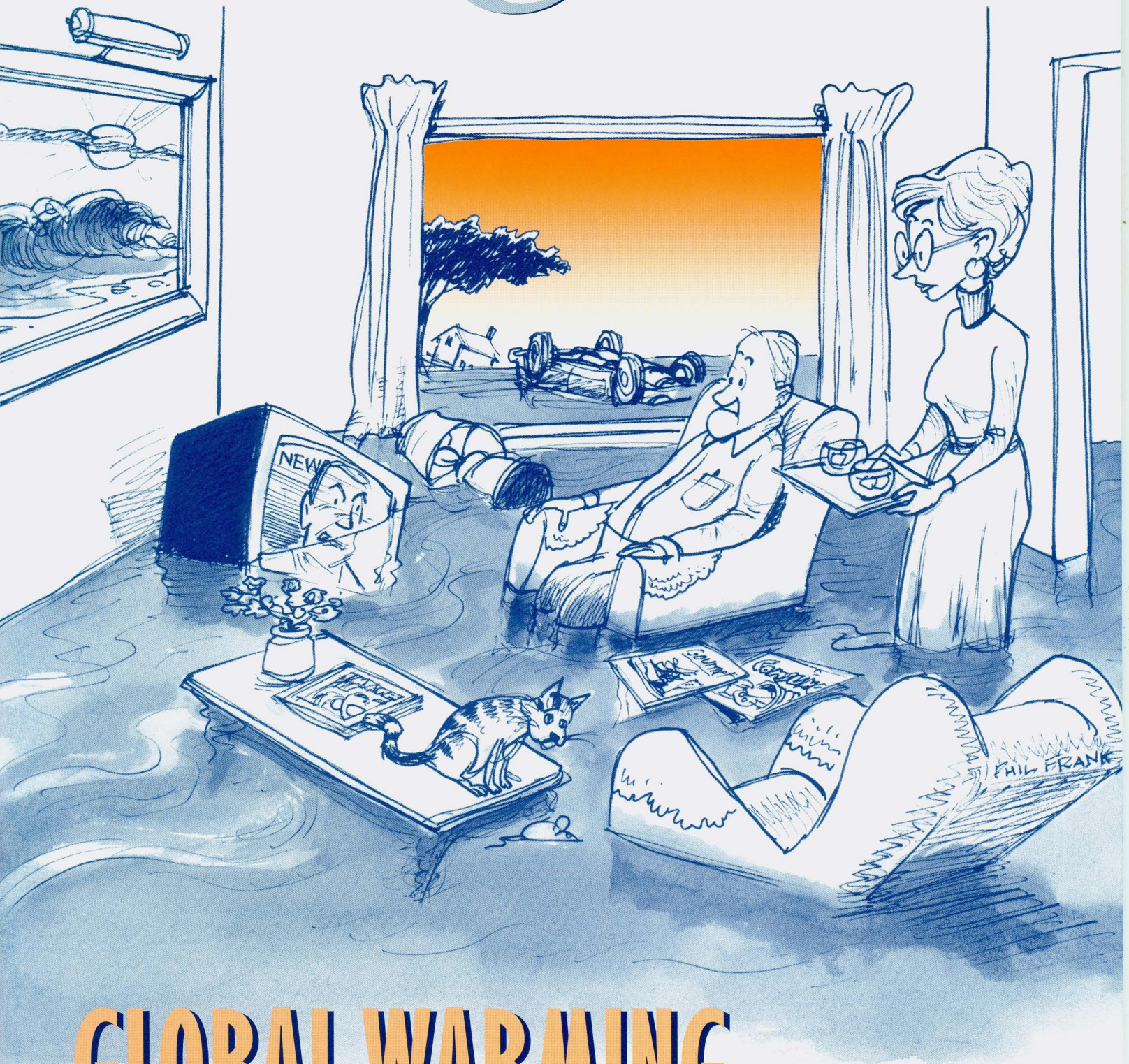
CALIFORNIA
COAST & OCEAN
VOLUME 19, NO. 3 AUTUMN 2003 • $4.95



GLOBAL WARMING

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Coastal Conservancy
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Cover: Phil Frank's daily comic strip "Farley" has appeared in the *San Francisco Chronicle* since 1986, illuminating issues and cultural trends in the San Francisco Bay Area through characters that include Farley, a not-always-clear-on-the subject reporter, four bears who run a restaurant catering to the animal set, feral cats in Golden Gate Park, a loquacious raven roommate, a meter maid, and feral pigs that run a personal injury law firm. He started the strip in 1975 as a nationally syndicated feature, but in 1986 chose to go regional. His fans credit him with keeping them off Prozac by supplying a daily dose of pure delight.

Back cover: Reid Glacier calving into Glacier Bay, Alaska. Photo courtesy Bear Track Inn, Gustavus, Alaska

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CALIFORNIA COAST & OCEAN
California Coast & Ocean is published by the Coastal Conservancy Association in cooperation with the California Academy of Sciences.

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Design and page composition: Seventeenth Street Studios
Prepress and printing: University of California Printing Services

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Articles appearing in *California Coast & Ocean* are indexed in *Environmental Periodicals Bibliography, Biology Digest,* and *Environment Abstracts.*

Printed on recycled paper with soy-based ink.

CALIFORNIA

COAST & OCEAN

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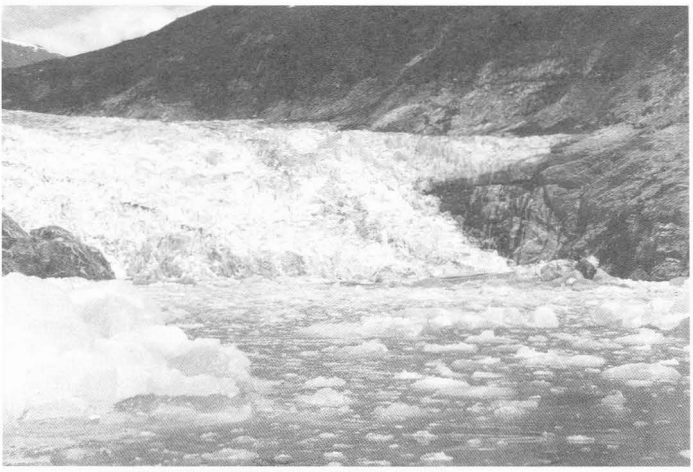
Getting ready for climate change

SINCE COAST & OCEAN published its first special issue on global warming and the California coast in 1989, the scientific debate has moved beyond the question of whether climate change is accelerating. A consensus exists, backed by ample evidence, that the Earth is heating up, largely because of fossil fuel consumption.

How this planetwide phenomenon will play out in different regions is by no means clear. Some areas may benefit temporarily from longer growing seasons, some may cool while others warm. In California, expected impacts—some already observed—include more extreme storm and wave events, earlier snowmelt and altered precipitation patterns, and changes in habitats that will further imperil already fragile species. Are we getting ready?



COURTESY BEAR TRACK INN, GUSTAVUS, ALASKA

Fourteen years ago, global warming was largely ignored by coastal planners. Lately, however, it has begun to command attention: the Sierra snowpack is melting much faster than expected, glaciers are shrinking around the world, Europe experienced a lethal heatwave last summer, and Alaskans worry about the strange warm weather and lack of snow, even as they enjoy fresh garden vegetables eerily late in the season. Birds and marine animals are being sighted north of their usual ranges.

Therefore we decided it was time for another special issue of *Coast & Ocean*, highlighting especially vulnerable coastal areas and what is being or could be done to prepare.

We have a guest editor: Gordy Slack, a former editor of *California Wild*, who writes on natural history topics for several magazines. In our lead article he points out that many coastal habitats are, in effect, small islands. Hemmed in by development and the ocean, plants and animals cannot adapt by moving. Landscape-scale conservation and wildlife corridors are essential if fragile species are to survive. In related stories, Seth Zuckerman considers what needs to be done to keep salmon restoration work from being undermined; Susan Davis looks at the Sacramento– San Joaquin River Delta, which is especially vulnerable to flooding; and Anne Canright considers sea level rise. Also in this issue is a report by Shirley Skeel on the mounting drive to build desalination plants along the coast. Atmospheric warming is sure to intensify conflicts over water.

Winter flows are likely to rise and spring runoff diminish, creating water supply problems for southern California, according to Peter Gleick, president of the Oakland-based Pacific Institute for Studies in Development, Environment, and Security. Sea level rise, combined with groundwater overdrafting, will allow more saltwater to intrude into coastal aquifers. "We clearly know enough to act," Gleick said at a public forum on global warming held November 15 at the California Academy of Sciences.

"There has not been as much progress as we had hoped and expected," a decade ago, observed Christopher Flavin, president of Worldwatch Institute, which cosponsored the event. "Very strong opposition by a minority allied with strong economic interests," bolstered by vociferous denial of scientific findings by some popular and well-connected commentators, has sown confusion, undermining public understanding.

In the past, local and state action on major environmental issues has led to congressional action. California's clean air standards and coastal protection program are two of many examples. Now California is defending its air quality standards against the Bush administration's lowering of national standards. Meanwhile, San Francisco and Marin County provide incentives for installing solar heating systems and Los Angeles promotes water conservation and energy efficient construction.

Energy efficiency yields a basket of benefits, even without considering global warming, said Ralph Cicerone, professor of earth system science and chemistry and Chancellor of the University of California, Irvine, at the Academy of Sciences forum. It can decrease our dependence on oil imports, thereby increasing national security, cut our trade deficit, lessen local air pollution, encourage others to do likewise, and create new market opportunities. Furthermore, the market for solar power is growing and would spurt ahead were it on an equal footing with fossil fuels, for which subsidies are high and increasing.

Global warming—the very idea that we humans are sabotaging our future—is frightening and makes us feel helpless. The antidote is action. We can shift course, and we can prepare.

—*Rasa Gustaitis*

Taking Global Warming to Heart

IN THE PAST FIFTEEN years global warming has moved from the esoteric scripts of scientists and mathematicians onto the real world stage. Record temperatures and devastating storms, droughts, and floods swamp the headlines. Scientists say it is neither hype nor coincidence. All these trends and events are in line with what mainstream modeling predicts for our disrupted climate.

We understand the problem's primary cause: the addition of too much carbon dioxide (CO_2) to the atmosphere, mostly through the burning of fossil fuel. Carbon dioxide traps solar energy that otherwise would radiate away from the Earth as heat. As we add CO_2, the Earth's temperature rises.

We understand many of the global consequences of climate disruption as well, and they are grave: increasingly intense and frequent storms, droughts, and heat waves; the rise of new illnesses such as SARS and West Nile Virus, and the spread to new places of old ones such as malaria and cholera; habitat displacement and extinctions of wild populations of plants and animals; the rise of sea levels and the battering and redefinition of our coasts. Climate disruption will wreak havoc on our water distribution system, our agricultural practices, and our basic ecosystem services, all fundamental to our economic and environmental welfare. The proportions of the problem make a reasonable person's head spin.

We also know what could alleviate the problem of global warming. It is, sensibly, the reverse of the cause. To slow or stop climate disruption we need to reduce the amount of heat-trapping gasses in the atmosphere.

So much for all that we know. Now to the salient remaining mystery: Why, given our insights and knowledge, do we not respond appropriately? Why don't we curb our carbon output?

The late philosopher David Love, who taught at Oberlin College, observed a key gap between merely knowing and what he called "taking knowledge to heart." Knowing the truth is an accomplishment in itself, he said, and can lead to well-formed opinions. But taking the truth to heart is manifest in action. In Love's formulation, we Americans have failed to take global warming to heart. That failure has already been costly. If it persists much longer, it will come at an astronomical price, a cost to be paid not only by ourselves, but by all people, plants, and animals in this and future generations. What mechanism of denial could allow us to carry on business as usual while accruing that kind of debt?

A frustrated dieter comes to mind. He too knows what he needs to do to solve his problem. For all the hand-wringing and pleading and promising that goes on, it boils down to a simple equation: reducing the ratio of calories going in to calories burned: eat less, exercise more, or both. Even though his doctor warns his weight may kill him, the man can't lose weight. His family pleads. He tries, but he doesn't stick to a program. Exercise is embarrassing, painful, time-consuming, and shows no immediate results. He reads books about Atkins, Ornish, vegetarianism, Weightwatchers, and other diets. Reading doesn't help. He blames his difficulty on advertising, on food-loving friends who feed him, on the constant and pervasive marketing of fast and caloric food and on his own weight-induced depression.

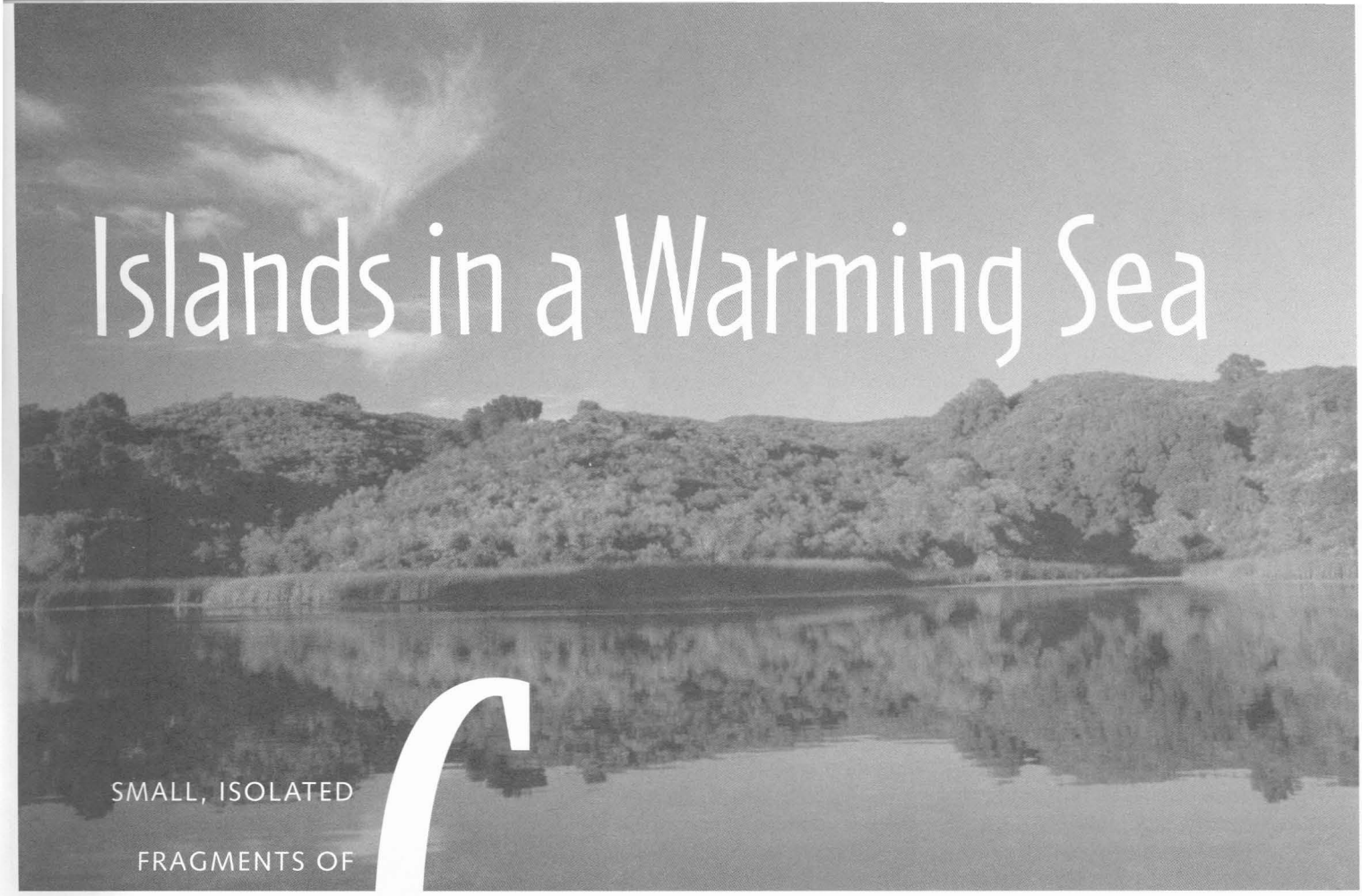
Then one day his heart stops. As life slips away he thinks of his children, of his loves, his favorite places, favorite flavors, of the world's excruciating beauty. How could he have done this to himself? He swears that if he lives he will change, will do whatever it takes to restore his health. Embarrassment? Inconvenience? Discomfort? How trivial they seem now.

We are something like that obese man on the eve of cardiac arrest. Our crazy weather is the warning sign. We understand our problem. We know the consequences. We know how to solve or minimize it. But somehow we just don't take the predicament to heart. We have excuses: our politicians, the inconvenience, the expense, the impracticality of, say, walking or taking the bus to work.

But ultimately, our excuses and explanations aren't worth a thing. Nor are our knowledgeable opinions of much use. What matters now is one thing: reducing greenhouse gas emissions by 70 percent before our own cardiac arrest. We can't wait for politicians to take the lead. They live on two- or four-year election cycles and can't afford to address a problem reaching forward decades and centuries. Nor can corporate heads, bound by duty to their quarterly reports, lead the way. It will have to be us, then. Ordinary people driven by knowledge and fueled by love for each other and the natural world and the epic story of life unfolding . . . or just plain old self-preservation.

—Gordy Slack

Islands in a Warming Sea



CAGAN SEKERCIOGLU

SMALL, ISOLATED FRAGMENTS OF INTACT COASTAL HABITAT ARE ALREADY VULNERABLE. NOW WE'RE PULLING THE RUG RIGHT OUT FROM UNDER THEM.

GORDY SLACK

CALIFORNIA'S isolation from the rest of North America, maintained by the barriers of mountain range, ocean, and desert, makes the entire state something of a natural island. That explains why so many plants and animals are found nowhere but here. The "Island Called California," to borrow the title of Elna Bakker's excellent natural history, is a marvelously creative place with more endemic species than any other state. Like many island species, California's endemics are particularly suited to specialized habitats; they are also especially vulnerable to change, including climate change.

For at least a thousand years, and in the past century most intensively,

Above: Searsville Lake, Jasper Ridge Biological Preserve

human populations have been carving the huge island called California into smaller fragments, islands in themselves. Early Native Americans used fire to burn swaths of woodland, chaparral, and grassland to enhance their hunting and cultivation prospects. Much less subtly, Europeans began carving up the landscape with barbed wire and roads, punctuating it with towns, dividing vast stretches of forest into smaller pieces separated by barriers of inhospitable clearcut. Through the 19th century, such isolating elements were relatively porous and forgiving. The railroad line connecting Los Angeles to San Francisco may have bisected kit fox range, say, but kit foxes could literally get over it. Recent barriers have been less penetrable: industrial farms and suburban sprawl stretching from one edge of the Great Central Valley to the other; Highways 5, 101, 80, and a hundred others roaring with cars and trucks day and night, chopping off any terrestrial mammal populations on one side from those on the other; rivers dammed and diverted or channelized and flowing too straight and fast for any wild thing to occupy or cross.

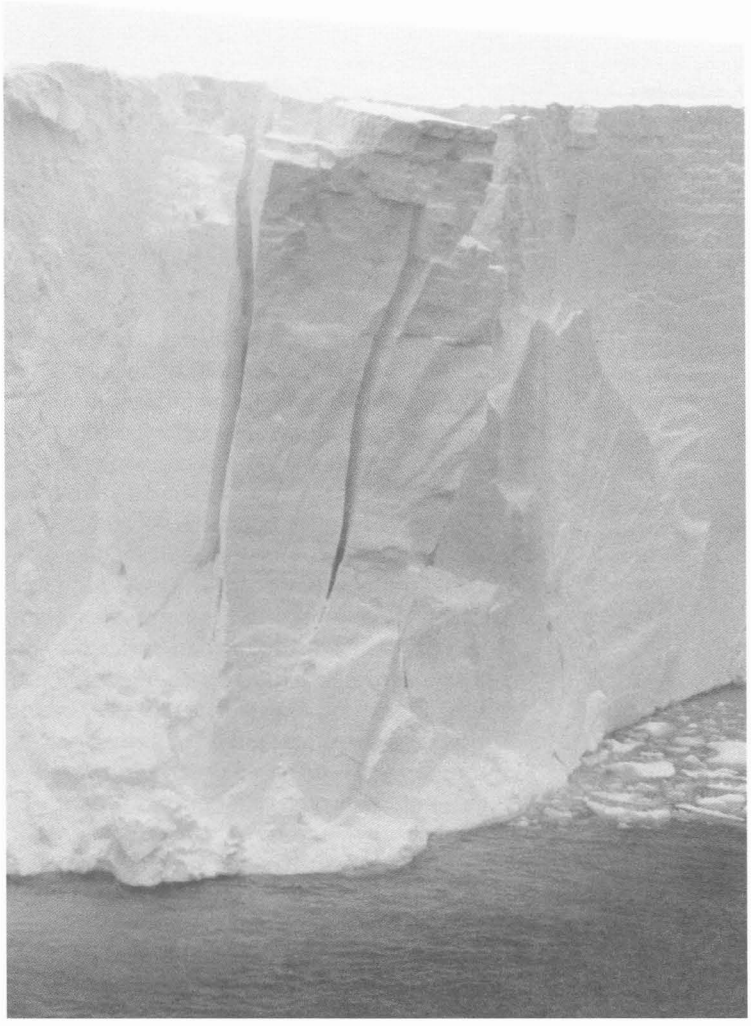
In the evolutionary blink of an eye, many of California's intact habitats have become effectively isolated, biological islands locked into place by the altered, inhospitable land surrounding them. Because of the perils of isolation and small size, ecologists are unsure how long these islands can sustain the plants and animals living within their boundaries. Add to that already troubling situation the impacts of rapid climate change and you have a recipe for ecological disaster. Like prisoners locked in a burning jail, many plant and animals species will perish as they have no place to go when their ranges become unsuitably hot, or wet, or dry.

