

The 1 salmon wave

Every year vast numbers of salmon surge from the open ocean up the rivers of Alaska to spawn, where an army of predators is waiting for them. The fish sustain an entire ecosystem, reveals **Isabelle Groc**.

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One of the many brown bears in Alaska's Katmai National Park fishes for sockeye salmon to build fat reserves for winter. The state has 35,000 brown bears, almost all of the US total.

Paul Souders/Alamy



Above: Brooks Falls in Katmai National Park acts as a barrier for sockeye salmon, creating a prime fishing spot for this bear. Below: grey wolves also gorge on the salmon, here an egg-laden female.

Bill Leacock speaks of Broken Ear with fondness and respect, and every year he looks forward to seeing her again. “She is a real character,” he says, one immediately recognisable to him because of her right ear. She has lost part of it, “possibly in a fight”. For over 10 years Leacock, a bear biologist for Kodiak National Wildlife Refuge, has been tracking Broken Ear, a 24-year-old brown bear, as she fishes for salmon with her latest batch of cubs in the Karluk River on south-western Kodiak Island in the western Gulf of Alaska.

Every year millions of salmon – mainly sockeye and pink – migrate from the open ocean to Kodiak’s hundreds of rivers, streams and lake beaches. They return to where they hatched, to spawn and then die. And every year Kodiak’s many bears are waiting for the feast, by the shallow streams where the fish are an easy catch. “Broken Ear has a route that she takes every year to optimise the number of salmon she has to eat,” says Leacock.

She is one of 40 brown bears that William Deacy, a post-doctoral

researcher at Oregon State University, has fitted with GPS collars to learn about their movements in Kodiak during the salmon runs. “Bears face a fundamental problem,” he says. “Sockeye salmon only spawn in a stream for about 40 days, but bears need salmon for more than 40 days.”

Salmon is critical to the survival of brown bears as they build their fat reserves for winter, and represents up to 80 per cent of their diet. The Kodiak Archipelago has an estimated population of 3,500 brown bears – and they are some of the biggest brown bears anywhere. Magnificent mature adult males can top 450kg.

A MOVABLE FEAST

Deacy has found that because salmon spawn at different times in different habitats, bears are able to eat the fish for longer by moving from one salmon run to another, effectively surfing the salmon ‘red wave’ across the landscape. On average, Kodiak bears visit three populations of spawning salmon in a year, and thereby prolong their feeding opportunities by more than one and a half times. Broken Ear has been observed surpassing all bears, and eating salmon at seven different spawning grounds for a total of 99 days. “She is the fattest bear ever in most years,” says Deacy.

In Kodiak, as well as elsewhere in Alaska, the great pulse of salmon enriches coasts, rivers and streams. It feeds not only bears but a tremendous diversity of other wildlife too. And even before the salmon reach fresh water, they must

run the gauntlet of the aptly named salmon shark, a stocky species in the same group as the great white, which patrols the coasts and river mouths. Meanwhile, in the land-based food chain, the bears have a very special role to play.

“The bears run the show in terms of providing food for everybody else,” says Taal Levi, an assistant professor at Oregon State University who studies interactions between salmon and other species. Bears mostly eat the brains of the fish and eggs from the females, as these provide the most concentrated nutrition, especially fat. They pull the fish out of the water and carry the carcasses onto land, making salmon available to a wide variety of animals.

Wolves, martens, mink and a host of birds – from bald eagles to gulls, ravens, jays, mergansers, gulls and even owls – all come to feast on the salmon. Blowflies lay their eggs in the carcasses and when the maggots hatch they feed on the decaying flesh and grow rapidly. Scientists have found that a single carcass can support 50,000 maggots that, in turn, are consumed by other insects, birds and fish. Back in the streams, spilled salmon eggs feed juvenile salmon, as well other fish such as Dolly Varden char and rainbow and cutthroat trout.

Some species have evolved ingenious strategies to make the most of the salmon bonanza. Biologist Jonny Armstrong, also an assistant professor at Oregon State University, has discovered that the finger-length juvenile coho salmon gorge on sockeye salmon eggs at night in the cold-water streams, then move to warmer water to digest

their meal. “When you have a month-long feast like this it is critically important for the fish to squeeze as much energy as they can out of it,” Armstrong explains. “It means they need to find water temperatures that allow their digestive system to quickly process food and convert it to fat.”

FISH ON A DISH

No fewer than five Pacific salmon species spawn in Alaska: sockeye salmon (*Oncorhynchus nerka*), pink salmon (*O. gorbuscha*), chum salmon (*O. keta*), king or Chinook salmon (*O. tshawytscha*), and coho salmon (*O. kisutch*). “When you go to a salmon stream, it is full of life,” says Mark Wipfli, a professor at the University of Alaska Fairbanks. “There is something about these salmon-rich zones that makes them seem so diverse: you feel the productivity around you and it is all centred on salmon.”

