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OCEAN!

Part 5:

Ocean and Food

SUSTAINABLE DEVELOPMENT GOALS

developed by

Smithsonian
Science Education Center

in collaboration with

iap SCIENCE HEALTH POLICY
the interacademy partnership

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PART 5: OCEAN AND FOOD

Find out More!

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

Part 5

Planner

Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 1: How are the organisms of the ocean linked in a system?					
Discover	Use existing knowledge of the ocean to create ocean food web diagrams and assign trophic levels to them.	• Paper • Pen or pencil		25 minutes	165
Understand	Play the Level Up Game and reflect on trophic levels and system removals.	• A pack of playing cards, or homemade cards from cardstock for each player • Items for the table, such as spoons or chunky markers • Class board or piece of paper and something to write with that can be erased	*Ocean and Food System Diagram*	25 minutes	169
Act	Consider baseline shifts in ocean ecosystems and decide on potential actions.	• Paper • Pen or pencil	*Ocean and Food System Diagram* *Food Web System Diagram*	20 minutes + action time	173

Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 2: How can people be a sustainable part of ocean food webs?					
Discover	Investigate how living things from the ocean are used in your community.	• Paper • Pen or pencil	*Ocean and Food System Diagram*	20 minutes + investigation time	176
Understand	Use data and a game to understand the problem of unsustainable fisheries and investigate possible solutions.	• 3 types or colors of items, such as paper clips, small coins, small blocks, or pieces of popcorn • Class board or piece of paper and something to write with • 1 die or 6 pieces of paper and a small container		30 minutes	179
Act	Learn more about fisheries policies and determine how you will take action.		*Ocean and Food System Diagram* *Ocean Identity Map*	20 minutes + action time	184

Meet Your Research Mentor, Suam Kim

Meet Dr. Suam Kim. Suam (pronounced *SOO-ahm*) will be your research mentor to help you understand more about food and food webs in the ocean.

Suam studies fish populations, including the effect of climate change on marine ecosystems. He has a doctoral degree in **fisheries** oceanography. As a professor for many years, Suam taught and mentored university students interested in fisheries. He has also served in the scientific community as an editor, researcher, and administrator. Since Suam is now working with you, it is important to understand who he is.

Suam's Identity Map

Is a husband, father, and grandfather

Thinks about the coexistence of nature and humans

As an emeritus professor, provides advice and lectures

Loves his family, friends, and students

Lives in Seattle, Washington, USA

Interested in recruitment variability in fish populations

71-year-old male

Korean

Wears glasses

Alpine club member

Doctorate in fisheries and oceanography

Very quiet and friendly to everyone

Enjoys short walks with his wife at the park or on trails

Wants to learn how to sing opera and play the piano

Loves nature including the sea

Polar issues always attract his attention

Shares views on environmental protection with his family

Is trying to spend more time with his family

Task 1: How are the organisms of the ocean linked in a system?

Organisms in the ocean are linked through **ecosystems**. An ecosystem is a community of interacting living and non-living things within a physical environment. The ocean has many ecosystems, such as salt marshes, coral reefs, kelp forests, mangroves, and hydrothermal vents. **Nutrients**, or what **organisms** need to nourish themselves, are always moving within and between ecosystems. The system of these nutrients moving among organisms is called a **food web**. A food web shows how organisms gain energy in the form of nutrients by consuming other organisms.

In this task you will ***discover*** more about what you already know about ocean ecosystems. Then you will play a game to better ***understand*** how nutrients cycle in the ocean. Finally, you will consider different threats to ocean ecosystems and ***act*** to help manage them.

Before you begin the rest of Part 5, think quietly to yourself about Suam's identity map and compare it to your *Personal Identity Map*.

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

Throughout Part 5 you will notice Suam 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: *What do we know about ocean ecosystems?*

Even if you do not live near the ocean, you probably have knowledge about the ocean from many different **sources**. A source is where you get your information from. Even if a source is very familiar or designed for people younger than you, it can be an important part of what you know about the ocean and its living things.

