (D) can range between 0 and 1. A value of 1 represents high diversity and a value of 0 indicates no diversity.

Simpson's Diversity Index (D).

$$D = 1 - \frac{n_1(n_1 - 1) + n_2(n_2 - 1) + n_3(n_3 - 1) + \cdots + n_s(n_s - 1)}{N(N - 1)}$$

Species	Species Count
Species 1	n_1
Species 2	n_2
Species 3	n_3
...	...
Species S	n_s
Total Individuals	N

Form a hypothesis.

1. Which seagrass site (low, medium, or high) do you think will have the highest Simpson's Diversity Index? Why?

2. Write your prediction from the previous question as a hypothesis using an if-then statement.

Calculating Simpson's Diversity Index (D).

Input the epifauna count data for your seagrass site (low, medium, or high) into the table below. Then, follow the steps to calculate Simpson's Diversity Index.

Site:

Species	Epifauna Count
Juvenile Blue Crab (Species 1)	$n_1 =$
White Amphipod (Species 2)	$n_2 =$
Hippolyte Shrimp (Species 3)	$n_3 =$
Bittium Snail (Species 4)	$n_4 =$
TOTAL	**N =**

Step A. Add up the total number of individual epifauna in your sample to get the total number of observations, N.

$$N = n_1 + n_2 + n_3 + n_4$$

$$N = _____$$

Step B. Evaluate N (N-1)

$$N(N-1) = _____$$

Step C. Evaluate n (n - 1) for each species and add them together.

$$n_1(n_1 - 1) = _____$$

$$n_2(n_2 - 1) = _____$$

$$n_3(n_3 - 1) = _____$$

$$n_4(n_4 - 1) = _____$$

$$n_1(n_1 - 1) + n_2(n_2 - 1) + n_3(n_3 - 1) + n_4(n_4 - 1) = _____$$

Step D. Divide the number obtained in Step C by the number obtain from Step B.

$$\frac{n_1(n_1 - 1) + n_2(n_2 - 1) + n_3(n_3 - 1) + n_4(n_4 - 1)}{N(N - 1)} = \underline{\hspace{2cm}}$$

Step E. Obtain Simpson's Diversity Index, D, by subtracting the number obtained in Step D from 1.

$$D = \underline{\hspace{2cm}}$$

Record your Simpson's Diversity Index below.

After calculating the Simpson's Diversity Index for your site, record it in the table below. Get the Simpson's Diversity Index for the other two sites from your other group members and record it as well.

Amount of Seagrass	Simpson's Diversity Index (D)
Low	
Medium	
High	

Complete the following questions below after obtaining Simpson's Diversity Index for all three seagrass sites.

3. Which site had the most diversity? Provide evidence to support your answer.

4. Which site had the lowest diversity? Provide evidence to support your answer.

5. Climate change can cause seagrasses to decline. Using if-then statements, form a hypothesis about how climate change will affect epifauna diversity and abundance in seagrass meadows.

Seagrass Survey – Epifauna Data Sheet KEY

Name_____

Date_____

Introduction.

You are working with a group of marine scientists to study seagrass meadows in Clearwater Bay. Epifauna, or the small animals that live on seagrass, play an important part in understanding the health and function of seagrass meadows. You and your team decide to collect epifauna samples from sites with low, medium, and high amounts of seagrass in order to count and identify the different epifauna species present.

Form a hypothesis.

1. Which seagrass amount (low, medium, or high) do you think will have the most amount of epifauna? Which one do you think will have the least amount of epifauna? Why?

The site with a high amount of seagrass will have the most amount of epifauna and the site with the low amount of seagrass will have the least amount of epifauna. This is because seagrass provides a food source and habitat for epifauna and higher amounts of seagrass correlates with increases in the number of epifauna

2. Write your prediction from the previous question as a hypothesis using an if-then statement.

If there is a high amount of seagrass, then there will be a higher amount of epifauna than if there was less seagrass.

Record your epifauna count data in the data tables.

Open your 'seagrass' sample, record which site your sample came from (low, medium, or high), and count how many seagrass blades your sample contains. Next, sort the epifauna by species. Count how many epifauna of each species were collected. If your sample did not contain some of the species, record a count of 0. Then, record the total number of all the epifauna in your sample. Get the epifauna count data for the other two sites from your other group members and record it as well.

