

FOOD WEB JENGA

Overview

This lesson plan describes how to set up and play a variation of the popular game JENGA® that models an **estuarine** food web and the effect human impacts can and could have on the health of the system at various **trophic levels**. During play, students will discover the many problems estuaries face today, and how estuaries are important ecosystems that need preservation and protection to ensure the safety and well being of all life. Students will also learn practical and feasible solutions to prevent or lessen the occurrence of these potentially damaging human-caused impacts. Some impacts included are already having a negative effect on estuarine food webs. These include the excess use of fertilizers which, especially during storm events, causes the **eutrophication** of water resulting in excessive algal blooms that can cause **hypoxia** resulting in fish kills and seagrass die-off. Other impacts mentioned are directly related to **climate change**. These pose possible threats that scientists predict could affect our **estuaries** in the future, such as the effect of a rising water temperatures on blue crab growth, or plankton populations. The science is clear that changes to our marine ecosystems are happening due to climate change. While there is still a need for more research to get a better understanding on *exactly* when and how fast these impacts will take place, this game informs students on how climate change predictions could affect estuarine food webs. Actions people can take to prevent possible impacts from becoming problems are included as it is important to realize that once an impact becomes a problem and populations and **biodiversity** decline, it is more difficult to stop or reverse the damage than to prevent a problem in the first place. We can make a difference by handling problems before they get worse, and the future depends on decisions and plans we make today.

Materials:

Traditional JENGA® game that has been labeled (using labels included in this plan) and modified by coloring the ends of three (3) blocks in purple, three (3) blocks in red, six (6) blocks in pink, six (6) blocks in yellow, nine (9) blocks in blue, and twelve (12) blocks in green or a labeled set of [Lewo Wooden Board Games Tumbling Tower Building Blocks for Kids](#).

Directions:

How to set up the game:

1. Place 3 green blocks side by side. Place 3 more layers of green blocks in alternating directions and on top of the first set. You should have a total of 4 layers of green blocks. This represents the base of the food web and 1st trophic level of **primary producers**.

- As you did with the green blocks, next stack 3 layers of blue blocks on top of the green blocks. This represents the next **trophic level** known as **primary consumers**.
- Stack 2 layers of yellow blocks and 2 layers of pink blocks on top of the stack. These represent **secondary** and **tertiary consumers**
- Next, stack 1 layer of red blocks on your stack. These represent **quaternary consumers** or **carnivorous predators**
- Lastly, top your stack with 1 purple block. This layer represents the **apex** or top **predator** in our model.
- Congratulations! You have built a model of a food web in an estuary!
- Cut apart and shuffle playing cards included in this lesson plan. Stack them face down.



Apex Predator- 1 block- (top block)
Quaternary consumers – red blocks (1 layer)
Tertiary Consumers- pink blocks (2 layers)
Tertiary Consumers -
Secondary Consumers- yellow blocks (2 layers)
Secondary Consumers
Zooplankton (Primary Consumers) - blue blocks (3 layers)
Zooplankton
Zooplankton
Phytoplankton (Primary Producers)- green blocks (4 layers)
Phytoplankton
Phytoplankton
Phytoplankton

What do the layers represent?

The different colored blocks represent different animals found in different trophic levels of the food web in an estuary as follows:

Green Blocks - represent the 1st trophic level. These are **primary producers** that convert sunlight into energy, which is phytoplankton and submerged aquatic vegetation in an estuary. They are the base of food web.

Blue Blocks - represent **primary consumers** such as zooplankton. They are on lower part of food web and many are herbivores that obtain their energy by feeding on phytoplankton.

Yellow Blocks - represent the 2nd trophic level or **secondary consumers** such as small fish, shrimp, and oysters. These organisms are at the center of the food web or chain and get their energy by feeding on phyto- and zooplankton.

Pink Blocks - represent the 3rd trophic level or **tertiary consumers** such as crabs and medium sized fish. They are the middle or upper parts of food web, and eat mostly **secondary consumers**.

Red Blocks - represent the 4th trophic level or **quaternary consumers** such as turtles or large fish such as striped bass or bluefish. These consumers are **carnivorous** predators, eating many different species. They are near the top of food web.

Purple Blocks – represent the 5th trophic level and is the top consumer or **apex predator** such as the Osprey. In an estuary, these animals are at the top of a food web since no other animals prey upon them.

Why are there more of blocks in some levels than others? In a food chain there tends to be more organisms available lower on the food chain because they are needed to provide energy for animals higher up on the food chain. As you move up a food chain, the animals tend to be larger and need more energy. For example, an average adult flounder is 24 inches long, compared to its prey, a shrimp, which only grows up to 2 inches long. Since the flounder is much larger than a shrimp, it needs too many shrimp (or other small organisms to eat) to provide it with enough energy to survive.

