SYMPOSIUM TALKS

Coupling Marine and Terrestrial Watershed Processes

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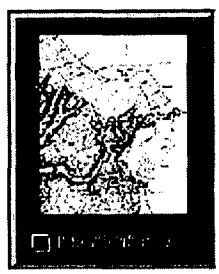
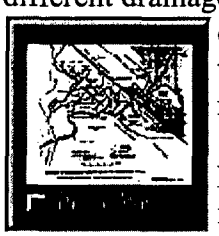


I am going to try to couple the terrestrial systems to the marine systems today, and, in doing so, the issue that I want to talk about is watersheds and how watersheds affect the marine system.

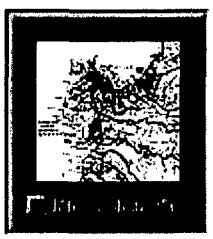
We are here today in the Monterey Marine Sanctuary. This is the basic Monterey Marine Sanctuary map [Figure 1], a piece of it, looking at where we are today, and you will notice these funny little creeks coming about a quarter of an inch off of the map. They aren't a quarter of an inch long. The Sanctuary is very much influenced by what goes on on the land, and the land influence zone is very, very much larger than what you would determine from this kind of a map. Just as our first speaker spoke about the Chesapeake Bay region, where much of this kind of linkage has been defined and worked on so very well by the U.S. Geological Survey and many other agencies participating over many, many decades to develop our understanding; so also must we do here in Monterey Bay. Unlike Chesapeake Bay, the Monterey Bay geology and the Monterey Bay terrestrial system, is enormously dynamic, rapidly changing, and incredibly geologically active. The streams that drain into Monterey Bay today didn't drain into it a few thousand years ago. A few hundred thousand years ago, we had very different streams, very different drainage [Figure 2]. The topography offshore in Monterey Bay is a function of rapidly changing geology, as Gary Greene's poster session I hope will demonstrate across the hall, and we need to understand this dynamism if we are to understand how we manage and how we live in this very, very unique area.



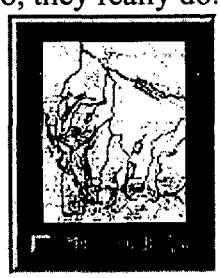
I'm going to try to talk just very briefly and introduce you to my absolute ignorance for only a small portion of the Monterey Marine Sanctuary. I will focus on just this piece that's on the over head right here where we are, and as Jo Guerrero pointed out this is but a small part of the whole marine sanctuary. I will try to look at the 6,000 square miles of terrestrial land area watershed systems that feed water into the Monterey Bay in this arcuate, beautifully balanced, energy expression that we call the arc of Monterey Bay [Figure 1]. So, my area of focus today is just this for which we have a fair amount of data, which could totally overwhelm the web pages if we try to put it all on. We have a record that is a reasonably good stream gauging record with a large number of years of record for many stations, with hourly or better data. [Table 1] The point is that we have a large number of stations that provide us with basic data. Some of the long-term stations that are more important, that give us the primary flux of water into the system, provide some continuous (if averaged) 1,200 cubic feet per second of water flowing into the bay. It works out to about 870,000 acre-feet of surface water a year, and about 580,000 acre-feet of groundwater and

non-point-source storm water a year that flows into Monterey Bay. It's very hard to come up with hard numbers. These are orders of magnitude kinds of numbers for the amount of water that flows into Monterey Bay. I was told to try to use some English units today, hydrologists do tend to use English units, but about 1,000 acre-feet is about a million cubic meters, so we're talking about 870 million cubic meters of surface water a year flowing into Monterey Bay. It's good to put this in perspective because the ocean isn't filling up, the ocean really doesn't need very much more water, and people in this region are frightfully afraid of the fact that they seem to be out of surface water, and yet, if we manage that water in more intelligent fashions we indeed do have a substantial amount.

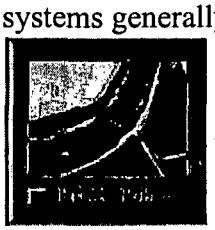
Now, the amount of water is not so critical as is the amount of material carried by the water. The work of rivers is not carrying water. The work of rivers is carrying sediment, and they simply do that with water. We tend to look at rivers and we see the water in rivers, and we think these are watersheds but, in fact, they are "sediment" sheds. We must deal with sediment entering Monterey Bay. I've tried to calculate roughly the amount of cation and anion nutrient loading that enters Monterey Bay in a year, and it works out to be something like 7 million metric tons of ions. This is just the ions, not the sediment, and just the biologically available nutrient ions. Seven million tons are entering Monterey Bay just this part of the Sanctuary; not talking about San Francisco Bay, not talking about large other fluxes, every annum. And much of that is carried on sediments. About 80% of that is carried on sediments. About 20% of it is carried as dissolved load directly into the system.

