Red Tide & Food Webs

Grade Level: Middle school

Content Areas: Biology, Marine Science

Method: Students match cut-out marine organisms to blank spots in a food web, or they simulate a food web.

Materials: Depending on the activity you choose and your setting, you may need chalk, yarn or string, scissors, scotch tape or glue sticks, Student Pages

Activity Time: One 45-minute class period

People Power: Any size group

Setting: Indoor, Outdoor

Terms to Know: Phytoplankton, microalgae, food chain, food web, primary producer, autotroph, heterotroph, consumer, herbivore, carnivore, omnivore, trophic level, feeding level, primary consumer, secondary consumer, tertiary consumer, quaternary consumer, apex predator, zooplankton, harmful algal bloom (HAB), *Karenia brevis*, red tide, brevetoxins

Aligned State of Florida Standards:

Grade	Standard Number	Title
6^{th}	SC.6.L.14	Organization and Development of Living Organisms
7^{th}	SC.7.L.17	Interdependence
8^{th}	SC.8.L.18	Matter and Energy Transformations

Aligned Environmental Education Standards:

North American Association for Environmental Education (NAAEE) guidelines: Strand 1 F, Strand 2.1 A & Strand 2.1 B.

Association Fish and Wildlife Agencies (AFWA) K-12 Conservation Education: Standard 1.5.1

Ocean Literacy Principles (National Marine Educators Association): 4A, 4C, 5B, 6A, 6D

Concepts that would be helpful for students to know beforehand:

What an ecosystem is, photosynthesis.

Opening Statement: How does red tide affect marine food webs?

Objectives:

Students will (1) differentiate between food chains and food webs (2) describe the importance of primary producers, particularly algae, in marine ecosystems, and (3) understand when algae can play a negative role in ecosystems with a focus on red tide in Florida.

Background for Teachers:

***Summary**: This lesson focuses on marine phytoplankton which are vital to ecosystems because they produce oxygen and are the base of the food web. Food chains are a representation of how energy moves through the ecosystem when each species in the chain eats or is eaten by only one other species. Food webs also represent this energy transfer and are more intricate and realistic because they show how organisms eat or are eaten by multiple other species. Most marine phytoplankton are beneficial, but when a species is present in large amounts ("blooms") or produces toxins, it can become harmful to the food web and ecosystem.* Karenia brevis *is an example of a harmful algae species in Florida. This marine species causes "red tide" which can make many animals and humans sick. People can protect themselves by following recommended guidelines during a red tide bloom (resources provided in "Wrap-up" section below).*

Phytoplankton are small, plant-like organisms that drift in water. Some phytoplankton are single-celled algae, which can live in all types of water systems, such as lakes, rivers, or oceans. Single-celled algae are also referred to as **microalgae** because they are microscopic. They are so small that you could fit one million of them onto a pencil eraser! Phytoplankton are crucial for aquatic ecosystems, producing about half of the oxygen on Earth. They are also critical to aquatic life because they are at the base of many aquatic food webs.

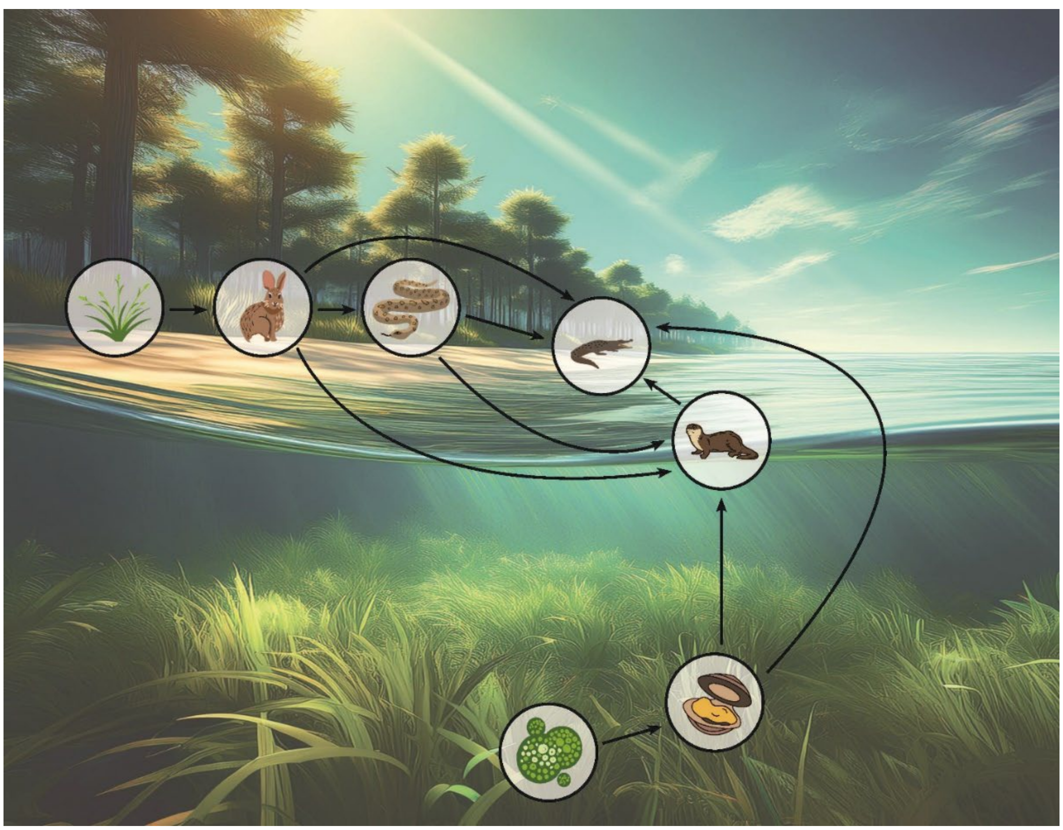
> Microalgae are so small that you could fit one million of them onto a pencil eraser!

