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EARTH AND ITS RESOURCES
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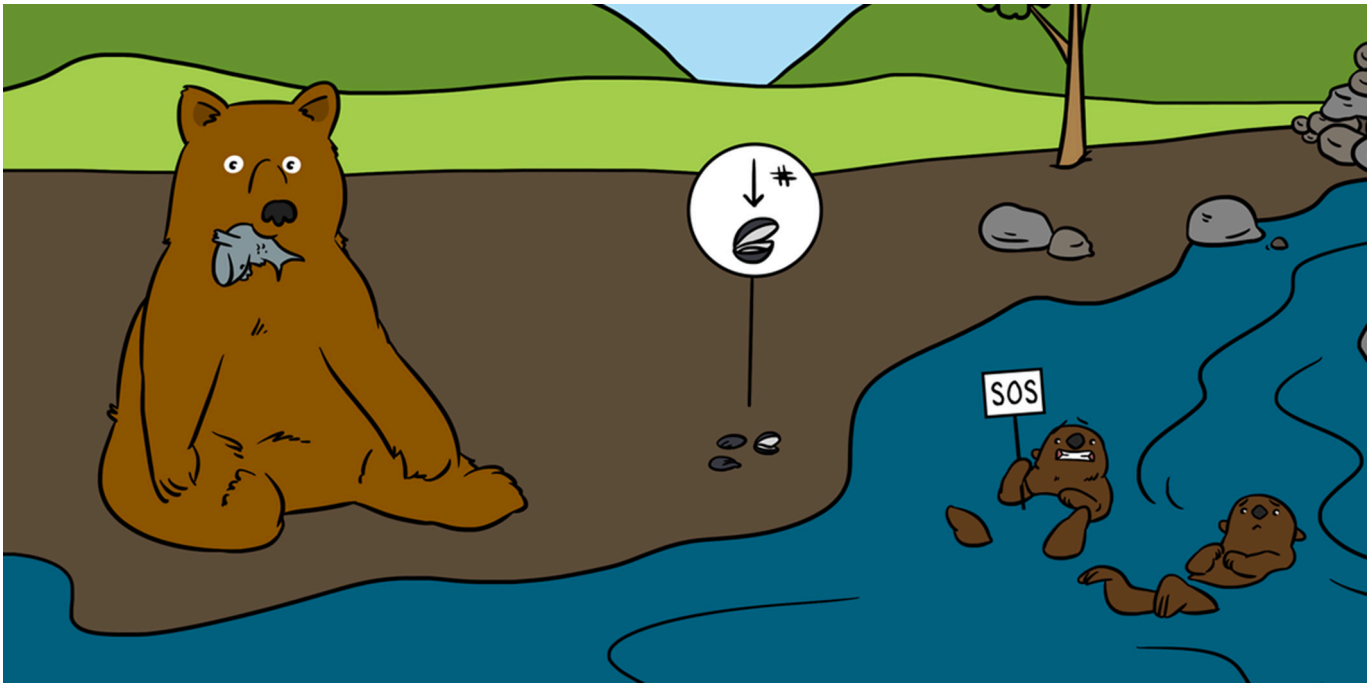

WHERE LAND AND SEA MEET: BROWN BEARS AND SEA OTTERS

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YOUNG REVIEWERS:

HEADWATERS ACADEMY 7TH GRADE

AGES: 12–13

ZION

AGE: 13

In Katmai National Park, Alaska, USA, we have seen changes in the number of brown bears and sea otters. The number of animals of a species a habitat can support is called carrying capacity. Even though bears live on land and sea otters live in the ocean, these two mammals share coastal habitats. Bears eat salmon, other fish, plants, clams, and beached whales. Sea otters feed on clams and other marine invertebrates. All these foods are influenced by the ocean. Recently, we have seen fewer bears but more sea otters! What changed? Many things, but several observations point to the ocean. There are fewer

salmon, whales, and clams, so bears rely more on plants for food. Fewer clams mean sea otters must work harder to find food. Our studies are helping us to understand how and why carrying capacity for a given species may change over time.