Site: Site 1
Seagrass blade count: 10

Species	Epifauna Count
Juvenile Blue Crab	0
White Amphipod	18
Hippolyte Shrimp	0
Bittium Snail	25
TOTAL	43

Site: Site 3
Seagrass blade count: 15

Species	Epifauna Count
Juvenile Blue Crab	0
White Amphipod	32
Hippolyte Shrimp	1
Bittium Snail	37
TOTAL	70

Site: Site 2
Seagrass blade count: 20

Species	Epifauna Count
Juvenile Blue Crab	2
White Amphipod	40
Hippolyte Shrimp	3
Bittium Snail	48
TOTAL	93

Graph the data after you have finished filling out the data tables.

Fill in the X-axis with the different species observed at your site (low, medium, or high). Create a bar graph to demonstrate the abundance, or number, of each species that you collected. Be sure to label each of your axes and give the graph a title.

Epifauna count data for low amount of seagrass

Epifauna species

Epifauna count data for medium amount of seagrass

Epifauna species

Epifauna count data for high amount of seagrass

Epifauna species
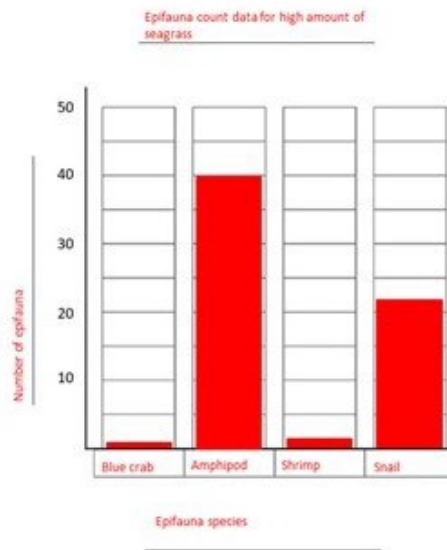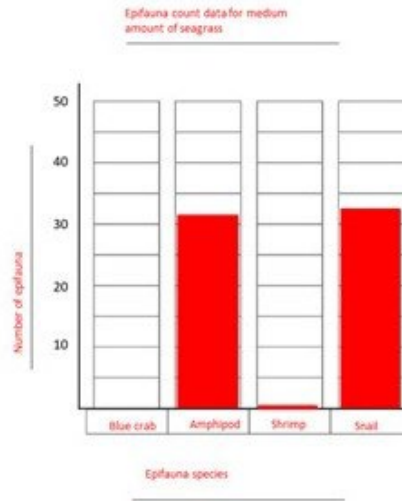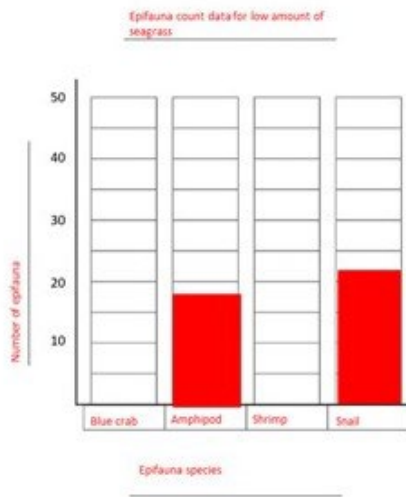
Complete the following questions below after graphing.

3. Which site had a low amount of seagrass? Which one had a medium amount of seagrass? Which one had a high amount of seagrass?

Site 1 had a low amount of seagrass, Site 3 had a medium amount of seagrass, and Site 2 had a high amount of seagrass.

4. Which site had the least amount of epifauna? Which one had the most amount of epifauna?

The site with a low amount of seagrass (Site 1) had the least epifauna. The site with a high amount of seagrass (Site 2) had the most epifauna.

5. Why do you think the amount of seagrass affects the amount of epifauna present?

Seagrass affects the amount of epifauna present because more seagrass means more space for epifauna to live and more food sources. Higher amounts of seagrass correlates with increases in the number of epifauna

Seagrass Survey – Biodiversity Worksheet KEY

Name_____

Date_____

Introduction.

Simpson's Diversity Index is a measure of biodiversity that considers the number of species present and the abundance of each species. The value of Simpson's Diversity Index (D) can range between 0 and 1. A value of 1 represents high diversity and a value of 0 indicates no diversity.