> About 50% of the oxygen on Earth is produced by phytoplankton!

When animals eat plants or other animals, they convert that food into energy. **Food chains** and **food webs** are ways to represent the flow of that energy through an ecosystem. Food chains happen when energy moves only from one species to another in a linear fashion. They represent one species that's eaten by another species, that's then eaten by another, etc. Food webs show the more complex, and generally more realistic, flow of energy when a species is consumed by multiple other species. This complexity arises because it is rare for an organism to eat or be eaten by one species exclusively. An example of a food chain in Florida can be seen in the below picture: algae are eaten by clams, otters eat the clams, and alligators eat the otters. The arrows point towards where the energy flows, or away from the organism that is being eaten and towards the animal which is eating. A food chain is a "zoomed-in" picture of a portion of the food web, while a food web shows a more "zoomed out" picture and demonstrates that more species are involved. Revisiting the Florida food chain example in the second picture below, it becomes a complex web when organisms such as snakes, rabbits, and grass are added into the picture because they share prey or are consumed by multiple organisms. Energy cannot flow "backwards" on the food chain or food web, only in the direction of the arrows, because each organism takes on the energy of what it consumes. Food chains and webs are models that can be modified depending on the species being studied. We cannot possibly show all organisms that are part of every food web in this lesson, because ecosystems are complex, and dietary habits can vary between species (for example, one species of crab might eat oysters while another eats shrimp).

Food chain:

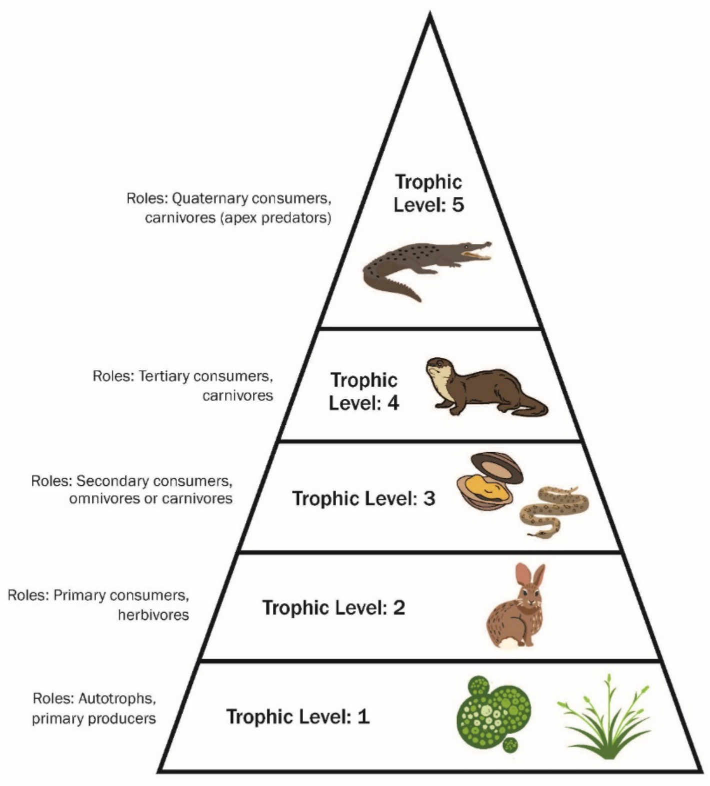
Food web:



