41° 10' N
112° 40' W

1141 01

SWINN/PUTHOFF
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A ✓
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DRAWINGS

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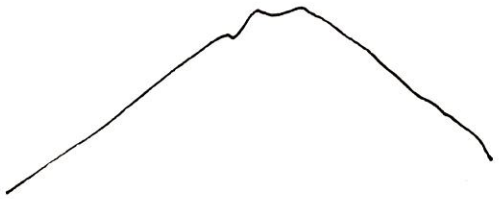
41° 10' N
112° 40' W

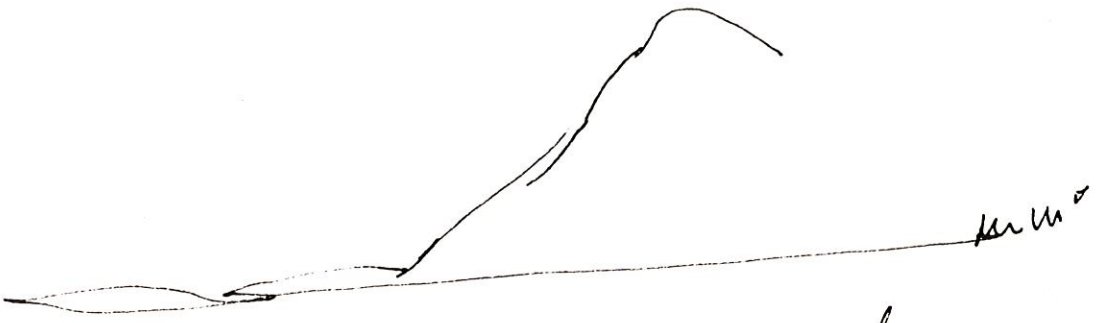
[Great Salt Lake]

