Salt Marsh Secrets

Who uncovered them and how?

By Joy B. Zedler

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:

Secrets of two endangered species: a plant and a bird

Let's follow seasonal behaviors of two salt marsh residents (a bird and a plant that live in the marsh all year long). Both are endangered species, protected by the United States Fish and Wildlife Service. That means no collecting or habitat damage!

First is the salt marsh bird's beak, *Cordylanthus maritimus* ssp. *maritimus*, a small annual plant of the high marsh. Second is the light-footed clapper rail (*Rallus longirostris levipes*), which nests in cordgrass (or sometimes in pickleweed). Here, I nickname them SMBB and LFCR. These are acronyms (the first letter of each word). On the right are a few words about species names, which you may skip if you're eager to read about SMBB and LFCR.

How do species cope with seasonal changes?

Because both SMBB and the LFCR have federal endangered status, we aimed to uncover many secrets about their habitat requirements in order to restore their habitat in San Diego Bay marshes. Both the US Fish and Wildlife Service and CalTrans (the state highway department) needed to know how to restore damaged habitat in Sweetwater Marsh, next to San Diego Bay. CalTrans needed to re-introduce the SMBB population and to restore nesting habitat for the LFCR. Perhaps you will understand the difficulties in satisfying each species by reading how each uses the salt marsh during a year's time.

When you visit the salt marsh in winter, spring, summer and fall, imagine what it is like to be a year-round resident, either a plant that is stuck in one place or a bird that can move around. Let's see how these two species are uniquely adapted to the southern California salt marsh.

- Binomial nomenclature. Don't be intimidated by the term; it just means the scientific two-name system for organisms. Common names are easy to use, and they are often more descriptive than scientific names. The problem is that the same plant or animal can have different common names in different regions. Likewise, the same common name might refer to different species, depending on where you are.
- The Swedish genius who created the binomial system was Carl Linnaeus, who lived from 1707-1778. What a legacy—we are still using his system 200 years later! A web site about plant names is http://plants.usda.gov.
- Each species has a unique genus and species name. The genus is like a surname; one or more species make up a genus; one or more genera (plural of genus) make up a family. Sometimes a species has variants that are called subspecies. Within a family, the names are written in italics: Family, *Genus species*, *subspecies*. Only the family and genus names are capitalized.
- The scientific name for salt marsh bird's beak is *Cordylanthus maritimus* subspecies *maritimus.*
- Subspecies (abbreviated as ssp. or subsp.) are slightly different from other populations of the species. The southern California subspecies of SMBB has more-pinkish flowers than the northern California subspecies.
- Zoologists follow a slightly different rule; their subspecies names are simply added to the genus and species names, so the light-footed clapper rail is *Rallus longirostris levipes.*
- Families can also have both a scientific and a common name. For example, salt marsh daisy, *Jaumea carnosa*, belongs to Asteraceae, the daisy family, and grasses belong to Poaceae, the grass family. Note that family names end in "aceae."
- Because taxonomists are continually revealing secrets about the relationships among organisms, the scientific names keep changing, based on international rules and published name changes. We relied on James Hickman's 1993 book, which was the authority for California plants at the time we were doing our research.

salt marsh bird's beak

This is SMBB in full bloom, photographed after cool-season rainfall.

Flowering plants are usually less than 15 cm tall. Flowers occur in clusters.

WINTER: Rainfall dilutes soil salinity and washes salts into estuary channels and out to sea. But January and February also have extreme high tides, which wash over the high marsh soil, making it salty again. So, SMBB seeds remain dormant in the soil of the high marsh. They won't germinate until salinity drops.

A secret uncovered by many who have studied salt tolerant plants (halophytes) is that salt makes their seeds go dormant (alive but inactive). The seeds wait to germinate until there is enough soil moisture to support seedlings. How do you think that works, when plants have no nervous system to sense moisture or temperature? A seed could germinate after rainfall if the seed coat had a germination inhibitor that washed away during rain. Or, if the seed had a very hard coat, it might soften during rainfall.

SPRING: In March, even the highest tides don't cover the high marsh, so any rainfall that occurs can reduce the salinity of the soil by "leaching" out the salt. Salt marsh annuals are easiest to see in years with frequent, prolonged rainfall. Why? Because more seeds germinate, plants grow taller, and flowers are present for a longer time period.

Greg Noe sampled soil salinities after rainfalls of different amounts and revealed a secret: A 3-cm rainfall was enough to stimulate plant seeds to germinate. He also learned that many annual plants grow very fast during the period of low salinity. Goldfields (*Lasthenia gabrata*), for example, can grow, flower and produce seeds within a few weeks!