INTRODUCTION

National parks along Alaska's coastlines are some of the most remote, undeveloped, and wild places on the planet. It is here, in Katmai National Park and Preserve (Figure 1), that we can see the natural world and how it changes over time and across ecosystems. We can ask questions about how many animals live here, what they eat, and how the populations are changing. Two species, brown bears and sea otters, are used as **vital signs** to help us monitor the overall health of the park. If we think of vital signs just like we do for our bodies—for example, a strong, regular heartbeat is one indication of good health—we can use bears and sea otters as vital signs to check on the health of Katmai. You can think of the number of animals in the park like the park's heartbeat—when the park's heartbeat is strong, the park has just the right number of bears and sea otters, but if the number of bears or sea otters decreases, it might be a sign that the park is not well. So, how many brown bears and sea otters can live at Katmai? In **ecology**, this concept is called **carrying capacity**, which means the number of individuals of a species an ecosystem can support. This article will describe Katmai's carrying capacity for both brown bears and sea otters, how and why it has changed over time, and how these

VITAL SIGNS

Signals that can be used to gauge the health of an individual (a pulse rate or temperature), a population (abundance) or an ecosystem (number of species present).

ECOLOGY

The study of how different organisms interact with each and their environment.

CARRYING CAPACITY

The ability of a habitat to support a given number of a particular species. Carrying capacity can change over time as the habitat changes.

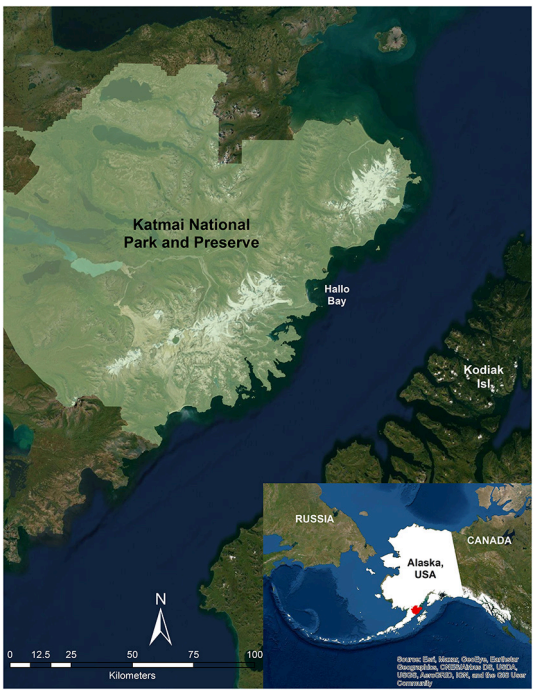

Figure 1

Katmai National Park and Preserve is located along the coast of Alaska, USA. Alaska is the northernmost state in the USA, shares a border with Canada, and is a close neighbor to Russia. Katmai is the red dot on the white Alaska map (inset). The larger map is a zoomed-in view of Katmai, which is just west of Kodiak Island, in the Gulf of Alaska.

changes might continue to occur [1]. All this information helps us to understand the overall health of the ecosystems in Katmai.

BEARS AND SEA OTTERS

TERRESTRIAL

Describes an organism or object that resides on land.

MARINE

Describes an organism or object that resides in salt water (oceans).

Surprisingly, the habitats of bears and sea otters overlap more than you might think. Bears eat some of the same foods sea otters eat, like clams! But bears and sea otters also use different spaces: bears are primarily on land (**terrestrial**), and sea otters are primarily at sea (**marine**). Studying them both can tell us about each habitat as well as how the habitats are linked, so we get a better sense of the health of the park's different ecosystems.

Brown bears are the largest terrestrial mammals in North America, with some bears weighing more than 1,000 pounds! After more than 300 years of over-hunting and habitat loss, the range of brown bears in North America has decreased drastically, but Alaska still has healthy brown bear populations. Bears are especially healthy in Katmai because so many types of food are available. Bears catch salmon in the summer and fall, and they eat washed-up whale carcasses when they find them, to fatten up. All that fat helps the bears prepare for hibernation as winter approaches. They also dig up clams and catch fish on the tidal flats and eat grasses in tidal meadows [2]. The amounts of these foods that are available to bears helps determine the carrying capacity of their environment.

Sea otters can weigh up to 100 pounds and live near the coast in the North Pacific Ocean. In the 1800s, sea otters were hunted for their fur and went extinct along the Katmai coast by the early 1900s. Without sea otters to eat them, some of the otters' favorite foods, like clams, crabs, and urchins, increased in size and number [3]. Once sea otters were protected, they returned to Katmai and had lots of food to eat. At first, all the extra food helped the sea otter population to grow. But once they ate most of the extra food, the number of sea otters went down a bit and now appears to have settled at a level that their food supply can support. That is carrying capacity at work!

