San Francisco Estuary Partnership

ESTUARY NEWS

SCIENCE • RESTORATION • WATERSHED • POLITICS • SPECIES • BAY

On the Left Coast, extreme tides are wetting our feet and teasing our brains with glimpses of a flooded future. Climate change is on a roll, and with it the prospect of accelerating sea level rise, and estuary scientists and managers are hustling to adapt.

PLUS: Sustaining Marshes, Saving Sparrows, Connecting Habitats, A Special Report from the Cal LCC.

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EDITORIAL

A Hotter, Wetter, Drier, Colder Future?

Americans may have just survived the hottest year since 1895, but for some of us on California's coast, it's been cooler. Depending on which projections you look at, it could be wetter in some places and drier in others, and rain and snow could come at different times of year, or not, and more or less of it. It's these kinds of uncertainties that promise to bedevil our plans for the future, whether they involve farming or governing or building or planning your next environmental restoration project. No matter how you look at it, though, more extreme and unpredictable flooding, drought, heat waves, and storms are already occurring, and it's our children, not our grandchildren, who may be the first in the really hot water.

The average American may have really felt the impact of extreme events linked to climate change for the first time last fall. "People aren't open to these types of ideas unless the water is looking them in the eye. I think people in New York, after hurricane Sandy, have more of an idea now of what things we all have to think about," says scientist John Takekawa of the U.S. Geological Survey, pointing out that extremes are becoming more "normal" in other places too. "This last year has been reported as hottest in history, and people knew it because their crops died, and they lacked water across the West."

The science is solidifying. In this special issue of *Estuary News* magazine you'll discover what some of the best and brightest in Northern California are thinking about climate change, sea level rise, and how to save our beaches, wetlands and wildlife. "It is not just about what the average temperatures or sea level will be in the future—it is also that we are experiencing much greater extremes today from drought and flooding to sudden food web shifts in the ocean. These shifts could again cause crashes in the salmon and seabird populations, as happened over the past few years," says Ellie Cohen, director of PRBO Conservation Science.

Behind all the unsettling news, and the talk of barriers, sea walls, and poor progress on curbing greenhouse gas emissions, the quieter voice of the natural resources community has also been reiterating their own important message. Our marshes and creeks and beaches can help buffer us from the impacts of sea level rise and storms.

"In Louisiana, after Katrina, they've shown marshes can help with flooding and surges, and can help protect urbanized areas behind them. Without them you get more severe up and down swings in water levels, there's no sponge to absorb the change. So natural habitats are valuable for other purposes like flood retention or water quality, not just for the wildlife resources within them," says Takekawa.

Clearly, the scale of this challenge is large, and we need unprecedented collaboration at regional, ecosystem, and landscape levels (see p. 3 and insert). Signs suggest we could be on the verge of another powerful collaboration between public, private and community interests, informed by good science, like the one the San Francisco Estuary Partnership pioneered for estuary management in the 1990s.

Indeed the Partnership set a new objective in its 2010 strategic plan to make the Estuary more resilient to climate change.

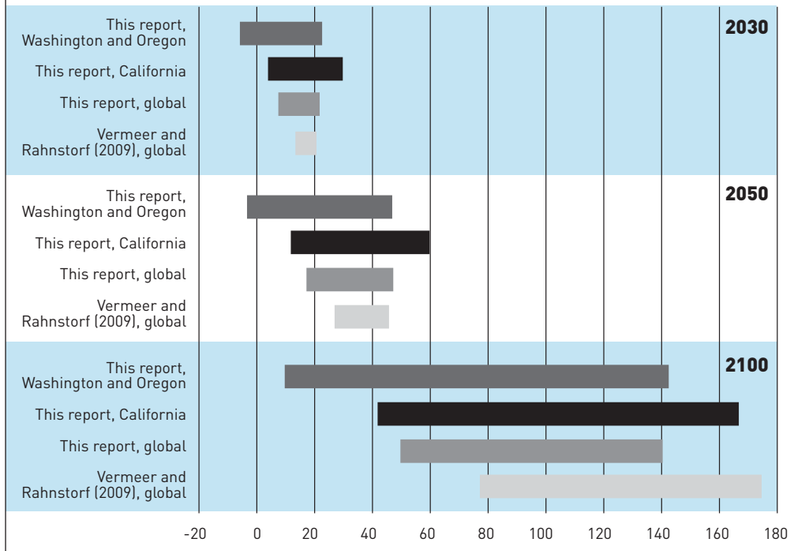
On the individual level, maybe it's time for some big picture New Year's resolutions. Drive less. Ride a bike or bus more often. Stock up on fluorescent bulbs. Dig up the lawn and plant sage. Maybe even convince your friends and colleagues that it's okay to pay taxes. Just look at all the cool things in this issue that were jumpstarted with public funding.

Thank you everyone who helped make these 20 pages possible.

Ariel Rubissow Okamoto, Editor

Cover Photo: *King tide off San Francisco's Embarcadero, a few feet from downtown skyscrapers, December 13, 2012. Photo: Michael Filippoff*

ESTIMATES OF FUTURE SEA LEVEL RISE IN CM.
NATIONAL RESEARCH COUNCIL, 2012 REPORT



Vermeer and Rahmstorf is a model that relates global surface temperature to global SLR. NRC is a more recent, robust approach that incorporates the variability in regional factors that drive SLR along the U.S. West Coast, including vertical land motion (uplift and subsidence), glacial fingerprinting, and regional wind and ocean circulation patterns. In general terms, scientists project a sea level rise for California of up to 1.6 meters (over five feet) by 2100, and also predict that winter storms will increase in magnitude and frequency. More localized projections suggest that within the next few decades, we're looking at more frequent shoreline flooding for the San Francisco Bay Area, further salt water intrusion into the Delta, and earlier snowmelt and reduced snowpack in the Sierra.

INTERVIEW

A Head Start on Rising Seas

Coastal geomorphologist Jeremy Lowe is the Sea Level Rise Program Manager for the wetland engineering firm of ESA-PWA. He is currently on the team updating San Francisco Bay's 1999 *Baylands Ecosystem Habitat Goals* to address climate change impacts. The goals originally set out to preserve or restore 100,000 acres of tidal wetlands to sustain a healthy ecosystem, and improve the fate of endangered species, but the rising seas raise new questions about future focus.

WHAT'S YOUR FORECAST FOR BAY WETLANDS?
For the next century, we've got two main stressors to our wetland habitats with different trajectories. We have sea level rise, which is accelerating, and suspended sediment concentrations in the Bay, which are decreasing. So we need to develop management measures that will increase resilience of present marshes, and prepare us for the high rates of sea level rise we're expecting to see at the end of the century. Marshes can only keep pace with sea level rise by building up sediment or organic matter and increasing their elevation, or by transgressing slowly inland. Present accretion rates will probably keep our big marsh plains going to 2050, 2060, 2070 but after that they may not be able to keep up (see Cal LCC insert).

WHAT'S ON THE *TO DO* LIST FOR THE SEA LEVEL RISE UPDATE OF THE BAYLANDS GOALS?
We're moving beyond just marsh plain restoration, and looking at the whole Baylands ecosystem, and how it overlaps with the 2010 *Subtidal Habitat Goals*.

We're adding a bay interface chapter, a mudflat chapter, and an upland ecotone chapter. All of these other parts of the baylands system provide benefits today, but in the future they're going to be even more important in enhancing resiliency of the whole system.

HOW CAN MARSHES MIGRATE UPLAND IF THEY ARE SURROUNDED BY LEVEES, CITIES AND INDUSTRIES? We might be able to help them by placing material at the top end of the marshes so instead of a steep levee slope, we provide a shallower upland ecotone slope. Another idea is to take treated wastewater, and pass it through the back of these slopes as seepage, rather than overland flow. That would allow brackish marshes and native vegetation to evolve on those slopes, and also provide denitrification, which is a big issue in the Bay. In fact we're now designing a 10-acre demonstration of this idea, with the help of regional water quality regulators, the Oro Loma Sanitary District, and the S.F. Estuary Partnership. This and other demonstrations will help us understand how the critical zone between the top end of the marsh and the bottom end of the uplands works.

WHY IS SEDIMENT THE NEW ROCK STAR IN THE BAY RESTORATION STAGE? Our wetlands can't keep up with sea level rise without it, and it's in short supply. So we need to look into how to make the most of the sediments we now dredge

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OUTSIDE THE BOX

Act & Adapt – A Tall Order for a Region

California has emerged as a national leader in climate change mitigation through aggressive laws aimed at reducing carbon emissions. But adaptation, which involves responding to the impacts of climate change such as sea-level rise and severe weather, is unwieldy at the state level. That's particularly true in the San Francisco Bay Area, where a dense population, waterfront location, and diverse range of cities, counties, and agencies make adaptation planning incredibly complex. Yet it's critical that we get it right, with so much coastal infrastructure threatened by flooding, storm surges, and sea-level rise, including many of the region's bridges, highways, airports, railways, wastewater treatment plants, seaports, and energy facilities and pipelines.

Until recently, the bulk of climate-change adaptation in the Bay Area has been piecemeal and largely conceptual. Local government autonomy continues to challenge attempts at regional coordination. But three projects are now taking exploratory steps toward a region-wide climate-change adaptation strategy, and may soon join forces.

The first, launched in July 2012, is called the Bay Area Climate & Energy Resilience Project. The project is led by the interagency Joint Policy Committee (JPC), which includes the big four in regional planning for land use (Association of Bay Area Governments), transportation (Metropolitan Transportation Commission), air quality (Bay Area Air Quality Management District) and the Bay (SF Bay Conservation & Development Commission, or BCDC). The aim of the Resilience Project is to assess the adaptation needs of diverse stakeholders in all nine Bay Area counties, including cities, special districts, and NGOs, says JPC climate strategist Bruce Riordan. "We're talking to the folks who are doing the work — or should be," he says. "From that we're devising a proposal on how to structure adaptation for the region." That includes re-

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INTERVIEW - *continued from page 3*

from the Bay, and the sediment that flows from creek systems into the Bay, or that collects in our marinas, channels, storm drains and culverts. We need to think about re-using sediment, rather than taking it out and dumping it in inaccessible areas. We also need to look at where sediment may be available in the upper part of our watersheds, or behind our dams, and whether it could be released in some way without causing flooding or water quality problems. Historically, these sediments would have moved through the back of the marsh. Today, we may want to place dredged sediments in upland areas to mimic the same function.