How to play the game:

Explain to the students that this game is a representation of how human-caused changes can potentially impact the stability of a whole ecosystem. In this game, the ecosystem is an estuary. Make sure students are familiar with vocabulary words (noted in bold) to ensure they will understand terminology used on the cards.

1. The first player picks a card, reads it aloud, and follows the instructions written on the card. Only the block being removed or returned may be touched. Player is not allowed to hold the rest of the stack together while removing the block(s).
2. If adding a block, player may return any block of their choice. However, they **MUST** return it to the same color layer it corresponds to. They may gently hold onto the stack while adding the block, but if other blocks fall while returning a block they **may not** put them back. Not putting fallen blocks back represents the hardships that sometimes occur when trying to resolve a problem.
3. Once played, used cards should be put into a discard pile.
4. Removed wood blocks should also be placed into a discard pile off to the side.
5. Have students continue taking turns until the tower falls and the food web collapses.
6. Reset to play again using the directions above.
7. If time permits, discuss some of the threats an estuary faces and answer the following questions relating to the trophic levels represented in this game.

Discussion Questions:

1. Who are the primary producers in the game?
2. Who are the primary consumers in the game?
3. Name some other consumers in the game.
4. Who is the apex predator in the game?
5. How many trophic levels are represented in this Jenga© game?
6. Explain why there are more green blocks representing primary producers than any other colored blocks.
7. Do you think all organisms are important in the estuary?
8. What happens to other organisms when one organism is removed?
9. Describe two ways humans can impact the food web in an estuary.
10. Where would you locate humans in the food chain?
11. How do you think the collapse of an ecosystem, such as an estuary, might impact humans?
12. How do changes in the food web or chain affect the estuary's health?

13. Name at least 2 ways people can help protect the life in an estuary and keep it healthy.
14. What do you think you could personally do to help keep our estuaries healthy?

Vocabulary

Apex Predator - the top consumer in a food chain, often they are carnivorous and eat only meat.

Climate Change - is a change in earth's average temperatures and weather patterns over at least a span of 30 years, often more. Today's climate change refers to ongoing and recent risings of the global average temperatures of the earth due to human's use of fossil fuels such as oil, coal, and gas and emitting rampant carbon dioxide into the atmosphere. The excess carbon dioxide in our atmosphere acts like a heat-trapping blanket surrounding our earth, causing the earth's temperatures to rise. Much of the excess heat and carbon dioxide are also absorbed by the ocean. Today's human-induced climate change will have many effects on the earth's land surface, atmosphere, oceans, and ice. Climate change will have many implications that will change life on earth as never before experienced in human history.

Consumer - an organism that generally obtains food by feeding on other organisms or natural substances due to the lack of ability to create its own food. There are often three or more levels of consumers in a food chain. Primary consumers are also known as herbivores and eat primary producers. Secondary, tertiary, and other top consumers eat primary producers and other consumers lower on the food chain.

Estuary - where the rivers meet the sea, often an enclosed body of water.

Eutrophication - is the excessive richness of nutrients in a body of water, frequently due to runoff from the land, which causes a dense growth of algae and death of animal life from lack of oxygen.

Fertilizer - substances added to the soil or sprayed on the leaves of plants to keep them well nourished and provide them with nutrients needed for growth such as nitrogen and phosphorus.

Greenhouse gases - naturally occurring gases such as carbon dioxide (CO₂), methane, and water vapor trap heat in the atmosphere, preventing heat from escaping into space and creating a greenhouse effect. A stable input of greenhouse gases into the atmosphere help keep temperatures stable for life on earth. However, with the burning of fossil fuels like oil, coal, and gas, adding CO₂, plus humans inducing the release of other greenhouse gases such as methane and nitrous oxide into the atmosphere, the earth is trapping excessive heat, intensifying the greenhouse effect. The current level of greenhouse gases in the atmosphere is the highest in the past 650,000 years.

Herbicides - chemicals often added to gardens, yards or other outdoor areas to control the growth of plants such as weeds.

Ocean acidification - refers to a change in the ocean's chemistry, which is preventing animals lower on the food web from building and creating protective shells they need to survive. Acidification is the lowering of the pH of the ocean over an extended period of time, caused primarily by uptake of the rampant carbon dioxide (CO₂) in the atmosphere caused by the burning of fossil fuels such as oil, coal, and gas. The ocean has become 30% more acidic since the start of the industrial revolution. Lowering the pH reduces the amount of carbonate in the ocean that sea animals need to build strong skeletons and shells.

Pesticides - chemicals used to kill pests, often insects and rodents.

Predator - an organism that captures and feeds on other organisms.

Prey - an organism that is hunted and eaten by other organisms.

Producer – located at the base or first trophic level of a food chain. Producers can convert sunlight or chemicals into energy to create their own food.

