Title
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Final report

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This project was developed into two avenues aiming at assessing levels of metals in kelp and salt marsh plants in the San Diego area. This information was then used to address whether metals levels found in kelp and salt marsh plants reflect bioavailable metals in the environment, which could help their use in environmental monitoring.

Metals in kelp

The kelp part of the project addressed the level of metals in the giant kelp *Macrocystis pyriferia* and the bottom kelp *Laminaria* sp. following two complementary approaches: one descriptive in the field, and the other experimental in the laboratory. The field approach consisted of describing the concentrations of metals from various areas of the Point Loma kelp bed during two seasons (fall and winter). The goal was to identify the metal signature profile of the kelp and determine whether this signature changed spatially and temporally within the kelp bed.

Data indicated that both species of kelp showed the same metals signature when collected from the field, having elevated concentrations of Ag, As, Cr, Mn, Ni, Pb, Se, Sr, and V. The highest concentration of metal found was for strontium (Sr), which ranged from 100 ppm to 325 ppm; Sr is a metal known to have a bio/terragenic origin, resulting from erosion and leachability from the soil and earth crust. Thus, high levels of Sr indicate elevated conditions of erosion, which could be associated to rivers, watershed runoff, or facilitated by anthropogenic activities.

Another interesting metal found was arsenic (As), which was present in concentrations from 8 ppm to 37 ppm. As usually occurs in trace concentrations in seawater and this therefore indicates that the metal is specifically uptaken by the kelp, n which it probably has a biological function. As is often associated with jelly organisms and could be associated here with the mucus produced by kelp.

All of the samples between the top and bottom for the *Macrocystis*, between *Laminaria* and *Macrocystis*, between fall and winter samples, and between the locations had very similar metal signatures. The data therefore did not indicate any impact from the metals contaminated water flushing out of San Diego Bay onto the Point Loma kelp forest. In addition, the metal concentrations were similar between the La Jolla site (control reference) and the site closest to the mouth of the bay thus indicating that the metals signatures found were inherent to the algae and not (or somewhat little) affected by surrounding environmental conditions.

The goal of the in-lab approach was to ascertain the dose-response profile of how *Macrocystis pyriferia* reacts to increasing copper concentration in seawater. It was shown that *Macrocystis* uptakes metal in the surrounding water extremely quickly. By the first day, the kelp had taken up high levels of the metal that were proportional to the level of exposure. In the subsequent days the copper level stayed constant, in balance with the ratio of copper added. We can therefore infer that kelp is very sensitive to metals in the water column and while the concentration may be higher in the algae than in the surrounding water, it is still an accurate estimate of metal concentrations in the surrounding water column. This finding however seems contradictory to our field data, in which the metals signature seemed independent from the surrounding level of contamination.

An interesting observation was made about the biology of the kelp. After few days of exposure to copper, the kelp started secreting a mucus material. It is hypothesized that this material is made of dissolved organic matter that can act as a chelator for the metal in solution, thus decreasing its availability to the algae. We conducted further experiments to address this point, exposing the kelp to one concentration of copper with increasing concentration of humic acid (a common proxy of dissolved organic matter). The data showed that indeed, the kelp exposed to copper with high levels of humic acid will uptake less copper than the kelp exposed to the same concentration of copper, but with less humic acid. Also, it was observed that the more humic acid added to the kelp, the less mucus material it would secrete.

This part of the project therefore indicated that kelp can make itself somewhat isolated from the surrounding environment in terms of change in metals content, probably by secreting a mucus material that can act as metals chelator to protect the kelp from extensive and potentially deleterious accumulation.

Metals in salt marshes plants

Salt marshes in Southern California are surrounded by urban development and therefore subjected to various levels of anthropogenic disturbances. In the San Diego area urban development increases in density from north to south, which would infer an impact on individual marshes. The objective of the field component of this study was to investigate the level of metal contamination in common salt marsh plants (*Batis maritima*, *Spartina foliosa*, and *Sarcocornia pacifica*) and sediment surrounding plant roots in four salt marshes (Los Penasquitos lagoon, Kendall-Frost lagoon, SweetWater river estuary, Tijuana river estuary). Generally, metals associated with sediment (viz., the bioavailable fraction of the metals present in the sediment) showed no particular gradient of concentration from northern to southern marsh. In contrast, plant metal concentration showed a clear trend with a decreasing gradient from northern to southern marsh. Increasing organic matter and decreasing grain size of sediment, which affect bioavailability of metals, appeared to be the main factors controlling such trend rather than the density of urbanization.

Samples were collected in the summers of 2007- 08, and winter of 2008. Winter season showed a 4.5x increase in metal content in plants compared to summer; however, metals associated with sediment only increased 2.5x in winter. These results suggest that metal accumulation occurred mainly from dissolved metals in seawater in the winter. The metals then enter the plant through the roots before being spread to the remaining of the plant during the spring/summer time. This suggest that analyzing metals from salt marsh plants in the summer provides a reliable estimate of the amount of bioavailable metals originating from the past winter runoff.

The laboratory objective was to test the rate of metal uptake by plants by a dose response of copper bioaccumulation experiment in aquaria using one of three local marsh plants. It was shown that copper was taken up first by plant roots, then sub-sequentially transported throughout the plant tissues. This indicates that plants can be used as ecologically relevant bioindicator of metal contamination in salt marshes, considering that metals originate mainly from the dissolved ionic phase rather than the sediments.

Results of this project will be summarized and presented into three scientific publications (in preparation) submitted to peer-review journals.