Claim stake. A lone stake casts a shadow on the site of the proposed Pebble Mine.

CREDIT: ERIN MCKITTRICK/WWW.GROUNDTRUTHTREKKING.ORG

FISHERIES

Fishing for Gold in The Last Frontier State

A gargantuan gold and copper deposit leaves some Alaskans fearful that they must choose between two great loves: salmon and mining

Tiffany's tastes are decidedly caviar, but the jewelry company has devoted itself lately to saving a less chichi seafood: sockeye salmon. Two years ago, Tiffany & Co. pledged never to buy gold from a gargantuan mine proposed for several dozen kilometers northeast of Bristol Bay, Alaska, a prolific salmon habitat. Since then, Tiffany has helped recruit a dozen other major jewelers to the preemptive boycott—some prestigious (Helzberg Diamonds), some less so (Sears, Walmart)—and continues to apply pressure. In October 2009, it took out a full-page, cyan-colored ad in the trade magazine *National Jeweler*, pleading that the "threat" to Bristol Bay "rises above all our immediate financial self-interests."

The jewelers' boycott is the most public skirmish in the touchy fight over the proposed Pebble Mine. In some ways, the fight feels familiar: Environmentalists see doomsday, whereas mining companies promise jobs and tax revenue. In other ways, this clash is atypical. Joining environmentalists are their sometime foes, fisheries, whose work buoys up much of Bristol Bay's economy. As a result, many people paint Pebble Mine as pitting two moneyed industries, mines and fisheries, against each other. And although people oppose the mine for other reasons, including a desire to shield other flora and fauna, salmon earn the most sympathy.

In another twist, it's not clear how much the mine would threaten the 40 million salmon in the bay. Foes and proponents agree that the mine, as planned, would disturb less productive salmon habitats there. But scientists are amassing evidence that the unproductive habitats of today may be vital for a robust salmon population tomorrow. By mucking around in ancient mud, they have charted salmon populations over hundreds, even thousands of years. They've discovered that somewhat barren streams and lakes were wildly productive once, and populations in each habitat wax and wane naturally with shifts in climate. So, as a precautionary measure and to ensure that Alaska has fish to fish in the future, scientists contend that the state must preserve its variety of habitats—by killing Pebble.

The Pebble Partnership—a joint venture of the mining companies Anglo American US LLC and Northern Dynasty Minerals—has said, many times, that it will proceed only if the project results in "zero loss" to fisheries, says Ken Taylor, head of the partnership's eight-person, $100 million (so far) environmental-assessment project. Taylor argues that giant mines and fisheries can co-exist.

Pebble officials also stress that they are merely exploring the site and have no firm plans. In fact, given the fickleness of Alaskan politics, it's not clear whether the mine will ever open. Pebble needs to secure state air and water permits, among others, and submit an environmental impact statement that the federal government will spend years scrutinizing. Tom Crafford, coordinator for large mines at the Alaska Department of Natural Resources, says Pebble would not crush its first rock until 2014, and that's if everything goes smoothly—if permits sail through, and court challenges end quickly. When Crafford mentions even that date, he chuckles, hard: "The likelihood of Pebble going smoothly is pretty minimal."

Mother lodes

The 3-km by 4-km Pebble deposit sits below marshy tan tundra, an expanse broken by mountains and veins of streams. Pebble West, 3.7 trillion kg of minerals, was discovered in 1988. Its ore was marginal, mostly low grade. Near the end of the survey, in 2005, engineers drilled a few last holes on the eastern edge. They hit the mother lode: Pebble East, an additional 3.1 trillion kg of higher-grade ore interred beneath a 1-km wedge of volcanic rock.

With that discovery, Pebble became a national environmental issue. The tiff with Tiffany focused attention on gold, but the Pebble deposit is largely copper—33 billion kg compared with 2.9 million kg (94 million oz.) of gold. (There's also 2.2 billion kg of molybdenum.) Metal markets can swing manically, but at today's healthy prices (gold at $1100 an oz.; copper at $7 per kg), the total deposit could be worth some $370 billion.

Most people surmise that Pebble East would be a subterranean "cave" dig that would require moving 4 trillion kg of rock. Pebble West, likely a strip mine, would remove 4 trillion kg more from an open pit. (Foes of the mine claim the pit would stretch 3 km across and 600 m deep. Taylor says it would be much smaller.) Pebble would have to build its own power supply, as well as a 160-km service road to a Pacific Ocean port in a region not conducive to ground transport—no road exists to Anchorage 330 km away. Pebble must also accommodate 1000 or so on-site employees for up to 80 years.