1. Sit in a circle with your team or with a smaller group.
2. Pick one teammate to take notes.
3. Have another teammate go first and share an example of an organism, or living thing, from the ocean that is part of a saying, song, movie, story, book, cartoon, other form of artwork, or a similar source. These sources can be designed for young children or older people. Have the person sharing also share their source.
4. Have the note taker write down the organism and the source.
5. Go around the circle and have each person share a different organism and the source their information is from. Make sure the note taker writes all the organisms down. You can use the same source more than once if you have a different living thing to share.
6. Keep going around the circle until someone runs out of ideas.
7. Skip anyone who is out of ideas and keep going around the circle until everyone is out of ideas or seven minutes have passed.
8. If you want, add your list of sources to the *Connections* on your *Ocean Identity Map*. These sources show the different ways we connect to the ocean through our experiences with books, arts, stories, and more.
9. Examine the list of organisms and silently, by yourself, pick five organisms that you think might be part of the same ecosystem.
10. Take out a piece of paper and title it "Food Web." On this paper draw a use these organisms as elements to draw a system diagram of the ecosystem's food web. Draw and label arrows to show the food relationships between the different organisms. For example, one organism might eat another one.
11. Place each *Food Web* on a wall or a table.
12. Move around and examine the other *Food Web*s carefully. Be sure to notice:
    a. Are there any living things you used in your food web ecosystem that were also part of other ecosystems?
    b. Do any *Food Web*s show a different place or ecosystem of the ocean?
    c. Are there any things that are missing from your food systems because they are too small for people to see?

13. Discuss with your team:
    a. What are the different parts you noticed in the *Food Web*s?
    b. Are all parts of the ocean represented? If not, why do you think some ecosystems are missing?
14. Read *Assigning Trophic Levels* and follow the directions to add trophic levels to your *Food Web*.

Assigning Trophic Levels

One way scientists analyze food webs is by assigning **trophic levels**. A trophic level shows how far an organism is from the initial source of energy. For most food webs on Earth, the initial source of energy is the Sun. Organisms that use **photosynthesis** to get energy from the Sun, sometimes called **producers**, are a trophic level 1. Organisms that get their energy by eating producers are a trophic level 2. Organisms that get their energy by eating trophic level 2 organisms are a trophic level 3. Food webs often continue to up around trophic level 5 or 6. **Consumers** are organisms with a trophic level higher than 1. Figure 5.1 shows an example.

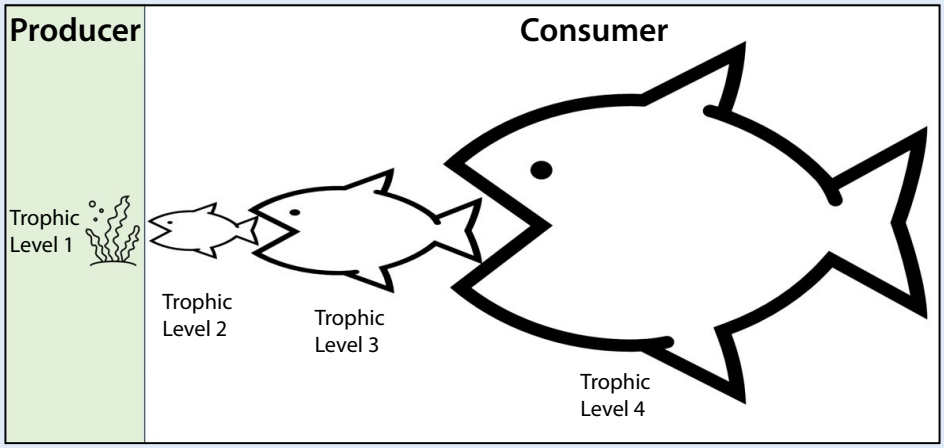

Figure 5.1: This diagram shows the relationship between trophic levels and producers and consumers.

Some organisms are between trophic levels. For example, if a large fish gets half of its energy from trophic level 2 organisms and half from trophic level 3 organisms, the trophic level of the fish would be 3.5. Figure 5.2 shows an example.

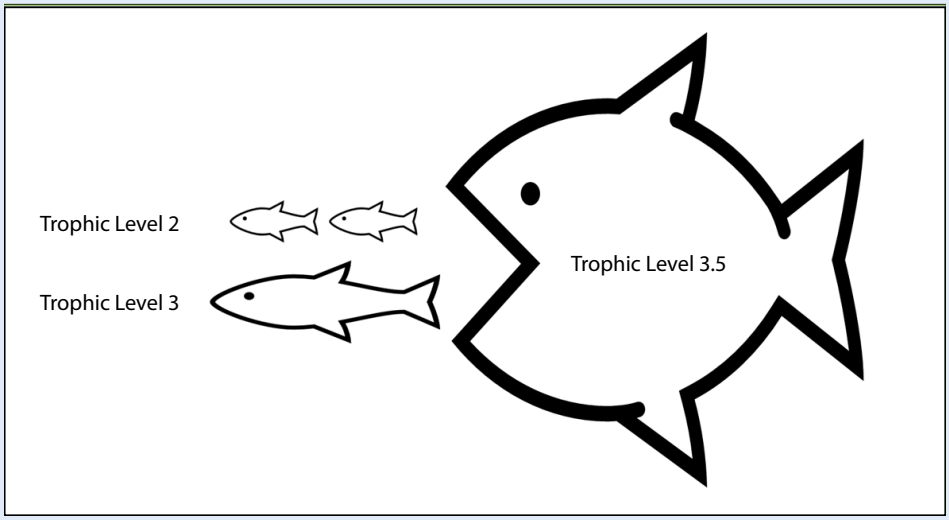

Figure 5.2: This diagram shows what a fish with a trophic level of 3.5 consumes.