The animals of the region are not the only beneficiaries of the annual glut. Salmon lies at the heart of Alaska’s culture, economy and ecosystems. In south-east Alaska alone approximately 51 million salmon are harvested every year in commercial fisheries, and the fish also support

Clockwise from top right: Tongass National Forest provides ideal habitat for spawning salmon; during salmon runs, Alaska’s rivers and streams brim over with fish; salmon sharks target the fish before they reach fresh water.



Clockwise from wolf: Fabrice Simon/Biosphoto/FLPA; Matthias Breiter/Minden/FLPA; Design Pics Inc./Alamy; Michel Regge/AP/L; Doug Perrine/NPL/Getty

THE KODIAK ARCHIPELAGO HAS AN ESTIMATED 3,500 BROWN BEARS – AND SOME OF THE BIGGEST ANYWHERE.



Sockeye: Roland Herrni/Imagetroler/PA Bear: Paul Saunders/Getty Migration left to right: Ron Niebrugge/Alamy; Michael Quinon/Minden/PA Design Pics Inc/Alamy; Four Nussbaumer/NPL; Jack Perks/PA Design Pics Inc/Alamy



ALASKA STILL BOASTS VAST TRACTS OF PRISTINE WILDERNESS WHERE SALMON THRIVE.

recreational and subsistence fisheries with a combined value of about \$1 billion. "Salmon are the cornerstone for a lot of economic activities and culture," says Mark Hieronymus of Trout Unlimited, a fishing conservation organisation. "It is part of what we do, part of who we are, and part of what we need."

In contrast to the dismal state of many salmon runs in other areas of North America's west coast, salmon stocks in Alaska are generally in good shape. The state still boasts vast tracts of pristine wilderness where salmon thrive, and the fishery is managed sustainably.

A single agency, the Alaska Department of Fish and

Game, is responsible for salmon stocks, which is an advantage. "There is an ethic of maintaining sustainable fisheries. It is part of the fabric of Alaska," says Daniel Schindler, a professor in the School of Aquatic and Fishery Sciences at the University of Washington.

KEEPING TRACK

Schindler belongs to the University of Washington's Alaska Salmon Program that dates back to the end of World War Two. It is one of the longest-running efforts to monitor salmon and their ecosystems. Every year, biologists conduct fieldwork in the rivers and streams of the Bristol Bay region, a mega-system in south-west Alaska composed of nine major rivers that collectively host one of the world's largest sockeye runs. Up to 40 million sockeye salmon return to this watershed each year. ▶

MIGRATION OF THE SOCKEYE



HEADING HOME

As early as June, schools of sockeye salmon leave the ocean and enter fresh water, running the gauntlet of waiting salmon sharks and other predators. They spend time in cold lakes at the mouths of streams, where they stop eating and start their transformation.



CHANGING COLOUR

While they are in the ocean, sockeye salmon have a silvery torpedo shape, but when they get ready to spawn their bodies dramatically transform. Within two weeks they become bright red. Males develop a humped back and hooked jaws filled with visible teeth.



LAYING EGGS

Once the physical transformation is complete, the fish migrate upstream to their natal stream where they will spawn. With their tail, females start digging a nest, or redd. A female lays 3,000 eggs on average, and will guard her redd against other females.



FEEDING FRENZY

Bald eagles (left) and brown bears catch the salmon while they are spawning. Bears carry the fish to the stream banks and nearby forest, where uneaten portions of the carcasses become food for many other species. After spawning, the salmon die within a few weeks. Scavengers feast on the dead bodies, cleaning up all evidence of the feast.



FISH EAT FISH

Salmon eggs in the stream also become food for the juveniles of other salmon species, and for Dolly Varden char, rainbow trout (above) and cutthroat trout. Some rainbow trout, like sockeye salmon, are themselves migrants.



COMPLETING THE CYCLE

Surviving eggs hatch in winter and the alevins (newly hatched young) stay in the gravel, living off their yolk sacs. In spring they emerge from the gravel as fry. Sockeye salmon spend 1–4 years in fresh water, then 1–3 years in the ocean, before returning to fresh water.

Top left: colourful male sockeye salmon shoal in the Gulkana River. Above: brown bears have developed a range of salmon fishing styles, including snorkelling and pinning prey with their paws.

SALMON RUN

HOW TO SEE ALASKA'S GREAT SALMON RUN

America's 49th state is vast, so here are some tips to get you started.