Ironically, islands have been at the center of the story of evolution from the beginning. They were the tip-off for both Charles Darwin and Alfred Russel Wallace, the two 19th-century scientists who independently arrived at the theory that natural selection is the engine powering evolution's extravagant diversity. Wallace was traveling through the Indonesian Archipelago when it hit him that the isolation of island populations fueled the speedy evolution of new species. Darwin was observing the distribution of plants and animals in the Galápagos when he had his legendary Eureka! moment.

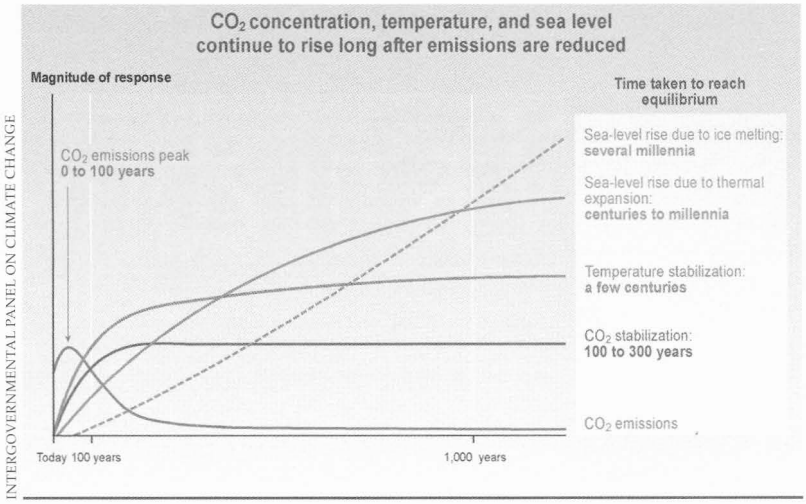
Since Darwin and Wallace, many studies have proved islands to be extraordinarily creative environments from an evolutionary point of view. But several others have shown them to be extraordinarily precarious ones. In the past half-millennium, as habitat-altering human populations have spread across the earth, island species have paid the highest price.

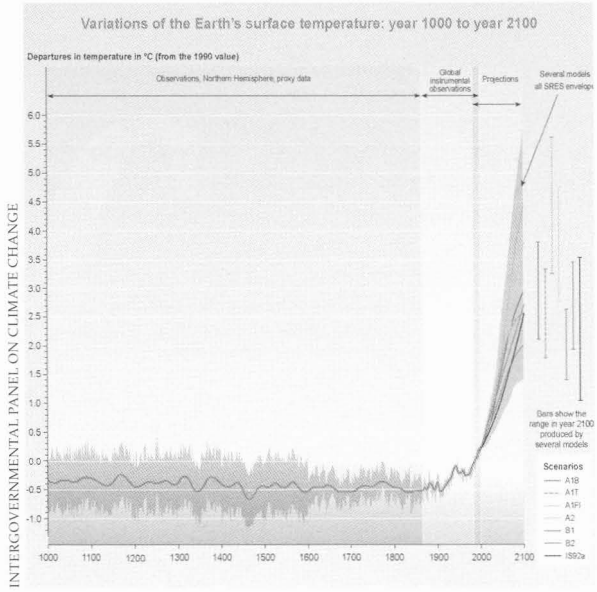
Jared Diamond, physiology professor at the University of California, Los Angeles, and author of *Guns, Germs, and Steel*, published a paper in 1984 about worldwide bird extinction patterns since 1600. He found that more than 90 percent of the 171 bird extinctions in that period were of island species. In other words, Diamond concluded, an island bird faces about 50 times as great a likelihood of extinction as a mainland bird. And the smaller the island, the greater the vulnerability. By implication, this vulnerability applies to any isolated habitat, not only oceanic islands surrounded by water. This is why conservation biologists try to maximize the area of the habitats they set aside.

The seaward edge of the floating Ross Ice Shelf in Antarctica has been calving gigantic icebergs.



MICHAEL VAN WOERT, NOAA NESDIS, ORA





Top: Even if CO_2 emissions are reduced, it will take a very long time to reduce their impacts.

Above: A steep rise in global temperatures is projected for the next hundred years.

Island species tend to specialize, adapting to the particular conditions of the habitats they occupy. That's why islands are home to a disproportionate number of giants and dwarfs, like the giant tortoise and the ant-sized frog of the Seychelles, or the extinct pygmy mammoth of the three northernmost Channel Islands. But to specialize is to go out on an evolutionary limb. As long as the conditions to which a species is well adapted persist, things are fine. But change can be deadly for island dwellers. Not only might a creature adapted to one set of conditions find itself unsuited for new ones, but because islands are by definition isolated, their specialized inhabitants have nowhere to run. If those inhabitants are the only known members of a species, change may well spell curtains for the entire group.

Take the dodo, *Paphus cucullarus*, so beautifully profiled in David Quammen's classic exploration of island biogeography, *The Song of the Dodo*. There were no predators on the island of Mauritius, but there was plenty of big fruit; so it was advantageous for the bird to grow large, storing calories for the fruitless season, as well as flightless and relaxed, so as not to burn those calories unnecessarily. Advantageous, that is, until the introduction of two exotic primates: European sailors (*Homo sapiens*), who killed thousands of dodos for food and, probably more importantly, crab-eating macaques (*Macaca fascicularis*), very adaptable generalists (likely brought by the *H. sapiens*) that preyed on young dodos and eggs.

Below I focus on three very different places that clearly illustrate the problems climate change will pose—and in at least one case is already posing—to California's fragmented habitats. The first is Ballona Wetlands, a battered but beautiful remnant of coastal wetland near Los Angeles. Second is Jasper Ridge, a chunk of serpentine grassland that's been as well studied in relation to climate change as any piece of land on Earth. And finally, a new preserve linking Humboldt Redwoods State Park, which includes the world's largest remaining patch of old-growth redwoods, to King Range National Conservation Area and the Lost Coast.

Overgeneralization is the bane of ecology, perhaps of any science, but there are some common themes that emerge from these three distinct places. Most importantly, to cope with relatively quick and severe changes in climate, California's plants and animals will need room to move. As University of Florida biologist Reed Noss says, "When the climate changes, organisms must move, adapt, or die." That goes for whole communities and ecosystems as well. In the unnaturally short time frame of current warming trends, genetic adaptation is out of the question for most species. So, in addition to doing what we can to slow the pace of climate change, the best we have to offer plants and animals is room to move. In many cases that will be impossible or impractical and extinctions will probably be high. But the opportunity to create a network of core reserves interlinked by protected corridors of habitat will never be as great as it is today. The California Wilderness Coalition is pursuing such a big-picture approach with their California Wildlands Project. If granted space, many of California's extraordinary native organisms and habitats may be able to ride the wave of global warming, perhaps the biggest ecological challenge we've given them to date.

CALIFORNIA COASTAL RECORDS PROJECT

Ballona Wetlands are hemmed in by development.

Ballona Wetlands Restoration Challenges

CALIFORNIA'S COASTAL wetlands are like pearls," says wetland ecologist Joy Zedler, now at the University of Wisconsin but long a student of coastal California. If they are evenly distributed and close enough to one another, you've got a beautiful necklace, a functioning network of integrated coastal ecosystems. Sell off some of the pearls and the necklace suffers, but it's still a pearl necklace. Remove too many, cut the string, and scratch the luster off the remaining pearls and you have nothing. Except, perhaps, nostalgia and regret.

Californians have lost or sold off quite a few pearls in the past 150 years. Ninety-five percent of the state's coastal wetlands have been filled and converted to some other purpose. Many of the pearls remaining are cracked and unevenly placed. Ballona Wetlands, for instance, is the only remaining large coastal wetland ecosystem in Los Angeles County. Once covering 2,100 acres, it has been diminished, battered, and abused almost beyond recognition. Today, only about 540 acres of wetland remain. Ballona, like many coastal wetlands today, is circumscribed by immovable perimeters: it is bounded to the north by Marina del Rey, Highway 1 cuts off its eastern end, and housing developments crowd the other edges.

The changes that will come with global warming pose several problems for Ballona and virtually every other coastal wetland. The most salient, says Zedler, will be sea level rise. In the past, the undulating patterns of ice age and thaw brought relatively slow climate change; wetlands would move upland as, over the centuries and millennia, the seas grew and swallowed up their lower marshes. No such retreat will be available to Ballona, the wetlands of south San Francisco Bay, or most of the other coastal wetlands along the Pacific. "If the upland margin is immovable," says wildlife biologist Robert van de Hoek, "the wetland creatures dependent on areas above the tide will have no place to go."

Marshland will in many cases be able to keep pace with sea level rise, says Zedler, as long as there is a good source of sediment that can be trapped and acquired by the salt-tolerant plants in a marsh. In some cases, where the movement of sediment through feeder streams and creeks has been impeded by damming and channelizing, sediment may have to be supplied from elsewhere. Dredge spoils, for instance, have been used to raise marshes at a quicker than natural pace around San Francisco Bay. In Ballona, some of the restorable land, now leveed off from the tides, has had much sediment dumped on it. Ironically, this may someday prove useful in helping the restored marsh stay above the tides.

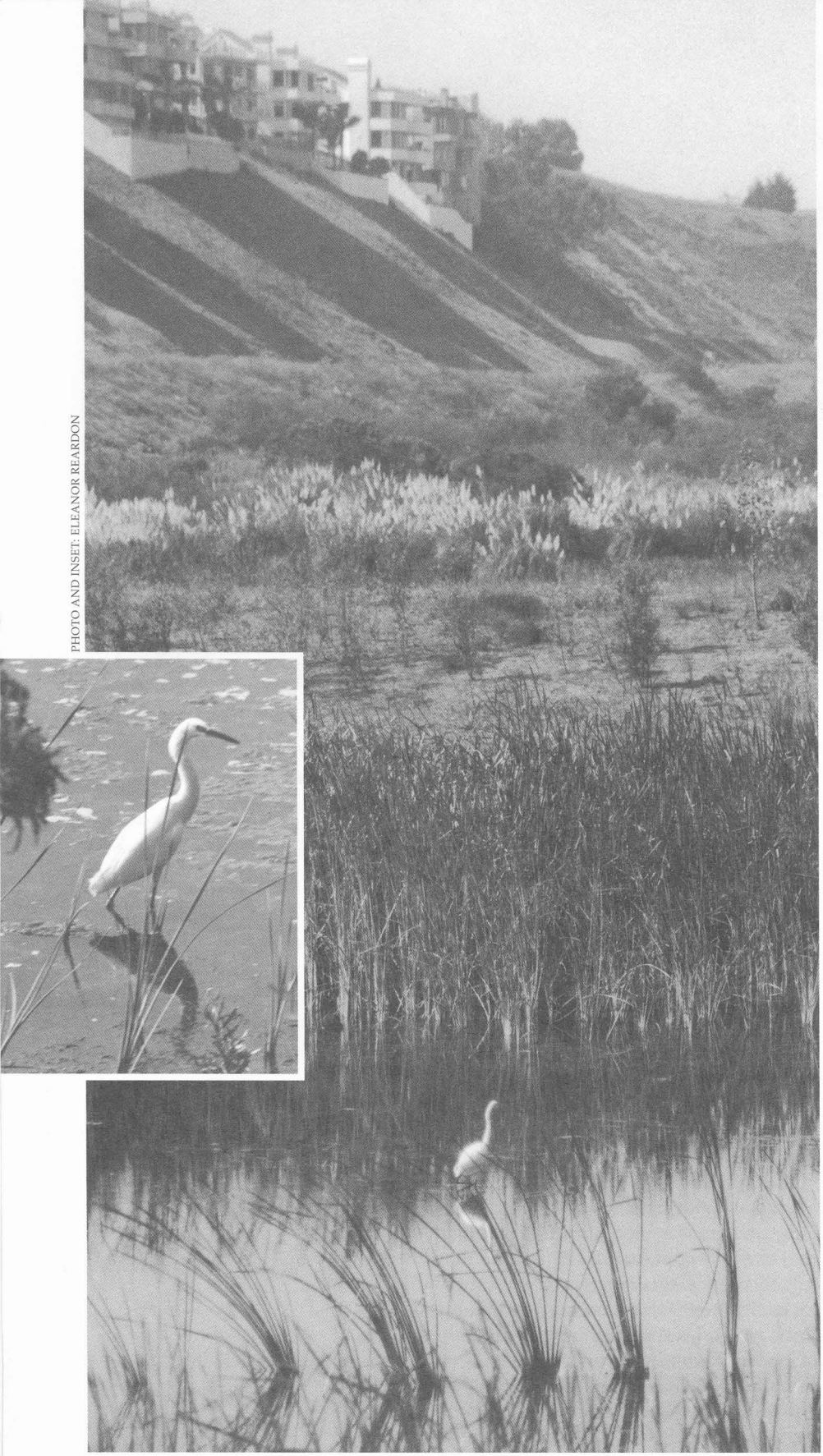


PHOTO AND INSET: ELEANOR REARDON

Top and inset: Snowy egrets in Ballona Wetlands

Among the wetland critters van de Hoek studies are fiddler crabs, crustaceans whose earliest stage of life is spent eating plankton in the open water. Once they reach maturity, however, fiddler crabs spend their lives in the moist but rarely submerged area above the tides—an area, van de Hoek says, that may well be squeezed out of existence as higher water floods more upland areas of the salt marsh. "We will likely lose fiddler crabs at Ballona with sea level rise," he says.

Another creature that relies on higher portions of Ballona is the wandering skipper, a butterfly whose caterpillars live in the salt grass in the lower marsh. Adult wandering skippers need access to drier upland marsh plants such as seaside heliotrope, a saltwater-intolerant plant likely to be squeezed out by rising tides and increasingly frequent and rough storms, says van de Hoek.

By far the most celebrated of wetland residents are the birds. Two hundred and fifteen different species live in or visit Ballona. Migratory birds in particular need the string of pearls to remain intact along the coast. Plying the Pacific Flyway, they rely on fecund wetland ecosystems for food and rest. Because Ballona lies halfway between the 2,000-acre Mugu Lagoon, 25 miles up the coast, and Los Cerritos Wetlands, 25 miles down, it was once and could again be a key pearl in the necklace.

Some birds, including the endangered light-footed clapper rail, are "island hoppers," Zedler says. They can't fly much farther than 25 miles at a stretch. Others, including Belding's savannah sparrow, may be unable to make a 50-mile jump. Even strong-flying, long-distance migrants need rest stops, says van de Hoek, and a restored Ballona would be of great value to them as well.

The last clapper rail seen at Ballona was photographed there a decade ago. It was only visiting and must have come either from the north at Mugu Lagoon, where there is now a tiny nesting population of six pairs, or from Seal Beach National Wildlife Refuge to the south, where there are about 50 pairs. If those two populations could be linked by a restored Ballona, it would help them regain genetic vitality and help protect them against site-specific calamities. The light-footed clapper rails will need Ballona, says van de Hoek, whether its upland portions are lost to rising sea level or not.

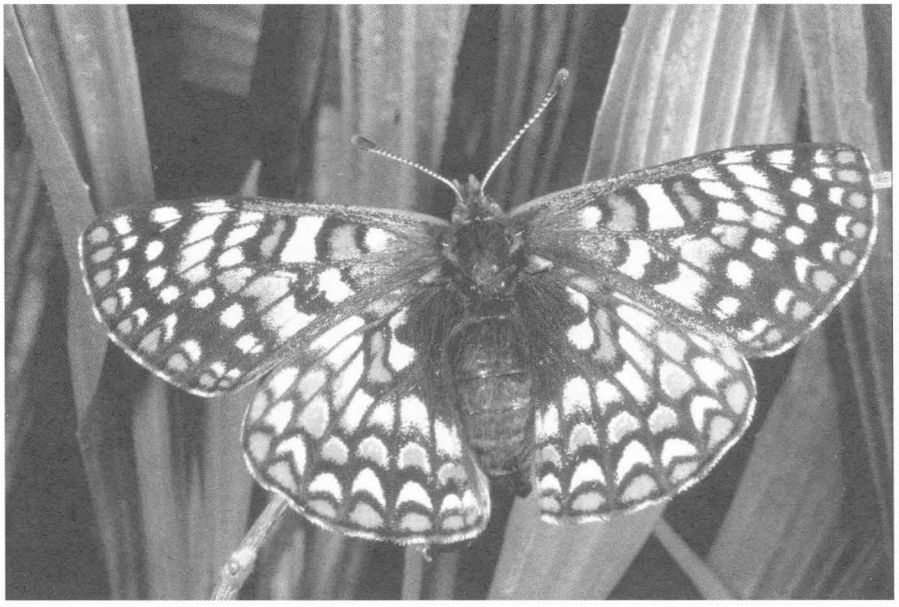
Ballona is also isolated from large terrestrial animals on the mainland—some of

which, coyotes, for instance, are helpful to clapper rails. "Coyotes hate to get their feet wet," says Marcia Hanscom, executive director of the Wetlands Action Network, a group dedicated to the preservation of wetlands along the Pacific Flyway. "And the rails stay in the cordgrass. So coyotes [stay out of the marsh and] don't prey on the clapper rails, but they do hunt other predators that eat juvenile rails and eggs, such as foxes and possums." Although there are coyotes in the area, they often can't get across the six-lane Highway 1 to access the upland portions of the wetland.

If a wetland island is too small, it can function as a population sink for birds, says Zedler, attracting them to a place that has no long-term future for them—a "wetland museum" as some ecologists call it, where they are likely to perish. Similarly, if a wetland is too far away from associated habitats to allow migration, it may have the same deleterious effect, stranding—and dooming—individuals and populations. If wetland islands are big enough, close enough, and connected to the larger ecosystems surrounding them, migrating birds will have a much better chance of surviving the changes to come.

In September, the State of California announced that it would pay $140 million for 540 acres at Ballona, rescuing them from a controversial housing development long in the works. The removal of roads that slice the wetlands into still smaller fragments, and the reconnection of several marsh areas to each other and to tidal flow, will give the plants and animals of Ballona a great advantage. The restoration plan also includes making a connection, along Ballona Creek, from the upland areas all the way to the beach. Within a decade or two this key piece in the coastal wetland necklace may have regained much of its former splendor and its value as critical wildlife habitat.

Even so, there may be other losses with climate change, ones more difficult to predict than the narrowing of upland boundaries. The extent and severity of these losses will depend on how much warming occurs. Zedler fears, for instance, that as temperatures rise at Ballona and other coastal wetlands, so will evaporation and the photosynthesis rate of plants, causing more salt to be drawn up into the soil. "If evaporation and plant activities increase soil salt concentrations to 4.5 percent, that will be toxic to many native wetland plants," she says. "Pickleweed may be the only plant around here that can tolerate such high concentrations." She's not predicting that, only saying it is possible. "There are so many variables," Zedler says, "and therefore many, many plausible scenarios."



T.W. DAVIES, CALIFORNIA ACADEMY OF SCIENCES

Too Late for Jasper Ridge Checkerspots

FOR THE PAST DECADE and a half, ecologists have warned that warming would shift temperature zones northward and up slopes to higher, cooler elevations, leaving overheated "island" populations behind. But scientists have also warned that changing precipitation patterns—specifically, increases in the extremes of wet and dry—will make it even more difficult for plants and animals to survive. Those worries proved justified for two of the last peninsular populations of Bay checkerspot butterflies at Jasper Ridge Biological Preserve, a Stanford University research center in the eastern foothills of the Santa Cruz Mountains.

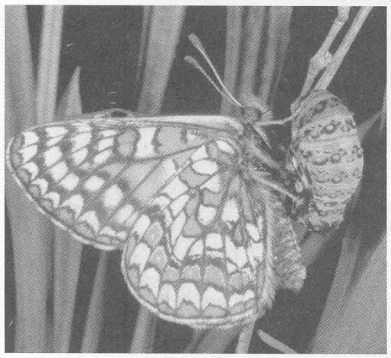
The serpentine grassland found at Jasper Ridge was once part of a continuous ocean of grassland flowing down the San Francisco Peninsula and east through the coastal ranges, out into the Central Valley, and on into the Sierra foothills. Today, the Jasper Ridge grassland is no longer connected to that sea. In fact, most of that original grassland has been replaced by development or by invasive plants that outcompete the natives. Because some of California's native grasses are well adapted to serpentine soils, however, which are inhospitable to many

Top: Bay checkerspot butterfly (*Euphydryas editha bayensis*) at Kirby Creek, near Morgan Hill in Santa Clara County

Bottom: Scientists of Jasper Ridge Global Change Experiment monitor the effects of several climate variables.

CHRIS FIELD

CHRIS FIELD



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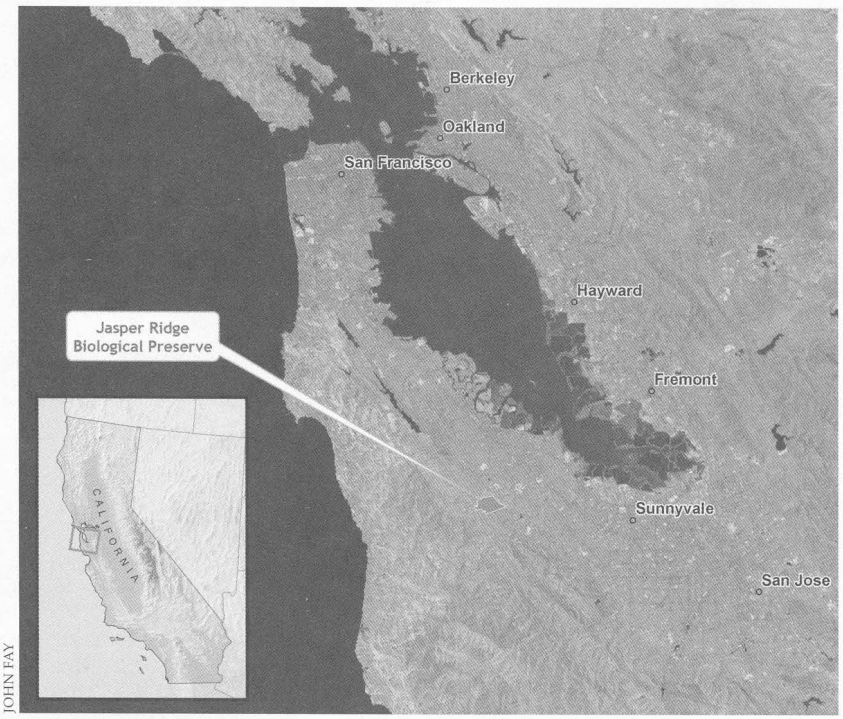
CHRIS FIELD



JOHN FAY

Plots of grassland are monitored to note the results of increased amounts of CO_2, nitrogen, water, and heat.

invasive aliens, native grasslands have found refuge in serpentine habitats at a few places, such as Jasper Ridge.