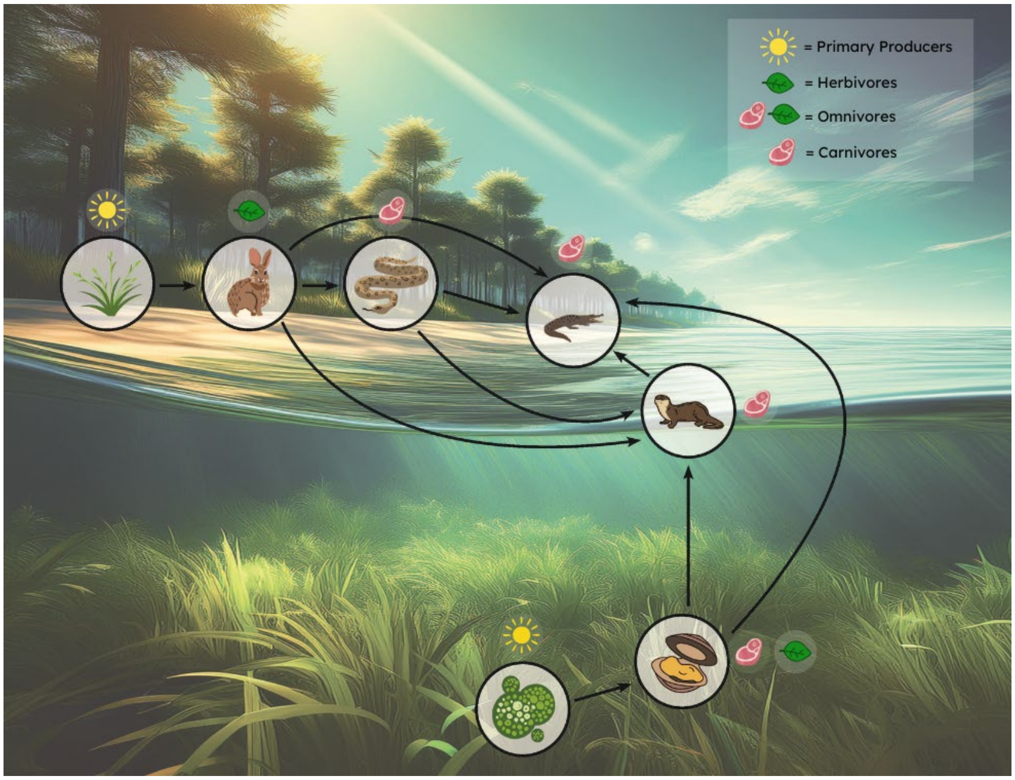
Whether for aquatic or terrestrial environments, notice plants and plant-like organisms (grass and phytoplankton) are at the base of this food web. Plants and plant-like organisms are categorized as **primary producers** because they produce their energy from the sun via photosynthesis. Primary producers fit into the larger category of **autotrophs**, which use inorganic molecules, including carbon dioxide, to produce energy and oxygen. Autotrophs are eaten by **heterotrophs**, or **consumers**, which are species that cannot use inorganic molecules to produce their own energy and therefore must consume other animals or plants to survive. In our food web example, these would be the marsh rabbit, clam, snake, otter, and alligator. Animals that mostly eat primary producers are called **herbivores**. Animals that mostly eat other consumers are **carnivores**. Animals that regularly eat both plant matter and other consumers are **omnivores**. In our food web example, the alligator, otter, and snake are carnivores. The clam is an omnivore. The marsh rabbit is an herbivore.

Each step of the food chain or food web is called a **trophic level** or **feeding level**. It begins with the 1st level, which are the primary producers. The next levels are **primary consumers** (herbivores, 2nd trophic level), then **secondary consumers** (carnivores or omnivores, 3rd trophic level), and **tertiary consumers** (carnivores that eat secondary consumers, 4th trophic level). Some ecosystems even have **quaternary consumers** (**apex predators** that eat tertiary consumers, 5th trophic level). Notice that carnivores can be in multiple levels, while the primary producers, herbivores, and omnivores are restricted to the first three levels. The number of levels depends on how complex the system is. Apex predators typically have no natural predators. If an animal has no natural predators, they can die due to old age, disease, or injuries.

