Historical changes in the Columbia River estuary based on sediment cores: feasibility studies

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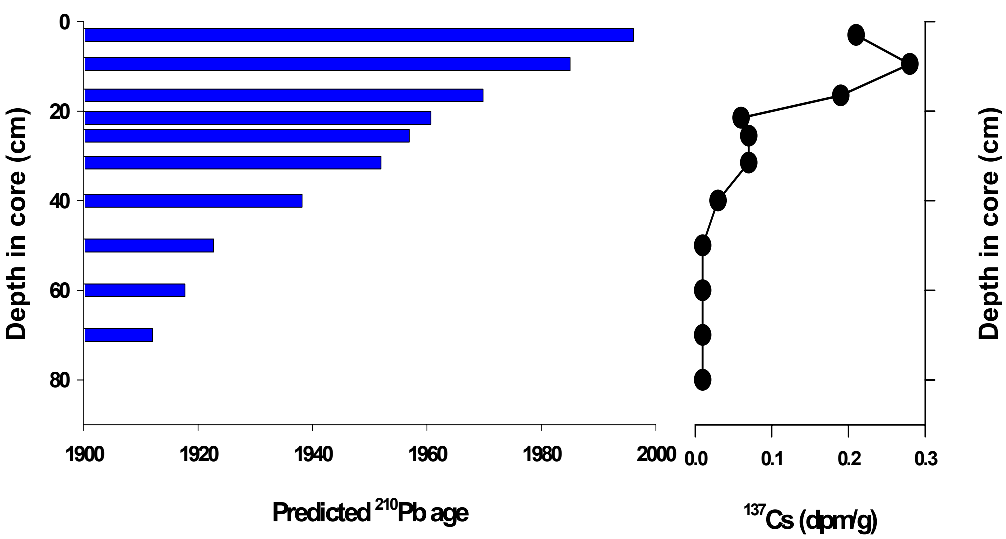
The importance of the Columbia River estuary to salmon, other fishes, migratory birds, and other species is fairly well established. Relatively little is known, however, about long-term, historic variations in biological processes and conditions within the estuary. For example, have conditions varied greatly with climatic regime shifts and how has dam construction on the Columbia River influenced biological communities over time? We conducted a feasibility study to see if sediment cores from the estuary could be aged and whether biological or contaminant indicators could be identified. Such information could be useful in understanding long-term environmental variation and in restoration studies.

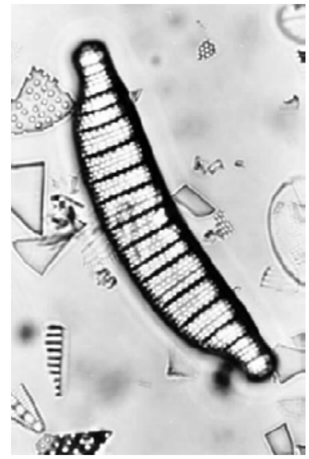
From a set of cores that were originally collected for a regional sediment study, we selected three for analysis, one each from Young's Bay, Gray's Bay, and Clatskanie Flats (floodplain). ^{210}Pb was used to age strata in these cores, with the oldest sediments being deposited in about 1850



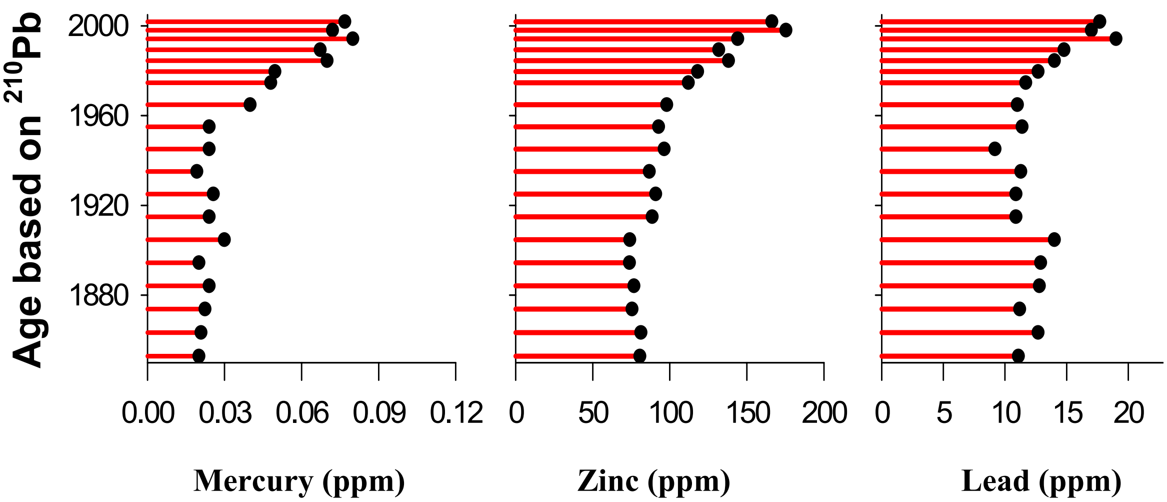
Depth and predicted age of sediment from Young's Bay core, Columbia River estuary.