Jasper Ridge's 37 acres of grassland form an isolated island, too distant from any others for them to replenish ailing populations or contribute genes. The nearest sizeable chunk of serpentine is 25 miles southeast on Coyote Ridge. To the north, up the San Francisco Peninsula, the once-abundant serpentine is "mostly paved over," says biologist Stuart Weiss, who has studied serpentine species at Jasper Ridge and elsewhere since 1979.

Last April, Huxley College biologist John McLaughlin, Stanford biologist Paul Ehrlich, and others published a study in the *Proceedings of the National Academy of Sciences* drawing a direct link between increasingly extreme weather conditions at Jasper Ridge and the extinction of the checkerspots there. Ehrlich had been watching the butterfly's population dynamics at Jasper Ridge since 1960 and had seen their numbers rise and fall in response to weather conditions. He had long noted a close relationship between the number of butterflies, rainfall patterns, and the timing of the butterfly's primary host plants. If it rained enough and at the right time, the butterfly larvae had adequate host plants to survive to their reproductive stage. Too much or too little rain, or rain coming too early or too late, and butterfly numbers dropped.

As predicted by several global warming models, extremes in precipitation did increase at Jasper Ridge through the 1970s, '80s, and '90s. Finally, in 1998 the last Jasper Ridge Bay checkerspots flickered out.

In the past, periodic weather fluctuations probably led to the disappearance of local checkerspot populations, including Jasper Ridge's, says Weiss, but proximity and access to other populations would have allowed for recolonization. Although there are still checkerspot populations in the Coyote Ridge area, they are too distant to repopulate peninsula habitats. And though it is possible that precipitation patterns amenable to long-term checkerspot survival occur elsewhere, island-bound populations, hemmed in by urban development and alien-dominated habitats, have no way to find them.

The extinction of Jasper Ridge's checkerspots is a significant loss in itself. But far more important are the indications of broader threats to California's biological diversity from changing precipitation regimes.

CAGAN SEKERCIOGLU

Redwoods to the Sea

ONE OF THE MOST dramatic examples of island making in California's history is the cutting of the once vast redwood forests. Today's old-growth redwood stands, only about four percent of the original, are isolated remnants, exposed on all sides to a number of threats, the most immediate being continued logging for their high-priced timber.

Predicting the long-term viability of these islands, and how they will respond to the warming trends in the coming century, is difficult, says UC Berkeley biology professor Todd Dawson. Individual redwoods can live more than two thousand years. "They are durable trees," Dawson says, "and they can withstand a lot of change in one life span." Precisely because they live so long—not to mention the fact that we have no way of knowing whether climate change will bring more or less precipitation, more or less fog—it is difficult to judge their long-term reproductive viability.

Redwoods prefer cool, damp conditions. Because large forests can preserve their own microclimates by keeping sunshine out and moisture in, says University of Florida biology professor Reed Noss, even a few degrees average difference on the outside of the forest might not make that big a difference inside. But the more exposed edge a forest has, the less able it is to determine its own interior climate, says Noss. Today's old-growth groves are all relatively small islands with a lot of edge exposure to weather change and other dangers.

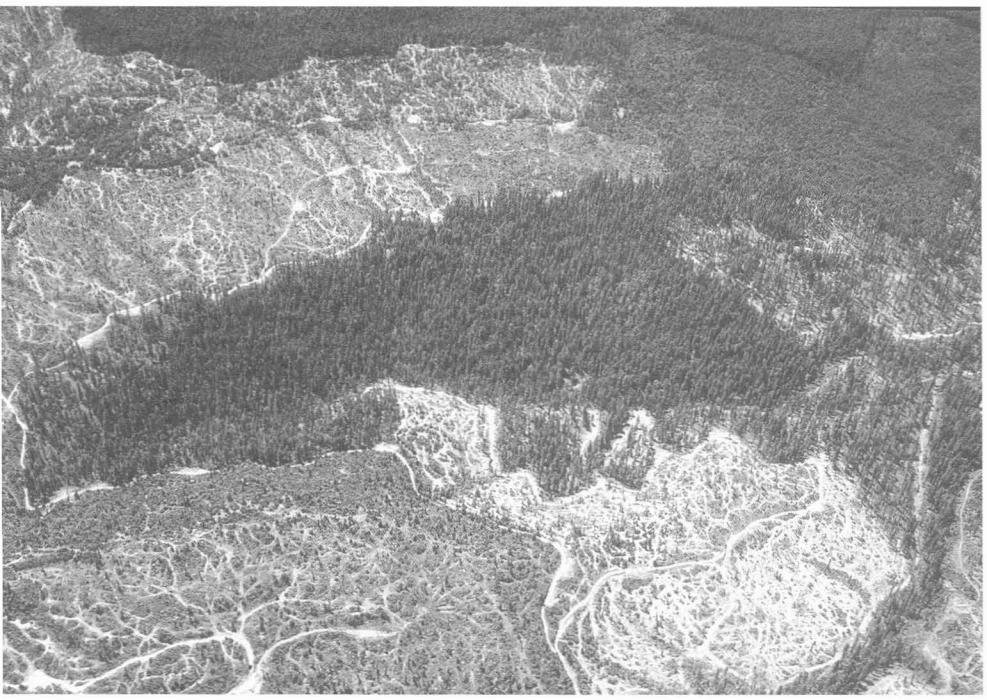
The fact that redwoods near Monterey, at the southern end of their range, have retreated to protected valley bottoms over the millennia suggests that warmer weather may bring on a slow redwood retreat northward as temperatures rise.

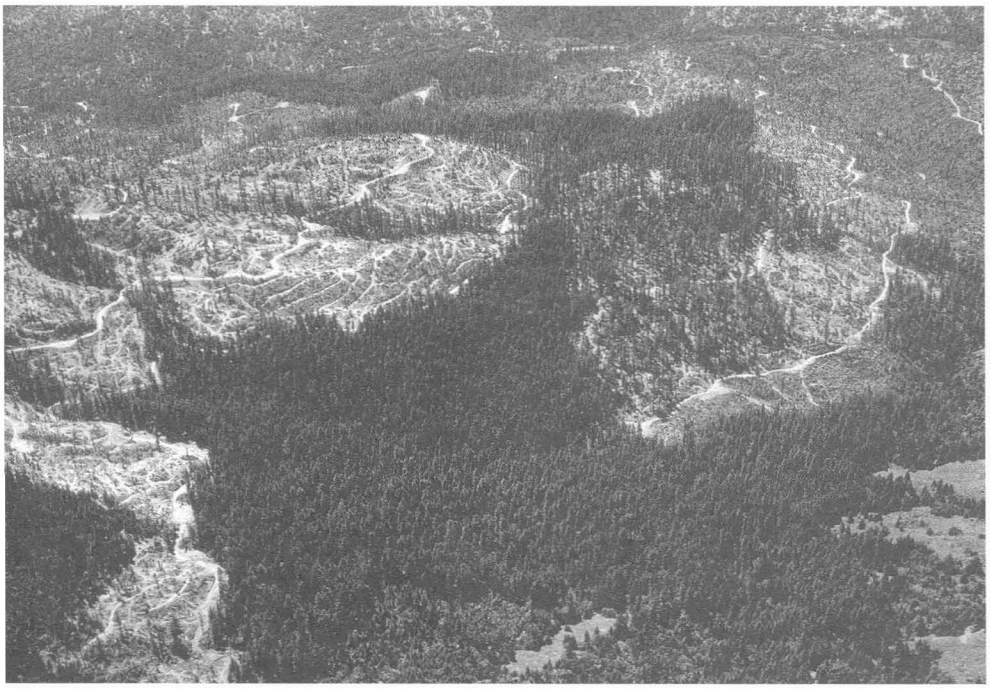
"Many climatologists predict that we are likely to get an ice age after the warming," says Noss, editor of *The Redwood Forest: History, Ecology, and Conservation of the Coastal Redwoods.* "These trees live so long that they well might survive the warming, but then

Top: Coast redwoods (*Sequoia sempervirens*) in the Jasper Ridge Biological Preserve

Bottom: Townsend chipmunks feed on huckleberries that grow high in the redwood canopy.

LLOYD GLENN INGLES, CA ACADEMY OF SCIENCES





PHOTOS THIS PAGE: DOUG THRON/LIGHTHAWK © 1994

Clearcutting has reduced many redwood forests to isolated groves, like these in the Headwaters Forest. Elkhead Springs Grove (top) has ancient redwoods and Douglas firs. This grove has been protected. Shaw Creek Grove shelters coho salmon habitat, but is not protected against logging. Each grove covers about 300 acres, and contains nesting habitat for endangered marbled murrelets.

they'd have to face the ice age that follows. That's going to be tough."

The ice age, if it comes, would be centuries or millennia off, says Noss. Chances are good that we'll have other, more drastic ecological breakthroughs and catastrophes before then. But in the long run, Noss's point is valid: "Like everything else, when climates undergo major changes, redwood forests have to move or go extinct," he says.

Individual redwood trees will respond slowly, perhaps imperceptibly, to warming, and whole forests more slowly still, but more transient plants and animals that live within their protective cover are much more vulnerable. Steve Sillett, a botany professor at Humboldt State University, studies the ecosystems in the upper canopy of redwood forests. Because of their proximity to the world outside the forest, these little-known communities are exposed to hotter, drier weather as the climate shifts. Hundreds of feet up, in the crotches of upper branches in redwood trees, as much as a meter of soil can accumulate. In and on that soil Sillett finds earthworms, salamanders, arthropods, ferns, and shrubs. If warming desiccates those upper soils and those organisms are lost, the ecology of the larger forest community will likely be affected.

At Humboldt Redwoods State Park (HRSP) that community includes some celebrated megafauna: spotted owls, mountain lions, red tree voles, golden eagles, pileated woodpeckers, Pacific fishers, and the extremely rare Humboldt marten. Of course there are also thousands of lesser-known plants and animals that have evolved in conjunction with the redwood forest. The park contains the largest protected stand of old-growth redwoods in California—which means it is the most impressive stand of the most impressive trees on Earth.

An effort is under way to link the 55,000-acre Humboldt Redwoods State Park to the 60,000-acre King Range National Conservation Area (KRNCA), five miles to the southwest. Below King Range is the 7,367-acre Sinkyone Wilderness State Park, which includes the wild mountains of the Lost Coast. Together the KRNCA and Sinkyone constitute the longest roadless coastline in the lower 48 states. The new linkage, known as the Gilham Butte/Redwoods to the Sea corridor, would unite three distinct forest habitat types: redwood, mixed fir and hardwood, and upland coastal. It would also protect key portions of the headlands

of the Mattole River watershed and serve as a bridge to the Eel River watershed.

The creation of this new preserve, or network of preserves, is a step toward the deislanding of HRSP, and it could be a model of conservation planning for the era of climate change.

"Heterogeneity of a preserve's landscape is important," says Stanford botanist David Ackerly. As climate changes, if there are a variety of elevational and latitudinal refugia for plants and animals, their chances of survival are heightened. If it gets too hot on the valley floor, they can move upslope. If a north-facing slope grows too dry, they can move around to a south-facing one. The absence of such alternatives may doom small island populations, says Ackerly.

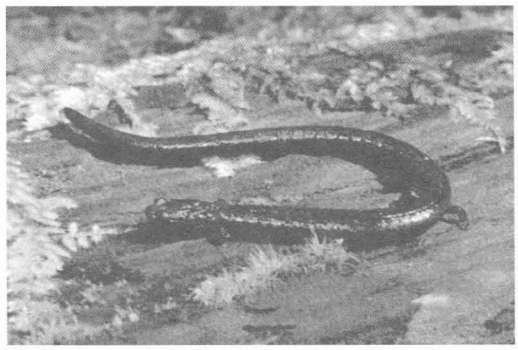
Furthermore, says Ackerly, if preserves are large, with varied native habitats, even when some species or communities are overcome by climate change they will more likely be replaced by other natives than by exotic invaders. If native redwood forest gives way in its southern range to California chaparral or oak woodland, that would be a lot easier to accept than its being overrun by star thistle or eucalyptus.

It is easy to become hopeless about the likely impact of global warming on California's coastal ecosystems. But if Save-the-Redwoods League can negotiate the purchase of private logging land, thereby creating a corridor connecting three major ecosystems, and if, even in the midst of budget woes, the State will buy a Pacific Flyway wetland already slated for development, then there is surely room for hope. Projects like Ballona and Redwoods to the Sea embody the best strategies for helping our wild lands cope with change: preserve as much intact habitat as possible, restore wherever possible, and make it a priority to link habitats that will help plants and animals adapt most naturally when the climate changes. It is also a great consolation that the scientists at Jasper Ridge have for decades been focusing their genius on observing the impacts of climate change as objectively as possible. In as charged a field as climate studies, where hyperbole is cheap and plentiful, scientific fact is a precious thing. ■

Gordy Slack, guest editor for this issue of Coast & Ocean, *is a freelance science writer and a columnist for* California Wild.

PAUL FURMAN

ALDEN M. JOHNSON, CA ACADEMY OF SCIENCES



WILLIAM FLAXINGTON

WILLIAM FLAXINGTON

Steve Sillett observed bushes of thinleaf huckleberry (*Vaccinum membranaceum*, top) over 20 feet tall growing on yard-thick soil accumulations on enormous branches in the redwood canopy. Chipmunks and bandtailed pigeons (*Columba fasciata*) feed on them.

Many other creatures inhabit the canopy, including the California slender salamander (*Batrachoseps attenuatus*, this one photographed at 200 feet) and the clouded salamander (*Aneides ferreus*, bottom).

Salmon and Climate Disruption

SETH ZUCKERMAN

PHOTOGRAPHS BY THOMAS B. DUNKLIN

AFTER A DOZEN WINTERS on California's north coast, I'm ready to experience a normal weather year, but every season seems to bring some anomaly: the rain arrives much too late one autumn, another spring is unusually wet, and a third winter is marred by an unsettling two-month dry spell in the middle of what should be the rainiest time of year, that period from October to May when you can't leave your living-room furniture outside.

My neighbors and I are attempting to support the recovery of the Mattole River's salmon populations, and salmon fare poorly in extremes of drought and deluge. These fish already have enough to deal with. A couple of decades of ill-advised logging and road building, punctuated by two record-setting floods, devastated their habitat. Runs of king and silver salmon plummeted, turning them from a mainstay of the local diet into rarely glimpsed royalty.

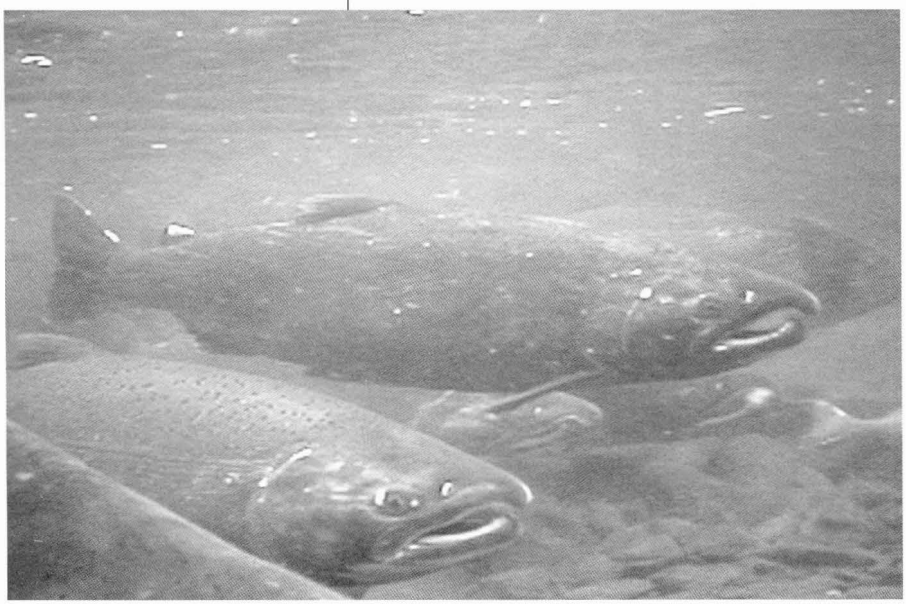
Under pressure from these and other challenges—such as water diverted for upstream farms and subdivisions—salmon runs all across northern and central California were swept by similar changes in the 1980s and '90s. The commercial catch was cut in half and the fishing fleet shrank by 75 percent, from nearly 8,000 vessels in 1980 to 1,800 in 1999. Still, we have hope. We've been learning how to care better for our watershed, to ally ourselves with the processes of healing that are already at work here, and to count our salmons' blessings. For all the injuries the Mattole has suffered, it still flows undammed through hills and valleys that are clad in native vegetation. Our river enjoys the attention of a cadre of caring human inhabitants, and in this it is far from alone: the annual state conference on salmon restoration attracts several hundred participants every year, and 153 groups are at work to protect salmon habitat in California, according to For the Sake of the Salmon, a Portland-based restoration organization.

But a new threat casts its shadow across our efforts. Even as we've pursued the gritty work of watershed restoration—planting trees, repairing roads, incubating fish eggs—we've come to wonder whether shifting weather patterns will undo our hard work. So we've begun to pay attention to the rain, clouds, and temperature even more obsessively than the average rural resident normally does.

It is difficult to pick out the harbingers of climate weirdness in our little corner of the world amid the natural variability of the weather from year to year. But our understanding can be bolstered by larger-scale studies and models that scientists use to study the climate. In the last century, temperatures across the entire planet increased by an average of one degree Fahrenheit, according to the 2001 report of the Intergovernmental Panel on Climate Change, an international scientists' forum. The report forecasts a further warming of 2.5 to 10.4 degrees by 2100, along with a rise in sea level of somewhere between four inches and three feet.

The same models that predict the planet's overall roasting also spell out specific regional changes that would influence salmon both at sea and in the streams where they spend their fryhood and later return to spawn and die. For instance, in a

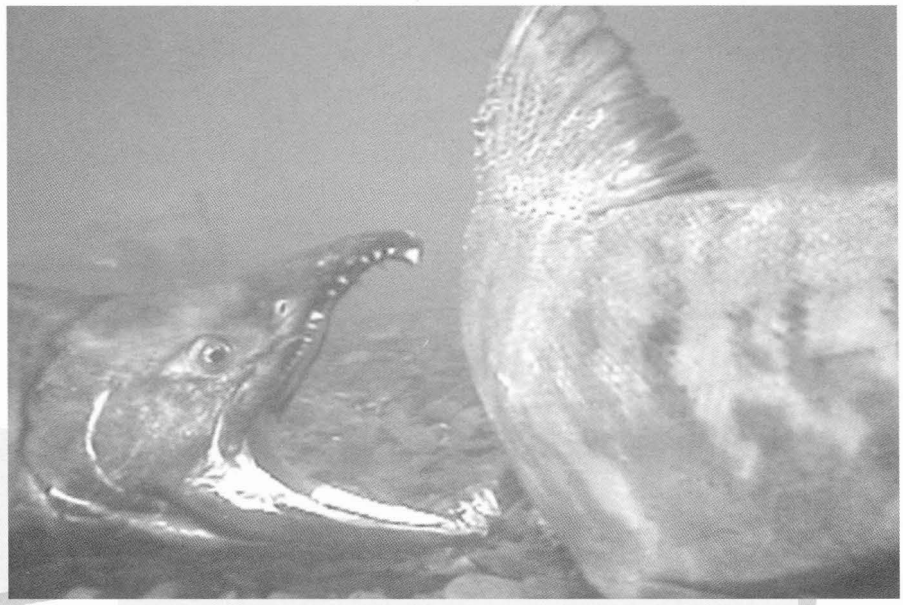
Coho salmon captured on underwater video.



warmed California, more precipitation would fall as rain instead of snow, and such snowpack as did accumulate would melt earlier in the spring, says a 1999 study from the Union of Concerned Scientists and the Ecological Society of America. As a result, snow-fed streams would be drier in the summertime. In California, the dry summer season is a critical period in the freshwater chapters of a salmon's life. That's when streams are lowest and water temperatures already approach or even exceed the maximum that the fish can tolerate. "The effects of climate change could be extremely devastating to salmonid populations, especially here [in California] at the southern end of their range," says Dan Freed, a biologist with the Arcata office of NOAA Fisheries (formerly the National Marine Fisheries Service), the federal agency charged with maintaining the health of salmon runs. "Water temperature and flow are the two big [factors]. There isn't a lot of room for change to occur before it would be catastrophic." And higher flows in winter could also be damaging, as they can scour salmon eggs out of the gravel beds where they are laid, and can flush young fish downstream before they are ready.

Of all these effects, "the change in snowpacks is the most troublesome, because salmon expect steady stream flow," says Zeke Grader, executive director of the Pacific Coast Federation of Fishermen's Associations. He predicts that silver (coho) salmon and steelhead trout will be most affected by warming, since they spend the longest time in fresh water. Already, he's seen the balance among salmon populations altered because of conditions in rivers and streams. Fall-run king (chinook) salmon used to be third in importance to fishermen, after their spring-run and winter-run cousins. (The seasons denote the time of year when the adults enter rivers to spawn.) But fall-run fish have come to predominate, he says, because they spend the least time in fresh water, where stream habitat has suffered serious damage from land-use practices. If a warming climate makes streams even less hospitable to fish, more changes along these lines would likely occur.

Recent die-offs of salmon bear out Grader's warnings. Several thousand spring chinook died in Butte Creek this summer in the wake of a heat wave that made them more vulnerable to disease. The deaths echoed a larger fish kill in the Klamath River in 2002 that claimed an estimated 33,000 chinook, blamed on a combination of high water temperatures and low river flows.



