Smithsonian | SCIENCE *for Global Goals*

OCEAN!

Part 2:

Ocean and Water

SUSTAINABLE DEVELOPMENT GOALS

developed by

Smithsonian *Science Education Center*

in collaboration with

iap SCIENCE HEALTH POLICY

the interacademy partnership

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PART 2: OCEAN AND WATER

Part 2

Find out More!

For additional resources and activities, please visit the *Ocean!* StoryMap at bit.ly/OCEAN2030.

Planner

Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 1: How does water move around our planet?					
Discover	Search for elements of your community's water system and map your watershed.	• Paper • Pen or pencil • Digital or physical map of your area	*Ocean and Water System Diagram*	40 minutes	43
Understand	Model surface currents and analyze a map of global ocean currents.	• Shallow basin, preferably clear • Water • Ground pepper or small bits of paper • Rock or similar item (optional)	*Ocean Identity Map*	30 minutes	50
Act	Connect ideas about local and global water systems and share what you have learned.	• Paper • Pencil	*Ocean and Water System Diagram* *Ocean Identity Map*	20 minutes	55

Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 2: How do circulating water pollutants affect our planet?					
Discover	Model types of water pollution and search for evidence of pollutants in your community that may be affecting the ocean.	• Shallow basin, preferably clear • Water • Flat, waterproof surface • Piece of scrap plastic • Scissors • Watering can or cup • Cooking oil • Food coloring • Sponge • Salt or sugar (optional) • Paper • Pen or pencil	*Ocean and Water System Diagram*	30 minutes + community investigation time	57
Understand	Investigate the impact of water pollution on ocean organisms.	• Paper • Poster board (optional) • Pen or pencil	*Ocean Identity Map*	25 minutes	63
Act	Determine which pollution problem you would like to help solve and take action.	• Paper • Pen or pencil	*Ocean Identity Map* *Ocean and Water System Diagram*	25 minutes + action time	72

Meet Your Research Mentor, Dr. Kālewa Correa

Meet Dr. Kālewa Correa. Kālewa (pronounced *KAH-lev-ahh*) will be your research mentor to help you understand more about the movement of the water in the ocean.

Kālewa is the Curator of Hawai'i and Pacific at the Smithsonian Asian Pacific American Center. Kālewa has a doctoral degree in learning design and an undergraduate degree in Hawaiian studies. He also managed the Mokupapapa Discovery Center for many years to help visitors connect with the ecosystems of the northwestern Hawaiian Islands and surrounding marine environments. Since Kālewa is now working with you, it is important to understand who he is.

Kālewa's Identity Map

- Kānaka Maoli (Native Hawaiian) and Cook Islands Māori ethnicity
- Azorean Portuguese, Scottish, Irish, and English ethnicity
- Historian, researcher, musician, and futurist
- Male
- 48 years old
- Lives in Hawai'i
- Interested environmental systems
- Have played guitar, bass, and synthesizers for over 30 years
- Interested in history, art, music, human potential, and future studies

- Have traveled to some of the most remote places in the Pacific
- Studied learning design and Hawaiian studies
- 1.85m (6'1") tall, brown eyes, dark brown and grey hair
- Naturally an introvert but have a jokester side
- Father to two young girls, 9 years and 12 years
- Husband to my wife of 20 years
- Enjoy growing my food and being the household cook
- Balance and justice are the two most important values to me.
- I look to the past to help me live in a *pono* (balanced) way.

Part 2

Task 1: How does water move around our planet?

In this task you will ***discover*** the water system in your community. You will model the ocean to ***understand*** what happens to water when it reaches the ocean. Then you will ***act*** to share this information with others.

Before you begin the rest of Part 2, think quietly to yourself about Kālewa's identity map and compare it to your *Personal Identity Map*.

- Are there things you have in common with Kālewa?
- Are there ways in which you are different from Kālewa?
- Can you see anything about Kālewa's identity that relates to understanding the system of the ocean?

Throughout Part 2 you will notice Kālewa sharing ideas and experiences with you. He may help you understand better ways to do your research or share some of the research he has done.

Discover: *How does water move through my community?*

Where does the water around you come from and where does it go? Water circulates between the land, the ocean, the atmosphere, and the **cryosphere**, or places on Earth where water is frozen, such as in glaciers. In this activity you will think more about how this system works and how it links to your community.

1. Read *Searching for Elements of Your Community's Water System* and follow the directions.

Searching for Elements of Your Community's Water System

Choose an area around you that you would like to investigate. This could be your city or town, your neighborhood, or another local area. If you can, move around the area you picked to find places that hold or channel water as part of the water system. If that is not possible, you can use your memory, online pictures or maps, or other resources.

a. With your team, take out a sheet of paper or open a digital document and title it "Ocean and Water System Diagram." Remember what you learned in Part 1 about creating a system diagram.
b. Divide your paper in half. You will diagram the water system in your local community on the top half. Later you will use the bottom half to diagram the water system of Earth.
c. Move around different spaces and try to notice things that use, move, or store water. Figure 2.1 shows some ideas. If you can, search for:

- Indoor elements: for example, a sink or washing machine.
- Outdoor elements around your building: for example, gutters on the side of the building or rain barrels.
- Elements that are other built places in your local area or community: for example, are there pipes, street gutters, storm drains, or drainage ditches that channel water?
- Elements that are natural areas in your community: for example, a stream or pond or **groundwater**. Groundwater is water found underground in the soil or in spaces between rocks.

Figure 2.1: Examples of places with water in a community.

Part 2 Task 1

d. As you search for parts of the water system in your community, pick at least four things you find and write them down in the top half of your _Ocean and Water System Diagram_. Draw a box around each word to show it is an element in your community water system, Figure 1.6 shows an example, if you need to remember how to create a system diagram.

2. In your _Ocean and Water System Diagram_ draw and label arrows to show how water moves between elements. For example, maybe groundwater is pumped out of a well and into the sink in your house, then goes down the drain and through the pipes to a water treatment plant. You could draw arrows and add labels to show the connection between the groundwater, well, sink, pipes, and water treatment plant. Figure 2.2 shows an example of how that system diagram might appear. The system diagram of your community will be different. Draw as many arrows as you need, but do not worry if you do not know all the ways water flows around your community. Just do your best.

