LINKS BETWEEN ENVIRONMENTAL MERCURY, SPECIAL EDUCATION, AND AUTISM IN LOUISIANA

A Thesis

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ABSTRACT

The number of children born every year with neurological disorders is increasing and some of this increase may be attributed to mercury exposure. Pregnant women ingest contaminated fish, which transfers high mercury concentrations to the unborn fetus. This exposure may result in methyl mercury buildup in the brain of the unborn fetus. Symptoms ranging from minor to severe may be observed as special educational needs in school systems. These include learning disorders, developmental delays, and autism. Louisianans are especially susceptible to mercury contamination because fish and shellfish are a major portion of their cultural diet. This study, through the use of Pearson's correlation and multiple regression, associates mercury levels in fish and air emissions, to developmental disorders such as autism, learning disabilities and developmental delays that are recorded in Louisiana's public schools (LDE 2002). Socioeconomic variables such as ethnicity, poverty levels, and population density were used as covariates with mercury to understand their potential influences on the relationship. This study found significant associations between mercury and some of the developmental disorders, specifically autism and developmental delay. While the mercury and socioeconomic variables did not account for all of the variability within the study area, these findings prompt further investigations into the complex relationships between environmental mercury and developmental disorders.

CHAPTER ONE: INTRODUCTION

1.1 Research Problem

Mercury is a toxic pollutant causing severe environmental and health impacts across the globe. Mercury poisoning was first recognized as a workplace hazard when hat makers in the 19th century used mercury to convert fur into felt. The poor ventilation in the workshops caused a great deal of mercury to be inhaled by the hat makers. They suffered symptoms such as tremors (referred to as the 'hatter's shakes'), memory loss, vision impairment, and often maintained a confused mental status.

Every year, approximately 63,000 children in the United States are born with symptoms of mercury poisoning. The predominant symptoms are neurological deficits, ranging from slowed development and poor motor skills to severely diminished mental capacity, cerebral palsy and autism. While the human brain's complexity is largely not understood by science, recent links between neurological disorders and exposure to toxic chemicals has been developed. Mercury is a toxic metal of increasing concern due to the increasing frequency of human consumption of contaminated fish (USDA 2005). In the United States, many federal agencies such as the Environmental Protection Agency (EPA), the Agency for Toxic Substances and Disease Registry (ATSDR), the United States Geological Survey (USGS); and many state and local agencies, have recognized the severity of mercury poisoning and have advised people to limit their exposure through fish consumption.

Mercury is found naturally in water, sediment, volcanic ash, and rocks. The industrial revolution initiated an increase of mercury to the atmosphere through mining, the fossil fuel burning, and other manufacturing processes. Current estimates suggest that 50-70% of atmospheric mercury is a result of anthropogenic activities (EPA 1997; Lutter and Irwin

2002). Mercury does not remain in the atmosphere but falls out onto land and in water bodies all over the world.

In the water, mercury, through the process of methylation by sulfur reducing bacteria is converted to an organic form known as methyl mercury. Methyl mercury poses the most significant threat to humans. Once ingested, methyl mercury binds not to fat as many toxins do, but to muscle tissue. This makes it easy for mercury to bioaccumulate through the food chain. In the water, mercury is absorbed into plankton cell walls. Fish and small aquatic species (clams, shrimp, crab, etc…) ingest the plankton. Higher in the food chain, mercury concentrations are magnified to increased levels, due to bioaccumulation. Top predator species such as sharks, polar bears and humans are ingesting the larger quantities of mercury as a result.

Once ingested by humans, the methyl mercury enters the blood from intestine walls, disperses throughout the body, and accumulates in muscle tissue. Accumulated methyl mercury in the brain causes normal brain functions to be impaired. The kidneys suffer a higher accumulation rate of methyl mercury than the rest of the body, causing their function to fail.

Pregnant woman share the ingested mercury with the unborn child through the placenta. Fetuses and young children are more susceptible to suffer the effects of mercury poisoning as their brains are still developing. The complexity of the brain’s timing with mercury exposure seems to regulate the effect the exposure will have. The common neurological effects exhibited are slowed development, learning disorders, poor motor skills, poor vision, poor kidney function, cerebral palsy, and autism.

