Mercury and PCB Contamination in the Bay

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I wrote Python scripts to analyze the data in the spreadsheets I downloaded from the SFEI database. I uploaded my code to GitHub: https://github.com/elikond/SFEI_Challenge.

Where is contamination the most acute?

This analysis explores which areas of the San Francisco Bay have the highest concentrations of mercury and polychlorinated biphenyl (PCB). Mercury and PCB are toxins which have been proven to negatively affect human health; high levels of methylmercury and PCB can stunt childrens' development and cause cancer in animals (OEHHA 2011).

To select the data for this project, I applied the following filters to the Contaminant Data Display and Download (CD3) tool: "Sediment Toxicity," and "Tissue" (Analyte Groups); "Mercury" (Analyte) and "PCBs" (Analyte Group). For this question, I only selected data from the year 2000 and forward. For sediment data, I allowed for values in ug/g (equivalent to ppm), ng/g, mg/kg and ug/kg, and translated all to ug/g (results in ng/g and ug/kg got divided by 1000, others remained the same). For tissue data, I allowed for all types of fish and only for the units of wet and dry weight because the overwhelming majority of the data were in those units. I used the formula: wet weight = dry weight/5 to translate everything to wet weight in ug/g.

I started my analysis by selecting twelve fishing piers from the provided Fishing Maps 1 and 2 which span the Bay: Benicia, Sturgeon Hole, Coyote Point, Candle Stick, Warm Cove, Point Pinole, San Francisco Municipal, Pacifica, Vallejo, Coyote Creek, Berkeley, and Oakland. I then found the latitude and longitude of every pier from Google Maps. Using Python, I drew a circle of radius 2.5 miles around each one. I then averaged all the data points which were collected in a circle to calculate the average value of mercury and PCB for that area.

Figure 1

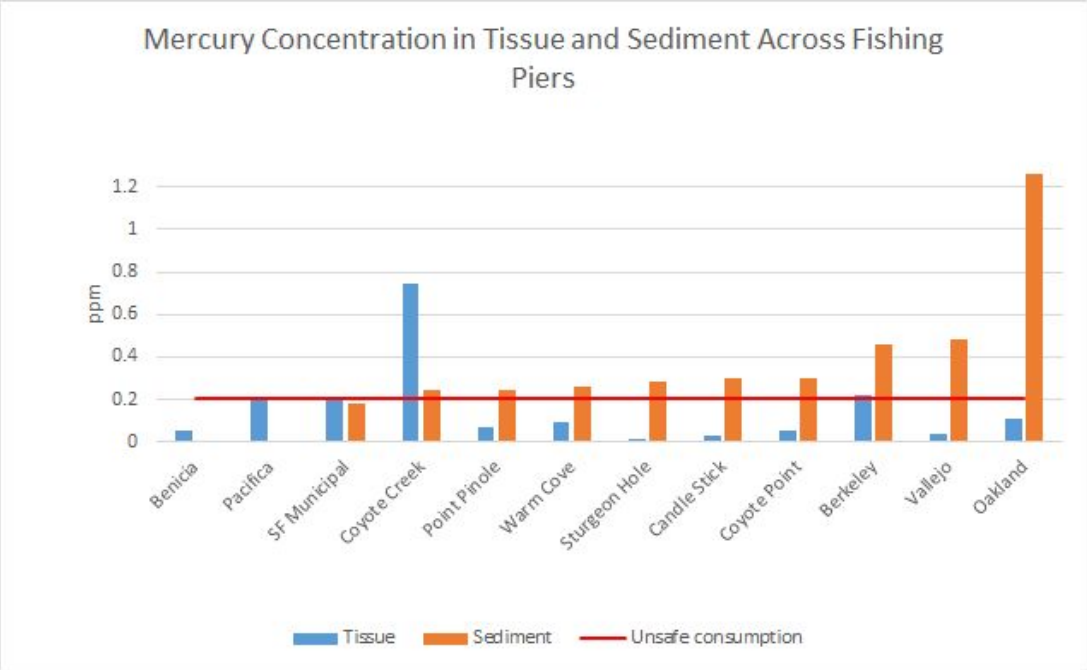
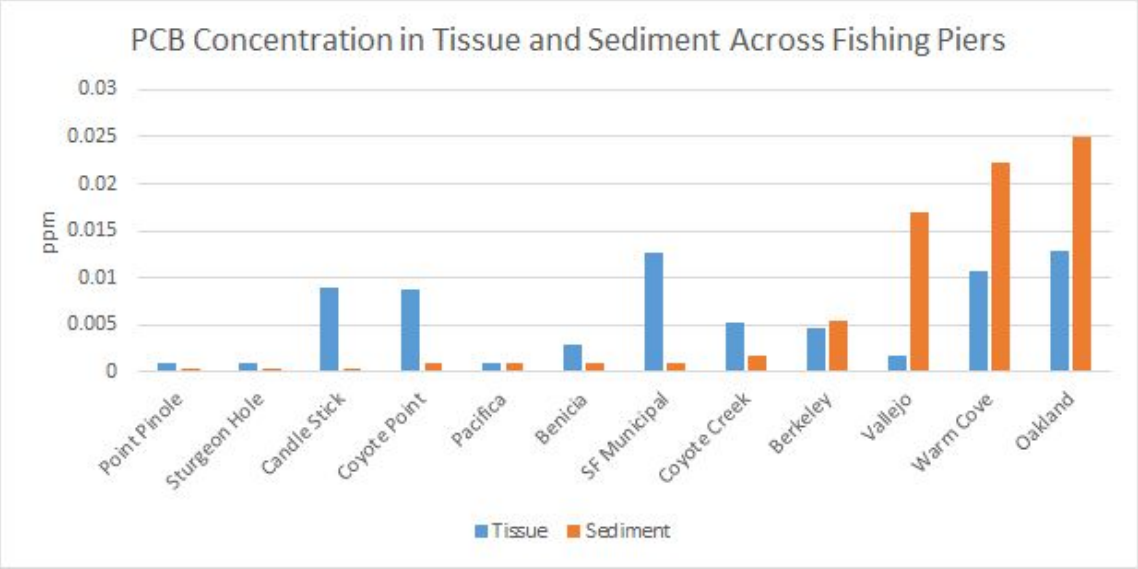