One coho threatens another.

Shifts in snowfall and snowmelt would likely affect Sierra and Klamath streams more than a coastal watershed like the Mattole. But the Mattole would face other consequences. Warming would make trees thirstier and thus less likely to survive the summer; it would also increase the risk of wildfires that could sear cooling shade from hillsides, and increase erosion.

In addition, water temperature—a limiting factor for the survival of young silver salmon and steelhead through the summer—fluctuates with the temperature of the air, says consulting fisheries biologist Pat Higgins; for streams that lack the shade of mature forests, hotter days will mean hotter creeks. Freed concurs. "If we had good buffers, changes in air temperature might not have that big an effect on salmonids," he says. "But as we know, most of our streams lack adequate buffers."

The picture is a little murkier in the ocean. The most destructive marine phenomenon

The mouth and estuary of the Mattole River

SHAPING A FRONT LINE OF DEFENSE

ELSEWHERE ALONG THE COAST, climate change concerns have increased the urgency of restoration projects that might help fragile salmonid populations to survive extreme events. Among the most endangered are the southern steelhead. In 2002, only 200 adults returned to coastal streams between northern Santa Barbara County and the Mexican border, according to NOAA Fisheries.

The Southern California Steelhead Recovery Coalition, a group of 33 organizations and agencies, is working to remove dams and other instream barriers to fish passage, "trying to get as many adult fish back into the spawning reaches of different watersheds as possible," said Jim Edmondson, South Coast manager for California Trout, a Coalition member. "This guards against the population-wipeout effect of a catastrophic event like wildfire or drought, which, although increasingly associated with climate change, are already common factors in southern California."

Although climate change may not be explicitly addressed in fish restoration work, habitat improvements may ease its effects. "We're already planting drought-resistant species because our creeks are so incised," said Brian Stark, at the Land Conservancy of San Luis Obispo County. "We already have less water than we used to, mostly because of diversions and overdrafting. And I've learned over the years that normal rainfall is a statistic, not a reality. We've incorporated that into our restoration planning without necessarily linking it to climate change."

By and large, this is an issue still on the back burner. "We have so many other immediate obvious challenges to deal with," said Connie O'Henley, executive director of Central Coast Salmon Enhancement. The Coastal Conservancy's Kate Goodnight, who is coordinating the inter-agency Integrated Watershed Restoration Program for seven watersheds, in Santa Cruz County, said that "although the subject does come up, global warming/sea level rise hasn't been factored in to a significant degree to the work we are doing. Partly, I think, this is because, compared to other areas, we don't have many estuaries, which are the first to feel the effects. We're concentrating primarily on erosion control, particularly from roads, and removing fish passage barriers."

Global warming is not considered, per se, in the draft of the Department of Fish and Game's Coho Salmon Recovery Strategy, released November 5, according to project manager Gail Newton. The proposed strategy does provide for monitoring ocean conditions and fish populations.

for California's salmon in recent years has been El Niño, a warming of the eastern Pacific that disrupts ocean circulation along the California coast. The rich life off the state's shores depends on an upwelling of water from ocean depths, which brings nutrients to the surface that invigorate the marine food chain. Apart from the floods it causes on land, El Niño warms the surface of the ocean, disrupting the upwelling. Without a bountiful flow of nutrients, the marine ecosystem is impoverished, just like a garden that doesn't get fertilized. That scarcity percolates all the way up the food chain, diminishing plankton populations, then crustaceans and herring in turn, which means less for salmon to eat. The 1997–98 El Niño event coincided with unusually low survival rates for salmon at sea, particularly for fish that first reached the ocean then. When food is scarce, it takes longer for young salmon to grow past the size where they themselves are prey for other fishes.

An overheating world could trigger more frequent El Niños, though links between climate change and El Niño are still ambiguous, according to University of Washington climatologist Nate Mantua. "We get surprised by El Niño all the time," he says. "Climate models provide just about every answer you could imagine, from being stuck in El Niño conditions to El Niño going away." In essence, adding greenhouse gases to the atmosphere amounts to a high-stakes roll of the dice when it comes to El Niño. On land, by comparison, Mantua says, continued global warming is sure to push the terrestrial climate beyond the range of variation seen during modern times.

That chancy outlook colors the perspective of people working to rebuild California's salmon populations. One of the first activists to highlight the connection between salmon and climate was David Simpson, a founder of the Mattole Salmon Group. "We've had some successes," he says, "but all of those could easily be undone by an aberrant climate. At a time when salmon most need stability, they are least likely to get it." The legacy of local habitat degradation makes the global climate trends all the more severe. "These changes aren't happening in virgin ecosystems," Simpson says. "They're happening on top of tremendous changes to the landscape."

It's a tough realization to live with: the trees you're planting in the bone-chilling rain might never make it to adulthood because the climate is turning hotter. Seedlings face an uncertain prospect in any case, thanks to the browsing of deer, the possibility of dry winters, and the vigor of competing plants. But uncertainty is harder to swallow when the threat is a product of human activity.

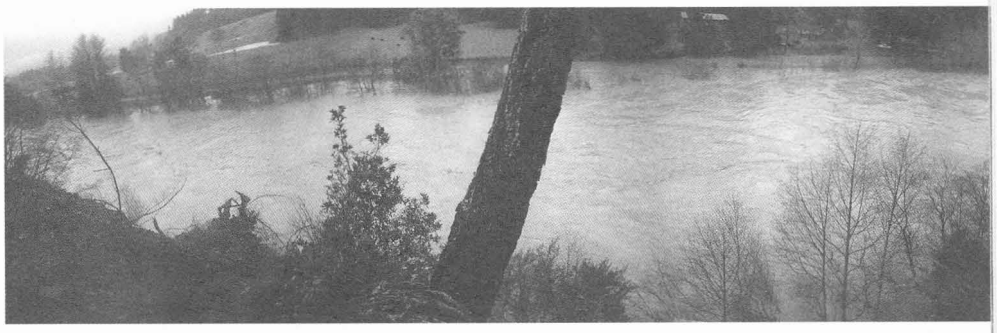
Although the climate is already showing signs of change, society is accommodating the new climate regime at a glacial pace. In the regulatory process, says Freed, "Climate change isn't taken into account—which is unfortunate, because it obviously should be. Perhaps the threshold for [determining that a species is in] jeopardy should decrease because of these changes."

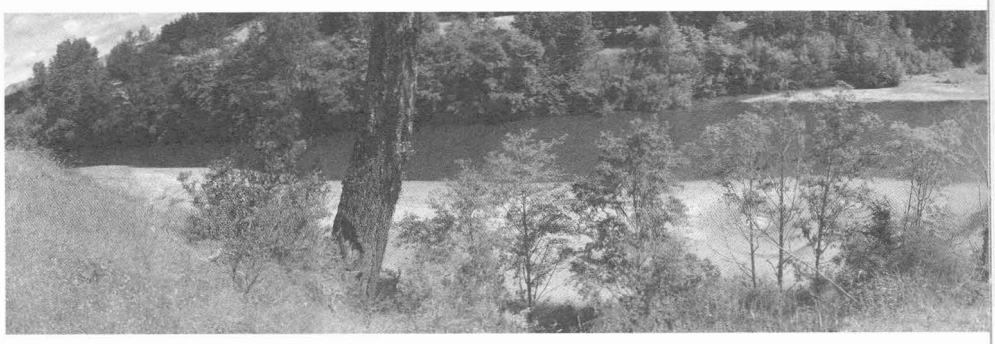
If we can learn anything from the example of salmon, it's that we can't count on the world to remain static. Inevitably, we will have to adapt. Today's salmon descended from 500-pound saber-toothed specimens of the Miocene Epoch, and attained their cur-

rent form about two million years ago. More recently, they have experienced sweeping changes, recolonizing whole river systems from Puget Sound northward, after the retreat of the glaciers that entombed the region during the last Ice Age. Even in my brief lifetime, they were shut out of their riverine homes on the flanks of Washington's Mt. St. Helens after the volcano's 1980 eruption, and went on to spawn in neighboring rivers instead.

So success goes not to those who deny or ignore change, but rather to those like the salmon who can accommodate it resiliently. For those of us working to protect salmon habitat, the implications are many. "On a project level, it means having to build to a higher design standard," beefing up construction so that habitat improvement projects can withstand more frequent and more intense flooding, says Chris Larson, executive director of the Mattole Restoration Council. On a regional scale, he suggests, it means planning for the disruption that climate change would bring. As sea level rises, for instance, estuaries will naturally tend to migrate upriver and outward along the floodplain. But if levees or seawalls are built to protect fields and pastures, the fertile habitat along the estuary's edge would be lost. Land trusts can play a role, Larson suggests, in purchasing land around river mouths to give estuaries the breathing room they'll need. Fortunately for the Mattole, much of the estuary and its surrounding land is already in public hands. Two other major estuaries on the north coast, Big River and Garcia River, have also been protected recently by means of conservation easements and land purchase.

Other ways of adjusting to hotter, drier summers could aggravate the effects on fish. For instance, if snowpack decreases and runoff comes earlier in the year, water users might move to build new reservoirs to store that runoff, says Peter Frumhoff of the Union of Concerned Scientists, which commissioned a 1999 report by seven university professors, "Confronting Climate Change in California: Ecological Impacts on the Golden State." Apart from climate change itself, those reservoirs would harm salmon by inundating stream habitat and impeding salmon migration. Similarly, if hotter weather increases the demand for irrigation, the extra water consumed would leave less in streams for the fish. The Trinity and Eel Rivers and the Sacramento Delta already suffer from a scarcity of fresh water—and extra demand would further imperil their diminished salmon populations.





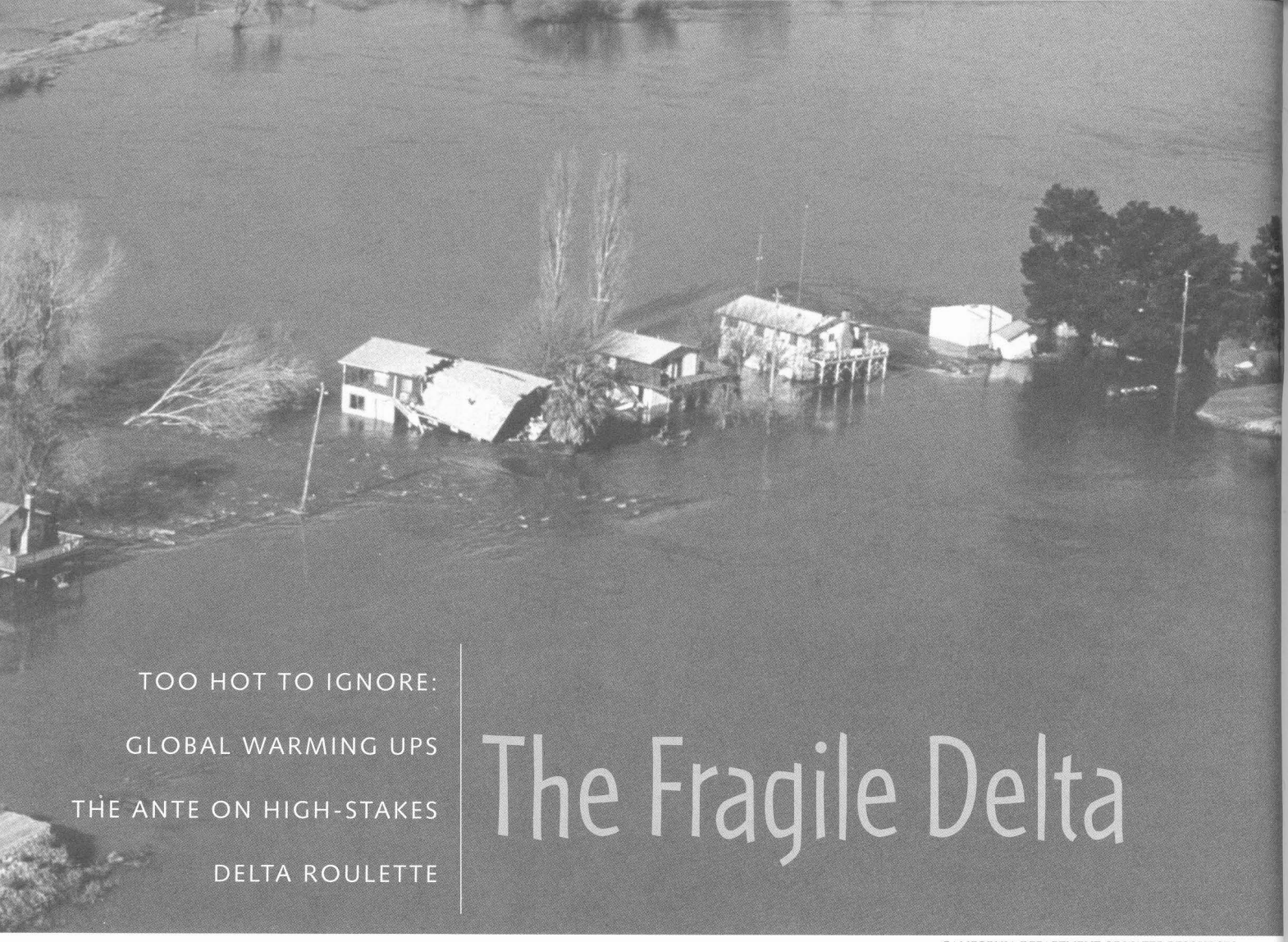
Top: A comparison of high and low flows in the Mattole watershed

Bottom: Coho in Morrison Gulch

Ordinarily, salmon might adapt to changes like these—but only if their numbers were large and the changes gradual. "There's natural straying between rivers," says NOAA Fisheries' Freed. As temperatures increase and suitable habitat moves north, "you would expect to see some colonization from nearby rivers. But at such low abundance levels, it may not be an effective strategy for them." For salmon to expand into new streams, he explains, they must be abundant enough that the few who stray represent a viable population in and of themselves. What's more, it takes generations for the strays arriving in a river to build up their numbers to the point where the straying process can keep marching northward—and for that, conditions must change fairly slowly. Nothing in the projections about impending climate disruption gives confidence that the changes will be gradual.

Freed's description of salmon behavior suggests how to protect the fish from the dangers of climate disruption: to keep salmon populations as robust as possible, and do what we can to reduce the factors that are destabilizing the climate, so that the changes are slower and less severe. In a world where "normal" winters vanish from our experience, that may be the best way to maintain at least one element of normalcy: the annual return of salmon to our streams. ■

Seth Zuckerman has participated in watershed restoration efforts in the Mattole Valley for 15 years. He is at work on a book about the false divide between people and the rest of nature.



TOO HOT TO IGNORE:

GLOBAL WARMING UPS THE ANTE ON HIGH-STAKES DELTA ROULETTE

The Fragile Delta

CALIFORNIA DEPARTMENT OF WATER RESOURCES

SUSAN DAVIS

THE SACRAMENTO–SAN JOAQUIN Delta is less than 40 miles from San Francisco, but once you soar over the Antioch Bridge you're in another space and time. You enter a thousand-square-mile expanse in which California's two biggest river systems converge and spread out before being funneled through the Carquinez Strait and out into San Francisco Bay. Two hundred years ago, the Delta was one of the world's largest wetlands. By the early 1900s, however, it had been cut and pumped and built into an intricate patchwork of agricultural islands surrounded by levees. Today, the Delta looks ruggedly rural, composed mostly of large farms and cattle ranches and ornamented with party boats and abandoned cars.

But despite the impression that this region has been left back in time, the Delta is intimately connected to both the state's urban infrastructure and the state's ecological health. More than 20 million Californians get at least part of their water via the Delta, from the State Water Project and federal Central Valley Project, and more than 130 species of fish and dozens of species of birds depend on the wetland habitat that has survived here.

The tiny town of Isleton (population 830), sits on Brannan-Andrus, one of the Delta's 76 islands. Isleton is nestled next to the Sacramento River, at the heart of the Delta, about 15 miles northeast of Antioch. Its residents used to work in local canning factories, or in the dredging and levee-building industries. Today about half of Isleton's residents are retirees, and many others make their living in small local shops, on neighboring islands, or, in some cases, in nearby towns. This sleepy town comes alive every June when it hosts 200,000 tourists at its Crawdad Festival. Brannan-Andrus Island, like nearly all Delta islands, is built on peat, a soil type that oxidizes and compresses when exposed to air. The island has been

Above: Very high flows in the San Joaquin River in January 1997 caused numerous levee breaks. (Note ends of levee in lower left corner and in front of trees at right.) Houses and other structures near the levees were heavily damaged by fast-moving floodwaters.

Opposite: Street scenes in Isleton

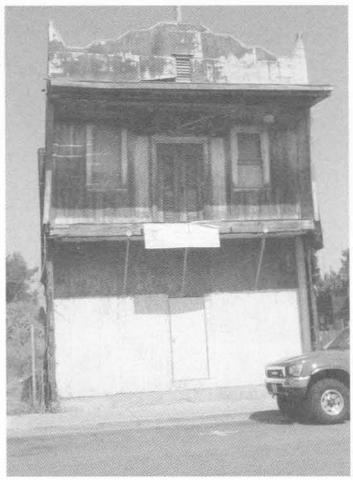
subsiding, and now some of Isleton is more than a dozen feet below the level of the water surrounding it.

Such lack of elevational symmetry is precarious, both to the Delta and to southern California's water supply. In June 1972 one of Brannan-Andrus's levees failed and Delta waters rushed in, inundating not only farmlands but most of the town as well. It was a catastrophe for residents, but the effects ranged much farther than the Delta. The sudden displacement of Delta freshwater onto the island sucked salt water in from San Francisco Bay and up into Jersey Point and Frank's Tract—up so far in fact, that the State Water Project intakes at Clifton Court Forebay had to be closed and the Central Valley Project pumps in Tracy had to be cut back to avoid contaminating the freshwater supply for two-thirds of all Californians, millions of acres of irrigated farmland, and the Delta's own endangered ecosystems. Even with increased freshwater outflow from three reservoirs, it took three months for the water to become drinkable again.

Never before or since have California's state and federal water projects been shut down. Yet a repeat of that scenario becomes increasingly likely as global warming and the associated sea level rise and hydrologic changes occur. The levees that protect the island from the Sacramento River could be washed out in a single storm or high tide, according to the "Levee System Integrity Program Plan," published in 2000 by CalFed, a partnership of federal, state, and local agencies responsible for managing the region's water supplies and improving the quality of San Francisco Bay–Delta habitat. And because the sea level would not be likely to drop for a long time after its predicted rise, says the CalFed report, Brannan-Andrus, along with a lot of other Delta islands, could be inundated repeatedly, even permanently, unless something more is done to protect them.

Fourteen years ago, when *California Coast & Ocean* first reported on the potential effects of climate change on the Sacramento–San Joaquin Delta, we discovered two disturbing facts: first, there was a very real potential for catastrophic events in the Delta; and second, few people in positions of power (at least relative to the state's water resources) were acknowledging that. Today the news is slightly better. Land managers and policy makers seem to have accepted what scientists are saying: that a rise in local sea level and changes in precipitation patterns could jeopardize the integrity of the entire Delta system within the next hundred years. Some levees have been strengthened, and more agencies are analyzing the problem and at least planning to make plans. But 15 years into the era of global warming, no comprehensive plans for protecting the Delta have been drafted, never mind implemented. And without concrete plans, island residents may soon be resorting to sandbags.

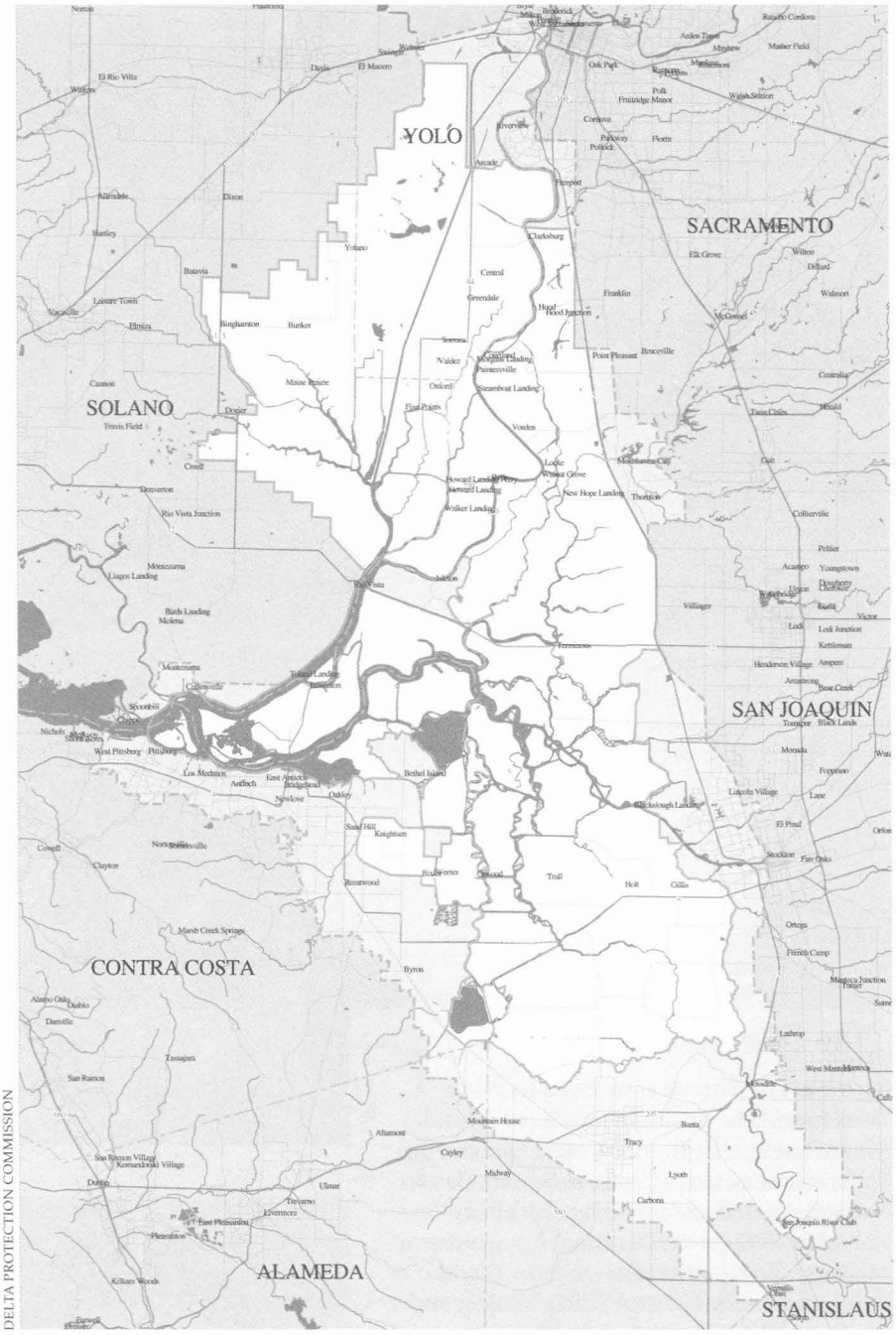
PHOTOS THIS PAGE: DAN ROBBIN



The Predictions

THE PREDICTED one- to three-foot sea level rise in the next hundred years could knock out levees, flood islands, and create a saltwater sea stretching from Suisun Bay to Sacramento, according to a report published in 1997 by the National Environmental Trust. That salty water, in turn, could contaminate the Central Valley Project and the State Water Project, as well as wipe out the Stockton and Sacramento Deep Water channels, hundreds of miles of interstate, state, and local roads, 14 miles of the East Bay Municipal Utility District's Mokelumne Aqueduct, and 35 natural gas fields. Even if the entire Delta isn't inundated, changes in precipitation (i.e., less snowpack and more rainfall) could intensify floods, levee failures, and potential saltwater intrusion, according to a 2000 study by Noah Knowles, a scientist at the Scripps Institution of Oceanography.