Meghan Fellows learned that the seeds of SMBB can germinate and grow into seedlings by themselves, but they probably won't set seeds unless they have some help. Seedlings need to attach onto the roots of a neighboring perennial plant in order to continue growing and reproduce. And remember that SMBB is an annual, so it has to produce seeds for its population to persist! Read on….

jaysullivan.org/goldfg.htm

Why does SMBB need haustoria (small pads at the end of roots)? Because the soil dries out during spring and summer, and the root system of SMBB and many other annual plants are too shallow to track the shrinking water supply. Its haustoria are ~2 mm in diameter.

Botanists call plants "hemiparasites" when they can begin life independently and then mooch off their neighbors. "Mooching" is the job of haustoria. SMBB grows pads that attach firmly to the host's roots and draw water and nutrients from the host. Seedlings that germinate too far from a suitable host or that do not attach in time to sustain their water and nutrient supplies will soon die.

Some hemiparasites are trees. Here's are photos of haustoria (white oval pads) of the Western Australia Christmas tree (*Nuytsia floribunda*), which parasitizes the roots of various host species.

www.anbg.gov.au/mistletoe/images/caption-image/nuytsia-floribunda-tree.html

SMBB can photosynthesize on its own, and its seedlings can establish in the high marsh. In a wet year, it can grow to near maturity, but most seedlings won't survive the summer drought long enough to produce seeds. After it produces haustoria that attach to a perennial host, it has the help it needs to obtain water and nutrients and to produce seeds. Later, you'll learn why the host must be perennial.

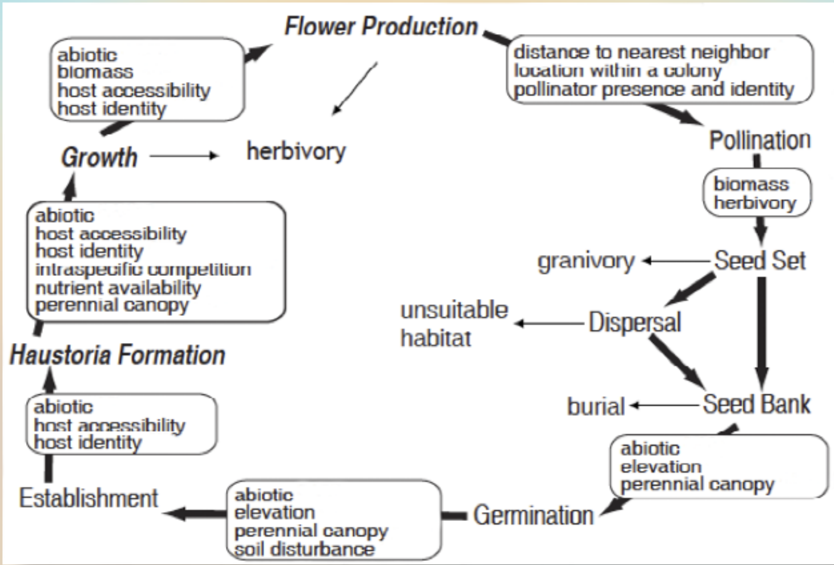
Like most salt-marsh annuals, SMBB grows rapidly and blooms in May. Because SMBB has haustoria, however, it can continue blooming in summer, long after cool-season rainfall.

How many SMBB flower clusters (inflorescences) can you spot here?

SUMMER:

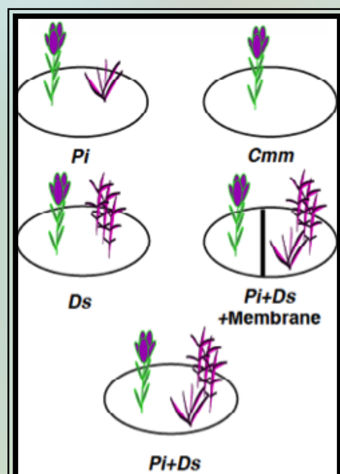
Flowering continues from May to August. Each flower needs to be pollinated in order for it to set seed and complete the plant's life cycle. Does the SMBB flower look like it would be easy to pollinate? In the close-up photo above, can you see its stamens with pollen and the pistil? No; they are hidden. The job of the flower petals is to attract a pollinator, usually an insect, to dive in for some pollen or nectar while distributing pollen from the previous flower it visited and to pick up more pollen for the next flower it will visit. Aren't flowers clever? Or is it the insects that are clever? Actually both have been selected for, over evolutionary time, to do their jobs well. Other salt marsh flowers are not at all showy; they are more likely to be pollinated by wind or water (if their pollen floats).