Examine your *Food Web*. Write a number next to each organism to show what you think its trophic level might be. Are there any trophic levels missing?

15. With your team, take out a piece of paper or open a digital document and label it "Ocean and Food System Diagram." You can use Figure 1.6 from Part 1 if you need a system diagram example.
16. Add the elements "Sun," "Producers," "Consumers (Trophic Level 2)," "Consumers (Trophic Level 3)," and "Consumers (Trophic Level 4)."
17. Within the box for each element, add the names of the organisms that should be there. For example, you might add "phytoplankton" to *Producers*. Use your team's *Food Web*s with the trophic levels marked to help you. Don't worry if you are not certain about trophic levels—just do your best.
18. Add the element "Decomposers." **Decomposers** are organisms such as bacteria that break down dead organisms and waste materials from the other trophic levels and make nutrients available for producers. Add any decomposers you can think of to the *Decomposers* element on your *Ocean and Food System Diagram.*
19. Draw and label arrows to show how energy and nutrients move between elements. For example, you could link "sun" and "producers" with an arrow labeled "the energy from the sun is used in photosynthesis." Remember, some elements may relate to several other elements.

20. Think carefully about what is missing. Are humans currently part of your *Ocean and Food System Diagram*? Read Suam's thoughts about the relationship between humans and ocean ecosystems.

Suam says . . .

Humans are part of Earth's ecosystems. However, as human activities become so immense and powerful, Earth's ecosystems, including the ocean, are often harmed. We must learn how to coexist in balance with the ocean and other ecosystems.

21. If humans are not already an element in your *Ocean and Food System Diagram*, add them now. Then add and label arrows to show their relationships with the other elements in your diagram. Don't worry if you don't know about all the relationships. You will learn more in the rest of Part 5.

***Understand**: Why are all parts of the ocean ecosystem important?*

All parts of food webs are important to keep an ecosystem healthy. In this activity, you will play a game to model the way nutrients flow through the food web of the ocean. Then you will think about how changes to elements of the system might affect the system itself.

1. Read the *Level Up Instructions* and play the game.

Level Up Instructions

You will play a game to show how nutrients and energy cycles through different trophic levels in the food web.

Getting Ready

You will need between 4 and 13 people to play and a table where everyone can sit.

Gather your items. You will need:

- A pack of playing cards, or you can create a set using cardstock. Cut the cardstock into rectangles of the same size. Make one set of four cards for each player in the game. On each set of four, draw the same recognizable symbol, such as a star or a circle.
- Items for the table: Choose items that are easy to grab and have no sharp edges, such as spoons or chunky markers. You need one item less than the number of people playing.
- A class board or piece of paper and something to write with that can be erased. Draw a grid and write all the players' names in the column on the left. Across each of the top columns write or draw: "Phytoplankton (T1)," "Zooplankton (T2)," "**Crustacean** (T3)," "Small fish (T4)," "Big fish (T5)." The T stands for trophic level. Figure 5.3 shows an example of the game scoring grid. You can also use a small item like a paper clip to keep track of which trophic level a person is on, if you prefer not to have to erase the board after each round.

	Phytoplankton (T1)	**Zooplankton (T2)**	**Crustacean (T3)**	**Small fish (T4)**	**Big fish (T5)**
Name 1					
Name 2					
Name 3					
Name 4					

Figure 5.3: Example of a game scoring grid.

Game Objective

In this game, each player starts as a phytoplankton and tries to become a big fish. The cards represent nutrients and energy you are gathering. You level up each time you are the first to grab an item from the middle of the table. You can grab an item from the middle of the table when you either have four matching cards or someone else has started grabbing an item because they have four matching cards.

Game Play

a. Place your items in the center of the table.
b. Have one person shuffle all the cards and deal four to each player. You can look at your cards, but do not show them to others.
c. The dealer says "pass" and everyone passes one card to the right. You can pass whichever card you want.
d. Keep passing until someone gets four matching cards and grabs an item in the middle.
e. Now, everyone tries to grab an item from the middle.
f. Check who has an item from the middle. This is how you score:
    - If you were the first one to grab an item, you move up one trophic level.
    - If you grabbed an item after the grabbing started, you stay on the same trophic level.
    - The person who did not get an item moves down one trophic level—unless they are a phytoplankton, in which case they stay a phytoplankton.
g. Make a note of everyone's new trophic level on your grid and then shuffle the cards and start a new round.
h. Keep playing until someone becomes a big fish (T5).

