Northern Gulf of Alaska
Long Term Ecological Research

Lesson Plan:

FOOD WEBS IN THE NORTHERN GULF OF ALASKA

In this set of 6 activities, students explore a marine food web in the Northern Gulf of Alaska through an immersive video game and short film. They work individually or as a class to make a model food web using illustrated species cards representative of Northern Gulf of Alaska organisms. Students then utilize the example of a recent marine heatwave (also known as "The Blob") to investigate how changes in the marine environment can affect different types of organisms and ripple through the food web. They compare the marine food web to a food web they are familiar with in a local ecosystem, and reflect on their learning and lingering questions.

Key Topics: Food Webs, Environmental Variability, Marine Ecology

Grade Levels:
5th-9th Grade
Can be adjusted for other grades

Timing:
3.5-5 hours
Can be split into 4-5 sessions

Next Generation Science Standards Performance Expectations:

MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

Science Practices:	Disciplinary Core Idea:	Crosscutting Concepts:
+ Constructing explanations + Engaging in argument from evidence	LS2 Ecosystems: Interactions, Energy, and Dynamics	+ Cause and effect + Mechanism and explanation + Systems and system models + Energy and matter + Stability and change

Other Relevant Standards for Alaska:

AK.RLST.6-8.1: Alaska Reading Standards for Literacy in Science & Technical Subjects 6-8th grade standard #1: Cite specific textual evidence to support analysis of science and technical texts.

AK.W.6.1: Alaska Writing 6th grade writing standard #1: Write arguments to support claims with clear reasons and relevant evidence.

AK.Cultural.E.2 (Alaska Cultural Standards) Understand the ecology and geography of the bioregion they inhabit.

Prior Student Knowledge:

Students should be familiar with basic relationships in ecosystems (especially predator-prey relationships and competition) but do not need to be familiar with marine environments or the Gulf of Alaska. Students should be familiar with key requirements for plant and animal life to survive.

Materials:

- Science notebooks
- Pencils
- Projector or SmartBoard to play the short film
- Student access to computers to play video game
- NGA Species Cards (copies for 2, 4, or 6 groups)
- String and scissors OR Large poster paper and tape
- Markers
- Large sheets of paper
- Printed copies of "The Blob" articles or digital access
- Local natural history/ID guides or digital access

Selected Vocabulary:

Food Chain vs. Food Web
Energy
Nutrients
Ecosystem
Physical Components
Biological Components
Chemical Components (i.e., nutrients)
Functional Redundancy
Variability

Background Information for Educators:

There are 28 sites across the US in the Long-Term Ecological Research network, funded by the National Science Foundation. Recently, the Northern Gulf of Alaska (NGA) was designated as an LTER. This builds on a long history of oceanographic research funded through many agencies and programs. Data for some components of the ecosystem has been collected along a transect (called the Seward Line) and a Gulf of Alaska mooring site (GAK1) for decades!

The Northern Gulf of Alaska is located in the North Pacific. It is a subarctic ecosystem centered on the continental shelf located south of southcentral Alaska. The shelf is generally deep (200-300 meters) and includes both an inshore and offshore region. Nearshore, the shelf is composed of fjords and sounds that link the Northern Gulf of Alaska with steep, mountainous terrain. There are glaciers in this area, and many mountains are seasonally snow-covered. Moving offshore, deep canyons cut across the shelf between sub-marine banks, leading to the deep oceanic trench at the shelf break.

In the NGA LTER, research is taking place to investigate the features, mechanisms, and processes that drive high productivity in the NGA ecosystem and support ecosystem resilience. Ecosystem resilience is a central focus for the NGA LTER. Environmental variability in the region is high -- including seasonal, interannual (year-to-year) and decadal variability in nutrients, light, temperature, freshwater, and wind. Researchers hypothesize that this variability actually has selected for a more resilient ecosystem. This means the ecosystem can more readily bounce back to its typical state after a disturbance. For example, consider the ways that zooplankton have adapted to environmental variability on a species level and on a community level.