Another idea we may want to try is "trickle charging," placing fine sediment in the shallow subtidal area of a mudflat, and then allowing waves to re-suspend that material and carry it on to the marshes. Another idea for increasing local supplies of suspended sediment is to build living shorelines, with oyster reefs and eelgrass beds.

SHOULD WE BE CONCENTRATING RESTORATION EFFORTS IN SOME AREAS MORE THAN OTHERS? Personally, I think we should look at what we can do everywhere in the Bay, because everywhere has a shoreline and everywhere is going to have the problem of sea level rise. There will be different solutions for different areas. Sure, we probably have to do the least amount of intervention in an area like the Petaluma River marshes, where there is a good natural sediment supply and an upland transgression zone, but restoration there is not going to help East Palo Alto or Fremont. Integrating wetland restoration with flood risk management in more urbanized stretches of the Bay is going to be the big challenge but could have very big rewards.

WHEN WILL IT BE TOO LATE TO ADAPT TO SEA LEVEL RISE AROUND THE BAY? My fear is that if we aren't proactive, and come up with measures that have multiple and early benefits, as well as long term sea level rise benefits, then we're going to end up with nothing happening until we've had several extreme storms and flooding. At that point we'll decide we've got to do something right away, and it will be a knee-jerk reaction, like a big levee with steep sides, because economic losses are going to overwhelm ecological benefits. We want to avoid that, so the key thing now is to make plans that fit into our existing capital improvement plans. So we're not building something specifically for sea level rise, we're building something to do another job, like flood control or wastewater treatment or freeways, but which can accommodate sea level rise.

HOW DO WE GET STARTED? The vulnerability analyses being done at the moment are really important. It's not so much when our shorelines are going to be vulnerable, but at what elevation they become vulnerable. This gives us an understanding of how resilient our systems are, and informs adaptive management. We'll never have one solution, we'll have a Plan A that works for one range of elevations, or one range of sediment supply, and then we'll have to have Plan B, and Plan C, and Plan D as sea level rise accelerates and sediment supplies decrease. We won't have grade it, breach it, and walk away anymore. **ARO**

OUTSIDE THE BOX - *continued from page 3*

sponding not only to adverse effects like sea-level rise, but also to heat waves, water and energy shortages, and health and economic impacts. An action plan should be complete by March 2013.

The second project focuses more narrowly on sea level rise impacts on coastal areas. Adapting to Rising Tides (ART) is a partnership between BCDC and the National Oceanic and Atmospheric Administration. The ART project kicked off in 2010 with two questions in mind: How will sea-level rise and storms affect the Bay Area, and what strategies (ranging from collaborative planning by public and private interests to physical changes such as seawalls or relocation) will allow us to reduce and manage this risk? To begin to get a grip on these complex issues, the project opened with a pilot program assessing the vulnerability and adaptive opportunities of the East Bay shoreline between Emeryville and Union City. This 23-mile stretch contains significant at-risk infrastructure, including the Oakland Airport, the Port of Oakland, extensive ground transportation, and 30 different wastewater facilities. Once the pilot project is completed, ART will expand into other stretches of the bayshore, and eventually to a region-wide perspective. "Part of the reason to look at the problem at a variety of scales is to remind people that it needs to be solved at a variety of scales," says BCDC senior planner Lindy Lowe. "The only way we're really going to be able to confront this as a region is to involve all levels of governance."

BAY AREA FACILITIES AT RISK FROM 16-55 INCH PROJECTED SEA LEVEL RISE

99-186 miles of major roads and highways
70-105 miles of railroad track
22 wastewater treatment plants
270,000 residents of 82,000 acres
72-93% of airports
57-87% public access sites to shoreline

Source: BCDC

The largest, longest-term project of the three, into which the others could be folded, is also the youngest. After lengthy and contentious discussion, the JPC voted unanimously last September to take responsibility for developing a Regional Sea Level Rise Adaptation Strategy. According to outgoing JPC senior advisor Will Travis, the committee will coordinate the effort, driven by BCDC and ABAG staff. It could take ten years and $20 million to hash out a plan, he says, and likely billions of dollars and decades more to implement it. That's daunting, but the consequences of inaction will be worse. "If you have flooding that affects the transportation infrastructure, it doesn't matter if your house is high and dry," Travis says. "It would really bring the region to its knees." For the time being, it's unclear where all that money will come from; only the first phase of the planning process, which involves supporting the expansion of the ART project to other parts of the region, has been funded to date. "We're at the very beginning of a very long race," Travis says. **NS**

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CALIFORNIA LANDSCAPE CONSERVATION COOPERATIVE

CREATING SCIENCE-BASED TOOLS FOR ON-THE-GROUND CLIMATE CHANGE PLANNING AND ADAPTATION....

It's been the hottest year on record, and California's long past questioning the science on climate change and hell bent on developing electric cars, building bullet trains, trading carbon, and designing the habitats of the future, both human and wild. Perhaps it's because we've always inhabited a continental crust primed for sudden shifts of ground. Perhaps it's that we've never had enough water and we've always had too many cars. Or maybe it's that we're still a frontier state where people go to stretch their legs and imaginations. Whatever it is, we're not running from the idea that temperatures may rise by 5-10 degrees Fahrenheit by 2100, and sea level by more than five feet. Extreme weather and changes in ocean ecosystems are already with us. By the time a child born today has a midlife crisis, it could be too hot to work outside on a summer day in Sacramento, and thousands of acres of San Francisco Bay wildlife habitats could be on the verge of drowning.

"Climate change is real, it's now, and it can't be ignored. It has to be integrated into land and resource management decision-making as soon as possible. If managers stay stuck in the day-to-day, they could really miss the boat as far being prepared, and conducting actions now that are going to set them up for success in the future," says Rebecca Fris of the California Landscape Conservation Cooperative.

In 2010, the Department of the Interior set up California's Landscape Conservation Cooperative, one of 22 similar collaborative efforts nationwide. Its purpose is to get good science on how climate change may impact California's diverse landscapes into the hands of those managing parks, preserves, natural areas and rare habitats on the ground. Its official boundaries stretch from northern Mexico up to Bodega Bay, as well as into the heart of the Central Valley, and along the spine of the Sierra.

California's landscapes are already populated with hundreds of initiatives to address changing temperatures, rising sea levels, and the increasing frequency of floods and fires in the Golden State, and the Cal LCC is not trying to reinvent the wheel. It doesn't fund projects that move dirt, grow organizations, build infrastructure, or revolve around single species or properties, says Fris. Instead it looks for projects connecting climate concerns across big landscapes encompassing many jurisdictions and ecosystems, projects such as those described in the pages that follow.

Inside, you'll read about two cutting edge computer modeling projects in the San Francisco Bay Area which seek to predict the future of the region's tidal marshes – first in the path of rising sea levels. One takes a big landscape view of the region, and the other ground truths predictions of sea level rise impacts on 12 historic marshes (see p. 3 and p. 6). Used together, they've given local shoreline managers a clearer sense of how to adapt to their rapidly changing environment. On page 8, you'll read about research elsewhere in California to map wildlife migrations in the Sierra in response to changing conditions, grapple with shrinking rangelands across the state, and sustain sensitive chaparral plants in Southern California threatened by the increasing intensity of fires. The story on page 11 details four telling case studies of how to apply climate smart principles

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INSIDE: SUSTAINING MARSHES, SAVING SPARROWS, CONNECTING HABITATS

Continued from cover story

and plan for resilience on the ground. Progress reports, data layers, and on-line planning tools coming out of all this Cal LCC-funded research are being collected on California's Climate Commons (see below).

Of course, the Cal LCC has done much more in the past three years than what's highlighted in these pages. In the San Francisco Bay region, it's worked especially hard to collaborate on, and to support, existing initiatives like the Bay Area Ecosystems Climate Change Consortium and the San Francisco Bay Joint Venture, and helped fund their high priority projects including a climate change update of the 1999 regional restoration bible (aka the *Bayland Ecosystem Habitat Goals*). It has organized workshops on how to do vulnerability assessments. And in 2011, it put more than fifty scientists, local agency staffers, and shoreline landowners in the same room for a week for an exercise in structured decision-making around specific resource management planning questions.

These are only a few examples drawn from 25 projects supported by the Cal LCC with over $2.5 million since 2010. Add in partner contributions, and more than $6.5 million has been invested in preparing for California's hotter, wetter, and more fiery future.

According to Debra Schlafman, coordinator of California's LCC, "Ever since the turn of the century, natural resource management has meant looking in the past, or restoring to some past, fairly stable, state. We're trying to change that fundamental process so we can look to the future, which is more uncertain, and provide assistance with how to make decisions and set priorities."

California Landscape Conservation Cooperative
www.californialcc.org

DAYLIGHTING CLIMATE DATA

BY SUSAN K. MOFFAT

You're a land manager trying to figure out how soon sea level rise will put your bayfront hiking trail underwater. Or you're an agricultural planner researching what kind of crops a particular plot will support in the future, given climate-driven changes in rainfall. Where do you turn for information?

The California Climate Commons aims to be the go-to library, data repository, and on-line forum for planners, land managers, and scientists who need up-to-date climate change data and analysis. "We want to make the information easy to navigate, transparent, and responsive to changing needs," says Deanne DiPietro, project lead for the Commons, which is based at PRBO Conservation Science's Petaluma offices. As shelves groan with new research reports and servers swell with terabytes of data on everything from groundwater movement to bird distribution, the need for someone to organize the research, put it in context, and make it available in formats data users need has become increasingly obvious. So the California Landscape Conservation Cooperative (Cal LCC) in mid-2011 booted up the Commons.

While scientists will find this information hub useful, it's aimed primarily at practitioners who need to make on-the-ground decisions about land acquisition, restoration design, and regulatory policy changes. The creators of the Commons hope it will become a digital watering hole where information and analysis gets exchanged among researchers and land managers so that it actually shapes decisionmaking. As a funder of climate research, the Cal LCC wants to make sure that its investments in science get as widely used as possible.

Deanne DiPietro demonstrates the resources and tools hosted by the California Climate Commons. Photo: Susan K. Moffat

DiPietro and the rest of the five-person team who spend time managing the Climate Commons don't just organize and index datasets and reports. They write guides to explain issues of data scale and resolution, and detail the differences among climate models. The Commons also hosts data sets — providing the physical server and architecture for storing and disseminating information. In other words, it provides the virtual shelfspace for information, as well as the card catalog and reference librarians.

DiPietro says that the more data users participate in uploading data and discussing technical issues on the site's forums, the more valuable the Commons will become. "We hope to build a community of practice, and the library is just one piece," she says.

