NOAA FISHERIES

# Seaweed in the Classroom

## Grades K-5 Lessons on Seaweed in Southeast Alaska

k'áach (dulse, red ribbon seaweed)

# About

## The Project

Seaweed is a common name for aquatic plants and algae that grow in marine environments. Seaweed farming is a new and rapidly growing industry in the United States, particularly in Alaska. The harvest and consumption of seaweed has been practiced by Alaska Native communities in coastal areas since time immemorial, but more recently, challenges to the sustainable harvest of seaweed in Alaska have appeared. This collaborative project between NOAA Fisheries researchers and rural and urban classrooms in Alaska involves students and communities in seaweed education and cultivation with three primary goals of 1) community engagement, 2) culturally responsive place-based education, and 3) promoting food sovereignty. We developed and implemented Science, Technology, Engineering, Art, and Mathematics (STEAM) lessons detailing the structure and function of seaweeds in comparison to true plants, the specific needs of seaweed and where those resources come from (nutrients, aeration, turbidity, salinity, pH, dissolved oxygen), the seaweed life cycle, and the traditional uses and cultural importance of seaweed. Classroom activities include activity worksheets, seaweed pressing instructions, and a mobile aquaculture unit assembly and maintenance guide. This work can inform other organizations and classrooms interested in culturally responsive place-based education to increase community engagement and inclusiveness in STEAM opportunities, especially as they relate to marine education.

## The Lessons

The following lessons are divided into three modules: “What Is Seaweed?”, “Seaweed Lifecycle”, and “Cultural Significance of Seaweed”. Ocean Literacy Principles (OLP) and Next Generation Science Standards (NGSS) addressed in each module are available at the end of the module. These lessons have been tailored to grades K-5, but can be adapted for middle and high school students.

## Who We Are

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# Module 1: What Is Seaweed?

## Lesson at a Glance

This lesson plan provides students with an overview of what a seaweed is and how it is different from a true plant. Students will make observations about the external anatomy of seaweed. They will compare and contrast seaweed with true plants to review the structures and functions of parts. They will identify the parts of a seaweed (blade, stipe, holdfast, and thallus). They will identify the specific needs of seaweed and where those resources come from (nutrients, aeration, turbidity, salinity, pH, dissolved oxygen).

## Student Learning Objectives

- Record observations (in words and drawings) of different types of seaweeds.
- Infer how seaweeds meet their needs based on their structures.
- Compare and contrast seaweeds and true plants based on their structures and patterns of survival.
- Give examples of ways in which seaweeds meet their needs.

## Enduring Understandings

- Seaweeds are marine photosynthesizing organisms also known as algae. They are found in marine and estuarine (saltwater) environments.
- Seaweeds have specialized parts that allow for photosynthesis and surviving in a marine environment.
- True plant parts are stems, roots, and leaves. Corresponding seaweed parts are stipe, holdfast, and blade or frond.
- Holdfast: anchors seaweed to a surface.
- Blade or frond: gives a surface to absorb sunlight.
- Stipe: acts like a stem in plants.
- Thallus: The body or part of the algae above the holdfast.
- Seaweeds are classified by color: red, brown, or green.

## Background Information

"Seaweed" is the common name for species of marine algae that grow in the ocean and in estuaries. Seaweeds are found in all oceans of the world. They occur wherever there is light, and are most abundant in the nearshore subtidal and intertidal areas along varied coastlines. They can be found from the tropics to arctic areas. There are over 500 (and counting) species of seaweeds in Alaska!

Seaweeds are important to nearshore ecosystems because they provide refuge for many invertebrates and fishes, and are a source of food and nutrients for many nearshore species. Thousands of edible seaweeds of various shapes and sizes occupy a wide array of ecological niches. The distribution of seaweeds worldwide and within regions depends on sea temperature, light availability, suitable attachment surfaces, nutrients, and wave action.

