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Effect of Dams and PCB Levels on Health of Striped Bass in the Hudson River

Yashaswini Bonthu[1] and Lydia Villa[#]

[1]Arlington High School, USA
[#]Advisor

ABSTRACT

Polychlorinated biphenyls (PCBs) are a major pollutant found in the Hudson River. PCBs can build up in fish and can have negative impacts on human health if consumed. Dams were originally built in the Hudson River to improve efficiency of transportation of commercial goods, but now affect fish migration and sediment transport. PCBs often accumulate in sediment, so if sediment transport is affected then PCB concentrations in certain areas of the river would also be affected in areas near dams. This paper seeks to answer the question of how dams and PCB levels affect the health of striped bass by using data collected at 7 different locations in the Hudson River. Based on this data, when lipid PCB levels were high, measures of fish health would decrease. This indicates a correlation between high lipid PCB measurements and a decrease in fish health. Dams also decrease the transport of sediment, so we hypothesized that there would likely be a greater concentration of PCB in the sediment in these areas of the river. This could explain the high PCB measurement at Below Federal Dam found in our study. Our results show convincing evidence of a negative relationship between lipid PCB content and health of striped bass. Dams could lead to decreases in fish health due to high PCB concentration in these areas, which could lead to an overall decline in the fish population in the Hudson River.

Introduction

The Hudson River was important for the transport of goods between New York Harbor and the Great Lakes after the Erie Canal was built, and it flows from the Adirondack Mountains to New York Harbor (*The Hudson Estuary*). The Hudson River is considered a tidal estuary, from the stretch from the Federal Dam in Troy to New York Harbor, which is a distance of 153 miles. A tidal estuary is a body of water in which salt water from the ocean combines with fresh water from tributaries. “Because the Hudson River is a tidal estuary, meaning it ebbs and flows with the ocean tide, it supports a biologically rich environment, making it an important ecosystem for various species of aquatic life. For many key species, it provides critical habitats and essential spawning and nursery grounds” (*Basics*, 2023). One such species that lives in the Hudson River is striped bass.

The Troy Dam was built in 1915 by the U.S. Army Corps of Engineers with the goal of improving navigation between the Hudson River and the New York State Canal System, which is comprised of the Erie and Champlain Canals. Dams were originally built to hold back water and form deeper navigation pools. Additionally, dams can ensure safe navigation of commercial goods (*Troy Lock & Dam NY reaches 100 Year Milestone*, 2016). However, dams can also block fish passage, affect hydrology, sediment transport, and water quality of tributaries. Wynants Kill is a Hudson River Tributary, and fish use tributaries to move between feeding, nursery, and spawning grounds, and dams block these pathways and restrict the habitat of fish (*Herring return to Wynants Kill,* 2020). Due to these negative impacts of dams, this leads us to question how dams might affect PCB accumulation in the Hudson River system and in fish populations.

Atlantic Striped Bass (Morone saxatilis) live along the East Coast. The typical size of a healthy striped bass is 609.6-914.4 mm and 4535.92-13607.8 g (*Striped bass*). There is no recorded difference in length and weight

between male and female striped bass. “In 2022, commercial landings of striped bass (from [New York] state waters) totaled 3.8 million pounds and were valued at $13.5 million.” Striped bass are overfished with the recreational harvest reaching about 36 million pounds (NOAA Fisheries, 2024).

Polychlorinated biphenyls (PCBs) are a major pollutant found in the Hudson River. PCBs were typically used as insulators and fire preventive in the manufacturing process of electrical devices because they could withstand extremely high temperatures. Between 1947 and 1977, General Electric, an multinational conglomerate incorporated in the state of New York, released about 1.3 pounds of PCBs into the Hudson River from two of their plants. The pollution was released at factories at Fort Edward and Hudson Falls (*Hudson River: Hazardous waste*, 2022). PCBs deposited in the sediment after they were released by General Electric, and tests of water and sediment showed the river was not cleaning itself. The PCBs that were deposited in the sediment were discharged from the sediment over time, so these contaminants were released back into the river. As a result, many fish were exposed to PCBs river pollution years after the pollution originally occurred. The Hudson River System became a superfund site in 1984 and it is one of the largest in the country. Superfund is the name of the program that allows the EPA to clean up contaminated sites (Environmental Protection Agency, 2023). Since PCB pollution was building up in sediments and being released, between 2009 and 2015, dredging occurred which aimed to address the issue of PCBs being released from sediment in the river (Environmental Protection Agency, *2024*). PCBs entered the habitats of fish through air, water, and soil while in use and through their disposal. PCBs remain in the environment for long periods of time after they are released because they do not break down. This means that there is more time during which PCBs can harm fish as they continue to pollute the river. Fish absorb PCBs from the water and sediments. PCBs also accumulate in fish as you go up the food chain (*Polychlorinated biphenyls, 2013*).