Variations

Decomposer

Once you have played a few rounds of *Level Up*, you can add in an additional rule to show how nutrients cycle. As you know, after organisms die, they decompose and those nutrients cycle back through the system. Choose one or two card types (such as aces with playing cards or stars if you made your own). If a player gathers four of that card type, not only do they get to grab an item from the middle of the table, but they also get to act as a decomposer and send one player back from the trophic level they are on to the beginning trophic level, phytoplankton.

Adding Humans

People are a big part of ocean food webs and nutrient cycling. People tend to remove organisms and nutrients from the food web. To show this, choose two to three card types (such as kings with playing cards or circles if you made your own). If a player gathers four of that card type, not only do they get to grab an item from the middle of the table, they can also "fish out" another player and remove them from the game. If someone is removed from the game, make sure you also remove an item from the middle of the table.

2. After finishing the game, discuss with your team:
    a. In what way do you think the game was a good representation of how nutrients cycle through ocean food webs?
    b. In what way did it not represent what happens in real life?
    c. If you completed the *Adding Humans* variation, how did that affect the game?
3. Add any new relationships or elements you noticed to your *Ocean and Food System Diagram*.
4. Read *System Removals*.

System Removals

You may have drawn some ***Additions*** to a system diagram in other parts in this guide. *Additions* are things that are added to a system. Ocean systems are changing because of *Additions* such as pollution, additional heat, and excess carbon dioxide.

Systems can also change because of ***Removals***, when things are taken out of them. Think about any *Removals* that involve people taking things out of an ocean system.

5. With your team, add at least one *Removal* caused by people on your *Ocean and Food System Diagram*. Figure 1.7 shows an example of how to do this, if you need help. Discuss how you think this output might change the system.

Act: *How can I act to keep ocean ecosystems healthy?*

Ocean ecosystems may be changing, but sometimes it is difficult to recognize how much they have changed. A **baseline** represents the balance of a system at a certain point in time. If a system has a lot of *Removals*, the baseline might be different than it was in the past.

Do you think it's always obvious when a baseline moves or shifts over time? For example, what if hundreds of years ago, before we started studying food webs, there was a lot more **biomass** in the ocean, but it has now been removed through fishing or other ways? Biomass is the total quantity or weight of all living things in an area. It may not be clear what a healthy ocean ecosystem might be like if the baseline has shifted a lot.

1. Read what Suam says. Think of one way a healthy ocean might be related to people in your community.

Suam says . . .

Healthy oceans are critical for the survival and prosperity of humanity. The ocean is connected and dynamic. Understanding the ocean is essential to understanding the entire ecosystem of Earth and to improving human society. Rising sea temperature, acidification, rising sea levels, **hypoxia,** and increased storms caused by climate change are major risks for fisheries.

2. Turn to a partner and discuss:
   a. Do you think people would know if ocean ecosystems were under threat or if the baseline of the ocean ecosystem had shifted?
   b. Is it possible that there were a lot more fish in the ocean in the past?
   c. What do you think we might study to find out? For example, how might written histories, archaeological records, or stories passed down over generations help people identify whether the baseline of biomass in the ocean has shifted?

3. Read *At the Smithsonian* to learn more about another way of learning whether a baseline shifted over time. How might different natural collections help answer important questions about change over time?

At the Smithsonian

To understand the present, sometimes you need to study the past. Dr. Madison Willert wanted to find out how recent threats to marine ecosystems, such as overfishing and dredging, might be changing food webs. She knew she could research what food webs are like today, but how could she find out whether they had changed?

The large collection of preserved fishes at the Smithsonian National Museum of Natural History provided the answer. Madison found that there were even fishes preserved by naturalists from the 1800s!

Madison used a special method called **stable isotope analysis** that allowed her to figure out the trophic level of a fish using chemicals she found in a sample of its tissue. Then she compared the trophic levels of the fishes from the collections to fishes currently being caught in coastal Massachusetts, a place that has a long history of destructive fishing methods.

Figure 5.4: Madison is taking a tissue sample from a fish from the Smithsonian National Museum of Natural History's collection of preserved fishes.

Madison found that older fishes from the collections had higher trophic levels than the same species caught today. She discovered that New England food webs are becoming simpler, which means destructive fishing methods in this area have hurt the health of the overall ecosystem.

4. Discuss with your team: How do you think having multiple things adding stress to ocean ecosystems might affect the food web system?
5. With your team, choose one of your team's *Food Web*s that shows an ocean ecosystem that is important to your community. Why is it important and how would it affect your community if that ecosystem had problems?
6. Pick one potential **stressor** to organisms in that ocean ecosystem. A stressor is something that causes stress on a system. If you have worked on other parts of the *Ocean!* Guide, use what you have learned about problems such as pollution, a warming ocean, or ocean acidification to help you consider potential stressors.
7. Discuss what you could do to help limit that stressor. For example, you could:
    a. Research to find out more about the changes
    b. Make others aware of the stressor
    c. Change your own behavior to make things better
8. With your team, put your idea into action.