Seaweeds are separated into three groups; brown, green, and red algae. They all need salt water and the energy of the sun to make their own food. Therefore, many live in the shallow, rocky intertidal and subtidal zones of the ocean to be able to photosynthesize. Sunlight is captured by blades of the seaweed and a chemical reaction involving water, carbon dioxide, and sunlight takes place producing

sugars and oxygen. Seaweed releases the oxygen into the water and the sugar is used for food. See the formula for photosynthesis below:

$$6H_2O + 6CO_2 \text{ ----------> } C_6H_{12}O_6 + 6O_2$$

Seaweed differs from plants in many ways. Seaweeds usually attach to large or small rocks using their holdfasts and grow tall or wide to capture the most sunlight. The coastal zone is often incredibly turbulent due to the crashing waves and swiftly flowing tidal currents so the holdfast secures the seaweed to the bottom. Some species of seaweed have air filled sacs or bladders, known as pneumatocysts, that help them float near the surface where the most light is found. Seaweed needs to be submerged in cool, nutrient-rich water. If seaweed is out of the water and is exposed to too much sunlight for too long, the blades will dry out and the algae will die.

Seaweeds can be broadly categorized based on growth form, shape, or color. Students will examine fresh seaweed specimens to make observations and categorize the seaweeds on their own.

If you are planning to collect seaweed, be sure to be aware of local regulations for seaweed harvesting. Alaska Department of Fish and Game's website includes details on where to find seaweed, appropriate times to harvest seaweed, how to harvest seaweed, and how to handle seaweed.

### Key Words

- Blade: flattened part of a seaweed that resembles a leaf
- Habitat: place where a plant or animal lives (its home)
- Holdfast: base of a seaweed that attaches it to a rock; this resembles roots
- Photosynthesis: a process used by plants and other organisms to convert light energy from the sun into energy that can be stored for later use
- Seaweed: marine algae that grow in the ocean and in estuaries and do not have true roots, stems, or leaves
- Sporophylls: specialized blades at the base of some kelp species that contain reproductive tissue and spores
- Stipe: stalk of a seaweed between holdfast and blade; this resembles a stem
- Thallus: the body or part of the algae above the holdfast

### Materials Needed

- Seaweed samples
- Plant samples
- Seawater or tap water
- Trays to hold specimens
- Microscopes or hand lenses
- Activity worksheets
- Crayons and pencils

## Engage: Pre-Activity Questions

Engage students in a discussion about identifying seaweeds: *Note: you may have to explain what a seaweed is. See the vocabulary list above.

- Who can describe what seaweed looks like?
- How do you recognize seaweed when you see it?
- What are the differences between seaweeds and land plants?

Ask students to spend ten minutes drawing a picture of a seaweed. They can draw the first seaweed that comes to their mind, even if it's not accurate. As they draw, walk around and ask students to discuss the following things with their neighbor:

- Where does your seaweed live?
- What color is your seaweed?
- Describe the shape of your seaweed.
- How does your seaweed stay attached to the bottom? Or does it float free?
- What makes your seaweed different from a plant on land?
- What else should we know about your seaweed?

After approximately ten minutes, ask the students to finish their drawings and ask for two to three volunteers to describe their seaweeds out loud to the group.

Explain that they will now explore the different types of seaweed that are common to Southeast Alaska.

## Explain

Explain to the students that there are important parts of each seaweed that make them very different from plants on land. Using the Seaweed Anatomy - Structure and Function Activity Worksheet ask students to:

- Point to the part of the seaweed that looks most like a leaf. In seaweed, this is called a "Blade." It is a leaf-like structure with a large surface area that absorbs sunlight for photosynthesis and nutrients from the water.
- Point to the part of the seaweed that looks most like a stem. In seaweed, this is called a "Stipe." It is a stem-like structure that is tough but flexible and provides support and stability to the large blades.
- Point to the part of the seaweed that looks most like roots. In seaweed, this is called a "Holdfast." It is a root-like structure that helps attach the seaweed to rocks, however it does not absorb nutrients from the seafloor like a plant root does.
- Point to the part of the seaweed that looks most like the body. In seaweed, this is called the "Thallus". The shape of the thallus influences the ability of the seaweed to withstand wave forces.

- Point to the part of the seaweed that looks most like young leaves. In seaweed, these are called "Sporophylls." They are specialized blades at the base of some kelp species that contain reproductive tissue and spores.

## Explore

### Seaweed Anatomy Worksheet

Ask students to complete the Seaweed Anatomy - Structure and Function Activity Worksheet. Students will use the word bank provided to label each part of the seaweed with the correct name and write 1-2 sentences describing what each seaweed structure does and how they think it helps the seaweed survive.