A buildings
B town or city

41° 10' N
112° 40° W



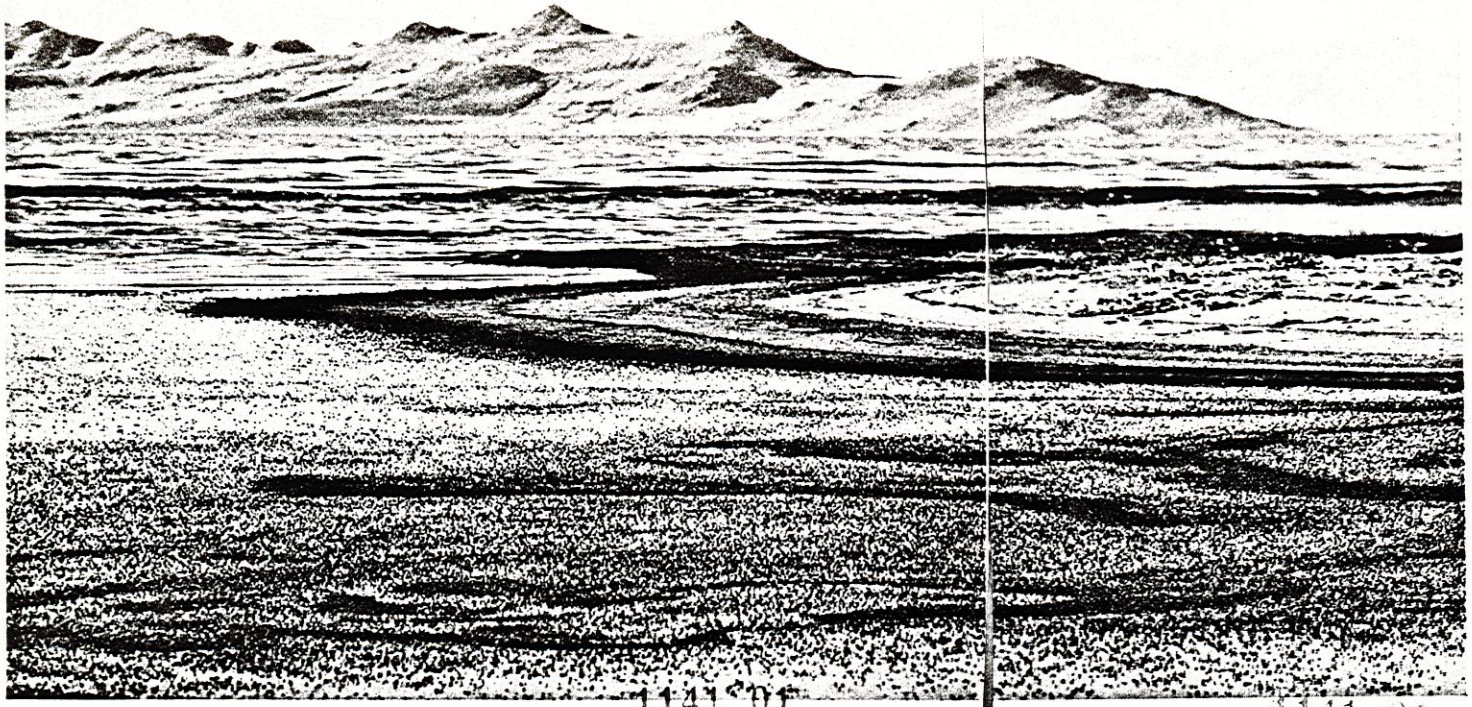
A distance
B mountain



forests

rocks.

rocks forests
a group of buildings.
End



many days or years they had been there, eyes staring sightlessly at the sky?

I asked Earl to demonstrate the lake's "no-sink" character. He waded out into the pink water up to his waist, then stretched out as if on a sofa. Head high, arms and legs above the surface, he floated like a cork (page 255).

In the glaring sun the temperature stood at 100° F.; a minute after stepping ashore Earl was dry—wearing a talclike coating of white crystals. Aside from smarting eyes, this sticky, gritty aftermath is the only uncomfortable part of swimming in Great Salt Lake.

Here in the lake's seldom-visited northern reaches, cut off by the Southern Pacific dike (preceding pages), the salinity soars to as much as 28 percent, in contrast to 18 to 24 percent in southern and eastern waters. But even there the swimmer cannot sink, a fact that visitors delight in proving for themselves.

Late that night, when I was back in town, my microscope instantly revealed—as John Samuelson had predicted—the secret of the pink water. Under the lens swam myriad single-celled, potato-shaped algae known to botanists as *Dunaliella salina* (page 259, top). Each reddish-orange cell sculled through the water by means of two long hairlike whips growing from one end. Other, even smaller species, *Dunaliella viridis* (page 258, bottom) and *Chlamydomonas,* were bright green and similarly propelled by whiskery flagella. Still another green variety, called *Aplanotheca* or sometimes *Coccochloris,* was encased in a transparent jelly of its own making.

Smallest of all were the bacteria, vaguely pink and revealed only as shimmering dots and rods even under the microscope's most powerful lens. A million could have perched on the point of a sharp needle.

Salt-hardy Life Draws on the Sun

The question persisted: How could these algae and bacteria survive, much less flourish, in a medium salty enough to kill almost every other form of life?

Our knowledge here is scant. We may only conclude that somehow, during the course of evolution, nature provided these curious forms with means either for preventing penetration of the salt or for keeping it from accumulating in toxic amounts.

But most crucial to the survival of these remarkable creatures is the capacity of the algae to draw on the sun for energy. Possessing the magic energy-trapping ingredient, chlorophyll, they are able to unite simple carbon dioxide with water to form starch, sugar, and protein. Without this process of photosynthesis, there would be no life at all, for it produces the basic foodstuffs on which all animals, including man, depend.*

Among the earth's many thousands of animal species, only a tiny shrimp and one genus of fly are equipped to survive in Great Salt Lake. Like the algae and bacteria, which belong to the plant kingdom, they have their heyday during the summer months.

Best known for its eggs, the brine shrimp *(Artemia salina)* is a feathery, semitransparent crustacean which at times almost chokes shore waters (pages 256-7). During July or August dip up a glassful of water, and chances are that in it you will see several, even scores, of these tiny creatures. Or watch gulls sitting on the lake, nipping down with swift beaks for a meal of brine shrimp.

