

The Otter, the Urchin and the Kelp: Reading a Food Web from the Top Down

Learning target: I can use evidence from a passage to explain how matter and energy move through a kelp forest food web and how a change in one population reaches populations it never touches.

Reading with evidence

About 40 min

Individual

MS-LS2-3 · practice

MS-LS2-4 · supports

reading

writing

Standards connections

MS-LS2-3 (practice): The passage traces energy from sunlight through kelp, urchins and otters to heat in cold water, and follows kelp matter into decomposers; students pull those pathways out of the text, which builds the ideas their own model will need.

MS-LS2-4 (supports): The island comparison in the passage is a real example of empirical evidence that removing a biological component changes other populations; students read and evaluate the evidence rather than constructing the argument themselves.

Purpose: build · **Time:** about 40 minutes · **Format:** individual

Answers with reasoning

The Otter, the Urchin and the Kelp

[1] Just off the rocky coast of central California, tall brown seaweeds called giant kelp rise from the sea floor toward the light. Giant kelp is one of the fastest-growing organisms on Earth; a single strand can lengthen by tens of centimeters in a day. Like a land plant, kelp is a producer. It captures sunlight and uses that energy to build sugars from carbon dioxide dissolved in seawater, taking the other nutrients it needs from the water around it. A healthy kelp bed is a forest, with a canopy at the surface and a shaded floor below.

[2] Surprisingly little of that forest is eaten while it is alive. Snails and some fish nibble the blades, and purple and red sea urchins chew at the base of each strand, where it anchors to the rock. But most kelp matter follows another route. Storms tear off blades and whole strands, which sink to the sea floor or wash onto beaches. There, bacteria and other decomposers break the dead kelp down, releasing carbon dioxide and nutrients back into the water, where living kelp can take them up again. The matter in a kelp blade is never used up; it changes hands.

[3] The animal most people picture in a kelp forest is the sea otter, floating on its back and cracking shellfish on its chest. Otters eat sea urchins, along with crabs, clams and snails. Unlike seals, an otter has no thick layer of fat to keep it warm, so it burns food fast in cold water, eating roughly a quarter of its own body mass every day. Most of the energy in those urchins is used by the otter's cells and leaves its body as heat that warms the ocean by a tiny amount. Only a small share is ever stored as new otter.

[4] For much of the last three hundred years, otters were missing from most of the California coast. Hunters prized their dense fur, and by the early 1900s the animals had been nearly wiped out; a small group survived near Big Sur. Where otters disappeared, the sea floor changed. Sea urchins, no longer eaten, multiplied until they covered the rocks. They chewed through kelp faster than it could grow, and in many places the forest became bare rock carpeted with spiny urchins, a landscape scientists call an urchin barren.

[5] Notice that otters never eat kelp. The change in urchins was a direct effect: fewer otters meant fewer urchins eaten. The change in kelp was an indirect effect, passed along through the urchin population in between. In the 1970s, scientists tested this explanation by comparing islands in Alaska. On islands where otters lived, urchins were small and scarce and the kelp grew thick; on nearby islands without otters, urchins were large and abundant and kelp was rare. Comparing places that differed mainly in whether otters were present let the scientists link the predator to the plants.

[6] The energy story explains why there are so few otters compared with urchins, and so few urchins compared with kelp. At each feeding step, most of the energy in the food is used for living and leaves as heat, or stays locked in parts that are never eaten. As a rough average, only about one tenth of the energy at one level becomes energy stored in the next. A kelp forest must capture a great deal of sunlight to support a modest number of urchins, and those urchins can support only a few otters. The exact fraction varies from place to place, but the shrinking pattern does not.

[7] Since the mid-1900s, otters have spread slowly along the central California coast, and in many bays the kelp has returned with them. Yet the simple chain from otter to urchin to kelp does not explain everything. Starting in 2013, a disease killed huge numbers of sunflower sea stars, another animal that eats urchins, and unusually warm water in the following years weakened the kelp. Along parts of the northern coast, where otters had not returned, kelp forests shrank sharply. A food web is a model, and a model with only three arrows leaves out a great deal. The more arrows scientists add, the better their predictions become.