Autism is the fastest growing developmental disorder increasing at an average rate of 17% per year according to the Autism Society of America (2003). There was a 172% increase in autism diagnosis in the 1990s. According to Louisiana special education profiles (LDE 2002a), school systems have seen an increase in the students enrolled in special education programs. This leads one to wonder what the cause behind this increase could be, and focus on environmental factors as a potential answer. A look to mercury consumption might provide insight to this increasing problem. Researchers in Texas found a relationship between mercury and special education (Palmer et al. 2006), inspiring an investigation into Louisiana for a similar relationship. Louisiana has a high rate of sustenance and recreational fishing, in addition to a cultural culinary identity based on freshwater fish and seafood. Because Louisiana's median income is 22.5% less than the national average (US Census 2000), fishing in local waters is an excellent way to increase protein in the diet for those with little money, thus making Louisianans' especially susceptible to the effects of mercury consumption.

1.2 Research Objectives

This research seeks confirmation of a relationship between environmental mercury and the presence of special educational needs in Louisiana. Specifically, the amount of mercury will be measured by air emissions and fish concentrations; and the special educational needs are broken down into four categories: autism, learning disabilities, developmental delay, and a combination of all other special education students. Given that there may be other contributing variables, socioeconomic indicators will be investigated to determine their importance to the relationship.

Once a relationship is established, it is a second objective to create an equation which can be used to predict the prevalence of special educational needs in the future based on mercury, and other socioeconomic factors for the parish level.

1.3 Hypothesis

Mercury concentrations in fish are positively linked to the prevalence of developmental disorders in Louisiana.

1.4 Research Structure

This research focuses on pre-existing data for Louisiana, is observational (non-experimental) and is of a correlational design. School districts comprised generally of the entire parish, set the smallest unit of comparison for the remainder of the variables that represented areas within the parish. The variables that contained a smaller unit size than that of parish were combined to create an average representative of the parish. All variables were not obtained at the same time, but were relatively close in time; collected for the year 2002.

CHAPTER TWO: LITERATURE REVIEW

2.1 Mercury Characteristics

Mercury is the most toxic non-radioactive element on earth. In large quantities, it is found as a silver liquid, having a melting point of -38.9° Celsius. Mercury, symbolized as Hg, exists in three main forms: elemental, inorganic and organic. The common forms of concern for discussion are elemental mercury (Hg°); inorganic mercury, also known as mercuric or divalent (Hg(II)); and organic mercury specifically, methyl mercury (CH_3Hg). All forms are found naturally in the environment, participating in the mercury cycle.

2.1.1 The Mercury Cycle

To understand where and how mercury affects human health, it is fundamental to know the characteristics of the mercury cycle in the environment. A cycle identifies sources, sinks, and the linking processes. Only three predominant forms of mercury will be mentioned in this study: elemental, inorganic and methyl mercury; as they are the most relevant for the purposes of this study. The basic components of the cycle can be visualized in Figure 1.

Through the process of oxidation, de-oxidation, de-methylation and methylation; the different species of mercury are able to convert back and forth. Elemental mercury oxidizes to inorganic mercury, which then methylates to form methyl mercury; the reverse also can occur. Elemental mercury is most commonly found in a gaseous form suspended in the atmosphere. Inorganic mercury is found in soils and suspended in water where it becomes part of the sediment sink. Methyl mercury, accounts for a small percentage of mercury in the environment compared to elemental mercury and inorganic mercury, accounting for less than 3% of atmospheric mercury (Lin and Tao 2003).