Mature female shrimp develop an underpouch of eggs, each no larger than a grain of finest sand. Those released in spring and summer soon hatch, but eggs laid in September or October remain dormant over the winter. Wind and currents concentrate them mainly on the southwest shores, where they accumulate at the waterline in siltlike windrows.

*The author described this process in "How the Sun Gives Life to the Sea," GEOGRAPHIC, February, 1961.

KODACHROMES BY PAUL A. ZAHL © N.G.S.

Black flotsam of insects laps the southern shore; beyond the lake's leaden swells rise barren peaks of Stansbury Island. Wade among the "buffalo gnats," as Westerners call the brine flies, and they rise in sluggish, harmless clouds, then quickly settle again.

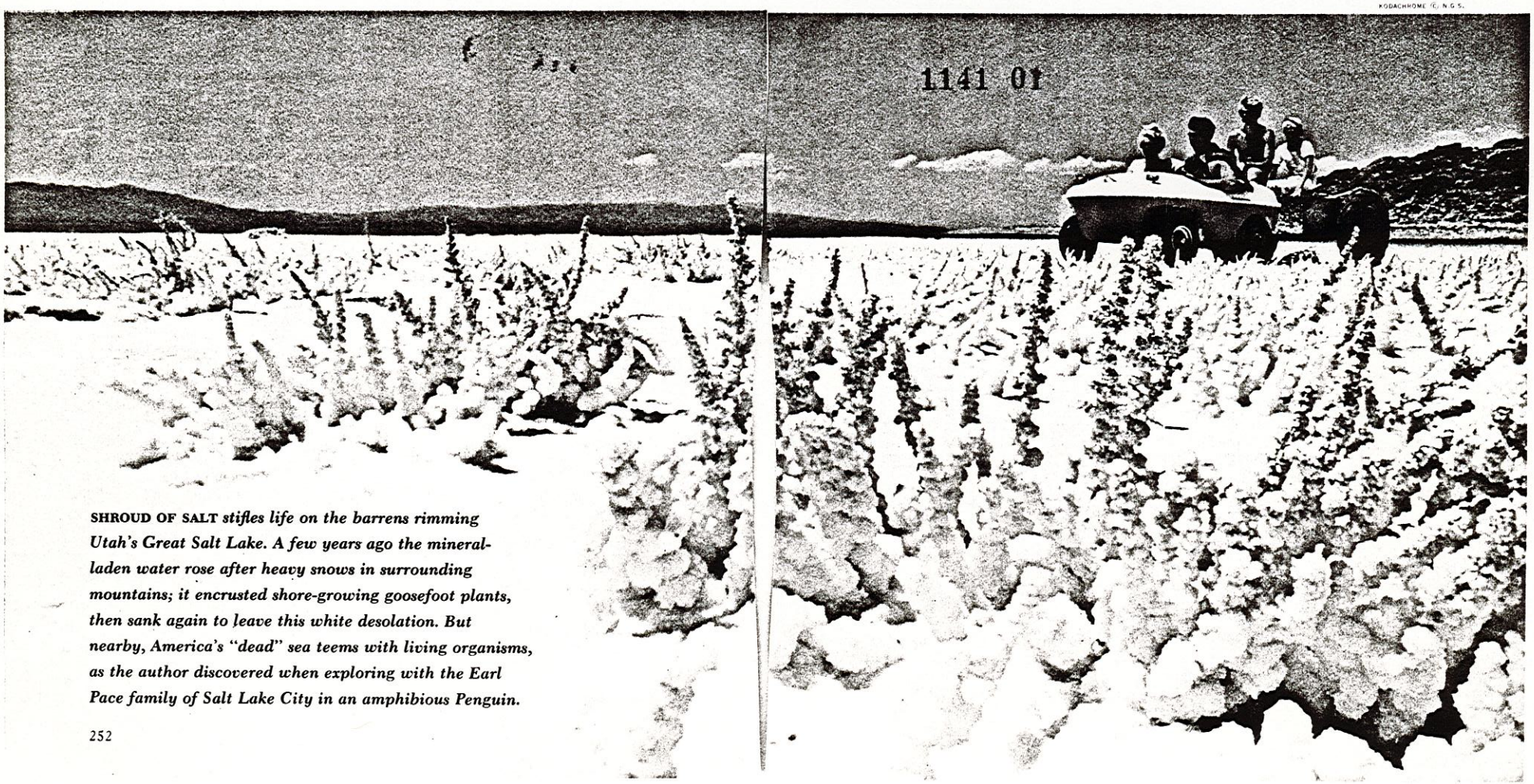
Like brine shrimp and algae, these flies of the genus *Ephydra* bear out a law of the lake: Few species can tolerate the harsh broth, but those few exist in stupendous swarms. So Capt. Howard Stansbury discovered when surveying the lake in 1850; he found the shore coated with a deep mud of decaying fly larvae "of the consistence of morter & very black slimy & offensive."