### Microscope Activity

Allow students to observe various seaweed and true plant samples. Then, ask them to select 1-2 samples of each specimen type to examine in more depth. Using the Seaweed vs. True Plant - Microscope Activity Worksheet, ask students to make predictions about the similarities and differences they expect to see between the specimens they selected. Give students time to draw the external anatomy of each specimen type and write down their observations.

Pass microscopes or hand lenses to each group. Scientists often use microscopes to get a closer look at seaweeds when identifying them. Aid students in using the microscopes. They can practice by looking at the table, their hands, a piece of paper, etc. *Note: it helps to practice this yourself before facilitating the activity. Once everyone has been introduced to the microscopes, encourage students to explore the various seaweed and true plant specimens using their microscopes. Give students time to draw what they see through the microscope and write down their observations.

Walk around to each group and ask them to separate their samples into two or more categories based on any criteria of their choosing. Each category must share a similar characteristic.

- Which of these samples would you group together based on similarities?
- What makes the samples similar to each other?
- What makes the groups different from each other?

Ask for two to three volunteers to share out loud to the group how they categorized their specimens and why.

## Evaluate: Reflection Prompts

Ask some or all of the following reflection questions after completing the activities. It may be helpful to return to students' thoughts and answers from the pre-activity questions.

- Name one of the special adaptations that help seaweeds survive in their turbulent environment.
- Name one similarity and one difference between seaweeds and true plants.

- Why do you think seaweeds are considered primary producers, just like plants?
- Engage students in a discussion about how they categorized their seaweed samples and why:
    - How does grouping seaweeds or plants based on their similarities and differences help us better understand them?
    - Can you think of other examples where this would be helpful?
- Engage students in a discussion of their experience:
    - Which was your favorite seaweed species and why?
    - What seaweed fact was most surprising to you?
    - What other questions or wonderings do you have about seaweeds?

## Printable Worksheets

- **Seaweed Anatomy - Structure and Function Activity Worksheet**
- **Seaweed vs. True Plant - Microscope Activity Worksheet**

# Education Standards

## Ocean Literacy Principles

- **Grades K-2: OLP 5A.2.** Many groups of organisms exist only in the ocean.
- **Grades K-2: OLP 5A.4.** Ocean organisms have a variety of different structures and behaviors that help them to survive in the ocean.
- **Grades 3-5: OLP 5B.2.** There are adaptations and life histories that exist only in the ocean, due to unique environmental and physical properties, such as salinity, pressure, temperature, light, and density, that are associated with living in a liquid environment.
- **Grades 3-5: OLP 5B.6.** There are many groups of organisms that occur in the ocean that do not occur on land or freshwater, such as sea stars, squid, jellyfish, corals, many types of worms, and seaweeds.

## Next Generation Science Standards

**NGSS Performance Expectation**
**K-LS1-1. Use observations to describe patterns of what plants and animals (including humans) need to survive.**

| Science and Engineering Practices | Disciplinary Core Ideas | Cross Cutting Concepts |
|---|---|---|
| **Analyzing and Interpreting Data**<br><br>Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations.<br>● Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions.<br><br>***Connections to Nature of Science***<br><br>**Science Knowledge Is Based on Empirical Evidence**<br>● Scientists look for patterns and order when making observations about the world. | **LS1.C: Organization for Matter and Energy Flow in Organisms**<br>● All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow. | **Patterns**<br>● Patterns in the natural and human designed world can be observed and used as evidence. |

**NGSS Performance Expectation**

| **4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.** | | |
|---|---|---|
| Science and Engineering Practices | Disciplinary Core Ideas | Cross Cutting Concepts |
| **Engaging in Argument from Evidence**<br><br>Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).<br>● Construct an argument with evidence, data, and/or a model. | **LS1.A: Structure and Function**<br><br>● Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. | **Systems and System Models**<br><br>● A system can be described in terms of its components and their interactions. |

| **NGSS Performance Expectation**<br>**5-LS1-1. Support an argument that plants get the materials they need for growth chiefly from air and water.** | | |
|---|---|---|
| Science and Engineering Practices | Disciplinary Core Ideas | Cross Cutting Concepts |
| **Engaging in Argument from Evidence**<br><br>Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).<br>● Support an argument with evidence, data, or a model. | **LS1.C: Organization for Matter and Energy Flow in Organisms**<br><br>● Plants acquire their material for growth chiefly from air and water. | **Energy and Matter**<br><br>● Matter is transported into, out of, and within systems. |

# Module 2: Seaweed Life Cycle

## Lesson at a Glance

This lesson plan provides students with evidence that all living things (including seaweeds) grow and change as they progress through their life cycle. Students will identify the factors that influence seaweed growth and development and where those resources come from (nutrients, aeration, turbidity, salinity, pH, dissolved oxygen). Students will compare and contrast the life cycles of seaweeds and true plants. They will sequence the life cycle stages of two types of seaweeds (red seaweed, dulse, and brown seaweed, kelp). They will explore the advantages and disadvantages of asexual versus sexual reproductive strategies.