Task 2: How can people be a sustainable part of ocean food webs?

People play an important role in changing ocean ecosystems. In addition to creating some stressors to ecosystems, such as ocean warming and acidification, people also remove a lot of biomass from the ocean. Fisheries remove biomass, but people also harvest other organisms, such as seaweed, from the ocean. Since living things grow, develop and reproduce, removing some biomass will not significantly change the baseline. But if the baseline is changing over time, it is a sign that the current human activities are not **sustainable**.

In this task you will ***discover*** how you and others in your community use living things from the ocean to meet your needs. Then you will investigate to ***understand*** the challenges to a sustainable fisheries system. Finally, you will consider different fisheries policies and ***act*** to support those you think are best for a sustainable ocean food web.

Discover: *How does my community use living things from the ocean?*

People use living things from the ocean for many different things—food, medicines, health and beauty items, and other products. Communities have important relationships with the ocean through these products.

1. Discuss with your team: What are some things from the ocean that people might eat or use in other ways? Be sure to consider different types of living things people eat in your culture and other cultures you might know about, and ways in which other products might use ocean organisms.
2. Read *Ocean Product Investigation* and follow the instructions.

Ocean Product Investigation

Move around your home and search for ways you and others in your household might be using things from the ocean. If you find an example, write it down or take a picture to share with your team. If you prefer, you can also go to a grocery store and search there.

Some items you may immediately recognize as coming from the ocean. For others, you may need to examine the ingredients list carefully. In addition to whole ocean animals, such as fish, crabs, mussels, and shrimp (prawns), you also might find products from those animals, such as fish oil. You also might find products from ocean plants and algae. Sometimes these might be listed with familiar names such as kelp, algae, or seaweed. Other times the names might be less familiar, such as agar, carrageenan (also known as E407), or alginates. Search in different rooms and among different types of products.

Make a note of any products you find. Make sure to consider:

- Food: Search for any refrigerated or unrefrigerated food, such as fish or seaweed, that might come from the ocean. Remember to examine the ingredients of sauces and condiments. Plant milks, ice cream, yogurts, jellies, and salad dressings frequently have ocean products in them.
- Health and beauty: Search for any lotions, makeup, toothpastes, soaps, shampoos, or other cleansers with ocean products in them. Some products, such as sea sponges, may have also come from the ocean.
- Medicine: Search for any vitamins or medications.
- Garden: Search for any fertilizers or related items.

3. Share your results with your team.
4. Examine your *Ocean and Food System Diagram*. Are there more relationships between *people* and the other elements in your ocean food web that you found during your ocean product investigation? If so, add and label arrows to show those relationships.
5. Divide your team into four groups.
6. Have each group discuss from one perspective the relationship between people and things they use from the ocean. For example:
    a. **Social** perspective: What are the social habits around food, health and beauty products, and other items that might influence how people in your local community use things that are originally from the ocean?
    b. **Environmental** perspective: What are the environmental reasons that might influence how people in your community use living things from the ocean? For example, do people try to use things from the ocean to put less stress on land ecosystems? Or do they try not to eat fish that are in danger of being overfished?

c. **Economic** perspective: What is the economic relationship between people in your local community and the ocean? Are there people in your community who use things from the ocean to earn money?

d. **Ethical** perspective: How do people's ideas about what is right and what is fair influence how they use living things from the ocean?

7. Share your group's answers with the rest of your team. Discuss as a team whether you can think of anything that might help people make more sustainable choices about the ocean products they use.
8. Read Suam's thoughts about changes in fishing technology. How do you think changes in technology influenced the baseline biomass of the ocean?

Suam says . . .

At the end of the 1800s, most people thought there were so many fish in the sea that overfishing was not possible. However, as demand increased in the 1900s, things changed significantly. New technologies, such as innovations in fishing gear and acoustic fish finders, made it easier to catch many fish quickly. In addition, fishing with bottom **trawlers** causes great harm to the habitats of fish, making it difficult for fish stocks to recover. A technique called purse seine fishing can catch and kill many unwanted organisms, known as **bycatch**. This wasted bycatch, which often includes seabirds, sea turtles, dolphins, whales, sharks, and rays, can impact species biodiversity.

Figure 5.5: A commercial fishing vessel.

Today, marine fisheries resources have been greatly affected by overfishing. By catching too many fish, many global fisheries are in a state of rapid decline or collapse.