Adaptations at the Species Level

At the species level, "bet hedging" and nutritional plasticity (flexibility on how they acquire food/energy/organic- matter) increase resilience. Specifically, the life histories of ***Neocalanus*** copepods are flexible, allowing them to hedge their bets. For example, they spawn at depth during the winter, and the arrival times of their offspring at the surface are staggered; this might compensate for variability in the timing of the spring bloom. Alternatively, many zooplankton in the NGA feed on a wide range of particle types. Some single-celled zooplankton even retain chloroplasts from the phytoplankton they eat, allowing them to use photosynthesis as an alternate source of energy. generate their own

Adaptations at the Community Level

There are several different species of ***Neocalanus*** copepods in NGA that have slightly different life histories. Therefore, when environmental conditions vary, different species become more or less successful. However, their functional redundancy (a term meaning species filling similar ecosystem roles) ensures that a relatively high biomass of large copepods remains in spring and early summer from year to year so that animals dependent upon them (such as fish and seabirds) generally remain well fed.

This overview of the NGA LTER was excerpted and adapted from https://nga.lternet.edu
For more information, visit https://nga.lternet.edu/research/environmental-basics/ and https://nga.lternet.edu/research/ecological-framework/ See also https://nga.lternet.edu/wp-content/uploads/2018/03/AMSS_Hopcroft_LTER_poster_reduced.pdf for a descriptive, technical introduction the Northern Gulf of Alaska LTER.

In this lesson, students look at the example of "The Blob" (a large marine heatwave that took place in the Northeast Pacific Ocean during 2014-2016) to investigate how a change to a physical component of an ecosystem (in this case water temperature) can affect populations, health, and behavior of various organisms. The readings assigned in Activity 4 can provide important background information for the teacher as well.

Activity 1 (~10 minutes)

Optional: Show students a map of the world and point out the Northern Gulf of Alaska.

Play the Northern Gulf of Alaska Food Web short film: [insert link]

Prompt students with one or more of the following questions, which they should respond to in writing:

- What do you notice about the organisms in the video?
- What do you wonder about the Northern Gulf of Alaska?
- What are your experiences with the Northern Gulf of Alaska or these organisms?
- What do you want to learn about the Northern Gulf Alaska?
- What do you know about food webs?
- What would you like to learn about food webs?
- What do you notice about the environment in the video?
- What does this place remind you of?

Ask students to share their response with a partner.

Optional: Allow time for sharing with the broader class.

Activity 2 (~45 minutes)

Instruct students to load the video game on their laptops, computers, or tablets. [insert link]

Provide question prompts to the students, and ask them to pause after each level of the game to read the field notes for that character and write or share a verbal response to the following questions:

- Based on the field notes, what types of food or resources does this organism need?
- Where in the environment do you think these resources or food sources would be most available?
- Does the video game provide a good representation of what the organism needs to do to get those resources or food sources? Explain your reasoning.

Allow 20-30 minutes for students to play the video game.

In addition to playing the game, instruct them to read the field notes for at least 3 organisms in addition to the 4 key characters.

Have students work in small groups to draw a simple model of a food web with the 4 organisms highlighted in the video game (Diatom, *Neocalanus* copepod, *Pseudocalanus* copepod, and Crystal Jelly) plus at least 3 other organisms featured in the field notes.

Activity 3 (~45-60 minutes)

Pass the printed species cards out to the students. Have each student read the information about a species to themselves and then tell a partner 3 interesting facts about their organism.

Re-divide students into 2, 4, or 6 groups. Provide each group with a copy of the printed species cards.

Instruct them to work with their group to construct a model food web based on the printed information for each species and any prior knowledge they have of the organisms. Explain that they need to include at least 15 organisms in their food web.

You can either 1) Have students lay the cards out on the floor and connect these with string to show who eats whom, or 2) Provide a large piece of paper and have students tape the cards onto the paper and draw arrows to connect them.

As groups finish their food webs, have each group pair with another group to present their food webs to each other. After presenting to each other, ask them to respond to the following prompts:

- How were the two food webs similar?
- How were the two food webs different?
- Are there any changes you want to make to your food web after seeing another model?

Optional Extension: Have the two groups work together to combine the two food webs into one.

Ask students to respond to the following prompts, in writing or verbally:

- What species do you think are most important in your food web?
- What other species do you think would be negatively affected if that species suddenly died off in the Northern Gulf of Alaska? Explain your reasoning.
- What other species do you think would be positively affected if that species suddenly died off in the Northern Gulf of Alaska? Explain your reasoning.

Finish this activity, by explain to students that sometimes in a food web, two different organisms can play a similar role. For example, in the NGA Food Web video the krill (euphausiid) consumed the ciliate and was in turn eaten by the capelin. But in the video game, copepods are the organisms that eat smaller plankton species like ciliates and diatoms. These copepods then are prey for not just crystal jellies but also fish like capelin. A food web with more criss-crossing links is generally going to support a healthier, stronger ecosystem than a food web with just one or two organisms at each level. Having many species that fill similar ecosystem roles creates functional redundancy. This means that if one species isn't thriving under a particular set of environmental conditions, other species can fill the void without the whole ecosystem fraying. In the Northern Gulf of Alaska, the many species of krill and copepods are an example of functional redundancy.

