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### Objective:

1. . Measure and compare the biodiversity of the rocky shore and sandy beach areas.
2. Learn methods for sampling and measuring diversity
3. . Relate the term biodiversity with the information theory

**Learning Skills:** Observation, Organization, Calculation, Comparison

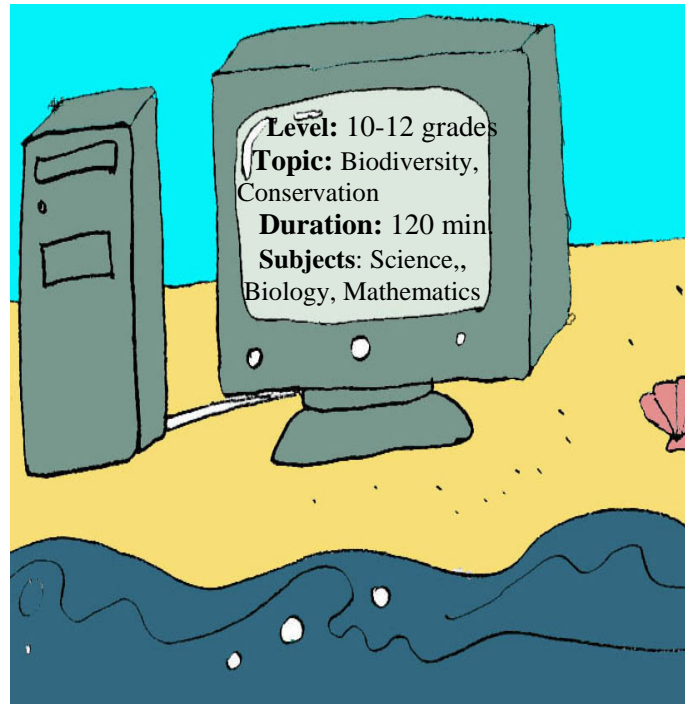
### Information Base:

Diversity is a measure of the amount of information obtained from a community; the more diverse a system, the more information is obtained. One of the formulas that is most commonly used to calculate diversity was derived from the information theory where the amount of information was calculated over a base quantity and the frequency of the symbols that were used in a message. These index units were expressed as Bytes.

A community can be studied as an ensemble of symbols represented by their different species, whose number and abundance determines the "style" of that community. For example, we can compare a tropical forest to a painting by Velazquez with its' infinite tones, while a degraded landscape will give information values similar to a pop-art painting.

In a system with many species greater organization is required to manage the large quantities of information, and the number of connections between species that can be established will increase. However, we can find two systems with the same number of species but the organization is different. Some systems have a few abundant species and the remaining species are considered "rare", while others have a large number of species with an intermediate abundances. The connections found in the latter will be larger than the former.

When we hear talk about conserving biodiversity, it refers to conserving the information that took nature millions of years to accumulate,



which is preserved in the species. As genetic manipulation techniques are being developed, we are closer today more than ever, to utilize this information.

- ☼ The simplest measure of diversity is the number of species ( $S$ ).
- ☼ Diversity indexes used most often combine characteristics for both the number of species and their relative abundance

$$D = S - 1 / \ln N$$

where,  $D$  = diversity index

$S$  = number of species

$N$  = number of total individuals

(This index will be larger if there are more species and their relative abundance are similar).

- ☼ The Shannon-Weaver ( $H$ ) Index:

$$H = - \sum P_i \ln P_i$$

where;  $P_i = N_i/N$  represents the proportion of species in the community

$N_i$  = number of individuals of a species  $I$

$N$  = total number of individuals

This index varies approximately from 1-5, where 1 is less diverse and 5 is more diverse.

The Shannon-Weaver Index for phytoplankton varies between 1 and 2.5; if we consider plankton in its totality this figure increases to 3.5 and 4.5. For birds, this index varies between 1.8 and 5.2, depending on the environment.

It must be emphasized that the diversity indexes are significantly comparable if they are obtained in a similar manner, with the same intensity of sampling, isolated from disturbances in the system, and maintaining the same trophic levels. Obtaining a diversity index of birds differs with that of invertebrates; as would an index of birds during rainy season to dry season, or during migrations.