Tom Robinson, a planner at the Sonoma County Agricultural Preservation and Open Space District, used information from the Commons to help recommend sites for preservation that will provide the greatest ecosystem benefits, given expected changes in the climate. He needed to get a sense of what the habitat, precipitation, and groundwater conditions in the vicinity of certain parcels, and in the region, are now—and what they are likely to be in fifty years.

Through the Commons, Robinson was able to get this information from the California Basin Characterization Model, which was created by Lorraine and Alan Flint of the U.S. Geological Survey and published by the California Energy Commission. Now, anyone with an Internet connection can access the data and find historic patterns as well as projections from four future climate scenarios.

Robinson says that "breaking down research silos" is what is exciting about the Commons. By meeting up in the ether, researchers and practitioners can collaborate more effectively to make good decisions on the ground.

Climate Commons
http://climate.calcommons.org

PARTNERS: Cal LCC, PRBO, UC Davis Information Center for the Environment

12 MARSHES AT THE END OF A HOCKEY STICK

BY ARIEL RUBISSOW OKAMOTO

'The hockey stick' is what scientists call the trajectory of accelerating sea level rise projected to flood many of San Francisco Bay's tidal marshes by early next century. The uptick — the bend in the stick where so much ice melts that ocean waters suddenly warm and swell — occurs between 2060 and 2080 for many Bay marshes according to new US Geological Survey models. The models are the first of their kind to combine extremely precise measurements of the elevations of 12 bay marshes, with variables such as sediment build up, vegetation coverage, and sea level rise. The result is a carefully-crafted methodology for projecting how your marsh may change decade-by-decade that is now out in print, on the web, and in video.

"It's not going to happen overnight," says Don Brubaker, manager of the San Pablo Bay National Wildlife Refuge. "It's going to creep up on you, where you once had pickleweed you're going to have mudflat, and eventually shallow open water. Whether that happens on my watch, maybe, maybe not, but in the meantime we're going to have a window where we need to farm as many endangered harvest mice and clapper rails as we can, while it's still good habitat. After that, maybe we'll have some other restoration techniques to try that no one thought possible before," he says.

"People want to do something about climate change, in a positive way, but a lot of the information is global scale, very broad and large. We're trying to make it local and actionable," says wildlife biologist John Takekawa, part of the USGS team that studied the 12 marshes in depth.

The methodology used by the USGS team offers a new scale of sea level rise projecting that is highly site specific. "We go out and tromp around the marsh, we take elevation readings and map vegetation, and we monitor water levels and collect sediment. And then we put that all into our models and talk about what's going to happen up until 2100," says Karen Thorne, a USGS ecologist with computer modeling skills who teamed with Takekawa on the project.

In particular, the team used recent advances in technology — Real Time Kinematic GPS — to survey marsh elevations to the centimeter level of accuracy. "Many areas at the edge of San Francisco Bay have very shallow gradients, so there's not a lot of difference between those areas and the level of the water," says Takekawa.

It took three years of painstaking work involving 7,437 elevation points, 11 transects, 3,303 vegetation plots, and thousands of cross-eyed hours at the computer, among other things, to develop the methodology. At the heart of this methodology is a computer model ("WARMER"), developed by another member of the team, Kathleen Swanson. The team put both the extensive field data, and various sea level rise and sediment availability scenarios, into the model. Although the scenarios are just scenarios, what actually happens in the future is uncertain, the resulting projections do give us an idea of how 12 of the region's most established wetlands could evolve from pickleweed- to cordgrass-dominated marshes, and later into mudflat and subtidal habitats, as the sea level rises (see chart p. 4).

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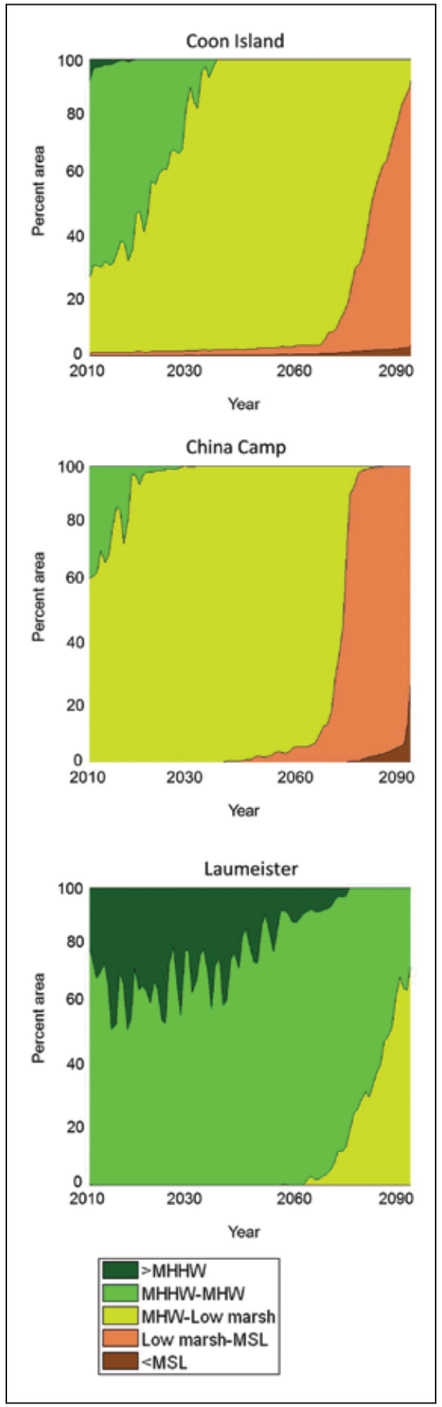


These figures depict habitat change to 2100, with increasing marsh loss after 2050 (the bend in the hockey stick projection for rapidly rising sea level). The colors represent habitat types at each marsh site. MSL represents mudflat habitat, MSL-Low marsh is the Spartina zone, low marsh to MHW is pickleweed habitat, MHW to MHHW is the upper marsh area with MHHW is the upper marsh transition zone.
Source: USGS, 2012.

Below: China Camp State Park

Continued from page 3

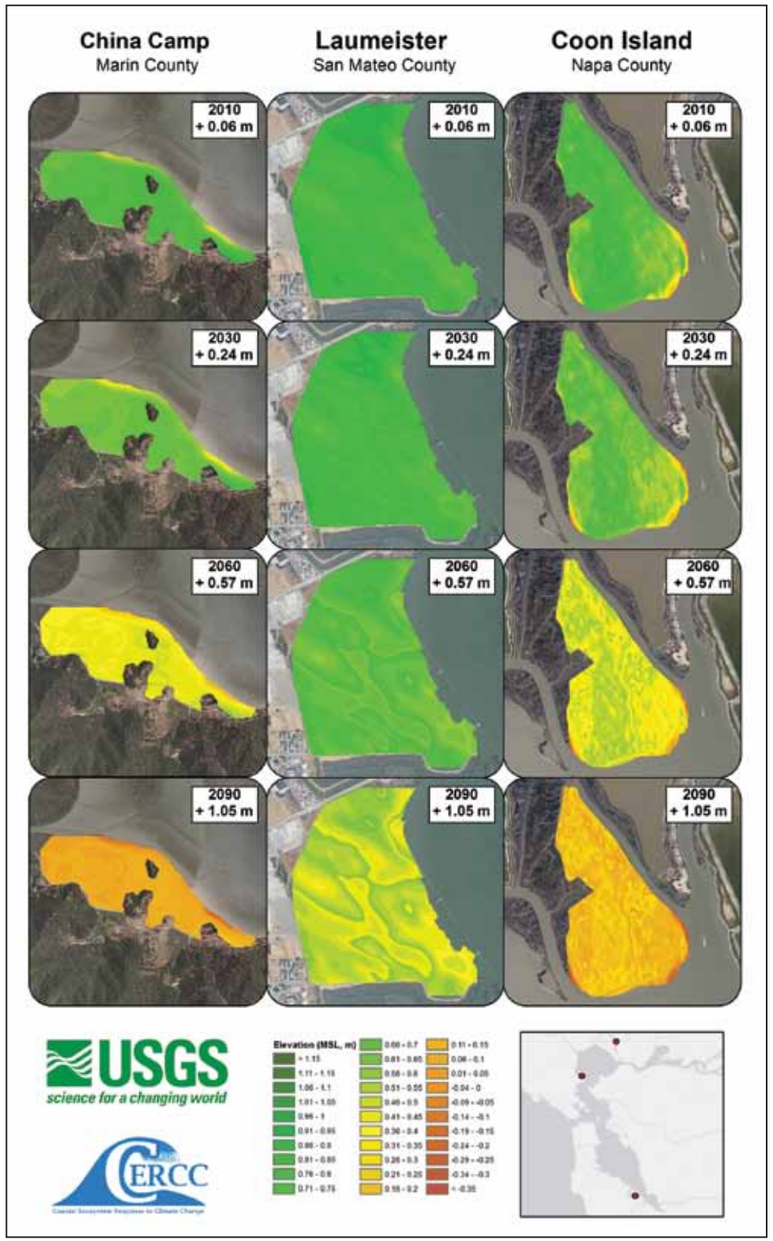
The study's results can be found on the web and in the USGS 2012 open-file *Final Report for Sea-Level Rise Response Modeling for San Francisco Bay Estuary Tidal Marshes*. According to the results, almost all of the marshes in the North Bay, including China Camp in Marin County, and sites along the Petaluma River, could flood completely by 2080-2100, after the bend in the hockey stick when sea level rise accelerates.

South Bay marshes could do better. "The difference has less to do with age and more to do with geography, where they are in the Bay," explains Thorne. "Marshes in the North Bay didn't keep up as long as marshes in the South Bay largely because sediment accretion rates are different." Marshes naturally keep pace with sea level rise by trapping sediment and accumulating organic matter, at least until the water level starts rising faster than they can build up. This set of models is particularly detailed because of localized accretion data collected in the San Pablo Bay Wildlife Refuge by the USGS team, and backed up by earlier work in other marshes led by University of San Francisco wetland ecologist John Callaway.

According to the team's future projections, the South Bay's Laumeister Marsh may survive longest, while Marin County's Corte Madera marsh may be the first to go under. Laumeister turns out to be in a good spot to collect sediment, whereas Corte Madera had further to go to keep up, because it has the lowest starting elevation of the 12.

"Knowing the elevations helps us predict when changes in water level will become a problem for species trying to survive in these fringe habitats," says Takekawa. "They live on the edge of the Bay and the edge of existence, in the zone where water meets land and where habitats change quite a bit. So when a climate change occurs that, from an evolutionary perspective is relatively rapid, it's likely wildlife populations will change too. They can't adapt that fast."

