Salt Marsh Secrets

Who uncovered them and how?

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An e-book about southern California coastal wetlands for readers who want to learn while exploring

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This e-book records favorite stories about salt marsh secrets that my collaborators and I uncovered while studying southern California coastal wetlands, from the 1970s to date. In 1986, we became the Pacific Estuarine Research Lab.

Please download the files as they appear online and enjoy learning what we learned…and more. You'll meet many "detectives," and you'll be able to appreciate how they learned so much--undeterred by mud and flood. Learn while exploring the salt marshes near you!

Each chapter (1-21) is being posted at the TRNERR as a separate file (PDF).
Chapter numbers precede page numbers (for chapter 1: 1.1...1.14).
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PDF name and brief description:

Damages to salt marshes

How many ways have people altered our salt marshes? Let's begin with on-site alterations, first considering those that are short-term, small-scale, then the longer-term, large-scale modifications.

As Kermit the Frog says, "It's not easy being green." When a piece of the landscape is still green, it's vulnerable to many kinds of damages. Even though coastal construction projects became regulated by the California Coastal Act of 1976, this law did not entirely stop the expansion of marinas or the construction of high rise condos and apartments on prime waterfront real estate. The law was a great improvement in coastal conservation, but some found loopholes (ways to get around the regulations).

On-site impacts of human activities

When I first visited the salt marsh at Tijuana Estuary, there were no fences or curbs to keep people from driving over the vegetation. It was wide open to off-road vehicles. Much of the high marsh and transition to upland was denuded (bare, devoid of vegetation) due to vehicle damage and dumping of trash.

All that changed in when the estuary became part of the National Estuarine Research Reserve System in 1982. Funds became available to build a visitor center and create a formal parking lot to confine vehicles. Next, Paul Jorgensen and many volunteers planted native plants around the parking lot and visitor center, and dense shrubs soon became a scratchy, spiny barrier to trespassers. Trails were designated and marked with a low cable fence, so people knew where to walk. Visitors began to see the salt marsh as a place to protect and treasure, rather than a dumping ground. A wasteland became a wetland (Zedler et al. 1998).

Compared to off-road vehicles, human trampling causes relatively minor impacts. Still, over time, our footsteps degrade the vegetation. A walk in the high marsh might seem harmless, but when many people follow a path, it becomes a narrow trail. With more use, narrow trails become wider, and new paths appear, criss-crossing the high marsh and transition to upland.

The long-term outcome of unregulated trails is a dissected high marsh (below). A trail might not seem to be harmful, but it can keep small species, like non-flying insects and spiders, from moving from one side to the other. A trail can also invite unwanted predators, such as terrestrial carnivores, to move into the marsh during nesting season.

Other examples of on-site human impacts are the noises that come from our talking and yelling, and also from our radios, cars, and barking dogs. How might birds respond to such noises? Some secrets are revealed in chapter fifteen.

Night lighting is also a threat. How are animals affected by our street lights, vehicle lights, indoor and outdoor home lighting, and patrol lights at the US-Mexico border? Can you find your impact in the night-light photo below, taken from a satellite?

(www.nasa.gov/mission_pages/NPP/news/earth-at-night.html)

You can read more in a book, *Ecological Consequences of Artificial Night Lighting* (Rich and Longcore, eds. 2006; www.islandpress.org), which has a chapter on southern California night lighting. One of the authors is Rob Fisher, who monitored nocturnal animals near the US-Mexico border lights, adjacent to Tijuana Estuary.

What did Rob learn? The Pacific pocket mouse (*Perognathus longimembris pacificus*) and two of its nocturnal predators were negatively affected by night lights. The predators were the California glossy snake (*Arizona elegans occidentalis*) and the Western long-nosed snake (*Rhinocheilus lecontei*), whose populations are declining near night lights but not elsewhere. In contrast, lots of insects were attracted to night lights—enough to attract an alien predator (geckos). How do night lights affect native pollinators and other valued insects? Again, more research is needed.

Roads definitely have direct negative effects on salt marshes. Except for Tijuana Estuary, the southern California coastal wetlands have roads along the coast, between the salt marsh and the ocean. The roads are built on berms that dissect (cut up) the marsh and estuarine habitats, changing natural patterns of water flow. That's not good for wildlife, especially animals that attempt to cross the road or insects that swarm in front of your windshield. The bridges across estuary or lagoon mouths are notorious for constraining the natural flows of water and sand. For example, Los Peñasquitos Lagoon has a strong tendency to close to tidal flushing, because its mouth cannot migrate south with the seasonal flow of longshore sand.