(Gray's Bay, 150 cm core; Clatskanie Flats, 140 cm core). ^{137}Cs activity was used to corroborate the predicted ^{210}Pb ages, with good success. Fitted second-order polynomials ($r^2 > 97\%$) were used to extrapolate ages prior to 1900 in the two deeper cores. Sections from cores (2 cm thick, taken about every 10 cm) were examined for 30 heavy metals, diverse algal pigments, percent organic content, diatom species, stable isotopes of C and N, and grain size distributions. Smaller samples of cores were also examined for invertebrate parts and fish scales, although none were observed.

The Young's Bay core was the shortest of the three examined (80 cm) and contained sediment that was deposited from about 1910 to 2000. During this period, there appeared to have been a major change in the physical conditions and biological community at this site. Grain size distributions changed around 1940, along with a shift from primarily benthic freshwater diatoms early in the century to planktonic freshwater species after 1940. The shift at this time was also well represented in algal pigments. For example, diatoxanthin and beta-carotene declined five- to ten-fold, while alloxanthin and chlorophyll-a increased sharply. These changes suggest that there may have been an overall 400% reduction in algal standing crop. We cannot identify specifically the mechanism(s) that led to these changes, but mainstem impoundment or local alterations in the Young's River drainage can be suggested. The concentration of a few heavy metals such as lead showed slight increases between 1920 (14 ppm) and 2000 (21 ppm).



The core from Gray's Bay spanned the period from about 1853 to 2000, and there appeared to be less change in the biological community at this site, but significant accumulation of heavy metal contaminants. Throughout this period, the diatom community was dominated by benthic freshwater species (>82% of all identified species) and algal pigments showed few trends, although the percent organic matter doubled from ~3% prior to 1970 to ~6% after 1970. As in Young's Bay, the ratio of ^{13}C



Selected heavy metals concentrations from the Gray's Bay core.

to ^{12}C (δ^{13}C) was characteristic of planktonic carbon sources. This core, however, showed the strongest evidence of increasing heavy metal contamination beginning about 1960. Mercury concentration, for example, was very consistent in sediments deposited between 1850 and 1950 (~0.03 ppm), but concentration increased steadily from about 1960 to the 1990s with a final concentration of ~0.08 ppm. Lead, copper, zinc, and other heavy metals showed similar increasing accumulations during the last 40 years.

Sediments in the core selected from the Clatskanie Flats area were composed of finer, siltier material than the other two cores, and the base of this core extended back to about 1855. Diatom analyses were not conducted for this core, but shifts in algal pigments, decreased percent organic material, an increase in an ultraviolet index, and change in $\delta^{13}C$ suggest some significant changes in the biotic community. A few heavy metal concentrations (e.g., lead and zinc) increased gradually over the last 150 years, while other metal concentrations remained fairly constant (e.g., mercury and copper).

In conclusion, we were able to successfully age the sediments within these cores. A variety of indicators suggested that major shifts in algal communities and contaminant levels have occurred either locally or regionally in the Columbia River estuary. These sorts of findings can be refined to assist with historical interpretations and hypothesis tests about mechanisms. Averages of indicators from deeper and older sediments often had small variances, suggesting they could be used in evaluating restoration actions, considering the impacts of dredging, or for detecting natural change. Overall measures of bioproductivity, such as total diatom concentration, might be used to compare the type of environment that juvenile salmon now encounter with the historical environment. Finally, a larger study may be useful in distinguishing the role of climate regime changes and human impacts on estuarine or freshwater conditions within the Columbia River Basin.