In this activity we will demonstrate that the method for sampling can be challenging for a realistic representation of the diversity in a system.



This activity will also permit us to introduce students to field methods employed by scientists and the difficulties they often face.

- ◆ We cannot "census" the entire beach and count every little animal living there. Therefore, we must choose "samples" of the beach. These samples will be taken in quadrants of  $1 \text{ m}^2$ , where we will count everything that is found within these boundaries.
- ◆ We cannot distribute our samples by chance. A simple observation will show us that the animals are not distributed by chance on the beach. Therefore, the quadrants should be strategically distributed in the areas where species are concentrated.
- ◆ We will only compile data on the small animals, not birds or reptiles.
- ◆ Because we are limited in time and know little about each species, we cannot expect our "sample" to be exactly like a real one, but it will be an interesting and realistic practice.

**Vocabulary:** Biodiversity, abundance, community, ecosystem, sample, index.

**Materials:** Clipboards, field and calculation forms. Field guides for the common organisms found on a sandy beach (6), and rocky shore (6). Calculators, chalkboard and chalk; or poster paper and markers, map of the beach area, 12 PVC quadrants of  $1 \text{ m}^2$ . LOW TIDE. Watch.

**Procedure:**

1. Welcome the students in the classroom and introduce the docents. Write the title of the activity on the chalkboard to create expectations.
2. After giving the students a welcome and presenting the Docents, ask them if they've heard of "biodiversity". "What do you think a biodiverse ecosystem has in common with a computer?" Explore the meaning of the term and its' importance in context with their experiences. The idea is to present a concept of biodiversity as being a quantity of information, an evolving system, the more diverse, the more information; just like the new generation of computers. The information is measured in bytes in the same manner that many scientists refer to diversity.
3. Explain what we will be doing; calculating and comparing diversity indexes of nearby environments: the rocky shore and the sandy beach. We will do it the same way that the scientists would, by applying a methodological approach to obtain field data. Calculations will be done later in the classroom.



- ◆ The method consists of dividing ourselves in 2 large groups, one for the rocky shore and the other for the sandy beach.
  - ◆ Each group will further divide into 6 smaller groups (which should give us approximately 3 students per group).
  - ◆ In order to calculate the diversity, we need to count the number of species that are found on the beach, and how many individuals there are of each species. We have 25 minutes to work so we cannot expect to count all the individuals on the beach. Therefore, we will utilize a "unit sample"; this will be a sample of the beach of equal size for each group (show them the 1m<sup>2</sup> quadrant).
  - ◆ With the quadrant placed in the zone of the beach that the Docent indicates (we will designate the areas on the map, see attached), we will observe the species that are enclosed in the quadrant and the number of individuals in each.
  - ◆ We can observe an organism or evidence of their presence, such as footprints or homes (i.e. crab holes = 1 crab, tubes of worms, sponge colony = 1 sponge, barnacles-are they alive or dead?).
  - ◆ Each group will have a clipboard, note paper, and a guide to help identify species (although we could recognize them before going down to the beach to begin our count).
  - ◆ It is very important that the students be meticulous in their observations and in note taking. One member of each group can take notes while the others provide information. There will be areas with more organisms where the work will be more difficult.
  - ◆ Return to the classroom with these notes. The introduction and the explanation of the methods should take approximately the next 25 minutes.
4. Once the methods are explained, distribute the materials and get to work! Is it preferable to identify the species or footprints with the students before you let the groups begin their work? This could take at least 15 minutes.
5. Two imaginary "transects" will be established in both environments, each one divided into high, middle and low beach areas, corresponding to each groups' quadrant (it would be ideal to mark the area with stakes before beginning the activity). This gives us a total of 12 quadrants, 6 on the sandy beach and 6 on the rocky shore. We can label the groups S1, S2, S3...S6,

and R1, R2...R6, respectively. Take a maximum of 30 minutes to gather data and return to the classroom on the docent's signal.