***Understand**: How could ocean resources be used more sustainably?*

You have learned about how people use living things from the ocean and how the ecosystems in the ocean have shifted over time. Biomass is constantly being produced in the ocean as plants photosynthesize and animals grow. At the same time, biomass is also being removed through fisheries and other uses of ocean products. Some organisms grow quickly, but others grow more slowly. Sustainable fisheries should not remove more biomass from the ocean than can keep growing back.

1. Examine the graph in Figure 5.6, which shows the percentage of decline in **predatory fish biomass** since 1910. Predatory fish biomass is the total quantity of fish in the ocean that eat other fish for nutrients.

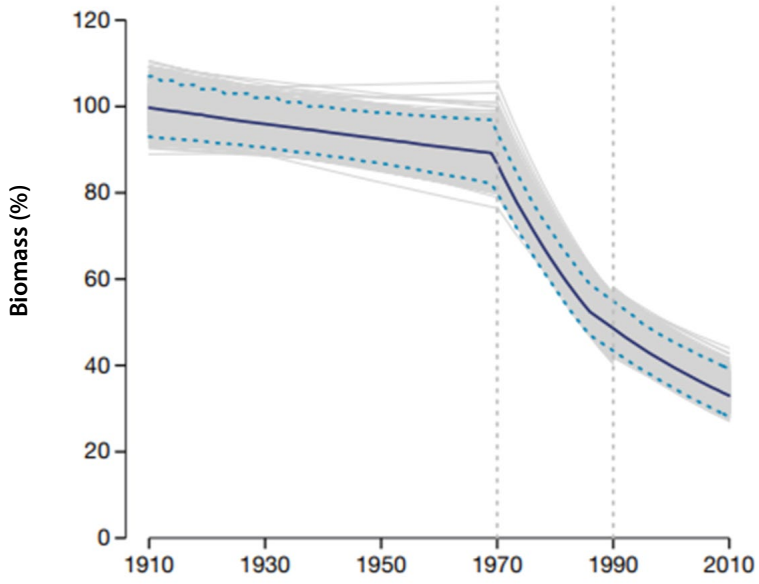

Figure 5.6: Global biomass trends for predatory fish from 1910 to 2010[1].

2. Divide a piece of paper or a class board into three columns and label them "Notice," "Think," and "Wonder." Answer the following questions:

a. Notice: In the first column, write or draw what you notice about the data shown in the graph. What is the baseline used in the graph for comparison?
b. Think: In the second column, write or draw what you think is causing the changes you noticed in the graph. If you started tracking fish in 2000 and made that your baseline, what do you think you might miss about changes to the predatory fish biomass in the ocean?
c. Wonder: In the third column, write or draw what you wonder about changes that might happen in the future.

3. Read *Sustainable Fisheries Game Instructions* and play the game.

Sustainable Fisheries Game Instructions

You will play a game to explore challenges to finding a sustainable future for fisheries and think about possible ways to help.

Getting Ready

You will need between 3 and 10 people to play the game. Players should sit in a circle around a table or common area.

Gather your items, you will need:

- Three different types or colors of items that are easy to pick up (paper clips, small coins, small blocks, small pieces of food such as popcorn, or other small items) to represent three types of sea creatures. For each person in your group you will need two of item 1, four of item 2, and six of item 3.
- A class board or piece of paper and something to write with. Write down each player's name to keep score.
- A die to roll. If that is not possible, write the numbers 1 to 6 on small pieces of paper and put them inside a container.

The middle of the table is your ocean. In the ocean place one big fish (item 1), two small fish (item 2), and three crustaceans (item 3) for each player. Set the remaining items to the side.

Game Objective

You will play the role of a fisherperson. Your goal is to reach 50 points.

Scoring

For each big fish you catch, you score 5 points.

For each small fish you catch, you score 3 points.

For each crustacean you catch, you score 1 point.

Game Play

a. Choose someone to start. That person will roll the die or pick out a piece of paper with a number on it. If they get a 6, they can catch anything in the middle of the table and move it to their area. If they get a 4 or 5, they can choose either a small fish or a crustacean. If they get a 1, 2, or 3, they can only catch a crustacean.
b. Keep track of the points for each player. Also keep track of which round you are on. (A round is over when each person has played once.)
c. After the third round, all the fish in the sea will reproduce.
    - For every big fish left in the ocean, add one more big fish.
    - For every small fish left in the ocean, add two more small fish.
    - For every crustacean left in the ocean, add three more crustaceans.
d. Continue playing.
e. When a player reaches 20 points, they can choose to use those points to buy a trawler. A trawler is a type of boat that pulls a net deep through the ocean that catches a lot of fish at once. If you choose buy a trawler, remove 20 points from your score to pay for it. Trawler rules:
    - If a player with a trawler gets a 4, 5, or 6, they can take two small fish at one time.
    - If they get a 1, 2, or 3, they can take five crustaceans at one time.
    - A player with a trawler can also choose to use their turn to steal a fish from another player.
    - If you do not buy a trawler as soon as you get 20 points, you can always buy one later (when it's your turn), as long as you have 20 points.
f. Continue playing. After eight rounds, all the fish in the sea will reproduce again, following the same rules from step c.

g. Continue playing. After 15 rounds, they will reproduce again.
h. The first person to reach 50 points is the winner! Other players can continue playing to see who takes the longest to reach 50 points.