Some scientists fear that those mining jobs, coveted by some locals, would undermine jobs in fishing. To scrub its low-grade ore, Pebble would require massive amounts of water, and as Crafford recognizes, "For mining projects, water, and water quality, and the protection of water quality, are the name of the game." With the identity of the region

Published by AAAS

The Secret Lives of Ocean Fish

It's easy to monitor the health of stocks of salmon because salmon spawn in small, discrete, and accessible freshwater bodies. Tracking fish in the ocean is a little tougher. But many scientists argue that ocean fish such as cod segregate themselves into distinct environments, as salmon do—and thrive or struggle for the same reasons.

For cod, population health depends on both human fishing and ecological factors. The 6 billion or so kilograms of cod living off Newfoundland and Labrador in Canada in the 1940s has dropped to hundreds of thousands of kilograms today, partly due to overfishing, says George Rose, a professor of fisheries conservation at Memorial University of Newfoundland in St. John's. "People thought little stocks [of cod] weren't important, and they got wiped out," he says. When large stocks faltered too, nothing could replace them.

But Rose's research reveals tremendous variation in the way cod stocks responded to the collapse. "Groups … very close geographically in fact are subject to very different ecological conditions," he says. As a result, "even in the worst possible times, in the 1990s, we had a couple of groups that were actually doing beautifully."

Work in biocomplexity—the physical diversity of fish habitats—explains why. To terrestrial animals (such as humans), oceans look homogenous—cold, deep, and empty—says Larry Crowder, a marine biologist at Duke University in Durham, North Carolina. However, oceans have currents, canyons, mountains, reefs, and forests of plants, which alter a habitat from top to bottom. Submerged vegetation supports prey at the expense of predators, given that prey can slip away in tangles of weeds. Fish rely on submarine currents to transport eggs and larvae from nests to feeding grounds. Climate change or fishing can alter habitats, and depending on how a stock's habitat responds, its population contracts or expands.

To thrive overall, species need to hedge themselves, by finding a balanced array of habitats to supply more or fewer fish as need be. "I guess it's like an orchestra," Rose says. "You have the horns playing for a bit, then the strings come in." **–S.K.**

tied up with salmon, he adds, "Pebble will be under an unprecedented microscope."

To outsiders, the names of local waterways blur together in a series of gutturals: Ugashik, Egegik, Naknek, Kvichak. To salmon, each "run" is a unique ecosystem, as distinct as a city. Salmon spend their adult lives at sea but spawn—mate and lay eggs in gravel beds—in fresh water, a biological quirk that requires them to thrash upstream for sometimes hundreds of kilometers. And salmon are homebodies; they spawn in the waterway where they were born, so depleting a run can doom a population.

Preliminary permit applications suggest that Pebble would draw at least 76 million liters of water (estimates by opposition groups range up to 265 million) per day from the Koktuli and Talarik rivers, which drain into other rivers and lakes and then Bristol Bay. Pebble would also likely discharge processed water into streams—a prospect that worries environmentalists, who fear that even clean discharge could alter a habitat's temperature or salinity or sediment composition, preventing adults from reaching spawning sites or retarding the growth of juveniles. And unfortunately, metal mines don't have a history of clean living. Again, Pebble has no firm plans, but many gold mines use cyanide for extraction; ground-up waste rock could also release sulfides, rendering water more acidic. Some evidence suggests that aqueous copper—at concentrations below Alaska's legal limit—interferes with the way salmon navigate and detect predators and disrupts their food chain, although ecologists also admit that the harm, if any, is impossible to predict because natural processes often mitigate the effects of copper.

Scientists also worry about pollutants leaking horizontally through the wet tundra, because Pebble would straddle two watersheds with complex hydrology, says Sarah O'Neal, a population biologist at State of the Salmon, a Portland, Oregon, environmental group. "It's really hard to tell where the water's going there, even the surface water. It can cross watershed boundaries, and you can find any potential contaminants across any watershed." It's therefore difficult to gauge which habitats are at risk, she says—and there are innumerable habitats: "Even the teeniest tiniest places, above disconnected channels, there are still fish in those little ponds."

Ups and downs. The productivity of different salmon streams varies greatly over decades, and some scientists worry that the Pebble Mine would harm tomorrow's prolific habitats.

