**What is a salt marsh?**

The salt marsh is defined in Webster’s dictionary as a flat land that is subject to overflow by salt water. A salt marsh is a flat coastal area that is somewhat over come by the incoming tides. However the salt marsh acts more of a buffer for the tides than as a flood plain itself. It has been argued that the functional role of the wetland environment is to act as a sort of filter improving water quality. But the extent of their role goes beyond that, salt marshes help to control floods and help to maintain lower shoreline erosion levels. They generally develop where salty waters of the ocean meet the fresh water of the rivers. The salt concentration in the marshes depends on the water that it is connected to. Marshes connected to the ocean have high salt concentrations while the marshes near the fresh water rivers have very low amounts of salt. (www.aura) The coastal salt marshes are located where the salty waters of the ocean or bay meet the fresh waters of estuaries and rivers. The salt marshes of the San Francisco bay generally have a lower salinity level than the salt marshes along the southern coast. This is because of the large amounts of fresh water runoff (www.tram). The salt marshes appear to have very little life and diversity, but with a closer look you can see the vast life that live in the marshes. Salt marshes are one of the most productive habitats per square acre. A large variety of plants and animals can be found within a salt marsh environment, the majority of these organisms are fully dependent upon the salt marsh for survival.

As the amount salt marsh habitat shrinks these animals are constricted to smaller and smaller habitats, which endangers the survival of the plants and animals within the salt marshes. The plants are forced to grow in tiny areas, which enforces Darwin’s Law: survival of the fittest. Many of the plants native to the marshes die off because of the competition they are faced with. Scientists are renovating returned and reclaimed salt   
marshes into the original salt marsh habitat, but it takes several years for the water to become suitable so the native plants and animals can re-establish themselves.

**What happened to them?**

Ninety-five percent of the California coastal wetlands have disappeared since the 1850s. “Historically the bay was ringed by roughly 190,000 acres of tidal marsh, 50,000 of tidal flats, 85,000 acres of seasonal wetlands and associated uplands, and over 69,000 acres of riparian habitat (San Francisco Bay Joint Venture). Today all that remains are 40,000 acres of tidal marsh and a mere 2,500 acres of riparian habitat.”(San Francisco Bay Joint Venture) This low amount of habitat has stressed the inhabiting wildlife, and has put many of them on the endangered species list. Some of this destruction is caused by nature’s evolution but humans have caused the majority of it. Most of the historic tidal marshes within the South San Francisco Bay area have been altered to salt ponds because of the destruction and changes made to the marshes. Over the course of the years we dredged the tidal marshes, diked them for agricultural purposes, and created flow diversions within them for municipal needs (San Francisco bay Joint Venture). In the past many of the large salt producing companies, such as Leslie Salt, would donate their salt ponds back to the local wildlife refugees as tax write-offs. Today there is increased pressure on the salt companies to return the land. The Don Edwards San Francisco Bay National Wildlife refugee owns approximately 20,000 acres of the original wetland area along the South Bay, but approximately 30,000 acres is still under use as salt production ponds. Despite all of the destruction that has occurred the San Francisco bay has the largest and most complex wetland structure in California, something that we do not want to lose.

# **How is the salt produced?**

The salt producing companies that use wetland areas to produce their salt have used processes that has destroyed the land and forced the native species to adapt to a significantly reduced habitat (USGS). Over the past century the amount of salt that is produced has increased from ten million tons annually to over two hundred million tons today (USGS). This high rate of salt loss will drastically change the conditions in the salt marshes and eventually force many of the native organisms to die off if nothing is done about it. North America alone produces over one fourth of the world’s salt (www.saltin). The facilities that are used range from primitive evaporation methods to multi-stage salt refineries. In California, specifically the San Francisco bay, a combination of the evaporation and the refinery methods are used.

It takes five years to produce the salt that you will use on your kitchen table (Don Edwards Interpretation center). The first step in the process is to damn a portion of the bay into a small pond. These small ponds are called intake ponds and are the first in a chain of successively more concentrated ponds. The intake ponds are filled with the bay water, which can be characterized by the green tint in the water and the presence of small fish, worms, and other bacteria.