Brine-fly eggs hatch each spring into water-borne wrigglers, then metamorphose into baglike pupae that fasten to shore and bottom debris (top, about life-size). After a few weeks the flies emerge to darken the lake surface and salt-crusted shores as they graze on algae. Adults above, about four times life-size, crawl on a clump of salt.

The flies help feed the lake's gulls, revered state birds of Utah. Gulls flocked to Mormon grain fields near Salt Lake City in 1848 to devour a plague of crickets that threatened to bring famine by destroying the infant settlement's first major crop.

Life in a "Dead" Sea– Great Salt Lake

Article and photographs by PAUL A. ZAHL, Ph.D.
National Geographic Senior Natural Scientist



SHROUD OF SALT *stifles life on the barrens rimming Utah's Great Salt Lake. A few years ago the mineral-laden water rose after heavy snows in surrounding mountains; it encrusted shore-growing goosefoot plants, then sank again to leave this white desolation. But nearby, America's "dead" sea teems with living organisms, as the author discovered when exploring with the Earl Pace family of Salt Lake City in an amphibious Penguin.*

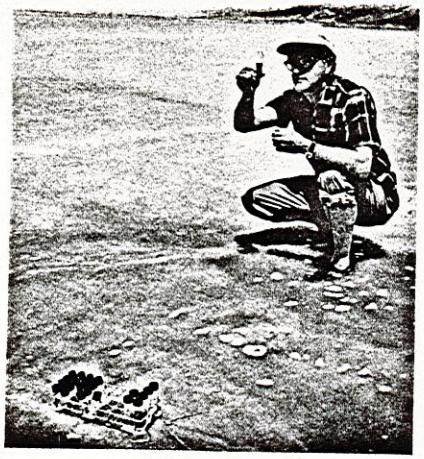
LIFE ON OTHER PLANETS? Scientists have pondered the question for ages. Most of us find it hard to conceive of life as we know it in such hostile environments: searingly hot or profoundly cold; with atmospheres lacking oxygen, showered by deadly radiation, or laden with noxious vapors and poisonous chemicals.

Yet life, we know, can exist—and multiply at times in incredible profusion—in the saturated brine of Great Salt Lake. Last summer I studied and photographed these remarkable organisms, which somehow have learned to thrive in seemingly deadly water, eight times saltier than the sea, thirty times saltier than most body fluids.

Behind me and on both sides shimmered an endless expanse of salt, showing no sign whatever of life, plant or animal. Before me sparkled a lake in which no fish swam. One could imagine few places, on this planet or any other, less hospitable to organic processes, more damaging to delicate cells.

Sharing with me this blend of dry heat, blinding whiteness, and crunching salt were Salt Lake City businessman Earl Pace, his pretty blond wife Beverly, and their two sons, Rand, 14, and Ron, 10 (below). A lifelong resident here, Earl is intimately familiar with Great Salt Lake—its coves, inlets, and islands. First we scouted his lake from the air.