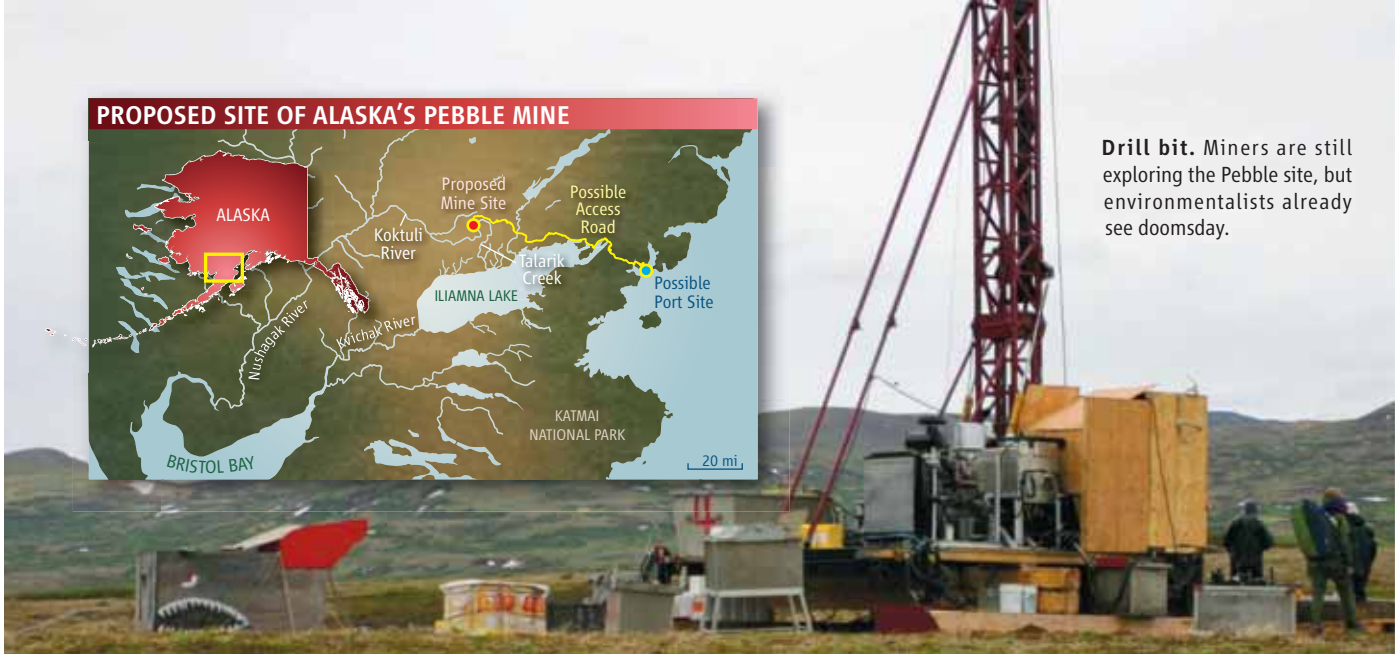
CREDIT: © NATALIE FOBES/CORBIS

Biocomplexity

Teeny-tiny ponds and creeks obviously don't supply millions of salmon and other fish, like trout, for Bristol Bay, but they're not irrelevant in the long term, say fishery scientists Daniel Schindler and Ray Hilborn, part of a University of Washington, Seattle, team studying the issue in Alaska with support from federal agencies and the Moore and Pew foundations. (A small percentage of support also comes from fisheries groups.) Hilborn estimates that the mine could threaten four or five of 15 distinct stocks of sockeye salmon, the most economically important species. Those four stocks account for 20% of the sockeye population now, "but at some times [those stocks] would have accounted for 80% of the production," he says. In different eras, "there's an enormous variation in what's being productive."

A few years before Pebble East was discovered, Schindler began charting those variations by using nitrogen-14 and nitrogen-15 isotopes in lake sediment. Oceans contain more of the heavy isotope than fresh water contains, so salmon have a higher percentage in their bodies than freshwater fauna. By plotting the rising and falling nitrogen-15/-14 ratio in cores of lakebed mud (where salmon

Published by AAAS



Drill bit. Miners are still exploring the Pebble site, but environmentalists already see doomsday.

