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Biodiversity of Terrebonne Bay

Introduction

Understanding how diverse an environment is can become important when studying an environment and the organisms that live there. A community that is more diverse is less at risk if environmental changes or disasters occur. A more diverse population consisting of many species has a better chance of including individuals that might be able to adapt to changes in the environment. For instance, consider a bay environment off the coast of Louisiana. If the bay is impacted by a large event like a hurricane or an oil spill, scientists would be interested in how that event impacted the ecosystem. Remember ecosystems are complex and interwoven interactions between all the biotic (living) and abiotic (non-living) components within the system. Any loss or depletion of one or more species in the bay could have cascading effects on the ecosystem. We could, for example, consider a situation where rising sea level and climate change cause changes in the water quality of the bay and that results in the loss of one species in a bay. Bay Anchovies are a very important food resource to many other fishes, birds, and mammals. If the water quality in the bay could no longer support the anchovy population, anchovies could move away from the bay to another location. If the anchovies were no longer present in the bay there would be less food for all other fishes. Over time that might mean the species that relied on anchovies as a food source would either move out of the system, deplete an alternative prey species, or starve. Either way the end result is large impacts to the food web. The effects which than could spread beyond the bay through the loss of commercially important species which would in turn impact the economy of Louisiana.

Knowing how an ecosystem, like the example, changes over time is a great asset to understanding the impacts of events (a hurricane) or changes over time (sea level rise). If enough information is gathered through data collection over a long period of time, we can use that information to predict how different events and changes will affect the system. Information gathered through this research helps society make better decisions about the environment, conservation efforts, disaster management, and laws that aid wildlife management.

Sampling method:

To learn what organisms are living in a geographical area often requires scientists to collect samples of organisms. It is harmful, impossible, and impractical to collect and identify every single individual organism in a geographical area lager than a small room. Instead of doing the impossible, scientists must use sampling methods that give them the ability to gather enough information to adequately meet their research needs and ensure limited impacts to the environment and the population of interest. A common collection method used by scientists is trawling. Trawls have been used as a commercial fishing method for centuries. Trawling is done by pulling a trawl net behind a boat to collect organisms. Using trawls as a sampling method gives scientists the ability to collect a large amount of data in a short amount of time compared to some other methods. Because trawls are not selective, meaning they do not just catch one certain species, they are a useful tool for sampling organisms that are present in a shallow water bay environment.

A trawl is a large tapered, funnel-shaped net (shown in Figure 1). Trawl nets have a wide opening called a mouth and a small closed end called the cod end. The cod end is tied off with a fishermen's knot. When deployed, the mouth of a trawl net is held open by two weighted doors that serve not only to keep the net open, but also to keep the net on the bottom of the water column. To keep the mouth open vertically (from top to bottom) the mouth of the net has a top line and a bottom line. The top line has a series of small floats attached to keep it up in the water column. This is called the float line. The bottom line is kept on the bottom of the water column by a series of lead weights. This line is otherwise known as the lead line. There are many sizes and styles of trawl nets used around the world, but all of them operate basically the same way. These nets commonly catch species that are demersal (along the bottom) or species that are pelagic (found within the water column).