Questions: cite the passage

1. According to paragraph 1, what does kelp use to build its sugars, and where does the energy for that come from? Explain why this makes kelp a producer.

Answer: Kelp builds sugars from carbon dioxide dissolved in seawater, taking other nutrients from the water, and the energy comes from sunlight. That makes it a producer because it makes its own food rather than eating other organisms.

Why: Paragraph 1 names carbon dioxide, dissolved nutrients and sunlight; the definition of producer is from the chapter.

Also acceptable: Accept 'photosynthesis' as the process name even though the passage does not use the word.

- Names carbon dioxide (and water or nutrients)
- Names sunlight as the energy source
- Explains producer as making its own food

2. Paragraph 2 says most kelp matter 'follows another route.' Describe that route and quote the sentence that tells what happens to the matter in the end.

Answer: Storms tear off blades and strands, which sink or wash ashore, and bacteria and other decomposers break the dead kelp down, releasing carbon dioxide and nutrients that living kelp can take up again. Quote: 'The matter in a kelp blade is never used up; it changes hands.'

Why: The route is dead kelp to decomposers to dissolved nutrients to new kelp; the final sentence states that matter is conserved.

Also acceptable: Accept a paraphrase such as 'the matter is not used up, it is passed on.'

- Describes dead kelp going to decomposers
- States that carbon dioxide and nutrients are released and reused
- Quotes or closely paraphrases the final sentence

3. An adult sea otter has a mass of about 28 kilograms. Using the fraction in paragraph 3, estimate how much food it eats in one day. Show the calculation, then explain in one sentence where most of the energy in that food ends up.

Answer: $28 \text{ kg} \times 1/4 = 7 \text{ kg}$ of food per day ($28 \div 4 = 7$). Most of the energy in that food is used by the otter's cells to stay alive and warm and leaves its body as heat into the water; only a small share is stored as new otter.

Why: Paragraph 3 gives 'roughly a quarter of its own body mass every day' and states the fate of the energy.

Also acceptable: Accept 'about 7 kg' or a range of 6 to 8 kg if the student says 'roughly'.

4. Using paragraphs 4 and 5, identify one **direct effect** and one **indirect effect** of removing otters. For each, name the two populations involved and say what population, if any, sits in between.

Answer: Direct effect: otters and urchins. Fewer otters means fewer urchins are eaten, so urchins increase; nothing sits in between because otters eat urchins. Indirect effect: otters and kelp. Fewer otters leads to more urchins, which eat more kelp, so kelp decreases; the urchin population sits in between.

Why: Paragraph 5 states both effects explicitly; paragraph 4 gives the observations.

Also acceptable: Students may describe the reverse case (otters returning) as long as the roles are the same.

- Direct effect names otters and urchins with no population between
- Indirect effect names otters and kelp with urchins between
- Direction of each change is correct

5. Paragraph 5 describes a test using Alaskan islands. What did the scientists compare, what did they find, and why was comparing islands a stronger test than studying a single bay?

Answer: They compared islands that had otters with nearby islands that did not. Islands with otters had small, scarce urchins and thick kelp; islands without otters had large, abundant urchins and little kelp. Comparing many islands that differed mainly in otters acts like a controlled experiment: it is hard to blame weather or chance when the same difference appears again and again, which one bay could not show.

Why: The passage says comparing places that differed mainly in otter presence let scientists link the predator to the plants; students should recognize the comparison as the control.

Also acceptable: Accept 'it is like having a control group.'

- States what was compared (islands with and without otters)
- States both findings
- Explains why a comparison is stronger than a single site

6. Paragraph 6 says 'only about one tenth' of the energy passes to the next level. Where does the rest go, according to the passage? Then explain why the passage says the fraction 'varies' but the 'pattern does not.'

Answer: The rest is used for living and leaves as heat, or stays locked in parts of organisms that are never eaten (which go to decomposers). The fraction varies because different organisms and ecosystems pass on different amounts, but in every case most of the energy is used or leaves as heat, so each level always receives much less than the one below; the shrinking shape is the same even when the exact number changes.