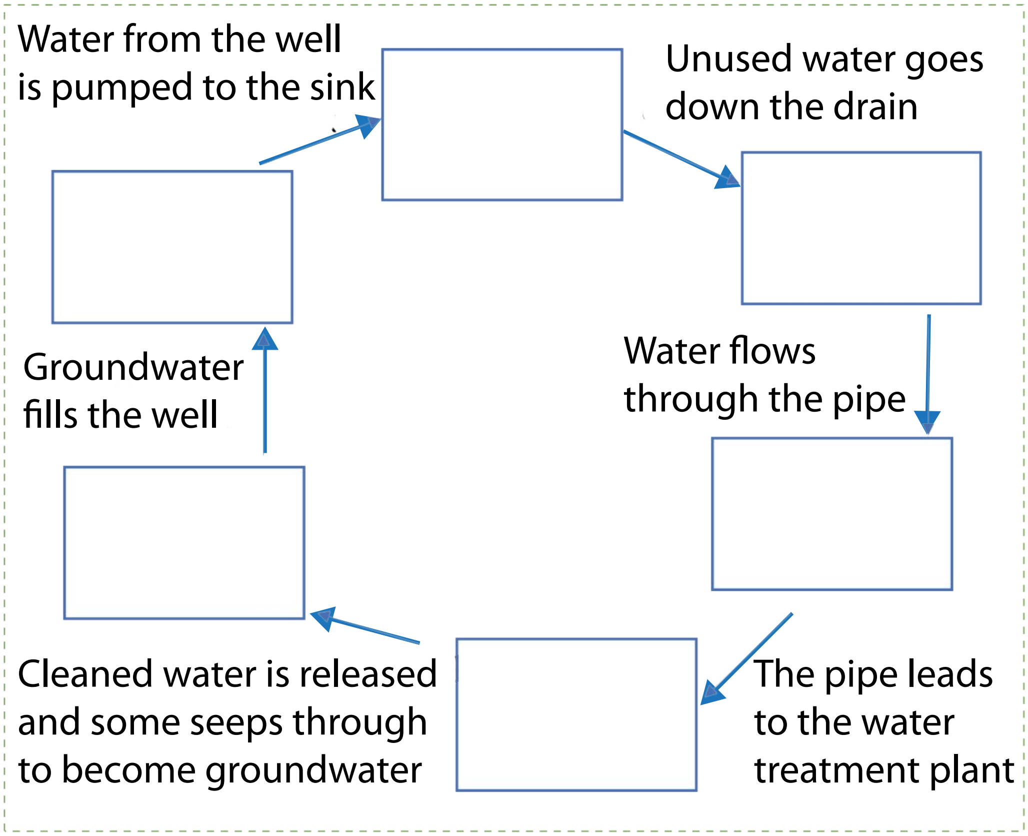

Figure 2.2: Example of a Community Water System Diagram showing elements and relationships.

Part 2 Task 1

3. Draw a large box with dashed lines around all the elements to show the boundary of your community water system.
4. Discuss with your team:
   a. What are the *Additions* to our community's water system? Where does the water come from? For example, from rain or a river.
   b. What water leaves our community's water system? How does it leave? Water leaving the system is a *Removal*.
5. Add any *Additions* or *Removals* you can think of. Use the sample system diagram in Figure 2.3 to help you.

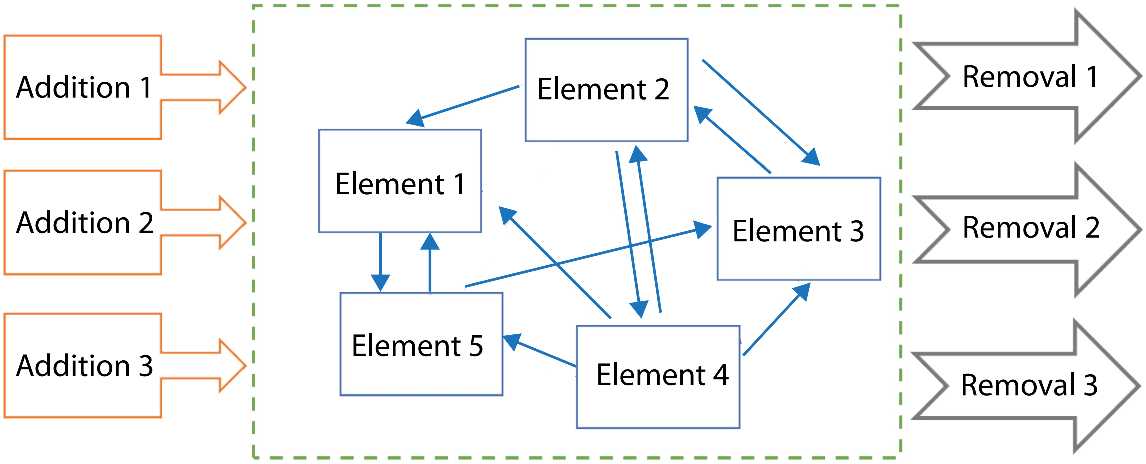

Figure 2.3: Sample system diagram showing Additions and Removals.

6. Read and carry out the instructions in *Mapping Your Watershed*.

Mapping Your Watershed

a. Open a digital map of your area or find a map you can draw on.
b. Think about places where you have noticed water flowing in your community, such as a river or stream. Which direction was the water flowing? Water can flow into your community from **upstream**. Water can flow out of your community to **downstream**. If you need more information, you can go to place where water is flowing or use a video of that place to examine the direction of water flow.

Part 2 Task 1

c. Use the map to try to trace any water flowing through your community back to its **source**, which is where it came from. For example, if there is a river in your community, follow it upstream on the map and notice which communities it flows through. Usually upstream is going to be away from where the water reaches the ocean.

d. Mark any **tributaries**, or smaller streams, creeks, or rivers that joined the water before it reached your community. Circle any towns or cities it flows through.

e. Add the names of all of your marked **waterways** as *Additions* on your *Ocean and Water System Diagram*. In this guide, the word "waterway" is used for any flowing water, such as a river or stream.

f. Use the map to try to trace and mark any water flowing out of your community downstream. Where does water flowing from your community eventually go? Follow it as far as you can. Circle any towns or cities it flows through.

g. Add each body of water flowing out of your community as *Removals* on your *Ocean and Water System Diagram*.

h. Examine the tributaries that meet with water from your community on its way to the ocean. Try to follow and mark each tributary as far as you can. Sometimes bodies of water do not reach the ocean. That is okay. Just note down where the water from your community goes.

i. Draw a circle around the whole area you have just marked. This is your **watershed**, an area of land where all the water flows together into the ocean.

7. Discuss with your team the connections between you and the other people and living things in your watershed.
    a. Which town's water system removals might be the additions to your community's water system?
    b. Examine the circled towns or cities that are upstream. How do the choices made by people upstream affect you?
    c. Which town's water system additions might be the removals from your community's water system?

d. Examine the circled towns or cities that are downstream. How do your choices affect people downstream?

e. What might feel unfair or difficult about a system where people's choices in one place might affect people in another distant place?

8. Read Kālewa's thoughts about the relationship between people and **ecosystems** in their shared water system.

Kālewa says . . .

The *kānaka maoli* (Native Hawaiian) traditional land division was known as the *ahupua'a*. The divisions are generally wedge-shaped areas stretching from the uplands to the sea, integrating the natural resources and geographic features from mountain to ocean. This land system showcases nature's and humans' interconnectedness. Every *kānaka* (Hawaiian person) in the *ahupua'a* had specific roles in ensuring the health and sustainability of the entire system. Those living *mauka* (upland) knew their actions affected their neighbor's *makai* (toward the sea).