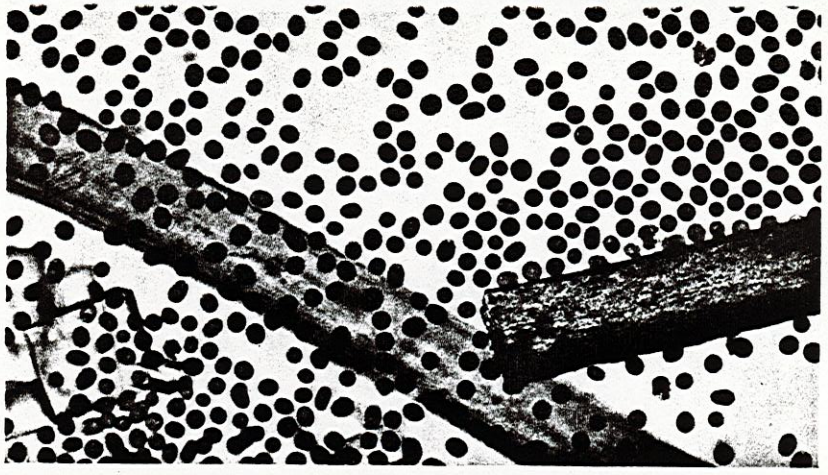
"Shorelines of old Bonneville," Earl shouted above the plane's roar, as we passed terrace-like striations high on a mountainside.

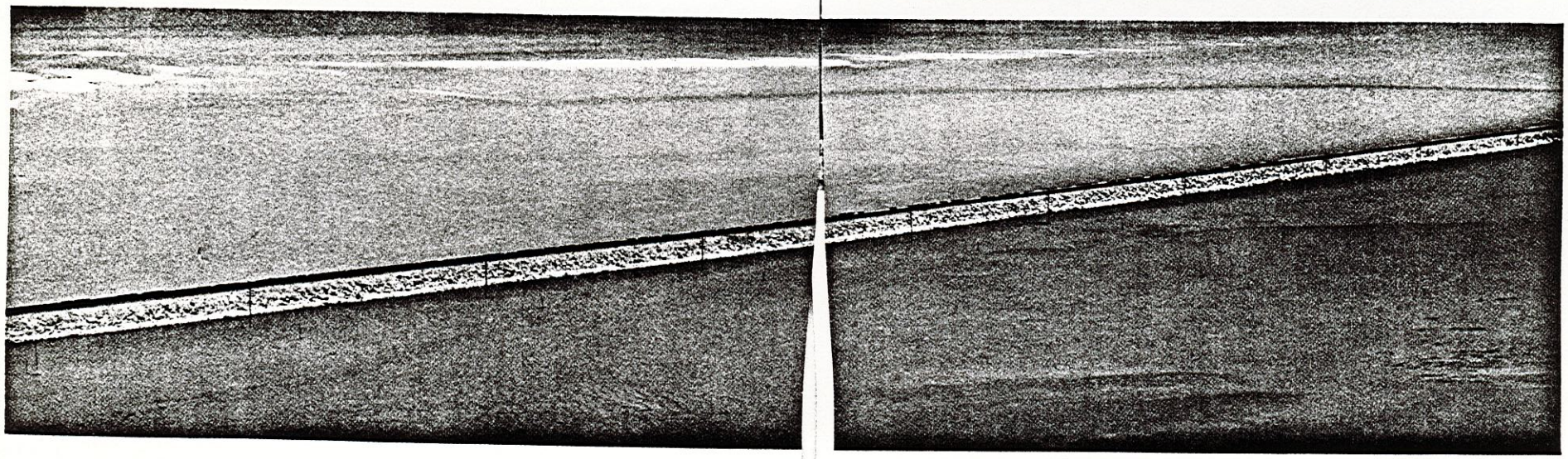


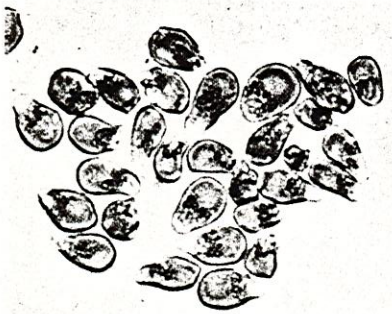
Shoe-deep in salty shallows, the author dips brine tinted by teeming *Dunaliella salina,* algae that thrive in the lake's harsh waters.