Reflection Questions

For a fishery to be sustainable, the fish population needs to remain fairly steady over a long period of time. When fish reproduce in a sustainable fishery system, the fish population should return to the original baseline level. When fish populations decrease over time, that means they are being overfished.

Discuss with the other players:

a. What happened to the number of fish in the ocean? Did the number of fish that were available change over time?
b. Were there still big fish, small fish, and crustaceans in the ocean by the end?
c. Did anyone use a trawler? How did that change the game?
d. What about the game do you think is a good model for fisheries in the real ocean? What is missing?

Play the game again, but this time add in the two policy variations to model how different policies might change fisheries. A **policy** is an action or rule made by a government or other organization.

Policy Variations

Catch Limits Policy

This time there will be some catch limits to help make fishing more sustainable.

New rules:

- If you collect more than half of the starting number of one type organism, you must not collect any more of that type until they reproduce. This is to help prevent overfishing.
- After each time all the fish reproduce, count their number. Each player may only collect half of the population until they reproduce again. For example, if after reproducing there are 18 small fish, one player may collect no more than 9 small fish until they reproduce again.

Reflection Questions

Discuss with the other players:

a. How did the catch limits policy affect the way you played the game?
b. Did catch limits stop overfishing?

Marine Protected Area Policy

Play the game once more. This time, in addition to catch limits, there will be a Marine Protected Area (MPA). No one will be able to fish from this area.

New rules:

- Set aside part of your table as an MPA.
- Decide with the other players how many of each organism you want to place in the MPA.
- No one can fish in the MPA. When organisms in the MPA reproduce, the additional organisms go in the rest of the ocean and can be caught.

If you have time, play again, changing the starting numbers of fish in the MPA. How does this affect how quickly you are scoring points? How does it affect the numbers of fish in the sea?

Reflection Questions

Discuss with the other players:

a. Do you think there is a sustainable way for every player to reach 50 points?
b. Think about the shifting baseline. For example, if someone came in near the end of the game, would they have a different impression of how many fish are naturally in the ocean?
c. If you were trying to create a sustainable fishery system, would you want to use catch limits, an MPA, or both?

4. Read what Suam says about protecting fisheries. Based on his ideas and what you learned through the game, what do you think are some of the threats to sustainable fisheries? What are some policies to combat those threats?

Suam says . . .

Most fish live near coastal areas, which form nursery grounds for the next generation. If these nursery grounds are lost or polluted, many fish species cannot survive to the adult stage. This means protecting these habitats is very important to maintain adequate fisheries resources. In addition, preventing illegal, unreported, and unregulated fishing is critical to maintaining healthy ecosystems and fish populations. Establishing conservation measures for fish species and enforcing bans on illegal fishing could reduce the risk of resource depletion.

***Act:** How will we act to make our role in ocean food webs more sustainable?*

People's actions affect ocean food webs. Removing ocean biomass from the higher trophic levels can have an especially large impact. As technology has changed, the amount of fish and other biomass people can easily remove from the ocean has increased.

The ocean is a valuable source of food for people. Globally, fish provides around 17% of the animal protein people consume. In some countries this can be up to 90%. In addition, fisheries and **aquaculture** are important economic activities for many communities. People's dependence on the ocean for food can be difficult to balance in a sustainable way.

1. Take out your *Ocean and Food System Diagram.* If you want, add any more *Removals* that humans are responsible for.
2. Take out your *Ocean Identity Map* and add any *Hopes* or *Concerns* you have, after learning about the ocean and food systems.
3. Turn to a partner and discuss:
   a. In addition to catch limits and MPAs, can you think of any rules or actions that governments, businesses, organizations, or individuals could take to help make ocean fisheries more sustainable?
   b. Are there some trophic levels that might be more important to protect?

4. Read *Fisheries Policies*.

Fisheries Policies

To have ocean and food systems that are sustainable, it is important for people to limit the amount and type of biomass they remove from the ocean. There are a number of policies that governments and people have used to try to accomplish this goal. They include:

Marine Protected Areas (MPAs): Marine protected areas can vary in size and location. Areas where young fish grow can be important to protect. MPAs can be different in what activities they allow and how closely governments monitor them to make sure people are following the rules. Some people would like at least 30% of the ocean protected by 2030.