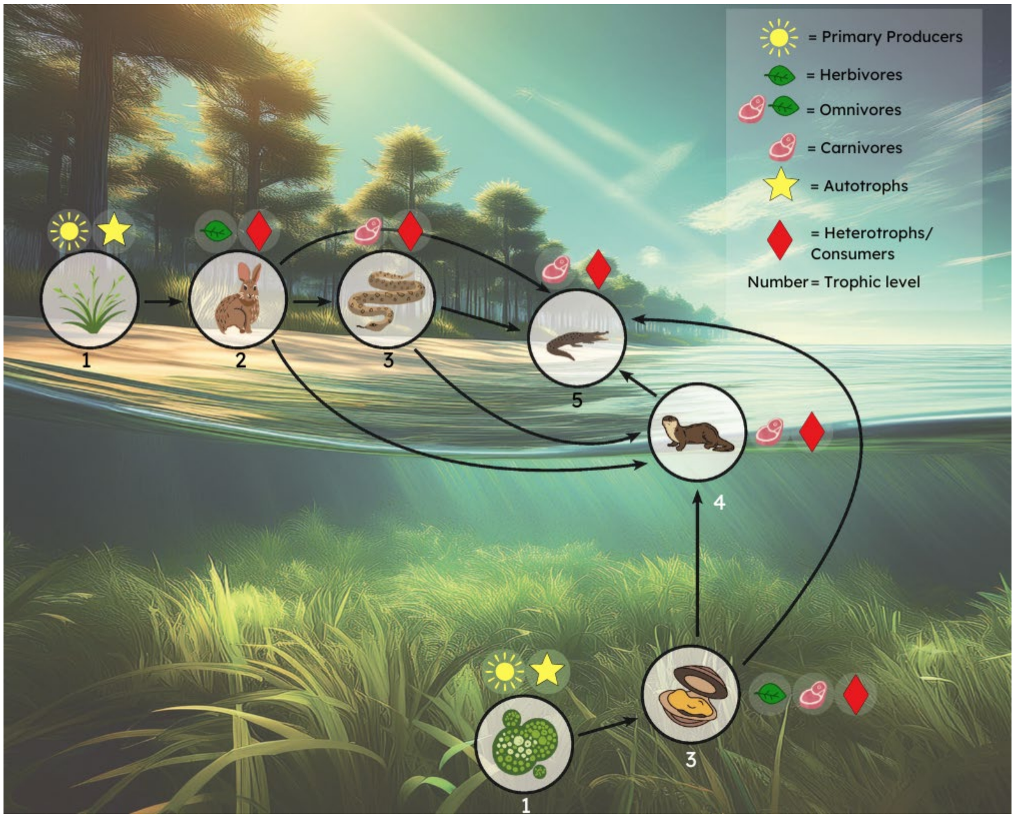
Here is a diagram of the trophic levels using the organisms from our Florida food web example:



Here is a picture of the Florida food web example with each organism's role added in:



Here is a picture revisiting our Florida food web that ties all these concepts together:

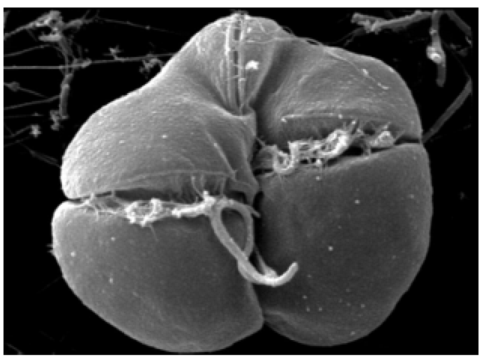


Generally, as you move "up" through the trophic levels, there are fewer individuals of each species. For example, there can be millions of individual algal cells in one body of water. By contrast, only one species is considered the top predator of some aquatic food webs: the orca, and there are only an estimated 50,000 orcas around the world.

Marine food webs are dependent upon microalgae because they are eaten directly or indirectly by various species, such as copepods (a type of **zooplankton**, which are small animal-like aquatic organisms that drift), fish, crustaceans, molluscs, and sea turtles. When environmental conditions (like temperature, salinity, nutrients, tide, wind, and sunlight) are suitable, there are a good number of microalgae for consumers to eat, and the ecosystem in the Gulf functions properly. However, under certain conditions, some species of microalgae can become harmful to ecosystems.

Microalgae can disrupt ecosystems via two main methods: excessive growth or production of toxins. When microalgae reproduce excessively due to favorable conditions it is called a **harmful algal bloom (HAB)**. There are various HAB species in many different ecosystems all over the world, so there is no single cause of blooms. Each species of microalgae has specific environmental conditions in which it thrives and increases reproduction. For example, many HAB species reproduce more in high salinity waters (marine HABs), while others depend on low salinity water (freshwater HABs). Since there are such a vast number of phytoplankton and algal species and their roles across ecosystems can vary greatly, for the purposes of this lesson, the focus will be solely on one species of microalgae in the marine ecosystem along Florida's Gulf coast.

One of the most infamous HAB species in Florida is ***Karenia brevis***. When *K. brevis* blooms, it is commonly referred to as "**red tide**." The nickname "red tide" refers to the fact that cells in high concentrations cause the water to turn various shades of red. Sometimes, it can look brown, green, yellow, or even pink. The coloring is due to a complicated process involving *K. brevis*'s physiology and chlorophyll. *K. brevis* was formally identified in the 1940s but phenomena like red tides have been reported for centuries in Florida and its neighboring states. *K. brevis* is naturally occurring and unique to the Gulf and Southeastern United States. The duration of red tide varies from days, weeks, months, or years. It is often associated with a foul odor which some describe as rotting or fishy. The smell happens for a few reasons, including decaying algae, fish, and other organisms. Red tides usually start in summer or fall but they have been documented starting at other times of the year, too. Factors including but not limited to sunlight, nutrients, water temperature, wind, and tide, can influence a red tide bloom starting and how long it lasts. Researchers are still working to understand how red tides start and what affects their duration.



Magnified picture of *Karenia brevis* taken with an electron microscope. This cell measures approximately 25-30µm across. Photo credit: Florida Fish and Wildlife Conservation Commission (FWC)-Fish and Wildlife Research Institute (FWRI).