In the Huntington Beach Wetlands, only 200 acres remain of what was once a 2,900 wetland at the Santa Ana River mouth. Roadways dissect the remaining wetlands (below).

(http://1x57.com/culture/huntington-beach-wetlands-conservancy/)

Roads have indirect effects, too. A road from Ensenada to the Pacific Ocean leads to a popular tourist attraction, La Bufadora ("the blowhole"). There, ocean waves splash into a cave under the rocks, often causing enough force to create an exciting water spout. As the road attracted more traffic, it became wider and more permanent, attracting more tourists. Following the tourists came tamale and taco stands and other shops. With increased popularity came erosion and garbage. As a result, sediment and wastes flow downslope into the salt marshes in Estero de Punta Banda.

Flood control channels are like roads, being straight and wide—like water freeways. Flood control channels are designed to handle major water flows from the watershed, to confine floods within a strait channel, and to move the water to the ocean as quickly as possible. By cutting a deep channel and lining it with riprap (giant rocks), one side of a salt marsh becomes isolated from the other side. Examples are in Mission Bay (San Diego River flood control channel) and Ballona Wetland (above). Ballona Wetland is visible as your airplane comes in for a landing at Los Angeles airport—it's the long narrow channel at top of the above photo—not the even-wider channel in Marina del Rey. One plan for the Ballona Wetland flood control channel is to shorten it so the coastal waters can mix with the river waters in an effort to restore both river and tidal influence to Ballona Wetland.

(www.sccwrp.org)

Boat marinas occur between the ocean and coastal salt marshes in Upper Newport Bay (on the left), as well as in Ballona Wetland and Los Cerritos Wetland. Much of San Diego Bay has been converted to marinas, replacing mudflats and salt marshes.

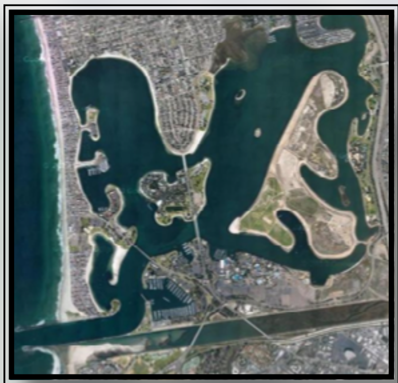
As in central California's Elkhorn Slough, the need to dredge channels for large boats can cause havoc in upstream wetlands. There, dredging augments water currents enough to erode channels, banks, and vegetated salt marsh. Some dredging for boating could help keep a lagoon mouth open to tidal influence, while too much dredging, by definition, has negative effects.

Conversion to ports was necessary for commercial ships and military purposes. Southern California has major ports in San Diego and side-by-side ports in Los Angeles and Long Beach (photo: geology.campus.ad.csulb.edu).

The impacts to salt marshes involved dredging and filling to recontour the coastline so channels could accommodate large ships, and shores could support piers. Plans to expand port facilities bumped into NOAA's mission to sustain marine fisheries, so when Los Angeles wanted to dredge more of San Pedro Bay, the city was required to mitigate damages (lessen impacts) in some way. NOAA fisheries experts recommended off-site compensation, namely, dredging Batiquitos Lagoon to create a deepwater tidal embayment (see chapter eighteen).

Conversion to an aquatic park. Historically, the San Diego River was "free ranging;" it could flow into San Diego Bay toward the south or into "False Bay" to the north. That lasted until a levee (dike) was built along the south side of the river, so sediments from upstream would not fill in San Diego Bay. "The only remedy for the evil is to turn the river into False Bay again" (A. D. Bache, quoted by William Smythe in his *History of San Diego*.

The levee was built in 1852, but it washed out in 1954, so in 1877, the river was permanently "tamed" by creating the present San Diego River flood control channel (photo on next page).



Next, the City began converting what was left of False Bay into what is now the country's largest aquatic park—Mission Bay. The salt marsh, mudflats, and shallow creeks were dredged to support boating, and the excavated spoils were mounded to create islands. The new roads, bridges, hotels, and playgrounds provided opportunities for recreation and coastal access. The park boasts 19 miles of beaches plus Mission Bay Marsh. Can you spot the marsh in the photo on the previous page? It's the brownish green patch in the upper middle edge.