6. Back in the classroom, distribute one calculation form per student (attached). Place examples of the formula on the chalkboard (one for each environment). Write the name of the observed species from each environment, the 6 number of individuals (one per group), for tallying (each docent can work with their group). Finally, we will count how many species and find the sum of the total individuals. We are now ready to calculate the first diversity index D.

7. Complete the calculation form (using a calculator): the  $P_i$ ,  $\ln P_i$ , and  $P_i \ln P_i$  columns. The sum of this last column, with signs inversed, is the Shannon-Weaver Index. Reinforce the significance of the  $P_i$  term, which weighs the relative abundance of each species; those with more representatives will have a greater contribution to the sum.

8. Now we compare and analyze the results:

-Which area contained a higher diversity?

-What characteristics are associated with the area of higher diversity? (Is it more stable or does it have protected cracks and niches, or...).

-Are there species that are more abundant than others? These are called "dominant species".

-If one single species had thousands of individuals and the other species had 2-3, what would be the index?

-Why are the results of this group different from the results of the XX school that performed this same census activity 3 months ago?

-Can we use these same quadrants to calculate diversity in forest trees or of bacteria in water?

We can now answer the question "What does the biodiversity of the beach have in common with a computer?" Each species is a unit of information. A system with many repetitions of only one or two species has less information than a system with less repetition, yet similar abundance for more species. What do we lose when we lose diversity? Answer: Information.

### **Suggestions for the Docent:**

If the group works slowly, only calculate the first diversity index.

**Suggested Activities for the Classroom:**

If the students take the data with them they can work with these indexes separating them into the 3 transects levels; high, middle and low beach areas. They can sum the two samples respectively and establish a "gradient" of diversity, if applicable. For this task, a methods sheet should be given to the teacher to complete.

**Evaluation:**

The conclusions that the group establishes are the evaluation.

**Reference:**

Miracle, Maria Rose. 1985. Ecologia. Coleccion Salvat Tema Clave. Salvat editors. Madrid. 64 pg.

Margalef, Ramon. 1980. Ecologia. Ediciones Omega. Barcelona.

Gilbert, Gregory. S.f. Metodos de Muestreo. Apuntes para Curso de Estadistica.

**Organisms found in the Field Guide:**

**Sandy Beach**

- Hermit Crab
- Fiddler Crab
- Ghost Crab
- Olives
- Tube worm
- Blue polychaetes
- Goose-Neck Barnacle
- Clams
- Polychaete Tube-Worm