Why: This checks that students read 'one tenth' as a rough average, which the chapter's accuracy notes emphasize.

Also acceptable: Accept 'the number is an average, but it is always a lot less' for the second part.

- Names heat from living (respiration) as a destination
- Names uneaten parts or decomposers as another
- Distinguishes the varying fraction from the constant shrinking pattern

7. Paragraph 7 gives two reasons the kelp shrank along the northern coast even though the otter explanation seemed to work elsewhere. Name both, and explain what the author means by 'a model with only three arrows leaves out a great deal.'

Answer: A disease killed sunflower sea stars, another urchin predator, and unusually warm water weakened the kelp. The author means that a model with only otter, urchin and kelp cannot predict what happens when other predators die or when the water changes, because those influences are not drawn in; adding more arrows (sea stars, temperature) makes the model's predictions better.

Why: Paragraph 7 lists both causes and ends with the model statement.

Also acceptable: Accept 'the otters had not come back there' as context, but the two causes named must be the disease and the warm water.

- Names the sea star disease
- Names warm water
- Interprets the three-arrow sentence as the model leaving out other causes

8. Does the sea otter 'control' the kelp forest? Using evidence from at least two different paragraphs, write a short argument that answers yes, no, or partly. Your argument must use the words *direct effect* or *indirect effect* correctly.

Answer: Model answer (partly): Otters strongly affect the kelp forest, but they do not fully control it. Evidence for their influence: in paragraph 4, where otters vanished, urchins multiplied and kelp forests became urchin barrens, and in paragraph 5 islands with otters had thick kelp while islands without had little; this is an indirect effect of otters on kelp through urchins. Evidence against full control: paragraph 7 shows that kelp also depends on other urchin predators such as sunflower sea stars and on water temperature, so kelp can shrink even where the otter story would predict recovery. So the otter is one strong arrow in a larger web.

Why: Yes, no or partly can all earn full credit if supported with evidence from two paragraphs and the effect terms are used correctly. A 'yes' answer should still acknowledge paragraph 7 to reach the top level.

Also acceptable: A 'yes' argument built on paragraphs 4 and 5 alone is acceptable at a good but not top level; a 'no' argument must still account for the island evidence.

- Takes a clear position
- Uses evidence from at least two different paragraphs with paragraph numbers
- Uses direct effect or indirect effect correctly
- Addresses the limits of the model (paragraph 7) for the strongest answers

Teacher notes

The passage's facts are accurate in outline: giant kelp growth of tens of centimeters per day under good conditions, otters eating roughly a quarter of their body mass daily, the fur trade and the Big Sur remnant, the 1970s Aleutian island comparisons (Estes and Palmisano), the sunflower sea star wasting disease beginning in 2013, and northern California kelp loss during the warm years that followed. The passage avoids exact dates for the otter decline and exact percentages for kelp loss so that no invented statistic is presented as real. Passage length is about 700 words. Emphasize in discussion that decomposers in the ocean are mostly bacteria, and that the passage says matter 'changes hands' rather than 'is lost,' which matches the chapter's accuracy notes. The q3 estimate uses 28 kg so the arithmetic is clean; real adult otters range widely.

Scaffold offered to students: Draw the web as you read

On scrap paper, write these names spread out: sunlight, kelp, urchins, snails, otters, sunflower sea stars, decomposers. Each time the passage says one thing eats another, draw an arrow from the food to the eater. Add an arrow from sunlight to kelp and arrows from kelp and urchins to decomposers. Most questions can be answered by looking at your drawing and then rereading the paragraph that gave you the arrow.

Extension: Add the sea star

Sunflower sea stars also eat urchins. Redraw your web with sea stars included, then write a paragraph predicting what should happen to urchins and kelp in a bay that has otters but loses its sea stars, compared with a bay that has neither. Explain which bay the passage's northern coast most resembles, and why having two different urchin predators makes a kelp forest more stable than having one.