Sea level rise – is the rise of water levels in the ocean and connecting waterways such as estuaries due to human-induced climate change. The two major causes of global sea level rise are thermal expansion caused by warming of the ocean (since water expands as it warms) and increased melting of land-based ice, such as glaciers and ice sheets. Also in some areas on earth, including the east coast of the United States, land subsidence (sinking of land) due to natural processes is adding to the rise in sea levels.

Trophic levels – are each of several levels in an ecosystem, each comprised of organisms that share the same function in the food chain and the same nutritional relationship to the primary sources of energy.

Watershed- -an area of land where water, sediments, nutrients, and other materials runoff the land and drains into a common body of water after a rain event. Watersheds may drain into ponds, rivers, lakes, estuaries, or oceans.

EXTENSION ACTIVITY FOR FOOD WEB JENGA: Solutions to the Challenges Facing our Estuaries

NOTE: By completing this activity, students will complete the requirements for Next Generation Science Standard MS-LS2-5 (Evaluate competing design solutions for maintaining biodiversity and ecosystem services). This activity is geared towards middle and high school students.

Overview

The following activity has students investigate and evaluate the solutions presented in the game that can alleviate problems facing our estuaries such as climate change and pollution. During this activity students will examine how people can help an estuary ecosystem maintain biodiversity, balance, and preserve its ecosystem services.

First, have students develop definitions for the terms biodiversity and ecosystem services. For more information about these topics, the following websites are suggested:

Biodiversity

<https://www.nwf.org/Educational-Resources/Wildlife-Guide/Understanding-Conservation/Biodiversity>

<https://www.amnh.org/our-research/center-for-biodiversity-conservation/about-the-cbc/what-is-biodiversity/>

<https://www.nationalgeographic.org/encyclopedia/biodiversity/>

Ecosystem Services

<https://www.nwf.org/Educational-Resources/Wildlife-Guide/Understanding-Conservation/Ecosystem-Services>

https://oceanservice.noaa.gov/education/kits/estuaries/estuaries02_economy.html

https://oceanservice.noaa.gov/education/kits/estuaries/estuaries03_ecosystem.html

<http://www.habitat.noaa.gov/about/habitat/ecosystemservices101.html>

Students may work in small groups or individually. Assign one “solution card” (the cards in the game that direct you to “Add 1 block of any color”) to each student or group to investigate. These cards describe a possible solution to a human impact on estuaries and include some information on how the solution can help tackle specific problems facing estuaries today. Using the internet, have students do further research to take a more in-depth look at the solution, and what human impact their assigned solution card tries to help solve. Students will try to determine if the solution will be effective in lessening a human impact to the estuary, and if the solution may help people, especially to people who live in a town along an estuary. From their research students should be able to describe how the solution may impact the biodiversity of life in the estuary, and list the ecosystem services the solution may provide to humans and to the estuary. Students should also consider any constraints or problems associated with implementing the solution. For instance, could the solution negatively impact people in some way? Would the solution be too costly to implement and/or install? If the solution has a cost, is the cost worth the benefit? (specific dollar amounts are not necessary--an estimation of cost versus benefits is adequate.) Students should also research and analyze ways to improve the proposed solution, find a different solution, or formulate their own solution to the human impact their card tries to solve. If they feel another solution is better than the one described on their card, they should state the reasons why. After students research the human impact and analyze the pros and cons of the solution described on their assigned solution card, ask them to state if the proposed solution is something they would recommend to community leaders living in a coastal town to take

action on and/or support, or if they have another solution they feel would work better than the solution described on the card assigned to them.

If time allows each student or group may present their research to the class. Students should be able to describe and discuss the following three points as a result of their research: 1. The harmful impact that their assigned card tries to solve and if the solution described on their card will help lessen the impact and improve the estuarine environment. As a result of their research they should also be able to describe if and how the solution will impact biodiversity and name the ecosystem services it may or may not help provide. 2. The pros and cons of their solution. Student should be able to discuss how to improve upon the solution described on their card, or even offer a better solution altogether and be able to justify their decisions. 3. If they would recommend the solution proposed on their card to coastal community leaders or propose another solution to be acted upon and/or supported.

Additional lesson plans to help further extend Food Web Jenga can be located at:

www.njseagrant.org/education/resources-for-educators/lesson-plans/

<https://coast.noaa.gov/estuaries/curriculum/estuary-food-pyramid.html>

<https://coast.noaa.gov/data/estuaries/pdf/biodiversity-in-an-estuary-student-worksheets.pdf>

<http://oceanexplorer.noaa.gov/oceanos/edu/lessonplans/media/09stressedout.pdf>

Playing Cards:

<p>Climate change has caused surface temperatures in the estuary to rise. This temperature change causes a shift in the nutrients used by phytoplankton, making them nutrient poor. The species of zooplankton that consume nutrient rich phytoplankton starve. (1)</p> <p>Remove 1 blue block</p> <p>1</p>	<p>When people use too much fertilizer on their lawns, this enters the watershed that leads to the estuary. Fertilizer entering the estuary's waters creates algal blooms that block sunlight from penetrating the water needed by sea grasses to grow.</p> <p>Remove 1 green block</p> <p>2</p>
<p>During a rain storm, excess fertilizer used on lawns, farms, and golf courses run off into the estuary. The fertilizer creates an algal bloom in the estuary. As the algae die they use up oxygen at the bottom of the estuary needed by many benthic animals (such as shrimp and crabs).</p> <p>Remove 1 yellow block and 1 pink block</p> <p>3</p>	<p>An increased use of herbicides runs off into the watershed, causing some species of phytoplankton to be unsuitable as food for zooplankton and other animals.</p> <p>Remove 1 green block</p> <p>4</p>
<p>Increase in carbon dioxide from the burning of fossil fuels (oil, coal, and gas) leads to increased ocean acidification. Some species of zooplankton are unable to grow properly.</p> <p>Remove 1 blue block</p> <p>5</p>	<p>A group of school kids put on a play for the entire school and community about how climate change affects the local estuary's health and how, by reducing the use of fossil fuels (oil, coal, and gas), people can slow or stop the impacts of climate change.</p> <p>Add 1 block of any color</p> <p>6</p>

<p>Climate change is causing the sea surface temperatures of the ocean to rise. Warmer water temperatures increase storm intensity. As a fierce storm blows through the estuary, it rips apart an oyster reef.</p> <p>Remove 1 blue block</p> <p style="text-align: right;">7</p>	<p>A forest was cleared to build new homes along the estuary. After a rain storm, sediments from the land now flow into the water, preventing sunlight from penetrating the water. Submerged aquatic vegetation (sea grasses) are unable to grow.</p> <p>Remove 1 green block</p> <p style="text-align: right;">8</p>
<p>Climate change is causing the estuary to warm. Some species of carnivorous fish will move northward or into deeper, cooler areas in the estuary to avoid the warmer water. The fish then find more small prey that are no longer able to avoid the larger carnivorous fish by hiding in cooler waters.</p> <p>Remove 1 pink block</p> <p style="text-align: right;">9</p>	<p>As the climate changes, seasonal changes in temperatures also change. Ospreys, who prey on larger fish, remain in the area longer than usual.</p> <p>Remove 1 red block</p> <p style="text-align: right;">10</p>
<p>As climate change causes ocean temps to rise, storms become stronger. A strong storm washes away a beach used as nesting grounds for terrapins and horseshoe crabs. This causes shrimp and worm populations to increase but leads to a decrease in zooplankton populations</p> <p>Add 1 yellow block. Remove 1 red block and 1 blue block</p> <p style="text-align: right;">11</p>	<p>Salt marshes provide essential habitat for wildlife in an estuary. They are great absorbers of carbon dioxide, and can absorb excess storm water, protecting areas from flooding and sea level rise. The community decides to restore 200 acres of a salt marsh in the estuary.</p> <p>Add 1 block of any color</p> <p style="text-align: right;">12</p>
<p>Excess carbon dioxide, caused by the burning of fossil fuels (oil, coal, and gas) is absorbed by marine waters causing the water to become acidic. Some species of zooplankton that build their own calcium carbonate shells are unable to grow and survive in the estuary due to acidic conditions.</p> <p>Remove 1 blue block</p> <p style="text-align: right;">13</p>	<p>A garden club turns an abandoned paved area along the watershed into a native plant garden to educate residents. The native plants can trap excess nutrients and carbon dioxide before they enter the water. A native garden is also more tolerant of pests, requiring no pesticides and with proper care will not require herbicides.</p> <p>Add 1 block of any color</p> <p style="text-align: right;">14</p>

<p>Ocean Acidification, caused by excess carbon dioxide in the atmosphere that is absorbed by marine waters, creates conditions that cause some small species of fish to be confused by their surroundings, making them easy targets for predators.</p> <p>Remove 1 yellow block</p> <p style="text-align: right;">15</p>	<p>Sea level rise is creating continuous floods in the estuary that kill off plants in parts of the salt marsh where many small fish and shrimp sought refuge and a place to reproduce.</p> <p>Remove 1 yellow block</p> <p style="text-align: right;">16</p>
<p>A large ship created an oil spill in the estuary!</p> <p>Remove one block of each color except purple starting from base of food web (remove 1 of each - green, blue, yellow, pink, red).</p> <p style="text-align: right;">17</p>	<p>A ship from another country enters the estuary and empties its ballast water that contains an invasive crab species. The invasive crab competes with other native crabs and fish for resources, such as food and hiding places.</p> <p>Remove 1 pink block</p> <p style="text-align: right;">18</p>
<p>Local businesses and schools in the estuary's watershed agree to use more renewable energy resources, such as solar and wind energy, to cut down their greenhouse gas emissions that are causing climate change and affecting nearby estuary.</p> <p>Add 1 block of any color</p> <p style="text-align: right;">19</p>	<p>As climate change causes the surface temperatures of the water to warm in the estuary, some species of phytoplankton are unable to grow properly due to the temperatures being warmer than they can tolerate.</p> <p>Remove 1 green block</p> <p style="text-align: right;">20</p>
<p>As sea levels rise, saltier water intrudes into previously fresh water areas of the estuary. The rise in salt levels causes some species of phytoplankton to decline in growth.</p> <p>Remove 1 green block</p> <p style="text-align: right;">21</p>	<p>The community decides it wants the storm protections oyster reefs provide by buffering against waves, currents and erosion. Oysters also filter and clean water. An oyster reef along part of shoreline is restored in the estuary.</p> <p>Add 1 block of any color</p> <p style="text-align: right;">22</p>