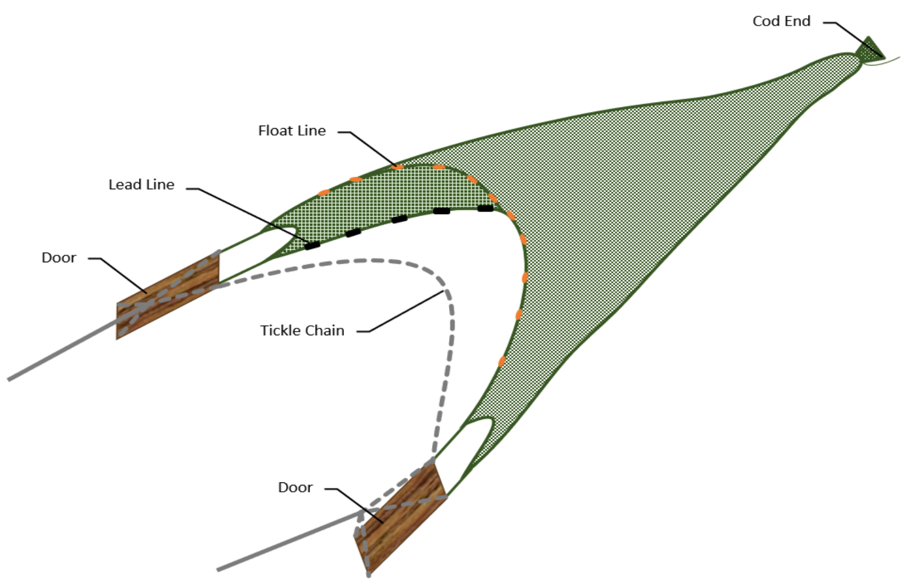

Figure 1: This diagram of a trawl net shows the net as it would appear in the "open" position while being pulled by a research vessel. The pressure of the water pushes organisms to the back of the net while the vessel moves forward. The organisms become trapped in the cod end unless they are strong enough or fast enough to swim out of the month while the net is open. Organisms can also escape if they can wiggle out of the openings of the mesh of the net.

VIDEO: If you are unfamiliar with trawling, or would like to see how the trawls were deployed to collect these samples, use this link to view a short video.

In this activity you will be using data collected by sampling done with a trawl in Terrebonne Bay, Louisiana, located south of Terrebonne Parish, Louisiana (see Figure 2), over multiple years. LUMCON has been collecting trawl samples in same area of Terrebonne Bay with students for decades. This information is now the largest and most complete record of demersal and pelagic species found in the bay. . Terrebonne Bay is a relativity shallow body of water partially surrounded by land. Water depth in the open bay ranges between 4 feet and 10 feet depending on tides and the predominate wind direction and speed. The Houma Navigation Channel is a channel that is dredged through the bay from the mainland to the Gulf of Mexico. The channel is approximating 22 feet deep and 200 feet wide. The bay was formed as part of the delta lobe cycle that has shaped and re-shaped the Louisiana coast for thousands of years. The organisms that live in Terrebonne Bay are influenced by processes and activities from the ocean and the mainland. Major influences on the bay are wind, weather patterns, human activities (drilling, dredging, etc.), freshwater discharge (from the watershed), and salt water input from currents and tides from the ocean. All of these influences can alter the water quality of the system. Changes to the water quality can be on a daily, seasonal, or long-term basis depending on what factors and water quality parameters are being observed.

