Seizing a Species: The Story of the Great Salt Lake Brine Shrimp Harvest

by

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ABSTRACT

In the early 1950s, C.C. "Sparkplug" Sanders began harvesting brine shrimp from Utah's Great Salt Lake. Sanders built up a small business selling their eggs, called "cysts," to aquarium stores across the country. During the 80s, cysts were found to be an effective food source for aquaculture and a multimillion-dollar commercial harvesting industry quickly emerged.

As the cysts rose in value, competition between harvesters grew fierce and annual catches soon began to drop. Environmentalists also became concerned, as the shrimp are an important food source for millions of migratory birds. The harvest was almost entirely unregulated during this period. Unlike other fisheries, where industry members have fought government intervention, many of the harvesters called on the state to increase oversight. Scientists hired by Utah's natural resource agency found that no comprehensive studies had ever been conducted on the lake's ecosystem, complicating initial efforts to manage the harvest. A twenty-year effort by the state, harvesters and other stakeholders to develop a science-based management strategy has recently begun to pay off as cyst populations appear to be stabilizing and the harvesting industry has once again become profitable.

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For Mom and Paul

Seizing a Species

The Story of the Great Salt Lake Brine Shrimp Harvest

By SAM WOTIPKA

In October of 1951 an enthusiastic letter telling of a discovery in Utah's Great Salt Lake appeared in The Aquarium, a magazine for fish hobbyists. "Brine shrimp by the billions!" C.C. "Sparkplug" Sanders wrote from Ogden. The shrimp themselves were nothing new—in fact their presence in the lake dates back some 15,000 years—but Sanders had found that they made great live feed for the betta fish he raised in an assortment of tanks in his home and sold locally.

Famous for its general deadness and putrid smell, the Great Salt Lake seemed an unlikely place to find nature's bounty. But, as Sanders had discovered, a simple but productive ecosystem of salt-tolerant creatures, brine shrimp among them, thrives in the lake's harsh, saline waters.

Often accompanied by his son, Sanders would make the 20 minute drive to the lake's eastern shoreline, turning towards the water down a rough dirt road that dead-ended out on the surface of the lake at an abandoned salt works. Though wide, the lake is extremely shallow and also muddy, especially at its margins. This point of entry made for less wading.

Carrying long-handled nets, they would step off the road and trudge out into the water, which becomes warm during the long, hot days of a Utah summer. When pushed towards the shore by the wind or lake currents, the shrimp often school so thickly that the water appears dark red. With a two-man net they could gather the schooling shrimp a half gallon at a time.

In a typical trip, it would take them two hours to drive out to the lake and gather around 40 quarts of live brine shrimp, which more resemble miniature silverfish than the seafood staple that shares their name. Each adult brine shrimp is roughly the size of a Tic Tac.

Back at home, Sanders poured his catch, a thick slurry of wriggling shrimp, into metal bread pans and stored them in a freezer. When need arose, he would slice off pieces of the frozen shrimp bricks with a band saw and drop them into his aquariums. The chunks melted in the warm water and the shrimp reanimated before being devoured by tropical fish.

After Sanders' letter was published, requests for the diminutive crustaceans began pouring in from across the country. Realizing an opportunity was presenting itself, Sanders got together with his friend and occasional business partner, Scott Wangsgard, a Salt Lake City high school teacher who moonlighted as an accountant, among various other odd jobs. Together they formulated a plan to profit from the discovery by selling the shrimp to aquarium supply stores nationwide.

Wangsgard began organizing small crews of workers and sending them out to the salt works in a burnt orange GMC pickup. Many of the laborers were fellow teachers looking to earn extra money over the summer. Armed with nets crafted from surplus army

parachutes, they slopped the shrimp into inflatable children's swimming pools that floated at their sides, secured by ropes tied to their waists. Periodically, as the pools became full they would tow them back to shore and pump their contents into a pair of 500-gallon rubber fuel tanks salvaged from B-17 bombers—another Buck's War Surplus find—that sat in the back of the truck. When the tanks were full, they packed up and drove back into town.

Back at Sanders' garage, he and Wangsgard improvised a more efficient method for processing and packaging the shrimp. They were first rinsed in freshwater and then dispensed from a soft-serve ice-cream machine into containers of varying quantities, ranging from one-ounce bags to quarts. The packages were stamped with a brand name—Sanders Brine Shrimp Company—before being hauled to a cold storage plant and eventually being shipped via rail to aquarium supply stores across America.

For Sanders, this was a business venture. And as he improved and refined his methods, it became a relatively successful one. Within fifteen years, he had a small, profitable company with a handful of seasonal employees. The company was eventually passed on to his sons and is still in business.

For the brine shrimp, those first harvests were fundamentally transformative. As the truck drove off, sagging under the weight of the day's catch, the brine shrimp were no longer a mere cog in the unforgiving ecosystem of the Great Salt Lake, but a natural resource. The men were about to seize a species for mankind.

Civilization has been built on the backs of other species that humans have figured out how to utilize in various ways. Often, this has involved a gradual process of selective breeding and domestication. Modern agriculture relies on plants and animals whose wild ancestors were handpicked centuries ago for traits deemed useful to mankind. A lengthy list of human-crafted species—cows, corn, wheat, horses, chickens, and so on—has been generated by this habit.

Nature is not always easily improved upon, though, and many species have proven so useful in their wild forms that humans have opted to "manage" rather than modify them. Game management, forestry and fisheries are among the subdisciplines of the management branch of humans' species utilization practices.

By now, most of the obvious candidates have been taken, yet our innate inclination to see opportunity among nature's creations has hardly waned. We're just reaching further into the bucket. Algae are being harnessed as a source of biofuel. Oyster colonies are being created in Chesapeake Bay to help filter out water contaminants.

The Great Salt Lake brine shrimp were mostly ignored by several thousand years worth of humans before Sanders realized their enormous potential.

Today Artemia franciscana, the particular species of brine shrimp that inhabit the Great Salt Lake, are the basis of an industry that is worth over 30 million dollars annually, on average, and employs more than 350 people. The harvesting process has evolved from a homespun experiment into a precisely orchestrated, high-tech operation involving spotting planes, global positioning systems, and fleets of boats with specialized equipment.

For the first 30 years, there wasn't much competition. "C.C. Sanders has a 1,500 square mile fishing hole to himself," read the first line of a 1961 Associated Press profile. Though he wasn't getting rich, Sanders made a decent living supplying pet and aquarium stores with brine shrimp eggs (which he had found, early on, were easier to pack and ship than live shrimp). Midway through the 1980s, though, it was discovered that the shrimp were a cheap and effective food source for prawns being raised on farms in Southeast Asia. The race was on.

Their suitability for aquaculture turned brine shrimp into a global commodity and the per-pound prices their eggs commanded soared. Cysts began selling for upwards of $8 a pound, and there were rumors of harvesters fetching prices over five times that amount. As word spread, newcomers flocked to the lake, hoping to grab a piece of the growing wealth. New companies sprang up overnight and Sander's

1,500-square-mile fishing hole began to get a little crowded. The harvest became frenzied and tense, as companies competed fiercely against one another for what many of them knew was a limited resource. The state wildlife division, which until then had mostly ignored the shrimpers, instead focusing their Great Salt Lake efforts on the mining and mineral extraction companies that operate on and around the lake, found themselves in over their heads as they struggled to reign in a fishery they knew almost nothing about.

