Our Ocean Backyard — *Santa Cruz Sentinel* columns by Gary Griggs, Director, Institute of Marine Sciences, UC Santa Cruz.

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Salt in the Sea

The oceans began to accumulate salt as soon as they started to form nearly four billion years ago. The ions of sodium, chlorine, magnesium, calcium, and just about every other element you can remember from the periodic table in your high school chemistry class, came from several different places. What may be a little surprising is that river runoff is one of the primary sources of the salt in the sea.

While we think of the water in our streams as "fresh", our creeks and rivers, whether the Colorado, the Amazon, or the San Lorenzo, actually contain small amounts of dissolved material from the erosion and weathering of rocks in their watersheds. This dissolved material or salt has been accumulating in the oceans for billions of years. The amount carried by individual streams varies depending upon the geology of the drainage basin, as well as the rainfall and climate of the region. Dissolved material is also added from thermal vents on the seafloor, and some even comes from volcanic eruptions.

Without a way to remove salts, however, seawater would continue to get saltier as more dissolved minerals enter the ocean. We know from analyzing fossils of ancient marine organisms and also from the composition of the water sometimes trapped within older marine sediments, that the salt content or salinity of the oceans hasn't changed significantly over geologic time. Water wells drilled into some sedimentary rocks in the Santa Cruz Mountains actually have pumped up ancient seawater, with a salt content essentially the same as the present day ocean.

So there must be some processes by which the salt in the ocean is removed at the same rate it's added in order to keep the salinity constant. Some elements, calcium and silica, for example, are extracted by marine organisms to make their shells, Other elements are attracted to the surfaces of clays or biological particles as they settle through the ocean to the seafloor where they incorporated into sediments.

What may at first glance seem like an unimportant process is the salt spray that is created as large waves break along the shoreline. You can feel the salt on your skin walking along the cliffs on a day with crashing waves. This process can remove a

large amount of salt. Water also seeps or infiltrates into the ocean bottom near hydrothermal vents on the seafloor, removing dissolved material.

Large volumes of salt are also precipitated in salt flats, on the edges of tidal embayments or lagoons, such as the margins of San Francisco Bay, where seawater evaporates and leaves the salt behind.

How salty is the ocean anyway? Well, too salty to drink is the short answer. The total amount of salt in seawater is only about 3.5% by weight. A gallon of ocean water contains about 4.8 ounces of salt. That's not much, but it's enough to make it totally undrinkable and of virtually no use for agriculture. The most common elements or ions that make the seas salty are sodium and chloride (which when combined make table salt), but there is also a long list of other dissolved materials in seawater. While there are only 4.8 ounces of salt in each gallon, if we took all of the salt out of the world oceans it would be enough to cover the entire planet with a layer about 500 feet thick! The importance of this more or less accepted source of the water in the sea has been questioned recently, however, with a less obvious source put forward- large volumes of water likely have been added over time from space. Icy comets or meteorites from the far reaches of the solar system colliding with Earth throughout its history, may well have also contributed significant volumes of water that helped cool the Earth's surface and gradually collected to help form the oceans.

As the primordial oceans began to form, their water began to dissolve minerals in the rocks at the Earth's surface. Large volumes of water were also being evaporated from the oceans, which then condensed in the atmosphere and fell back down as rain. This precipitation and runoff through the earliest rivers and streams, towards the low areas or oceans, also helped to break down the rocks and transport their constituents to the sea. In addition, many of the ions that contribute to the salinity of the oceans are believed to have come from within the Earth, from both volcanic eruptions and also thermal vents on the sea floor, over millions of years. As a result, the oceans began to accumulate these ions and become salty very early in its history.