CREDIT: ERIN MCKITTRICK, WWW.GROUNDTRUTHTREKKING.ORG; (MAP SOURCE) RENEWABLE RESOURCES COALITION/ALASKA DEPARTMENT OF NATURAL RESOURCES

sink when they expire, exhausted, after spawning), Schindler can trace demographic booms and busts back 10,000 years in some areas. He found that the population in each inland waterway—whether a mountain creek just centimeters deep, a meter-deep river from an underground spring, a lake beach, etc.—fluctuates erratically and independently of its neighbors. That's because its temperature, depth, and other qualities respond to different environmental factors—heavy rains, ice, tree cover, floods—in unique ways. Salmon also spawn or migrate back to sea as juveniles in different months, and El Niño and decades-long weather patterns fiddle with ocean habitats. Salmon thrive where conditions are favorable each decade, and given the diversity of Bristol Bay, odds are they will be favorable somewhere.

Schindler and Hilborn refer to this buffer of redundant habitats as "biocomplexity." "Regular biodiversity focused on the biotic component of the system, like genetic diversity, population diversity, species diversity," Schindler explains. "But that's not thinking about the coupled physical landscape. In the case of salmon, it's important to consider them together because the habitat is evolving." Other fish scientists argue that biocomplexity underlies the health of many fish populations worldwide. George Rose of Memorial University of Newfoundland in St. John's, Canada, finds only subtle genetic differences between some of the thriving and crashing stocks of Atlantic cod he studies. "There's nothing obviously different between these fish—except they have a different home." The reasons are murky, he says, "but one group does really well for a while, then the other does well for a while" (see sidebar, p. 264).

But that murkiness has been clearing up lately, and Schindler and Hilborn argue that the failure of some fisheries shows the folly of focusing only on productive watersheds. Dams in the U.S. Pacific Northwest—often built decades ago on nonproductive runs—have cut off spawning grounds that might have helped salmon recover when the population in other places flat-lined. In British Columbia, Canada, fishers long neglected all but the teeming Fraser River stock, which replenished itself each year. But extenuating circumstances caused the stock to collapse last summer to just 1.7 million salmon, well under the expected 11 million to 13 million, and left the industry gasping.

But the Fraser situation holds other lessons, too, claim Pebble officials. Large mines had been excavating copper within 10 km of Fraser River for decades before the salmon collapse, with seemingly no toxic effects. (Most scientists, including Schindler and Hilborn, blame the collapse on climate change or a lice infestation from fish farms.) Taylor, Pebble's environmental man, also points out that Alaska's Copper River, named after nearby and well-mined deposits, supports some of the premium salmon runs in Alaska. Moreover, the Bristol Bay salmon are hardly endangered or reeling: Schindler has never seen a higher population in his demographic studies.

Given Alaska's unreliable political climate—the state has a history of mavericks and ruthless moneyed interests (the *Anchorage Daily News* has a Web page to help sort through the endless federal inquiries into corruption there, http://www.adn.com/fbi)—most people declined to handicap whether Pebble Mine will actually open, much less when. Governor Sean Parnell has taken no public stand on Pebble. Neither has former Governor Sarah Palin, though her husband, Todd, works part-time fishing salmon. Nevertheless, those who read tea leaves interpret her comments and actions as pro-Pebble. Other former governors, as well as former U.S. Senator Ted Stevens, widely viewed as in favor of mining anything, have denounced Pebble.

Alaskan citizens send conflicting signals, too. Polls have shown that over half of Alaskans oppose the Pebble project, including about 70% of the people, largely Native Americans, near Bristol Bay. Then again, native groups recently opposed a strict clean-water initiative that many viewed as a referendum on Pebble, because it would have made mining there effectively impossible. (Some residents worried that the initiative would hamper all large mines in the state.) The initiative lost 57% to 43% during a statewide election in August 2008. So for now, Pebble lives, and, ultimately, Taylor feels, public pressure won't sway or disturb the regulatory agencies that will decide its fate. Pebble likely will not begin submitting permits until 2011.

Perhaps the one thing more uncertain than Alaskan politics is the potential effect of global warming on salmon runs. Alaska has grown rainier and warmer in the past few decades, and as glaciers melt and established ocean currents wobble, scientists do not pretend they can predict what will happen to spawning grounds. But really, that's the point of the biocomplexity work: Nobody can know. An empty river today could be boiling over with salmon in 20 years—if it remains habitable. "Life choices that work in one decade may not work in another," says Hilborn. "You want something out there that's going to be doing well in a warmer world."

–SAM KEAN

Published by AAAS