Wai (fresh water) is viewed as a communal resource, and its equitable distribution is very important. Water and land are considered ancestors and *'ohana* (family) within the Native Hawaiian culture. The Native Hawaiian philosophy is that water is a shared resource and must not be hoarded or wasted. Any changes or disturbances upstream would directly influence the resources and livelihoods downstream. For example, if forests were cleared carelessly or overharvested, it could lead to erosion and sedimentation, affecting the coral reefs and fisheries downstream.

Native Hawaiians have had a deep understanding of the intricate relationships within and of their ecosystems that have spanned thousands of years within the Hawaiian Archipelago.

9. Read *The Water Cycle* and follow the directions.

The Water Cycle

Not all water stays in the ocean. It can also move through other parts of the **water cycle**. Water from the ocean evaporates into the atmosphere, condenses to form clouds, and eventually falls again on land and in the ocean as rain, snow, or other types of precipitation. Figure 2.4 shows a representation of the water cycle.

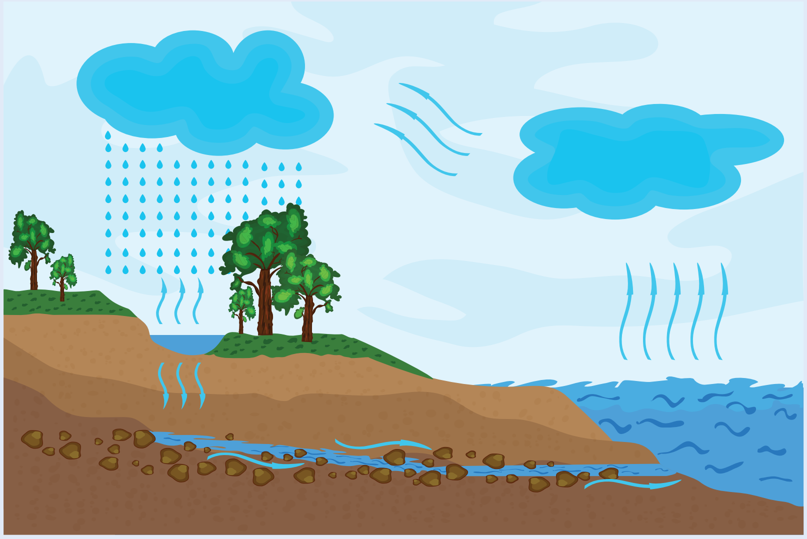

Figure 2.4: The water cycle includes precipitation from clouds, water in a lake, river, and groundwater, water moving to the ocean, evaporation from the ocean and lakes, condensation into clouds, and then clouds moving over land.

a. On your *Ocean and Water System Diagram,* add elements from Earth's water cycle to the bottom half of your paper. Be sure to add elements to show how water reaches, moves around, or leaves the ocean.
b. Draw and label arrows to show relationships between the parts of the water cycle. For example, you might use the words "evaporation" or "precipitation" to show how water is moving through the system.
c. Examine your diagram. Can you use arrows to connect your community water system's removals with the additions by using parts of the water cycle?

Even if you are far away from the ocean, it is very likely that precipitation falling on your community evaporated from the ocean. Around 86% of global evaporation comes from the ocean. Evaporation creates water vapor in the air and condenses to form clouds. These clouds travel over land and drop the water in the form of precipitation.

***Understand**: How does water move around the surface of the ocean?*

Water does not stop moving when it reaches the ocean. In fact, there are **currents** similar to rivers within the ocean. A current is when water flows in a specific direction. Ocean water moves horizontally in currents along the surface of the ocean. It also moves vertically in currents between the deep ocean and the surface. On the surface, water evaporates out of the ocean, providing most of the water vapor found in the air and clouds. In Part 4 you can learn more about deep water currents within the ocean. In this task you will concentrate on surface currents.

Sometimes people use the word "ocean" to refer to a geographic area or **ocean basin** within the larger ocean, such as the Pacific Ocean. But this is a little misleading. All the areas of ocean on Earth are connected. So they are all one ocean of water moving and mixing. Water flowing into one part of the ocean will eventually travel to other parts. In this activity you will think about why this movement is important. Then you will model some of the reasons ocean water moves and mixes.

1. Think to yourself, why is it important to people that water moves around in the ocean?
2. Read Kālewa's description of the significance of the ocean to the people of the Pacific Islands. What stands out to you as important to remember? Add anything related to the way people connect to the ocean to the *Connections* circle on your *Ocean Identity Map*.

Kālewa says . . .

The movement of ocean water has a profound impact on the cultures of the Pacific islands. For these island communities, the ocean is not just physical; it's a big part of their way of life. Imagine this: The sea is like a teacher and a provider. It taught their ancestors how to navigate the vast Pacific using stars and currents, a skill passed down for generations. It's a central character in their stories, dances, and daily life, especially in activities like fishing. The ocean is like a family member—it's always there, shaping their traditions, guiding their way, and giving them what they need.

But there's another side to this story. As the ocean moves, it also affects the weather. Weather can be suitable for farming and fishing, but it can also bring storms and rising sea levels. Recently, climate change is making the ocean rise, which can be a real danger to these islands. So for these communities, the ocean isn't just a part of their culture; it's a challenge they face, too. They must adapt and find ways to protect their homes while keeping alive their deep connection to the sea.

3. Discuss with your team: What are the things you can think of that might cause ocean water to move? Write down or find some other way to record your ideas. You will think about them again at the end of this activity.
4. Read and follow the instructions in *Surface Current Modeling*.

Surface Current Modeling

Surface currents are the horizontal movement of water in the first 50 to 100 meters near the ocean's surface. What do you think might be causing this movement?

a. Take out a long, shallow container and fill it about halfway with water. If possible, use a clear plastic or glass container to make it easier to observe. Figure 2.5 shows an example.

Figure 2.5: Example of a current model setup.

Part 2 Task 1

b. Examine the water in the container. Other than moving the container, how could you make the water move without touching it?
c. Try out any ideas you might have.

You may have thought about blowing across the water to move it. This is similar to wind blowing across the ocean and is one of the major causes of surface currents.

Are you familiar with the jet stream, the tradewinds, or the westerlies? They are all **prevailing winds** on Earth. This means they are important winds that blow in the same general pattern and direction.

The strongest sunlight hits Earth's land and water in the **tropics**. As the air in that region is warmed, it rises into the atmosphere and moves toward the cooler poles of Earth. At the same time, Earth's rotation causes air moving just above the equator to move to the right in the northern hemisphere and to the left in the southern hemisphere. This is called the **Coriolis effect**. The combination of movement of air from the tropics toward the poles and the Coriolis effect means that winds generally rotate in a clockwise direction to the immediate north of the equator and counterclockwise (or anticlockwise) to the immediate south.