Conversion to salt ponds. People need salt, and if you live next to seawater in a warm sunny climate, the easiest way to get it is by evaporation—an early use of solar power! The San Diego Bay salt ponds grew from an early small diked enclosure to a series of huge impoundments, as demands for salt increased. Eventually the entire south bay was diked and pressed into service as a salt factory. However, chapter eighteen describes the beginnings of restoration.

You can try this at home: Put a shallow bowl with a carefully measured volume of seawater (about a liter or quart) in full sun. Then, watch the water level drop and the salt crystals form around the edges. When all the water has evaporated, scrape all the salt crystals into the center of the bowl—does it look like it's 3.4% of the initial water volume? How would you measure the amount of salt produced? Caution--animals need salt too, so if your experiment needs to continue overnight, cover the bowl or bring it indoors!

Oil wells are prominent features of Los Cerritos Wetlands (on the left) and Ballona Wetland.

Over centuries, southern California salt marshes have been damaged by all the above human activities. In addition, the dunes have been trampled and the high marsh has dwindled due to filling for urban development.

Impacts from human activities off-site

Salt marshes damages are not limited to activities on-site. Their downstream location makes them vulnerable to some activities that occur far upstream. In earlier chapters I described how stormwater (urban runoff, with sediments and nutrients) flow into a salt marsh from its watersheds. I mentioned sewage spills and discharges of treated wastewater, and I showed how flood control channels can disconnect a salt marsh from its watershed. What more can happen? Oil spills!

Now that ports and marinas and industry operate upstream from our tiny salt marsh remnants, the plants and animals are at risk to off-site oil spills. This oil spill (blogs.agu.org/geospace/2010/07/01/oil-spill-science/) was in the Gulf of Mexico, but tanker spills could occur more frequently in southern California, given more frequent storms.

Damage assessment

Spills of oil and other toxic contaminants are included in federal legislation that indicates how to assess damages. The US and state governments share responsibility for restoring areas that are damaged. They must somehow make up for damages that cannot be undone. That's called compensation. When someone else messes up your room and you have to clean it up, you expect some compensation, right? Maybe you'd rather pay a younger sibling to do it for you. Likewise, if your tanker full of oil spilled onto a salt marsh, you'd have to clean it up yourself or pay someone to do it for you. If so, you'd need to estimate how much "damage" you've done so you'd know how much to pay for clean-up.

As the big BP spill in the Gulf of Mexico demonstrated, it's not always possible to clean up all the oil that gets spilled. Some of the damages and toxic materials remain after the cleaning process. How then does the "spiller" get charged for spilling? Here's a summary from Peterson et al. (2008).

Step one is to assess the "injury." This is done by

- mapping areas covered by a spill according to heavy, moderate or light amounts;
- estimating loss of each marsh service (see below).
- analyzing soils for spilled material at (and below) the ground surface.

Step 2 is to estimate the portion of each ecosystem service lost and its recovery time.

Step 3 is to compensate for damages.

The impacts of a spill could be compensated with cash if we knew what a salt marsh is worth or what dollar values of services were lost where the marsh species were damaged. We don't yet, so the process is indirect and based on many estimates. Perhaps in your lifetime, there will be better information on the dollar value of ecosystem services. At present, we are still compiling lists of what the services are.

Which services need to be assessed?

Here are eight types of services listed by Peterson et al. (2008):

1. Habitat and food web support: High production at base of food chain, vascular plants, biofilms, microbial decomposers, benthic and invertebrates (herbivores and detritivores), refuge and foraging grounds for small fishes and crustaceans, feeding grounds for larger crabs and fishes during high water, and habitat for wildlife (birds, mammals, reptiles)
2. Buffers against storm wave damage
3. Shoreline stabilization
4. Hydrologic processing: Flood water storage
5. Water quality: Sediment and nutrient cycling, chemical and metal retention, pathogen removal
6. Biodiversity preservation
7. Carbon storage
8. Socio-economic services to humans: Aesthetics, natural heritage, ecotourism, education, psychological health

Ideally, one would estimate each service as being heavily, moderately or lightly damaged, then multiply area for each degree of loss by the percentage of each service that was lost and sum up the damages. An example would be to characterize the dominant plants of each area covered by the spill, estimate lost NPP using an indicator, such as plant stem density and height, and repeat for each area of heavy, moderate and light spills. Other indicators could be numbers of dead fish, birds, turtles or mammals or the post-spill condition of oysters, snails, crabs and mussels by species. Where the plants or animals that are damaged are endangered or threatened species, further assessments are needed.