K. brevis produces toxins called **brevetoxins**. Brevetoxins can cause neurological damage and severe illness in fish and other marine wildlife when they are ingested or inhaled. Whether an organism becomes sick and the severity of illness depends on a multitude of factors including its biology and how much of the *K. brevis* it took in. Consumers lower in the food web, like fish or molluscan shellfish (such as clams and oysters), can accumulate brevetoxins which may transfer to other consumers when they are eaten. When a predator comes along and eats these consumers, the brevetoxins can "work their way up" the food web. Not all species become sick from brevetoxins. For example, molluscan shellfish do not usually become sick or die from brevetoxins. However, they can become very toxic to the animals and humans that eat them.

Brevetoxins can make humans sick a few different ways. When people eat recreationally harvested molluscan shellfish they may become sick with Neurotoxic Shellfish Poisoning (NSP) if those molluscs have accumulated brevetoxins. Seafood at restaurants and grocery stores are safe to eat because they are properly prepared and tested. Never consume recreationally harvested shellfish from a closed harvest area. In addition, when *K. brevis* cells are broken by wave action, brevetoxins are released into the air which can cause throat, eye, and nose irritation. They can also irritate lungs leading to coughing, which can be especially harmful for people with severe or chronic respiratory conditions, such as asthma or emphysema.

For the most up-to-date and detailed information on fish and shellfish consumption during red tide, please refer to the FAQs at MyFWC.com/RedTide. To check the status of a harvest area here, please refer to the FDACS link in the "Wrap-up" section."

Commonly referred to as “red tide cough,” people experiencing these allergy-like symptoms should leave the area and find an indoor air-conditioned space to recover. People and pets should not swim in affected waters, particularly where dead fish are present, due to potential ingestion or skin irritation. Although no human deaths have ever been recorded as a result of *K. brevis* or NSP, it is important to stay informed to avoid illness.

In addition to posing a risk to human health, red tide can cause negative effects to ecosystems, wildlife, and the economy. Red tides are not a recent phenomenon, but some human impacts on the environment, such as increasing atmospheric carbon dioxide, warmer waters, and increased pollution that *K. brevis* can use as nutrients, may increase the frequency, strength, and geographic range of blooms. Researchers are still investigating these factors, as well as various approaches, tools, and technologies to help prevent or control them. However, they have not yet discovered a prevention or control method because it would likely involve removing *K. brevis* and brevetoxins from the water without causing additional harm to other forms of marine life and the ecosystem, which would be a complicated task. For now, the best thing an individual can do is keep themselves, as well as their friends, family and pets, safe with the safety guidelines provided here and below.

Picture of a *Karenia brevis* bloom in the Gulf along the west coast of Florida. Photo credit: National Oceanic and Atmospheric Association (NOAA).

Picture of a *Karenia brevis* bloom in the Gulf in Pinellas County, FL. Photo credit: FWC-FWRI.

In this module, we will explore the marine food web in Florida's Gulf waters, how it is dependent on microscopic algae, and how it is impacted by red tide.

Procedure:

Warmup

If you would like, use the accompanying slide deck (slide numbers noted throughout the warmup).

1. [Slide 2] Show the above pictures of discolored water and ask students what observations they have or what stands out to them. Ask what they think it is. Write answers on the board.
2. Tell students/confirm that this is red tide. Ask by a show of hands, if they know of, have seen, or have experienced red tide. Call on a student or two to share their stories.
3. Describe what red tide looks, feels, and smells like. The water can be a red color (which is why we call it "red tide"), or it can sometimes look reddish-brown, green, yellow, or pink. Sometimes at the beach you can see dead fish or animals. [Slide 3] You might notice odd smells, start coughing, or have irritated eyes. Ask the students if they have any guesses of what causes red tide. Write the answers on the board.
4. If a student said red tide is caused by algae or *Karenia brevis*, say that's correct. [Slide 4] Discuss how in Florida's Gulf waters, red tide is caused by an organism called *Karenia brevis*. When there are a lot of *Karenia brevis*, they make the water look red due to a complicated process with their biology and chlorophyll.
5. Explain that *Karenia brevis* is a type of algae. [Slide 5] Algae are plant-like organisms. Just like plants on land, they are usually very helpful for ecosystems. They can be found in different types of water systems and come in all shapes and sizes. Microscopic algae are a type of phytoplankton, which means they photosynthesize (create their own sugar and oxygen from sunlight, water, and carbon dioxide) and drift on water. They're frequently confused with bacteria, but they're not the same.