Figure 2



The red line at 0.2 ppm on Figure 1 indicates the level of unsafe mercury consumption according to the California government mandate (BACWA 2004). The FDA has set the level of unsafe PCB consumption at 2 ppm; the data in Figure 2 is well below 2 ppm so I did not graph a line (ATSDR 2014).

As Figure 1 shows, Oakland, Vallejo, Berkeley, Coyote Point, Candle Stick, Sturgeon Hole, Warm Cove, Point Pinole, and Coyote Creek all have unsafe mercury contamination in

sediment. Coyote Creek, Berkeley and SF Municipal have unsafe mercury contamination in tissue. Although Oakland and Vallejo have the highest concentrations in sediment, they have low concentrations in tissue. However, sediment concentrations are more telling than tissue concentrations because "[m]ercury binds to sediment particles, so mercury concentrations in the sediment deposits on the bottom of the Bay are an important index of contamination of the ecosystem" (SFEI 2017).

As seen in Figure 2, while Oakland, Warm Cove, and Vallejo are the areas with the highest PCB concentrations in sediment, their concentrations are still well below the unsafe threshold. I followed precedent and sorted the data in terms of sediment contamination instead of tissue contamination as "concentrations of PCBs and mercury on suspended sediment particles...are measured as an index of the degree of watershed contamination and potential for effective management action" (SFEI 2017).

These results are important not only because they help anglers find safe areas to fish but also because they inform scientists of the areas where load reduction is critical/where contamination management has been ineffective.

Is there evidence that fish and nearby sediment contamination are linked?

For this research question, I also used data from 2000 and forward and converted all data into ppm. I only included values from stations that had collected more than ten tissue/sediment measurements to increase the accuracy of the calculations. Using Python, I created a circle of radius 2.5 miles around each station. I averaged the sediment values and then the tissue values within those regions. From every circle, I got an (x, y) point; x representing the sediment value and y representing the tissue value. I created a scatter plot of all the (x, y) points.