ANAN CREEK

This fishing site in Tongass National Forest, accessible only by boat or floatplane, has a massive run of pink salmon. Visit Anan Wildlife Observatory in July–August for large numbers of brown and black bears, as well as bald eagles.

www.wrangell.com/visitorservices

KATMAI NATIONAL PARK

One of Alaska's premier brown-bear-viewing areas, with around 2,200 individuals. Its many top locations include Brooks Camp, where bears gather to feast on sockeye salmon in the Brooks River. There are three wildlife observation platforms along the river, best in July and September.

www.nps.gov/katm

CHILKAT BALD EAGLE PRESERVE

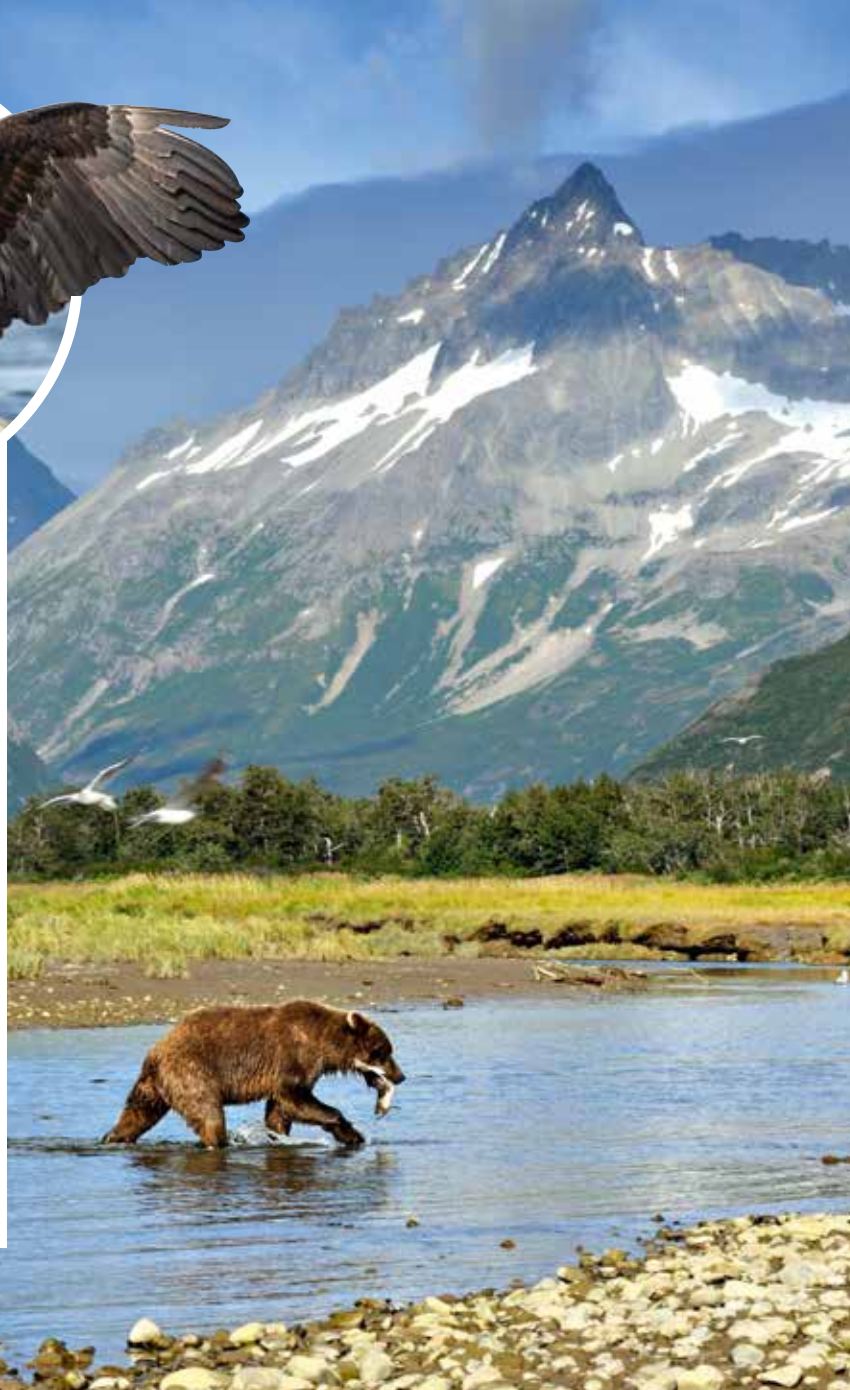
Chilkat Valley in south-east Alaska hosts up to 3,000 bald eagles

between October and February, which flock here to feed on the late run of chum salmon.

www.dnr.alaska.gov/parks

TOUR OPERATORS

Companies that offer a variety of land-based wildlife tours of Alaska include Natural World Safaris (www.naturalworldsafaris.com, 01273 691642), Naturetrek (www.naturetrek.co.uk, 01962 733051), Steppes Travel (www.steppes-travel.co.uk, 01285 601495), Wildlife Trails (www.wildlifetrails.co.uk, 0800 999 4334), Wildlife Worldwide (www.wildlifeworldwide.com, 01962 302086) and Windows on the Wild (www.windowsonthewild.com, 020 8742 1556).