The good news is that all 12 marshes were able to keep pace for the next four or five decades. "We encourage people to look at this as a positive period, when you can boost your resources, and try to keep them very healthy. That way when the rapid sea level rise comes, your adjustment is from a base of strength, rather than from fragmented, weak populations across a landscape that have no chance of surviving," says Takekawa.



This window of opportunity has shoreline managers already looking at the ups and downs of the North and South Bay results to see what opportunities they may present for stronger adaptive management. While the North Bay has lower sediment accumulation rates, for example, it has more open space behind marshes where wetlands could migrate inland and stay viable – so opening up avenues for tidal influence further inland may be important. And while South Bay marshes may build up more easily, and have a bigger sediment supply, most border big levees with houses and urban areas on the other side – leaving them little room to migrate inland. So managers there are considering innovative types of setback levees and ways to help marshes grow in place.

Matt Ferner, who coordinates research for the National Estuarine Research Reserves at Marin's China Camp and Solano's Rush Ranch, has been given mandates to address climate change but hasn't had the money or the computer modeling expertise to do much. "It was a breath of fresh air to have the USGS scientists come in and do the RTK surveys, think carefully about the habitats, monitor the water levels, and develop this really nice report that has explicit predictions we can turn to," he says.

Ferner compared the projections for China Camp with detailed maps of the reserve, and with projections from two other sea level rise modeling efforts — one done by PRBO conservation science (see p. 6) and one done by U.C. Berkeley doctoral student Lisa Schile. "I was relieved that these models agreed on where the most sensitive and most dynamic areas are at China Camp," he says. "Using these tools, I looked for the places where we have the most diverse plant communities, and where change was predicted to occur quickly because of steeper elevation gradients, or because of dynamic features in the vegetation. The comparison enabled me to lay out our transects across the marsh for long-term monitoring, so we can see if actual changes in the marsh match up with predicted changes."

Ferner says the model projections also helped him move a key project to the front burner, namely the restoration of two brackish marshes cut off from the bayfront marsh by North San Pedro Road. "If there's any chance of China Camp marshes surviving accelerated sea level rise, it's going to be by transgressing up slope, but with the road in the way that's not going to happen," he says. "The report helped us get our brackish marsh restoration project top priority status with state parks."

On the 17,000 + acres of the San Pablo Bay Wildlife Refuge, Brubaker has also been shifting his management perspective based on the USGS findings. He talks about what he calls "restoration on the fly," a happy euphemism for "adaptive management." He points out that over a big, complicated, three-year restoration project like the one he has underway at Cullinan Ranch, "later and greater" climate change modeling information can come in during construction, and you've got to be ready to make adjustments.

"Models are a great tool, but when it comes down to doing stuff on the ground, it may be just a matter of let's just push this up a little higher with the dozer, or, as we cut away this levee, let's smooth out the leftover material into an extra island, or stockpile it on site for later levee-raising. Or let's cut this channel in a slightly different direction in case of a storm surge. We want to build in a certain amount of resiliency, because errors in those models could be just a matter of centimeters, and 2-3 centimeters could put your high tide refugia underwater all the time. Then you'd wonder why, when you had the dozers and excavators out, you hadn't added a few more scoopfuls of dirt," he says.

Giselle Block, a biologist who works for the U.S. Fish & Wildlife Service's Inventory and Monitoring Program, says response from refuge managers like Brubaker has been very positive all along the West Coast. Indeed, with support from the California Landscape Conservation Cooperative (Cal LCC), the USGS model is now being applied in the Tijuana Slough refuge on the California-Mexico border, and at the Seal Beach Refuge on Anaheim Bay. California's neighboring LCC pitched in to take the model north to Humboldt Bay, and USGS Climate Science Centers are supporting work in coastal marshes in Oregon and Washington. "This is not something refuge staff or budgets could get done by themselves. They're getting assistance in areas that take quite a lot of expertise," says Block. "This work not only informs what we do on individual refuges, but also informs at a regional level, and at a higher leadership level. Few refuge managers could make the kind of changes we need alone," says Block.

No wonder Thorne's phone has been ringing more since the report came out, and many of the calls aren't local. Indeed Thorne recently got a call from Ferner's boss in Washington, who wants to encourage similar collaborations between scientists, research reserves and LCCs across the country.

"We've found that rather than just saying that everything's going to be gone or different by 2100, which can be paralyzing, it makes more sense to talk in decades. People almost always circle back to shorter-term goals and strategies. They aren't ready to give up, they want the wildlife to stick around," says Thorne.

12 Marsh Results, USGS
www. werc.usgs.gov/sfbayslr

PARTNERS: USGS, USFWS, Cal LCC

CLIMATE-MINDED WEEDING

BY JOE EATON

Invasive plant and animal species may benefit from climate change, finding altered habitats more hospitable. With Cal LCC support, the California Invasive Plant Council (Cal-IPC) is prioritizing landscape-level responses to invasive plants. Cal-IPC has been working to implement regional strategies based on CalWeedMapper, an online decision-support tool with statewide maps for 200 invasives showing future spread projections under midcentury climate conditions. The first region to begin on-the-ground implementation has been the Central Sierra.

"It's not rocket science," says Cal-IPC's Doug Johnson. "But the tool is able to evaluate invasive plant species over a large territory, and then put it into a digestible form so managers can draw conclusions about regional management options ranging from eradication to containment to surveillance."

Cal-IPC's regional prioritization work using CalWeedMapper fills the gap left by the defunding of the California Department of Food and Agriculture's weed control program. "There's consensus that controlling invasive species is a no-regrets action that can be taken immediately to help native species adapt to climate change," says Johnson. "This landscape-level approach makes sure that we're getting the most conservation impact with limited funding."

CaWeedmapper
http://calweedmapper.calflora.org

California Invasive Plant Council
www.cal-ipc.org

MARSH BIRDS SQUEEZED

BY LISA OWENS VIANI

The Estuary's rarest and most unusual birds—those that skulk and flit through pickleweed, cordgrass, and gumplant, their buzzy trills and rattles often the only clue to their presence—are in trouble, having lost much of the tidal marsh habitat that used to fringe San Francisco Bay. Their future may be even grimmer as sea level rises and the climate changes, say scientists, based on recent Estuary-wide modeling done by PRBO Conservation Science. And while the birds are threatened on one side by rising water, predators lurk on the other side of the marsh in the uplands the birds need as a refuge.

The future of the Estuary's tidal marshes—and tidal marsh birds—will depend a lot on mud. If sea level rises and marshes do not keep pace by collecting sediment and building up ("accreting"), habitat will likely be inundated for the endangered California clapper rail and threatened California black rail, as well as for several California species of concern: three tidal marsh song sparrow subspecies and the San Francisco common yellowthroat. Can't birds just fly away and nest and forage elsewhere? Not tidal marsh obligates, says PRBO's Julian Wood. "These birds live their entire lives—and have evolved to adapt to—this harsh environment with high salinities. If this habitat is gone, these birds will be gone as well."

With support from the California Landscape Conservation Cooperative (Cal LCC), the Coastal Conservancy, and others, PRBO's Sam Veloz and partners took a look at what the future may bring for tidal marshes and tidal marsh birds. They modeled marsh accretion using two sea level rise scenarios: high and low sediment input, and high and low organic accumulation. These are the two ways marshes build up naturally, by collecting sediment from mudflats, bay waters, and runoff, and by growing plants that decompose and leave new layers of organic matter. Modeling by federal and state scientists suggests that the bay's sediment supply is slowly decreasing, but some parts of the bay are more sediment rich than others. Organic accumulation assumptions depended on salinity and followed previous modeling by PRBO's Diana Stralberg.

Albany shore and fringe marsh. Photo : Drew Kerr

"We found that tidal marsh sustainability over 100 years was very sensitive to the sediment scenario used but not to organic accumulation," says Veloz. Veloz then used the high and low sediment models—and PRBO's long-term studies of tidal marsh birds—to try to figure out how the four tidal marsh dependent birds, plus the more common marsh wren, will respond to changes in marsh elevation—a proxy for nesting and foraging habitat—and salinity.

"The worst case scenario [high sea level rise, low input of marsh-building sediment], shows declines for all of those species, even the marsh wren," says Veloz. "Most of them trend down to 100 percent loss. Clapper rail, interestingly, does the 'best,' but they're starting from such a low number."

Song sparrows, of which there are three endemic subspecies in bayland habitats around the Estuary, fared poorly. "If we assume high sea level rise, under low sediment, we project a 50-100 percent decline in the Estuary's song sparrow population," says Veloz. But under high sediment conditions, the population could increase slightly—at least initially. "You see the dramatic effect of sediment. Given the same sea level rise scenario, you could have a sustaining population or a really declining population."

Common yellowthroats and marsh wrens showed a greater sensitivity to changes in salinity. These species are more abundant in brackish marshes with taller vegetation like tules and bulrushes, which grow where salinity is lower, as in Suisun Bay. But if those marshes flood and become more saline, that habitat could disappear.

Resource managers can visit PRBO's Climate Smart Planning Tools where maps based on the various modeled scenarios demonstrate how sea level rise could affect tidal marsh and birds around the Bay over the next 100 years. The tool is also designed to assist funders in deciding on whether to fund specific projects. "We want people to use the tool to see how their site responds to different scenarios,'" says Veloz. He urges people to look at a range of possibilities, not just pick one scenario. "Even if you pick a scenario that doesn't turn out to be true, you're still better off than ignoring the future in terms of providing tidal marsh habitat for birds."

Veloz says his other message for managers who are planning restoration projects is to think about resilience. "All of the restoration projects we're engaging in are valuable to tidal marsh birds, but some projects are more resilient to all of the different scenarios we modeled. If you're in a high sediment area, your project is more likely to be sustainable, but regardless, birds do better if we do restoration than if we don't." In other words, even if a project might be under water in 100 years, the habitat it provides in the meantime will help boost bird populations along the way.

One resilient site seems to be Sonoma Baylands. "That one comes out really well because it's in a high sediment area plus is such a large restoration project and includes areas that are now upland. It's also at a higher elevation and has more capacity to allow the marsh to transgress in the future. So there's a lot of adaptive capacity in the project," says Veloz.

Restoration sites that are less resilient—where there is less sediment coming in and building up—may need to be managed more adaptively, he points out. "If we get high sea level rise rates, we might need to bring in sediment. Or if you're starting now, you might want to engineer higher elevations and allow for transgression as sea level rises." The bottom line? Start planning now, and have a plan in place, suggests Veloz.