As word spread, newcomers flocked to the lake, hoping to grab a piece of the growing wealth.

Brine shrimp thrive where little else does. They are part of an elite group of organisms that biologists have designated as "extremophiles." That is, species adapted to environments that are particularly inhospitable to life—volcanoes, mountaintops, deep sea vents, geysers, caves, deserts, and the like. Rather than relying on nature's bounty, these organisms, many of them microbes, eke out an existence from the leftovers by extracting nutrition and energy from places that other species can't.

Salty lakes are where brine shrimp make their living. There are hundreds of saline lakes worldwide, give or take a few that dry up seasonally and others, like the Aral Sea in central Asia, that have seen their inflowing waters reduced to the point that they have ceased to be lakes for all practical purposes. Many of these water bodies are relatively mild in their saltiness and support diverse ecosystems that often include brine shrimp among various species of aquatic birds, mammals, fish, insects and microorganisms. With salinity levels on the order of 2-4%, they resemble inland oceans (the world's oceans are generally around 3.5%).

It is their ability to subsist in waters with far greater salt levels that has earned brine shrimp their extremophile status. Hypersaline lakes, like the Great Salt Lake and the Dead Sea, where salinity concentrations can reach upwards of 30%, or ten times that of the ocean, have greatly reduced biodiversity, as few species can cope with concentrations of salt that high. For brine shrimp this actually an advantage. In milder bodies of water, they are easy prey, especially for fish. But even saltwater fish species can only handle so much salinity.

Excess internal salt causes the cells of most plants and animals to rapidly become dehydrated. Salinity-adapted organisms have various strategies for managing salt. Ocean-dwelling fish, for example, filter it out through their gills. The marine iguana, found exclusively near the Galápagos Islands, sneezes salt out through a specialized gland in its nose. These types of adaptations are energetically costly, however, and have an upper limit. Past a certain point the brine shrimp are left mostly to their own devices.

Scientists have described brine shrimp as the best osmoregulators in the animal kingdom. Their exoskeletons are impermeable to the water surrounding them, but when they open their mouths to feed, their bodies are flooded with saltwater. Specialized cells that line their stomachs absorb the water while a pair of internal pumps excrete excess salt through their gills and a gland in their neck. The pumps can speed or slow depending on the concentration of salt in their environment, which can vary significantly depending on factors like the amount of freshwater inflow to a lake at any given point, evaporation rates, and even the extent to which humans are harvesting it (about 2.5 million tons of salt are removed from the Great Salt Lake each year for commercial purposes)—allowing brine shrimp to maintain relatively stable body salt levels.

The true key to the unique survivability of brine shrimp, though, is their evolution of something akin to foresight. Many animals time their reproductive cycles to coordinate with the seasons, the goal being to give birth when weather is mild and food is abundant. For brine shrimp, good timing is rarely a guar-

Bagged cysts are transferred from a boom boat to a haul boat before being taken ashore for processing.

antee of favorable conditions. Many of the salty lakes where brine shrimp live periodically dry up entirely due to heat evaporation. Sometimes salt levels can swing wildly due to influxes of water from snowmelt or other sources.

During pregnancy, female brine shrimp have the ability to "perceive" trends in environmental conditions and give birth to either live offspring, called nauplii or, if conditions appear unfavorable, they produce cysts, which are essentially highly fortified eggs that can remain in a state of suspended development indefinitely, a phenomenon called cryptobiosis. They hatch only when the environment returns to a survivable state. Cysts can be thought of as genetic time capsules. Faced with unlivable conditions, brine shrimp are able to use cysts to store their genes for safekeeping and ensure the perpetuation of their species. Cysts that manage to stay dry can remain viable for up to five years.

During winter months, temperatures in the Great Salt Lake frequently drop below zero degrees Celsius (the water rarely solidifies, though, because saltwater has a much lower freezing point than freshwater). Hardy as they are, even brine shrimp can't tolerate water this cold, and by October most of them die off. Left behind, though, are the cysts, which float on the surface of the lake and sometimes, when they are pushed together by currents or the wind, amass in expansive streaks that harvesters refer to as "slicks." From above it can appear as though broad red brush strokes have been made on the surface of the lake. Come spring, the cysts hatch and repopulate the lake.

Before Sanders showed up, most of the attention the Great Salt Lake brine shrimp received came from birds. Though its waters are largely "dead," in a manner of speaking (save for the brine shrimp, of course) avian life abounds at the lake's margins where its freshwater inputs—the Bear, Weber and Jordan Rivers—have created vast estuaries and wetlands. Over seven million birds spend time at the lake each year; an intensive long-term study conducted by the state recently identified over 250 individual species.
Much of the winged traffic the Great Salt Lake receives is from migratory birds. The lake is a critical stopover point for resting and refueling during annual journeys between the northern United States and Canada, and wintering grounds throughout Mexico and Central and South America. Ornithologists like to describe this phenomenon using the analogy of an hourglass, where grains of sand all funnel towards a central point before dispersing back outwards.

Brine shrimp have eleven pairs of leg-like appendages that branch out from the center of their body, which in combination with their tail, enable them to swim, in theory at least. But because of their diminutive size—adults are about .4 inches long—in the Great Salt Lake brine shrimp are usually drifters. Pushed shoreward by the movements of the water, they become a source of protein for travel-weary birds that requires little effort to collect.

Two species in particular make heavy use of the shrimp. Eared grebes—small, duck-like water birds—are by and large the most numerous species of bird on the lake. Around 2.5 million of them, representing over half of their North American population, come to the lake each fall where they feast almost exclusively on brine shrimp. A bad year for the shrimp can cause significant casualties for the grebes, which have no other dependable food source in the area. Wilson's phalaropes also rely heavily on brine shrimp when they arrive at the lake in late spring, an event that is the greatest annual gathering of their species worldwide.

Mark Jensen is a renaissance man in the true spirit of the American West. His résumé includes years spent as a river guide in the Grand Canyon and Alaska, being featured on the November 1974 cover of Skiing Magazine (clad in a skin-tight black and green racing suit and bright red ski boots, shoulder-length blonde hair streaming behind him), a stint as an organic farmer, and owning a successful brine shrimp harvesting company. More recently, he was the subject of a profile in the Deseret News that praised his work as an amateur botanist. "Gardener creates paradise of hybrid daylilies," read the headline.

At times he seems more like a character from a book than a real person. There is, perhaps, some truth to this. Jensen features prominently in several short

stories by Edward Abbey, who was a passenger on several of his river trips. "Gather at the River" recalls a ten day voyage Jensen led down the Kongakut River in the northernmost reaches of Alaska. Abbey writes admiringly of Jensen, feigning jealousy of his athletic prowess and youthful energy, and lauds him for his camp stove coffee, which he describes as "powerful enough to deconstipate a sand-impacted Egyptian."

Jensen remains true to Abbey's version of him. Now in his 60s, his hair has begun to grey but he has retained his lean, powerful build. He has a manner that is at once affable and gritty, which encapsulates the frontier years of the brine shrimp harvest. Gregarious and excitable, Jensen powers through the day with a steady drip of caffeine and alcohol.