Levee failure has always been a problem in the Delta. In the 1840s, islands were first carved for agriculture out of the Delta's



DELTA PROTECTION COMMISSION

The Sacramento–San Joaquin River Delta includes 76 islands and vast levee systems. The white area is designated the Primary Delta Zone.

tangle of sloughs and marshes. Early levees were constructed by hand in a process that was as difficult as it was defective. High tides and storms often knocked out levees, sometimes only a year or two after they were built. In the 1870s, the invention of the clamshell dredge speeded up the building process, and made levees easier to maintain and more reliable. By the 1930s some 550,000 acres of the Delta's fertile peat were under cultivation. Since then, all of the Delta's islands have flooded at least once. As the islands subside farther below sea level and the levees age, the risks of collapse and flooding increase. So much is at stake in the Delta that even before the specter of global warming, massive levee failure caused by earthquake or heavy rains was a major concern. As of 1998, only 42 percent of the Delta's 1,100 miles of levees were in compliance with FEMA standards, according to CalFed's Levee System Integrity Program Plan. The numbers have improved but still hover above a disconcerting 50 percent. Over the next five years, CalFed plans to spend approximately $90 million for improving the levees throughout the Delta. Budget woes may reduce that number significantly, however, says David Mraz, program manager for the Delta Levee Program at the Department of Water Resources(DWR). CalFed was prompted to develop this Program Plan by a combination of three factors: heavy flooding in the 1970s and 1980s; mounting pressure to balance the competing needs of farmers, urban water users, and the environment; and growing concern about global warming.

"We've been talking about levee vulnerability for decades," notes hydrologist Phil Williams. "The climate change factor doesn't create a new risk to the levees; it just makes the existing risk worse."

Peter Gleick, president of the Pacific Institute for Studies in Development, Environment, and Security, believes that global warming is already affecting the Delta. He has found that changes in the pattern of precipitation and run-off are resulting in declining springtime flows in the Sacramento and San Joaquin rivers, even while annual averages remain the same. "That just points to what we've all been talking about for the last ten years," he says. "Winter flows are getting heavier," which means levees could begin breaking sooner than we expect.

The Plans

SLOWLY BUT SURELY, state and federal agencies have begun to acknowledge the reality of global warming. Several conferences have been held on the topic, and the state's next master water plan—the so-called "Bulletin 160"—will contain several pages on climate change. These plans are published every five years by the Department of Water Resources (DWR). This one, which is due out late this year, will be the first to address the potential impact of climate change. The draft language available in July was free of earlier waffling: "Evidence that global climate will have significant effects on water resources in California continues to accumulate." This new draft

master plan clearly identifies the Delta as the area of biggest impact. A one-foot rise in sea level could transform the current 100-year high tide peak in the western Delta into a 10-year event, putting yet more pressure on the ever-fragile levees. In addition, the report noted, "increased salinity intrusion from the ocean . . . could degrade fresh water supplies pumped at the southern edge of the Delta or would require more fresh water releases from upstream reservoirs to repel ocean salinity." Such seesawing in the amount of salinity in the Delta could have strong impacts on the wildlife that live there, including fish and some species of birds—an issue that has come up again and again as Californians north and south struggle to decide who most deserves the water that flows through the Delta.

DWR also participates in monthly meetings of the Joint Agency Climate Team, which was formed to develop an overall climate change policy strategy for the state and which draws in a wide range of state agencies with interests in global warming, including the Energy Commission, Department of Fish and Game, CalEPA, Business, Transportation and Housing, and the Office of Planning and Research. "It's hard to imagine any activity in the state that won't be affected by climate change," says Doug Osugi, chief of the special planning project section of DWR. "That includes ecosystem health, transportation, public health, the state's economy, and our energy needs. We're continually trying to figure out what those impacts might be, both in the Delta specifically and in the state at large."

Although there is near consensus today that sea level rise and changing patterns of precipitation will intensify the Delta's problems, there is no agreement on what, aside from improving levees, can be done to address the dangers.

Gleick is among those who believe that keeping state reservoirs lower in the winter, to catch the earlier runoff, could help to alleviate the risk of both water shortages (due to diminished snowpacks) and flooding (due to earlier runoff and heavier rainfall). But such a plan would entail a massive reworking of dam operations, which "hasn't even begun to be evaluated yet," he says.

Heightening and fortifying the levees is one obvious approach. Over the last 10 years, DWR has put more than $100 million into levee fortification, says Curt Schmutte, chief of levees and the Northern Delta at DWR, along with about $10 million in emergency funds, via the U.S. Army Corps of Engineers. "It was those improvements that allowed the levees to withstand the dramatic floods and high-tide events of 1997 and 1998," Schmutte says. "So the Delta levee system does seem to be performing better. But that performance is hard to measure because the stresses on levees are so complex. No two events are exactly the same."

CALIFORNIA DEPARTMENT OF WATER RESOURCES

San Joaquin River floodwaters rushed through a broken levee, January 1997.

In the past, building higher levees presented sizeable technical problems; the underlying peat is so unstable that levees either sank again (sometimes within a day) or remained prone to breakage. Nowadays, however, new ways of creating toe berms—wide flat banks along the levees—mean that many levees can grow and be fortified. "A good toe berm adds strength to the foundation of the levee," Schmutte says, "and protects it against the constant erosion. By acting like a cap, it also keeps the peat material from oozing out the sides, which keeps the levee itself from sinking." Such an undertaking isn't cheap, Schmutte observes, but "if society feels we should pay the price for keeping more of the levees strong, we can do it. The technology is there."

Whether the money will be there remains to be seen. One of DWR's levee projects was on Twitchell Island, which, like Brannan-Andrus Island, is a valuable bulwark to the state's water supply. Along the south side of the island, sections of the levee were falling into the San Joaquin River, so DWR spent $3 million to move the entire levee back about 100 feet and create a new riparian zone there. Such expensive improvement projects may

PHOTOS THIS PAGE: DAN ROBBIN

Delta farmlands (top) are at risk of inundation if levees break. Many delta roads are built on levees (above) and must be repaired after floods.

be viable for some islands (such as those vital to agriculture or key to protecting water supplies) but perhaps not for all.

"The hard question is: What do we want to save in the Delta?" says Gleick. "Clearly some levees have to be strengthened, and others need to be abandoned because it's so expensive to maintain all of them." So far, because no one agrees on just which islands are worth saving, no one knows how much it would cost to save them, but CalFed expects to spend another $90 million in the next five years on those levees that haven't yet been improved, as a means of protecting water supplies, agriculture, and wildlife.

The current plan, however, is only to build those levees up to meet current 100-year flood specifications—which could change dramatically if current predictions about warming and sea level rise come true, says Ron Ott, Delta Coordinator for CalFed. The plans also don't provide for improving seismic stability. But preparing for every scenario is practically impossible without firm projections on the effects of global warming. That is, just how high and how strong levees should be and how many islands can or should remain in place depends on the water regime likely to come to this area. At present, though, no one can say with any confidence what that regime will be. While scientists are comfortable predicting global averages, they have much less confidence predicting changes in particular locales like the Delta. No one knows, for instance, just how warming and sea level rise will impact freshwater flow into the Delta. Some climate models predict conditions drier than today's, while others suggest wetter ones more prone to floods. "That can make it hard to decide how we should plan for infrastructure changes," says Levi Brekke, a water resources modeler with the U.S. Bureau of Reclamation, which runs the Central Valley Project.

"We're very concerned about the problem," says CalFed's Ott, "but the current challenge is just to figure out what the magnitude of the problem may be. Once we have a handle on that, we can start to make real plans."

As Bay Area housing needs press upon the Delta, deciding which islands to sacrifice will get harder and harder. There's not a lot of room for growth on the islands themselves, as zoning generally prohibits the development of ag land. But Brentwood, which lies on the southernmost edge of the Delta, bills itself as the fastest-growing city in California; nearby Oakley's population has doubled since 1999. Current floodplains—the areas kept free of development because they are considered too likely to flood—don't reflect the potential for sea level rise. FEMA and other regulatory agencies may someday revise floodplain districts, but right now gung-ho developers aren't constrained from building in marginal areas.

Another approach, embraced by environmentalists but viewed warily by some local landowners, is to allow low-lying farmlands on the west end of the Delta, which are more vulnerable to both earthquakes and sea level rise, to revert to tidal marsh-

lands, providing valuable habitat and serving as a buffer for encroaching salt water. Sherman Island, most of which is already owned by DWR, is one candidate. Although it lies significantly below sea level, DWR engineers are considering ways to raise Sherman by unloading rice, hay, and other organic materials into it, flooding it slightly even at its low elevation, and allowing native plants to rebuild the peat back up to sea level gradually—a requirement for ultimate restoration to salt marsh. Such a process would take years or decades, says Schmutte, but it could be done.

Schmutte envisions a 30,000- to 50,000-acre ecological corridor of such tidal marsh restoration that could absorb some of the impacts of sea level rise. "This would allow us to save some of the more critical islands —like Brannan-Andrus—that have ecological value and aren't as vulnerable to seismic risk," he says. Restoring the islands to marsh would also grant a "glimpse of what the Delta used to look like hundreds of years ago," Schmutte says, "before these islands existed at all." Such a plan could cost hundreds of millions of dollars for even one island, never mind enough to make a corridor, and would entail convincing farmers—many of whom have been there for generations—to sell their land. "It will be expensive, but the cost of doing nothing would be so much more; we just have to address these problems," says Schmutte.

The recent purchase for marsh restoration of 1,200 acres of farmland on an island at the base of Marsh Creek in Oakley shows how this process can work. Purchased with funds from the state and federal government, Dutch Slough, as the property is called, will be flooded and restored over the next decade. But the years of finagling and negotiating required to make the deal happen also show how difficult it will be to translate Schmutte's vision into reality.

Two things we know for sure: first, stronger levees are called for on the islands we want to protect—with or without global climate change. Second, restoring wetlands in the Delta would be an ecologically welcome and, in the long term, prudent form of progress.

In addition to the technical challenges in the Delta, the state also faces an educational challenge. Most Californians don't take to heart just how central the Delta is to their own well-being. To shift into a higher gear on these projects will require great political resolve and a lot of money, two resources in which public perception plays a key role. In today's deficit economy, the temptation (and the opportunity) for denial and delay in high places is already great. But it is enabled and bolstered by a complacent public, especially local residents who have their own natural propensity for denial.

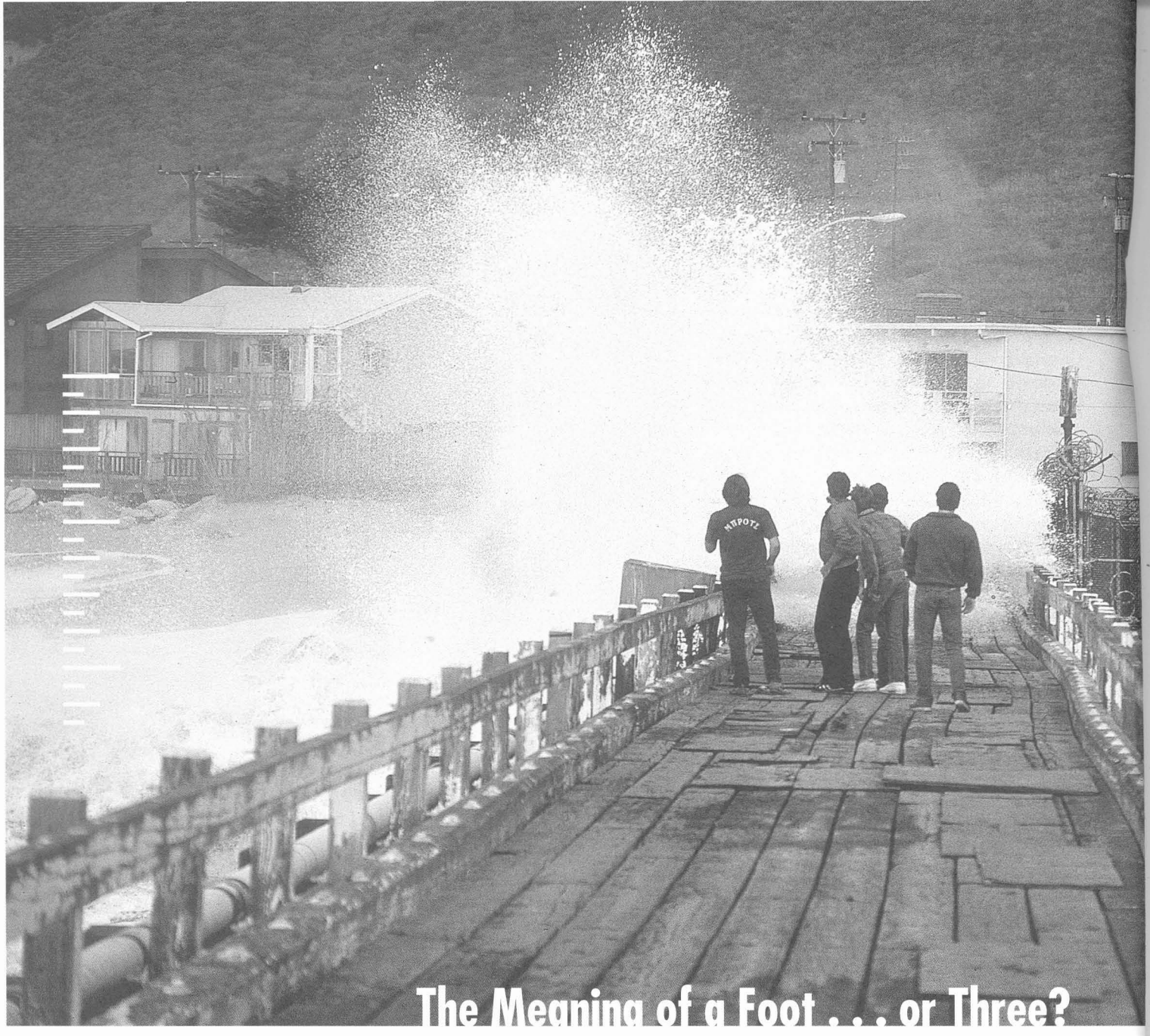
"Is there sea level rise?" queried one realtor I talked to in Isleton. "I live right on the water and I don't see the water rising. So no, I'm not really worried." Walter Landi, who runs Mango, a gift store on Isleton that sells carved wooden furniture from Bali, had the same attitude. When asked if he's concerned about sea level rise, or even seasonal flooding, he shrugged and said, "I don't think about it. A flood once came within ten feet of my house in Rio Vista, and I still don't think about it. That's just the way it is on the Delta."

Long-term environmental problems that progress in small increments are always harder to understand and take to heart than imminent threats that manifest with a bang. Of course, it is only levee weakening and sea level rise that are incremental. Massive levee failure, should it come, will be bang enough to convince everyone of the need for action . . . only too late. ■

Susan Davis, a freelance writer based in Alameda, reported on the Delta in Coast & Ocean's *first special issue on climate change, in 1989.*

CALIFORNIA DEPARTMENT OF WATER RESOURCES

In March 1995, floodwaters and very strong winds damaged Twitchell Island and washed out a 100-foot span of the Interstate 5 bridge at Arroyo Pasajero.



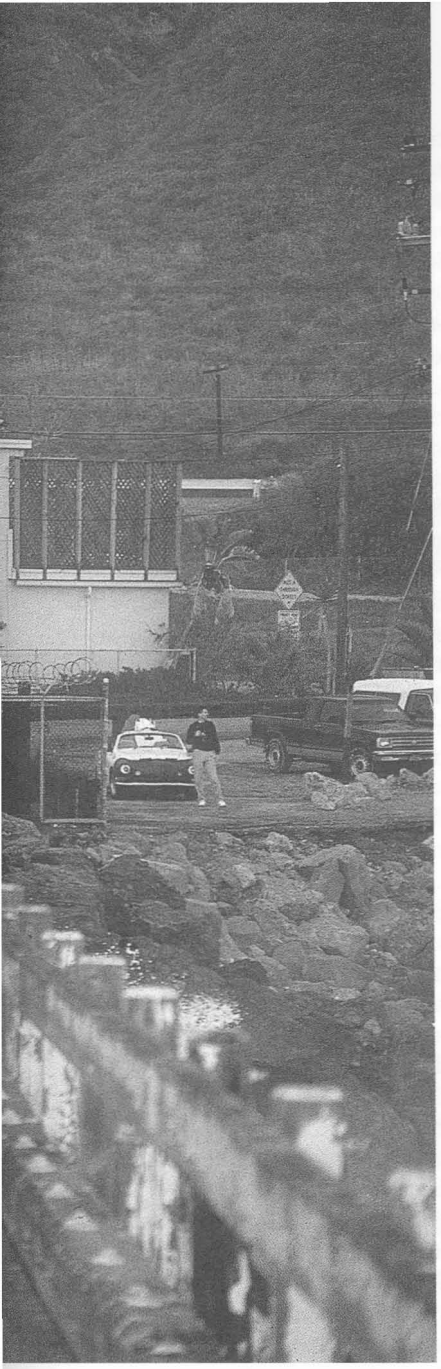
The Meaning of a Foot . . . or Three?

ANNE CANRIGHT

I WAS STANDING ON THE BEACH the other day, just beyond the reach of the waves, looking out over the blue, blue water of Monterey Bay. A friend and I had been talking about sea level rise, and I was interested in learning what it might mean—in practical, real-world terms. I decided to begin with a trip to the shore. There, I planted myself in the sand and imagined the water creeping up my legs: one foot, two feet, three feet—on me, almost navel high. Scientists predict that a one- to three-foot rise in sea level is quite likely by the year 2100—not very long from now, in the grand scheme of things.

It was a calm day, and the water was barely moving. But I threw some huge, lashing waves and heavy surge into my imaginary scenario—because scientists also predict that along with sea level rise, we will be experiencing more extreme weather events, with heavier seas battering the shore.

That was enough to get started. And once I set to imagining, I was shocked at how vulnerable this coast seems, even to one extra foot of water, much less three. All along the shore are buildings and roads. Already riprap is piled on Monterey Beach, protecting a condominium development



PHOTOS THIS SPREAD: DON BALCH

that marches from high land directly onto the sand—and every year the beach suffers a bit more in skirmishes with the superior forces of nature. At my back was a sturdy concrete wall that protects a beachfront hotel. Sturdy now, but it already feels the splash of high tides; more water would leave it not long for this world. The beach would vanish under the waves, and the dunes would likely be undercut and washed out to sea. Farther along, the shore is built up: there are wharves full of tourist shops and fish-processing plants; more hotels, restaurants, shops; the Monterey Bay Aquarium. All now out of reach of the sea, but how soon before they fall victim to higher water and fiercer waves?

Rising Tides

RISING SEAS; extreme weather; bigger waves—these things are not simply predicted, they are already happening. Why? The answer may well be global warming, a shift in the balance of greenhouse gases that has been positively connected with numerous observable changes in global climate. According to a report succinctly titled "Climate Change 2001," issued by the Intergovernmental Panel on Climate Change (a joint project of the United Nations Environment Programme and the World Meteorological Organization), the 20th century, for example, saw an increase in global mean sea level of about half a foot, caused by the

Above left: Huge waves lashed La Conchita pier near Santa Barbara, 1986.

Top right: 1983 El Niño surf destroyed homes north of Ventura.

Above: Heavy seas in 1983 filled a Santa Barbara parking lot with boats.

DON BALCH

In 1996, storms led to cliff collapse, crushing houses at La Conchita, between Santa Barbara and Ventura.

thermal expansion of seawater and by the melting of land-based ice caps; a decrease in snow cover and sea-ice extent and thickness, and widespread retreat of mountain glaciers; an increase in the frequency of extreme precipitation events in some regions of the world; and an increase in average precipitation over the middle and high latitudes of the Northern Hemisphere. All are explained as the consequences of global warming.

These processes are rather broad, and to be sure, they don't occur uniformly over the surface of the earth. However, they are manifesting themselves everywhere. In much of California, for example, during the last century sea level rose measurably, according to a 1997 report by the U.S. Environmental Protection Agency, "Climate Change and California"—by three inches at Los Angeles, five inches at San Francisco, and eight inches at San Diego—and it is anticipated to rise another 13 to 19 inches by 2100. (Sea level does not rise by the same amount all over the globe, or even at places relatively nearby on the same coastline, because of the effects of the earth's rotation, local coastline variations, differential change in major ocean currents, regional land subsidence and emergence, and differences in tidal patterns and seawater density. At Crescent City, for example, sea level dropped somewhat during the past century, likely because of uplift of the coastal landmass.)