THINGS WE LEARNED

Over the past 20 years, the number of bears counted along the Katmai coast has decreased by about 66%. The bears' diets also changed over this same time, from about two-thirds salmon and one-third plants in the 1990s to one-quarter salmon and three-quarters plants in recent years. What happened? One change is that salmon used to be more plentiful. Between 1978 and 2006, nearly a million salmon returned every year to spawn along the Katmai coast. Over the 10 years that followed, only about half as many salmon returned. In 2018, scientists counted more **sedges**, a favorite coastal plant that bears like to eat,

SEDGES

A grass-like plant that grows in wet ground, like tidal meadows.

than were counted in 2008. Lower numbers of salmon likely decreased the carrying capacity for bears along the Katmai coast, even though there were more sedges to eat. Why? Well, salmon have more calories than sedges, and so it takes more sedges than salmon to fatten up a bear. But individual bears remain healthy, there are just fewer of them being seen (Figure 2) [4].

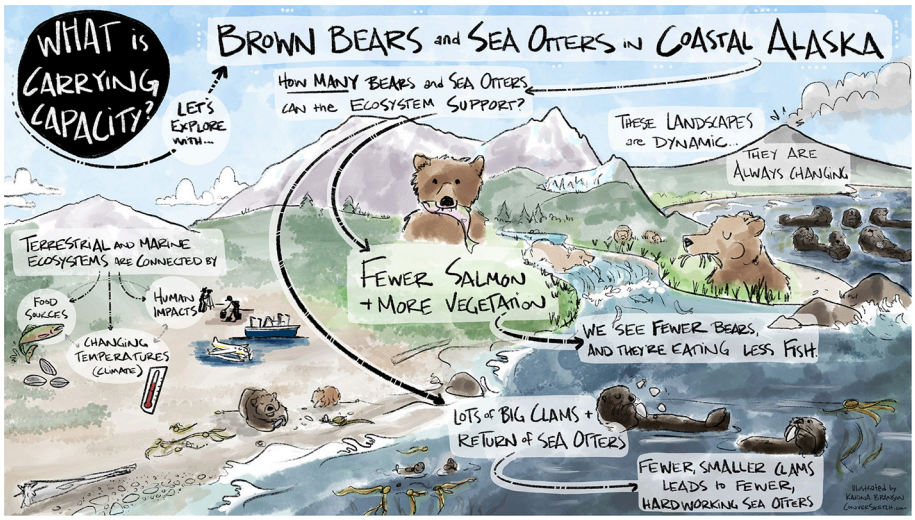

Figure 2

The carrying capacity of the Katmai ecosystem changes over time, for both brown bears and sea otters. Marine and terrestrial ecosystems are linked by rivers. Freshwater, sediments, and nutrients flow from the land to the ocean. Changing ocean temperatures, sea-level rise, and fish like salmon that grow in the ocean return to the rivers, linking the marine ecosystem to the terrestrial ecosystem. Human impacts take place across all ecosystems (Image credit: Karina Branson—CoverSketch, LLC).

Sea otters came back to the Katmai coast around 1950. Their population size peaked in 2012 at 8,600 when there was a lot of extra food, but today there are about 6,000 sea otters (a 30% decline). In addition to counting sea otters, scientists also measure how much food the otters eat. In 2006, because food was still abundant and easy to find, the average sea otter could eat lots of food in a short time, but this plentiful food did not last. From 2006–2019, we measured how many clams there were, and found that the number of clams went down following the peak in the sea otter population! Fewer clams meant the sea otters had to spend more time looking for food, and this eventually led to a reduced carrying capacity for sea otters along the Katmai coast [5] (Figure 2).

DRIVERS OF CHANGE

What else might have changed the carrying capacity for brown bears and sea otters? Currently, there are no cities on the Katmai coast, but human activities still affect the carrying capacity of Katmai for both bears and sea otters. For example, because of whaling in the 1900s, there are now fewer whales in the ocean [6]. That means fewer whales wash ashore for bears to eat. Since whale carcasses have lots of blubber and provide lots of energy for bears, the loss of whales reduces the carrying capacity of the coast for bears.

FOOD WEB

All the linkages in an ecosystem that relate to food. A food web links consumers and producers together.

PLANKTON

Organisms that cannot swim against a current of water. Most plankton are microscopic and can be plant-like or animal-like.

Although Katmai is a remote wilderness, both the ocean and the land will still feel the effects of a changing climate. As the planet warms, glaciers are melting and the rivers that salmon need are changing. As the ocean warms, the whole **food web** may be impacted. There may be less **plankton** (or different plankton) to feed the small fish that salmon eat. Less plankton also affects the clams and mussels that sea otters eat. A changing climate will probably shift the carrying capacity of Katmai for brown bears and sea otters again, as well as for the plants and animals that call Katmai home.