Additionally, the New York State Department of Health has issued advisories on which species of fish are safe to eat in certain areas of the river. PCBs can also build up in humans through fish consumption, leading to chloracne, related dermal lesions, and respiratory problems (Centers for Disease Control, 2023). High levels of PCBs in fish has prompted New York State to close both recreational and commercial fisheries.

The Hudson River system is a location that has been greatly affected by PCB pollution, resulting in fish consumption advisories due to health risks of consuming fish that contain PCBs. The dams were originally built for the purpose of transporting commercial goods, but now they block fish and sediment transport along the river. Because of the Hudson River system’s history with dams, PCB pollution, and commercial fishing, it is an ideal system to explore how dams could affect PCB levels in certain areas of the river and how those different PCB levels affect fish health.

Methods

The data used in our research was published by the Cary Institute of Ecosystem Studies. Data are collected by NYSDEC scientists every year on the Hudson River. This data was provided by the New York State Department of Health (NYDOH) for 2001-2011 (Cary Institute). The data recorded included location, river mile, the date the sample was collected, year, season, sex, length, weight, moisture (%), lipid (%), and total PCB. The data was collected at Albany/Troy, Catskill, George Washington Bridge, Haverstraw Bay, Poughkeepsie, Stony Point, Tappan Zee Bridge. River mile indicates miles from the New York City Battery to the respective sampling location. Percent lipid indicates the percent of fish body weight from lipids. PCBs tend to accumulate in lipids because they are lipophilic. Total PCB indicates the PCB content of fish measured in parts per million (ppm). Lipid PCB was calculated by dividing the Total PCB value by the Lipid (%) value for each fish (Cary Institute). Lipid PCB measurement measures the body burden of PCBs to better represent the body they are in (*Biomonitoring: Polychlorinated biphenyls*). After initial analysis there was no significant difference in lipid PCB contents in fish each year from 2001 to 2011, so data from all years were considered in the final analysis.

We thought sex or seasonality might have an effect on the system. However, given the initial analysis of our data set which considered sex and seasonality, we concluded that these factors had no significant impact on the results

of our study. But in the future these factors may be considered in the effects of water temperature in different seasons on PCB pollution.

Using the lipid PCB values and comparing it to the length and weight of 1727 samples of striped bass, we ran a significance test for linear regression to determine if there was a negative relationship between lipid PCB values and both length and weight of a fish. Using the locations of lipid PCB values we built a box and whisker plot for each location's distribution of PCB values and we ran an ANOVA Single Factor Test to determine significance.

Results

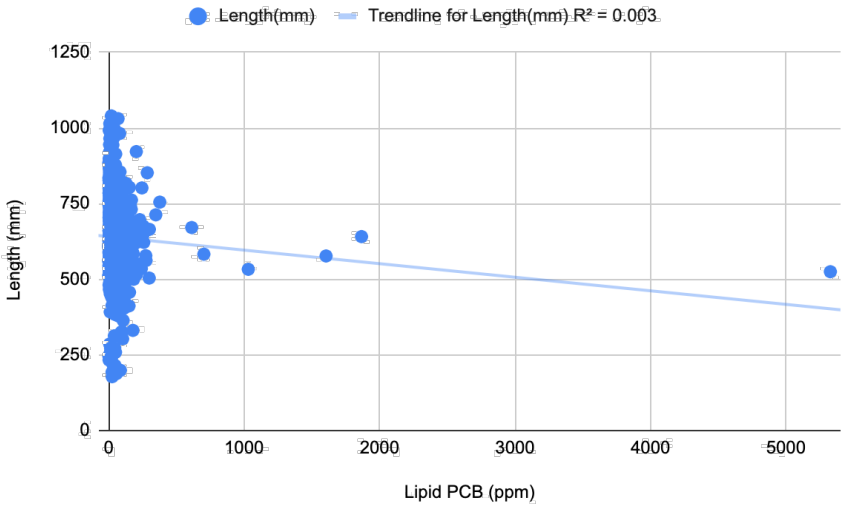

Figure 1. Effect of Lipid PCB on Length of Striped Bass in the Hudson River. This figure shows the lengths of several fish with various amounts of lipid PCB. Each point represents an individual striped bass. The light blue line shows the least square regression line for the data points.

Our results show convincing evidence that there is a negative relationship between lipid PCB content and length of striped bass. As lipid PCB content increases in striped bass, length decreases. P-value is 0.01959466648, which is less than 0.05, so we can reject the null hypothesis. The result is statistically significant.