Loglike strands of human hair (right), enlarged 200 times by a microscope, dwarf black-banded ovals of *Dunaliella salina.*

Drawing a sharp line, the Southern Pacific's rail causeway (below) separates waters dyed by two of the lake's species of algae. *Dunaliella salina* tints pink a backwater of concentrated brine on the far side; emerald *Dunaliella viridis* (lower left) reigns on the near side. Trains cross the lake on 31 miles of dike-supported track that bypasses historic Promontory, Utah, where in 1869 officials drove the Golden Spike to complete the first transcontinental railroad.







Tiny one-celled plants like *Dunaliella viridis* (left) create basic foods for the lake's creatures. Such algae use the sun's energy to turn carbon dioxide and water to sugar, starch, and protein.

Feast of *viridis* turns adult brine shrimp green (right). A gleaming needle indicates size. Lake life's adaptability to a hostile environment intrigues scientists probing the possibility of life on other planets, such as Mars.

By "Bonneville" he was not referring to a car or a speedway but to a gigantic body of water that 50,000 years ago covered much of western Utah and parts of Idaho and Nevada. In area comparable to present-day Lake Michigan, the waters of ancient Bonneville reached depths of more than 1,000 feet.

Then, when the last age of glaciers waned and its ice tongues retreated northward, weather in this part of the world became hotter and drier. Lake Bonneville shrank below the level of its outlet. Streams continued to add their water, but not enough to offset evaporation. The lake grew saltier and saltier.

Today the largest remnant of that once mighty inland sea is known as Great Salt Lake. Only a twentieth the size of the original and now nowhere deeper than 50 feet, it is one of the world's wonders—so salty that no swimmer can possibly sink in it.

Pilot Ed Dreier banked the plane and we headed northwest. We were looking for a "bloom"—a patch of rose-hued water caused periodically but unpredictably by the sudden mass multiplication of bizarre organisms that dwell not only in Great Salt Lake but also in warm, salty waters elsewhere in the world. Such organisms belie the very name of the Near East's Dead Sea, for example, whose waters are even saltier than Salt Lake's.

Storm-lashed Brine No Place for Boating

The gray-blue, 30-by-70-mile sheet of water spreading out below us appeared lifeless indeed. To the east, at the foot of the majestic Wasatch Range, from which Brigham Young and his stalwart followers in 1847 got their first glimpse of the "Promised Land," lay fair Salt Lake City. Along the lake's south shore sprawled a checkerboard of dike-enclosed salt pans, backed up by the smoking chimneys of a great copper refinery, and beyond them the mineral-rich Oquirrh Mountains.

Oddly, there were no sails on the lake, no craft of any sort. Earl, a sailing enthusiast, told me why. For one thing, he said, sudden storms are a constant threat; without warning, a mirror surface may be whipped into a fury of breaking swells.

"Not only dangerous but miserable to be caught in—your boat white and weighted with salt, your clothes and hair coated with crystals, your eyes stinging from the spray, your motor more than likely dead from an ignition short."

Then, too, much of the lake is shallow, offering few places for convenient launching and landing. Great Salt Lake has nothing to offer the angler. Most of its islands are arid and desolate, some with shores encrusted forbiddingly with salt.

One such island we were now approaching. Our map identified it as Gunnison, about eight miles offshore in the lake's northwest quadrant, and inhabited only by terns, gulls, and pelicans. Bays and shallows shimmered in delicate shades of pale pink to deep rose—"blooms," unmistakably.

Ed eased down to about 200 feet, then slowly circled. Comprising less than 170 acres, the island was starkly bare except for scrubby bushes here and there and a central crest of rock heaps and hummocks. Its entire shore was white with glistening salt.

I regretted that our plane was not a helicopter so that we could land and wade out into the tinted shallows to appraise the strange color there. We circled once more, then headed back to our base.