## Student Learning Objectives

- Give examples of how seaweed grows and changes throughout its life cycle.
- Compare and contrast the life cycles of seaweeds and true plants.
- Explore the pros and cons of asexual reproduction in seaweeds.

## Enduring Understandings

- Understand that seaweeds have a complex life cycle that varies depending on species.
- Understand that seaweeds can reproduce sexually and asexually.
- Sequence the stages of seaweed throughout its life cycle.
- Understand that the life cycle of seaweeds is different from the life cycle of true plants.

## Background Information

Seaweeds display a variety of different reproductive and life cycles involving both sexual and asexual stages. Their appearance may change markedly between these stages. Red seaweeds have some of the most complex life cycles known in living organisms.

K'áach (dulse) is a perennial (a plant or seaweed that lives more than two years) that can regrow new blades every year from the same holdfast. The maximum life span of individual blades or holdfasts is unknown other than they can persist through the winter.

The life history of dulse is unusual in that females from each generation are reproductive their first year but males aren't reproductive until their second year.

After tetraspores (specialized reproductive cells) are released from specialized sorus (spore-producing) tissue on the mature sporophyte blade, they quickly adhere to any suitable substrate (rock, shell, or kelp stipes). The tetraspores then develop into male and female gametophytes. One-year-old male gametophytes release sperm which combines with the egg from the female gametophyte to create a sporophyte (spore producing individual).

Dulse can also reproduce asexually, by fragmentation — that is, the blades shed small pieces that develop into completely independent organisms!

Asexual reproduction allows for fast propagation of the species but carries with it an inherent danger of limited genetic variation. Sexual reproduction ensures better genetic variation, but it leaves the

species that depend on this method of reproduction with an enormous match-making problem, as the egg and sperm cells need to find each other in water that is often turbulent.

Sú (bull kelp) is an annual brown algae known as geesh (kelp), meaning it usually lives for one year and dies off in the winter.

Like dulse, the life history of kelp involves two major life stages: the microscopic gametophyte stage and the macroscopic sporophyte stage. Unlike dulse, kelp cannot reproduce asexually.

After zoospores are released from sorus tissue on the fronds of bull kelp sporophytes, they quickly adhere to suitable hard substrates. The zoospores then develop into male and female gametophytes. The gametophytes release gametes which, when they meet, create a sporophyte.

## Key Words

- Annual: a seaweed or plant that completes its life cycle within one growing season and then dies
- Asexual reproduction: a mode of reproduction that involves one parent and produces offspring that are genetically identical to each other and to the parent
- Fragmentation: a form of asexual reproduction or cloning, where an organism is split into fragments; fragments develop into mature, fully grown individuals that are clones of the original organism
- Gamete: specialized male and female reproductive cells
- Gametophyte: the stage which produces sex cells in algae that undergo alternation of generations
- Life Cycle: the series of changes and developments that an organism passes through from the beginning of its life until its death
- Microscopic: so small as to be visible only with a microscope
- Macroscopic: large enough to be seen with the naked eye
- Perennial: a seaweed or plant that lives more than two years
- Sexual reproduction: a mode of reproduction that involves two parents and produces offspring that are genetically unique
- Sorus tissue: specialized tissue on mature sporophytes that creates tetraspores (for red algae) or zoospores (for kelp)
- Sporophyte: spore-producing phase of life cycle of brown algae that undergo alternation of generations
- Tetraspore: specialized red algae reproductive cell
- Tetrasporophyte: adult stage of red algae
- Zoospores: specialized kelp reproductive cells that propel themselves using a long appendage called a flagellum

## Materials Needed

- Activity worksheets
- Crayons and pencils

## Engage: Pre-Activity Questions

Ask some or all of the following pre-activity questions before beginning the activities. It may be helpful to write down students' thoughts and answers to return to during the reflection questions.