Sea level rise due to global warming, however, is only part (a small part, say some) of what coastal residents and planners need to be concerned about. Already in California sea level can rise as much as six to eight inches a *year* in association with El Niños, says Reinhard Flick, an oceanographer at Scripps Institution of Oceanography. Most of us don't even realize the water is higher—though we do realize that things get a lot wetter, because of more energetic storm systems, higher tides, higher waves. When water becomes deeper, wave heights increase, and wave energy—the pounding of water on shorelines—increases exponentially. In 2001, the California Coastal Commission issued a report titled "Overview of Sea Level Rise and Some Implications for Coastal California," which stated that "along the California coast, the best analogy for sea level rise is thought to be an El Niño, where a significant rise in sea level will be like El Niño on steroids."

Non-pumped-up El Niños are short-term: they sweep through, often causing extensive damage, and then we scurry to mop up the mess and shore things up. According to the Commission report, a long-term rise in sea level will have more enduring impacts on the coast, in various ways—mostly deleterious. Port and harbor infrastructure will experience more ongoing damage from strong waves, while cargo-handing facilities may become more dependent on lower tides as ships ride higher in the water relative to terminals. Breakwaters and jetties will become less efficient, and will likely require reinforcement or enlargement. Wetlands will be inundated more completely, and in many cases development along their edges will prohibit an inland retreat of saltwater- or flood-intolerant plants and animals; meanwhile, scouring caused by stronger tidal currents will undermine many muddy- and sandy-bottom habitats. As coastal wetlands and saltwater estuaries are inundated, the life cycles of many fish and shellfish—including ones we eat—will be disrupted. Beaches and bluffs, too, will suffer as they are exposed to greater and more frequent wave attack, with erosion, shoreline retreat, and cliff undercutting increasing as a consequence. Coastal agriculture will have to adapt as saltwater intrusion increases.

The main immediately positive effect of sea level rise will be that some harborside shipping channels may be cut deeper because of increased scouring, lessening the need for dredging.

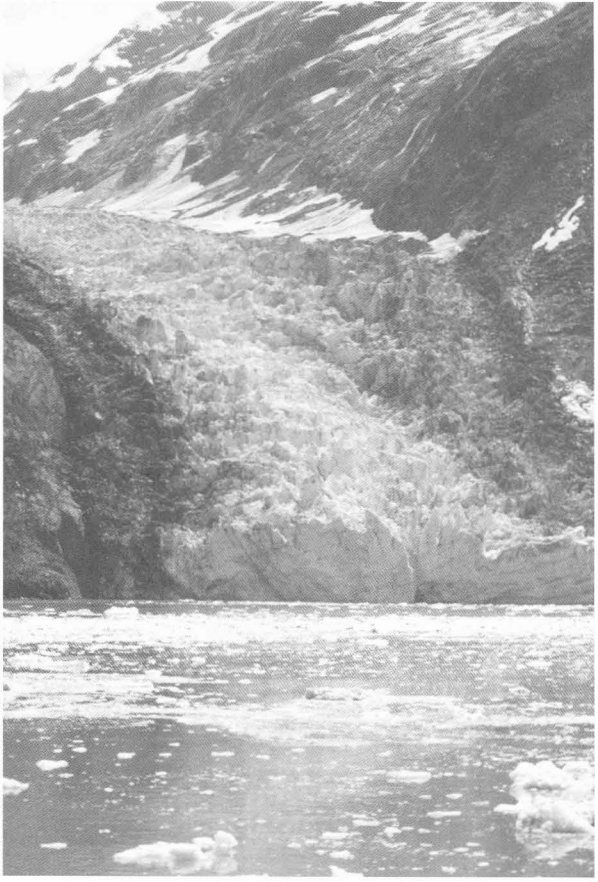
Global warming seems to be causing more immediate changes in coastal waters,

however. In 2001, researchers Nicholas Graham of Scripps and Henry Diaz of the National Oceanic and Atmospheric Administration Climate Diagnostics Center presented evidence that waves in the North Pacific—and particularly in southern California—have increased substantially in both size and intensity over the past half century as a result of stronger wind and storm activity. In Encinitas in the 1950s, for example, waves might reach 9.5 feet, but by the 1990s they were in the 13-foot range. Fifty years ago too, a "100-year wave"—the highest wave that could be expected—would have been about 20 feet. Now, there is the possibility of waves in the range of 27 feet. "That's a huge difference," says Graham, and it will likely have enormous consequences. "We have to pay attention to the coastal structures and how they're built."

What is causing the fiercer wave action? The study concluded that increases in upper-level winds may be providing an environment more favorable for the formation and intensification of strong winter storms. And what is behind these stronger jet streams? Graham argues for a combination of factors, including changes in sea surface temperatures in the tropics—which in turn may be related to greenhouse warming, natural climate variations, or both.

Graham also found that since 1975 storms have changed track, making them more dangerous for San Diego County. Before that time, storms typically had a northwestern trajectory, hitting the Channel Islands and losing some energy before waves reached San Diego. Now, though, storms more frequently originate farther south and move straight in from the west, unleashing more energy into waves headed directly for California's southernmost coast. "These are profound, long-term changes, and they have important implications from economic and beach-management perspectives," Graham says. "They play into questions about coastal construction, coastal erosion, and debates on coastal protection strategies."

Indeed, the potential for damage to cliffs, oceanfront buildings, and beaches has grown markedly as a result of shifts such as these, mainly through erosion and storm surges that hit during high tides. This leads to ongoing armament and restoration. As the EPA reports, "The beaches stretching from Santa Barbara to San Diego have been replenished with sand, and undoubtedly will be replenished further or protected with structures if threatened by sea level rise. Cumulative costs for sand replenishment to protect California's coastline from a 20-inch sea level rise through 2100 could be $174 million to $3.5 billion." The United States generally has $3 trillion at stake along beachfront property, Bruce Douglas of Florida International University observed last year at a Natural Disasters Roundtable hosted by the National Academy of Sciences. "Now is not too soon to consider serious mitigation."

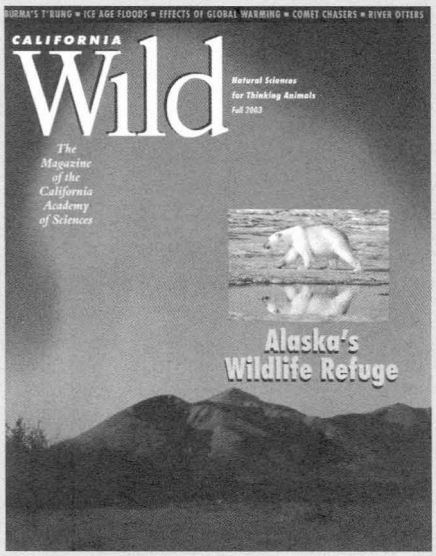


COMMANDER JOHN BORTNIAK, NOAA CORPS

Johns Hopkins Glacier calving into Glacier Bay, Alaska

What can be done? Potential responses to sea level rise include hard engineering (sea walls, levees, breakwaters, and other structures built to protect inland areas), soft engineering (beach nourishment, vegetated buffers), accommodation such as raising at-risk structures or switching agriculture to salt-tolerant crops, and retreat. All but retreat will require ongoing efforts as the sea continues its attack (and retreat may mean quite a distance inland from the present coastline).

Much of California's coastline is public land or public infrastructure: roads, beaches, parks, life guard towers, sewage treatment facilities, power plants, railroads, even a marine lab or two. Yet so far, California is doing little proactively to address the issues of sea level rise or increased tidal range. In fact, according to the Coastal Commission report, few states have passed



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LOOKING OUT FOR THE WETLANDS

ALONG MOST OF California's coast, accelerated sea level rise is not expected to cause major problems, as it will along the sloping Eastern seaboard and on the Gulf of Mexico, where flooding is a chronic issue. Significant impacts are expected, however, in low-lying coastal areas, including estuaries and bays. So what will happen to coastal wetlands, including those now being protected and restored? Will they be inundated and lost?

In some habitat restoration projects, sea level projections for the next 50 to 100 years are being factored in. Each site has to be considered on its own because no two present the same issues. Normally, as sea level rises, wetlands retreat inland. This is still physically possible in some places, such as Ormond Beach, in Ventura County, where marshland and dunes are backed by farmed fields. The Coastal Conservancy's plans for habitat restoration at Ormond Beach include conservation easements on adjoining farmlands.

In most other places, however, wetlands are caught in a squeeze between the ocean and roads, buildings, and other hard structures. Most marshes on San Francisco Bay, for example, cannot migrate up, pointed out David Schoellhamer, research hydrologist at the U.S. Geological Survey (USGS). "The question becomes," he said, "Can marshes restore themselves by accretion? Is the sediment accretion rate high enough?" If it is, sediment will build up the marsh even as sea level rises.

This and other questions related to sea level rise will be considered by a multi-agency project team led by the Coastal Conservancy in planning for one of the most ambitious marsh restoration projects in the state: to reconvert 15,100 acres of salt ponds, recently acquired from Cargill Salt, to a mix of tidal wetlands and managed ponds. Schoellhamer is a scientific advisor for the project.

According to hydrologist Philip Williams, the key to success will be quick revegetation. "In the south bay we had a [de facto] experiment in the '40s, '50s, and '60s, when accelerated groundwater pumping led to subsidence that exceeded the highest levels of sea level rise projected for the next 100 years," he said. "The marshes persisted and were fine. Once vegetation is established, San Francisco Bay marshes are amazingly resilient."

If revegetation is part of the south bay salt pond restoration project, sea level rise will have to be considered in decisions on where to plant, noted R. Michael Erwin of USGS Patuxent Research Center, a member of the National Science Panel for the project. "If cordgrass is planted at currently optimal elevations, it will no doubt be inundated within the next 50 years," he said.

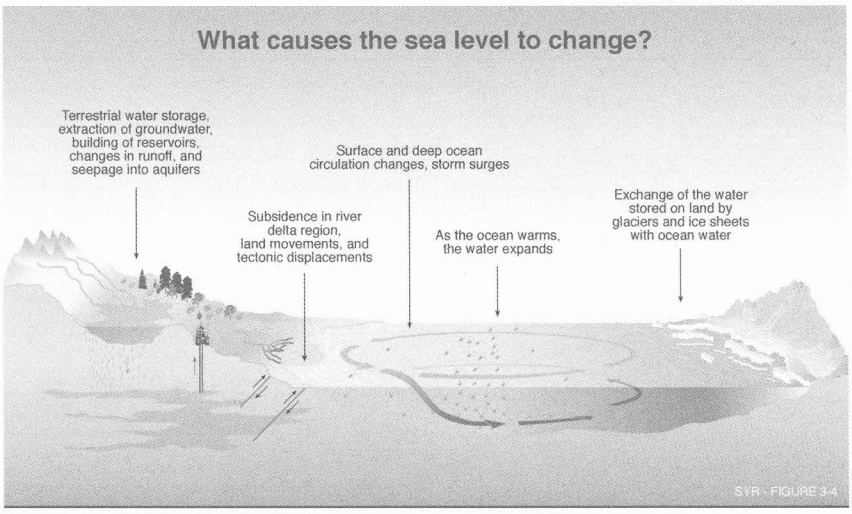
To Williams, a pioneer in marsh restoration, the challenge posed by sea level rise presents "an opportunity to address broader restoration problems." The Big Lagoon project in Marin County, for which his firm is the principal consultant to the National Park Service, is a case in point. The Park Service intends to restore wetlands near Muir Beach in Marin County while also reducing flood hazards.

About 150 years ago there was a big lagoon at the mouth of Redwood Creek, behind a sandy beach with rocky areas and tidepools at both ends. Sea level rise at that time exceeded the rate at which sediment was deposited by stream flow, and the lagoon was probably expanding. But then grazing, logging, and grading in the watershed led to erosion upstream, sediment delivery to the lagoon increased tenfold, and the lagoon filled in.

Although the Redwood Creek watershed is now protected within the Golden Gate National Recreation Area and major restoration work has been done on lower parts of the creek, the sedimentation rate is still about five times what it would be under natural conditions. In the last few years, as sediment built up in the stream bed, Redwood Creek overflowed during storms, impeding public access to Muir Beach and to homes. It became clear that a major storm could do serious damage to nearby public and private property.

Looking at historic sediment delivery trends and taking accelerating sea level rise into account, Philip Williams Associates projected how the system would evolve for the next 50 years under different restoration alternatives, including one that would recreate the "big lagoon." The Park Service's next step is preparation of an environmental impact report, then funding must be acquired for the restoration. "It's easier and more effective to address many of these problems now," Williams said. "Fifty years down the road they'll be harder to deal with." —*RG*

special regulations to address sea level rise, but rather respond "as needed"—granting funds for sand replacement as beaches disappear, for example, or issuing new building permits with stricter setback or reinforcement parameters. Texas has a rolling easement program that relocates public land boundaries to the current line of vegetation. The Carolinas and Massachusetts prohibit the construction of hard shoreline armoring, thus limiting responses to sea level rise and tidal change to soft engineering, accommodation, and retreat. And Maine prohibits rebuilding structures that have been damaged by storms if the new structure could reasonably be expected to be damaged within the next 100 years. These are steps in the right direction, though future efforts will likely be even tougher.



INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

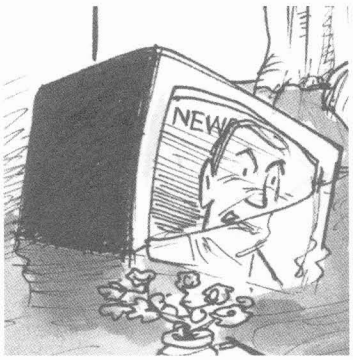
Sea level rise has numerous causes and effects.

Add Warm Water

GLOBAL WARMING is causing the sea not only to rise, but also to warm. And that has an impact on the critters living in it—not just in theory, but in fact. In the early 1990s Rafe Sagarin, a graduate student at Hopkins Marine Station in Pacific Grove, launched a telling study driven by two key sets of data. One was an inventory carried out 60 years before by another Hopkins grad student, W. G. Hewatt. Between 1931 and 1933, Hewatt counted every invertebrate animal he found along a 108-yard transect stretching out to sea from the high tide to the low tide mark. The second data set was a temperature log, kept at Hopkins since 1917. This log revealed that the average temperature in 1993 was three-fourths of a degree warmer than it had been when Hewatt conducted his study—and two full degrees warmer during the warmest part of the season, in late summer.

Suspecting that warmer waters would affect the intertidal community, Sagarin repeated Hewatt's inventory, sampling along the same transect during 1993–1994. "When the results began to come in," Sagarin said, "it was incredibly exciting. I never expected any changes to be so obvious." Obvious, but also startling: of 45 invertebrate species selected for close analysis, fully 32 showed statistically significant changes in abundance. Moreover, a northward population shift was clear: whereas eight of nine southern species had increased markedly in abundance, five of eight northern species had decreased. Several snail species that Hewatt had not even seen are now among the most common gastropods on the rocky reef off Hopkins.

Sagarin (now a professor in the Department of Environmental Health Sciences at UCLA) attributes these changes to global warming, and is adamant that we should be concerned. "People may not be interested in the fate of a few invertebrates in tide pools," he says, "but consider that mosquitoes, which bear some of the world's deadliest diseases, are also invertebrates, and they are expected to respond to climate change in a similar fashion, and quite quickly at that. Cities that have been spared malaria and other diseases solely as a geographical consequence of being far enough north, or high enough in altitude, may be infested as climate warms. Likewise, ideal conditions for crops may move northward, and since plants don't care about political or economic borders, some farmers may end up hurting a lot."



The Future

THE ISSUE OF GLOBAL warming raises many questions, especially with regard to the particulars: how it will make itself felt, how it will influence other processes on Earth. For example, we all know that El Niños have a strong impact on California's weather patterns—causing landslides, floods, power outages, extreme tides, and dramatic changes in ocean fisheries—and they will certainly do so in the future. How will global warming affect this climatic phenomenon? Nobody really knows, though two studies reported within the last decade in *Nature* suggest that El Niños could become the norm, with the California climate of the future looking like an amplified

version of the last few decades (remember those El Niños of 1982–83 and 1997–98?). General storminess—frequency as well as location—likewise is difficult to predict. One thing does seem sure, however: a warmer global climate will increase evaporation from the oceans, increase moisture in the atmosphere (because warmer air can hold more water), and increase precipitation worldwide. These changes in the global water cycle are likely to bring more rain to the western edges of the continents in major frontal storms and to increase the number and/or intensity of thunderstorms bringing brief bursts of heavy rainfall. And the temperature is likely to continue rising—and with it, sea level.

With all that I'd learned in mind, I went back to the beach and took another look. A family, parents and three children, were at the surf line, the kids running in and out of the water kicking at the white foam and laughing with glee. A young man was flying a wind-sock kite that looked like a dangly pair of legs, its feet waggling high in the sky. Several couples and individuals, some with dogs, walked along the shore, enjoying the warmth and calm of the afternoon. A statuesque great dane being tugged forward by two clownish cairn terriers made me laugh. We were all out relishing the sand and surf, taking it entirely for granted.

Then I envisioned the beach gone—or at least, different. The shoreline in another hundred years will certainly not look like it does today, and this particular stretch of beach probably *will* be under water. Will a new strand, a little farther inland, provide a spot for kite flyers and dog walkers to enjoy? How will "hard" and "soft" engineering change the look of the bay's edge? Will the Monterey harbor and wharves, the aquarium and Asilomar boardwalk, still exist?

Imagine yourself at a favorite seaside spot. Now add a foot, or two, or even three feet of water. What do you see, what do you feel? ■

DON BALCH

Blufftop homes in La Jolla are vulnerable to extreme weather.

Is It Time for Desalination?

A PIECE OF THE ANSWER—MAYBE

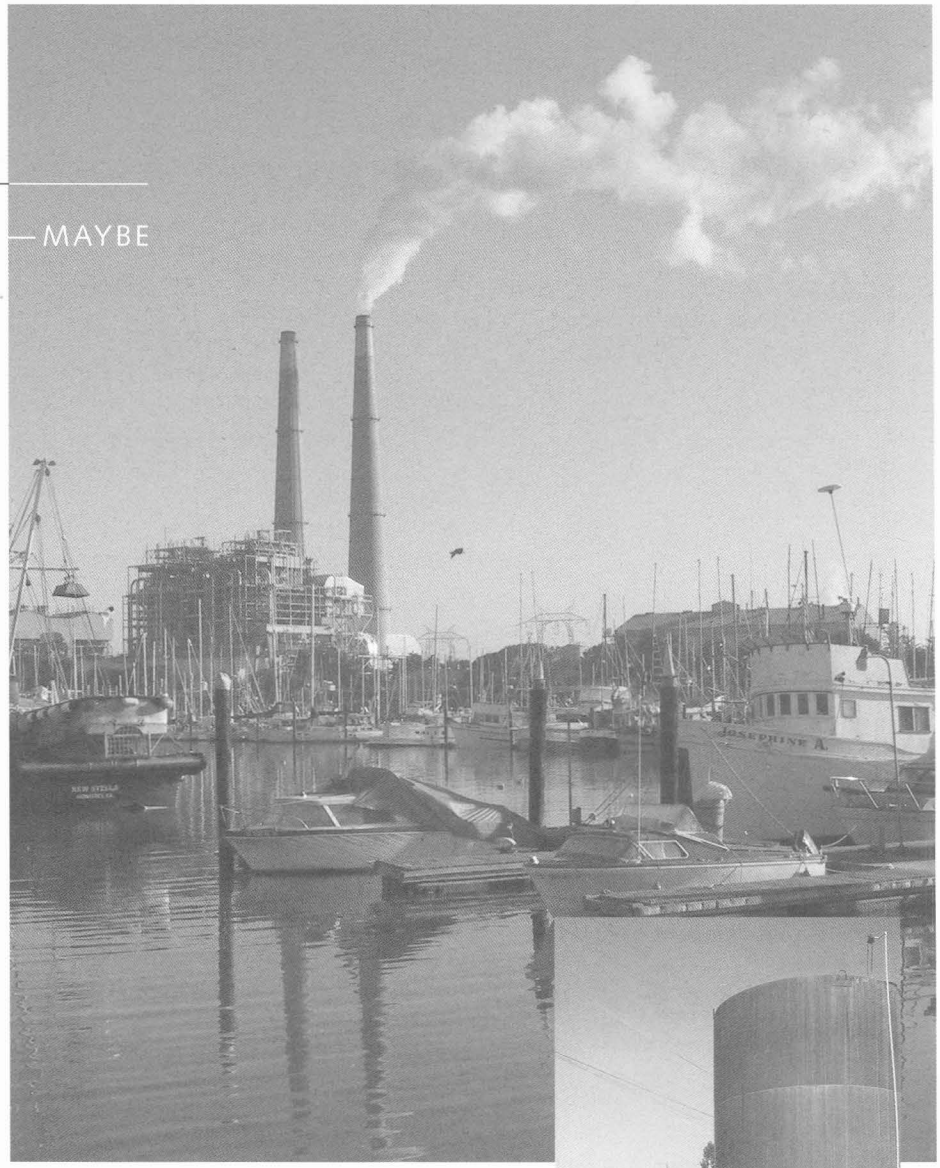
SHIRLEY SKEEL

THE GROUNDWATER LEVEL in northern Monterey County keeps sinking. For Carolyn and Gene Anderson, who share a well with five neighbors in the unincorporated Royal Oaks area, 10 miles southwest of Moss Landing, this is just one source of worry. Eleven years ago, their mutually owned well had to be closed because high levels of nitrates were found in it. They dug again—much deeper. According to the Monterey County Public Health Department's Environmental Health Division, every year a dozen or more north county wells go dry or are contaminated by nitrates or saltwater intrusion.