In southern California, it would not be good enough to record marsh dominants; the plant heights would need to be known to estimate loss of nesting habitat for the endangered light-footed clapper rail, because it needs tall cordgrass stems to anchor its nests and protect eggs and chicks from aerial predators (see chapter three).

Conclusions of Peterson et al. (2008) that are relevant to southern California:

- Tidal marshes provide multiple ecosystem services.
- Assessing impacts in southern California marshes will be more complicated than for extensive and relatively uniform cordgrass (*Spartina alterniflora)* marshes of the East and Gulf Coasts. Pickleweed stems are not easily counted, so habitat value might need to be estimated from plant layering or height distributions.
- Separate indicators would be needed for the cordgrass marsh at the water's edge, the marsh plain, and the high marsh.
- No single indicator can represent all salt marsh ecosystem services.
- Below-ground biomass might be a useful indicator of resilience (ability to recover).
- Threatened or endangered species need detailed assessments of injury.
- Diverse marshes need to be tracked to assess changes in species richness and composition.
- Invasions of exotic plants need to be mapped. Maps should show where they have established and where they might spread.

Can you imagine other damages? What if a tanker truck on Freeway 5 spills chemicals upstream from a salt marsh? Or how about an airplane pilot who has to make an emergency fuel dump? Do you remember the plane in NYC that had to land in the Hudson River? It could happen near LAX. And what would the impacts of an earthquake be (as has happened in central California's Elkhorn Slough)? It is often said that, "Forewarned is forearmed." Managers who understand and anticipate damages will be better able to repair future damages to our remaining salt marshes

How not to treat coastal wetlands...

The November 21, 2014, issue of *Science* highlights massive seawall construction that is underway in China (red line on map on right). Why is the ocean being cut off from the salt marshes? To create land for development. The 9 authors (4 from China) say it's because there is no national legislation to protect wetlands, too much emphasis on short-term economic goals, conflicting goals between local and national agencies, and not enough appreciation of the values provided by wetlands.

As a result, China's 5.8 million ha of coastal wetlands are being separated from the ocean by a seawall that is already 11,000 km (6,835 miles) long!

Behind the seawall, sediments dry out, marshes, die, biodiversity plummets, and waterbirds leave. The lost value of former coastal wetland services is estimated at $31 billion per year (Ma et al. 2014). Places that were once removing pollutants began producing pollutants when the wetlands were converted to farms, aquaculture, factories and ports.

How much more salt marsh will be walled in? Estimates are about 150,000 acres per year through 2020.

The authors suggest approaches that are needed, including educating the public about the values of salt marshes.

WHAT'S YOUR ADVICE? In the US, we have damaged wetlands in many ways and then tried to restore those damages. Based on many examples, my advice is not to damage them in the first place. Even where major engineering projects seem appropriate at the small scale and for the short term—for a few who will profit--it is essential to consider larger-scale impacts over longer time periods….for human well-being.

Let's reverse damages from the past century

Tijuana Estuary at low tide (above).

Comparing three estuaries near San Diego (graph on right), Tijuana Estuary lost the least salt marsh area during the past century. By losing less area, it shifted from having the lowest salt marsh area of the three to providing the largest salt marsh area by 1987.

A wetland ethic...

Wetlands need extra protection because they provide more services per area than uplands and oceans while occupying far less area of the earth (probably <10%).

What are the wetland ecosystem services? They are biodiversity support, water quality improvement, flood abatement, carbon storage, educational and scientific use, recreation, and esthetic and heritage values. Wetlands need more protection to continue providing those services. That includes more and larger restoration projects (see chapter eighteen) to expand their services.

I suggest that each of us adopt **A WETLAND ETHIC** along these lines:

> I acknowledge that wetlands provide multiple ecosystem services (functions that enhance human-well being) at rates far greater than their global area indicates.
>
> I support wetland conservation and restoration of wetland species and natural functions for posterity.
>
> I accept obligations along with the benefits I receive from wetlands. For example, I try to minimize pollutants that might reach wetlands.
>
> I also support the protection of watersheds upstream from wetlands, so the downstream wetlands can continue to provide all their ecosystem services.

Read more at uwarboretum.org [publications menu, Leaflet #36].