The next few ponds are called intermediate ponds. As the water is pumped from the intake pond into the intermediate the concentration of salt in the ponds becomes higher. During this process the water in the pond sits in the sun causing the water to evaporate and leave the salt behind. Also, as the water progresses from pond to pond the water is less and less referred to as saltwater and more so as brine. The concentrations in each progressive pond are higher than the one prior to it. Because the concentration of salt in these ponds is higher small fishes and worms can no longer live in the ponds. The main organisms that are found in these ponds are the brine shrimp. Also the green tint from the algae is replaced by a red tint due to red-colored algae that can withstand the high salt concentration: the redder the pond, the higher the salt concentration.

Eventually the water in the ponds will become so concentrated that even the brine shrimp can no longer survive within the ponds. When the salt concentrations reach approximately 25.8% salt crystals begin to form. The deep red color of the water now can be attributed more to bacteria than to the algae. At this point there is very little water left in comparison to the concentration of salt and a layer of salt crystals would be found along the bottom of the ponds. It is in these ponds, the crystallizing ponds, that the final steps in the solar-evaporation method are completed. The layer of salt on floors of these ponds will build up to a level of salt between 10-25 cm. It this layer of salt on the pond floors that is harvested yearly.

**How does the production of salt affect the environment?**

In a healthy salt marsh environment there is an abundance of plant life and animal life. The salt marshes and the tidal mud flats, “contain the densest, richest growth area for animals of any natural community in the world.”(Conradson, p6) This diversity creates stability within the ecosystem. Each species has its own niche within the community and provides essential resources for the rest of the species in the community. When an environment is altered so that portions of species niches are eliminated, the species are forced into a smaller environment where they will be less productive and Darwin’s Law will set in forcing many of the organisms to die off. Eventually most of these transplanted species will force into extinction or will force other species into extinction. “The marshes of a hundred years ago formed a vast community of mud flats, slat marshes, and shallow waters,” (Conradson, p6) but today this extensive community has been drastically reduced.

# **Plants of the salt marshes**

The salt marsh environment is one of the harshest environments that a plant could live in. Most roots systems of plants that live in areas that lack salt in the soil have developed as to take advantage of the polar properties of water. “Because water molecules cohere to each other via chemical bonds, called hydrogen bonds, water molecules at the top of the plants are connected to water molecules in the soil much like the cars of a train.When water transpires (*a diffusion process*) from the leaves, other water molecules are brought closer to the root surface.”([www.ussl](http://www.ussl)). This mechanism helps plants to absorb water and carry it to the top of the plant. But how do plants control that the water flows into the plant rather than out of it? Plants have also evolved to take advantage of the osmotic properties of water. When a cell has the same amount of solutes inside of it, as outside of it the water will stay in place. This means that the water has come to equilibrium. However in a plant that does not live in salty areas the solute concentration is greater inside of the plant than outside of the plant. This works to the advantage of the plant because water will flow from where it is less concentrated to where it is more concentrated. Because the water is flowing into the plant the plant can carry it to it leaves.

In a plant that lives in salty soils or a halophyte, the concentration level of solutes is greater outside of the plant than in the plant (www.ussl). This would, in plants that are not adapted to live in salty environments, create a reverse flow of water. This reverse flow would cause the water in the plant to flow out of the plant to the more concentrated soil, dehydrating the plant. Salt marsh plants have developed to absorb the salt water and excrete the salt through special cells. By doing this they are creating fresh water, which they can utilize. (Conradson, 12)

Pickle-weed is by far the dominant plant of the salt marsh. It has evolved to withstand a salt concentration of 6-½ %, while most other salt marsh plants can only withstand a salt concentration of 2%. “In salt-succulent halophytes like pickle-weed, energy requiring pumps within each cell move the salt into the vacuole where it is stored.  When the vacuole cannot hold any more salt the cell breaks down and dies.  Younger cells then take over the job of pumping and storing salt.  This process results in what is called "salt-succulence", where the green photosynthetic tissue of the plant has many large cells holding massive amounts of salt in the interior vacuoles of the cells.  If you could taste the glands, they would be very salty like pickles.  That is how they got the name pickle-weed.” ([www.npsc](http://www.npsc).) Eventually the because the pickle-weed plant does not excrete salt, the salt will become so compacted in the stems of the plant, that that part of the plant will turn pinkish red and fall off. This is much like the process of those trees that leaves will turn color and fall off. (Conrason p12) Not all of the salt marsh plants are able to efficiently grow in soil with as high a percent of salt as the pickle-weed plant. Most are not able to survive in soils with a ratio much higher than 2% ([www.npsc](http://www.npsc).) Because of this, the different plants of the salt marsh tend to group together in bands. The plants will only grow in the soils that they can tolerate.