Figure 3

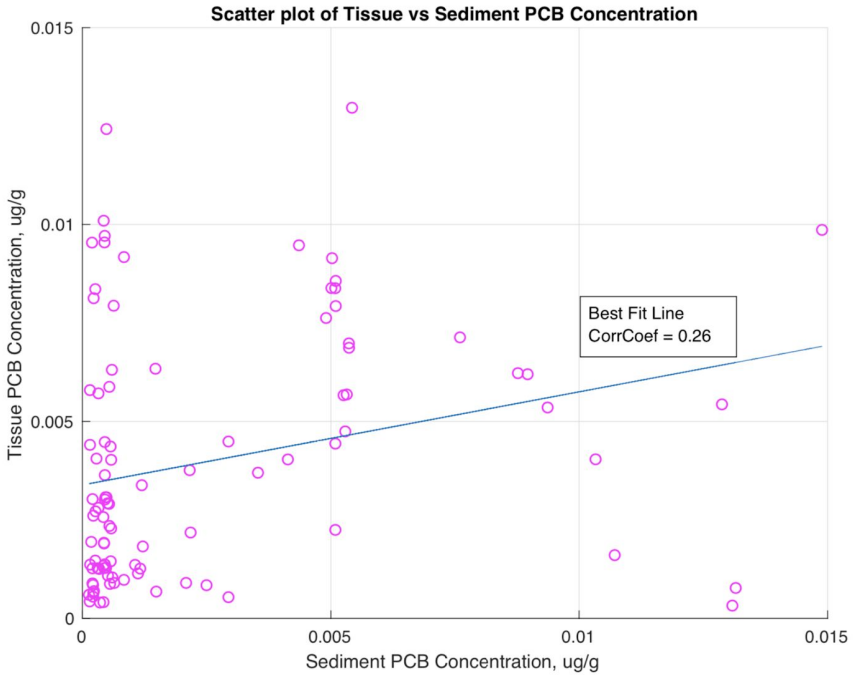


Figure 4

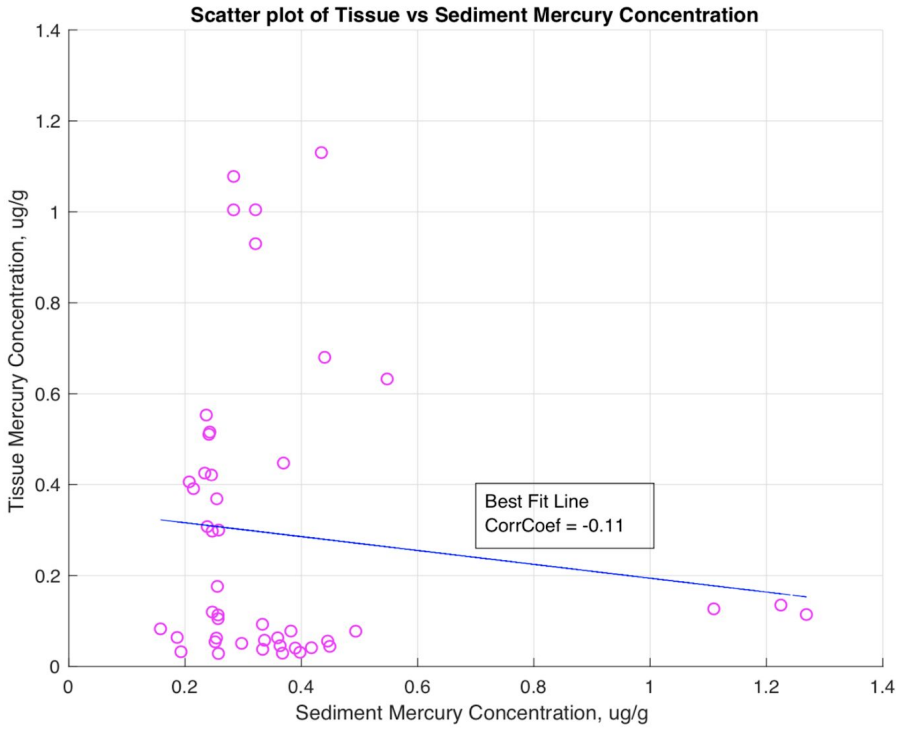
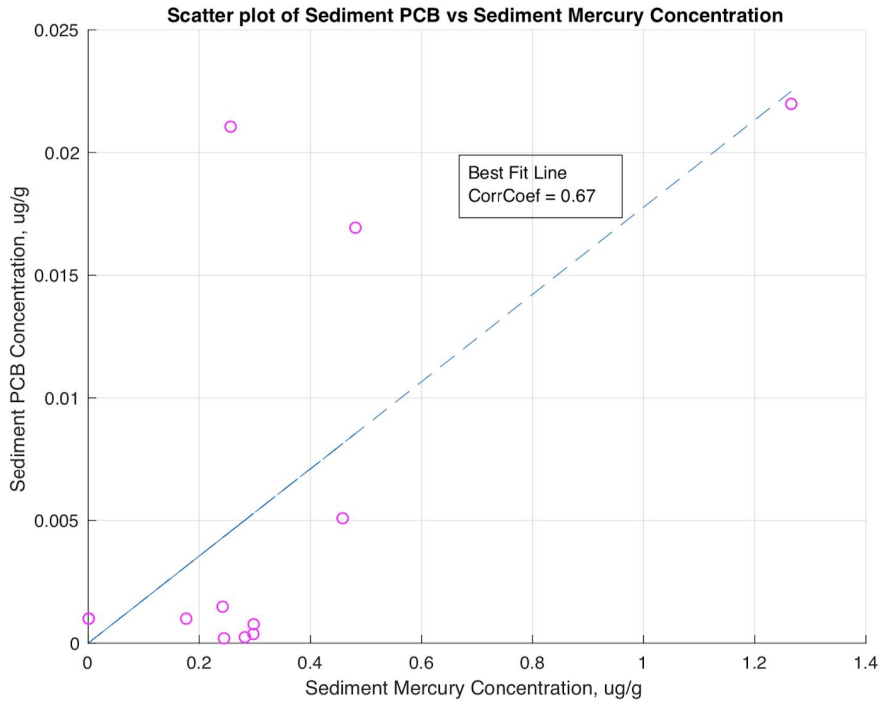