<p>Sea level rise floods the beaches' diamondback terrapins used as nesting grounds. Terrapins are forced to travel to higher grounds, which may be roadways, in search of a nesting area. They are run over by cars when crossing the road.</p> <p>Remove 1 red block</p> <p style="text-align: right;">23</p>	<p>Sea level rise causes flooding in many parts of the salt marsh. Larger predators are able to enter the areas where small fish and crabs used to be able to find refuge and protection</p> <p>Remove 1 yellow block and 1 pink block</p> <p style="text-align: right;">24</p>
<p>Increased carbon pollution causes some species of crab to grow abnormally large shells, turning this species into large predators. The larger, hungrier crabs have the ability to eat many more oysters and shrimp, causing their populations to decline.</p> <p>Remove 1 yellow block and 1 blue block</p> <p style="text-align: right;">25</p>	<p>With a changing climate, water temperatures are reaching extreme highs that are killing off sea grasses, which are a primary breeding ground for crabs. This causes the crab population to decline.</p> <p>Remove 1 pink block</p> <p style="text-align: right;">26</p>
<p>The laws banning CFC's for commercial use are lifted, causing harmful ultraviolet (UV) rays from the sun to reach the earth and kill some species of phytoplankton.</p> <p>Remove 1 green block</p> <p style="text-align: right;">27</p>	<p>As sea levels rise, more ocean water is entering the estuary, causing some of the upper reaches of an estuary to become saltier. Some species of fish are unable to find spawning areas that are suitable for their young.</p> <p>Remove 1 red block</p> <p style="text-align: right;">28</p>
<p>Oysters and other shellfish are expected to suffer from weaker, slower-growing shells due to acidic water conditions caused by the estuary absorbing more carbon dioxide from the burning of fossil fuels.</p> <p>Remove 1 blue block</p> <p style="text-align: right;">29</p>	<p>A tax is put on the emission of carbon dioxide when creating electricity. To avoid the tax, people start to use more renewable resources, such as solar and wind energy, to create electricity. Reducing the emissions of carbon dioxide helps slow the rate of climate change and its impact on estuaries.</p> <p>Add 1 block of any color</p> <p style="text-align: right;">30</p>

<p>The school decides to take action to become a certified “Sustainable Jersey” school and takes action for Climate Mitigation and Renewable Energy, and energy efficiency. They encourage all schools in their district to become certified.</p> <p>Add 1 block of any color</p> <p style="text-align: right;">31</p>	<p>To help reduce CO2 emission from cars, students decide that at least 2 times per month they will create a “Walking School Bus.” Instead of having their parents drive them each to school separately, a large group of students decide to walk to school together with the supervision of 1 or 2 parents.</p> <p>Add 1 block of any color.</p> <p style="text-align: right;">32</p>
<p>Not cleaning up after your pet outside causes nutrients and bacteria to run off into the estuary’s watershed after rainstorms. This creates algal blooms that kill off some species of young marine life.</p> <p>Remove 1 blue block</p> <p style="text-align: right;">33</p>	<p>An environmental club in a community in the estuary’s watershed creates a campaign to educate people about how pet waste is toxic to the estuary.</p> <p>Add 1 block of any color</p> <p style="text-align: right;">34</p>
<p>The schools in the estuary’s watershed decide to educate their students about the affects humans can have on an estuary, and encourages students to take the message home to their family and friends.</p> <p>Add 1 block of any color</p> <p style="text-align: right;">35</p>	<p>A group of citizens in the estuary’s watershed decide to raise awareness about the proper use of fertilizers and encourages people to plant native plants, trees, and shrubs that soak up excess rainwater and nutrients to prevent run off.</p> <p>Add 1 block of any color</p> <p style="text-align: right;">36</p>
<p>A new roadway is constructed along the estuary. After rainstorms, the oil and other toxic contaminants from cars and trucks run off into the estuary. The runoff from roadways affects the growth of many small plants and animals.</p> <p>Remove 1 green block and 1 blue block</p> <p style="text-align: right;">37</p>	<p>A community encourages local officials to protect the nearby maritime forest in the estuary’s watershed. The forest is now labeled as “Green Acres” and no one will be able to develop the area.</p> <p>Add 1 block of any color</p> <p style="text-align: right;">38</p>