- What are the main factors that affect seaweed growth?
- How does seaweed change as it grows and develops?
- Discuss how the life cycle of seaweed is similar to and different from the life cycle of plants.
- Remind students of the stages of human development: newborn, toddler, child, teenager, young adult, middle-aged adult, elderly adult. Ask students if there are comparable stages in the life cycle of seaweeds.

## Explain

Explain to students that seaweed growth depends on temperature, nutrient availability, and light.

Explain to students that as a seaweed matures, it undergoes the processes of growth and development. Growth arises from the addition of new cells and the increase in their size. Development is the result of cells differentiating into a diversity of tissues that make up specialized structures such as holdfasts, stipes, blades, and spores. Each of these structures has specialized functions coordinated to enable the individual seaweed to complete its life cycle.

Explain to students that seaweeds can reproduce sexually, by the joining of specialized male and female reproductive cells, called gametes. Some seaweeds can also reproduce asexually through fragmentation or division. This occurs when parts of a plant break off and develop directly into new individuals. All offspring resulting from asexual reproduction are clones; they are genetically identical to each other and the parent seaweed.

## Explore

Using the The Life Cycle of Seaweeds Activity Worksheet, ask students to identify the different stages of the red seaweed and kelp life cycles.

To deepen student's understanding and engage kinesthetic learners, ask students to act out the red seaweed life cycle. Break students into groups and have each group of students pretend to be (1) adult seaweed (tetrasporophyte or sporophyte) waving in the current, (2) microscopic tetraspores or zoospores released from the adult drifting through the water, (3) settled out tetraspores or zoospores growing into microscopic gametophytes, (4) gametophytes releasing gametes and settling into juvenile tetrasporophytes or sporophytes, and (5) juvenile tetrasporophytes or sporophytes growing into adult sporophytes waving in the current.

## Evaluate: Reflection Questions

Ask some or all of the following reflection questions after completing the activities. It may be helpful to return to students' thoughts and answers from the pre-activity questions.

- How does seaweed grow and develop during its life cycle?
- What do seaweeds need to reproduce?
- How is the life cycle of seaweed similar to and different from the life cycle of plants?
- What are some pros and cons of asexual reproduction in seaweeds?

## Printable Worksheets

- **The Life Cycle of Seaweeds Activity Worksheet**

# Education Standards

## Ocean Literacy Principles

- **Grades K-2: OLP 5A.4.** Ocean organisms have a variety of different structures and behaviors that help them to survive in the ocean.
- **Grades 3-5: OLP 5B.2.** There are adaptations and life histories that exist only in the ocean, due to unique environmental and physical properties, such as salinity, pressure, temperature, light, and density, that are associated with living in a liquid environment.
- **Grades 3-5: OLP 5B.5.** Organisms in the ocean exhibit an amazing variety of life cycles. Some undergo metamorphosis and have planktonic phases, some lay eggs, and others nurse their young.

## Next Generation Science Standards

**NGSS Performance Expectation**
**1-LS3-1. Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.**

| Science and Engineering Practices | Disciplinary Core Ideas | Cross Cutting Concepts |
|---|---|---|
| **Constructing Explanations and Designing Solutions**<br><br>Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions.<br>● Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. | **LS3.A: Inheritance of Traits**<br><br>● Young animals are very much, but not exactly like, their parents. Plants also are very much, but not exactly, like their parents.<br><br>**LS3.B: Variation of Traits**<br><br>● Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways. | **Patterns**<br><br>● Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. |

**NGSS Performance Expectation**
**3-LS1-1. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.**

| Science and Engineering Practices | Disciplinary Core Ideas | Cross Cutting Concepts |
|---|---|---|
| **Developing and Using Models**<br><br>Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.<br>● Develop models to describe phenomena.<br><br>***Connections to Nature of Science***<br><br>**Scientific Knowledge is Based on Empirical Evidence**<br><br>● Science findings are based on recognizing patterns. | **LS1.B: Growth and Development of Organisms**<br><br>● Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. | **Patterns**<br><br>● Patterns of change can be used to make predictions. |