And as you have just learned, surface ocean currents often move in the same direction as the prevailing winds. When ocean currents rotate in these circular patterns, they are called **gyres**.

a. Try to model a gyre by having two people blow in opposite directions from opposite sides of your container.
b. Observe the water in the container. Which part of the water is moving the most? What happens to the water in the center?
c. Float something light, like ground pepper or a few small bits of paper, on the water and blow again to create your gyre. Where do the items end up?
d. Imagine there is something like an island or a continent in the way of your currents. How do you think that would change the way the water moves?
e. If you want, add something like a rock or another large item to model this.

If you want to learn more about weather, the *Ocean!* StoryMap includes links to a game you can play.

5. Examine the map in Figure 2.6. Which currents and gyres are nearest to you?

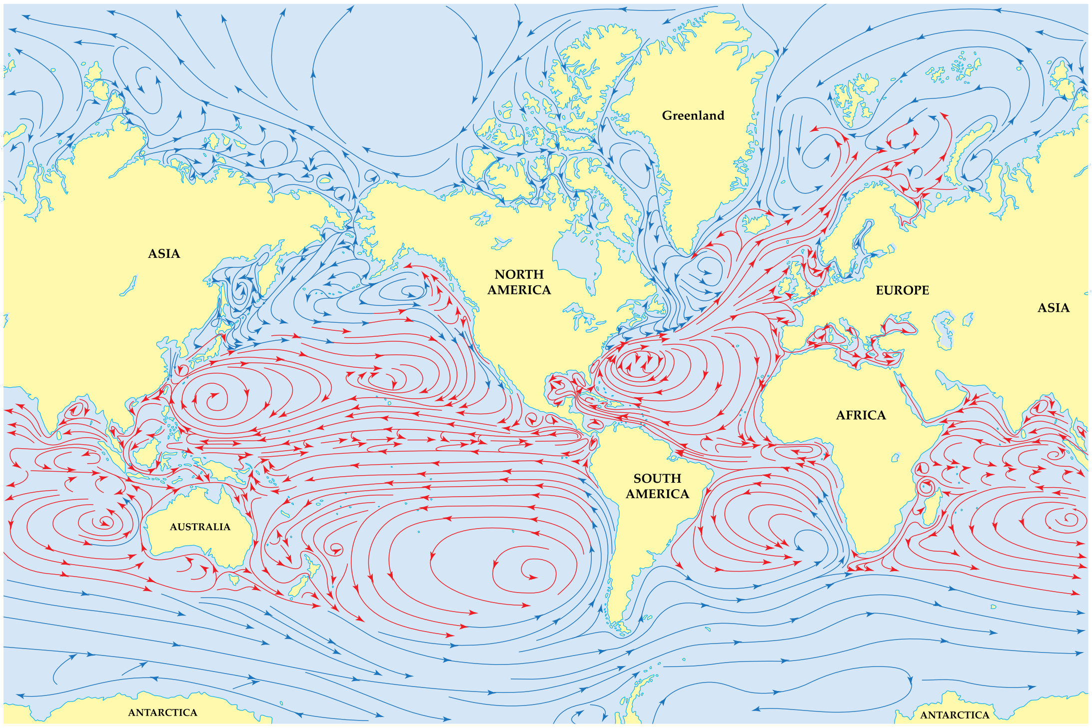

Figure 2.6: Map of surface currents on the ocean.

6. Using the map, pick a place across the world from you and try to trace how water that came from your community might make it to that place. If you learned in the Discover activity that your watershed empties into the ocean, start where it enters the ocean and try to find currents that could move the water from your community to a distant location.
7. Read Kālewa's thoughts about living on an island and how the water of Hawai'i connects with places far away.

Kālewa says . . .

The ocean connects us as humans. Even if we never meet each other in person, we can understand that the ocean's saltwater touches the shores of where we live, from continents to islands and **atolls**. The ocean provides us with the resources that sustain and nourish us; we play a role in the ecosystem and are responsible for caring for those waters.

Part 2 Task 1

From the lens of Native Hawaiian philosophy, the *Moana* (Pacific Ocean) is not just a vast expanse of saltwater but a living entity that binds, connects, and sustains all life. It is a bridge rather than a barrier. The ocean surface currents, or the pathways of the *Moana*, are like the veins of a body, pulsating and circulating life throughout, linking distant shores and the people who reside upon them.

Currents are the surface maps of open ocean voyaging harnessed by Pacific Islanders. Currents can indicate heat, cool, forthcoming weather, and even pockets of fresh water coming up deep from the ocean floor. In the ancient *a kānaka maoli* (Native Hawaiian) worldview, the *Moana* wasn't an empty expanse but a vibrant superhighway filled with signs, patterns, and destinations.

The ocean surface currents are intimately linked with the stars above and the year's seasons. *Kālai wa'a* (master navigators) would read the stars and understand the shifts in currents, winds, and even the behavior of marine life. Each current, each pathway on the ocean, carries with it a *mo'olel*o (story), a legend, a memory of ancestors who once voyaged these same routes.

8. With your team, discuss:
    a. How does the global water system connect people around the world?
    b. How do you think prevailing winds and ocean current gyres might affect shipping and airplane routes, weather systems, and the living things in the ocean?

Find out More!

Other things are also part of the movement of water, including tides, evaporation, underwater earthquakes and volcanoes, and deepwater currents. To learn more please visit the *Ocean!* StoryMap at bit.ly/OCEAN2030.

***Act:** How can we be a positive part of the global water system?*

Water has been mixing since there was water on Earth. But sometimes the movement of the water system moves other things as well. You will learn more about this in the next task. But first it is important to link what you learned about your local watershed and ocean currents.

1. Take out your *Ocean and Water System Diagram*.
2. Examine it and think about the relationship of your community's water system with rest of the planet. For example:
   a. How do people and other living things depend on the water system?
   b. What responsibility to keep water clean do people in one place have toward people and other living things in other places?
3. Examine your *Ocean Identity Map* *Hopes* and *Concerns*. Do you notice anything that might depend on the movement of water?
4. Read Kālewa's ideas about how to be a responsible **steward** of water. A steward is someone who cares for the environment and helps manage resources wisely.

Kālewa says . . .

From the Native Hawaiian perspective, *wai* (fresh water) is a profoundly sacred resource, deeply honored and safeguarded across generations. It embodies the essence of life, connectivity, and spiritual sustenance. For students aspiring to become responsible stewards of our global water system, here's some valuable guidance rooted in Hawaiian traditions and worldviews.

First, approach the care of water with reverence and thoughtfulness. It's essential to honor both traditional wisdom and modern scientific knowledge. Combining these approaches allows you to tackle the complex challenges surrounding water issues. Both ways of understanding are important for water conservation and watershed management.