We have also seen a change in the number of people that visit Katmai. Before 1990, for example, few people visited the coast in Hallo Bay, but lately more than 3,000 visitors come to the bay each year by plane or boat. They come to watch brown bears and to see sea otters. Since hunting is not allowed in the park, bears have become less fearful of humans, but they are wary, and large numbers of visitors might affect where bears go. If too many people are watching the bears at their favorite places, the bears may not stay to eat as much as they would if people were not there. In this case, the carrying capacity may change—not because less food is available but because more people are visiting (Figure 2).

CONCLUSION

We expect some changes in an ecosystem to have a larger effect than others on the carrying capacity of that region for a given species. For example, in Alaska's coastal habitats, salmon may be the most important food for brown bears. We expect larger numbers of salmon to increase the number of bears and fewer salmon to decrease the number of bears. In contrast, we expect decreasing numbers of clams to have a small effect on the region's carrying capacity for bears because clams make up a small part of the bears' diet. But fewer clams could have a large effect on the sea otter carrying capacity because otters like to eat lots of clams. In another example, we expect that fewer whale carcasses would tend to have a negative effect on bears, but little effect on sea otters because sea otters do not eat whale carcasses. One thing that has not changed is the size and general health of the bears. This presents a riddle. We would expect that, as food becomes less abundant or nutritious, the bears' physical condition and size should diminish. However, we think that bears may adjust their abundance and stay healthy as opposed to keeping the same numbers of individuals with potential declines in overall health. This example is an indication of how animals may adjust their numbers in response to changes in carrying capacity.

As scientists, we will continue to study brown bears, sea otters, and other species at Katmai to see how they interact and how their populations change over time (Figure 3). Both bears and sea otters live in dynamic environments. Environmental changes can be natural

or caused by humans. The ability of these species to adapt to change allows them to stay healthy as individuals and as populations. Because of the important role these mammals play by interacting with many other species, bears and sea otters are good indicators of ecosystem health. Thus, they serve as effective vital signs for "taking the pulse" of Katmai.

Figure 3

(A) A brown bear eating salmon (NPS Photograph/K. Jalone). **(B)** A crew collecting data on salt marsh/sedge vegetation (NPS Photograph/M. Shepherd). **(C)** A brown bear eating sedges. **(D)** A brown bear eating a clam. **(E)** A scientist collecting sea otter foraging data. **(F)** A sea otter. **(G)** A sea otter eating a clam. **(H)** Brown bears eating a whale carcass (NPS Photograph/J. Erlenbach). (C-G credits: NPS Photograph/J. Pfeiffenberger).

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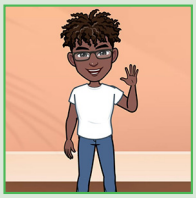
CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

HEADWATERS ACADEMY 7TH GRADE, AGES: 12–13

The 7th grade class of Headwaters Academy, with all of its eccentricities, is a humorous and adventuresome community. Our class is made up of great backgrounds of both sport and mind. Our community, built to create leaders and learners for a changing future, has allowed us to thrive and develop in our beautiful ecosystem, though it allows us to look upon the world in a different way: to know what should be and how to improve upon what is.



ZION, AGE: 13

Zion loves to play video games on the weekend and loves all things Marvel. His favorite subject is Math and his favorite food is spaghetti with meatballs. Zion plays baseball, football, and soccer, but enjoys working in the community garden more than anything.

AUTHORS

HEATHER COLETTI

Heather Coletti is a marine ecologist for the National Park Service. She has studied nearshore marine ecosystems, in particular sea otters and their prey, since 2001. Her favorite part of her job is to be in the field, which includes living on a boat, conducting lots of coastal surveys and watching sea otters. She also hopes her work contributes to marine conservation. For fun, Heather likes to spend time with her family cross-country skiing and mountain biking in Alaska. *heather_coletti@nps.gov

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Grant Hilderbrand is a wildlife biologist who studies brown bears and wolves. He is interested in how these animals are impacted by and shape their environments. He currently leads the natural resource team for the National Park Service in Alaska.

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James Bodkin was a research biologist with the US Geological Survey from 1977 until his retirement in 2012. Nearly all of his career was spent studying the biology and ecology of sea otters from California to Russia, but mostly in Alaska. Jim continues to study sea otters and nearshore marine ecosystems in Alaska and Washington while residing in Port Townsend, WA.