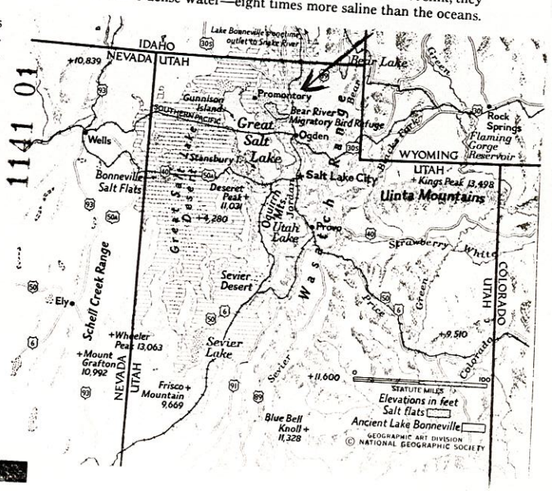
The Pace family helped me arrange a return trip to the intriguing island a few days later. We all set out at dawn in Earl's 3/4-ton truck. Loaded on the back was a rented Penguin, a vehicle

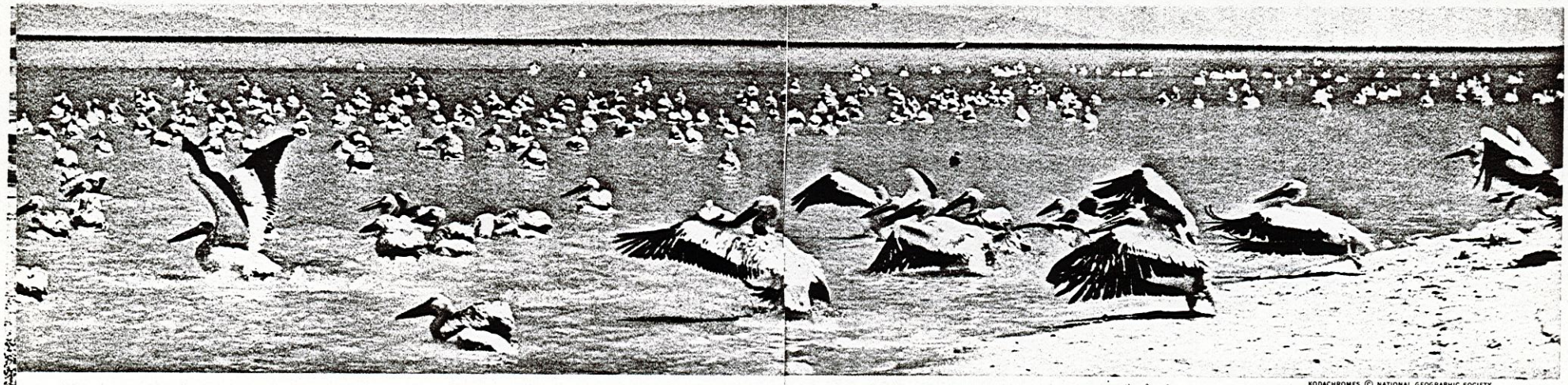
KODACHROMES © NATIONAL GEOGRAPHIC SOCIETY

As if borne on a billowing pink cloud, Earl Pace reclines atop mineral-heavy water tinted by algae and bacteria. His wife Beverly, twirling the quill of a Great Salt Lake pelican, perches with son Ron on salt "coral" deposited by surf and spray. Though swimmers literally cannot sink, they risk choking on the saltiness of the lake's dense water—eight times more saline than the oceans.

Red galaxy of life: Trillions of halophilic (salt-loving) bacteria streak a laboratory culture beside large salt crystals, here magnified three times.

Broad and briny splash in the Utah desert, Great Salt Lake survives as a remnant of Lake Bonneville, a vast inland sea once a thousand feet deep. Though Great Salt Lake's level has dropped 17 feet in the past century, river inflow today balances loss by evaporation. The lake's four billion tons of dissolved minerals—sodium chloride, magnesium, lithium, potash—lure chemical firms to the liquid mine.





Salt on their tails but quick to flee, white pelicans usher their preflight young into shallows off Gunnison Island. Thousands of the huge birds nest on uninhabited Gunnison, seeking protection from coyotes and other

marauders. They share the 165-acre domicile with gulls.

With Great Salt Lake barren of fish life, the pelicans commute 25 miles and more to feed from fresh-water streams and swamps in the Bear River Migratory Bird Refuge (map, page 255). If startled while winging homeward, the parents may jettison their catch—the fate of the salt-cured carp that Rand Pace holds (above).