Losses of nesting, roosting, and foraging habitat aren't the only possible problems looming for tidal marsh birds. Predators, changes in temperature and precipitation, and extreme tides pose additional challenges. To assess these and other potential risks, PRBO's Nadav Nur developed population-dynamic models of the long-term viability of black rail, clapper rail, common yellowthroat, and song sparrow populations. In a closer look at song sparrows, PRBO scientists analyzed 11 years of data collected from 7 different marsh sites and 3,000 nesting attempts, and developed a more complex population-dynamic model incorporating the sea level rise and climate change scenarios from Veloz's model, and the same assumptions of sedimentation and organic matter accumulation. In addition, Nur's modeling drew on projections for future temperature, precipitation, and extreme tides.

When they analyzed the 11 years of song sparrow nesting data, "The magnitude of failure due to flooding surprised us," says Nur. In some years as many as 55 percent of nests had failed. Nur and his colleagues then analyzed the species' reproductive success in relation to projected changes in temperature, precipitation, and extreme tides. The higher the extreme tides, the lower nest success was.

Nur says that overall rates of nest failure due to predation and flooding are currently too high to allow for song sparrow populations to be stable or to grow. "Any additional nest failure will tip the balance between population stability and decline," says Nur—even one additional extreme high tide in 10 years is sufficient to affect song sparrow population trends. He adds that while most people think of the "king tides" as being a winter phenomenon, tides can also be quite high during the spring — just when song sparrows are nesting.

The problem is that tidal marsh birds face two devils, says Nur: nest predators and flooding. If tides get too high, nests will flood. But if birds choose to build nests higher in the vegetation, the nests will be more conspicuous and accessible, becoming as Veloz puts it, a "predator buffet."

managers and getting their feedback, as well as making presentations at meetings and conferences. "Eventually what we'd like to see is as people use the tool, to put their info up on the web site. When new people come, they can see how others have used it," says Veloz.

The next step is for PRBO to overlay its bird demographic model onto the sea level rise maps so that managers can see both changes to the marsh and potential changes to bird populations at the same time.

Marsh wren (left), San Francisco common yellowthroat (center) and tidal marsh song sparrow (right). The latter two species frequently nest in the bright yellow gum plant that lines tidal marsh channels. Gumplant grows taller than other marsh plants, and the birds can conceal their nests in leaves up above the high tide level. The clapper rail sometimes nests in the open marsh plain in clumps of Spartina or in dense pickleweed. Black rails prefer to nest in tall, dense vegetation, especially alkali bulrush. Black rail nests are so well concealed that you can be standing right over them and not even see them. Photos: Jerry Ting

Changes in precipitation will also affect song sparrows, Nur found. "The models showed the wetter and cooler the breeding season, the longer the breeding season; yet nest survival is lower. Conversely, during breeding season when conditions are expected to be drier and warmer, nest survival will increase, but the breeding season will shorten, and the number of breeding attempts will decrease."

The news from the models is not completely discouraging. They also showed that short-term (20-year long) management actions could help the populations of all four tidal marsh obligate birds recover or at least arrest their decline. Actions could include removing or reducing predator populations—or possibly more importantly, removing predator access to marshes.

PRBO has been getting the word out about its online Climate Smart Planning Tools by showing them to resource

Says PRBO's Ellie Cohen, "Birds are great indicators of what's happening in the world around us. Everybody's been asking us what can we do differently today to address climate change. These new tools allow managers to see a range of possible future scenarios so they can make better decisions today. Support from the Cal LCC and Coastal Conservancy helped us to take these tools to a new level, not only to communicate different potential future scenarios but also to prioritize restoration sites across multiple scenarios so we can reduce the impacts of climate change and secure more healthy ecosystems in an ever changing world."

PRBO Climate Smart Planning Tool
http://data.prbo.org/apps/sfbslr/

PRBO Population Dynamics Models
http://data.prbo.org/apps/sfbslr/demography

PARTNERS: PRBO, Cal SCC, Cal LCC

CALIFORNIA'S WILDLIFE REACTS TO CHANGING CLIMATE

BY SUSAN SULEIMAN

Nearly a century ago, Joseph Grinnell, the first director of the Museum of Vertebrate Zoology at the University of California, and a man who spent 38 years on a definitive list of the state's birds, was aware that his painstaking notes might be all that remained of many of the species he chronicled.

"The India ink and paper of permanent quality will mean that our notes will be accessible 200 years from now," he wrote to the museum's founding patron, Annie Montague Alexander. Grinnell added, by way of explanation: "We are in the newest part of the new world where the population will be immense in fifty years at most."

As prescient as Grinnell was when he assembled his early ecological map of California, he didn't foresee climate change. Climate change is already affecting wildlife from Lassen Peak to Mount Whitney, the same places Grinnell conducted field research to build the museum's collection of California species. Rather than engaging in the basic science that Grinnell pioneered, scientists today are using cutting-edge technology to fashion plausible scenarios that can help land managers include climate change in their decision-making. It's a bit like preparing for war. But instead of a map with pins indicating troop movements, they are putting together a new biological map, tracking the movements of birds and mammals as they adapt to rising temperatures and see-sawing rainfall. Since 2009, key pieces of this strategic map have been falling into place with the help of collaborative initiatives and support from the California Landscape Conservation Cooperative (Cal LCC).

As Hurricane Sandy revealed, the climate war is everywhere. But the American West has been affected more dramatically than most places. From 2002 to 2007, the average temperature increase in the western U.S. was 70 percent greater than the world average. Scientists studying California are observing an increase in rain versus snow, and earlier budding of plants. (More rain might sound good to perpetually water-starved California, but without storage, the most tangible effects are likely to be flooding and mudslides.) Fires also are becoming more frequent and severe.

In other words, climate change isn't a distant possibility. It's here.

"One way to think about it is this: when people were debating about whether climate change was happening, a lot of the plants and animals had figured it out," says Steve Beissinger, a professor of Conservation Biology at UC Berkeley.

Ten years ago, Beissinger and a team of scientists undertook an historic task: re-surveying the landscape where Grinnell and his colleagues tracked California's birds and mammals. Between 2002 and 2007, they used Grinnell's colorfully annotated maps as they tromped around Yosemite, Lassen and Kings Canyon National Parks, and Southern California's White Mountains.

In Yosemite, the researchers noted that about half of the small mammal species had remained in place. Others, such as the pinyon mouse, had migrated uphill, seeking cooler temperatures. This wasn't entirely surprising: minimum temperatures in the central Sierra had warmed by 5-6 degrees Fahrenheit since Grinnell's surveys. But it wasn't always clear why species reacted differently. As they resurveyed other parts of the state, the picture only grew more complicated.

"Sometimes two species in the same genus might have different patterns," Beissinger says. "One might be moving uphill and another not at all. When we started looking at birds, we saw some species moving up, as we expected with climate warming, but others were moving down. And the same species was doing one thing in the Sierra and another in Lassen."

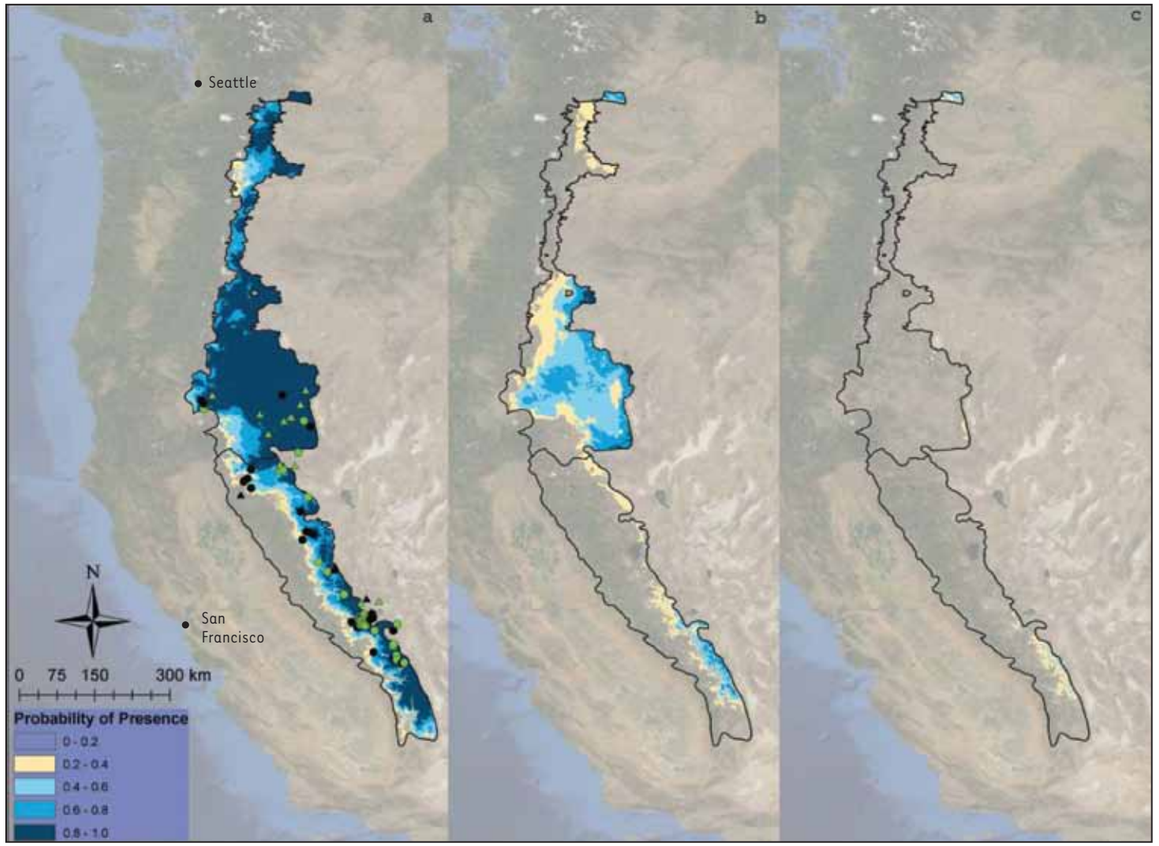
"We began to get a sense of how climate change is different in different places and how it is different for different species," says Beissinger.

The two main variables are temperature and precipitation, but California's mountain ranges seemed to be experiencing many permutations of those two, according to Beissinger. While Yosemite was warming, Lassen was growing cooler and rainier. The southern Sierra were warming, and experiencing the same amount of rain or getting drier. Plants and animals were all over the map, too, with some reacting to temperature, while others responded to precipitation.