Instruct each student group to add 2-3 species to their food web in order to increase the amount of functional redundancy represented. *(Educator note: As an alternate option, you can instruct each student to draw the food web in their science notebook and then add 2-3 species to their drawing).*

Activity 4 (~55-70 minutes)

Explain that food webs are **models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers** as organisms interact in an ecosystem. When organisms are linked in a food web like this, changes to the environment that affect one organism can end up having many impacts on other organisms connected in the food web.

Then explain that something happened in the Northern Gulf of Alaska – and much of the northeast Pacific Ocean -- in 2013-2016 that illustrated these sorts of connections. A mass of warmer than typical water showed up near the surface of the northeast Pacific Coast in late 2013 and persisted through 2016. This was nicknamed "The Blob."

Tell students that scientists have been working together across different types of research to understand how a change in the physical characteristics of the water (temperature) affected various organisms who live in and around the Northern Gulf of Alaska.

Explain that students are going participate in a jigsaw reading to learn about different parts of what happened and put these ideas together into a bigger picture.

Divide students into 3-4 groups. Have each group read one of the following articles:

1. Gulf of Alaska cod are disappearing. Blame 'The Blob' (https://www.nwpb.org/2018/08/20/gulf-of-alaska-cod-are-disappearing-blame-the-blob/)
2. 'The Blob', food supply squeeze to blame for largest seabird die-off (https://www.washington.edu/news/2020/01/15/the-blob-food-supply-squeeze-to-blame-for-largest-seabird-die-off/)
3. A striking new view of the Pacific "Blob" (https://www.nationalgeographic.com/culture/article/space-map-pacific-blob)
4. Did the 'blob' drive humpbacks out of Southeast Alaska waters? Some scientists think so (https://www.adn.com/alaska-news/wildlife/2018/08/24/did-the-blob-drive-humpbacks-out-of-southeast-alaska-waters-some-scientists-think-so/)

Students first take time to do their assigned reading individually and make annotations about the important parts.

Question prompts include:

- What type of organism or environmental phenomenon does this article focused on?
- How does the reading help to explain the changes in the environment or in marine organism populations or behavior?
- What evidence is there to support these ideas?

Students then discuss these articles within their small group who all read the same article, ensuring that key parts have been identified. Students should do a check for comprehension within the small group so that everyone feels prepared to report back.