Commercial collectors scout the shoreline in planes to locate the densest and most accessible deposits. Then crews in trucks with wide-tread tires cross the salt flats to harvest the shrimp eggs, scooping them up in bags. Great Salt Lake brine-shrimp eggs find a world market as a source of live food for tropical fishes. Properly dried, they remain viable almost indefinitely.

Some years ago I gave away my aquariums, tropical fish, and pet sea horses when I moved from New York to Washington. Four years later, while rummaging through a drawer, I came across a bottle of brine-shrimp eggs, label faded but contents intact.

Were the eggs still alive? I sprinkled some into a beaker of sea water, and within two days there was another crop of swimming shrimp larvae, brought to life as if by magic after a four-year sleep.

A tough outer shell and the fine knack of remaining dormant, like the wound spring of a stopped clock, suggest how this remarkable suspension of life may take place. As to why, one need only consider the grinding adversity imposed by seasonal extremes. Worked upon by searing sun in autumn, ice and snow in winter, the beached eggs are successively baked, frozen, and thawed. But the life spark survives.

When spring rains and mountain runoff temporarily reduce salinity near the shore, a crack appears in the leathery outer shell of each quickened egg, and a single larva emerges. It swims off in an immediate and urgent quest for food—providentially supplied by the lake's algae and bacteria, just beginning to burgeon.

It is true that other organisms—amoebae, ciliates, diatoms, and the like—inhabit waters of Great Salt Lake, but only where rain and inflow have a diluting effect. They cannot be regarded as truly indigenous, for they cannot survive in the saturated brine that harbors the tiny shrimp and the lake's only other animal inhabitants, flies of the genus *Ephydra*.

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My first encounter with the flies occurred not far from where the railroad causeway spans the lake, here 31 miles across. The beach was typically salt white, but ahead lay a patch blackened as if by coal dust. As I approached, a low murmur told what I was seeing—an almost solid blanket of tiny flies. The insects rose, hovered for a moment, and then moved en masse along the beach, finally to settle again on the salt.

I crept close enough to observe that some were mating, some depositing eggs, and others licking algae from the salt crystals. In the nearby surf I found scores of fly wrigglers, each a little larger than its mosquito counterpart, apparently feeding on algae and bacteria. These would soon metamorphose into brown pupae, eventually into adult flies.

In summer, *Ephydra* flies may blacken miles of shoreline (pages 260-61). When disturbed, they simply take evasive flight, then resettle. Never did a single fly alight on my skin, or even approach me in curiosity.

Strange Species Thrive in Harsh Worlds

One objective of my summer's work was to collect live cultures of micro-organisms for shipment to my research colleagues of the Department of Biological Sciences at Fordham University in New York City. There we are studying biochemical and life-cycle details of salt-resistant microbes. By August my collection was complete, except for fresh samples of *Dunaliella salina,* the orange-red algae.

On a final sortie I drove 120 miles to a remote corner of the lake, where on an earlier aerial reconnaissance I had spotted reddish water. A prevailing wind had pushed the discoloration close inshore, where the water was now a virtual pink soup. I filled several vials, and through a microscope perched on the hood of my car, I saw an incredibly dense population of vermilion algae. Here were thousands of the curious *Dunaliella* cells, pigments gleaming, flagella lashing.

The brine under my microscope was at true saturation; sodium chloride was recrystallizing as fast as it was being drawn into solution. Here was proof that this species could thrive in the absolute maximum of saltiness, and compelling evidence that adversity may exist only in the eye of the observer.

Many another little-known plant and animal on our planet has adapted to conditions similarly harsh. We do not often see these hardy creatures, for they live mainly in a microscopic world. One group, for example, actually "eats" carbolic acid; others metabolize iron, carbon monoxide, naphthalene, soap, paraffin, kerosene.

Some species thrive without oxygen; some flourish in the scalding waters of hot springs; others on the slick ice of glaciers. Cave dwellers, including some vertebrates, live perpetually in a total blackout. And miles below the surface of the sea live scores of abyssal wonders, under pressures of as much as 16,000 pounds per square inch.

Who can define the potential of creative forces in the universe? If life has been able to evolve and adapt to such bizarre earthly habitats, why not in even harsher and weirder environments—say, perhaps, on some distant planet? THE END