"With montane species, there's a push and pull; warmer temperatures push species upslope to stay in the same climate, since temperate decreases with altitude. But increased rain pulls them downslope, because rainfall generally increases with elevation," he says.

Climate change gets even more complicated when you consider the conundrums faced by land managers. That's where the new map being constructed by scientists becomes not just an interesting set of observations but also something of practical use.

"With a changing climate, you're likely to have new species coming in," Beissinger says. "You might think, 'Wow, this could increase the biodiversity in my reserve!' That could be true, for a period of time. But it will be a species colonizing at the warming end of their geographic range. For species at the cool edge of their range, or for an endangered



Belding's ground squirrel, **Urocitellus beldingi**, *species distribution model results projecting (a) current distribution from historical presences and absences, (b) future distribution from less severe climate change scenario and (c) future distribution from more severe future scenario.*
Source: Morelli et al. 2012 Proceedings of the Royal Society B.

species, you could have a whole lot of problems. In addition, exotic species and new diseases from locations with warmer climates are showing up."

One thing became clear after Beissinger finished his study: land managers needed to plan, and do it quickly. Like the rest of the country, many of California's parks, forests, and wildlife refuges had been established back in Grinnell's day, when scientists didn't understand landscape-level conservation. Scenic vistas, so-called "rocks and ice" were protected, but lowland habitat needed for migrating species was often left open to development. As climate change forced species from their customary niches, scientists felt they had to move quickly to update California's biological map. It wouldn't be possible to save everything, but prioritizing areas essential to wildlife could help buffer the impacts of climate change.

In California, researchers had the advantage of the state's tradition of valuing its landscape, which included a wealth of scientific research, and of land managers accustomed to collaborative decision-making. For example, post-doctoral researcher Toni Lyn Morelli would never have known that the Belding's ground squirrel was disappearing from the Sierra without access to Grinnell's exhaustive research. Grinnell had studied this common squirrel, also called the sage rat, pot gut or picket pin, in 1918. With funding from the National Science Foundation and later the Cal LCC, Morelli, under the direction of principal researchers Craig Moritz and Steve Beissinger, decided to study the squirrel because small mammals can be bellwethers of climate change, reacting to both temperature and precipitation.

"I went back to every site I could find," Morelli says. "I brought along female undergraduates on backpacking trips through Yosemite. Some of them had never been hiking before, and it was a great experience for them. And then our data surprised everyone."

When the results came, Morelli's research showed that while heads of state were arguing in Kyoto, Copenhagen, and Durban, Belding's ground squirrels had disappeared from 42 percent of the sites where Grinnell and his team saw them.

Morelli and another post-doctoral researcher, Sean Maher, drilled down to causes and solutions. The Belding's ground squirrels live in meadows, where cooler air pools, providing a buffer from climate change. But these oases are

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fragile, and many were disappearing. Their research is now being used to help land managers identify these climate refugia for protection.

Belding's ground squirrel, aka sage rat, pot gut or picket pin. Photo: Toni Morelli

While Morelli and others update and collect information about specific species in specific places, others are weaving together that information in the larger map of the region. The Cal LCC provided support for Jason Kreitler, a research geographer with the U.S. Geological Survey (USGS), to develop an overall map that will help land managers incorporate climate change scenarios into management of wildlife corridors. Kreitler has developed algorithims that apply general circulation models of the earth's oceans and atmosphere to the specific topography of California. He's fine-tuning and coordinating climate change modeling with scientific knowledge of wildlife behavior. Because his mapping stretches across jurisdictions, he's found himself communicating with all kinds of agency personnel.

"People are doing this kind of climate science in different parts of the country, but in the Bay Area people are used to working collaboratively, and tackling issues without waiting for the federal government. So the response of managers has been: 'Great! Tell me what I can do.' With the Cal LCC involved, there's an incentive for interaction with different agencies, state land managers, the forest service, everyone," Kreitler says.

"Everyone" includes people who farm or run cattle ranches. Another Cal LCC-funded project is sketching out possible futures for California's shrinking rangelands. Thirty one million of the state's more than one billion acres are grazed, and much of this land provides habitat for wildlife as well as domestic animals. Kristin Byrd of the USGS is working with a multi-disciplinary team looking at both climate and development patterns in the Central Valley and its surroundings. Byrd says that the most likely scenario is that higher temperatures will, in the aggregate, reduce water availability for pasture and wildlife. The researchers are identifying water and wildlife "hotspots" and assessing their vulnerability, information that can be used not only by wildlife agencies but also for land-use planning.

In a panoramic view, how does this emerging map of 21st century California look?

"Landscapes are really lumpy out there, in terms of what will happen to them, climate-wise," says Steve Beissinger. "Some species will adapt. Others will move, which increases the importance of connectivity. And others may disappear if we don't find ways to sustain them. What did that great social critic and songwriter Tom Lehrer say? 'Be prepared. It's the Boy Scout marching song.' "

California Climate Commons
http://climate.calcommons.org/
Grinnell Resurvey Project
http://mvz.berkeley.edu/Grinnell/

Partners: UC Berkeley, USGS, Cal LCC

THE TRIPLE THREAT

BY JOE EATON

Climate change doesn't act alone. Resource managers must address its interaction with other forces, such as habitat loss and altered fire regimes. Case in point: San Diego County's chaparral, where sensitive plant and animal species were being displaced by urban development and stressed by more frequent fires before climate change was on anyone's radar.

In another Cal LCC project, UC Riverside biologist Helen Regan is developing a management decision tool for that triple threat. Her team looked at three shrubs: Tecate cypress (*Hesperocyparis forbesii*), a California near-endemic and the only host of a rare butterfly, Thorne's hairstreak (*Mitoura thornei*); wart-stem ceanothus (*Ceanothus verrucosus*), also endemic; and the more widespread desert ceanothus (*C. greggii.*) None are listed as endangered or threatened; but the cypress and *C. verrucosus* are covered by the San Diego Multiple Species Conservation Plan.

A wildland fire in mixed chaparral moving downslope in San Diego, California. Photo: Richard W. Halsey

All three plants require fire for their seeds to germinate. "But fires in quick succession can be a threat," says Regan. With a fire- return interval of less than 20 years, they can't produce enough seeds to persist. (Unlike some relatives, the two ceanothus species don't resprout after fires.)

The project used two climate models, one predicting drier and warmer conditions, the other wetter and warmer, along with species distribution and urban growth models. Results: "Suitable habitat is projected to decline in most cases, but frequent fire is a much more serious threat than loss of habitat with climate change." Regan plans to include the threatened California gnatcatcher (*Polioptila californica*), a coastal sage-scrub bird, and the big-eared woodrat (*Neotoma macrotis*) in the next phase of her study.

Her US Fish and Wildlife Service collaborators "want a scientifically defensible method for investigating the potential of different types of management action under the threats of climate change, urban growth, and altered fire regimes," she says. "They're interested in how the science can inform managers."

CLIMATE SMART HOW TO?

BY ARIEL RUBISSOW OKAMOTO

If anyone could be called a cheerleader for climate change preparation in the San Francisco Bay Area, it might be Ellie Cohen. Listening to her speak at a November 2012 Climate Smart workshop for regional professionals, it was hard not to imagine red hot poms-poms twirling above her head. Her sense of positive purpose, her call for constructive work, is as enlivening as looking at climate models is deadly. But there are more like her. Cohen is part of a diverse group of Bay Area professionals that meets quarterly to discuss what information land, water and wildlife managers need to plan ahead, and how scientists can better provide it. This Bay Area Ecosystems Climate Change Consortium (BAECCC), formed in 2009, collaborated with The Nature Conservancy and the California Landscape Conservation Cooperative to put on the workshop where Cohen made her pitch for action.

"To prevent total climate chaos, we have to engage in both mitigation and adaptation, whether you're a city planner or a governor or a parks director or the President," said Cohen, who heads up PRBO Conservation Science. "Conserving ecosystems is just as important as reducing greenhouse gas emissions. We need to collaborate and coordinate from the ocean to the Sierra, break down the silos in the way we do our work, and share information openly across organizations and communities."

Cohen was one of 12 speakers who acquainted the 130 attendees at the Oakland workshop with the climate changes projected for the Bay Area, and what we might do about them. First, the USGS's Tom Suchanek gave an overview of west coast trends in precipitation, temperature, wave surges, storm frequencies and sea level rise. USGS projects a 3-6 degree centigrade rise in temperature for Northern California, and 45-165 cm (16-65-inch) rise in sea level by 2100. "Wave surges are going to increase in magnitude and frequency. How many 100-year storms are we going to start seeing every year?" he asked. Part of being prepared is to do a vulnerability assessment, and the next speaker, The Nature Conservancy's Kirk Klausmeyer, explained how to do one. If you can figure out where on your property vulnerability is low and where high, you can take informed actions to minimize threats and enhance resilience, he said.

In the next section of the workshop, land managers described what steps they had taken to make their restoration or acquisition or development projects "Climate Smart" – a new term adopted from the National Wildlife Federation by workshop organizers. As one speaker commented, "We called it 'resilience' a couple weeks ago."

First, the National Park Service's Carolyn Shoulders described restoration work at the mouth of Redwood Creek at Muir Beach, on Marin County's ocean coast. The work involved realigning the creek channel to follow its more natural course and to fully connect the creek with its floodplain, rebuilding a pedestrian bridge over the new floodplain, and expanding a tidal lagoon. In summer 2013, the visitor parking lot that has dammed the system for decades will also be relocated. "Visitor access is still important, but needed to be accommodated without compromising ecosystem function," she said. "The hallmark of the project is that it allows natural floodplain processes and creek migration, and it's no surprise that the benefits of opening up the flood plain will increase with sea level rise. We removed obstacles so the landscape can adapt as it may."

Next, The Nature Conservancy's Sasha Gennet described a strategic assessment they conducted of how Mt. Hamilton's open spaces south of San Jose would adapt to climate change. Though the assessment suggested this landscape might be relatively climate resilient, connectivity of wildlife habitats emerged as a real concern. "The mountain could become an island, it's very threatened by development spreading south from Silicon Valley," said Gennet. As a result, the Conservancy took a broader, more regional look at habitat connectivity and ended up identifying one unassuming, degraded stretch of riparian habitat in the Pajaro Creek watershed "as a small but mighty piece of the connectivity puzzle," she said. "It was a challenge to convince our funders that this 167 acres of farmland was a linchpin property, and that acquiring and preserving it should be the highest conservation priority in the Bay Area," she said. She described plans for restoring some riparian habitat on the linchpin property, and returning other areas to farming or grazing uses. "Increasing the pace and scale of protection and restoration in the face of climate change is important, but stewardship is incredibly expensive and forever. We have to engage private landowners, including the farming community, in adaptation," she said.