"It's not too late to have a beer," he's fond of saying at breakfast.

Jensen was in his 30s when he got a call from a friend who had become aware of a mini-gold rush that was occurring out on the Great Salt Lake. He asked Jensen if he could spare $10,000 to help start a company harvesting brine shrimp cysts. Jensen didn't have the money, but needing something to occupy his time when it wasn't river-running season, he joined Bonneville Artemia International as a captain that winter.

Jensen found that harvesting brine shrimp suited him well. The hours were long, the conditions were wretched, and the work was backbreaking, but it was also rewarding—both spiritually and financially. And, as a bonus, there were ample opportunities for the same sorts of good-natured debauchery that he enjoyed during his summers as a river guide.

He soured on BAI after a few years when he discovered that his girlfriend and the owner were, in his words, "doing the hokey pokey." But Jensen recognized that there was good money to be made in cyst harvesting and started up his own company, which he named Great Lake Artemia.

Each day of the harvest season begins with a signal from the sky. Hired pilots in single engine planes begin making broad sweeps across the lake early in the morning. If they spot a sizable accumulation of cysts—ideally a "gagger," as the biggest streaks are called colloquially—they call out the GSP coordinates over a radio system to a "chase boat" standing by near the shore. The chase boat races out into the lake to stake their claim to the streak by dropping a large buoy next to it, while they wait for larger, equipment carrying boats to arrive.

Sparkplug Sanders was the first to make use of spotting planes when he began venturing from the shorelines out into to the lake to harvest cysts. The southern arm is 28 miles wide in some places, and searching for slicks from the surface was simply too time-consuming.

Once a slick has been claimed, a "boom boat" shows up with what is essentially oil spill containment equipment. A small dinghy is dropped into the water and begins dragging the boom—a long, snake-like floating barrier—around the perimeter of the slick. When the boom has been brought all the way around and back to the boat, it is cinched and then tightened, forcing the enclosed floating cysts inward into a round "cake." By this point, the "haul boat" has usually arrived. From a platform that hangs from the boat, crew members rake the cysts into a small working area where they are vacuumed into 2,000-pound bags that sit on the deck. The whole process usually takes several hours, and if it's a gagger it can occupy the better part of a day. The bags are eventually brought back to shore and driven to warehouses in Ogden and Salt Lake City where the cysts are dried, processed and stored before being shipped across the globe.

Known to outsiders as the clean-cut hub of the Mormon Church, Salt Lake City is not without its own gritty underbelly. Just south of the town's spotless urban core, nestled between a motorcycle dealership and a used car lot, Duffy's Tavern is a divey, oasis of vice.

It's not a big building and it's easy to miss. Salt Lake City's famously wide streets—about 132 feet across, typically—have the effect of making any building smaller than the Salt Lake Temple look minuscule by

comparison. The official story is that Brigham Young wanted them to be wide enough for a team of oxen pulling a covered wagon to be able to turn around in.

Duffy's is the sort of place where you get a sideways look for asking what micros are on tap. Bud and Miller aren't good enough for you? The interior features the standard pub decor: red vinyl booths and barstools, a mosaic of sports memorabilia covering the walls (go Utes), and a complete absence of natural light. A bumper sticker on a mini-fridge behind the bar reads, "Fuck yeah, I'm a Mormon."

After long stints out on the lake, or any other period of unoccupied time, really, Jensen and his crew would roll in, exhausted and reeking of sweat and brine. Taking up every stool at the bar, they would drink until closing time (1 a.m., per Utah's liquor laws), heading home to catch a few hours of sleep before going back out on the water in the morning. "You had to stay hydrated," says Jensen.

Their revelry is memorialized at the top of Duffy's menu in the form of a monstrous ten dollar sandwich called the GLA, named for Jensen's harvesting company. It features "relish, piles of Mozzarella, pepperoni, ham, pastrami, and tomato with Duffy's balsamic sauce on artisan Ciabatta bread." Served hot.

"We owned this place," Jensen remarked earlier this year, sipping his Budweiser from one of the oversized cast-metal mugs reserved for the bar's most dedicated patrons. It seems like they still do.

To his right sits Marty Stenerson, formerly a captain on one of Jensen's boats. Now he makes his living as a tailor, oddly enough. Tim Begue, who ran his own company, Prime Artemia, is perched on the next stool over.

When you talk to the scientists and state workers that were around during the nascent years of the harvesting industry, the phrase "wild west" tends to get thrown in a lot. There are tales of boats being used as battering rams, physical confrontations and drawn guns.

Jensen and his comrades smirk and roll their eyes at the suggestions. "More like primitive equipment and hillbillies," says Stenerson.

"More like primitive equipment and hillbillies," says Stenerson.

As a twenty-two-year-old, Stenerson relocated to Utah from Elkhart, a small town in northern Indiana known for being the RV manufacturing capital of the world. He got his start in the brine shrimp industry in 1989 at BAI, where Jensen had recently been hired as a captain. Stenerson spent his first season in the company's warehouse rinsing batches of cysts in potassium permanganate, a disinfectant, then drying and packaging them. The next season, he joined the harvest crews out on the lake. After a few years, he jumped ship for Jensen's newly formed company where he eventually became a captain himself, operating a 34-foot Kvichak skiff that was used as a haul boat.

The crews out on the boats are a hardy bunch. A lot of them work the commercial salmon and king crab fisheries in Alaska during the summer, migrating south in the winter to make a little extra cash harvesting brine shrimp. Jensen staffed his boats with fellow river guides. "When shit hits the fan, they're not afraid," he said.

Even for seasoned fishermen and river runners, being out on the Great Salt Lake in January and February can be trying. Utah winters are cold and the lake waters are often subfreezing. Snow and wind are commonplace, as are stomach-turning waves, which roll across the surface of the lake and can reach several feet in height. Owing to the water's elevated density (a product of its saltiness), the waves can pack a substantial punch.

Before most of the industry coalesced into a single cooperative, companies competed intensely against one another, and the harvest ran nearly 24/7. Often, instead of towing their boats back into town when night came or conditions on the lake became un-

bearable, crews would rest in makeshift camps set up along the shorelines for a few hours and then head back out, spending days or weeks harvesting before returning home.

"We used humor to get through it all," Stenerson said. Booze and pot helped too.

Most of the conflicts out on the lake arose from disagreements over who had the right to a particular cyst streak, Begue explains. A good-sized gagger can be over a mile long, and might be worth over $10,000 depending on the going rate on cysts at any given time. To lay claim to a streak, harvesters simply place a buoy next to it. Before the state became involved, it was basically an honor system, and with the fast-paced, high-stakes nature of the harvest, honor was sometimes in short supply.

Per the scant regulations that were in place at the time, companies were allowed a buffer zone of 300 yards around their buoy. The spirit of the law was meant to give the first boat on the scene the right to harvest all of the cysts in a slick. But late-arriving companies would frequently show up and start harvesting at the opposite end of a slick, technically beyond the 300-yard limit, a maneuver known as "corkscrewing."

Curses and middle fingers might be exchanged, but the confrontations rarely escalated beyond that. Jensen sometimes tried to ease tense situations by offering cans of beer to his adversaries, a strategy that usually worked well, except when he was dealing with the companies that staffed their boats with Mormons.