**NGSS Performance Expectation**
**4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.**

| Science and Engineering Practices | Disciplinary Core Ideas | Cross Cutting Concepts |
|---|---|---|
| **Engaging in Argument from Evidence**<br><br>Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).<br>● Construct an argument with evidence, data, and/or a model. | **LS1.A: Structure and Function**<br><br>● Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. | **Systems and System Models**<br><br>● A system can be described in terms of its components and their interactions. |

# Module 3: Cultural Significance of Seaweed

## Lesson at a Glance

Students will learn about the benefits of seaweed and discover the impact that seaweed can have on climate change, the environment, and human health. Students will explore the vast array of ecosystem services seaweeds provide and how different seaweeds are used traditionally and commercially. This lesson will culminate in a beach field trip where students will have the opportunity to explore seaweeds using all their senses. Students should be encouraged to incorporate their own customs, cultural identities, and lived experiences during this lesson. Consider working with a school-based cultural specialist to provide planning and in-class support for Traditional Ecological Knowledge content and collaboration with Elders.

## Student Learning Objectives

- Define ecosystem services.
- Identify the ecosystem services provided by seaweed and their benefits to human society.
- Use multiple senses (sight, smell, touch) to explore real seaweed samples.

## Enduring Understandings

- There is interdependence among plants, animals and their environment.
- Seaweed provides a wide range of cultural, provisioning, regulating, and supporting services to human society.
- Human activities can disrupt ecosystem services, potentially resulting in economic and ecological consequences.

## Background Information

Seaweeds play many important roles in coastal ecosystems. Seaweeds provide food and habitat for other marine species, clean coastal waters by removing excess nutrients from runoff, and absorb carbon dioxide from the water which may protect shelled animals (like oysters and mussels) from ocean acidification.

Seaweeds have a number of health benefits and can be found in a variety of foods. For example, seaweeds are an excellent source of protein, fiber, and iron and other essential nutrients like Vitamin K and the healthy long-chain omega-3 fatty acids found in seafoods.

Seaweeds have many uses besides food. You can find seaweed in ice creams (to keep the ice cream thick and prevent ice crystals from forming), cosmetics, pharmaceuticals, fertilizer, and animal feeds.

Seaweeds can also be used to make biodegradable packaging, a great alternative to plastic packaging that contributes to pollution in our oceans. Red seaweeds can be used in feeds for cows to help them reduce their methane emissions. Methane is a greenhouse gas that contributes to climate change.

Seaweeds can be responsibly harvested or farmed to provide nutritious food and help support healthy ecosystems and combat climate change.

Seafood produced through marine aquaculture, or seafood farming, helps support a sustainable food supply for the U.S. and the whole world. Seaweed farming emits far fewer greenhouse gas emissions

than some other sources of food production. It can also diversify how we grow nutritious food, helping to support a more consistent food supply when events like floods and fires impact food production on land. Seaweed does not require freshwater or land resources to grow, so those resources are available for wildlife and other ecosystem functions.

Seaweeds are particularly vulnerable to climate change, threatened by rising ocean temperatures, increasing levels of severe weather, and the introduction of invasive species. Preserving productive seaweed beds by limiting pollution runoff, carbon footprint reduction, and sustainable harvest practices assures that seaweed will grow back for future harvests and continue to nourish sea life.

### Key Words

- Ecosystem: all living and nonliving things in an area, as well as the interactions among them
- Ecosystem Services: the benefits people obtain from nature through use, consumption, enjoyment, and/or simply knowing these resources exist (non-use)
    - Cultural: the non-material benefits people obtain from ecosystems, including aesthetic inspiration, cultural identity, sense of home, and spiritual experience related to the natural environment
    - Provisioning: the benefit to people that can be extracted from nature such as food, raw materials, medicinal resources
    - Regulating: the benefit to people provided by ecosystem processes that moderate natural phenomena such as water purification, erosion and flood control, and carbon storage and climate regulation
    - Supporting: services that maintain fundamental ecosystem processes, such as habitat for plants and wildlife, or the maintenance of genetic and biological diversity
- Marine Aquaculture: the breeding, rearing, and harvesting of aquatic plants and animals; it can take place in the ocean, or on land in tanks and ponds

### Materials Needed

- Science notebooks
- Pencils

## Engage: Pre-Activity Questions

Ask some or all of the following pre-activity questions to prepare students for the beach field trip. It may be helpful to write down students' thoughts and answers to return to during the reflection questions.