"Everyplace north of Salinas has severe overdraft problems, pulling more water out of the ground than is recharging," according to County Supervisor Louis Calcagno. "Because of overdraft there is saltwater intrusion. We're limiting our development because of the water shortage." All households in unincorporated areas of north county draw on groundwater, mostly from privately owned wells. All treated wastewater from the Monterey Peninsula, Castroville, Fort Ord, Seaside, and Marina is being recycled, irrigating 12,000 acres of agriculture. Yet the water shortage is getting worse.

The Andersons, retired public service employees, are diligent in conserving. The tap goes off once the toothbrush is wet. Showers are short affairs. The washing machine gets a run only when the lid falls off the clothes basket. They hope their well will last.

Early this year, they heard that California-American Water Company (Cal-Am) was planning to build a $190 million desalination plant at Moss Landing, beside the Duke Energy power plant and Elkhorn Slough National Estuarine Research Reserve. The desalted water would be piped south to the company's 35,000 customers in Monterey, Carmel, Carmel Valley, Pacific Grove, Sand City, Pebble Beach, and Seaside.



ANNE CANRIGHT

RASA GUSTAITIS

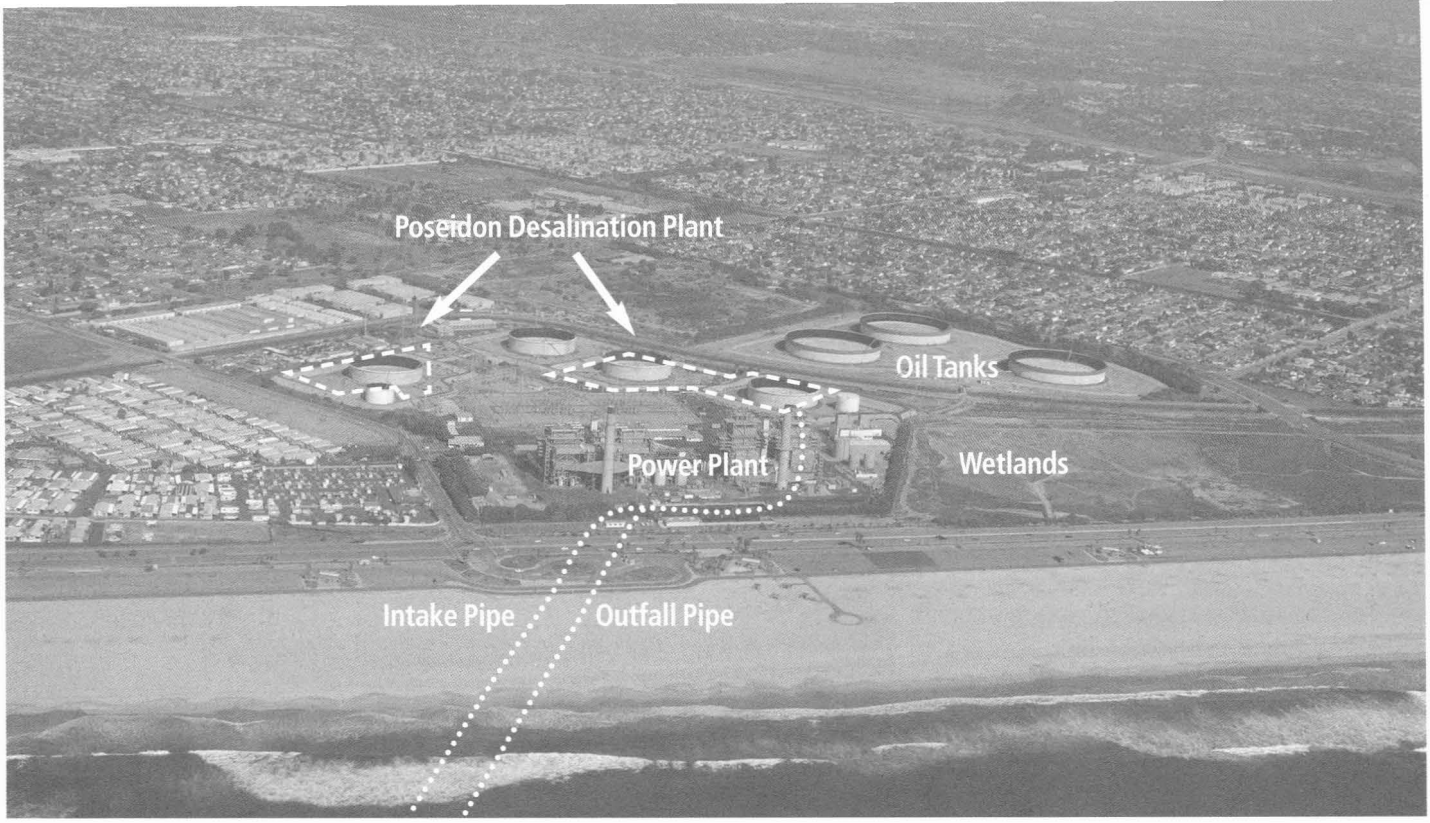
Top: The smokestacks of the Moss Landing power plant are a dramatic landmark.

Above: Carolyn and Gene Anderson share the well behind them with five other families, pumping water from the shrinking aquifer.

Carolyn Anderson was alarmed. "They're going to plunk it down in our backyard, and yet our community is not expected to get any of the water from it—only the negative impacts," she said. "It doesn't seem fair."

Calcagno, a dairy rancher on Elkhorn Slough, agrees: "You're not going to come into north county, build a desal plant, and move the water to another area without considering the needs of this area." The project had been moving ahead without the community's input, he said. "We didn't know. The supervisors, Moss Landing Marine Lab, the Moss Landing Harbor District were not consulted."

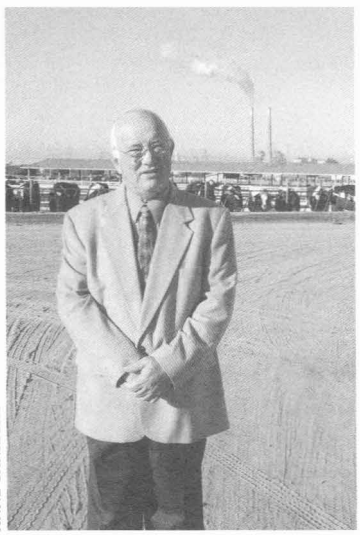
Cal-Am, the main water supplier for the Monterey Peninsula, had been looking for a new water source since the State Water Resources Control Board (WRCB) found, in 1995, that Cal-Am "does not have a legal right to" about 69 percent of the



CALIFORNIA COASTAL RECORDS PROJECT

Top: A seawater desalination plant proposed for Huntington Beach, in Orange County, would be built adjacent to the AES power plant. Two of the old storage tanks would be removed.

Bottom: Louis Calcagno



ANNE CANRIGHT

water supplied to its customers. Two dams on the Carmel River had lost most of their storage capacity to silting in, and groundwater that would have flowed to the river was being tapped by Cal-Am wells. The river was going dry, undermining steelhead restoration efforts. The WRCB told Cal-Am to find new sources.

The company first proposed building another dam, but in the face of strong opposition and with support from the State Public Utilities Commission (PUC), it turned to desalination instead.

North county is primarily agricultural, Carolyn Anderson points out, and it tends to get things that would not be tolerated in other communities, such as wrecking yards and power plants. Four years ago she co-founded a watchdog group, North County Citizens Oversight Coalition, to give residents a stronger voice in county planning. With the desal project looming, she rallied the members to speak out.

In February, a public forum to discuss the proposed plant filled the Grange Hall in Prunedale. Cal-Am came, as did agency representatives, scientific advisors, and Calcagno. Some people thought the plant might be helpful, if the area could hook in. Others figured that the cost of doing that would be too high. (Presently, people with private wells don't pay for water, only for the cost of pumping.) Fears were expressed that the availability of new water would encourage new development without adequate planning, further depleting water supplies. And finally, there was concern about potential impacts on the Elkhorn Slough Research Reserve with its varied and delicate habitats.

In October, Cal-Am spokesperson Kevin Tilden said that the environmental impact study has just begun. He added: "We want to consult with the community every step of the way."

Since the February meeting, Calcagno said, there have been further discussions with Cal-Am and PUC staff. "We want the option to pull water from [the plant]," he said. "We are increasing our population. We have the world's best ground, the best agriculture—there's not a For Sale sign on any ranch in the county; and we have tourism. Both those industries need affordable housing for labor." Whether desalted water would help meet that need is an open question.

Solution or Problem?

THE DESAL CONTROVERSY in north Monterey County is only one of many along the California coast. About two dozen plants are currently in various stages of planning, in San Diego, Dana Point, Los Angeles, Cambria, Fort Ord State Park, Sand City, Santa Cruz and Marin Counties, and elsewhere. Plants proposed for Huntington Beach and Carlsbad are twice the size of the largest plant in North America, which went into

operation in March in Tampa Bay, Florida. Each would supply 112,000 households.

If all the proposed projects go ahead and operate successfully, they could produce a total of 220,000 acre-feet of water a year—enough to supply up to 440,000 families of four. (An acre-foot equals 326,000 gallons, or one acre of water one foot deep.) Although that would satisfy no more than a small fraction of California's water needs, the consequences to the coast and ocean could be significant.

"In some areas along the coast, desalination could remove what may be the single largest constraint to growth: a limited supply of potable water," states a 56-page report published by the Coastal Commission in August. "Some desalination facilities may be operated in an environmentally benign manner, others could cause significant adverse effects." Because some plants could help ease the strain on local rivers or groundwater, the report recommends a case-by-case investigation of each plant.

In September, the Coastal Commission unanimously approved a small experimental plant in Long Beach with the goal of getting some answers to the questions being raised, according to Tom Luster, environmental specialist at the Commission. Among these are issues of cost and who pays for the plant, citizen participation in deciding how the water is distributed, energy use, impacts on efforts to conserve water, and concerns about control and oversight. Cal-Am, for example, is owned by the German company RWE, one of the three largest international water companies in the world.

The Commission's report expresses significant concern about provisions of some international trade agreements that exempt companies that operate internationally from local and state regulations if those regulations are found to restrict free trade.

Why Now?

IN THE PAST, only dry countries such as Saudi Arabia, Israel, and Spain were willing to pay the cost the process required. In the United States—especially in Texas, California, and Florida—desalination was used primarily to clean brackish ground water for farm use. Then came the California drought of the early 1990s, when the cities of Santa Barbara and Morro Bay built the first large plants to supply drinking water. Santa Barbara's plant was never used and is now decommissioned, and Morro Bay's is used only intermittently.

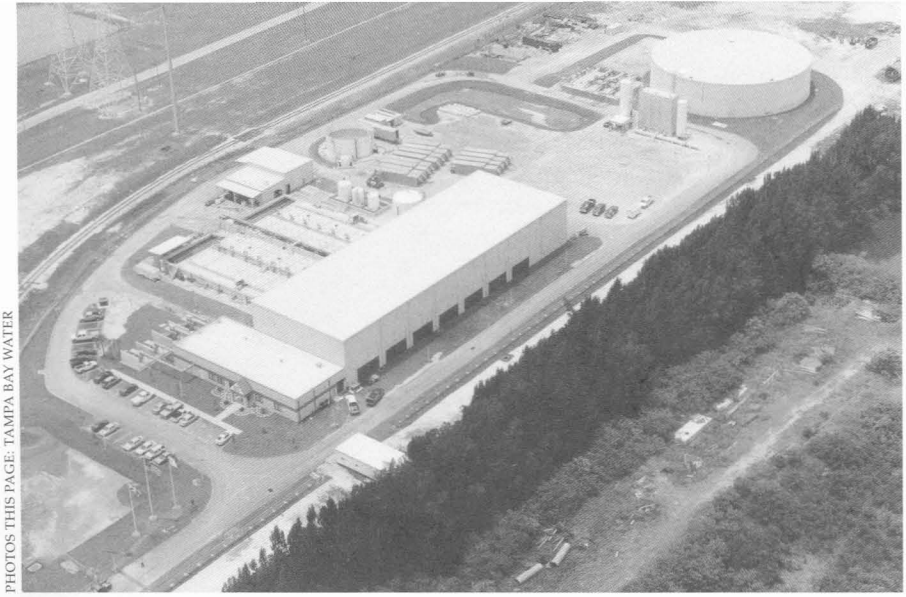
Within the past decade, however, the cost of desalting seawater has dropped dramatically, stimulating new interest in this process as one response to the state's ever more acute water problems.

A study by Shahid Chaudhry, program manager for the Process Energy Group of the California Energy Commission, shows a big drop in production costs for desalination by reverse osmosis. The price of the membranes that purge the water of salt has fallen 86 percent since 1990, while their productivity has almost doubled. In 1990, desalinated water from a large plant typically cost about $2,000 per acre-foot according to estimates supplied by the U.S. Bureau of Reclamation. Costs were somewhat higher in 1991 for California's small plants, said Chaudhry. He estimated that the price could fall to $500 by 2006. The cost of producing water at the proposed California plants would run somewhere between $710 and $1,170 per acre-foot.

That's still considerably more costly than water currently supplied by other sources. The Metropolitan Water District of Southern California, for example, pays an average of $460 per acre-foot for water from rivers and reservoirs. However, there is the problem of diminishing supplies.

California's water conflicts have been exacerbated by recent climatic variations, federal cuts in California's share of Colorado River water, and pressures of continuing population growth. With the state's population expected to reach 50 million by 2030, Charles Keene, chief of water management in the southern district of the Department of Water Resources, predicts that "we are going to be in trouble if we do not do something to stretch our existing supplies [of drinking water] and to develop new supplies." Assuming current patterns of use, he says, current supplies can be expected to suffice for no more than 30 years, and perhaps for only a decade.

In addition, Keene said, global climate change needs to be considered. Michael Dettinger, research associate at the Scripps Institution of Oceanography, predicts that global warming could reduce the western states' water supply by as much as 30 percent by 2050, partly by causing the snowpacks of the Sierra and the Rocky Mountains to melt sooner. A sensible option would seem to be to store the rain and earlier snow melt. But Keene said, "most of the very good dam sites are already built. And



PHOTOS THIS PAGE: TAMPA BAY WATER

Top: The Tampa Bay desalination plant, now the largest in the U.S., has been plagued with problems.

Above: A section of the Tampa Bay desalination process train

there are environmental problems with dams and reservoirs that are very costly."

Expensive desalination is by no means a panacea, but in some areas, Keene said, it "makes sense."

A Long Way to Go

IN SEPTEMBER 2002, the state legislature created a 27-member Desalination Task Force. After interviewing experts and holding public hearings, it reported findings and recommendations to the legislature. Charles Keene, executive officer, said the Task Force was "cautiously optimistic but would like to see small plants, to resolve some of the problems, before large plants move ahead, particularly in light of technical problems that arose at the Tampa plant."

Interest in funding desal research was expressed by a representative of the Department of the Interior during a one-day panel discussion, "Water 2020," organized in Washington and held in Sacramento in July.

Among proposed plants now moving through the planning process, the $180 million project proposed for Huntington Beach is the farthest along. It would occupy six acres, five acres more than the now-shut Santa Barbara plant. The City Council was to consider the project December 15, along with complaints that environmental review was based on inaccurate assumptions. Even if it clears the project, however, more than a dozen agencies would have to sign off on it.

The issues involved in desalination are many, and they become more problematic as the size of the plant increases. As Tom Luster points out, "In California the existing plants are very small compared to the ones proposed. They're not a good basis for comparison."

Both the intake of seawater and output of wastewater from desalination plants are of concern. Most modern plants use one of two methods. In the "distillation" process, seawater is heated to produce a vapor that condenses into potable water. A salty liquid concentrate or brine is left behind. In "reverse osmosis," the process proposed for nearly all new desal projects in the U.S., seawater is pumped at high pressure through permeable membranes that filter out the salt. This process requires considerably less energy than distillation. For each two gallons of seawater going in, one gallon of drinking water and one gallon of brine come out. (Curiously, the water produced is so tasteless that chlorine, carbon dioxide, and lime are added, not only to treat the water, but to give it a familiar taste.)

Both kinds of plants draw water from the ocean, as do many existing California power plants, which use seawater to cool their generators. Experience with these power plants has raised concerns about the impacts a swath of new desal facilities will have on the marine environment.

Pete Raimondi, professor of ecology at the University of California, Santa Cruz, says some power plants take in hundreds of millions of gallons of seawater a day, and "everything in it dies." Larvae, fish eggs, and plankton are killed by "entrainment," that is, from the heat and pressure as they are pulled through the plant's systems. Fish and birds might die by "impingement" when they are sucked up against the intake screens.

Studies that Raimondi participated in at the recently upgraded Duke Energy power plant at Moss Landing showed it could destroy 13 to 28 percent of the planktonic life (young fish, invertebrates, and algae) in Elkhorn Slough, while the Diablo Canyon nuclear power plant near San Luis Obispo could destroy six to 13 percent of such local ocean life. "That's not catastrophic," said Raimondi." The ocean would not become a desert because of these (power plant) operations, but it is a large impact."

Luster pointed out, however, that most coastal power plants' intake structures were sited in the 1950s and '60s, before environmental regulations were in place, and many of them are located where they cause entrainment levels that would be difficult to approve today.

One way to reduce some of the negative impacts of new desal plants, and to reduce

energy costs, may be to situate them next to power plants where they can share the same intake pipe, as would be the case in the plant proposed at Moss Landing. The desal plant would draw off some of the seawater that has been used to cool the generators and convert it to potable water. If operating the desal plant would not change how the power plant operates, the impact from intake pipes on marine life should be no more than when the power station is operating alone, according to the Coastal Commission's report.

Sharing pipes with a power plant can also ameliorate problems associated with the wastewater, or "brine," which is twice as salty as ocean water and often contains chemicals. Jeffrey Graham, a marine biologist at the Scripps Institution of Oceanography who was contracted to do oceanic studies for Poseidon Resources, says the biggest desalination plants would generate 50 million gallons of salty wastewater a day. At Poseidon's proposed Huntington Beach plant, as at Moss Landing, this would be mixed with the cooling seawater leaving the adjacent power plant. Models suggest the diluted brine would sink and spread over a "footprint" about the size of six football fields.

Graham says the salinity in this area might reach up to 38 parts per 1,000 (ppt), about 10 percent above normal ocean salinity of 33.5 ppt. Salinity of 40 ppt cannot be tolerated by some fish. Even less extreme levels can have adverse effects if the fish stay in the area too long. Graham says bottom-dwelling sand dollars, hermit crabs, and worms could become less numerous as successive generations move to other, more salubrious habitats. But "this is a broad new area of inquiry. There's very little known about the upper salinity tolerance of marine organisms."

Chemicals used during the desal process include chlorine, ozone, various coagulants, acids, and anti-scalants. Many of these compounds are neutralized or removed from the brine stream before being discharged, according to the Coastal Commission report. But others are likely to remain.

Billy Owens, spokesman for Poseidon Resources, maintains that in a properly operated system no foreign compounds should be left in the brine. The exception may be the cleaning chemicals used to flush out the membranes. It is up to the State Water Resources Control Board whether these are injected into the brine, or sent instead to the sewage treatment system.

Some of the proposed plants are sited next to wastewater treatment facilities, so brine could be diluted with treated waste before it is piped out to sea. But at least a dozen of the proposed plants stand on their own. These would likely have to use diffusers or multiple output ports to ensure that the salty brine is quickly dispersed.

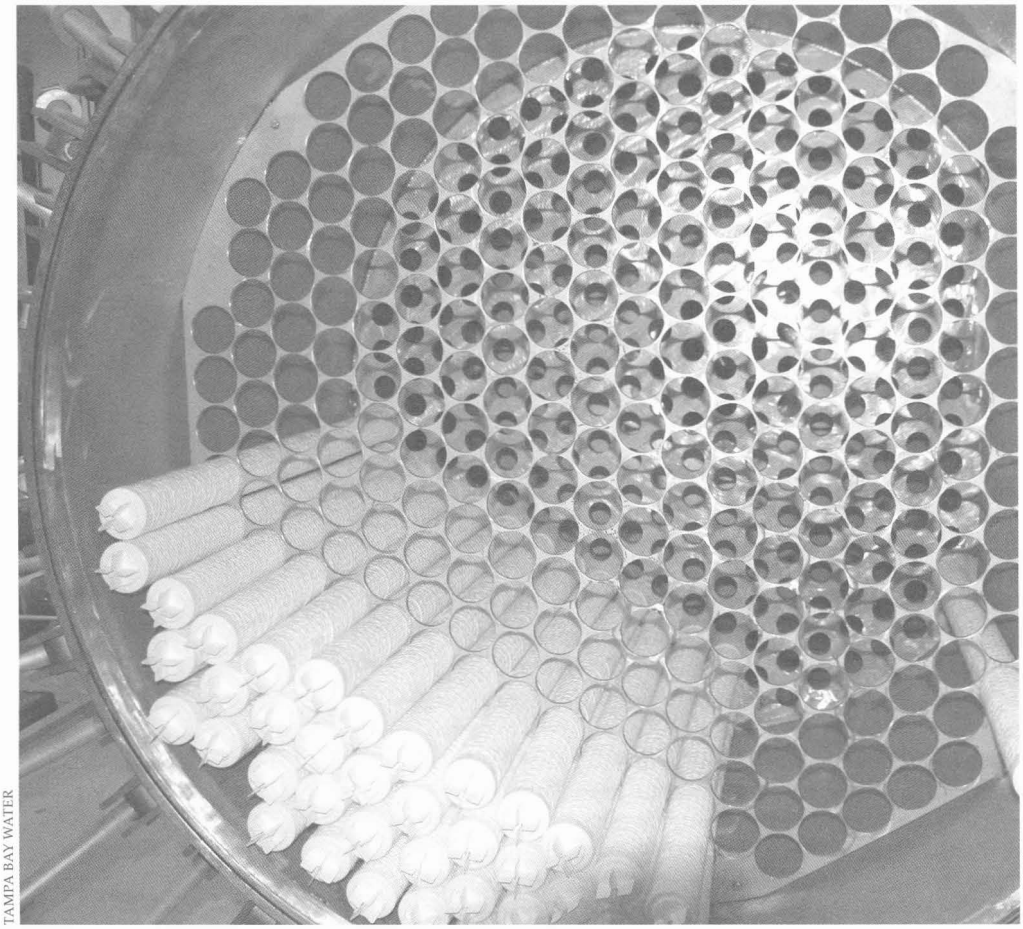
A Spur to Growth?