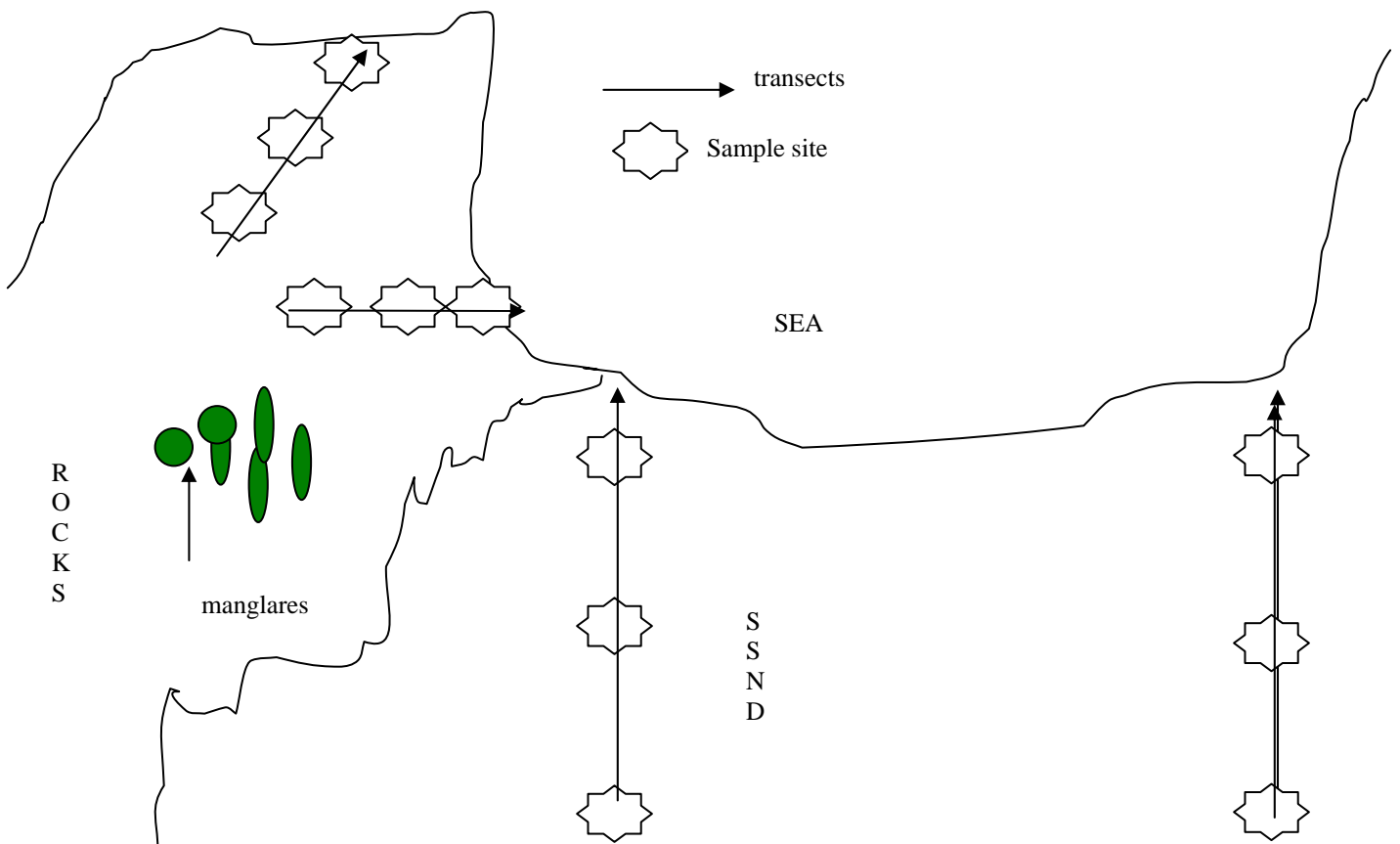
**Tide Pools**

- Sea Slugs
- Sea Urchins
- Brittle Star
- White tube worm (spaghetti)
- Sponges
- Bryozoans
- Anemone
- Chinese Hat

**Rocky Shore**

- Barnacles (Volcano)
- Black Snail
  
- Sea Roach
- Limpets (*Patella sp.*)
- Rock Crabs

Note: The main idea is for there to be two field guides in the form of a map/drawing; one for the sandy beach and one for the rocky shore





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**DOCENT WORKSHEET FOR THE CHALK BOARD**

Environment: \_\_\_\_\_

Species	S1	S2	S3	S4	S5	S6	Total
1							$N_1 =$
2							$N_2 =$
3							$N_3 =$
4							$N_4 =$
5							$N_5 =$
6							$N_6 =$
7							$N_7 =$
8							$N_8 =$
9							$N_9 =$
10							$N_{10} =$
11							$N_{11} =$
12							$N_{12} =$
13							$N_{13} =$
14							$N_{14} =$
15							$N_{15} =$
16							$N_{16} =$
17							$N_{17} =$
18							$N_{18} =$
19							$N_{19} =$
<b>S=</b>							<b>N=</b>



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Environment: \_\_\_\_\_

$$D = \frac{S - 1}{\ln N}$$

S = number of species

N = number of total individuals

Where  $P_i = \frac{N_i}{N}$

$N_i$  = number of individuals of species I

N = number of total individuals

	Name	$N_i$	$P_i(N_i/N)$	$\ln P_i$	$P_i \ln P_i$
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
S		N			$\Sigma$

Shannon-Weaver Index:

$$H = - \Sigma P_i \ln P_i =$$