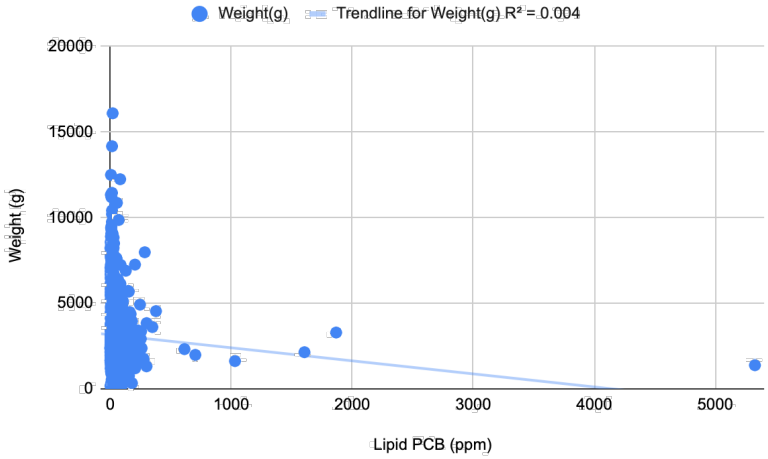

Figure 2. Effect of Lipid PCB on Weight of Striped Bass in the Hudson River. This figure shows the weights of several fish with various amounts of lipid PCB. Each point represents an individual striped bass. The light blue line shows the least square regression line for the data points.

Our results show convincing evidence that there is a negative relationship between lipid PCB content and weight of striped bass. As lipid PCB content increases in striped bass, weight decreases. P-value is 0.01085282565, which is less than 0.05, so we can reject the null hypothesis. The result is statistically significant.

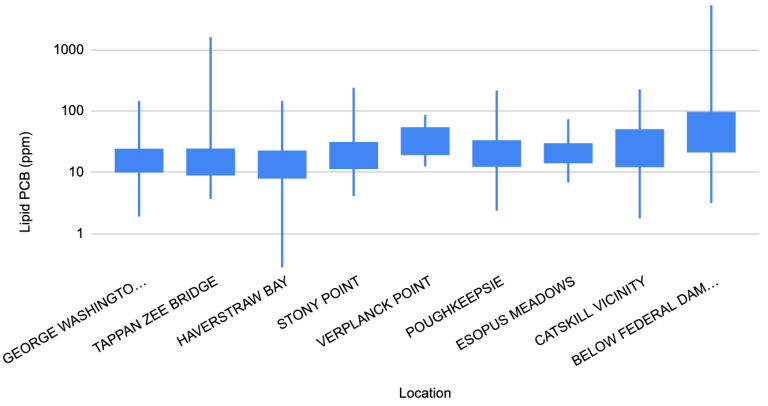

Figure 3. Lipid PCB Content in Striped Bass at Different Locations in the Hudson River. This figure shows the distribution of PCB content in various striped bass at different locations in the Hudson River. The endpoints of the vertical line indicate a minimum and maximum. The lipid PCB content is shown on a logarithmic scale. The shaded box area shows the middle 50% of lipid PCB contents for fish.

The striped bass with the highest lipid PCB measurements were located at Below Federal Dam. There were also striped bass with lipid PCB measurements greater than 1000 ppm at the Tappan Zee Bridge. The lipid PCB measurements at Verplanck Point have the smallest range. The median lipid PCB measurements at Stony Point, Verplanck Point, and Below Federal Dam are higher than at the other locations. The striped bass with the lowest lipid PCB measurements were located at Haverstraw Bay. F is 6.83584313853457. P-value is 0.00000000712869530072879, which is less than 0.05. We can reject the null hypothesis and the result is statistically significant.

Discussion

The variables in figures 1 and 2, length and weight, are indicators of fish health. A smaller length or weight of a fish indicates a lower fish health. When there was a greater lipid PCB measurement in a fish length and weight would decrease. This indicates a correlation between high lipid PCB measurements and a decrease in fish health. PCBs are not biodegradable and are “lipid-soluble.” As a result, PCBs tend to accumulate in the lipids of fish. PCBs disrupt the processes of metabolism and can therefore be classified as a MDC, or metabolism-disrupting chemical (Rypel & Bayne, 2010). If PCBs slow down metabolic rate in fish, then processes such as growth will occur at a slower rate. As a result, the average length and weight of fish that are exposed to high levels of PCB will be lower than those of fish with lower levels of PCB. Therefore, the reason for a decrease in fish health as shown by the indicators in the data could be due to the decrease in metabolic processes in fish. If the health of fish in the Hudson River decreased

dramatically, then the population might decrease, which could lead to a decline in commercial fishing in the Hudson River.

The striped bass with the highest PCB measurement was located downstream of the Federal Dam. Dams block fish passage and affect sediment transport (*Herring return to Wynants Kill after 85 years*, 2020). PCBs tend to accumulate in sediment, so if sediment transport is affected then the concentration of PCB in certain areas of the river would also be affected in areas near dams. Dams would decrease the transport of sediment, so there would likely be a greater concentration of PCB in the sediment in these areas of the river. PCBs are discharged from the sediment as it is settled there (*NOAA Fisheries*, 2024), so if there is a greater concentration of PCB in the sediment than a greater amount of PCB can be discharged from the sediment over time. A greater amount of PCB being released in this area would result in a high PCB concentration in many fish in the area near a dam. This could explain the high PCB measurement at Below Federal Dam found in our study. Dams could lead to decreases in fish health because of the high PCB concentration in these areas, which could lead to an overall decline in the fish population in the Hudson River.

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