<p>Due to the warming of the estuary, Striped Bass are moving to estuaries further north to lay eggs. Because of the lack of this predator in NJ's estuaries the populations of small fish and shrimp rise. The food they feed upon, zooplankton and phytoplankton are preyed upon too heavily and their populations decline.</p> <p>Add 1 yellow block (if possible). Remove 1 red block and 1 green block and 1 blue block</p> <p style="text-align: right;">39</p>	<p>As salt marshes flood, due to sea level rise, Clearnose Skates are finding more areas in the estuary to populate. Their populations increase however they are preying upon more crabs. Crab populations start to decline.</p> <p>Add 1 red block (if possible). Remove 2 pink blocks</p> <p style="text-align: right;">40</p>
<p>A pesticide used on nearby farms wash into the estuary. Animals in the estuary absorb the pesticide, the pesticide is toxic to osprey and their populations decline. Bluefish populations are able increase but these fierce predators cause a decline in crab and fish populations.</p> <p>Add 1 red block. Remove 1 yellow block and 1 pink block</p> <p style="text-align: right;">41</p>	<p>An increase use of fertilizers causes some species of phytoplankton (algae) to bloom, however only sea nettles feed on these algae, sea nettle populations increase dramatically. They out compete many species of zooplankton, small fish and shrimp for food.</p> <p>Remove 1 blue block and 1 yellow block</p> <p style="text-align: right;">42</p>
<p>A decline in pH and increase in temperatures causes a decline in clam and oyster populations. This causes phytoplankton (algae) populations to increase but they start to block sunlight, decreasing the growth of sea grasses that blue crabs use to hide from predators.</p> <p>Remove 1 blue block and 1 pink block</p> <p style="text-align: right;">43</p>	<p>A collection of scientists and citizens work together to restore eelgrass in the estuary. Eelgrass can absorb excess carbon entering the estuary from the burning of fossil fuels (coal, oil and gas). This helps the animals that enjoy hiding and laying eggs in the eelgrass and helps slow climate change impacts.</p> <p>Add 1 block of any color</p> <p style="text-align: right;">44</p>
<p>Blue crab populations decline because of overharvesting. This causes small fish and shrimp populations to increase, however this also increases the consumption of phytoplankton and zooplankton.</p> <p>Add 1 yellow block (if possible). Remove 1 pink block and 1 blue block and 1 green block</p> <p style="text-align: right;">45</p>	<p>Crab Traps are trapping Diamondback Terrapins causing their populations to decline. This causes an increase in snail populations – the snails are destroying eelgrass beds and salt marsh grasses.</p> <p>Add 1 yellow block Remove 2 green blocks and 1 red block</p> <p style="text-align: right;">46</p>

Lower Level Edition (easier version)

<p>Increase use of herbicides (weed killers) run off into the watershed and cause phytoplankton to become an unsuitable food for many animals.</p> <p>Remove 1 green block</p> <p>1</p>	<p>A group of scientists and citizens comes together to help restore an oyster reef surrounding the salt marsh. This will help give the community protection from storms.</p> <p>Add 1 block of any color</p> <p>2</p>
<p>A fertilizer used on people's lawns and golf courses create an algal bloom that contains harmful bacteria to crustacean, such as shrimp and crabs</p> <p>Remove 1 yellow or pink block</p> <p>3</p>	<p>A marina located next to a salt marsh cleans up its facility to provide areas for the safe disposal of chemicals used on boats, encouraging boaters not to pollute the waterways.</p> <p>Add 1 block of any color</p> <p>4</p>
<p>Carbon dioxide increases from the burning of fossil fuels (oil, coal and gas) and leads to ocean acidification. Some species of zooplankton are unable to grow properly.</p> <p>Remove 1 blue block</p> <p>5</p>	<p>Too much fertilizer used on peoples lawns, run off into the estuary after rainstorms. This creates algal blooms that block sunlight from penetrating the water.</p> <p>Remove 1 green block</p> <p>6</p>
<p>A community, with the help of local scientists are able to restore 200 acres of salt marsh in the estuary.</p> <p>Add 1 block of any color</p> <p>7</p>	<p>A factory nearby releases a toxin into a stream that leads to the estuary; this toxin acts as an herbicide preventing the growth of some species of plants.</p> <p>Remove 1 green block</p> <p>8</p>