SMBB faces many challenges in trying to survive to produce seeds. Here is Meghan's chart of its life history showing each stage, all the factors that influence its ability to reach the next stage, and all the hurdles it must leap in a single year (Fellows 1999). Note that haustoria formation, growth and flower production are all in italics, indicating that the wrong host has an effect at these stages. Read on….



Meghan Fellows uncovered the secret that SMBB cannot produce many seeds when its haustoria attach to an invasive annual grass. She learned that the annual grass dies too early, before SMBB can produce fruits. SMBB needs a perennial halophyte to serve as hosts through spring and summer. The lesson for marsh managers is to keep invasive annual grasses out of this endangered plant's habitat. It takes several months for SMBB to produce seeds, and a short-lived annual grass dies before that job is done.

How did Meghan figure that out? By growing the hemiparasite outdoors in pots having two water treatments: water baths kept wet versus water baths allowed to drain until dry. In each case there were five "host treatments": with the exotic annual sickle grass (Pi [*Parapholis incurva*]), the SMBB (called Cmm in the diagram on the right) alone with no host as a control, with the native perennial salt grass (Ds [*Distichlis spicata*]), and with both (Pi+Ds)—with and without a membrane separating bird's beak from the two potential hosts. The membrane experiment was designed to test the belowground effects of the hosts and the hemiparasite. Again, she had 2 water levels, and she compared SMBB with hosts nearby, with and without a membrane separating their roots (Pi+Ds+Membrane). The membrane allowed water and nutrients to cross the barrier but not roots and, of course, not haustoria.

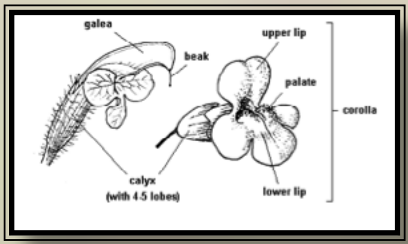


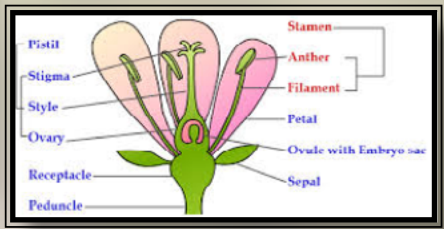
With a native perennial host, SMBB produced an average of 270 haustoria per pot and an average of 13 flowers. With the exotic annual grass, SMBB plants averaged just as many haustoria but only 1 flower. Compared to growing with a native perennial host, the exotic annual grass cost the endangered hemiparasite just as much in haustoria production for a benefit of 1/13 as many flowers.

Belowground, where Meghan prevented SMBB from tapping into a native host, the hemiparasite produced only 10 haustoria and only 1 flower per pot. The exotic annual grass was no more effective than where there was no host. How do you think that SMBB knew not to produce many haustoria when it did not have access to a host?

We called the annual grass a "pseudo-host," implying that it allowed SMBB to attach under false pretenses (Fellows and Zedler 2005). While it's not accurate to give plants human-type motives, the term pseudo-host is a way to remember that the grass was not a true or adequate host.

Lorraine Parsons uncovered more secrets about SMBB. First she showed that SMBB can be pollinator-limited in our regional salt marshes. Then she learned that, because flowers are pollinated by native ground-nesting bees, the places that bees need for their burrows—above the high tide line—limit the pollinator populations.

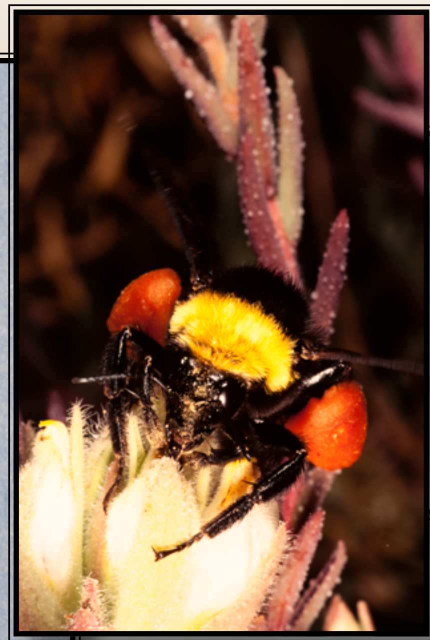




Left photos: A ground-nesting bee (www.edf.org/blog/2013/11/14/summer-surprise-native-bee-sanctuary-my-backyard) and SMBB in full bloom. Upper right drawing: A flower in the bird's beak family (montana.plant-life.org/families/Scrophulariaceae.htm). Lower right drawing: Simplified flower structure.