6. [Slide 6] Tell students that phytoplankton create about half the oxygen on earth via photosynthesis. They are also the base of many aquatic food webs which means many animals depend on them for food.
7. [Slides 7 & 8, or if you're not using slides, draw a food chain and food web on the board] Ask students how many of them have heard of a food chain or food web. Explain what they are and the difference between the two. Explain that both food chains and food webs are models that can be built many ways depending on the species being included. Point out that for both aquatic or terrestrial environments, plant-like organisms (like phytoplankton and grass) are at the base food webs. [Slide 9] Explain what trophic levels are, and how they are broken up into primary producers/autotrophs vs. consumers/heterotrophs. Define carnivore, omnivore, and herbivore. [Slide 10] Look at the pyramid that shows the trophic levels and the organisms' role in the food web. Explain primary consumers, secondary consumers, tertiary consumers, and quaternary consumers/apex predators. [Slide 11] Show the food web again with icons added in and point out each organism's role (primary producers, herbivores, omnivores, or carnivores). [Slide 12] Now show the web with the roles of autotroph vs. heterotroph/consumer and trophic levels added in.
8. Explain that this shows that algae play an important role at the base of the marine food web because many organisms depend on them. Say that when there is the right amount of algae for consumers to eat and the algae is not toxic, the ecosystem in the Gulf functions properly. However, under specific conditions, some species of microalgae can be harmful to ecosystems.
9. [Slide 13] Explain that when there is too much of one species of microalgae, it can cause problems and it's called a harmful algal bloom, or HAB. This is not to be confused with when a flower blooms, because it's a unique use of the word to describe when there is too much algae. There are many different HAB microalgae species all over the world. Red tide in Florida is when there is a bloom of *Karenia brevis.* [Slide 14] Ask if students remember what plants need to grow. Explain that just like terrestrial plants, algae need sunlight, nutrients and carbon dioxide and when these are all at levels that algae "like," the amount of them can increase a lot and create a bloom. Factors that can start a bloom and affect how long it lasts include but are not limited to sunlight, nutrients, water temperature, wind, and tide, but researchers are still working to understand these relationships better. *K. brevis* is naturally occurring and unique to the Gulf and Southeastern United States. The organism *K. brevis* was formally identified in the 1940s but phenomena like red tides have been reported for centuries in Florida and its neighboring states. Researchers are working on how to prevent or control them but haven't yet found a way that wouldn't involve causing issues with other marine life and the ecosystem.
    - Refer back to the students' guesses about what causes red tide and see if any of them match up with correct answers.

> If you would like to show a video about what red tide is, how it forms, and how it can affect humans and wildlife, go to the FWC educational video included in the "Additional Free Resources" section. Also available in that section is a video on how FWC monitors HABs.

10. [Slide 15] Some microalgae also produce toxins. *Karenia brevis* makes toxins called brevetoxins which can make animals sick and sometimes die. Organisms in all trophic levels can be impacted by brevetoxins. Whether or not an organism is affected depends on factors such as the species' biology and how much exposure they had by eating, inhaling, or coming into direct contact with brevetoxins.
11. To tie this back into the food web, as organisms lower on the food chain die off because of brevetoxins, this makes it harder for their predators to find food and the food web may be temporarily affected. The food web is also important because brevetoxins can "work their way up" the food web if a consumer eats prey that has eaten brevetoxins already, and then another consumer eats that consumer, and so on. This can cause animals higher up the food chain to get sick from brevetoxins.
12. Red tide can make humans sick in a variety of ways too. Swimming or wading in a red tide can also irritate your skin and causes rashes or itchiness. Brevetoxins can make humans sick when they eat them (either directly or in other organisms). Also, during a red tide, waves crashing can release brevetoxins into the air, which can cause coughing and itchy eyes. There haven't been any recorded human deaths caused by *K. brevis*, but it is still important to learn about to stay safe.
    - Let them know that you will talk more later about ways they can keep themselves safe from brevetoxins.
13. Inform the students that they will play a game to understand better how red tide affects the food web in the marine waters of Florida's Gulf [Slide 16]!

> Some animals are more resilient to environmental stressors due to special adaptations. See the "Extension" section for ways students can continue learning about this.

Activity

Student Pages and Teacher Key: See other documents for the organism boxes, trophic list, game board, and Teacher Key. There are variations available as well, including a more active version (see "Variations" section below).

- Split students up into groups of 3-4.
- If you haven't already done so, distribute pages 1, 2, and 3 of the Student Pages to the students and have them cut out the organism boxes on page 2. Have them leave the *K. brevis* box off to the side for now.
- Based on the descriptions in the Trophic List, students discuss with their groupmates and place the organism boxes in the corresponding squares. (They should wait to tape/glue the squares down until the end of the game, when they have final answers.)
- Each group can raise their hand and get up to three clues from the teacher if they get stuck. Examples:

If students are curious about feeding behaviors, see the "Extension" section for ways they can continue learning about them.

- Copepods only eat primary producers. Placing copepods in spot G indicates that they eat a consumer too.
- Remember that primary producers are at the *base* of the food web.
- If you put green sea turtles in spot E, that is the bottom of the food web, and that would indicate that they create their own food from the sun. Can they do that?
- If you put sharks in spot D, that would indicate they are eaten by other animals. Do they have any predators?