- What is an ecosystem?
- What role(s) do seaweeds play in marine ecosystems?
- Why is seaweed important to people and the planet?
- How is seaweed used in everyday life?
- When was the last time you used seaweed? How did you use it?

## Explain

Explain to students that an ecosystem is made up of two parts: the living things in an area (plants, animals, fungi, and microbes) and the nonliving things in an area (air, water, and soil). Ecosystems often contain many living things and can be as small as your backyard or as large as the ocean.

Explain to students that ecosystems and their living and non-living components provide essential life-sustaining resources or services for humans.

Explain to students that seaweeds provide a wide range of vital cultural, provisioning, regulating, and supporting services to people in Alaska and around the globe. Examples include:

- Carbon Storage: seaweeds store organic carbon as standing biomass and can sequester carbon through the export and burial of detritus in the deep ocean.
- Coastal Defense: seaweeds may help protect coastlines by decreasing the power of waves during storms and reducing coastal erosion.
- Cultural Value: seaweeds support the identities of many coastal peoples around the world, allowing humans to develop a sense of place and connectedness with nature.
- Fisheries: seaweeds offer complex three-dimensional habitat and provide food and shelter to coastal fish and shellfish worldwide.
- Harvesting/Cultivation: seaweed is used for food, livestock feed and fertilizers, and is a primary source of alginate which is used for a wide range of industrial and commercial products.
- Nutrient Cycling: seaweeds require nutrients for growth and reproduction such as nitrogen and phosphorus, and can filter the water from excess nutrients especially in periods of algal blooms.
- Ocean Acidification Mitigation: seaweeds may reduce ocean acidification effects at local scales by absorbing carbon dioxide and elevating pH levels of surrounding waters.
- Recreation and Tourism: recreation and tourism activities related to seaweeds range from direct interactions with seaweeds such as snorkeling and diving or indirect activities such as fishing, boating, swimming, and surfing.

Explain to students that people play critical roles in marine ecosystems and in Alaska, many people depend on the health of these ecosystems for their subsistence or cash income. Recently, the farming of seaweed has gained attention for its commercial, food security, and climate change mitigation possibilities. Alaska presents an ideal location for the seaweed farming industry, as it has the longest coastline in the United States and more than five hundred species of seaweed.

Look for ways to include local uses and the cultural importance of local seaweeds. For example, explain to students that seaweeds have been used for foods and other goods in Alaska since time immemorial. Seaweeds can contribute to food sovereignty because seaweeds grow quickly and, in some cases, have a high protein content (some red, green, and brown seaweeds).

The Alutiiq, Eyak, Tlingit, Haida, and Tsimshian people use seaweed as food, trade items, fibrous material, and food storage. Black seaweed is a particularly important wild-harvested food. Other wild-harvested seaweeds in Alaska include bull kelp, giant kelp, and red ribbon seaweed. Seaweed collection is a significant time of the year for many Alaska Natives, and many culturally important foods and ceremonies depend upon the continued existence of seaweed.

## Explore

During this field trip activity, students will focus on the cultural services that seaweeds provide.

Give students an orientation to the field trip site and review beach etiquette and safety rules. Ask students how they can help take care of animals and plants they encounter during the field trip. Through their concern for life and habitat, have students develop some rules: step softly and quietly while observing animals, replace rocks or logs after looking underneath (to keep the roofs on animals homes), handle animals gently, fill in holes after looking in the dirt or sand or cobbles (to prevent suffocation of the animals next door), and don't take live animals or plants away from their homes.

For more information about tidepool etiquette, please see the guidelines from the Alaska Fish and Game or a similar agency in your local area. If you plan to harvest marine invertebrates, fish, or seaweeds or collect them for educational or scientific purposes, review the local guidelines and permit requirements for these activities.

Allow students to freely explore and investigate the beach area and tide pools. Encourage them to use all of their senses to make observations about what seaweeds they find, where they found them, their defining characteristics, and the services they may provide people. After approximately 30 minutes, bring the group back together and with the guidance of an adult (teacher, parent volunteer, paraprofessional or aide) ask students to share their observations and discoveries with the group.

Next, ask students to sit quietly and record their observations, questions, and ideas in their science notebooks. Ask students to use their observations to explain what they have found out about seaweeds during their exploration of the beach. Ask students to draw a seaweed of their choosing and describe the types of ecosystem services it might provide.