Next, the Sonoma Land Trust's Julian Meisler identified three climate change challenges for his 2300-acre shoreline restoration site at Sears Point: designing a marsh that wouldn't go underwater with sea level rise; providing refuge for endangered wildlife from extreme events (such as a combination king tide and storm); and anticipating what level of protection was necessary for the adjacent railroad and highway infrastructure. "Highway 37 is completely in harm's way, it sits at or below sea level, and we need to be careful we don't worsen the condition," he said. To address some of these challenges, the project includes a big levee complete with setbacks and stockpiles of sediment stored in place so it can be used later to raise the levee as needed. In closing, Meisler said the smartest, most resilient, restoration actions work under multiple climate change scenarios, and that an even bigger challenge may the strings and deadlines attached to many restoration grants.

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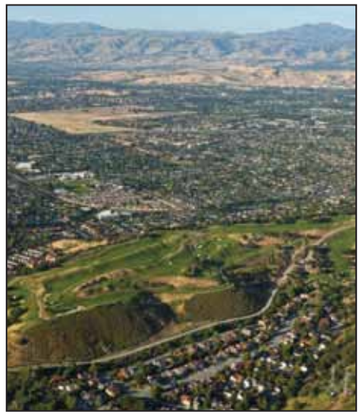
The next speaker, John Parodi who manages PRBO's STRAW program, called climate change in restoration "a game changer." Parodi described a recent experiment in which he modified the planting palette and lay out for a stream-side restoration project in Marin County with climate change in mind: "We added redundancy to our design, we wanted to make sure if one piece of the project failed another would be there to take it's place." To do this experiment in coastal Marin County, he and 282 students and 82 parents did a traditional and a climate smart restoration side-by-side, so STRAW can compare results in the decades ahead. In the climate smart plot, they planted twice the number of species and also at a higher density, for example, and also included some atypical species based on projected changes in precipitation. "We tried to end-run it and get rock-star plants that could handle both extremes," he said.

After these case studies in how to adapt on the ground, the final hours of the workshop were spent on some key tools and information for managers now brewing in various computer models and labs around the Bay Area. David Ackerly from UC Berkeley described the Terrestrial Biodiversity Climate Change Collaborative, and work to downscale models of global climate shifts to the local and watershed level. The models project a sharp rise in summer temperatures, but less of a change in winter months. "The entire Bay Area is going to shift to a new climate, it will be more like Santa Barbara in San Francisco," he said. He urged land managers to confront the possibility that rock star species like blue oaks might not be the showpiece of their properties in the future. "If your focus is a piece of parkland, you won't be able to move the land, and your favorite species may disappear," he said.

The workshop closed with descriptions of several powerful climate change planning tools under development. Stuart Weiss of the Creekside Center for Earth Observation described watershed change projections for 18-acre grids developed by USGS's Alan and Lorrie Flint, which model 100 futures over 10 Bay Area counties. Combining some of their modeling with data on soil storage, recharge, runoff and other factors, he and others have been developing tools to assess what he calls an area's "climatic water deficit" (dry season intensity and stress). After Weiss, Ryan Branciforte described the Bay Area Open Space Council's efforts to enhance the Conservation Lands Network Explorer with a new feature that will allow users to access projections of climate change. "We're trying to customize the tool to show you what your city, your county, might look like in the future," he said. Indeed the many modeling tools that have rapidly been developed over the past few years for the Bay Area, along with other planning resources and research results, are well organized



View looking east toward Mt. Hamilton, with development encroaching across the Santa Clara Valley floor. Just south lie the farms and ranches of the Upper Pajaro Valley, where conservation and restoration could not only protect farming but enable animals to move between big blocks of core habitat in the mountains, and adapt to climate change. Photo: William K Matthias

and presented on-line on the California Climate Commons, explained the final speaker, Deanne DePietro.

After the workshop, several participants commented on its usefulness. Erin Chappell, from the state's Department of Water Resources, whose job it is to bring one of the largest water agencies in world, as well as numerous local water agencies, up to speed on climate change, said: "Most people can understand the climate change concept, but when it comes time to design your water supply or flood control or restoration project, it's not so clear what it should look like. These climate smart principles interest me because they provide a link from theory to practice, and the case studies make the concepts more tangible," she says. She points out that most water planning is based on past hydrologic records that can no longer be counted on to indicate the future. "It's a big transition in thinking for many agencies, not just our agency. Having these examples is very useful."

Another participant, a San Mateo County planner, felt the case studies could come in handy as a reference when he reviews permit applications for park and open space projects. "It's difficult for the public and politicians to understand things like vulnerability and adaptation, so hearing about specific projects like moving the Muir Beach parking lot to enhance natural drainage, and how the planners got the public on board, was intriguing," said San Mateo's Matt Seubert.

In the end, Cohen reiterated some of the climate smart principles BAECCC is promoting. "We have to have a future focus, and imagine beyond the science that's there today. Going forward, we're going to have more and more uncertainty because our environment is changing at an accelerated speed. So don't wait for your boss to tell you, or your government to tell you, what to do. The time to test and experiment is now."

Workshop Presentations & Links:
http://climate.calcommons.org
http://baeccc.org
www.bayarealands.org/explorer/

Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future, National Research Council, 2012
http://dels.nas.edu/Report/Level-Rise-Coasts/13389

Workshop Case Studies & Climate Smart Principles Packet:
www.sfestuary.org/estuary-news/#CALCC

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Saving Homes from Swollen Creek

On a day of super-high "king" tides last December, Len Materman walked along the levee on the south bank of San Francisquito Creek. The Palo Alto Golf Course stretched off to the right and San Francisco Bay lay a half mile ahead. Beyond the channel to the left, rooftops of one-story homes in East Palo Alto peeked over the top of the levee. With their backyards running right up to the north bank levee and their foundations below sea level, these homes are highly vulnerable to flooding. So are homes upstream in Palo Alto, where 1,700 homes flooded in 1998 when this slender creek could not carry rainwater out to the Bay fast enough to prevent it from overflowing its banks.

On his phone, Materman pulled up a recent photo of the spot where he was standing. It showed the water nearly at the top of the levees during a moderate storm — the sort that happens every five years or so. If all that rain had fallen on this day, when a king tide was pushing Bay waters more than two feet above a typical high tide, the homes could have flooded.

Materman is head of the San Francisquito Creek Joint Powers Authority, and it is his job to protect Palo Alto, East Palo Alto, and Menlo Park from the excesses of the creek and the Bay. He is leading a project to improve flood protection and also provide habitat benefits along the stream and at the wetlands near its mouth. The project will widen the creek channel by moving the southern levee over into the golf course to give flood waters another 7.5 acres to spread out. On the other side of the creek, downstream from the homes, the north levee will be lowered so that floodwater can flow more frequently into a wetland in the Don Edwards San Francisco Bay National Wildlife Refuge. The overall result should be not only safer homes, but a healthier marsh, nourished by mud and sand that will help it hold its own against sea level rise.

This approach is part of a region-wide project, dubbed Flood Control 2.0, that aims to manage sediment as an asset rather than a burden and to incorporate more natural methods of flood control. "We're taking advantage of a time in history where the flood control infrastructure around the Bay needs maintenance," says Caitlin Sweeney of the San Francisco Estuary Partnership, who is managing the $3.1 million project, which includes a $1.6 million U.S. EPA grant, as well as state and local funds. These dollars are not for capital costs, but will encourage innovation in planned projects through design workshops, data collection and analysis, monitoring, and information-sharing. "We want to seize the opportunity to think more broadly and redesign flood control facilities to increase the resiliency of watersheds in the face of sea level rise. And we want to incorporate habitat benefits too."

San Francisquito Creek is just one of three Bay Area sites in the ambitious project, which also includes Novato Creek in Marin County and Walnut Creek in Contra Costa County. Four regional organizations are collaborating on the project, namely the Estuary Partnership, the SF Bay Conservation & Development Commission, the SF Estuary Institute, and SF Bay Joint Venture. And they in turn will be working with local agencies, flood control districts, and the public to monitor and share information on new approaches to creek and wetland management. The three pilot projects could become regional and national models for ways to combine restoration and flood control, and also help identify any regulatory changes needed to manage sediment to better benefit the environment.

Flood Control 2.0 will also help the SF Estuary Institute increase knowledge of the interface between creeks and the Bay, which is still relatively understudied. "These are nodes of ecological richness and complexity [as well as] high flood risk," says ecologist Robin Grossinger of the project's research team. The results of monitoring the effects of channel reconfiguration at San Francisquito Creek could help shape the design of the other two creeks in the program—and many others. "It's a fairly new thing, and a complicated subject scientifically, with a lot of technical, political and regulatory challenges. The reason we took this on is it's not easy," says Grossinger. SKM

Len Materman points to the marsh that will receive floodwater after the San Francisquito Creek levee is lowered, making homes near the marsh safer as well as providing habitat benefits. Photo: Susan K. Moffat.

ALARM BELLS

Acid Waters Weaken Shells

Some have called it "the other carbon dioxide problem." As the world's oceans absorb part of the anthropogenic increase in CO_2, their chemistry is changing, becoming more acidic. Lower pH reduces the amount of calcium carbonate that marine invertebrates can use to build their shells. The impact on vulnerable species and food webs could be catastrophic—and could happen too quickly for these organisms to adapt. It's not just a concern for tropical coral reefs and polar oceans: California is on the frontline.

Recent research indicates that the coastal upwelling that nourishes the productive ecosystem of the California Current is also bringing more acidic water from the depths to the surface. It enters estuaries like Tomales Bay and San Francisco Bay, which also receive low-pH water from runoff. According to UC Davis geologist Tessa Hill, this poses a double threat to shelled creatures — including commercially valuable oysters and mussels — as they transform from larvae to juveniles.

Hill is one of four scientists heading the Bodega Ocean Acidification Research (BOAR) program at the

continued on page 6

ALARM BELLS, *continued from page 5*

Bodega Marine Laboratory. They're monitoring the chemistry of offshore, nearshore, and estuarine water, and rearing marine organisms under varying levels of acidity. Initial research has focused on native oysters (*Ostrea lurida*) and mussels (*Mytilus californianus*), which appear vulnerable. Previous studies elsewhere had documented reduced shell growth in commercially-farmed species.