- Once the students have their final answers, they glue/tape the pieces in place.
- If some groups finish early and have extra time at the end of the activity, use these prompts:
    - Brainstorm additional Floridian food webs, and if time allows, sketch them out:
        - A terrestrial food web
        - A food web (terrestrial or marine) that includes humans
        - The shortest (terrestrial or marine) food web that includes primary producers and a top predator you can think of
    - Have you seen any recent news stories about a red tide in Florida? Where was it located, and what effects did they mention?
    - Have you heard of any other HABs that occur outside of Florida, and what species do you think would be affected by those?
    - What do you think would happen to the food web if the number of carnivores got smaller? What do you think would happen if it got larger?

Wrap-up

- Review and compare answers as a class. If it is a smaller group of students, ask them to present their charts. If it is too big a group, ask students, "by a show of hands, how many of you put bull sharks in box A?" and so on to reveal the correct answers, or just have one group present.
- Ask the students which organisms in the web are herbivores (green sea turtles and copepods), then omnivores (fish), then carnivores (squids, birds, bottlenose dolphins, and bull sharks). Ask them which are autotrophs (algae) or heterotrophs (all other organisms). Next, ask them which are primary consumers (green sea turtles and copepods), secondary consumers (fish), tertiary consumers (birds and bottlenose dolphins), or quaternary consumers (bull sharks).
- Discuss what happens to animals, the food web, or people in two different scenarios:
    1. A beneficial quantity of non-toxic algae is present in an ecosystem
        - Answer: Food web is balanced, ecosystem functions without disruption.
    2. Have students paste over the non-toxic algae in spot "E" with the *K. brevis* organism box. Ask them to imagine *K. brevis* is present in relatively high numbers/there is a red tide bloom.
        - Answer: Respiratory irritation in people is likely. Follow the safety guidelines below. Sickness or death in fish is probable, with birds and other large animals potentially getting sick too. Animals may also die due to lack of available food. There can be temporary declines in fish populations that will probably disrupt the food web temporarily. Although red tide can make it harder to find prey, some animals can adapt and find other food.

- Discuss with students what they can do to keep themselves, families, guardians, friends and pets safe. [Slide 17].
  - Give out take-home sheets (optional, and available in 8 total languages here: MyFWC.com/Research/RedTide/Media/Rack-Card/)
  - Do not swim in waters affected by a red tide bloom. People with severe or chronic respiratory illnesses should avoid red tide areas altogether.
    - Check current red tide status map here: MyFWC.com/RedTideMap
  - Follow proper procedures for fishing and shellfish consumption during a red tide bloom. Find guidelines and FAQs here: MyFWC.com/RedTide
    - Never consume recreationally harvested shellfish from a closed harvest area. To check open or closed status of an area before harvesting shellfish (specifically oysters, clams and mussels): FDACS.gov/Divisions-Offices/Aquaculture
    - Seafood at restaurants and grocery stores are safe to eat because they are properly prepared and tested.
    - If you believe you are experiencing health effects from contact with red tide in any way, call Florida's poison control center: 800-222-1222
  - Report fish kills and sick or injured wildlife (such as whales, manatees, dolphins, sea turtles) to the FWC alert hotlines:
    - Fish Kills: 800-636-0511 or MyFWC.com/FishKill
    - Wildlife: 888-404-FWCC (3922)

Assessment:

- What is a harmful algal bloom?
- What happens to the food web when there is a red tide bloom?
- What is the main difference between an autotroph and a heterotroph?

Variations:

- You could provide one of the variation game boards with fewer organisms to make it less complicated. These are available in the Student Pages.
  - One variation is a food chain rather than food web. After the students complete this, you could stop there or have the students go on to make it into a web with the next board in the sheet.
  - Another variation is a smaller food web with fewer connections than the original. If you are using this variation, you could also use the original as a more complicated bonus round.
- For the wrap-up discussion, you may want to use an additional student sheet without organisms taped down, a board with Velcro, or a slideshow to take off organisms and visually represent holes in the food chain/web to explain the effects of *K. brevis*.
- For portion of the wrap-up where you ask students the organisms' roles (herbivores, omnivores, carnivores, autotrophs, heterotrophs, and each level of consumer), you can visually represent the trophic levels by drawing a triangle (like the one from the introduction) on the board and writing the various organisms in it as the students answer. You can also build off the previous

bullet's variation and use the loose organism boxes, Velcro organism boxes, or slideshow to group up the organisms in their respective categories.

- You could give fewer or more than three clues to each group.

Simulate a food web with the students (good for more active groups):

- In a large classroom, gym, or outdoors, outline boxes on the ground with masking tape or chalk that represent the food web, including arrows.
- Assign each child an organism in the food web depicted in the Instructor Key. If you'd like, you can have each child find and hold a token to represent each group, such as stones, leaves, shells, or pinecones. For groups that don't have time to find items, you can use supplies such as pipe cleaners, party hats, or popsicle sticks, or just have them remember their organism. There should be more organisms at the base of the food web and fewer at the top. Depending on the amount of time available and the children's focus levels, you can always take out organisms to simplify. For example, if you have 26 children, give 12 children green party hats and tell them they represent non-toxic algae; 5 children brown party hats and they represent copepods; 4 children get yellow hats and they represent fish; 3 children get blue hats and they represent dolphins; and 2 children white hats and they represent sharks. Keep 12 party hats off to the side, not assigned to any students.