Compared to SMBB's beaked flower, the simplified flower looks easy to pollinate—an insect can easily brush against pollen produced by the anthers, and the top of the pistil (the stigma) makes a good landing pad for an insect to pollinate. A pollen tube grows from the pollen grain down into the ovary to fertilize and produce a seed. SMBB is a challenge for any old insect to pollinate. The tiny, solitary halictine bees, for example, appear to be inefficient in pollinating SMBB, because they thrust their head and thorax through sides of the corolla lips, or they climb into the flower entirely to collect pollen from the anthers, which minimizes contact with the stigma. *Bombus, Melissodes,* and *Anthidium* are larger bees; they thrust their head through the upper side of the corolla, and they contact the stigma and deposit pollen from a previously-visited flower.

Bombus crotchii, B. sonorous, and *B. californicus* (bottom to top, all females).



Bombus crotchii and flower of SMBB.

Melissodes tepida.

Thanks to R. Parks, San Diego County Museum of Natural History, for identifying and photographing the bees!

Lorraine monitored pollinator visits to SMBB flowers at the restored population in Sweetwater Marsh and at the donor population at Tijuana Estuary. Not surprisingly, pollinator numbers varied from year to year. In 1992, halictine bees accounted for ~90% of flower visits. *Melissodes* and halictine bees are ground-nesting species, excavating burrows close to where they forage. These bees were less numerous at Sweetwater Marsh in 1993, perhaps because the January 1993 flood drove them from their burrows. *Bombus* is not such a home-body, it ranges more widely, so it should be less affected by flooding.

At Sweetwater Marsh, pollinator visits to SMBB averaged ~10 visits per 0.25-m^2 during 135 minutes of observation in 1992 but less than half as many in 1993 (average = ~4). But that didn't limit seed capsule set (see data below). The ability of seed capsules to mature was better explained by *which* pollinators visited SMBB flowers. When *Bombus* or *Melissodes* visited SMBB flowers in addition to halictines, more seed capsules were set than when only halictines visited the flowers.

Three years in the life of SMBB at Sweetwater Marsh, San Diego Bay.
Data are averages ($\pm$ standard errors).

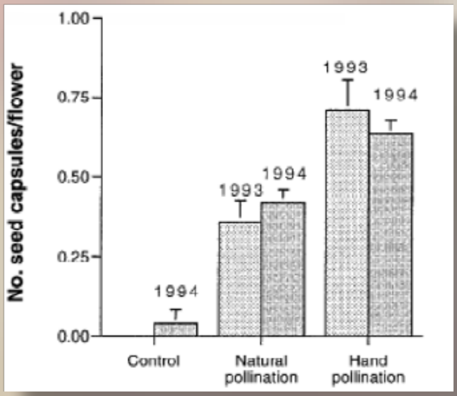
Characteristics	**1992**	**1993**	**1994**
Number of patches	21	7	10
Density (seedlings/ dm^2)	1-222 (range)	1-36 (range)	7.3 $\pm$ 1.5 (average)
Height (cm)	12.1 $\pm$ 0.5	12.1 $\pm$ 0.7	13.4 $\pm$ 0.6
Flowers per plant	11.1 $\pm$ 1.9	46.3 $\pm$ 3.1	16.7 $\pm$ 2.6
Seed capsules	0.19 $\pm$ 0.02	0.40 $\pm$ 0.05	0.43 $\pm$ 0.04 (0.39 $\pm$ 0.04 not eaten)

Anthidium edwardsii (undersides of bees; note pollen on female; photo: R. Park.

Two pollinators at Tijuana Estuary were missing at Sweetwater Marsh. They were species of *Anthidium: A. edwardsii* and *A. palliventre*. *A. edwardsii* might be the most effective pollinator of SMBB (Parsons and Zedler 1997). If so, their absence at Sweetwater Marsh could be an important problem. The reasons for their absence should be determined. Future research is encouraged!

If the surrounding area has patches of supratidal soil (above the high tide), there should be habitat for ground-nesting bees, so flowers can be pollinated, and SMBB can persist. If seeds are sown to an intertidal island that floods entirely during high tide, the bees can't nest, the flowers don't get pollinated, they don't produce seeds, and the population won't be sustainable!