Understand that the privilege of using water comes with *kuleana* (responsibility) to protect it. Use water mindfully, avoid wasteful practices, and advocate for policies prioritizing water conservation and quality over individual interests. Engage in sharing and listening to water stories from your community and worldwide. Water stories reveal the profound emotional and cultural connections people have with water, offering guidance and inspiration for sustainable actions.

While water challenges are global, solutions often originate at the local level. Always consider the broader implications of local water decisions. Engage with your community, educate them about the significance of water conservation, and initiate or participate in projects promoting sustainable water use and protection.

5. Think quietly to yourself: What is one thing you have learned that you think is important for people to understand about the global water system?
6. Choose one person, whether it is a friend, family member, or someone in your community. Explain to that person how your community's water system relates to the global water system. Make sure you make it clear how this connects to their daily life.
7. Ask the person to share their thoughts on how to be a steward of the water system.

Task 2: How do circulating water pollutants affect our planet?

The global water system moves **pollutants** as well as water. Pollutants are harmful or poisonous substances that pollute something such as water or air. In this task you will ***discover*** more about types of water pollutants and which ones might be coming from your community. You will investigate to better ***understand*** how pollution affects the **organisms** or living things in the ocean. Then you will ***act*** to improve the pollution problems you found.

Discover: *What pollution might be coming from my local area?*

There are many types of pollution that enter waterways. Some are easy to notice, such as a plastic container or bag floating on the water. Some are more difficult to notice, such as chemicals or **microplastics**. In this activity you will be exploring more about water pollution in your local area.

In Task 1 you learned about how water moves through your local area and, in many cases, into the ocean. In this task, first you will model how pollutants might mix into that water. Then you will search for evidence of pollutants in your area.

1. Read and follow the instructions in *Modeling Water Pollution*.

Modeling Water Pollution

How does pollution from your community end up in the ocean? Think back to your watershed investigation in Task 1. You noticed how water flows in your community. When pollutants enter streams or rivers, they may eventually reach the ocean.

You will now model how three different types of pollution might reach the ocean. You may want to take out a piece of paper or a notebook, or find some other way to record your results.

Creating Your Model

Before you start to model pollutants and how they enter waterways, you will first need to set up a watershed model. As you know from Task 1, watersheds can be very large and can include many different types of land and water. For this model, you will make things simple.

a. Take out the container of water you used in Task 1. This will be the waterway in your model.
b. Find a piece of waterproofed cardboard, plastic, or another item you can place on an angle next to your water container. This will represent the land area near the waterway. Figure 2.7 shows an example.

Figure 2.7: Example of the setup for a watershed model.

Marine Debris

Debris are small items or bits of garbage that end up being blown by wind or pushed by water into waterways. Debris can be many different types of things—pieces of plastic, cigarette butts, wrappers, or even fishing nets. Debris can be very tiny, such as a small paint chip, or large items like tires or refrigerators, or even an abandoned boat.

a. Find a piece of plastic, such as a plastic bottle, that is being thrown away.
b. Cut it into small pieces to represent debris.
c. Place a few small pieces of plastic directly in the water container. What do you think that might be modeling?
d. Place the other pieces on the angled surface.
e. Try to blow the plastic toward the water, to model wind. Does it reach it?

Part 2 Task 2

f. Use a watering can or cup of water in your hand and let it drip out to model rain. Can the rain wash the debris into the water?

Marine debris is sometimes thrown directly into a waterway or the ocean, like you modeled by putting the plastic directly into the water. Sometimes it is blown by wind or washed by rain into a waterway, like you just modeled.

Figure 2.8: Example of some marine debris.

Chemical Pollution

Chemical pollution is when chemicals from industry, farming, or households enter the water cycle. Chemical pollution includes manufactured chemicals, pesticides, detergents, oil, mercury, and other chemicals.

a. Use cooking oil or another liquid substance to model chemical pollution.
b. Place a small amount of your substance directly into the water. What do you think that is modeling?
c. Place a small pool of oil on your angled surface and place the surface next to your water container, like you did when you modeled marine debris.
d. Model wind. Does the oil get blown into the water?
e. Model rain. Does the oil get washed into the water?

Too often, chemicals are released directly into waterways through industrial waste, oil spills, or other sources. Even some types of sunscreen people wear can be chemical pollutants if they are washed off into the water when the people are swimming. Chemical pollution can also reach waterways by being washed into them.

Figure 2.9: Trying to clean up after chemical pollution from an oil spill.

Nutrient Pollution

Nutrient pollution is when excessive **nutrients** flow into the water supply. Nutrients are substances that help living things survive and grow. When thinking about nutrient pollution, nitrogen and phosphorus have been found to create the most problems. These nutrients can come from **fertilizer runoff**, waste from animals (like poop from dogs or pigs), or human waste such as from sewage treatment plants or septic systems. Runoff happens when nutrients like fertilizer wash off of fields or lawns when it rains. You will now model this.

a. Take a small cup of water and add food coloring to it.
b. Soak a sponge in the water and then place it on the angled surface.
c. Model rain over the sponge. What do you observe?

The colored water represents fertilizer that is used on farms and lawns. Fertilizer can run off when it rains, if too much is used. The more fertilizer used, the more likely it is to run off and enter the waterways.

Figure 2.10: Field with water running off which might contain nutrient pollution.

Part 2 Task 2

Like marine debris or chemical pollution, nutrient pollution can also directly enter the waterways, or be blown or washed there. If you want to model this, you can use salt or sugar to represent the nutrient pollution and then follow the directions for modeling marine debris.

In the Understand activity you will learn more about what happens to marine debris, chemical pollution, and nutrient pollution when they reach the ocean. For more information about these types of pollution, visit the *Ocean!* StoryMap.

2. With a partner, a small group, or your whole team, take a piece of paper and divide it into three columns.
3. Label the columns "Type of Pollution," "Description," and "Location."
4. Read *Water Pollution Sources Investigation* and together investigate sources of water pollution in your local area.

Water Pollution Sources Investigation

Picking Your Investigation Area

You will need to pick an area outside where you can move around. You can limit your investigation to the area just outside of where you are, such as a schoolyard, or you can go farther into your local community. If you have a waterway nearby, try to investigate that in addition to the land.

You will be investigating the three types of pollution you modeled: debris, chemical, and nutrient pollution. Direct observation may be the best way to find out things that might be polluting the waterways in your area. If you can, go outside and move around your investigation area and search for evidence of the three types of pollution.

Marine Debris

a. Search carefully for any items you can find that are small enough that they could be blown by wind or pushed by flowing water. For example, a food wrapper, a plastic bottle, a small bit of a car tire, a chip of paint, or a cigarette butt.

b. When you find an item, even if it is very small, write "debris" under *Type of Pollution*. Then describe the item in the *Description* column and write where you found it in the *Location* column.

c. If it is safe to do so, pick up the pollution and discard it in a trash or rubbish bin. Make sure you either wear gloves or wash your hands thoroughly afterward.