On July 2nd, 1992, John Crosbie, the Canadian Fisheries Minister, announced a complete moratorium on the nation's northern cod fishery. "I'm making a decision based on the desire to ensure that the northern cod survives as a species," he said at the time as a group of protesting fishermen attempted to break into the press conference through a barricaded door. The announcement was dubbed "the biggest layoff in Canadian history." Over 35,000 jobs were eliminated overnight.

Not that there was any other option at that point. After a decades-long decline, the northern cod population was one one hundredth of its historic high during the 60s. The signs had been there for years, but under pressure from fishermen and processing plants, the government mostly ignored the projections of their own scientists until it was too late to simply reduce the size of the harvest. The population was not simply on the verge of collapse—it had collapsed. All that could be done was to try to save the fishery from total extinction.

Even now, the species has still not fully recovered (the northern cod population of eastern Canada is now at about 15% of what scientists consider to be healthy) and the moratorium remains in place. It was originally supposed to last two years.

Similar situations, though mostly not quite so severe, continue to play out across the United States and the rest of the world as they have for much of the past century. Allowable catch limits in New England's northern cod fishery have been reduced to a fraction of what they were previously, as managers scramble to prevent a crisis like the one in eastern Canada. The Pacific bluefin tuna, highly sought after as an ingredient in high-end sushi, has dropped 96% from its levels prior to commercial harvesting. This year's pink shrimp harvest in the Gulf of Maine was recently canceled when scientists discovered that stocks were at lower levels than had ever been recorded. Overfishing, combined with rising ocean temperatures that appear to be a consequence of global warming, were identified as the main culprits.

The shutdown of the northern cod harvest drew significant international press, and it did not go unnoticed in the close-knit brine shrimp community. There were plenty of parallels to be drawn between the failed fishery in eastern Canada and their own industry, which was just starting to come into its own.

The reasons for the cod's collapse, and the decline of fisheries world-wide are various. Poor science, lax or non-existent regulations, pollution, overfishing, and an insatiable human demand for seafood have all contributed. But it was the rapid technological

Above: a single-engine Cessna passes across the lake in search of cyst streaks. Below: a "gagger."

advances in harvesting methods, which followed the end of the Second World War, that enabled the exploitation of the world's fisheries to proceed at an unprecedented pace. The use of global positioning systems and radar took the guesswork out of locating stocks, new techniques like gill-netting and mid-water trawling made it possible to harvest in greater volumes than ever before, and bigger, more powerful vessels gave fishermen the means to harvest faster and further from shore.

Great Salt Lake brine shrimp were not even identified as a potential natural resource until the mid-1950s, and the influence of technology on the industry was therefore delayed compared with other fisheries. Few people other than Sanders and his collaborators made any large-scale attempts at collecting the cysts prior to the 1980s. But when the shrimp's utility in aquaculture was recognized, and subsequently their value as a commodity, a technological arms race quickly unfolded between new harvesting companies.

An investor in Jensen's company suggested equipping their spotters with night-vision goggles. Jensen was initially skeptical of the plan, but eventually relented, and they purchased several sets through an army surplus store. They turned out to be extremely effective, and Jensen's pilots began flying over the lake before the sun rose each day, giving his harvesters a considerable head-start each morning.

"The race was fucked," Jensen readily admits now. Still, aware of his advantage, Jensen pushed the state to allow a 24-hour harvest, a request that was eventually granted, and the harvest became a round-the-clock affair that ceased only in the most severe weather.

It was around this time that the northern cod collapsed. "That was a warning to us," said Don Leonard, now the director of the Great Salt Lake Artemia cooperative. "And we heeded the warning."

Jensen and some of the harvesters began talking among themselves. The unwritten rules of the lake, they realized, were no longer enough, and they decided that if they were going to avoid a tragedy of the commons situation, something needed to be done. They brought in Leonard, at that point a local lawyer, to head a consortium of harvesting companies interested in coming up with solutions. After considerable discussion, they decided to do something almost unheard of in the commercial fisheries world: they asked the government to intervene.

Gary Belovsky was on an elk hunting trip in the fall of 1997 when he got a call from the Utah Division of Wildlife Resources. They wanted a number. Specifically, they wanted to know how many cysts needed to be left behind in the lake at the end of winter, after commercial harvesting had ended, for a healthy population of brine shrimp to be able to regenerate in spring. They wanted to open the harvest season in a couple of days.

Belovsky climbed inside of his pickup and made some rough calculations on a scrap piece of paper. Twenty-three cysts per liter of Great Salt Lake water is what he came up with. It wasn't much better than a guess, he readily admits today.

Two years earlier, the state had hired Belovsky to initiate and lead a comprehensive study of the Great Salt Lake ecosystem, with a goal of developing guidelines for a sustainable annual harvest of brine shrimp eggs. The move was part of their response to growing calls from harvesters to monitor and regulate the rapidly expanding industry.

Then a young biology professor at Utah State University, Belovsky was excited for the opportunity and quickly set out to find and examine all of the previous research that had been done on the lake. A literature search yielded almost nothing relevant beyond a few short-term, cursory studies.

Though the Great Salt Lake and its surroundings have long been of interest to geologists and hydrologists—the lake sits in the footprint of the massive prehistoric Lake Bonneville, which covered an area roughly a quarter of the size of Utah—it never attracted much attention from biologists. It's difficult to say why, exactly, but perhaps being known as "America's Dead Sea" served as a deterrent.

The United States has a proud tradition of preserv-

ing our most unique and outlandish landscapes, usually in the form of national parks or monuments: Yellowstone, Crater Lake, and the Grand Canyon are prominent examples. Somehow Utah's Great Salt Lake, one of the largest saline lakes in the world and a total aberration in the American terrain, got passed over for such honors.

Instead, it has been largely given over to extractive industries that harvest minerals from the lake by diverting water into shallow evaporation ponds along its shorelines. In addition to salt, magnesium and sulfate of potassium (a common ingredient in commercial fertilizers) are both gathered on an industrial scale by a handful of companies and processed nearby.

A railroad causeway built across the lake from east to west during World War II is another environmental indignity. Initially, it was a wooden trestle design, but the salty water proved more corrosive than had been anticipated and the structure was filled in with rocks in 1959, before environmental impact statements became standard fare for large-scale construction projects. Ever since, the lake has effectively been split in two. The northern arm of the lake (roughly one third of its total area) receives virtually no freshwater inflow and has consequently become saturated with salt. With salinity levels that typically stay within the range of 26% to 28%, the water is usually too salty for brine shrimp or much of anything else. Two species of bacteria persist, though, occurring so densely that they give the water a distinct purplish hue.

Sanders sued Southern Pacific over the filling in of the causeway shortly after it was completed. The court agreed that the project had had a significant and negative impact on Sanders' still-exclusive fishery, but ultimately sided with the railroad anyway.

The water to the south of the causeway more closely resembles the lake's original state, although it is undoubtedly less saline than it would be if the causeway were removed. Depending on several factors including rainfall, evaporation rates, and the amount of inflowing waters, the southern arm is generally between 8% and 16% saline, although it has been measured both above and below that range in outlying years since the causeway was filled. It supports a simple but productive ecosystem that includes microbes, algae, bacteria, brine flies and brine shrimp along with the birds that eat them.