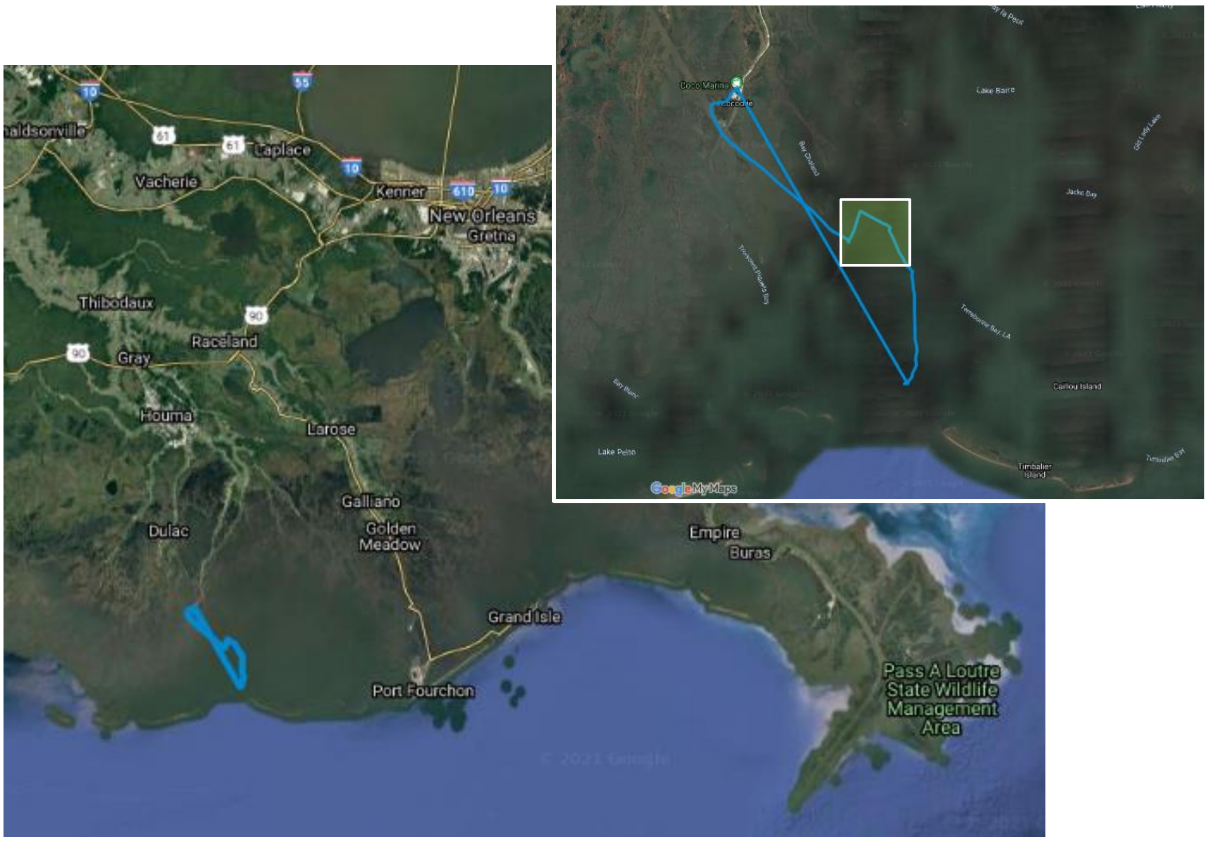

Figure 2: A map of Terrebonne Bay from Google Earth shows the GPS track of a sampling trip conducted in the bay on the R/V Acadiana. The area highlighted in the yellow box shows the area where sampling is generally done. Detailed records and data from sampling trips go as far back as 2007.

Before beginning to work with the data, let's first consider the sampling method and what that means for the patterns and relationships we see in the data and what conclusions you can reasonably expect to make. Answer the questions below as best you can based on what you have learned so far.

1. How well do you think trawl samples represent the entire population of Terrebonne Bay?

2. Explain what you think are the advantages and the limitations of this sampling method.
    - What are the advantages?
    - What are some of the limitations?

3. Could you, as a scientist, then use the data to say that the same population exists across all bay environments of south Louisiana? Explain why.

Working with Data

For the next section we are going to analyze a small amount of data from the larger dataset that you'll be getting later to answer your own questions about the population of Terrebonne Bay. You will be using something called a biodiversity index to determine the amount of biodiversity of two different samples. Tracking the biodiversity of samples is one way to observe changes to the community over time. Normally you would want a greater amount of data, but that will come later. This section is so you can practice developing the skills you need. Determining the reason, if a change is observed, can be a bit more complicated, but all scientific investigations have to start somewhere.

For more detailed step-by-step instructions on how to do the calculation you can review our Calculating Biodiversity activity by using this link.

Terms:

Species Richness - is simply the number of species in a community.

Species evenness - refers to how close in population size (number) each species in a community are.

Biodiversity (or biological diversity) - is a term that describes the variety of living organisms found in an ecosystem.

Biodiversity Index - is a scale that provides a way for scientists to talk about and compare the biodiversity of different geographical areas.