Lorraine tested for pollen limitation by putting net bags (about the size of a golf ball) around flower clusters to prevent pollinator access (her control treatment), then compared bagged flowers with flowers left open to pollinators (natural pollination) and with "hand pollination," where she add pollen. (No, she did not wear a bee costume.) She put net bags around those flower clusters to exclude other pollinators. With pollen added, the flowers produced about as many seed capsules as naturally-pollinated flowers, and naturally-pollinated flowers outdid the control, which could only self-pollinate. Voila! Pollination was a limiting factor.



Capsules release seeds from July through September. Seeds fall to the soil near the parents or are dispersed, perhaps by floating. The parents die and the seeds carry the population to the next year.

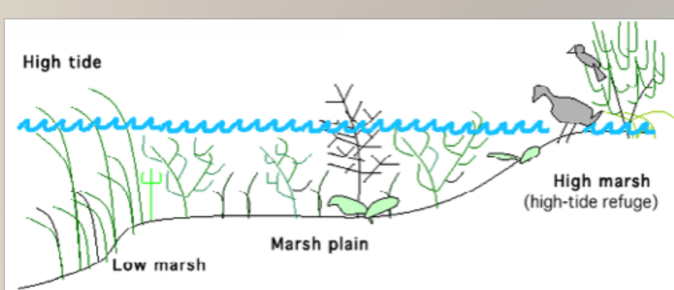
FALL: The seeds of SMBB remain on the plants or fall to the ground. We don't know how long SMBB seeds can stay dormant (inactive). From lab tests, there is some evidence that seeds can stay viable (alive) for a decade. But in the salt marsh, there are many hazards: Seeds might float away or be eaten or be damaged and decompose (rot). Seeds might also get buried under too much debris to germinate or they might stick to the feet of anything mobile. Seeds can even be carried away on the boots of salt marsh researchers! Only the seeds that are stored on site can remain dormant over winter in the right place, so the life cycle can begin again.

Over the year, SMBB responds to salinity stress by germinating when tides are low and rainfall leaches out salts. Seedlings develop and grow in the presence of perennial hosts, and flowering adults are pollinated by bees that live above the high tide line. The ability to avoid winter and drought and hypersalinity as dormant seeds allows SMBB to persist. With its many dependencies on just the right environment and just the right hosts and pollinators, it's no wonder that SMBB is restricted to only a few of the region's salt marshes. Please appreciate this rare and complex species; help managers make sure no one collects or tramples it!

light-footed clapper rail

While SMBB is germinating, growing, reproducing and lying dormant as seeds, what is the LFCR doing?

WINTER: Clapper rails are marsh birds, but they don't seem to enjoy being wet. Rails come out of the marsh to avoid high-tide water. If you visit the salt marsh during a winter extreme high tide, you might find a LFCR trying to escape high water. Plants of the salt marsh are almost entirely underwater during the king tides of January and February. Cordgrass grows at about 1.5 m (~5 feet) above mean lower low water (MLLW), and when the plant is only about 60 cm (2 feet) tall, the higher high tide water completely covers it. A marsh bird that usually hangs out in cordgrass is challenged by high daytime tides. If it has to move upslope to the upland, it will be vulnerable to predation.



Birds can find a high-tide refuge, but plants have to stay put and tolerate regular inundation.

Two clapper rails are looking for a refuge during a January high tide. But the dog is a potential predator. Note that the dog is on a leash, stretched tight—otherwise it would probably have attacked the rails already.

Can you see the cordgrass between the backyard and the distant buildings? Only the tallest leaves are above water. No wonder the birds left home during the high tide.

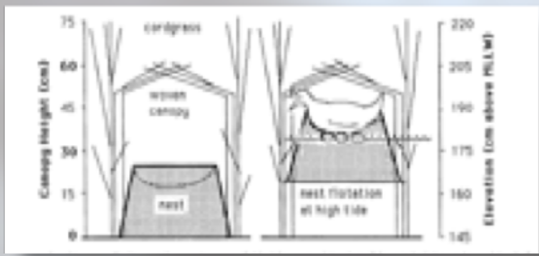
Photo: Abby Powell

For much of winter, the resident salt marsh birds have broad foraging areas. In late winter, they set up territories for nesting and begin to defend their nesting territories against interlopers. They wait to nest, after the high winter tides!

SPRING: In March, the tides have minimum amplitude, meaning that the higher high tides are not very high, and the lower low tides are not very low. Also, there can be rainstorms or ocean surges. Why do you think the LFCRs choose this time to nest? They time their nests to coincide with the longest period of minimal tidal amplitude (range) during the year. Smart birds!—or at least well-adapted birds--because high tides would wipe out early nests and eliminate genes of individuals programmed to be "first on their block" to lay eggs. But just because a male establishes a territory and a female nests and produces eggs does not ensure that lots of young will fledge.