The paucity of basic ecological research on the lake came as a surprise to Belovsky. "We had the fourth largest hypersaline lake in the world," he said, "and we knew virtually nothing about how it worked."

Undeterred, he set to work, hoping, at the very least, to be able to answer what he saw as some very basic biological questions: How many brine shrimp were there in the lake? How many brine shrimp could the lake support? How many of the cysts overwintering in the lake actually hatched and became adults?

Without this information, it would be impossible to project the effects of the commercial cyst harvest or determine how it should be managed.

Belovsky developed a sampling regiment, making use of large fishing nets with extra-fine meshing and long handles, not unlike the ones that Sanders and Wangsgard had improvised several decades earlier. With a team of students and technicians, he began collecting data from carefully selected locations across the south arm of the lake and collaborating with other researchers employed by the state and the USGS to try to get a sense of how the broader ecosystem functioned. Did yearly fluctuations in the lake's salinity have any effects on the shrimp? Was the harvest negatively impacting water birds by limiting their food supply?

Population dynamics is a branch of ecological science that seeks to understand the complex relationships between the species in an ecosystem and their environment. It is an essential component of all fisheries and wildlife management efforts. While the basic question is simple—what causes the populations of a particular species to grow or shrink?—the number of factors that can be considered is almost infinite.

For scientists, situations in which things can be simplified are a distinct advantage. This is why biologists have long sought out isolated islands to study, as they tend to have fewer species and are smaller in

scale than continental ecosystems. Like real-world labs, islands allow biologists to test their theories in a more controlled setting. Some of the most influential ecological science has come from places like the Galápagos Islands, which famously provided Darwin with evidence for his theory of evolution, and Isle Royale in the northwestern corner of Lake Superior, a National Park that has been the setting of one of the longest running and most-cited population dynamics studies ever, a detailed survey of the relationship between moose and wolves that began in 1958. Incidentally, Belovsky is among the many ecologists that have made use of Isle Royale, having done research there as a graduate student in the 70s.

The early years of oversight were marked by tension and mistrust.

Hypersaline lakes create similarly favorable conditions for ecological studies because a limited number of species are able to inhabit them. Piecing together a basic food web of the Great Salt Lake proved relatively simple for Belovsky. At the bottom are an assortment of microorganisms—mostly species of algae and cyanobacteria that subsist on various nutrients from the lake's waters—which in turn provide a source of food for brine shrimp as well as brine flies, which lay their eggs in the lake. The shrimp and flies are both eaten in large quantities by resident and migratory bird species, although many go unconsumed and eventually wash ashore and decay, contributing to the lake's famously putrid smell.

More difficult, though, would be determining the power of the relationships between species—for example, would a bad year for cyanobacteria result in fewer adult brine shrimp?—and the magnitude of effects from a litany of environmental influences like water temperature, inflow, precipitation, evaporation, pollution and nutrient availability.

Belovsky hadn't expected to be asked to give a verdict so soon. When the state called in 1997, he had only two years of research to draw from, plus what he had cobbled together from previous studies. And while he felt confident about the work he had done so far, he knew he would need many more years to even begin to understand the Great Salt Lake's biological intricacies.

The basic structure of the State of Utah's brine shrimp fishery regulatory scheme has remained the same since the first harvest limits were put in place in 1997. The Division of Wildlife Resources sells permits, each of which allows the holder the right to harvest brine shrimp cysts in one place at a time either on the surface of the lake or from the surrounding shorelines. Companies may hold multiple permits, which then allow them to harvest in multiple locations at once. The price of a permit was recently raised from $10,000 per year to $15,000. Additionally, the state receives a royalty of three-and-three-quarters cents per pound of biomass drawn from the lake.

Unlike most other regulated commercial fisheries, the state doesn't rely on catch quotas to prevent over-harvesting. Instead, they set a minimum number of cysts per liter of lake water that they say must be left behind in order to regenerate a full population in spring. Once the season opens on October 1st, the harvest proceeds until the population is depleted to that number or the end of January, whichever comes first. The logic behind this setup is that it better ensures a healthy and consistent population of brine shrimp by guaranteeing that a set amount will always remain in the lake. The contained and simple nature of the lake makes it possible to estimate how many adult shrimp or cysts are present with a much higher level of confidence than is possible for most other fisheries.

Despite the fact that it was largely pressure from the harvesters themselves that brought about stricter regulation from the state, the early years of oversight were marked by tension and mistrust. Members of the industry clearly deserve credit for being forward-thinking, and their actions may well have preempted a decline or collapse of the Great Salt Lake brine shrimp fishery, but there was also an element of self-interest in their push for the state to take tighter control.

In the years leading up to the implementation of the new management structure, the harvest was no longer a well-kept secret. It became clear the era in which there was enough to go around was over and competition for cyst slicks among the companies out on the lake was starting to cut into profits.

There was also increasing pressure from foreign competitors. Although the Great Salt Lake was and remains the source for a majority of the global brine shrimp cyst supply, companies operating on lakes in eastern Europe and Asia have been steadily gaining a larger market share, and they are able to offer cysts at reduced prices due to lower labor costs.

As much as the harvesters were worried about depleting a resource, they had equal reason to be worried about their own potential obsolescence even if the brine shrimp population in Utah remained healthy.

One component of the regulations that the industry fought hard for was a limit on the number of annual harvesting permits issued. The state obliged and in 1997 they capped the permits at 79, effectively closing the market to outsiders. The limit remains in place today.

Public meetings were scheduled for the state to present their progress on developing regulations and researching the lake. Belovsky's work met a chilly reception. His calculations meant that many companies would not be able to harvest as extensively as they were expecting, and the harvesters, many of whom had been on the lake for more than a decade by this point, homed in on the weaknesses of Belovsky's science. Two years, they said, wasn't enough to know anything.

"It was bullshit," said Jensen. "It didn't match what we saw on the lake."

Being a newcomer and an academic in a tight community of hardscrabble fishermen didn't help Belovsky's cause either. In his mind, he was simply stating what his science showed. It was up to the state what was done with the results.

"I didn't make any decisions," he said. "I still don't make any decisions for the state, I just present the data. I analyze the data for the state and I interpret it."