Continued on page 6

Activity 4 *Continued*

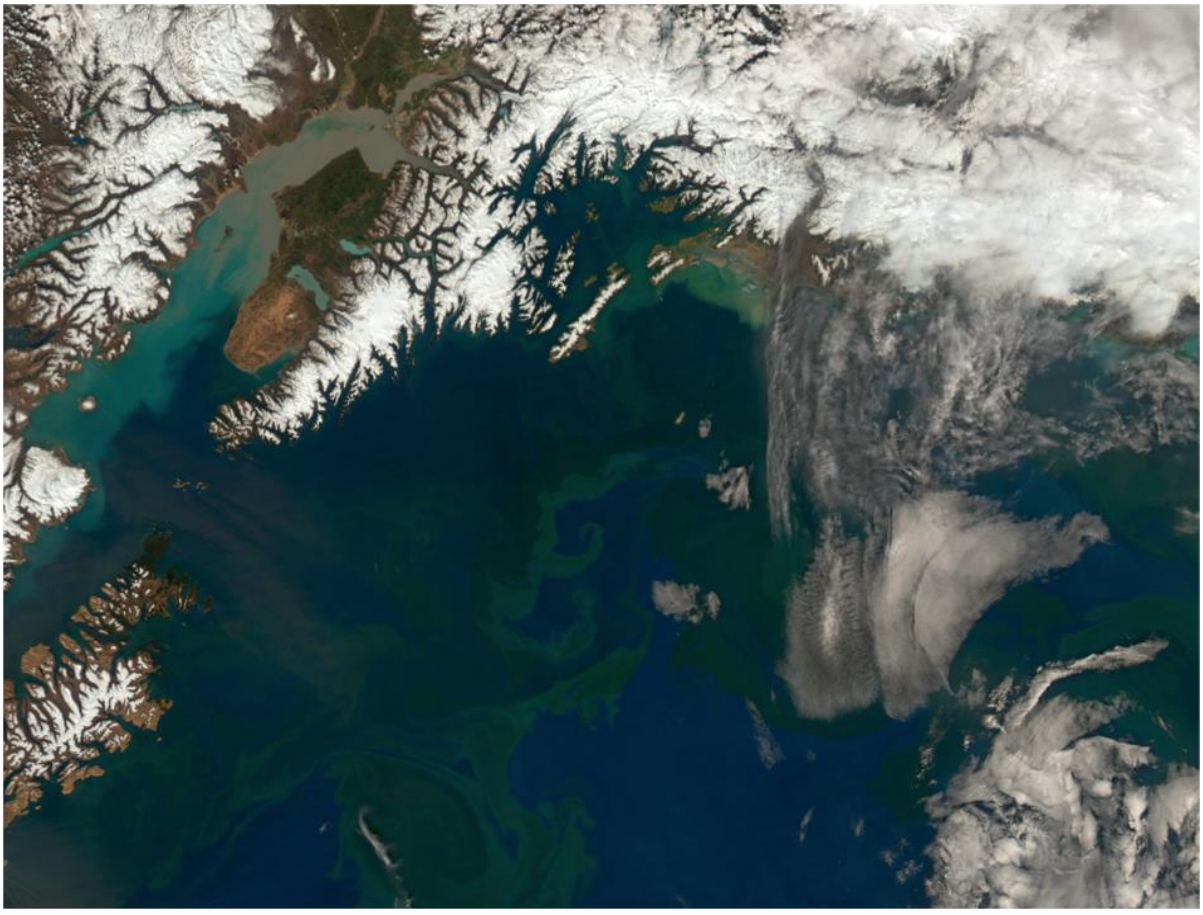
After becoming familiar with their piece, students are then divided into new groups. Each group should have 1-2 people who read each of the articles.

Students share what they learned from the reading and work together to build a model of how 'The Blob' affected food webs in the Northern Gulf of Alaska. Give each student (or pair of students) 3 minutes to share, followed by 3 minutes of questions for each student.

After everyone in a group has shared, give them 15 minutes to build their model.

Then together as a large group, ask students to direct you in creating a model on the whiteboard that explains the potential impacts of 'The Blob' on the NGA food web. You should press for evidence-based explanations throughout this process, only adding components to the model that students can support with evidence from the readings, prior knowledge, or lived experience.

Finish the lesson by explaining that "The Blob" was a dramatic change for the Northern Gulf of Alaska, but that there is always a lot of variability in this region. Each day, season, and year can have different combinations of environmental conditions like temperature, salinity, light, oxygen, pH, and a variety of key nutrients. This type of variability means that sometimes it is easy for organisms to find food (or make food if they photosynthesize!) and sometimes it is a lot more difficult for them.



Activity 5 (~45-90 minutes)

Explain to students that now that they are familiar with an example of the NGA food web and changes that have happened there, they are going to create a model of a food web for a local ecosystem.

Instruct students to identify a local ecosystem that is interesting to them.
Using resources available to them (natural history guides, ID guides, digital access, etc.) students should create a model of a food web that exists within that ecosystem. Their food web must include at least 8 different species of organisms, and it needs to start with energy from the sun. Provide students with ample time to find information about the ecosystem and illustrate a model food web.

Educator Note: You may choose to make this portion of the assignment homework. You might also encourage students to contact experts to learn more about the ecosystem, or you could schedule a field trip to their ecosystem(s) so they can observe them in person.

Once their ecosystem models have been created, ask students to think about changes in their local environments that they have heard about or noticed in their lives. List some of these changes on the board.

Instruct students to each choose one environmental change that could affect the food web they have modelled.

Have each student annotate their food web to indicate how this environmental change might impact various organisms. They should base these annotations on their understanding of how changes to physical, biological or chemical components of an ecosystem affect populations and how nutrients cycle through the food web and energy flows through the food web.

Activity 6 (~15 minutes)

To wrap-up this lesson, have students complete a self-evaluation, including a piece on "next steps."

- List four things you know about food webs in the Northern Gulf of Alaska.
- I am still confused about _____.
- Something I would like to know more about food webs or the Northern Gulf of Alaska ecosystem is _____.
- A research question that would help me learn more about this is _____.

Instruct students discuss these research questions in a small group. Have student groups work together to suggest research activities or experiments that could help answer each student-identified question.

Students can also submit their questions to the NGA LTER for answers from the science team.
[insert link]