The Simpson's Biodiversity Index – is a measure of biodiversity that uses the species richness and species evenness within a population or community.

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)} \right)$$

- **D** is the Diversity as estimated by the Simpson's index.
- **n** is the total abundance of organisms of a particular species
- **N** is the total number of organisms of all species.
- **Σ** means "the sum of".

Look at the two different sets of data provided on the next page. The data you have is the when the trawl was conducted, which species were caught (each in a separate row), and the number of individuals of each species that were caught. In order to do the calculation for Simpson's Biodiversity Index we need to find the result for each part of the equation.

Date	***Species (Scientific name, common name)***	Abundance
8-July-2014	*Farfantepenaeus aztecus, Brown Shrimp*	24
8-July-2014	*Litopenaeus setiferus, White Shrimp*	4
8-July-2014	*Sphoeroides parvus, Least Pufferfish*	4
8-July-2014	*Leiostomus xanthurus, Spot*	23
8-July-2014	*Micropogonius undulatus, Atlantic Croaker*	65
8-July-2014	*Anchoa mitchilli, Bay Anchovy*	23
8-July-2014	*Lolliguncula brevis, Atlantic Brief Squid*	2
8-July-2014	*Calinectes sapidus, Blue Crab*	16
8-July-2014	*Selene vomer, Lookdown*	2
8-July-2014	*Peprilus paru, Harvestfish*	5
8-July-2014	*Chloroscombrus chrysurus, Atlantic Bumper*	7

Date	***Species (Scientific name, common name)***	Abundance
9-June-2015	*Paralichthys lethostigma, Southern Flounder*	1
9-June-2015	*Sphoeroides parvus, Least Pufferfish*	4
9-June-2015	*Anchoa mitchilli, Bay Anchovy*	13
9-June-2015	*Leiostomus xanthurus, Spot*	33
9-June-2015	*Lolliguncula brevis, Atlantic Brief Squid*	16
9-June-2015	*Cynoscion arenarius, Sand Seatrout*	2
9-June-2015	*Farfantepenaeus aztecus, Brown Shrimp*	183
9-June-2015	*Calinectes sapidus, Blue Crab*	3
9-June-2015	*Lagodon rhomboides, Pinfish*	1
9-June-2015	*Micropogonius undulatus, Atlantic Croaker*	3

Let's begin by calculating the biodiversity index for the sample collected on July 8, 2014. Fill out the tables as you follow the steps.

First, we need to find the value for **Σ n(n-1)**.

Step 1: First we need the value of **n** (or the abundance) for each species. Since we already have the abundances for each of the species, we already have the values for **n**.

Step 2: Subtract 1 from the abundance for each of the species. Write the result for each species in Column B of the table.

Step 3: Take the value you found for **n-1** (Column B) and multiply that by **n** (Column A). Write the result in Column C for each of the species.

Step 4: Add up all the values in Column C. The result will be the value for **Σ n(n-1).**

		A	B	C
Date	***Species (Scientific name, common name)***	**Abundance (n)**	**n-1**	**n(n-1)**
8-July-2014	*Farfantepenaeus aztecus, Brown Shrimp*	24		
8-July-2014	*Litopenaeus setiferus, White Shrimp*	4		
8-July-2014	*Sphoeroides parvus, Least Pufferfish*	4		
8-July-2014	*Leiostomus xanthurus, Spot*	23		
8-July-2014	*Micropogonius undulatus, Atlantic Croaker*	65		
8-July-2014	*Anchoa mitchilli, Bay Anchovy*	23		
8-July-2014	*Lolliguncula brevis, Atlantic Brief Squid*	2		
8-July-2014	*Calinectes sapidus, Blue Crab*	16		
8-July-2014	*Selene vomer, Lookdown*	2		
8-July-2014	*Peprilus paru, Harvestfish*	5		
8-July-2014	*Chloroscombrus chrysurus, Atlantic Bumper*	7		
	TOTAL			

Next, we need to find the value for **N(N-1)**. Fill in the table below

Step 1: **N** is the total number of individuals collected. Add up all the abundances in the table above (Column A) to find the value of **N**. Write the result in Column D in the table below.

