WETLANDS AND COASTAL WATER QUALITY: SHOULD WETLAND SIZE MATTER?

Monique R. Myers* and Richard F. Ambrose

Introduction

Generally, wetlands are thought to perform water purification functions, removing contaminants as water flows through sediment and vegetation. This paradigm was challenged when Grant et al. (2001) reported that Talbert Salt Marsh (Figure 1.) increased fecal indicator bacteria (FIB) output to coastal waters, contributing to poor coastal water quality. Like most southern California wetlands, Talbert Salt Marsh has been severely degraded. It is a small (10 ha), restored wetland, only 1/100th its original size, and located at the base of a highly urbanized watershed. Is it reasonable to expect that this or any severely altered wetland will perform the same water purification benefits as a natural wetland? To determine how a more pristine southern California coastal wetland attenuated bacterial contaminants, we investigated FIB concentrations entering and exiting Carpinteria Salt Marsh (Figure 2.), a 93 ha, moderate-sized, relatively natural wetland.

Wetlands and FIB Water Quality

Runoff from coastal watersheds carries bacteria to the ocean, causing human health risks. FIB, including *Enterococcus* (ENT) and *Escherichia coli* (EC), are natural components of human, bird and other animal's intestinal fauna used to indicate the presence of human pathogens that cause unhealthy conditions for humans in coastal water (Cabelli, 1980; Balarajan et al., 1991; Haile et al., 1999). Sources of FIB include: faulty or overflowing sewage systems, homeless populations and domestic and wild animals (Mallin et al, 2001; Crowther et al., 2002). FIB concentrations are used as a guide to determine when Southern California beaches should be closed to recreational activities.

It is well known that freshwater wetlands perform water treatment functions (Kay and McDonald, 1980; Breen et al., 1994; Davies and Bavor, 2000). While coastal tidal wetlands also are thought to reduce the risk of bacterial contamination to coastal waters, few studies have addressed this topic. Since animals, such as birds, attracted by wetlands produce FIB-laden feces, coastal wetlands are a potential source of FIB. Bacteria either from within wetland or outside sources may settle in slow-moving wetland waters where they can accumulate in sediment and possibly re-grow (Solo-Gabriele et al., 2000; Desmarais et al, 2002). Bacteria living in the sediment may be tidally flushed out to coastal bathing waters (Sanders et al., 2005).

We investigated FIB in Carpinteria Salt Marsh, a 93 ha (230 acre) wetland of pickleweed habitat (*Sarcocornia pacifica* [=*Salicornia virginica*]) located in Santa Barbara County, California. Influenced by a Mediterranean climate with heavy, intermittent rainfall in the winter and dry, usually rainless summers, nearly 90% of average annual rainfall occurs between November and April. During the winter rains pollutants accumulated during the summer are washed from the watershed into the wetland (Ferren et al, 1997). The watershed of CSM is composed of three subwatersheds that are drained by two creeks and a western coastal plain area. During summer tidal creeks receiving water from coastal plain agricultural establishments may flow with non-point source runoff.

To determine whether Carpinteria Salt Marsh (CSM), a moderate-sized, mostly natural Southern California wetland, acted to attenuate or exacerbate FIB loads to coastal waters, we evaluated FIB concentrations at all the inlet sites where watershed runoff entered the wetland and at the wetland-ocean interface where watershed runoff flowed to the ocean after passing through the wetland. Samples were taken during summer dry weather and 1-2 days after winter storms.

We found FIB concentrations at the mouth of Carpinteria Salt Marsh were not substantively higher than concentrations at the inlets. Carpinteria Salt Marsh transferred high levels of FIB to coastal waters only after the largest storm event of the year. During this storm, sedimentation, die off, and/or dilution were insufficient to remove bacteria from the large volume of surface water before the water entered the ocean. High volumes of bacteria-laden water overwhelmed the wetland's ability to reduce loads.

Figure 1. Areal view of Talbert Salt Marsh (10 ha).

Figure 2. Areal view of Carpinteria Salt Marsh (93 ha)

Discussion

The capacity of a wetland to remove FIB is affected by a variety of factors including: wetland size, sediment size, tidal flow, bird and other animal populations, vegetation type, size and abundance and tidal creek length and shape. Larger, more pristine wetlands, with longer tidal creeks and longer residence time of bacteria and sediment-attached bacteria, likely are better at reducing FIB loads to the coastal ocean. Generally, our investigations of Carpinteria Salt Marsh indicated this relatively large wetland was effective at attenuating fecal contamination. While surface waters entering CSM often had high FIB concentrations (during both wet and dry weather), they generally exited the wetland with low FIB values**,** indicating bacteria populations decreased as a result of flowing through the wetland.

Bacteria removal from CSM waters was likely the result of processes such as predation, destruction by ultraviolet light, and sedimentation (i.e. adsorbing to particles that then settle to the bottom) (Alkan et al., 1995). Bacterial concentrations may also have been reduced due to dilution by tidal waters. Within wetland factors, such as bacterial growth in the sediment or feces from resident bird populations, did not appear to significantly contribute to surface water FIB loads. Low values of bacteria in the sediment indicated FIB were not stored there nor did they re-grow in wetland sediment.

A recent study by Jeong et al (2008) indicated that Talbert Salt Marsh was able to remove FIB more efficiently as the volume of storm water runoff entering the marsh decreased. They concluded that a wetland may have a maximum capacity to attenuate contaminants; when loads exceed this value the wetland becomes a net source of contaminants to coastal waters. Wetlands with more area are able to attenuate contaminants from larger volumes of water than smaller wetlands. The reduction of Talbert Salt Marsh from its historic 1200 ha size to 10 ha undoubtedly had an impact on its ability to remove contaminants. The 93 ha Carpinteria Salt Marsh attenuated FIB most of the time despite a similar bird population.

Factors related to wetland size allowed Carpinteria Salt Marsh to attenuate FIB better than a smaller wetland such as Talbert Salt Marsh. The flow rate of water through Talbert Salt Marsh was reported by Grant et al. (2001) as <0.7 m/s, not surprisingly since this small marsh is located at the bottom of a highly developed 3,400 ha watershed. Carpinteria Salt Marsh flow rates were much lower with highest rates of 0.34-0.39 m/s. Talbert Salt Marsh water residence time was less than 1 hour.

Conclusions

Our results support the paradigm that coastal wetlands act to attenuate FIB populations. While this conclusion is in contrast to recent work that indicates coastal wetlands generate bacteria (Grant et al., 2001, Sanders et al., 2005), this is likely because the size and condition of the wetlands studied was different. We conclude that a 93 ha, mostly natural southern California coastal wetland is an adequate size to allow for natural removal of FIB when the contributing watershed(s) have low to moderate levels of development. With relatively little loss of original wetland habitat and only moderate levels of development in its watershed, Carpinteria Salt Marsh is able to provide a valuable ecosystem service of improving the quality of water before it reaches coastal waters. In light of this research we pose the question “Should minimum size guidelines/regulations be established for coastal wetland restoration projects?”

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Monique R. Myers
California Sea Grant
University of California Cooperative Extension
669 County Square Drive
Ventura, CA 93003
Ph (805) 645-1482
nicmyers@ucdavis.edu