A spectacular region of large glacial lakes, home to BBC One's *Wild Alaska Live*, this is where Daniel Schindler got to appreciate the true diversity of habitats used by salmon. "The reason why the salmon runs are so reliable there from year to year is because the habitat is so complex," he says. "Each of the rivers balances out the highs and lows of its neighbouring rivers."

Within the rivers, individual salmon populations occupy different tributaries that have their own unique features, with different water temperatures. "Salmon are incredibly resilient and adaptable fish that can flourish under a wide range of conditions," he explains.

Even the timing of salmon runs has its own complexity. In some streams salmon spawn as early as June, and in others as late as January. This diversity of timing benefits a wide range of wildlife. Taal Levi has found that in late autumn and early winter bald eagles travel long distances

BALD EAGLES TRAVEL LONG DISTANCES TO FEED ON A LATE RUN OF CHUM SALMON, AT A TIME WHEN THERE IS NOT MUCH TO EAT ANYWHERE ELSE.

to congregate in high numbers at the Chilkat River. They flock there specifically to feed on a late run of chum salmon, at a time when there is not much to eat anywhere else. Thereby, the eagles get an energy boost that helps them make it through the lean winter.

"Not all salmon runs are created equal for all species. Late salmon runs and very early salmon runs are important for the species that can move," says Levi.

Across Alaska, salmon are found in a surprising diversity of habitats. Take Tongass National Forest, covering 80 per cent of south-east Alaska. In this vast forested landscape, which includes nearly a third of the planet's intact temperate rainforest, a complex network of small creeks, rivers and lakes provides ideal habitat for abundant runs of pink salmon, as well as the other four salmon species, and fish such as rainbow trout, cutthroat trout and Dolly Varden char.

By contrast, native communities along the massive Yukon River have long relied on its runs of Chinook, chum and coho salmon. The Yukon is the largest river in Alaska, originating in British Columbia and flowing to the Bering

Above: a brown bear wades through a river with its catch. Top left: bald eagles can be seen catching salmon at Chilkat Bald Eagle Preserve in late autumn.



PRODUCER'S notes

ADAM WHITE • WILD ALASKA LIVE

Katmai National Park is remote even by Alaskan standards. Nearly 500km from any road or track, it is accessible only by floatplane at high tide or, with a tricky beach landing, by wheeled aircraft at low tide. And if getting there is hard enough, broadcasting bears, wolves, sharks and orcas live is another matter altogether. The task falls to a very special engineering manager, Gareth Wildman, who oversees all of the BBC's tech for *Springwatch* and Glastonbury Festival. He was also responsible for getting us those unforgettable live images of the blue whale in *Big Blue Live* last July. But our new location has really tested Gareth.

Not only did we reduce our crew size – everyone



has doubled up on job roles and is sharing tents – but we also stripped our equipment

right down to the bare essentials. Gareth even worked with manufacturers to reduce our kit's power consumption, as power supply and recharging batteries is such a challenge out here. At times it has felt more like planning a space mission."

● Adam White is series producer of *Wild Alaska Live*.

Above: black bears also benefit from the salmon run. A mother and her cubs feature in BBC One's *Wild Alaska Live*. Below: naturalist Steve Backshall searches for orcas in the series.

FIND OUT MORE

3-part series *Wild Alaska Live* airs on BBC One from Sunday 23 July.

Sea. The migrating chum salmon have to travel up to 3,500km upstream to the Yukon's headwaters.

However, while most salmon runs are very strong in Alaska, there is no room for complacency.

"The fish have evolved ways to exploit all of the variation across the landscape, so when we develop watersheds or build roads, we take away their options," says Schindler.

"The salmon are feeding the economy and the culture. Everything we plan should be around the salmon, not the other way around," adds Mark Hieronymus.

WIN SOME, LOSE SOME

It is not just locally generated hazards that will impact the salmon, either. Projections for an increasingly warmer and wetter climate in Alaska have raised concern about climate change impacts on salmon. Some streams that used to be too cold for the fish are now proving more amenable, but the benefits may not last. "Some tributaries will suffer from warmer, drier summers, while some glacially influenced streams are likely to become better for salmon," says Mark Wipfli. "There will be winners and losers."

Ultimately, the future of salmon and other species that benefit from them is not just about protecting large rivers with the highest numbers of fish, but also the small

streams that have early or late runs. "It is important to think of salmon habitat as a mosaic of conditions," warns Schindler. "We should be optimistic," he adds. "But we have to be smart about what we protect."

In the meantime, bears, eagles, wolves and the rest will be enjoying the abundance of fish this year. And, in Kodiak, Broken Ear will be returning to her favourite fishing spots. 🐾



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