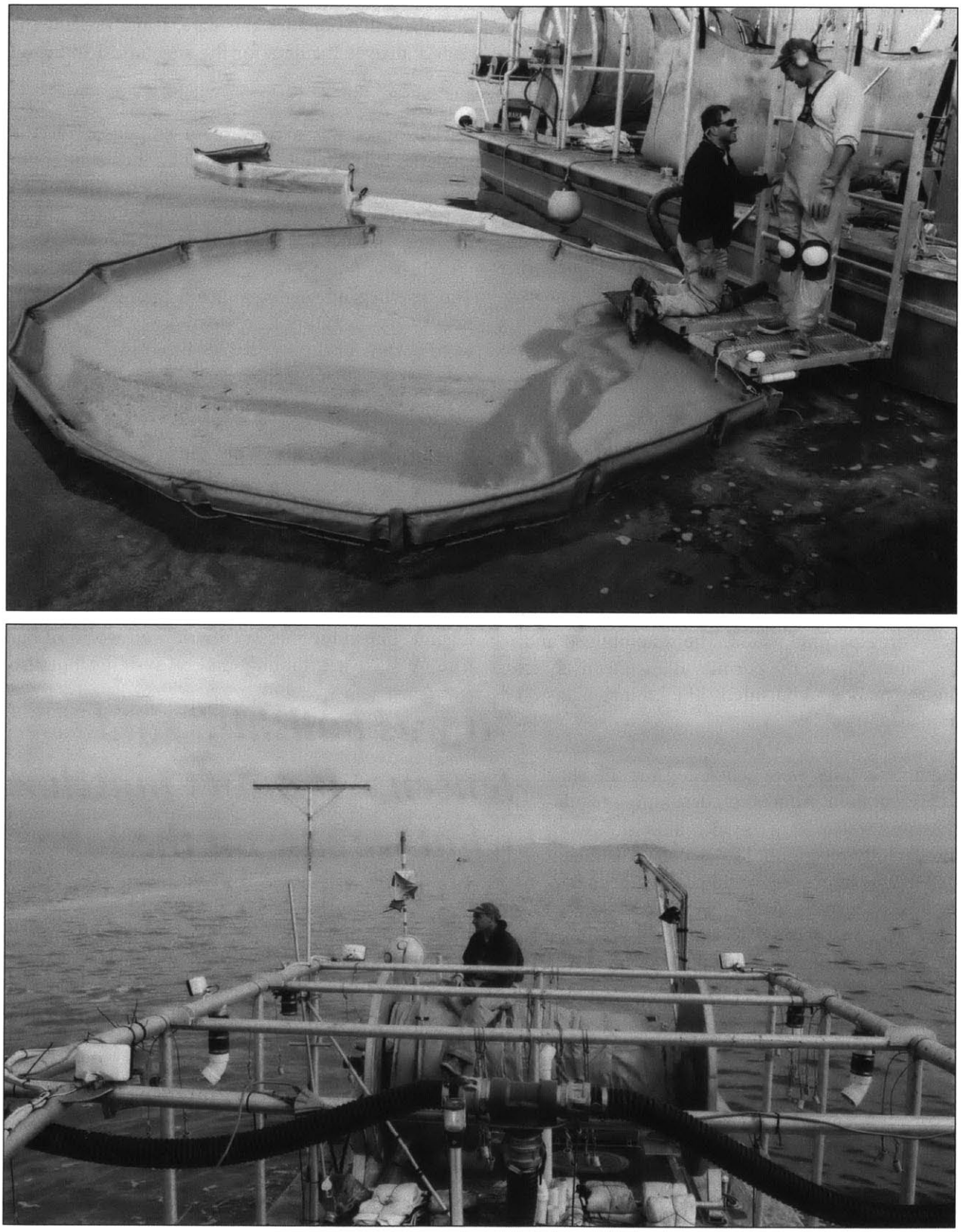
But Belovsky was a convenient scapegoat for the anxieties harvesters had about the rapid changes to their industry and what some of them felt was an affront to their livelihood. Many of the early public meetings devolved into heated shouting matches.

The state began bringing in armed game wardens to help keep order and escort Belovsky to his car afterwards. Some of the companies hired their own scientists to refute what they said was flawed research. When cyst numbers dropped below Belovsky's prescribed levels and the season had to be closed early, a DWR employee called and advised him to consider leaving town for a few days.

One of the pitfalls of natural resource management is that it is rarely able to proceed purely as a science. Managers do not operate in isolation in labs or academia, but in the messy, complicated world of nature. At stake are not only natural systems, but also the fates of individuals, businesses and entire industries, not to mention secondary consequences such as effects to food supplies or tax revenues, which are sometimes tied to specific and completely unrelated government functions. In Oregon and Washington, for instance, royalties from logging on state-owned lands are used to help fund public schools. If forest managers decide to decrease the number of harvestable acres, they are, in effect, taking money away from education.

"It was bullshit," said Jensen. "It didn't match what we saw on the lake."

Most resource managers and many of the specialized scientists they collaborate with are civil servants who work for federal, state or municipal agencies. Though they are non-political, in theory, their budgets, priorities and enforcement powers are all sub-



Above: a "cake" of cysts enclosed by a cinched boom. Below: riding on the back end of a boom boat.

ject to the approval of elected officials and partisan legislative bodies. In the case of Utah's brine shrimp harvest, any changes to the rules and regulations must be voted on by the Utah State Legislature.

Resource managers may come into their jobs with a great deal of scientific expertise and experience in their respective fields, but they are not always as well-versed in the more subjective business of navigating politics and special interest groups.

Knowing what to do when a managed species is having a bad year because their food supply has declined is one thing; knowing how to respond to opposing pressures coming from industry groups, environmental lobbies and politicians is quite another. To be a resource manager is, quite often, to be perpetually stuck in the middle.

John Luft has been at the center of the Great Salt Lake brine shrimp harvest for the past ten years. As a college student, he thought that his degree in natural resource management might one day land him a position dealing with big game species like cougars or black bears. Becoming the man in charge of regulating one of the world's most unusual fisheries isn't something he ever planned on.

"To be honest with you, I don't think anybody studies brine shrimp when they're going to school," he said.

Luft has careful measuredness about him. He speaks slowly and deliberately, as if briefly weighing each word before it leaves his lips. Tall and athletic with closely cropped blond hair and intense blue eyes, he doesn't quite fit the image of a paper-pushing government bureaucrat.

After graduating from Kansas State University, Luft joined the Utah Division of Wildlife Resources as a depredation technician, an entry-level position that Luft described as "the dead deer picker-upper."

"You could tell the guys that knew what they were doing, especially during the summer," Luft recalled. "They always grabbed the back end of the deer because everything comes out the deer's mouth. ... With a lot of the guys it would be a joke to make sure you got the right end, otherwise you'd have a shirt or pants stained with blood and guts and stuff."

During this period, Luft also became well-acquainted with the sorts of conflicts that modern wildlife management tends to entail, responding to calls from citizens about elk grazing in backyard gardens and moose ambling down suburban streets.

After nine years, he managed to transfer to the Great Salt Lake Ecosystem Project (GSLEP), the DWR management unit that oversees the brine shrimp harvest and monitors the lake's waterfowl populations. He spent two years as the program's avian biologist before being promoted to the director position.

Outsiders tend to know two things about the Great Salt Lake: it's lifeless, and it stinks. These were Luft's general first impressions as well. "I wasn't overly encouraged when I started out," he said. With no recreational hunting or fishing to speak of and none of the human-animal issues he was used to handling, Luft felt like the lake wouldn't require much actual management.

"How do you do anything out there?" he thought. "Really probably polices itself." It didn't take too long for him to realize that this wasn't the case.

When Luft came onboard, the harvest limits had been in place for five years. The public meetings had grown somewhat less heated by this point, but the harvesters remained mistrustful of the state's approach and reports of dangerous behavior out on the lake continued to pile up on his desk. Making matters worse was a series of uncharacteristically low-yielding years.