LFCRs nest in March, when the tidal amplitude is small and the risk of inundation is minimal.

However, just in case there's a high storm tide, the nest can float.



Conceptual floating nest by J. Zedler (1993).

Secrets of nesting: LFCR optimize (make best use of) the brief period without major risks from high tides and storm surges. They set up territories in late January or February, in anticipation of lower tides in March. Then, they concentrate nest building, egg laying (9-10 eggs per nest), and the incubation period (nest-tending) into little more than a month.

Paul Jorgensen, long-term manager of Tijuana Estuary, studied LFCR nesting habits for his MS degree. He walked through the marsh and counted nests---more in the cordgrass than in pickleweed, and more in tall cordgrass than in short. In 1974 he found the first nest on April 17. On average, eggs took 23 days to hatch, with a range of 18 to 27 days. Chicks began hatching on May 5, and most hatched by May 21; however the last hatched on July 28 (Jorgensen 1975).

Photo: C. Nordby

Even though the tides are not predicted to be very high in April and May, chicks are vulnerable to a late storm surge when water levels can swamp a nest. Chicks risk becoming the prey of flying predators, such as osprey and hawks. And when the water level is low and their nests are close to the upland, chicks risk becoming prey of coyotes (or nowadays, dogs and cats).

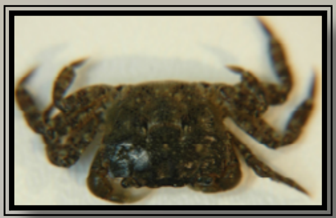
Large cordgrass marshes with wide wetland-upland transitions are safer places for LFCR nesting than urban wetlands! Regrettably, the marsh-upland transitions have mostly been filled for urban development, as is obvious in the photo of the back yard dog and LFCR "refugees" during a winter high tide.

Barbara Massey (Long Beach) and Richard Zembal (US FWS) learned many secrets about clapper rails during their years observing and monitoring of LFCR throughout southern California. At Upper Newport Bay, they followed hatching in 30 nests in 1979, where the majority of chicks hatched by May 30 and all chicks hatched by July 6. After hatching, LFCR chick use the incubation nest as a raft or switch to a brood nest (a platform) as a refuge above the rising tide water.

Jorgensen, Massey and Zembal deserve major credit for sustaining a large regional population of LFCR. Zembal spent much of his career at the US Fish and Wildlife Service. Among other innovations, he built artificial nesting platforms and organized efforts to rear chicks in captivity and to reintroduce them to the region's tidal marshes.

SUMMER: From March through August, the salt marsh vegetation grows tall by leaps and bounds (scientists say exponentially to describe rapid growth, like weekly doubling of 10 to 20 to 40 units tall). Tides achieve their maximum amplitude in summer, but unlike the Jan-Feb extreme tides, the Jun-Jul highest highs and lowest lows tend to occur at night. Visit the salt marsh on a summer morning and look for the high-tide line from the previous night. Wet soil and lines of debris (trash, twigs, dead biomass) are good indicators. Also, look for seeds in the debris line, as a clue to dispersal.

If you visit during the highest high tides of June, you might see clapper rails within the high marsh, as in winter…..but you would have to visit at night. Presumably, the chicks and adults are safer moving upslope at night, since some of their predators are visual feeders—osprey, northern harrier. Coyotes, dogs and cats might still be a major threat, especially to slow-moving chicks. Do you think that the chicks have black feathers so their predators can't see them on the black mud? Perhaps a black chick is camouflaged in a muddy marsh.



The shore crab (*Hemigrapsus oregonensis)* is a favorite food of LFCR, according to Jorgensen (1975). (Photo by: Dave Cowles)

Vertical banks support crab burrows, until the burrows cause the bank to collapse. Tidal creeks are dynamic.

Tall dense cordgrass provides camouflage for LFCR as well as for their foods. Small crabs, large insects, snails and worms are all fair game. Creek edges are particularly good places to see rails feeding, because the banks are often riddled with crab burrows, which are easily seen below the depth where cordgrass thrives. Still, the cordgrass is close by, so that rails can seek cover if they sense intruders.

Left: Cordgrass next to a mudflat with algae, snails, worms and crabs.

Right: Small tidal creek lined with cordgrass.

Edges are important habitat features---a salt marsh without creeks has little tidal flow (Later, I describe our 20-acre Model Marsh restoration site, where we compared areas with and without creek networks).