Step 2: Take the value for **N** and subtract 1. Write the result in Column E of the table below.

Step 3: Take the number in Column E (N-1) and multiple it by the number in Column D (N). Write the result in Column F of the table below.

D	E	F
N= Total number of individuals	**N - 1**	**N(N-1)**

Finally, we can solve the equation for the Simpson's Biodiversity Index. Show your work in the space provided below.

$$D = 1 - \left(\frac{\sum n(n-1)}{N\,(N-1)} \right)$$

Step 1: Write in your value for $\sum$ **n(n - 1)** in the equation on the top**.**

Step 2: Write your value for **N(N - 1)** in the equation on the bottom.

Step 3: Solve the equation. Following the order of operations, start by dividing $\sum$ **n(n – 1)** by **N(N-1)**. Then you are going to subtract the value you just got from 1. This should give you a number less than 1.

What does this number mean? A biodiversity index is a scale on which biodiversity is estimated. Indexes provide scientists with the ability to compare and talk about biodiversity more reliably. The closer to 1 the result of the equation is, the higher the biodiversity index. In other words, the greater the number you calculate the more diverse a community or ecosystem is.

- Did the trawl sample collected on July 8, 2014 show high or low biodiversity in Terrebonne Bay that day?

Now that you know the steps, do the same thing for the trawl data collected on June 9, 2015. If it helps you can draw tables just like the ones above. Once you have completed that, answer the following questions on a separate piece of paper.

1. Were there any differences in the biodiversity of the two samples?
2. What things did the samples have in common?
3. What were some differences in the samples that you noticed?
4. Is there something you can think of that might explain the differences you noticed? If so, explain what those could have been?

At this point you are ready to work with a larger amount of data. This link will take you to a Google Sheet which contains trawl data collected from 2014 to 2016. Spend some time looking over the data to familiarize yourself with the information. Consider the following questions as you are looking at the data.

- Do you notice changes over time?
- Do you notice that some species are always present verses others that are not?
- Do abundances change? If so, how often?

What you will do next is formulate a hypothesis based on the data found in the spreadsheet. Think broadly, but remember you must have a hypothesis that can be tested with the data provided.

- Write your hypothesis in the space below.

- What data do you need to test your hypothesis?

- Does it require you to do any calculations first? If so, what are they?

- Will you need graphs, charts, tables, etc.? If yes, use a spreadsheet or a piece of paper to create these. Remember to include titles, labels, units and other important information.

- Does the data support your hypothesis?

- Summarize your results below. Include possible explanations for what you observed.

- What are 2 questions about the Terrebonne Bay population you'd like to investigate further?

Answer Key

The first set of questions were designed to get learners to really consider trawling as a scientific sampling method. Most learners, if they are familiar with trawling, might only consider it from a commercial fishing method targeting a specific species.

How well do you think trawl samples represent the entire population of Terrebonne Bay?

Trawling is a good method for collecting data to answer specific research questions. However limitations means trawling will not tell you what organisms make up the total population within a geographical area. Trawl nets catch organisms that can't escape the path of the net. Strong swimmers (like dolphins, sharks, adult skates, turtles, etc) and individuals that are small enough (like small fishes) to wiggle out will not be caught.

Consideration then about what questions can reasonably be answered is needed when learners formulate their hypotheses.

Explain what you think are the advantages and the limitations of this sampling method.

- What are the advantages? Once again, learners should be allowed to think creatively when answering this question. However there are some things they may not consider at first.
    - Cost – Trawling doesn't require a huge amount of equipment or staff time.
    - Time – You can get many samples collected in a relatively small amount of time compared to other sampling methods. This will also reduce the staff time needed to accomplish data collection during the collection stage of the project.
    - Sample sizes – generally you will collect large enough samples to answer a variety of questions and meet the research goals.