During the winter of 2002-2003, over 25 million pounds of biomass was harvested from the lake before the season closed. The following year, the harvesters managed only 5 million pounds before the state shut the season down early. The harvest rebounded only slightly the next two seasons, drawing 6.8 million and then 9.7 million pounds.

It is important to note that a pound of biomass does

not equal a pound of sellable product. Along with the cysts, a good amount of empty shells, brine fly casings, bird feathers, plant matter and other materials get sucked up in the harvesting process. By the time everything has been filtered and sorted, brine shrimp cysts represent about 10-15% of the total weight. The quality of the cysts—determined primarily by the percentage of them that are able to hatch when the dried eggs are put into warm water—also varies considerably from year to year.

It is difficult to know precisely how bad this stretch of years was because none of the harvesting companies are willing to divulge their final cyst yields or hatch rates. Secrecy is part of the culture on the lake. Jensen likes to joke that if you were to ask a brine shrimper what time it is they would cover up their watch.

Simultaneously, environmental groups like the Friends of Great Salt Lake and the Utah chapter of the Audubon Society were starting to publicly voice their concerns about the state's management of the industry. Brine shrimp are often spoken about as a commodity in these circles as well. The difference is that the "end users" of interest to conservationists have feathers.

Until the mid-90s, the shrimp seemed so plentiful that no one worried that the commercial harvest might be taking food out the mouths of the lake's resident and migratory birds. But when the harvesters themselves began to advocate for regulations to protect the long-term viability of their industry, members of the environmental community began to realize the severity of the situation.

The Great Salt Lake has never inspired the same level of conservationist fervor as most other major American lakes. Still, it has its supporters and they are a dedicated bunch.

The Friends of Great Salt Lake was formed in 1994 as an all-encompassing environmental advocacy organization for the lake and its adjacent wetlands. Many of their first meetings were consumed with anxieties about the effects the brine shrimp harvest might be having on bird populations, recalled Lynn de Freitas, who became the group's President in its third year of operation. There wasn't a lot of concrete information to be had, but rumors about heated confrontations between competing companies on the lake seemed to lend credence to the idea that the shrimp might be in danger of running out. The stretch of low yielding years that began early in the 2000s seemed to confirm their fears.

Resource harvesting industries and environmental groups are often vehemently at odds with one another. Finding common ground is usually left to the government resource managers. As a whole, though, the prevailing attitude among those on all sides of the cyst harvesting issue has primarily been one of pragmatism. The shrimp themselves may be partially responsible.

Brine shrimp are not cute or majestic. They don't elicit empathy the way that more charismatic species like elk or polar bears do, nor do they inspire the same feelings of awe and wonder as a stand of towering old-growth redwoods.

The Great Salt Lake has never inspired the same level of conservationist fervor as most other major American lakes.

The lake suffers from a similar lack of grandeur. While the West is rife with landscapes that seem to be proof of some sort of divine natural beauty, the Great Salt Lake seems like more of an accident. Tourists come to gawk, but are often more dumbfounded than reverent. That such a massive body of water could be so caustic and inhospitable to humans and other life forms begs the question: What the hell happened here?

Brine shrimp and their environment are unlikely to win any contests for natural beauty, and this fact has probably helped diffuse some of the passion that has characterized so many other battles over the use of

natural resources.

To their credit, the position that Friends and other groups took was simple and practical: If cysts were being harvested at a level that was negatively affecting the birds that rely on brine shrimp as a food source, then the state needed to restrict the harvest to the point where this was no longer the case. If the science showed that the harvest wasn't harming the birds or the broader ecosystem, they saw no reason to oppose it.

"Unless we're willing to be honest and sincere about the way that we look at our natural resources and the environment...then we're only speaking half-truths," de Freitas said.

In 2002, the 79 harvesting permits were spread out between 32 separate companies. The permits themselves cannot be bought and sold privately. To gain the right to harvest in more locations simultaneously, companies must buy up other permit-holding companies along with all of their boats and equipment. During the down years, the industry consolidated significantly as larger operators bought out smaller companies, attempting to grab a larger share of the shrunken pie.

In 2006, the consortium of companies that Jensen had helped to organize formed an official cooperative, Great Salt Lake Artemia (GSLA). Faced with weak harvests, rising fuel prices and growing competition from foreign sources, the members felt they would be better off sharing expensive resources like maintenance facilities and canning factories. Jensen opted to remain independent until he sold his company two years later, but many of the remaining harvesters joined immediately.

Within a few years, almost all of the companies had either joined the cooperative or sold out to its members. Today there are seventeen harvesting companies. Only one of them is not part of GSLA.

Leonard was made the organization's director and pushed its members to take a more cooperative approach with the state. The attitude, he said, should be "let science decide."

Even as the brine shrimp population seemed to be failing, the state faithfully stood by Belovsky's research. When the number of eggs in the lake dropped below his prescribed minimum number of cysts per liter they immediately ended the season in spite of protests from harvesters who said their livelihoods were being taken from them. At the time, Belovsky lacked the long-term data necessary to understand what was causing the decline. He was certain, though, that the population could not be allowed be reduced any further, as painful as it was for the industry.

Outside of the lab, science is rarely a fast process. Even in a simplified system like a hypersaline lake, determining what might be causing a particular species to thrive or struggle with any meaningful degree of certainty takes years or decades. In the Great Salt Lake, brine shrimp follow a pronounced annual cycle. To find out why the lake was flush with cysts in some years and barren in others, Belovsky had no choice but to wait it out and watch to see if any trends emerged.

As the years slowly added up, he tracked the numbers closely, comparing the monthly brine shrimp census counts with the physical conditions of the lake and other environmental variables, and cross-referencing his findings with the scant data that was scattered between a handful of previous studies of the lake.

Given that brine shrimp thrive amid exceptionally salty water, scientists and harvesters alike long suspected that salinity levels were the driving factor affecting cyst numbers and the overall health of brine shrimp populations. But when he looked at the data, Belovsky found that this wasn't the case. There were clearly lower and upper limits at which the shrimp had a hard time surviving, but their comfort range was large and even though lake salinity levels varied significantly from year to year, it didn't seem to be having much of an effect on them.

Interestingly, the harvest didn't seem to be a factor in causing bad years either. In some of the years since Belovsky had begun studying the lake, over 90% of the overwintering cysts in the lake had been collected without making a noticeable effect on the amount of adults that were present in the spring. Even after

winters in which a tremendous amount of cysts had been taken from the lake, a healthy adult population often emerged. Belovsky took this as evidence that minimum cyst levels that he had come up with for the state were doing their job. Something else must be causing the low years.

The harvest began to rebound midway through the 2000s and has generally increased over the past decade. Record amounts of biomass have been harvested from the lake in the past two seasons. The most recent harvest ended on January 31. Over the course of four months, companies pulled in over 27 million pounds.

Weight is only part of the story for the harvesters, though. The "hatch-rate" of the cysts is an equally important number. A low hatch rate leads to low market prices for their product. Leonard was quick to point this out when asked about the seemingly successful season that ended in January. Fearful of foreign competition, the co-op does not release numbers describing the quality of their catch. "We're going to have a decent year," is all Leonard will offer on the matter.

"I always say it's the least glamorous thing."

Still, the annual numbers released by the GSLEP make it clear that both the brine shrimp population and the industry are, at the least, healthy.