FALL: Just as in mid-March, during the equinox (equal hours of day and night) the tides in September have very low amplitude. This time of year is great for marsh field work—the plants rarely get covered by seawater, and the marsh-plain soil is relatively stable (less likely to engulf one's feet). Researchers still need boots to sample the cordgrass marsh, which is low enough in elevation to be wetted on a daily basis, at least every other week (spring tides). Cordgrass has a strong preference for continual tidal influence. It dies if planted at too high an elevation or if tidal influence is lost following closure of the estuary's ocean entrance.

Dr. John Callaway braving a mudflat at Tijuana Estuary. Waders were essential for this job!

Sally Trnka measuring cordgrass in late summer,wearing just knee boots and not sinking (much).

FWS biologists estimated that the rails need 2.5-acre home ranges (space to forage, escape predation, and nest). That's about 1 hectare (abbreviated ha). Because the birds don't seem to fly or swim much, a 1-ha home range might be enough for walking about. Or perhaps the home range is just right for the male parent to defend. Any larger, and the bird might be exhausted trying to keep other males at bay.

Does this site along Freeway 5 in Chula Vista look suitable for LFCR nesting in spring? No.

Is there habitat for high-tide refuges in winter? Not much.

What should attract LFCR nesting?

NOT our non-tidal lagoons, not marshes without much cordgrass, not marshes with short cordgrass, and not tiny wetlands.

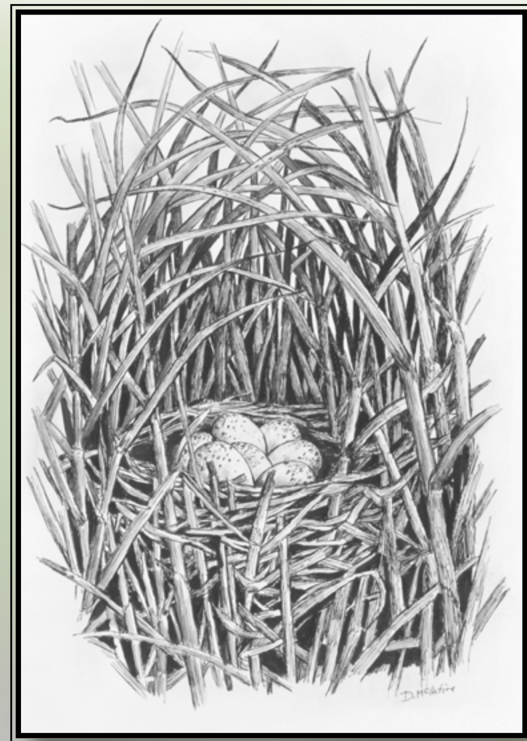
The optimal place for LFCR would be a large, fully tidal salt marsh with tidal channels and creeks, with large areas of tall cordgrass marsh that can support LFCR foods (crabs, worms, snails) and with substantial patches of tall cordgrass.

What's so great about cordgrass? Most plants don't get much attention unless they produce spectacular flowers or are threatened with extinction. Grasses don't even have showy petals (instead they have "glumes" that protect the "palea and lemma"). Some of us like cordgrass just because it's a graceful native grass that can live lower in the intertidal marsh than all the other halophytes.

Tall cordgrass offers year-round cover, even when the stems are dead in winter. We call them "standing dead," because most stems and leaves remain upright and can still hide the LFCR, regardless of season. You might argue that there's no trick to surviving a southern California winter, because temperatures are mild. But that doesn't mean the storms and floods are mild. Think of a typhoon that can blow down a house—then imagine floods or storm waves splashing over a salt marsh. People can dash to a shelter, but the LFCR has to seek refuge upslope, which might be a parking lot or a backyard with someone's dog.

Cordgrass is still widespread in California, although it has disappeared from some estuaries. In 1942, Edith Purer said it was robust in Los Peñasquitos Lagoon, but it hasn't been seen there for decades, and it didn't persist when I planted it there. In San Diego Bay, it used to occur along the mudflats, but the shoreline has been developed into port and industrial facilities. In Mission Bay, much of the shallow intertidal area has been dredged or filled to create the nation's largest aquatic park; only a small area remains as a salt marsh remnant.