> If you can't draw on the ground or put masking tape down, you can still have students group up in their trophic levels. Have one of the students in each group hold a piece of string connecting to a student in the next trophic level, and so on.

> If you have a larger group, you could start some students off to the side who are assigned *K. brevis* tokens. When it's time to demonstrate a bloom, switch out the students already in the food web with non-toxic algae tokens for students with *K. brevis* tokens off to the side. You can also use all the organisms in the Student Pages food webs, including green sea turtles and birds.

- Ask the non-toxic algae group to stand where they think they go in the laid-out food web. Then ask all the copepods to stand where they think they go, and so on. You can use the prompts in the Student Pages' Trophic List. All the children in all organism groups should now be on the board except for those representing *K. brevis* off to the side.
- After all the children are organized in the web, explain that there are fewer children in each group as they go up the trophic levels because this represents how there generally are fewer individuals in each type of species as they go higher up the food web.
- Ask the students to raise their hands if they think they are in a group that is a primary producer (algae), then herbivores (green sea turtles and copepods), omnivores (fish), and then carnivores (squids, birds, bottlenose dolphins, and bull sharks). Ask them to raise their hands if they are autotrophs (algae) or heterotrophs (everyone else). Finally, ask them to raise their hands if they are primary consumers (green sea turtles and copepods), secondary consumers (fish), tertiary consumers (birds and bottlenose dolphins), or quaternary consumers (bull sharks).
- Next, run through two different scenarios with the children:

  Scenario A: What do they think is happening the way they are set up now in the ecosystem?

    Answer: A beneficial quantity of non-toxic algae is present in an ecosystem. The food web is balanced, and the ecosystem functions without disruption

Scenario B: Have all the children with non-toxic algae tokens switch them for the *K. brevis* token and say they represent a large increase in *K. brevis.* Have a few of the children from other organism groups step off the food web and go to the side. Ask the children what they think this represents.

> Answer: There is a red tide bloom. Respiratory irritation in people is likely. Follow the safety guidelines above. Sickness or death in fish is probable, with birds and other large animals potentially getting sick too. Animals may also die due to lack of available food. There can be temporary declines in fish populations that will probably disrupt the food web temporarily. Although red tide can make it harder to find prey, some animals can adapt and find other food.

Extensions:

- Encourage students to become volunteer community scientists (must be accompanied by adult): MyFWC.com/Research/RedTide/Monitoring/Offshore-Monitoring/.
- Students research a historic red tide in Florida and write a report about its effects on areas such as the ecosystem, economy, tourism, or public health.
- Students explore what adaptations marine consumers have that allow them to eat other organisms (such as feeding behaviors, types of teeth, or camouflage). They can pick a marine consumer, research it, and present it to the class.
- Students investigate what makes an animal more likely to survive short-term environmental problems (such as being food or environment generalists, or moving to another location). They can pick a helpful adaptation or an organism and its strategies and present them to the class.

Additional Free Resources:

Aquatic food webs: NOAA.gov/Education/Resource-Collections/Marine-Life/Aquatic-Food-Webs

HABs in general: NOAA.gov/What-Is-Harmful-Algal-Bloom

Hui, D. (2012) Food Web: Concept and Applications. Nature Education Knowledge 3(12):6. Retrieved from: Nature.com/Scitable/Knowledge/Library/Food-Web-Concept-And-Applications-84077181/

People and pet health: FloridaHealth.gov/Environmental-Health/Aquatic-Toxins

Photosynthesis: Smithsonian Science Education Center. (2018, March 27). What is Photosynthesis. Smithsonian Science Education Center. SSEC.SI.edu/STEMVisions-Blog/What-Photosynthesis

Red tide additional info: MyFWC.com/RedTide/

Red tide educational video series: MyFWC.com/Research/RedTide/Media/Video/. Please note, these videos are not specifically written for children, but they can still be helpful supplemental videos.

Video on FWC HAB monitoring: MyFWC.com/Research/About/MarineQuest/2020/School/HAB/

In Step with STEM:

Have students research the traits of *Karenia brevis* cells. Ask them to investigate why their biology is unique compared to other types of microalgae. Students can draw diagrams of the cell anatomy and label the anatomy. If your school has access to a 3D printer, you can print a larger-than-life, highly detailed 3D model of the cell. Students who are blind or have low vision might particularly enjoy the 3D printed model. You can download the template stl file here: HAB.WHOI.edu/Regions-Resources/Interactive-Graphics-3D-Models/.

Wild Work:

If students are interested in a career related to HABs, there are many options. They can pursue research in microbiology and oceanography, wildlife rescue and rehabilitation, public health, advocacy and legislative work, communications, social science, education, and more!

Credits:

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