> ⚠ **Physical Safety Tip**
>
> It is helpful to stop pollution from entering waterways, but only pick it up if it is safe to do so. Ask an adult for guidance if you are unsure.

Chemical Pollution

a. Search carefully for evidence of chemical pollution. You might want to investigate:

- Any place you find pooled oil or other chemicals
- Leaking fluids from cars or dumpsters
- Any local industry that might be releasing chemicals into waterways

b. When you find any evidence of chemical pollution, write "chemical" under *Type of Pollution*. Then fill in the *Description* and *Location* columns.

> ⚠ **Physical Safety Tip**
>
> Do not touch or go near any chemical or nutrient pollution, it can be harmful.

Nutrient Pollution

a. Search carefully for evidence of nutrient pollution. You might want to investigate:

- Any waste you notice from animals
- Evidence that people are using fertilizer on their lawns or fields

b. When you find any evidence of nutrient pollution, write "nutrient" under *Type of Pollution*. Then fill in the *Description* and *Location* columns.

Alternative Investigation

If you are unable to move around outside, that is okay. Think carefully about things you have noticed when you have been moving around your community in the past. Make a note of the type, description, and location of any pollution you have observed.

5. Come together with your team and examine your papers to think about the pollution each group found.
6. Discuss with your team:
   a. What pollution did you find in your community during your *Water Pollution Source Investigation* that concerned you the most?
   b. Can you think of any way to stop this pollution from entering the waterways?
7. Add the types of pollution as new *Additions* to your *Ocean and Water System Diagram*. Connect them to the other elements in the system. For example, if you found debris that has been washed into a stream, draw an arrow connecting the debris addition with the stream element.
8. Examine your *Ocean and Water System Diagram* and think about how pollutants from your community can enter the global water system. Use the arrows you drew earlier between your *Removals* and *Additions*.

Understand: *What happens to pollution in the ocean?*

You now understand how water carries pollutants from your community, such as debris, chemicals, and nutrients, to the ocean. But what happens when those pollutants reach the ocean?

1. Go back to Figure 2.6 and with your team think about where pollutants from your community's watershed might go if they reach the ocean. Remember, water and pollutants often move and are mixed by currents. Can you trace a path for a pollutant you noticed during your *Water Pollution Source Investigation* to travel to another community across the world?
2. Read *At the Smithsonian*. If you were trying to understand pollution in the ocean, why do you think it would be important to sample beaches from around the world?

At the Smithsonian

Have you ever been curious about something? Martin Thiel is a scientist who is curious about ocean travelers and marine debris. An ocean traveler is a marine organism that attaches itself to a piece of floating marine debris and ends up traveling to a new location. Ocean travelers moving around on floating marine debris might become **invasive species** that can change ocean ecosystems if they are able to reach and colonize new coastlines. Invasive species are species that are introduced and are not native to a specific area.

But how could one person figure out what was happening with marine debris and ocean travelers all around the world? Martin knew he could only travel to a few beaches himself to investigate. But what if other people were curious as well?

Martin partnered with the Smithsonian and an organization from Chile called Cientificos de la Basura (Litter Scientists) to start a **citizen science** project called Ocean Traveler. Citizen science is a project in which anyone, whether or not they are professional scientists, can help gather scientific data.

Figure 2.11: Citizen science volunteers analyzing marine debris.

Part 2 Task 2

For Martin's Ocean Traveler citizen science project, more than 2,000 teachers, students, volunteers, and scientists all came together to gather and analyze marine debris samples from more than 470 beaches between July and December 2022! As they shared their data, these researchers learned a lot about marine organisms floating on debris around the world.

For more information about citizen science projects related to the ocean, visit the *Ocean!* StoryMap.

Part 2 Task 2

3. Take out your *Ocean Identity Map* and examine it. Do you notice anything in the ocean system that pollutants might harm? Turn to a partner and share your ideas.
4. Read *Ocean Organisms Investigation* and follow the directions.

Ocean Organisms Investigation

Pollution caused by humans has been found all over the ocean. Pollution has a huge effect on living things in the ocean. In this investigation you will start to explore some of those effects.

a. Have each team member pick one living thing from the *Marine Organism Table* in Figure 2.12 to represent. Or, if you prefer, choose a different marine organism that is not listed. Try to pick as many different organisms as possible within your team.

Organism	Description
Oyster	Oysters eat by filtering tiny living things, such as **phytoplankton** and **zooplankton**, out of ocean water. They live in fairly shallow areas near the coast and help keep the water clear.
Stony Coral	Stony corals usually live in the sunlit part of the ocean and have a **symbiotic** relationship with a type of **algae** that helps provide food for them. They also eat phytoplankton and zooplankton.

Figure 2.12: Marine Organism Table. (continued)

Organism	Description
Phytoplankton	Phytoplankton, also called microalgae, live in the upper part of the ocean. They are **photosynthesizers** and form the base of the food web in most of the ocean, as well as in fresh water systems. Their growth is often limited by available nutrients. They are an important food source for many things.
Sea Otter	Sea otters breathe air and frequently dive from the surface to deeper water. They eat sea urchins, crabs, fish, and many other things. They live near coasts and rely on their fur to keep them warm.
Ocean Fish	Fish in the ocean vary widely in size. Small fish eat zooplankton and small bits of organic matter, such as fish eggs. Larger fish eat smaller fish. Different species of fish live at different depths and locations in the ocean.
Seabirds	Seabirds are often found along the coast, but some can fly thousands of miles without stopping on land. Seabirds can eat a variety of ocean organisms, including plankton, krill, and small fish.
Humans	Humans usually live along the coasts and inland from the ocean. They use the ocean for shipping, swimming, and as a source of food. Humans frequently eat ocean organisms such as oysters, fish, crabs, and seaweed.
Sea Turtle	Sea turtles can travel long distances, but are often found in relatively shallow coastal waters. Different sea turtle species eat different things, including crabs, seagrass, algae, and jellyfish.
Seagrass	Seagrass uses photosynthesis to grow on the bottom of the ocean in relatively clear water. Seagrasses are an important food source for animals, such as sea turtles. They are also an important habitat for animals such as fish. Seagrass captures carbon and is important for the fight against climate change.

Figure 2.12: (continued)

Organism	Description
Whale	Whales are the largest animals in the ocean. They eat many different things, from tiny zooplankton called krill to other mammals. When they die, whales provide an important food source for animals that live on the ocean floor.
Zooplankton	Zooplankton are tiny organisms found near the surface of the ocean and are moved by ocean currents. They eat phytoplankton and other zooplankton and are eaten by many organisms, from oysters to whales.
Crab	Crabs can live in many places, from beaches to the relatively deep ocean floor. Crabs eat many things, including zooplankton, algae, fish, and dead animals. Fish, sea otters, and turtles all eat crabs.