Many Alaska school district bilingual programs have resources for teaching local plant and animal names in the local Alaska Native language (as appropriate for this age group) and describing their cultural importance. If possible and appropriate, include an Elder, other Alaska Native culture bearer, or other community member who harvests from the beach to talk about local use of edible beach and marine plants. Invite them to be part of the field trip, share their stories, and explain how they know where to find plants and animals they harvest.

## Evaluate: Reflection Questions

Ask some or all of the following reflection questions after completing the activities. It may be helpful to return to students' thoughts and answers from the pre-activity questions.

- Ask students to describe one ecosystem service that seaweed provides for them or their community.
- Ask students how they can contribute to a healthy ocean and protect seaweeds for generations to come.
- Engage students in a discussion of their experience by asking them:
    - What are 3 new facts or words that you have learned today?

    - What are 2 ideas or concepts that are new to you?
    - What is 1 question you still have?

- Ask students to reflect on their own experiences harvesting seaweed and other coastal resources, and how it ties into their family and community values.

# Education Standards

## Ocean Literacy Principles

- **Grades K-2: OLP 6A.2.** The ocean provides much of the food we eat.
- **Grades K-2: OLP 6C.8.** Ocean resources are limited, so people need to use these resources wisely.
- **Grades 3-5: OLP 6A.1.** The ocean is an important source of food for humans
- **Grades 3-5: OLP 6A.2.** Food from the ocean includes organisms such as fish, crabs, and oysters, as well as prepared products that contain organisms such as algae.
- **Grades 3-5: OLP 6C.5.** Ocean resources are finite and should be respected and cared for by people.

## Next Generation Science Standards

**NGSS Performance Expectation**
**K-ESS3-1. Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live.**

| Science and Engineering Practices | Disciplinary Core Ideas | Cross Cutting Concepts |
|---|---|---|
| **Developing and Using Models**<br><br>Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, storyboard) that represent concrete events or design solutions.<br>● Use a model to represent relationships in the natural world. | **ESS3.A: Natural Resources**<br><br>● Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do. | **Systems and System Models**<br><br>● Systems in the natural and designed world have parts that work together. |

**NGSS Performance Expectation**
**K-ESS3-3. Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.**

| Science and Engineering Practices | Disciplinary Core Ideas | Cross Cutting Concepts |
|---|---|---|
| **Obtaining, Evaluating, and Communicating Information**<br><br>Obtaining, evaluating, and communicating information in K–2 builds on prior experiences and uses | **ESS3.C: Human Impacts on Earth Systems**<br><br>● Things that people do to live comfortably can affect the world around them. But | **Cause and Effect**<br><br>● Events have causes that generate observable patterns. |

| | | |
|---|---|---|
| observations and texts to communicate new information.<br>● Communicate solutions with others in oral and/or written forms using models and/or drawings that provide detail about scientific ideas. | they can make choices that reduce their impacts on the land, water, air, and other living things.<br>**ETS1.B: Developing Possible Solutions**<br>● Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (secondary) | |

**NGSS Performance Expectation**
**5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.**

| Science and Engineering Practices | Disciplinary Core Ideas | Cross Cutting Concepts |
|---|---|---|
| **Obtaining, Evaluating, and Communicating Information**<br>Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluating the merit and accuracy of ideas and methods.<br>● Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. | **ESS3.C: Human Impacts on Earth Systems**<br>● Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. | **Systems and System Models**<br>● A system can be described in terms of its components and their interactions.<br>**Science Addresses Questions About the Natural and Material World.**<br>● Science findings are limited to questions that can be answered with empirical evidence. |

# Extension Activities

The following activities can be done during any of the three modules. The crossword puzzles and word search were designed to give students an opportunity to practice vocabulary words and definitions. The bookmark activity can help students connect and engage creatively with the content.

- **What Is Seaweed? Crossword Puzzle**
- **Seaweed Life Cycle Crossword Puzzle**
- **Name That Seaweed Word Search**
- **Seaweed Bookmark Instructions**

# Resources

- ***Seaweeds of Alaska*** by Mandy Lindeberg and Sandra C. Lindstrom; Alaska Sea Grant College Program
- ***Common edible seaweeds in the Gulf of Alaska*** by Dolly Garza; Alaska Sea Grant College Program
- ***Elders in the Classroom*** by Roby Littlefield; University of Alaska Fairbanks Alaska Native Knowledge Network

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