Figure 5

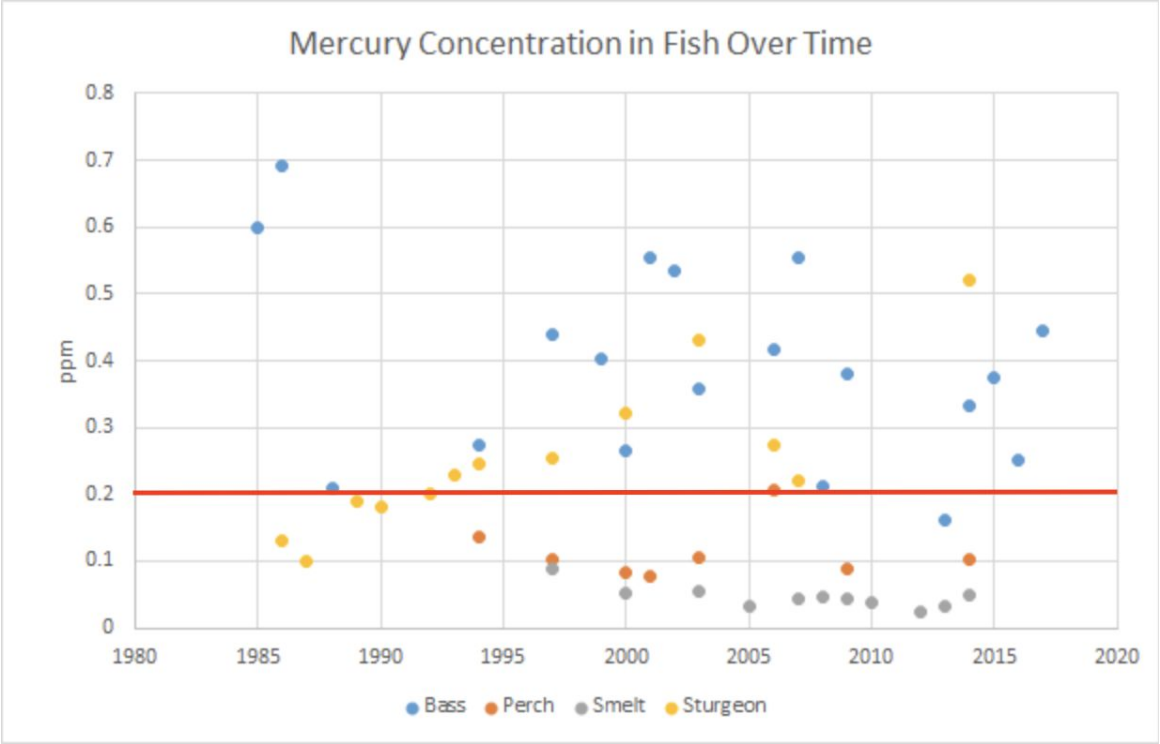


As the Figure 3 and 4 show, there is a low correlation between mercury or PCB concentrations in sediment and tissue (the correlation coefficients are -0.11 for mercury and 0.26 for PCB). The low correlation between tissue and sediment concentrations may be caused by the low variability in the sediment values. However, there is correlation between mercury and PCB concentrations in sediment (correlation coefficient is 0.67). This correlation makes sense because areas with high waste water dumps and agricultural runoff receive both PCB and mercury. Thus, areas with high contaminant loads will have both high PCB and high mercury concentrations in the sediment.

Is there evidence of improvement over time in sediment and/or fish tissue?

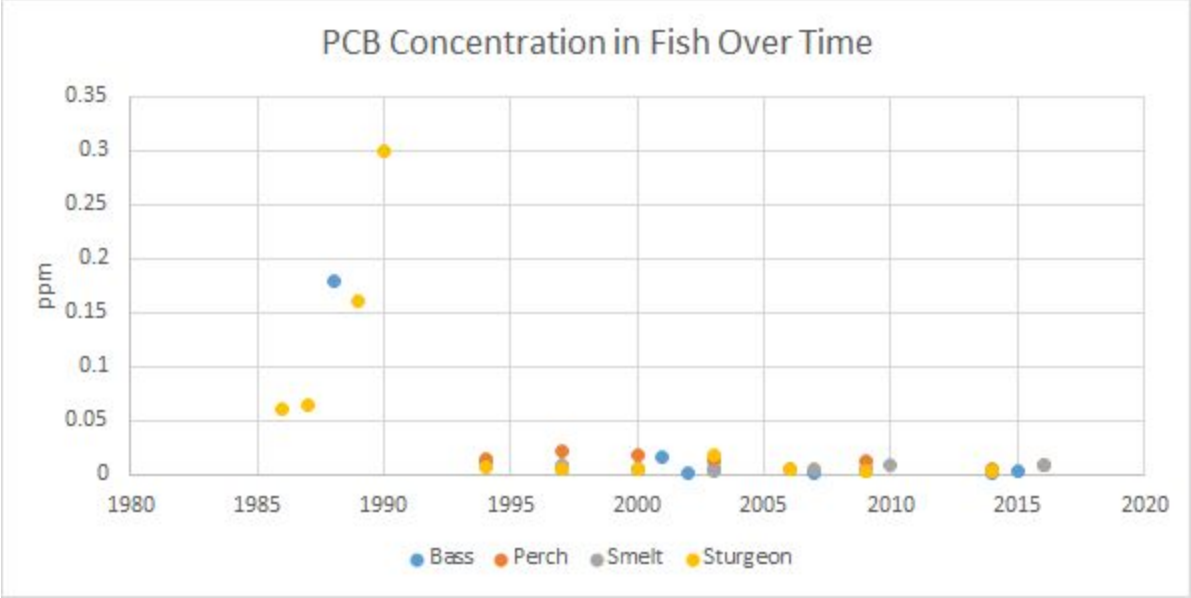
For the final research question, I analyzed data from 1985 and forward. I took data from across the Bay for four fish. I combined subspecies into the general category (i.e. “Striped Bass” and “Largemouth Bass” both fell under bass; “Top Smelt” and “Jacksmelt” both fell under Smelt). I took the values of all these fish and averaged them per type per year.

Figure 6



*Red line indicates unsafe consumption levels

Figure 7



Mercury concentrations displayed in Figure 6 are much more troubling than PCB concentrations shown in Figure 7. Bass and sturgeon mercury levels have mostly remained above unsafe consumption levels through the years. Sturgeon concentrations rose in a relatively linear

fashion from 0.1 ppm in 1987 to 0.5 ppm in 2014. On the other hand, perch and smelt mercury concentrations have remained relatively steady below unsafe levels; they stood at 0.1 and 0.05 ppm respectively.

As seen in Figure 7, PCB concentrations for all fish remained low. Sturgeon and Bass concentrations were highest between 1985 and 1990, however, they dropped to below 0.05 ppm in the next five years. Data collection on PCB contamination in perch and smelt started later on, with values between 0.05 and zero.

References

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