Catch Limits: This limits the amount of fish legally allowed to be caught in an area. These may be limits on the overall number or weight of fish, the type of fish, or both. Catch limits can be difficult to monitor to make sure people are following the rules.

Fishing Controls: These are limits on the number or types of boats, types of technology, or fishing methods. This can also include temporarily closing fishing or limiting the quantity and size of fish that can legally be caught in certain areas.

Licenses and Fees: Sometimes certain catches require a license, which can be expensive. If licenses are limited, deciding who can get a license can be difficult and can sometimes mean that certain groups are disadvantaged.

Consumer Labeling and Choice: Fish can be labeled with where they come from and whether they are from a species that is overfished. This means **economic consumers**, or people who are buying a thing, can make the choice to support sustainable fisheries. Businesses may then change what they sell in response to consumer choices.

5. Divide into five groups and assign each group to one type of fisheries policy.
6. Within your group, answer the questions about your policy. If you need more information and you are able, you can go online to learn more. The *Ocean!* StoryMap has resources to help.

a. Who is involved with this policy? Include not only the groups implementing the policy, but others who are affected by it.
b. What are the challenges to carrying out this policy? Are there ways people might be able to get around it?
c. Why might this policy be good or bad from a social, environmental, economic, or ethical perspective?

7. Share your group's ideas with the rest of the team.
8. Examine your *Hopes* and *Concerns* from your *Ocean Identity Map*.
9. As a team, decide which policy you think is most important to work on at this time.
10. Think together about how you would like to help with this policy. For example, you could:
    a. Support local organizations helping with this policy.
    b. Write a letter or email supporting or arguing against current government policy.
    c. Tell or teach others about changes to the ocean's biomass and possible policy tools to help make it more sustainable.
    d. Use your personal power, such as the choice of what you buy, to help encourage change in businesses or other organizations.
11. Come to consensus with your teammates and decide what action you will take.
12. Plan and implement your action.
13. Read what Suam says and think about your own role. How have you collaborated with others in the past and how can do so in the future?

Suam says . . .

For maintaining healthy fisheries in the future, many different perspectives and views from various groups should be considered, because there are many ways to contribute to reach the goals of sustainable fisheries. Successful fisheries management and protection of species diversity and habitats can be achieved through collaborations between individual consumers, nonprofit organizations, scientific groups, governments, and industries.

14. Keep your *Ocean and Food System Diagram* to use in Part 7.

Congratulations!

You have finished Part 5.

Find out More!

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

End Note

1. Christensen, Villi, et al. "A century of fish biomass decline in the ocean." *Marine Ecology Progress Series* Vol. 512, (2014): 155–166, accessed December 7, 2023, https://www.int-res.com/articles/theme/m512p155.pdf.

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.

Additions: Things that are added to a system

Aquaculture: Rearing aquatic animals or raising marine plants for food

Baseline: The balance of a system at a certain point in time

Biomass: The total quantity or weight of all living things in an area

Bycatch: When fishing techniques catch unwanted organisms

Consumers: Organisms with trophic level higher than 1; these organisms obtain their nutrients by eating other organisms

Crustaceans: Shelled mainly aquatic organisms such as crabs, lobsters, and shrimp

Decomposers: Organisms such as bacteria that break down dead organisms and waste materials from the other trophic levels and make nutrients available for producers

Ecosystem: A community of interacting living and non-living things within a physical environment

Environmental: About the natural world

Economic: Concerned with money, income, or the use of wealth

Economic consumers: People who are buying something

Ethical: The fairness of something

Fisheries: The fishing industry

Food web: How organisms gain nutrients by consuming other organisms

Hypoxia: A low level of oxygen

Nutrients: What organisms need to nourish themselves

Organism: A living thing

Removals: Things that are taken out of a system

Photosynthesis: The process plants use to make food, taking in sunlight and carbon dioxide and releasing oxygen

Policy: An action or rule made by a government or other organization

Predatory fish biomass: The total quantity of fish in the ocean that eat other fish for nutrients

Producers: Organisms that use photosynthesis to get their energy from the sun, or use other nonliving sources of energy, such as hydrothermal heat vents

Social: The interaction of people in the community and their education, health, and well-being

Source: Where you get your information from

Stable Isotope Analysis: A technique used to analyze tissue samples from fish to determine their trophic levels

Stressor: Something that causes stress on a system

Sustainable: An approach that balances different perspectives and can keep working for a long time

Trawler: A type of boat that pulls a net deep through the ocean, which means a lot of fish can be caught at once

Trophic level: The level in a system where an organism gets its food; this shows how far an organism is from the initial source of energy in a food web