Belovsky is now a tenured professor at Notre Dame University, but he has continued his research on the lake, relying on the state's technicians to regularly take samples and collect data. Now in its twentieth year, his study has begun to unravel some of the lake's mysteries. Time has made all the difference.

"We know a lot more today," he said recently.

It turns out that Belovsky's hunting trip estimates weren't too far off. Based on the two decades of data, the minimum cysts per liter number has been revised downward only slightly to 21. Belovsky readily admits that this was, to a certain degree, a stroke of luck, but he takes pride in it nonetheless.

By incorporating data that other researchers have been collecting into his models, Belovsky has also begun to develop a better picture of what causes annual fluctuations in brine shrimp levels. Rather than salinity, the availability of food seems to play the biggest role. As the amount of phytoplankton in the lake rose and fell, so did brine shrimp populations. Phytoplankton levels, in turn, correspond to the amount of nitrogen in the water, which varies from year-to-year for reasons that scientists don't fully understand yet.

Another important and somewhat counterintuitive finding was that, to a certain point, the harvest actually benefits the brine shrimp. When he ran the numbers, Belovsky discovered that leaving too many cysts behind could cause the shrimp population to experience significant crashes. With an overabundance of cysts hatching in the spring, the shrimp would quickly exhaust their supply of food, causing the entire population to plummet. The harvest is a way of culling the herd, helping to eliminate boom-bust cycles, which is also a boon to the eared grebes and other birds that rely on the shrimp.

The harvesters, Belovsky says, have begun to warm to the state's handling of the industry, and are appreciative of the science-based approach. "They came to realize that by collecting the data we weren't trying to get them or do anything to them, and in fact we were trying to manage the system for their long-term benefit," he said.

These days, Luft cheerfully embraces his role as the man at the helm of the Great Salt Lake brine shrimp fishery. "I always say it's the least glamorous thing," he remarks with a note of pride in his voice. While his colleagues in other departments are busy responding to complaints and playing peacemaker, Luft spends his time overseeing a growing scientific enterprise. In addition to Belovsky, who remains their lead contracted biologist, the GSLEP now employs a small team of technicians and scientists to monitor and study the lake's ecosystem. Last season's harvest brought in over two million dollars in permit fees and royalties, more than enough to cover

the GSLEP's operating costs. The leftovers help the state pay for the management of non-game species like bald eagles.

The relative calm that the brine shrimp fishery now enjoys is a source of excitement for Luft.

"What I found here is you actually get do to what you went to school for, which is biology, not just putting out fires," he said. "It's more complicated and interesting than I ever thought it would be."

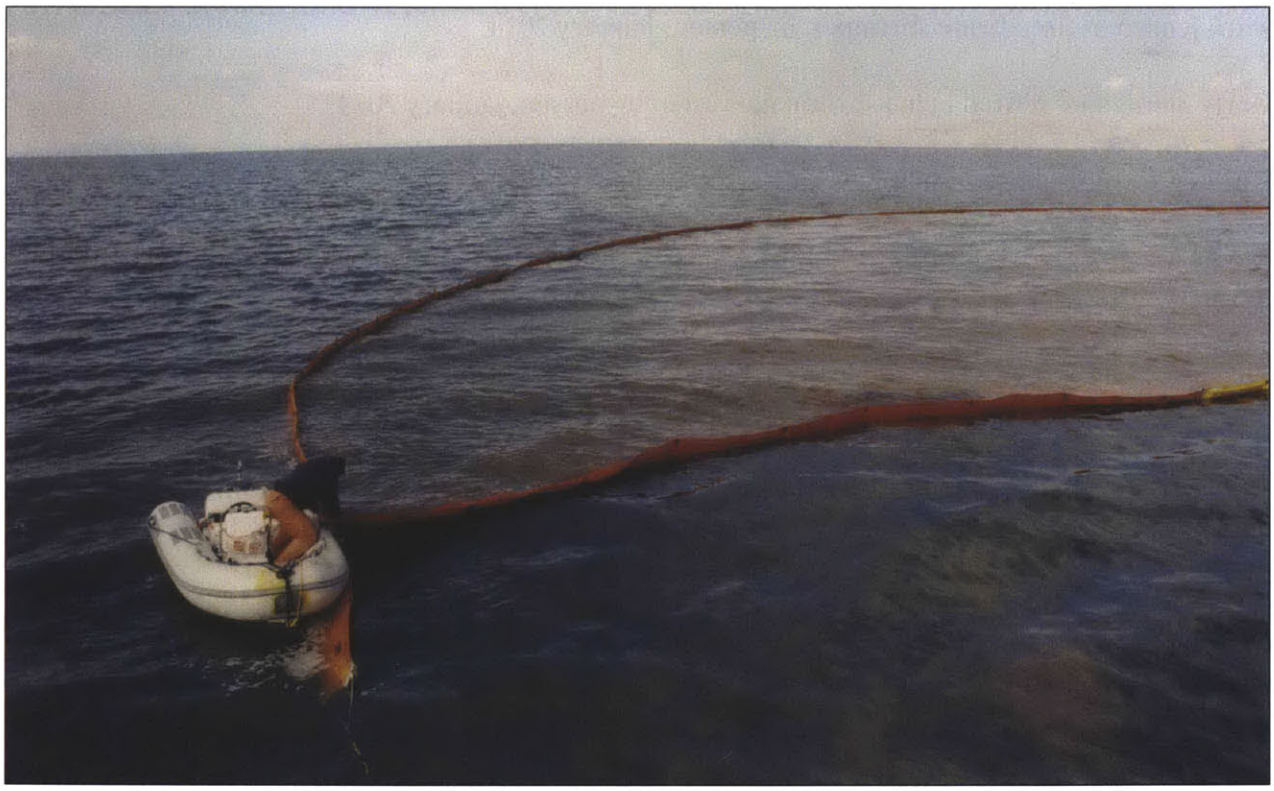
Resource management has few natural endpoints. The perpetual goal is balance, but achieving this is usually difficult and always temporary. In Utah, after a struggle that has lasted almost two decades, Luft and the Division of Wildlife Resources seem to have finally reached this rare point. How long they will remain there is anyone's guess.

There is a common misconception that in the absence of human interference, nature remains in a peaceful state of equilibrium. In fact, nothing could be further from the truth. Conditions change, species rise and fall. It's a battle out there. Like every other species, brine shrimp have good years and bad years.

Whole industries are built around trying to avoid this reality. We plant rows of corn, throw our nets into the ocean, and trudge out into the forest carrying chainsaws with the expectation that each year will be as good as or better than the last. The science of resource management has developed as an attempt to moderate the chaos of nature. Sometimes it is successful and other times it isn't.

At present, the brine shrimp harvest is working out. True, the Great Salt Lake offers certain advantages over more typical ecosystems, where nature's complexity can prove overwhelming for scientists and managers. But the harvest is also an example of exceptionally rational thinking in a field where passion and politics often win out.

The brine shrimp, of course, have never had a say in any of this. Fifty years ago they were just another species trying to survive long enough to pass their genes on to the next generation. Thanks to an industrious pair of friends, they have been swept up into a struggle that is a distinctly human creation.



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Images

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