Due to the harsh environment of the salt marsh and the high salinity levels there isn’t a variance in the salt marsh plant species. The most common salt marsh species are:

|  |  |
| --- | --- |
| **Plant** | **Scientific Name** |
| Alkali Heath | *Frankenia grandifolia* |
| Wild mustard | *Brassica spp.* |
| Sand dock | *Rumex spp.* |
| Curly dock | *Rumex crispus* |
| Beet or Swiss chard | *Beta vulgaris* |
| Fat hen or salt brush | *Atriplex patula* |
| Pickle-weed | *Salicornia Virginica* |
| Marsh Dodder | *Cuscuta salina* |
| Fennel or sweet anise | *Foeniculum vulgare* |
| Jaumea | *Jaumea carnosa* |
| Gum plant | *Grindelia humilis* |
| Coyote Brush | *Baccharis piluaris* |
| Brass Buttons | *Cotula coronopifolia* |
| Star Thistle | *Centurea solstitialis* |
| Cat tail | *Typha latifolia* |
| Salt grass | *Distichlis spicata* |
| Wild oats | *Avena spp.* |
| Cord Grass | *Spartina foliosa* |
| Sea Lettuce | *Ulva spp.* |

Chart from Exploring our Bay lands, p54

**Saving the marshes…**

Salt marsh restoration is a fairly new science that had no “standard cookbook of tested methods and very few experts with answers” (www.aura). Each salt marsh is different and has unique characteristics depending on it’s location, so scientists have to take that al into account when they try to restore them. If something works on one marsh, it is possible that that technique may be very harmful to another. Even small differences can have a huge effect on the organisms living in the marsh.

Scientists have discovered that it is now possible to create entirely new salt marshes where old ones have been destroyed or have never existed before. They found it to be as simply as to remove a layer of fill that covers the old marsh and allow the plants to re-colonize themselves. This process takes a very long time because the “sediment deposition and removal have to reach a new balance” (www.aura). The process can be sped up by the formation of dredges and pumps, but most of the restoration is dependent on nature. The marshes now have a better chance to be restored to their natural state but there will not be a concrete answer until nature had taken into full effect.

# **The Salt Marshes and Our Project…**

When we were trying to find a topic, we decided we wanted to research something that was relevant today, and we wanted something that we were interested in. We started out by going through books, newspapers, and talking to the people around us. Slowly we came up with the idea of looking into the reclaimed salt marshes.

After we had an idea of what we wanted to look into, we took a trip to the salt marshes. Just by walking around the marshes, we decided to go ahead with the topic. We then had to decide on a specific area to focus in on. We knew that we wanted to compare the salt marshes that had never been destroyed to those that were transformed into reclaimed salt marshes. Our curiosity seemed to revolve around concept of the salt marshes being restored to their full health, if this was even possible. After doing some research about restored salt marshes we found that a “research project first has to identify all of the major organisms that live the marsh. This means counting birds and their nests, digging up worms and other invertebrates that live in bottom muds, and identifying the plants that grow in, on, and right up through the water.”(Hayward Marsh Expansion Project) This information helped to once again narrow down our topic to a population study, but at the same time we knew that there was no way that we could, in the given time, count all of those organisms.

The last bits of research that we did were to decide what type of organisms that we wanted to study and were able to study. Once again we ventured to the salt marshes and looked around. We wrote down everything that we saw, and later went over our notes. In the end we decided that because plants were the first organisms to start the re-inhabitation of the salt marshes and are the basis for all other life within the ecosystem, that plants would be our main focus. So our final topic was narrowed down to a population study on the different plants within the salt marshes that have been restored, in comparison to those marshes that have never been destroyed.