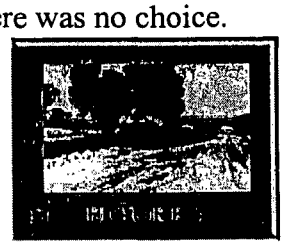


We have a fairly good data base. In Santa Cruz County, for example, at the north side of this Monterey Bay we have about 20 years of record for 1,000 surface water stations and 1,000 groundwater stations keeping track of the changing chemistry of the water moving into the bay. It's a remarkable record. It's not digitally available, it simply has never been entered, but it all exists. The critical thing that we need to think about is that not all of the information that we have comes from a gauged stream record. This, for example, right around where we sit here today represents a small sampling of the number of inches in diameter of various undocumented storm flow outfalls into the bay [Figure 3a] . These outfalls don't carry water all year round, but when they do, they really do. Here's the same thing for a few watersheds in Santa Cruz County [Figure 3b]. The massive amount of water that flows into the bay, generally reasonably contaminated water, that comes from these undocumented sources is indeed more significant than that which comes from documented sources.

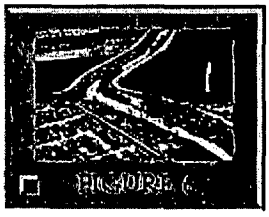


So what can we do about this water? We all know, as our first speaker said, that riparian systems generally modify and enhance water quality, and that estuarine systems generally modify and enhance water quality. This represents the Pajaro River at Watsonville at the time about a year ago when they started clearing off the vegetation on the inside of the levees after a major regional flood [Figure 4 & Figure 5] . It seems absurd to be clearing the wonderful riparian vegetation that filters our water and captures the sediment and thus captures the nutrients before it gets into the bay. But, in fact, from a hydrologic engineering standpoint, there was no choice. The system was not designed to carry the water and the sediments supplied to it. The Corps of Engineers designed the system to carry water. Somehow they hired all these people who thought rivers carried water! And, when you look at what the rivers are carrying they are carrying sediment, and the design of the river has to be different to carry sediment. To most efficiently transport sediment, you need a narrow, sinuous course that's allowed to flow over its banks. I question whether or not we're ever going to be able to restore our river



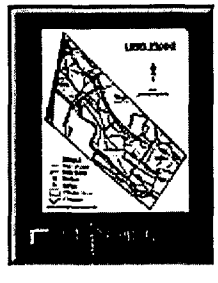


systems to the proper design. Given a good engineer, they can learn to design things properly, as long as they understand that irivers do not carry only water. But in the mean time we're clearing the sediment and reducing the capacity of the system to modify and enhance the water quality.



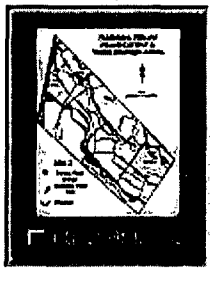
The sediment capturing abilities of these river and estuarine systems is well-known, there is a very large database, a very large literature on it. We know that the effectiveness of estuaries and riparian systems operating as a system in a flood plain will capture about 80% of the sediments and sediment-borne nutrients, and about 65% of the dissolved load nutrients in water. That is a gross generalization, it goes from +/- 0-100%. But we do have data, we do see here in Monterey Bay, that, for example, a 300-meter long reach of an old ditch with vegetation growing in it along the side of a highway will capture 100% of the petroleum residues, 65% of the lead and other heavy metals that pass through that ditch on their way to the ocean [Figure 6]. All we need to do is to design and enhance these things. We can capture the sediment and the nutrients headed into Monterey Bay. But, I want you to ask yourself, is it wrong that the sediments and nutrients go into Monterey Bay [Figure 7] ?

We spend a huge amount of money treating sewage and treating our systems to try to capture sediments, to try to evaluate non-point-source pollution and reduce non-point-source pollution. Certainly toxics heading into the bay are a serious threat. But is nitrogen heading into the bay a serious threat? Yes, we change the marine ecosystem when we nitrify the system. When we move large quantities of nitrogen into Elkhorn Slough we change the dynamics of the system. But the system is designed to handle those fluxes, and we can indeed capture and utilize those nutrients for the calamari that you and I have for dinner. So we can recycle some of what we put out as long as we are willing to eat relatively low on the food chain, and keep track of that.



The flood plain system such as this one on the Pajaro during the 1995 March floods captures a great deal of sediment and captures the nutrients in that sediment [Figure 8].

I want to end with some ideas that give us some solutions. One solution to our basic need to modify the runoff and maintain the quality of water entering Monterey Bay is to zone areas of recharge. Dan Haifley, with Senator Mello's office, here in the audience, is working now to develop watershed governance. It's a very intelligent



way to go. It is what General Vallejo did when he was first Governor of California, interim Governor, and it is what Major John Wesley Powell proposed to each western constitutional convention as they came on-line. He said, "Don't establish county governments that don't have watershed boundaries." And if we have already done that, let's pick every watershed that has 100,000 people in it or more and allow that group to establish their own governance and establish their own working guidelines. Let's tax withdrawals of groundwater, a very modest amount of $5 to $10 an acre-foot, nothing that actually pays for the water, but put that money into a kitty that we can pay back to farmers, pay back to cities, pay back to any entity that is willing to retain runoff. Pay them by the cubic foot of water retained, and by the amount of time that you slow its passage to the sea. This is the way to effect flood control, this is the way effect groundwater recharge, this is the way to capture some of that immense amount of water that is passing into Monterey Bay and to keep it in the system.The strategy of ecosystems in estuaries and riparian systems is to capture the nutrients and keep them on land and recycle them as much as possible. We can do that, we can help them, we can provide financial and tax incentives to work it, we can capture and slow runoff, we

can increase storage, we can decrease saltwater intrusion, and we can maintain a healthy bay [Figure 9 & Figure 10].