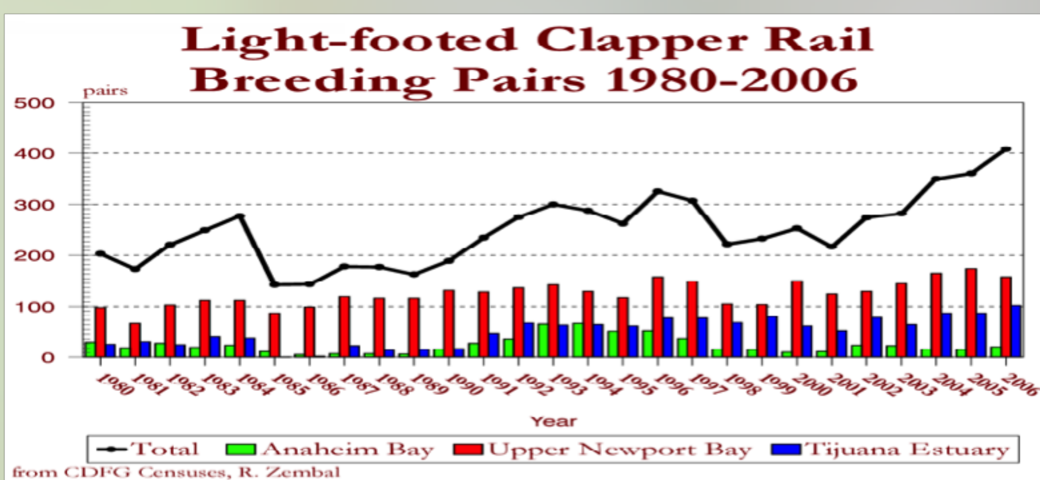
Is cordgrass presence enough, or must it grow in a particular way?



Why must the cordgrass be tall? Donovan McIntire's drawing (right, © Zedler) shows how the birds use the tallest stems to anchor the nest so it won't float away. They use the longest leaves to weave a canopy overhead—like a gazebo. The "gazebo roof" hides eggs and chicks from avian (bird) predators.

For many years, the US Fish and Wildlife Service has kept track of clapper rails. LFCR are easy to count during the January-February high spring tides, when the marsh floods and the rails move up into the surrounding high ground. According to recent surveys with thanks to Dr. Zembal and others at the US FWS, the LFCR population seems to be doing well in southern California. Among other heroic efforts, an artificial rearing program led to the release of 164 rails into target wetlands between 2001 and 2007.

The 2011 census was the 32nd year of monitoring LFCR. Between 4 February and 4 June, the team surveyed 30 coastal wetlands from Mugu Lagoon to Tijuana Estuary, of which 21 sites had 441 pairs exhibiting breeding behavior in 21. It and the 2007 census (439 pairs) were highest counts on record. So where were all those birds? There were 137 pairs in Upper Newport Bay, 113 pairs at Tijuana Estuary, 43 pairs in Batiquitos Lagoon, 34 pairs at Seal Beach, 19 pairs at Kendall-Frost Reserve in Mission Bay, 16 pairs at Mugu Lagoon, 15 pairs at San Elijo Lagoon, and 40 pairs in 12 more sites, each with 1-7 pairs.



So why are LFCR still endangered with extinction? Only 10-15% of the historical coastal wetland area remains in southern California. Territorial birds need plenty of space. Each pair of rails needs a home range that includes tall-cordgrass nesting habitat, mudflats and banks to forage, refuge from predators, high ground to escape high tides, space to hide from interlopers, and space to rear young.

Summary: Secrets about SMBB and LFCR:

• In winter, cool weather, low light, and high spring tides inundate the entire salt marsh, making it inhospitable (not "friendly") for plants, LFCR and SMBB. Rails move onto the high marsh and the transition to upland to find a refuge from deep water, but they encounter predators (dogs, cats) where houses and yards are too close to the marsh.

• Winter rains perform a critical function, leaching salt from the high marsh soil, preparing the way for seeds of SMBB and other species to germinate.

• In spring, tidal amplitudes are diminished, sunlight is brighter, marsh plants grow rapidly, LFCR nest and fledge their young, and SMBB roots tap into perennial hosts.

• In summer, the marsh is abuzz with activity that is visible daily, because high tides occur mostly at night. Plants achieve maximum biomass, algal mats are highly productive, invertebrates feed on the algae; insects consume tender plant tissues; SMBB gets pollinated and produces seeds; LFCR chicks mature.

• In fall, narrow tidal amplitudes and long days in the hot sun stress the marsh plants and dry the algal mats in between high tides. Dead biomass is inundated and decomposes; the marsh consumers feed on detritus and high January-February tides export dissolved organic carbon to estuarine channels.

That's how just two endangered residents use the salt marsh across the tidal and weather seasons. Every species has its own unique annual pattern. I hope you will uncover more of the secrets that all the other salt marsh species are waiting to reveal.