BRENDA BALLACHEY

Brenda Ballachey is a scientist with the US Geological Survey in Anchorage, Alaska. Her research has included studies of physiology, toxicology, and genetics in both wildlife and domestic livestock. She spent many years exploring the effects of the 1989 *Exxon Valdez* oil spill on sea otters and continues to study sea otters and the nearshore areas where they live. When not working, she loves to be outdoors, exploring nature, or to curl up with a good book.

JOY ERLENBACH

Joy Erlenbach is a wildlife biologist specializing in bears. She is primarily interested in why bears do the things they do—including what they eat and where they spend their time. She currently works in Kodiak Alaska for the US Fish and Wildlife Service.

GEORGE ESSLINGER

George Esslinger is a zoologist at US Geological Survey in Alaska. His research focuses on sea otters and understanding the nearshore ecosystem they live in. He enjoys working and playing with all forms of water, from boating and diving to skating and skiing.

MICHAEL HANNAM

Michael Hannam is an ecologist for the National Park Service in Alaska, where he studies changes in plant communities in southwest Alaska, and explores new ways to find patterns in data. Dr. Hannam has studied marine plants and helped with research on prairie dogs and black-footed ferrets. For fun, Michael likes to hike, ski, and cook fancy food.

KIMBERLY KLOECKER

Kimberly Kloecker is a USGS marine ecologist at the Alaska Science Center. She grew up playing in Lake Erie and was inspired to study marine biology by family trips to marine parks. Her work centers on sea otter health, population status, and behavior. She has two favorite types of workdays: sitting on shore with a spotting scope, stopwatch, and data sheet watching sea otters forage and working with students of all ages. In her spare time, she hikes and paddles with her teens but will drop everything to give belly rubs to her adopted kitties, Cha-Cha and Rhumba.

BUCK MANGIPANE

Buck Mangipane is the natural resource program manager for Lake Clark National Park and Preserve. Trained as a wildlife biologist, he has taken part in research and monitoring of caribou, Dall's sheep, brown bears, black bears, wolves, moose, and bald eagles. In his current role, he facilitates scientific research in the park that ranges from describing ocean currents to completing an acoustic inventory. Working in his 20th year at the park, he continues to be fascinated by wildlife ecology. Outside of work he enjoys fly-fishing and biking with his wife Lindsey and dog Stanley.

AMY MILLER

Amy Miller is an ecologist with the National Park Service. She has worked since 2004 as a plant ecologist and supervisory ecologist with the Inventory & Monitoring Program, Southwest Alaska Network, where she has focused on the effects of climate and disturbance on vegetation communities, including coastal marshes. In her spare time, Amy enjoys skiing and hiking in the nearby mountains.

DANIEL MONSON

Daniel Monson is a research wildlife biologist who works with sea otters and is interested in the role otters play in structuring the nearshore marine ecosystem where they live. He enjoys observing otters as they forage and interact with their environment, diving into their world to assess the abundance of their prey, and even capturing sea otters to assess their health and study their physiology. Dan works

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BENJAMIN PISTER

Benjamin Pister is the director of resource management at Kenai Fjords National Park. His job is to preserve the natural and cultural resources of the park for the education, inspiration, and enjoyment of current and future generations. By training he is an intertidal ecologist with a Ph.D. in biology and loves to study all things in the ocean—but especially invertebrates! When not working, he enjoys fishing, hunting, gathering, and spending time outdoors in Alaska with his kids.

KELSEY GRIFFIN

Kelsey is a wildlife biologist working for the National Park Service in Alaska. She is interested in understanding the roles that species play in their ecosystems and how we can inspire people to protect parks and natural areas through science. She studies many species, everything from birds and bats to bears and wolves. She enjoys exploring new areas, hiking and skiing with friends and family, and watercolor painting.

KELLY BODKIN

Kelly Bodkin is a special education teacher with over 14 years of experience working with students with autism, social emotional behavioral disorders, multiple health impairments, Down's syndrome, visual impairments, and learning disabilities. Kelly is inspired by the creativity, determination, positivity, and potential of each student she has worked with. She is currently pursuing her doctoral degree in special education. She has also participated in many field projects related to sea otters in Alaska.

TOM SMITH

Dr. Tom Smith has worked as a federal research scientist at the USGS Alaska Research Center and presently at Brigham Young University as a professor of wildlife management. His research is largely focused on bear ecology, human-bear conflict, and ways that we can live in harmony with bears. Current projects include four species of bears: black, brown, polar, and sloth. Dr. Smith serves on the Polar Bear Specialist Group, an international body tasked with conserving polar bears.