Simpson's Diversity Index (D).

$$D = 1 - \frac{n_1(n_1 - 1) + n_2(n_2 - 1) + n_3(n_3 - 1) + \cdots + n_s(n_s - 1)}{N(N - 1)}$$

Species	Species Count
Species 1	n_1
Species 2	n_2
Species 3	n_3
...	...
Species S	n_s
Total Individuals	N

Form a hypothesis.

1. Which seagrass site (low, medium, or high) do you think will have the highest Simpson's Diversity Index? Why?

The site with a high amount of seagrass will have the highest Simpson's Diversity Index because it had the most species and the most individuals present.

2. Write your prediction from the previous question as a hypothesis using an if-then statement.

If a sample has a high amount of seagrass, then it will have a high Simpson's Diversity Index.

If a sample has the most species and the most individuals present, then it will have a high Simpson's Diversity Index.

Calculating Simpson's Diversity Index (D).

Input the epifauna count data for your seagrass site (low, medium, or high) into the table below. Then, follow the steps to calculate Simpson's Diversity Index.

Site: Low/ Site 1

Species	Epifauna Count
Juvenile Blue Crab (Species 1)	n_1 = 0
White Amphipod (Species 2)	n_2 = 18
Hippolyte Shrimp (Species 3)	n_3 = 0
Bittium Snail (Species 4)	n_4 = 25
TOTAL	N = 43

Site: Medium/ Site 3

Species	Epifauna Count
Juvenile Blue Crab (Species 1)	n_1 = 0
White Amphipod (Species 2)	n_2 = 32
Hippolyte Shrimp (Species 3)	n_3 = 1
Bittium Snail (Species 4)	n_4 = 37
TOTAL	N = 70

Site: High/ Site 2

Species	Epifauna Count
Juvenile Blue Crab (Species 1)	n_1 = 2
White Amphipod (Species 2)	n_2 = 40
Hippolyte Shrimp (Species 3)	n_3 = 3
Bittium Snail (Species 4)	n_4 = 48
TOTAL	N = 93

Step A. Add up the total number of individual epifauna in your sample to get the total number of observations, N.

$$N = n_1 + n_2 + n_3 + n_4$$

N = 43, 70, or 93

Step B. Evaluate N (N-1)

$$N(N-1) = \text{_____}$$

1,806 or 4,830 or 8,556

Step C. Evaluate n (n - 1) for each species and add them together.

$$n_1(n_1 - 1) = \text{0 or 2}$$

$$n_2(n_2 - 1) = \text{306 or 992 or 1,560}$$

$$n_3(n_3 - 1) = \text{0 or 6}$$

$$n_4(n_4 - 1) = \text{600 or 1,332 or 2,256}$$

$$n_1(n_1 - 1) + n_2(n_2 - 1) + n_3(n_3 - 1) + n_4(n_4 - 1) = \text{906 or 2,324 or 3,824}$$

Step D. Divide the number obtained in Step C by the number obtain from Step B.

$$\frac{n_1(n_1 - 1) + n_2(n_2 - 1) + n_3(n_3 - 1) + n_4(n_4 - 1)}{N(N - 1)} = \text{0.5017 or 0.4812 or 0.4469}$$

Step E. Obtain Simpson's Diversity Index, D, by subtracting the number obtained in Step D from 1.

D = 0.4983 or 0.5188 or 0.5531

Record your Simpson's Diversity Index below.

After calculating the Simpson's Diversity Index for your site, record it in the table below. Get the Simpson's Diversity Index for the other two sites from your other group members and record it as well.

Amount of Seagrass	Simpson's Diversity Index (D)
Low	0.4983
Medium	0.5188
High	0.5531

Complete the following questions below after obtaining Simpson's Diversity Index for all three seagrass sites.

3. Which site had the most diversity? Provide evidence to support your answer.

The site with a high amount of seagrass (Site 2) had the most diversity because it had the largest D value at 0.5531.

4. Which site had the lowest diversity? Provide evidence to support your answer.

The site with a low amount of seagrass (Site 1) had the most diversity because it had the smallest D value at 0.4983.

5. Climate change can cause seagrasses to decline. Using if-then statements, form a hypothesis about how climate change will affect epifauna diversity and abundance in seagrass meadows.

If climate change causes a decline in seagrasses, then epifauna diversity and abundance will be negatively impacted and be lower.