Photos: Julie Stalker

Mussels (top), and Native California Oyster (below)

Free-swimming organisms are not exempt. Fish exposed to acidic waters in early developmental stages grow more slowly and have lower reproductive rates. Acidification impairs blood oxygen transport and respiration in squid. The shells of pelagic snails, a major prey item for juvenile pink salmon in the North Pacific, can dissolve under acidic conditions.

"There will be winners and losers," Hill notes. Crabs and sea urchins, whose shells are a mix of calcium carbonate and organic material, appear less susceptible than mollusks. Other reports suggest jellyfish, eelgrass, and cyanobacteria will thrive under more acidic conditions. Acidification may even change the acoustic properties of seawater, affecting whales.

"The science is very sound," Hill says. There's no debate as to whether ocean acidification is happening, only its relative importance among other stressors such as temperature changes, biodiversity loss, and invasive species. Analogies from deep time are ominous, though. A spike of acidification at the Paleocene-Eocene Thermal Maximum, 55 million years ago, is associated with a dieoff of marine microorganisms. Acidification was also implicated in an event 252 million years ago that claimed 96 percent of all marine species. **JE**

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COAST

Managed Retreat

Call it the Canute Syndrome, after the 11th-century monarch who is said to have ordered the waves not to approach his throne. In the past, when storms and waves eroded a heavily-used California beach, the automatic response was armoring the shoreline—putting down boulders, building revetments or groins. That's changing, though, due to a constellation of forces: nonprofits like the Surfrider Foundation advocating for natural beaches; engineers willing to take on projects that build shoreline resilience; Coastal Conservancy funding to implement them; a Coastal Commission majority unwilling to approve hardscape solutions; and the certainty of sea level rise. From San Francisco to Ventura, a new consensus is emerging that the soundest approach to beach erosion is to step back, even if that means relocating infrastructure. The strategy is "managed retreat," a phrase coined by ecologist Reed Noss of the University of Central Florida with reference to habitat corridors for wildlife.

Our coastline is "a temporary line in the sand," writes Gary Griggs in *Introduction to California's Beaches and Coast*. We've ignored its temporary nature by building out onto the beach. Bob Battalio, an engineer with ESA PWA involved with several managed retreat projects, points out that sea level has been rising over the last 20,000 years, cutting into low landforms: "We shouldn't be surprised if the shore encroaches upon what we build. It's hard to stop this large-scale geologic process even if you own the property. When we try to intervene and manage the system, we end up with man-made problems. We're throwing public money off the cliff to try to maintain something that's ultimately not sustainable."

The master plan for San Francisco's Ocean Beach, developed by the San Francisco Planning and Urban Research Association (SPUR) incorporates managed retreat. Not yet officially adopted by the city, its goals include dismantling the Great Highway south of Sloat Boulevard, letting dunes migrate inshore, and restoring native dune vegetation. "Closing the Great Highway is a spectacular move," says SPUR's Ben Grant. The plan took shape after the Coastal Commission rejected further shore armoring. SPUR brought together stakeholders like the Golden Gate National Recreation Area (GGNRA), S.F. Park & Rec, the S.F. Public Utilities Commission, Surfrider, and Golden Gate Audubon, and won across-the-board political support. It's not all retreat: the sewage treatment plant will be protected by a dynamic revetment. "We worked hard to get out of the framework of armoring versus retreat," Grant adds. "It's a careful combination of managed retreat, beach nourishing, and selective armoring. We came in from the outside without a dog in the fight and made people acknowledge each other's constraints."

The regulatory constraints associated with the plan are formidable, including wastewater permits under the Clean Water Act, state and regional water board permits for federal dredging, Coastal Commission coastal development permits allowing emergency armoring and future management activities, and GGNRA permits for activities on a national park property. In addition, two sensitive bird species use the beach: snowy plovers winter in the central and northern portion, bank swallows nest in the bluffs south of Sloat. Under the master plan, the plovers would benefit from dune habitat restoration. "The bank swallow habitat is one of the major constraints that has regulatory teeth," says Grant. "A lot of the embankment is artificial fill, not really good nesting habitat, which we propose incrementally removing."

Surfer's Point, Ventura. Photo courtesy City of Ventura and Rasmussen Construction

Pacifica State Beach, post construction, 2005. Photo courtesy City of Pacifica

Down the Peninsula at Pacifica State Beach, managed retreat entailed relocating a parking lot and a bike path, rerouting access roads, and demolishing two homes. "The main problem was a lack of trust," recalls Battalio. "The city had a varied record, with a lot of armoring in the northern part of town." When funding constraints killed a proposed cobble berm, ESA PWA came in with a design alternative. "It's an ongoing process," he says. "We moved back 40 feet and we're good for 20 or 30 years. Then we have a problem about what we do if sea level rise really accelerates."

Santa Barbara has a long history of attempted erosion control at Goleta Beach, with rock revetments emplaced, removed, then reinstated. The city proposed a $20 million sand-trapping groin to stabilize the beach and found a Southern California engineering firm to build it. Surfrider and the local Environmental Defense Center (EDC) argued that this would cause downcoast beaches to narrow as much as Goleta Beach would widen. Despite support from a group called Friends of Goleta Beach and local politicians, the Coastal Commission voted down the groin plan. "It was a tremendous victory," says EDC's Brian Trautwein. "Immediately afterward we started talking with the county about a managed retreat approach." That led to the Goleta 2.0 plan, with Phase 1 construction budgeted at about $3.5 million. The plan will remove a parking lot at the beach's erosion hot spot, squeeze out more spaces in another lot, move sewer and water lines and a bike path inland, and build a dune system on geotextile bags.

Consensus came more easily with the Surfer's Point project in Ventura, where the Coastal Commission denied a permit for a rock revetment. According to UC Santa Cruz researcher Marc Beyeler, the key figure was Surfrider activist, city councilman and restaurateur Brian Brennan, who restarted a stalled process by bringing stakeholders together at a "Caesar Salad Summit." As with Pacifica, a bike path and parking lot were moved back. "Surfer's Point is a leading example cited by federal and state agencies," says Beyeler. He believes social scientists should investigate ways to generate this kind of community support for adaptive shoreline management: "Even if we have the best natural science, the real limitation is the disconnect between science and policy."

Beyeler feels the "managed retreat" concept needs rebranding, preferring "resilient shorelines." ESA PWA's Battalio agrees that "retreat is not a popular word. Lots of people are calling it realignment. But I use 'retreat' because it's important to communicate with people. We're going to retreat. The only question is how much money we waste and how much of the environment we destroy before we figure that out." **JE**

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COMIC RELIEF

The Little Red Rail Finds a New Home

Illustration by Erika Gomi, 10th grader, San Francisco

"The sky is falling," squawked the little red rail. She'd been sitting in her nice thatched house on the East Bay shore, floating on a king tide, thinking about how lucky she was to have housing provided by the federal government, not to mention getting on reality TV, when the roof fell in. A northern harrier in a BatHawk costume peered in at her with beady eyes. "Can I see some ID?" he screeched.

Petrified, the little red rail lifted a leg to reveal a band bearing the letters LRROTP (Last Red Rail on the Planet). "Didn't you see the 'Do not disturb,' sign on the roof," she squawked gamely, displaying the courage that had enabled her to survive global warming, a five foot sea rise, massive reconstruction of the shoreline around her marsh as humans rebuilt highways, bridge approaches and airports, very bad air, the loss of her mate to mercury poisoning – he wandered off crazy as a coot and never came back — the crack in her last egg (DDT thins the shells, everyone knows that), and a foreclosure notice (the federal deficit), only to come to this. "Was he playing good hawk or bad hawk?" she wondered, looking up at the beady eyes.

The unauthorized story of the little red rail continues off the page, a fractured fairy tale better told in unofficial print.

READ ON:
www.bayariel.com/tales.html

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San Francisco Bay and the Sacramento-San Joaquin River Delta comprise one of 28 "estuaries of national significance" recognized in the federal Clean Water Act. The San Francisco Estuary Partnership, a National Estuary Program, is partially funded by annual appropriations from Congress. The Partnership's mandate is to protect, restore, and enhance water quality and habitat in the Estuary. To accomplish this, the Partnership brings together resource agencies, non-profits, citizens, and scientists committed to the long-term health and preservation of this invaluable public resource. Our staff manages or oversees more than 50 projects ranging from supporting research into key water quality concerns to managing initiatives that prevent pollution, restore wetlands, or protect against the changes anticipated from climate change in our region. We have published *Estuary News* since 1993.

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A Starter Kit of Left Coast Climate Change Resources & Tools

ONLINE

Climate Central
www.climatecentral.org

CALIFORNIA

The California Climate Commons
http://climate.calcommons.org

California Climate Change Portal
www.climatechange.ca.gov

California Landscape Conservation Cooperative
http://californialcc.org

COAST

Digital Coast
www.csc.noaa.gov/digitalcoast

SAN FRANCISCO BAY AREA

(see Cal LCC insert for tidal marsh tools)

Bay Area Ecosystems Climate Change Consortium
www.baeccc.org

Our Coast Our Future
http://data.prbo.org/apps/ocof/

The Conservation Lands Network
www.bayarealands.org

DELTA

CASCaDE: Computational Assessments of Scenarios of Change for the Delta Ecosystem
http://cascade.wr.usgs.gov

ARTICLES

Bay Nature Magazine
www.baynature.org

(see *Climate Change* category and *Making the Most of Mud*, Jan-March 2013)

REPORTS

Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future,
National Research Council, 2012
http://dels.nas.edu/Report/Level-Rise-Coasts/13389

COOL STUFF

California King Tides Initiative
www.californiakingtides.org

Rebutting Global Warming Misinformation: www.skepticalscience.com

Cooler Smarter: Practical Steps for Low-Carbon Living: www.ucsusa.org/global_warming/what_you_can_do/practical-steps-for-low-carbon-living.html

Climate Smart Conservation, NWF:
www.nwf.org/What-We-Do/Energy-and-Climate/Climate-Smart-Conservation.aspx

School Curricula & More :
www.epa.gov/climatechange/

Note: *The San Francisco Estuary Partnership is deeply involved in climate change planning through the Flood Control 2.0 project, participation in BAECCC, as staff support to ABAG and the Joint Policy Committee in their efforts to develop a Regional Sea Level Rise Adaptation Strategy, and in our staffing, along with the Coastal Conservancy, of the San Francisco Bay Restoration Authority.*