Figure 2.12: (continued)

b. Use a piece of paper or poster board and create a sign for the organism you are representing. Write the name of your organism and use drawings or words to represent what you know about the organism. You can use the description in the *Marine Organism Table* to help you. Make your sign as visually pleasing as possible.
c. Move around and examine other people's signs. If you find an organism that seems to relate to the one you are representing, stand or sit nearby.
d. Create a line of organisms that are linked to one another and stand or sit in this line.

5. Choose one team member, or someone outside the team, such as a teacher or another student, to read *Pollution Threat 1*, *2*, and *3* aloud. If understanding information read aloud is difficult for someone on your team, find another way to communicate the information.
6. Pay attention as *Pollution Threat 1*, *2*, and *3* are read aloud. For each type of pollution threat, if you think this might harm the organism you are representing, raise your sign and share how this pollution might affect the organism you are representing.

7. After each pollution threat discussion, make a note on the back of your sign about how the pollution might affect the organism you are representing.

Pollution Threat 1: Marine Debris Information

As plastics and other debris enter the ocean, they can create many different problems.

Gyre Garbage Patches

You remember that ocean gyres often move in large circular patterns. Although at the edge of a gyre the current may be moving quickly, in the center the water is relatively calm and still. This means when debris drifts into the middle of an ocean gyre it can stay there for a long time. There are at least five major garbage patches in the middle of ocean gyres. The largest is the Great Pacific Garbage Patch.

The plastic and other materials in garbage patches can block the sun and prevent phytoplankton production. The marine debris can entangle many types of animals, making it difficult for them to swim, eat, or fly. Animals can also eat the plastic by mistake, which can choke them or block their digestive tract.

Microplastics

Microplastics are bits of plastic that are so small they can be hard to see. Often larger plastic debris is broken down into microplastics by the sun, water, and movement of the ocean. There are also microplastic sources from people, such as the small fibers that are shed when washing synthetic clothing (like fleece or polyester), small bits of rubber from tires, small paint chips, and small beads from cosmetics, like facial scrubs.

Microplastics are so small that some can enter the bloodstream or tissues of animals. Microplastics can be toxic and affect the health of marine organisms and people. Plankton, filter feeding organisms, and shellfish may ingest microplastics. Because they are then eaten by other organisms, those organisms eat the microplastics as well.

Stop and Assess

Consider the biggest marine debris threats to the organism you are representing. Is it blocking sunlight, entanglement, choking, microplastics, or something else? Have each team member raise their hand if they think their organism might be harmed by this pollution threat. Have them share why this harm might be a problem for their organism and other organisms linked to it.

Pollution Threat 2: Chemical Pollution Information

There are many chemicals that present a potential hazard to living things.

Oil Spills

One type of chemical pollution you may be familiar with is when oil is released or spilled into the ocean. This can harm any living organism in the area, but is perhaps most harmful to seabirds, whose feathers become coated with oil making it so they cannot fly, and mammals like sea otters, whose fur becomes coated in oil making it so it no longer keeps them warm.

Biomagnification

One problem with releasing toxic chemicals into the ocean is that they can cause harm in ocean organisms and the people who eat them. **Biomagnification** means that some chemicals are concentrated in larger animals that eat smaller animals. A big fish like a shark, which eats smaller fish, concentrates the toxic chemicals from each of the smaller fish it eats.

For example, the toxic chemical mercury is naturally released into the environment, but it also is released because of human activities, such as burning coal for energy and using mercury to help extract gold during mining. As mercury enters the environment, almost every living thing is exposed to a little bit of it. But the more mercury an organism is exposed to, the greater the risk of harm. Biomagnification means that sharks, other large predators, and humans have a greater risk of suffering harm due to mercury or other toxic chemicals.

Stop and Assess

Consider the biggest chemical pollution threats to the organism you are representing. Is it oil spills, biomagnification, or something else? Have each team member raise their hand if they think their organism might be harmed by this pollution threat. Have them share why this harm might be a problem for their organism and other organisms linked to it.

Pollution Threat 3: Nutrient Pollution Information

There is a threat of **dead zones** when too many nutrients reach the ocean, especially in areas like gulfs, bays, and inlets where water mixes more slowly with the open ocean. Seagrasses are also often affected by nutrient pollution because of the decrease in water quality.

Dead Zones

When too many nutrients reach coastal waters, they can cause phytoplankton, or single-celled algae, to grow quickly. There is sometimes so much algae that it is visible and can look green or red. Some types can be toxic.

The algae can grow so much that it blocks the sunlight from reaching the ocean beneath it. This can kill organisms that rely on photosynthesis. In addition, after the algae dies, large amounts of oxygen are used up during the decomposition process—so much that the levels of oxygen in the surrounding ocean can drop all the way to nothing. This area without enough oxygen dissolved into the water for most organisms to live is called a dead zone. Dead zones can lead to the death of fish, crabs, oysters, and anything else caught in the zone.

Stop and Assess

Consider whether nutrient pollution might be a threat to the organism you are representing. Is your organism likely to be caught in a dead zone or be unable to grow because of bad water quality? Have each team member raise their hand if they think their organism might be harmed by this pollution threat. Have them share why this harm might be a problem for their organism and other organisms linked to it.

8. Examine all your notes on the back of your sign. If you want more information about any of the pollution threats to the organism you are representing, you can do more research on your own. You could research using the *Ocean!* StoryMap, which includes links to websites where you can learn more, you could find books or magazines with more information, or you could talk to an expert.

9. Use your hands or another method to have each team member show how worried they are about the overall threat of pollution to the organism they have been studying. For example, if you think the threat is low, you could hold your hands low. If you think the threat is high, you could raise your hands high.

10. Consider everyone's thoughts about the seriousness of the threats of pollution to ocean organisms.

11. Turn to the front of your sign and add drawings or words to show the pollution threats this organism faces.

12. Place your sign on a wall or table.

13. Have everyone move around the room and examine everyone's sign.

14. Read Kālewa's experience with pollution and ocean organisms.

Kālewa says . . .

Pollution profoundly impacts our beloved ocean organisms and ecosystems. When toxins and plastics drift into our waters, they poison the fish, shellfish, and corals that have sustained our communities for generations. Our *ʻohana* (family) has witnessed the declining health of our precious *honu* (sea turtles) as they ingest plastic debris and are plagued with tumors from sewage runoff. The diminishing populations of *ʻopihi* (limpets) on the Hawaiian coastlines are often due to water contamination and excessive runoff. These changes disrupt the delicate balance of life in the *kai* (ocean).

As stewards of these waters, it is our *kuleana* (responsibility) to protect and restore the ocean for future generations. By embracing our ancestral wisdom, we strive to *mālama i ke kai* (care for the ocean) and to inspire others to join us in this sacred mission for the well-being of our *ʻāin*a (land) and our people for the generations yet to come.