<p>Climate change is causing sea levels to rise. This causes continuous floods in the salt marsh that provide protection and spawning areas for many species of fish and shrimp.</p> <p>Remove a yellow block and pink block</p> <p>9</p>	<p>There is an increased use of pesticides that are toxic to many species of animal larva.</p> <p>Remove 1 blue block</p> <p>10</p>
<p>A forest was cleared to build new homes along an estuary, after a rain storm, sediments from the land flow into the estuary and prevent sunlight from passing through the water.</p> <p>Remove 1 green block</p> <p>11</p>	<p>A visiting ship in the estuary leaves behind an invasive species of crab. They are able to outcompete the native blue crabs for food and space.</p> <p>Remove 1 pink block</p> <p>12</p>
<p>Trash and debris blows off the land and into the local streams that flow into the estuary. The trash breaks down into small pieces that are eaten by fish and they die.</p> <p>Remove 1 yellow and pink block</p> <p>13</p>	<p>A ship has a major oil spill in the estuary!</p> <p>Remove 1 block of each color starting from the base off the food web (remove 1 of each—green, blue, yellow, pink and red).</p> <p>14</p>
<p>The state passes a law that reduces the amount of nutrients allowed in fertilizers. This prevents too much fertilizer from running off the land after a rain storm.</p> <p>Add 1 block of any color</p> <p>15</p>	<p>The shopping areas located near the salt marsh replaces its impervious parking lot with a parking lot that filters rain water.</p> <p>Add 1 block of any color</p> <p>16</p>

<p>Climate change causes coastal storms to become more intense. This increases the amount of run off and non-point source pollution from streets to storm drains to the salt marsh. Some of the run-off contains toxic pollutants to some species of fish.</p> <p>Remove 1 pink block</p> <p>17</p>	<p>Climate change has shifted a change in seasonal temperatures in the area. Osprey that prey upon larger fish remain in the area longer than usual.</p> <p>Remove 1 red block</p> <p>18</p>
<p>Sea level rise floods the beaches' diamondback terrapins used as nesting grounds. Terrapins are forced to travel to higher grounds, which may be roadways, in search of a nesting area. They are run over by cars when crossing the road.</p> <p>Remove 1 red block</p> <p>19</p>	<p>Excess carbon dioxide caused by the burning of oil coal an gas is absorbed by water. This causes some species of crab to grow abnormally large. The larger, hungrier crabs have the ability to eat many more oysters and shrimp, causing their populations to decline.</p> <p>Remove 1 yellow block and 1 blue block</p> <p>20</p>
<p>A new road is constructed along the estuary. After rainstorms, the oil and other chemical pollutants from cars and trucks run off into the estuary. The runoff from roadways affects the growth of many small plants and animals.</p> <p>Remove 1 green block and 1 blue block</p> <p>21</p>	<p>As sea levels rise, saltier water intrudes into fresh water areas of the estuary. The rise in salt levels causes some species of phytoplankton to decline in growth.</p> <p>Remove 1 green block</p> <p>22</p>
<p>Climate change is causing temperatures to warm in the estuary. Some species of phytoplankton are unable to grow properly due to the temperatures being warmer than they can tolerate.</p> <p>Remove 1 green block</p> <p>23</p>	<p>Too many pesticides were used on a local farm. After a rainstorm the pesticides washed into the stream that lead into the estuary. Pesticides can be toxic to some small plants and animals.</p> <p>Remove 1 green and 1 blue block</p> <p>24</p>

An environmental club in a community in the estuary's watershed creates a campaign to educate people about how pet waste is toxic to the estuary.

Add 1 block of any color

25

A group of citizens in the estuary's watershed decide to raise awareness about the proper use of fertilizers and encourages people to plant native plants, trees, and shrubs that soak up excess rainwater and nutrients to prevent run off.

Add 1 block of any color

26

To help reduce emission from cars and buses, students decide that at least 2 times per month they will create a "Walking School Bus." Instead of having their parents drive them each to school separately, a large group of students decide to walk to school together with the supervision of 1 or 2 parents.

Add 1 block of any color.

27

A beach and waterway clean up is held all across the state.

Add 1 block of any color

28

All the local shops and schools surrounding the estuary agree to use more renewable energy resources, such as solar and wind energy, to cut down the amount of carbon dioxide emissions that are causing climate change and affecting the nearby estuary.

Add 1 block of any color

29

All the towns located around and near the estuary decide to cut down their carbon dioxide emissions by making their community and municipal buildings more energy efficient. They also install solar panels on the roofs to power the electricity in the buildings.

Add 1 block of any color

30

A collection of scientists and citizens work together to restore eelgrass in the estuary. Eelgrass can absorb excess carbon entering the estuary from the burning of fossil fuels (coal, oil and gas). This helps the animals that enjoy hiding and laying eggs in the eelgrass and helps slow climate change impacts.

Add 1 block of any color

31

A garden club turns an unused parking lot along the estuary into a native plant garden. The native plants can trap excess nutrients and carbon dioxide before they enter the water. A native garden is also more tolerant of pests, requiring no pesticides and with proper care will not require herbicides.