ONE OF THE PRINCIPAL concerns about desal is the effect new water supplies will have on pressures for growth. Joe Geever, a coordinator for the Surfrider Foundation, said the Huntington Beach plant will feed a 14,000-unit development project at Rancho Mission Viejo in Orange County. Aside from the extra cars and people this development would bring, it could mean more wastewater and polluted urban runoff flowing to the ocean. "And we'd still have the same problem (of water shortages) with a bigger population," he said.

Poseidon's Billy Owens says his firm does expect to sell water to the Santa Margarita Water District, which would service the development. As he sees things, however, "We are feeding growth that is already planned for, not new growth."

Growth is also the hot potato in the case of the nine-million-gallon-a-day Cal-Am plant at Moss Landing, according to Alexander Henson, chairman of the Monterey Peninsula Water Management District. If it is built larger than now planned or expanded later, he said, "it would mean our limited roadways would become clogged with cars, our mountainsides will become a sea of houses." In response to such apprehensions, and to keep control over water supplies in local hands, the water district has proposed to build its own, publicly owned desal plant at Sand City to serve the Monterey Peninsula.

Desalination got a boost in November 2002 when California voters approved Proposition 50, allowing the state to issue $3.46 billion in bonds for water and environmental projects. Included in this is $50 million for desalination research and construction projects. One interesting candidate for funds is a Long Beach research project in nanofiltration, a thin-membrane technology that promises to use far less energy than reverse osmosis. Meanwhile, the Metropolitan Water Authority of Southern California is offering 25-year subsidies worth $250 per acre-foot for water produced by desalination



TAMPA BAY WATER

Desalination cartridge filter at the Tampa Bay plant

plants. Five projects, both public and private, are being considered, in Los Angeles, Long Beach, Dana Point, Carlsbad, and the West Basin Municipal Water District in southwest Los Angeles County.

What's Being Counted?

PETER GLEICK, president of the Pacific Institute, an independent think tank, says it is "ridiculous" to subsidize desalination when water demand can easily be reduced by 30 to 40 percent by simple conservation measures such as low-flush toilets, top-loading washing machines, and low-flow showerheads. Flushing the toilet is the biggest use of water by individual householders, he says, so simply replacing the older six-gallon and three-and-a-half-gallon toilets in California homes with the new 1.6-gallon standard introduced in 1994 would make a significant difference.

Charles Keene at the Department of Water Resources, however, is skeptical of conservation's potential. Getting any more water efficiency at this point, he says, would be expensive and produce a limited result. He also says it's hard to persuade people to conserve, especially those in the northern part of the state, who tend to see saving water as water saved for the south.

The next year or so will be key to the future of desalination in California, as regulators and politicians mull over the issues and assess specific proposals.

The giant Huntington Beach project will probably be the first to make it to the Coastal Commission—possibly by next spring. The other proposals will trickle in over several years, with targeted operational dates for the plants running from mid-2006 for Huntington Beach and 2007–8 for Moss Landing to 10 or more years out for some of the others.

Bob Yamada, seawater desalination program manager for the San Diego Water Authority, hopes to get 15 percent of his region's water from desal by 2020. He estimated that at today's prices he would pay about $800 per acre-foot, close to the price of alternatives. Recycling treated wastewater for irrigation and groundwater recharge costs $700 to $900 an acre-foot, according to Yamada, while water imported from the north is priced "in the same ballpark" as desalination, when fees paid for transport are included.

In the state legislature, desalination is getting a mixed reception. In August, then-Governor Gray Davis signed a bill that requires seawater desalination projects to be weighted equally in state funding alongside dams, aqueducts, and other projects (but not including conservation projects). Desalination advocates had a temporary setback, however, when AB 860, which would have allowed water agencies to buy electricity to run desal plants at wholesale rates, was held over till next year.

Experts agree that, overall, desalination may never be a big part of California's water picture. It could, however, have a significant impact on the coast. How coastal communities are affected will depend, in large part, on who gets to turn on the tap, where, and for whose benefit. ■

Shirley Skeel, a freelance writer based in Berkeley, covered utilities for Bloomberg News *in London.*

COASTAL CONSERVANCY NEWS

RECENT ACTIONS

BETWEEN AUGUST and October, the Coastal Conservancy approved more than 50 projects, along with more than $48.6 million in funding, enabling local governments and nonprofit organizations to protect and improve coastal wildlife habitats and farmland, expand and improve public access to beaches and shorelines, and revitalize the economies of coastal and San Francisco Bay counties. Almost all the funding comes from parks and resources bond acts passed by voters in 2000 and 2002.

Major South Coast projects include approval of the disbursement of $10 million to the Wildlife Conservation Board to acquire 193 acres of the historic Ballona Wetlands in Los Angeles County; and $10 million to the Santa Monica Mountains Conservancy for acquisition of the 2,900-acre Ahmanson Ranch in the Malibu Creek Watershed, Ventura County.

Two North Coast projects aim to help cities hard-hit by the contraction of the timber industry to undertake essential economic conversions. Fort Bragg will develop a community plan for reuse of the former Georgia-Pacific mill site; Crescent City will plan for revitalization of its harbor.

Typically, Conservancy projects serve more than one purpose, and many serve several. In Contra Costa County, for instance, the acquisition of Dutra Ranch by the Muir Heritage Land Trust, in Martinez, will not only prevent habitat fragmentation and protect scenic open space in an area undergoing rapid urban sprawl, it will also expand public access, add another segment to the Bay Area Ridge Trail, and open opportunities for environmental education to secure future stewardship of California's natural wealth.

The 158-acre Dutra Ranch lies on Franklin Ridge, west of Martinez, between two properties the land trust already owns, and is near Briones Regional Park and large landholdings of the East Bay Municipal Utilities District. The $790,000 purchase is being funded with $500,000 from the Conservancy, $190,000 from the Wildlife Conservation Board, and $100,000 from the Bay Area Ridge Trail Council from funds the Conservancy allocated for the Trail last year. The land trust is in the process of raising $125,000 for stewardship.

Other projects include:

SOUTH COAST

South Coast Counties:

- To develop the Coast Alive! education program for San Diego, Orange, and Los Angeles Counties, $250,000 to the California State Parks Foundation

San Diego County:

- To improve wildlife habitat and public access in the Tijuana River Valley, along Rose Creek in the City of San Diego, and at San Elijo Lagoon, a total of $447,000 to the International Community Foundation, San Diego EarthWorks, and the San Elijo Lagoon Conservancy
- To acquire properties within the San Diego River and Otay River watersheds, a total of $14.62 million as part of the State's Natural Communities Conservation Planning Program, with $7.2 million going to the San Diego River Park–Lakeside Conservancy and $7.42 million to the Department of Fish and Game

Orange County:

- To improve facilities at Aliso Beach, $160,000 to Orange County

Los Angeles County:

- To design the reconstruction of the Strand walkway, $150,000 to the City of Manhattan Beach
- To remove invasive plants in lower Topanga Canyon, $180,000 to the Mountains Recreation and Conservation Authority

Ventura County:

- To improve wetlands at Ormond Beach, $600,000, plus reservation of $23 million to acquire properties for restoration of wetlands and related habitat

STEPHEN JOSEPH

Dutra Ranch

Santa Barbara County:

- To prepare engineering designs, environmental documentation, and permit applications for fish passage improvement projects in coastal streams on the county's south coast, $453,000
- For environmental restoration at the Carpinteria Salt Marsh and the University of California, Santa Barbara, Campus Lagoon Natural Area, $1.65 million, with $1.55 million going to the Land Trust for Santa Barbara County, and $100,000 to the University

CENTRAL COAST

San Luis Obispo County:

- To acquire a conservation easement on the 1,860-acre John Maino Ranch, $1.5 million to the Morro Bay Foundation
- Toward acquisition of a 42-acre property for addition to Montaña de Oro State Park, up to $1.25 million to California State Parks
- To acquire a 1.6-acre parcel for addition to East-West Ranch in the community of Cambria, $200,000 to the Cambria Community Services District

Monterey County:

- To acquire 183 acres near Moro Cojo Slough for protection of habitat and water quality, $273,000 to the Elkhorn Slough Foundation

Santa Cruz County:

- To reconstruct the 26th Avenue beach stairway, to improve disability access, and for related costs, $250,000 to the nonprofit O'Neill Sea Odyssey and $300,000 to Santa Cruz County
- To develop Phase 2 of the Permit Coordination Program for Santa Cruz County, $106,000 to the Santa Cruz County Resource Conservation District

San Mateo County:

- To acquire the Driscoll and Bolsa Point ranches, restore the environment of San Pedro Creek, and assist farmers with construction of irrigation ponds, over $12 million to Peninsula Open Space Trust, Sustainable Conservation, and the City of Pacifica
- To carry out habitat restoration on Año Nuevo Island, $88,000 to the nonprofit Oikonos Ecosystem Knowledge, working with the Point Reyes Bird Observatory

CALIFORNIA COASTAL RECORDS PROJECT

Sheared-off rocky headlands at the Georgia-Pacific site in Fort Bragg

San Francisco County:

- For improvements to the south windmill in Golden Gate Park, $750,000 to Friends of Recreation and Parks
- To complete Phase 2 of the design for the Yosemite Canal Wetland Restoration and Public Access Project at Candlestick Point State Recreation Area, $650,000 to the California State Parks Foundation

Marin County:

- To acquire a conservation easement on the 870-acre Grossi Ranch, $585,000 to the Marin Agricultural Land Trust

Sonoma County:

- To improve salmon and steelhead habitat and fish passage at the Mumford Dam on the Russian River, and to prepare a grazing management plan for coastal grasslands, a total of $210,000 to the Sonoma County Water Agency and the Sotoyome Resource Conservation District
- Toward the expansion of "green" programs at Salmon Creek School, $300,000 to the Harmony Union School District of Occidental

San Francisco Bay Area:

- For restoration projects as part of environmental education programs for grades K–12 in eight Bay Area counties, a total of $665,000 to 14 nonprofit organizations

NORTH COAST

North Coast Counties:

- To remove barriers to salmon and steelhead trout passage in Mendocino, Humboldt, Del Norte, and Trinity counties, $400,000 to Trinity County

Mendocino County:

- To plan for the reuse of the former Georgia-Pacific mill site in Fort Bragg, develop the Gualala Blufftop Trail, and prepare a management plan for new California State Parks property along Big River, a total of $240,000 to the City of Fort Bragg, the Mendocino Land Trust, and the Redwood Coast Land Conservancy
- To plan, design, and implement projects pursuant to the Navarro River Restoration Plan, $713,000 to the Mendocino County Resource Conservation District

Humboldt County:

- For environmental restoration of Salt River, $215,000 to the Humboldt County Resource Conservation District
- To implement salmonid habitat improvement projects in the estuary and artificial rearing facilities of the Mattole River, $70,000 to the Mattole Restoration Council
- For engineering feasibility studies, environmental documentation, and permit applications for the rehabilitation of the Shelter Cove breakwater facility, $100,000 to the Humboldt Bay Harbor, Recreation, and Conservation District

Del Norte County:

- A $218,000 grant to the Crescent City Harbor District toward revitalization of the harbor

STATEWIDE:

- For design of a program to monitor coastal ocean currents, $275,000 to the nonprofit Commonweal.

MARINE HAVENS AND "THE PROMISE"

Editor:

As president of a statewide professional association of harbor managers, I am writing to express our disappointment over the article "Towards Safe Havens for Marine Life," in the Summer 2003 issue of *Coast and Ocean*.

Though the article promotes the laudable goals of marine biodiversity and sustainability, it does so via generalizations and popular (negative) myths about the management of commercial and recreational fisheries, advancing incorrect, unsupported perceptions about the state of California's marine resources.

Consider, for example, the claim that "almost every major species in coastal waters is now severely depleted, or in some cases, recovering from depletion." How then, do you explain the abundance of California spiny lobster, rock crab, albacore, yellowtail, barracuda, kelp bass, sand bass, sardines, mackerel, Pacific swordfish, pink shrimp, fall-run Chinook salmon, Pacific herring, red sea urchins, and ridgeback prawns—to name a few?

Many California marine species are not "depleted," nor do they deserve poster-child status for eco-campaigns that ignore sound science and management success in favor of promoting the fear and over-reaction that attends species-specific variability and/or collapse. Remember: Fisheries management is extremely complex business. Just because one or two species are in need of rebuilding has no bearing on the overall state of marine resources or the ecosystem as a whole. Facts and sound science about specific fisheries bear this out. If you wish to talk about apples, talk apples. If you wish to talk pears, talk pears. But they do not represent all the fruit in the basket.

Consider also the over-simplified statement that "bottom trawling devastates underwater ecosystems." Indeed, some trawls used in some habitats in certain ways deserve this description. Many trawls, however, like those used in California's halibut, sea cucumber, and pink-shrimp fisheries, are deployed over mud or sand bottoms absent of reef, coral, or hard-bottom structure. For these fisheries, there is no scientific evidence of ecosystem demise. If anything, the fact that the fisheries have sustained themselves quite well for decades suggests the opposite.

Regarding the statement that, "Not until the sanctuaries gain the authority and the will to fully regulate destructive activities within their boundaries will they accomplish their mission of comprehensive management," let me add this: National sanctuaries were designed to prevent oil development, illegal discharges, and seabed alterations within their boundaries, thus preserving their rich biological heritage. They were not intended to regulate fisheries. Underscoring this notion was a promise made by Leon Panetta to the fishing community of Monterey Bay, in exchange for fishermen's support of sanctuary status. "The Promise," as it's known, remains real, but poses an ethical dilemma for sanctuary managers bent on reining in fishing effort via, among other means, implementation of marine reserves.

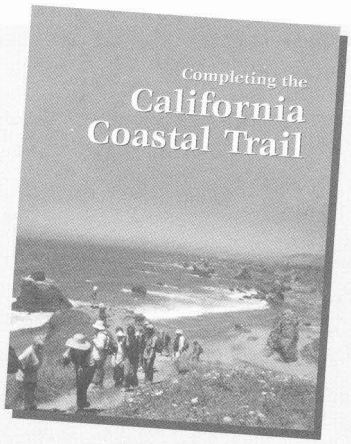
In conclusion, I wish to affirm that our association supports the notion that biodiversity and well-managed, sustainable fisheries are keys to the health of our marine resources. The way to achieve these goals, however, is through sound science and attention to facts, not drama, generalizations, and politics posing as journalism.

Ted Warburton, President
California Association of Harbor Masters & Port Captains Inc.

Michael Bhargava replies:

It is only partly true that national marine sanctuaries were designed to prevent oil development. The sponsors of the 1972 bill that authorized their creation intended far greater protection. The bill called for marine reserves to "maintain the natural biological communities in the national marine sanctuaries, and to protect, and, where appropriate, restore and enhance natural habitats, populations, and ecological processes."

When the central California sanctuaries were created, political compromises put fishing off limits to regulation. Those compromises, including Mr. Panetta's famous promise, came in an era before scientists understood how overfishing can harm entire ecosystems. The promise remains in effect, but to the detriment of the marine ecosystems that marine reserves are designed to protect.



COASTAL TRAIL REPORT

In keeping with a 2001 legislative mandate, a strategic blueprint for completing the California Coastal Trail has been published. It was shaped during two years of intensive effort by a working group representing the State Parks Department, Coastal Commission, Coastal Conservancy, and Coastwalk. *Completing the California Coastal Trail* will be available at www.scc.ca.gov. For copies on CD or in print, contact the Coastal Conservancy, 1330 Broadway, 11th Floor, Oakland, CA 94612; (510) 286-1015; coastaltrail@scc.ca.gov.

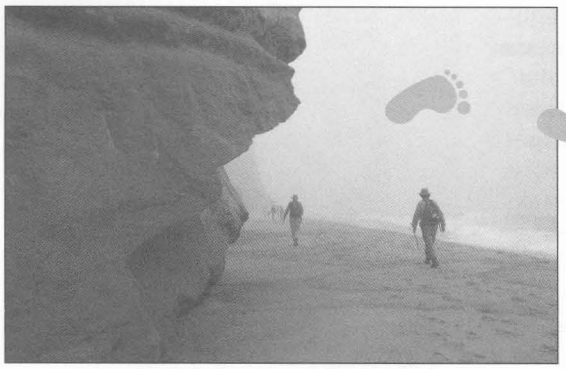
COASTAL TRAIL EXPEDITION 2003

WYN HOAG

June 3: Del Norte County. The morning was glorious with only a gentle breeze off the Pacific. . . . For the first several hours, we walked along broad sandy and pebbly beaches, often protected by large offshore stacks.

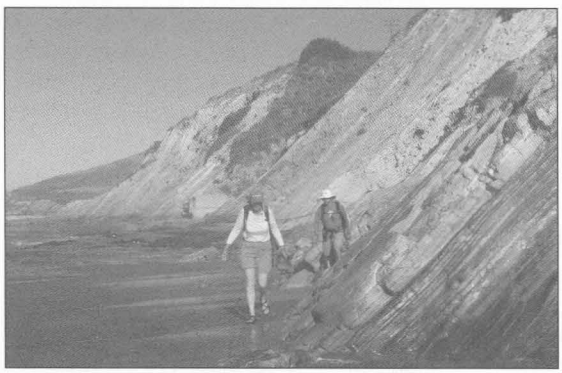
WYN HOAG

July 16: Marin Headlands. Unlike other people walking across the bridge that day, we had put in 466 miles before we started across.



LINDA HANES

July 22: San Gregorio Store to Pigeon Point. We walked at the base of 100-foot-tall vertical sandstone bluffs.



LINDA HANES

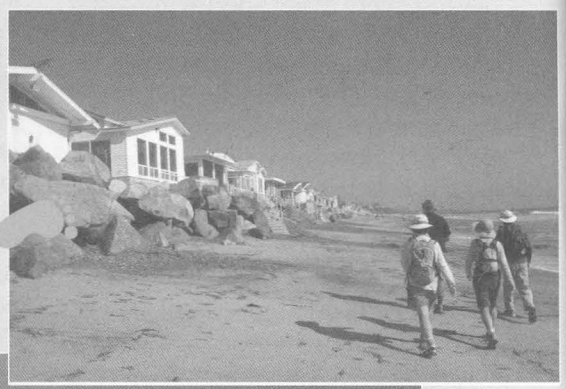
August 24: Gaviota State Park to El Capitan State Park. Like reverse surfers, we timed our moves for the smallest waves.

WAY BACK IN 1972, a handful of citizens envisioned a trail running along the coast from Oregon to Mexico. "It was written into the Coastal Initiative and made its way into the Coastal Act," said Bill Kortum. "It was kind of a pipe dream." Now, more than three decades later, the California Coastal Trail is official and well under way. About 60 percent of it is in place, other pieces are in the works, and the Coastal Conservancy, following a legislative mandate, has produced a plan for completing the rest.

To advance the cause further, ten men and women gathered at the Oregon border on June 3 to begin walking to Mexico. On September 22—112 days and 1,200 miles later—all ten arrived at Borderfield State Park, where Secretary of Resources Mary Nichols and the Coastal Conservancy's deputy director Steve Horn presented a copy of the current challenge: *Completing the California Coastal Trail*, the plan shaped during the past two years by a working group representing the State Parks Department, Coastal Commission, Coastal Conservancy, and the nonprofit Coastwalk. The long walk, Coastal Expedition 2003, was sponsored by Coastwalk, which has been working tirelessly to realize the original vision, primarily by leading hikes.

The Expedition's journal is available on the Coastal Trail web site: **www.californiacoastaltrail.info**

September 13: Doheny State Beach to San Clemente State Beach, at Capistrano. Passage in front of riprap is possible at low tide only.



LINDA HANES

WYN HOAG

September 22: San Diego County. The ten of us, hand in hand, reached the border. With us were some 40 other hikers who represented the hundreds and hundreds of volunteers who made the entire walk possible. . . . Raul Soria Mercado, delegado municipal de Playas de Tijuana, spoke his words of greeting and literally showered us with gifts of fruit [which he had to throw over the border fence. One of the apples was from Washington State.] The joining of sea and land is a commons, a place for all of us.

Aveces uno toca el cuerpo

A veces uno toca un cuerpo y lo despierta
por él pasamos la noche que se abre
la pulsación sensible de los brazos marinos

y como al mar lo amamos
como a un canto desnudo
como al solo verano

Le decimos luz como se dice ahora
le decimos ayer y otras partes

lo llenamos de cuerpos y de cuerpos
de gaviotas que son nuestras gaviotas

Lo vamos escalando punta a punta
con orillas y techos y aldabas

con hoteles y cauces y memorias
y paisajes y tiempo y asteroides

Lo colmamos de nosotros y de alma
de collares de islas y de alma

Lo sentimos vivir y cotidiano
lo sentimos hermoso pero sombra

Sometimes we touch a body

Sometimes we touch a body and we wake it
and it is a way through the night which opens
to our senses the pulsing of its arms like the sea's

and we love it like the sea
like a naked song
like the only Summer

We say it is light as one says now
we say it is yesterday and other places

we fill it with bodies and bodies
with gulls our own gulls

We go climbing it peak after peak
with ears and roofs and door latches

with hotels and ditches and memories
and landscapes and time and asteroids

We fill it to the brim with ourselves and with soul
with collars of islands and with soul

We feel ourselves living and everyday
we feel ourselves beautiful but shadow

—Homero Aridjis
translated by W. S. Merwin
from Antes del reino, *1963*

Mexican poet Homero Aridjis is founder and president of Grupo de los Cien (Group of 100), an environmental association of writers, artists, and scientists. He has won international awards for his writing and environmental leadership. His latest book is *Eyes to See Otherwise* (*Ojos de otro mirar*).

Coastal Conservancy

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