14. Come back together as a team and discuss:
    a. Which pollution threats do you feel most concerned about?
    b. Add that information to the *Concerns* circle on your *Ocean Identity Map*.

Act: *How can we limit the ocean pollution caused by our community?*

You have learned about how pollution from your community enters the ocean and how it affects ocean organisms. Now you will decide what you would like to do to take action on the problems you have identified.

1. Consider the three types of pollution from the Understand activity and have each member of your team vote on the type of pollution they most want to prevent.
2. Examine the results. Is there a clear sense of which type of pollution your team would like to take action on? If not, discuss your ideas further until you can find **consensus**—a balanced decision that works for everyone. If you are having a hard time deciding, you can use your *Ocean Goals* or your *Hopes* or *Concerns* on your *Ocean Identity Map* to help guide you.
3. Examine your *Ocean and Water System Diagram*. You have listed the pollution you found as *Additions*. Use the diagram to think about how you can either prevent these *Additions* from reaching the ocean or remove them once they are in the ocean.
4. Have each group member take out a small piece of paper. Now that you have chosen a type of pollution to focus on, you will need to decide what you will do to help prevent it. Write down one action idea. For example, you could:
    a. Organize a cleanup of an area around your community.
    b. Plant plantings near the edges of a waterway to help filter runoff before it enters the waterway. Or create a low area with plants to allow water to slowly seep into the ground.
    c. Create signs or other ways of sharing with people that a waterway and any pollution it carries leads to the ocean.
    d. Talk to businesses or your local government about pollution you noticed.
    e. Educate others about a type of pollution and how it affects people and ocean organisms, using the signs you created.
    f. Come up with another idea that will help address your pollution problem.
5. Kālewa also shared these ideas to consider.

Kālewa says . . .

It all starts with our choices as humans, as consumers, and as participants in this world. Most of the world's ocean pollution is plastic, from fishing nets to toothbrushes, water bottles, and lighters. You have more power than you might think. Know that every small action adds up, and you can be a part of the solution. Start by reducing single-use plastics like water bottles, straws, and bags. Instead, grab a reusable water bottle and a cloth tote bag to use every day. Connect with and support organizations doing watershed and beach clean-up events. Lastly, support businesses and policies that prioritize eco-friendly practices. Your choices and voice matter!

6. Share your ideas with your teammates. Do other people have different ideas? Listen carefully to one another while you explain your perspectives about why different actions would be important. Try to build a team consensus about the action you will take.
7. With your teammates, make a plan to take action. Create a list with the steps you need to take to carry out your action. Be sure to consider:
    a. If you need to share information, where, when, and with whom will you share it?
    b. If you need to do something, what and where do you need to do it?
    c. If someone outside your team needs to be involved, how will you communicate with them?
    d. If you need to get any materials, when and where will they be gathered?
8. Think about how each team member will help. Put their names with the steps they would like to help with.
9. Title a sheet of paper "Action Plan" and record the following:
    a. The steps your team would like to take
    b. The order of those steps
    c. Who will help with each step (it might be more than one person)
    d. When and where you will take these steps

e. Partners or others you will involve

f. How you will communicate your action plan to the community

10. Think about what you will do if your plan doesn't work or you run into another problem. For example, what will you do if an adult in your community says you need permission to do something? Record these ideas as part of your action plan.
11. Remember to create an **inclusive** action plan. Being inclusive means everyone on your team can participate in some way. You may need to make changes to the plan so that everyone feels safe, comfortable, and able to help. Those changes are okay! They are part of being a good teammate and taking sustainable action.
12. Put your plan into action.
13. Afterward, reflect on your action:
    a. What seemed to go well?
    b. What was hard?
    c. Were you able to make the changes you thought you would be able to make?
    d. Will you keep going with your plan or are there things you would do differently in the future?
14. Save your *Ocean and Water System Diagram*. You will need it in Part 7.

Congratulations!

You have finished Part 2.

Find out More!

For additional resources and activities, please visit the *Ocean!* StoryMap at bit.ly/OCEAN2030.

Glossary

This glossary can help you understand words you may not know. You can add drawings, your own definitions, or anything else that will help. Add other words to the glossary if you would like.

Algae: A photosynthetic aquatic plant; there are many different types, from one-celled organisms to what is commonly called seaweed

Atoll: A ring-shaped coral reef, island, or group of islands

Biomagnification: How chemicals are concentrated in larger animals that eat smaller animals

Chemical pollution: When chemicals from industry, farming, or households enter the water cycle

Citizen science: A project in which anyone, whether or not they are a professional scientist, can help gather scientific data

Consensus: A balanced decision that works for everyone

Coriolis effect: Deflection of air to the right or left due to the Earth's rotation

Cryosphere: Places on Earth where water is always frozen

Currents: Water flowing in a specific direction

Dead zone: An area that does not have enough oxygen dissolved in the water for most organisms to live

Debris: Small items or bits of garbage that end up being blown by wind or pushed by water

Downstream: Father away from the source of water; the direction that water flows toward

Fertilizer: A kind of nutrient to help plants grow

Groundwater: Water found underground in the soil or in spaces between rocks

Gyres: Ocean currents that move in circular patterns

Inclusive: Everyone can and is welcome to participate

Invasive species: Species that have been introduced and are not native to a specific area

Marine debris: Plastic or other non-biodegradable items that are polluting the ocean; they can range from tiny microplastics to floating nets to large items such as abandoned ships

Microplastics: Bits of plastic that are so small they can be hard to see

Nutrients: Substances that help a living organism survive and grow

Nutrient pollution: When excessive nutrients flow into the water supply

Ocean basin: A geographic area within the larger ocean, like the Pacific Ocean

Organisms: Living things

Photosynthesizers: Plants that take in sunlight and carbon dioxide to make food, and release oxygen in the process

Phytoplankton: Photosynthetic organisms living in the upper part of the ocean that are moved by ocean water; also called microalgae

Pollutants: Harmful or poisonous substances that pollute something such as water or air

Prevailing winds: Important winds that blow in the same general pattern and direction

Runoff: Water that runs off roofs, driveways, sidewalks, lawns, and agricultural lands, often picking up chemicals and soil in the process

Steward: Someone who cares for the environment and helps to manage resources wisely

Source: Where a body of water came from

Surface currents: The horizontal movements of water near the ocean's surface

Symbiotic: A description of relationship between species which benefits both

Tributaries: Smaller streams or rivers that join larger bodies of water

Tropics: The region surrounding Earth's equator; the region stretches from the Tropic of Cancer to the Tropic of Capricorn

Upstream: Nearer to the source of water; the direction that water flows from

Water cycle: The process of evaporation, condensation, and precipitation that moves water around Earth and its atmosphere

Watershed: An area of land where all the water flows together into the ocean

Waterways: Flowing bodies of water, such as a river or stream

Zooplankton: Tiny organisms found near the surface of the ocean and moved by ocean water; they eat phytoplankton and other zooplankton