- What are some of the limitations? This is an opportunity for learners to consider the big picture with respect to this sampling method. Below is a list of things that may not be obvious at first.
    - Limits on what organisms are not being caught because the big net and a very noisy boat are easy to see coming. Often trawl samples can be accompanied with data collected using other methods like long lines, box dredges, traps, observation, etc.
    - Since the mouth of the net is a certain size how much of the water column is actually being sampled. This may change what you catch each time you sample unless there are ways to control for that.
    - Cost – this was mentioned above as an advantage, but could also be a limitation. Researchers may not be able afford the cost of renting a research vessel. That is why you often see projects where researchers team up with commercial fishers to collect data.

Could you, as a scientist, then use the data to conclude that the same population exists across all bay environments of south Louisiana? Explain why. No. The data collected by trawl (or any other method) can be used to make general statements about coastal populations on a local scale. The data is very specific to the bay and what factors (both biotic and abiotic) that are unique to that geographical area.

		A	B	C
Date	***Species (Scientific name, common name)***	**Abundance (n)**	**n-1**	**n(n-1)**
8-July-2014	*Farfantepenaeus aztecus, Brown Shrimp*	24	23	552
8-July-2014	*Litopenaeus setiferus, White Shrimp*	4	3	12
8-July-2014	*Sphoeroides parvus, Least Pufferfish*	4	3	12
8-July-2014	*Leiostomus xanthurus, Spot*	23	22	506
8-July-2014	*Micropogonius undulatus, Atlantic Croaker*	65	64	4160
8-July-2014	*Anchoa mitchilli, Bay Anchovy*	23	22	506
8-July-2014	*Lolliguncula brevis, Atlantic Brief Squid*	2	1	2
8-July-2014	*Calinectes sapidus, Blue Crab*	16	15	240
8-July-2014	*Selene vomer, Lookdown*	2	2	4
8-July-2014	*Peprilus paru, Harvestfish*	5	4	20
8-July-2014	*Chloroscombrus chrysurus, Atlantic Bumper*	7	6	42
	TOTAL			6056

D	E	F
N= Total number of individuals	**N - 1**	**N(N-1)**
175	174	30450

$$D = 1 - \left(\frac{6056}{30450} \right)$$

6056 / 30450 = 0.1989

1 – 0.1989 = **0.8011**

This result means that sample is diverse since it is close to a value of 1.

A result of 1 would indicate infinite diversity. A result of 0 would indicate no diversity.

		A	B	C
Date	***Species (Scientific name, common name)***	**Abundance (n)**	**n-1**	**n(n-1)**
9-June-2015	*Paralichthys lethostigma, Southern Flounder*	1	0	0
9-June-2015	*Sphoeroides parvus, Least Pufferfish*	4	3	12
9-June-2015	*Anchoa mitchilli, Bay Anchovy*	13	12	156
9-June-2015	*Leiostomus xanthurus, Spot*	33	32	1056
9-June-2015	*Lolliguncula brevis, Atlantic Brief Squid*	16	15	240
9-June-2015	*Cynoscion arenarius, Sand Seatrout*	2	1	2
9-June-2015	*Farfantepenaeus aztecus, Brown Shrimp*	183	182	33306
9-June-2015	*Calinectes sapidus, Blue Crab*	3	2	6
9-June-2015	*Lagodon rhomboides, Pinfish*	1	0	0
9-June-2015	*Micropogonius undulatus, Atlantic Croaker*	3	2	6
	TOTAL			34784

D	E	F
N= Total number of individuals	**N - 1**	**N(N-1)**
259	258	66822

$$D = 1 - \left(\frac{34784}{66822} \right)$$

34784 / 66822 = 0.5206
1 – 0.5206 = **0.4794**
This result means that sample is somewhat diverse (boarding on low biodiversity).
A result of 1 would indicate infinite diversity. A result of 0 would indicate no diversity.