Add 1 block of any color

32

<p>Carbon dioxide from the burning of fossil fuels (oil, coal and gas) gets absorbed into the estuary. Excess carbon dioxide causes some species of fish to become confused and unable to identify predators or find food.</p> <p>Remove 1 pink block</p> <p style="text-align: right;">33</p>	<p>As salt marshes flood, due to sea level rise, <u>Clearnose</u> Skates are finding more areas in the estuary to live. Their populations increase however they are preying upon more crabs. Crab populations start to decline.</p> <p>Add 1 red block (if possible.) Remove 2 pink blocks</p> <p style="text-align: right;">34</p>
<p>Not cleaning up after your pet outside causes nutrients and bacteria to run off into the estuary's watershed after rainstorms. This creates algal blooms that kill off some species of young marine life.</p> <p>Remove 1 blue block</p> <p style="text-align: right;">35</p>	<p>As climate change causes ocean temperatures to rise, storms become stronger. A strong storm washes away a beach used as nesting grounds for terrapins and horseshoe crabs. This causes shrimp and worm populations to increase but leads to a decrease in zooplankton populations</p> <p>Add 1 yellow block (if possible.) Remove 1 red block and 1 blue block</p> <p style="text-align: right;">36</p>

References for Web of Life Jenga

This game was modified from: http://sailorsforthesea.org/sites/default/files/Whale_Jenga_Food_Web_Game.pdf

Background for more information on estuaries:

http://oceanservice.noaa.gov/education/kits/estuaries/estuaries03_ecosystem.html

<http://www.bioone.org/doi/abs/10.2112/JCOASTRES-D-11-00136.1>

Affects from fertilizers, pesticides and herbicides:

https://toxics.usgs.gov/highlights/phytoplankton_blooms/

Springer. "Fertilizers: A Growing Threat To Sea Life." ScienceDaily. ScienceDaily, 22 October 2008. <www.sciencedaily.com/releases/2008/10/081021120927.htm>.

Richardson, Anthony J., In hot water: zooplankton and climate change. CES J Mar Sci (2008) 65 (3): 279-295. doi:<https://doi.org/10.1093/icesjms/fsn028>

Springer. "Fertilizers: A Growing Threat To Sea Life." ScienceDaily. ScienceDaily, 22 October 2008. <www.sciencedaily.com/releases/2008/10/081021120927.htm>.

Starr, A.V., Bargu, S., Maiti, K. et al. The effect of Atrazine on Louisiana Gulf Coast Estuarine Phytoplankton. Arch Environ Contam Toxicol (2016). doi:10.1007/s00244-016-0335-z

Climate Change Impacts:

<https://earthobservatory.nasa.gov/Features/Phytoplankton/page5.php>

<https://www.nwf.org/Wildlife/Threats-to-Wildlife/Global-Warming/Effects-on-Wildlife-and-Habitat/Blue-Crab.aspx>

<http://www.whoi.edu/ocean-acidification/>

https://www.washingtonpost.com/national/health-science/2013/04/07/a0c29f48-972f-11e2-b68f-dc5c4b47e519_story.html?utm_term=.f1dcd60252ae

<https://www.fws.gov/news/blog/index.cfm/2011/5/19/Mississippi-A-Terrapins-View-of-Climate-Change>

http://papers.risingsea.net/DRBC_salinity.html

<http://earthobservatory.nasa.gov/Features/ClimateStorms/page2.php>

<http://science.sciencemag.org/content/328/5985/1523>

<https://ben.biomimicry.net/uni/2012/oysters-in-a-storm/>

<http://edis.ifas.ufl.edu/sg138>

Woodland, R.J., Rowe, C.L. & Henry, Changes in Habitat Availability for Multiple Life Stages of Diamondback Terrapins (*Malaclemys terrapin*) in Chesapeake Bay in Response to Sea Level Rise. P.F.P. Estuaries and Coasts (2017). doi:10.1007/s12237-017-0209-2

<https://www.nps.gov/gate/learn/news/upload/Pages16-24-2.pdf><http://conservationmagazine.org/2015/01/predatory-fish-follow-their-food-despite-climate-change/>

Solutions to Climate Change:

<https://the-macroscopic.org/so-what-can-i-do-bfd03e46974e#.yfzcvpfjl>

<http://www.nwf.org/What-We-Do/Energy-and-Climate/Climate-Smart-Conservation/Climate-Smart-Communities/Nature-Based-Adaptation-Guide.aspx>www.eschooltoday.com/climate-change/what-can-i-do-about-climate-change.html

Other Human Impacts:

http://oceanservice.noaa.gov/education/kits/estuaries/media/supp_estuar09d_invasives.html

Additional Activities:

Trophic levels

http://www.chicagobotanic.org/downloads/nasa/Unit_1_Grades_7-9_Activity_1-6_FoodForThoughtTrophicCascades.pdf

Terrapins and sea level rise

http://oceanservice.noaa.gov/education/pd/climate/activities/casestudies/eastern_coastline_activities_6_9_09.pdf

Food Webs

http://njseagrant.org/wp-content/uploads/2014/03/web_of_life.pdf