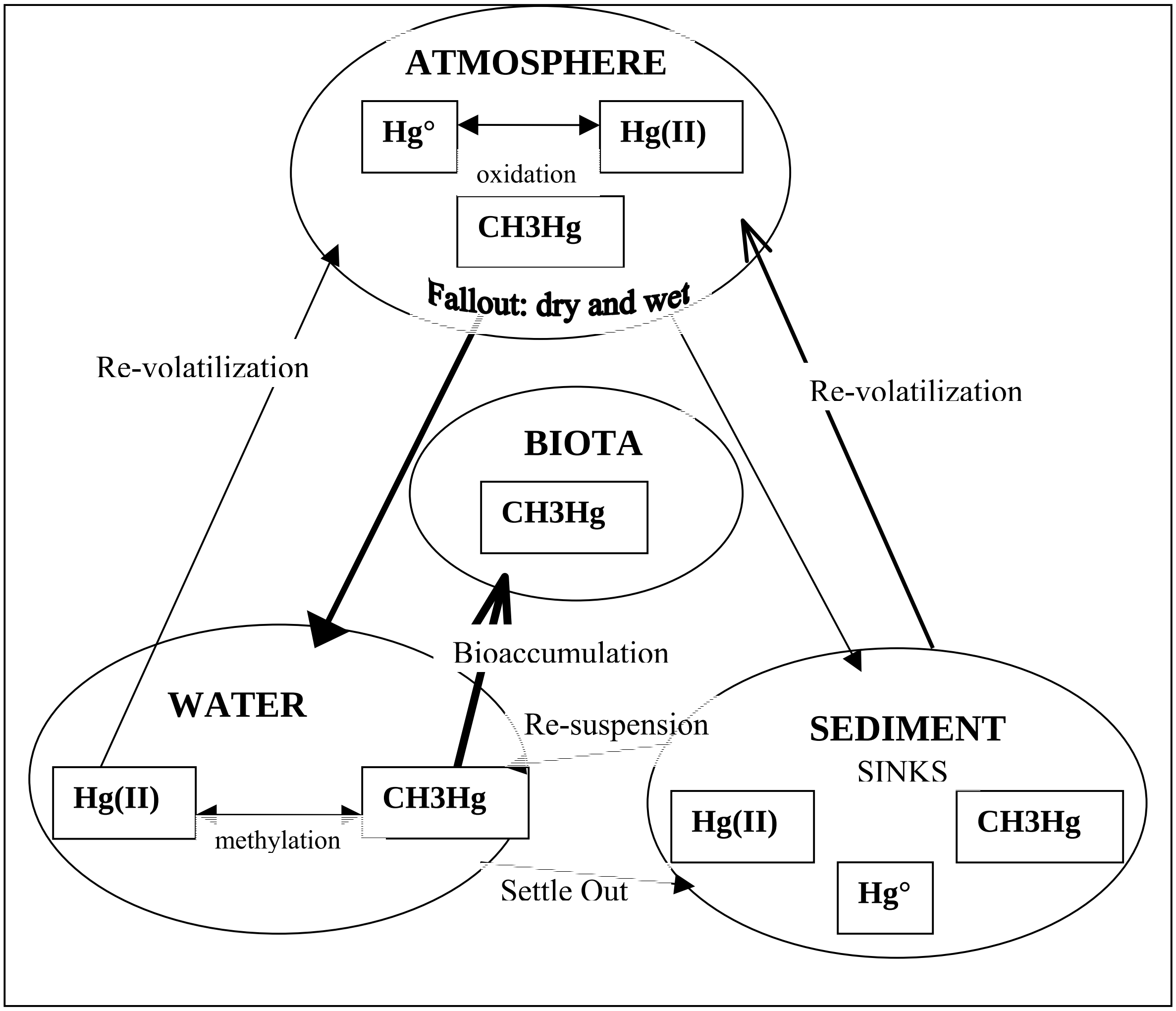

Figure 1: The Mercury Cycle

2.1.2 Sources

Mercury is found naturally in the environment in small concentrations from such sources as rock and sediment erosion, forest fires, and volatilization within large water bodies mainly the ocean. Throughout history, volcanic eruptions have accounted for large immediate sources of mercury. The onset of the industrial revolution introduced anthropogenic sources of mercury into the environment. Mercury trapped in coal and other rocks was released into the environment through mining and burning. Deposition records of the past found in glacial ice cores clearly denote the natural baseline of mercury prior to what is considered the industrial revolution (Shuster et al. 2002). The ice cores for the post industrial revolution leading up to the present period show increasing mercury deposition.

The industrial revolution coincided with a significant increase of large scale mining. The Gold Rush in the United States in the late 1800s released significant amounts of mercury into the environment and has continued to be a source of local mercury pollution. The mining and burning of coal has been a fundamental source of mercury in the atmosphere since the industrial revolution and continues today.

Up to 75% of the mercury found in the atmosphere is from anthropogenic sources (Slemir & Langer 1992). Chan et al. (2003) lists base metal mining and smelting, gold mining, chlor-alkali production, biomedical waste incineration, fossil fuel burning, and municipal waste incineration as some of the major point sources of mercury contamination at both local and global scales. In the United States, fossil fuel combustion, specifically coal fired power plants, are responsible for up to 54% of emissions, with other industrial activities mainly chlor-alkali plants accounting for 34% (Hylander 2001). Figure 2 illustrates the emissions attributed to major United States anthropogenic sources, as reported to the Environmental Protection Agency.

An additional important source of mercury in the atmospheric environment is volatilization of mercury from water bodies and disturbed or exposed soils. It is difficult to categorize mercury volatilization into natural or anthropogenic sources (ATSDR 1999). This uncertainty is due to the volatized mercury having an unknown origin. With the increased deposition of mercury from anthropogenic sources, the natural assumption is that there is an increased re-volatilization of the mercury.

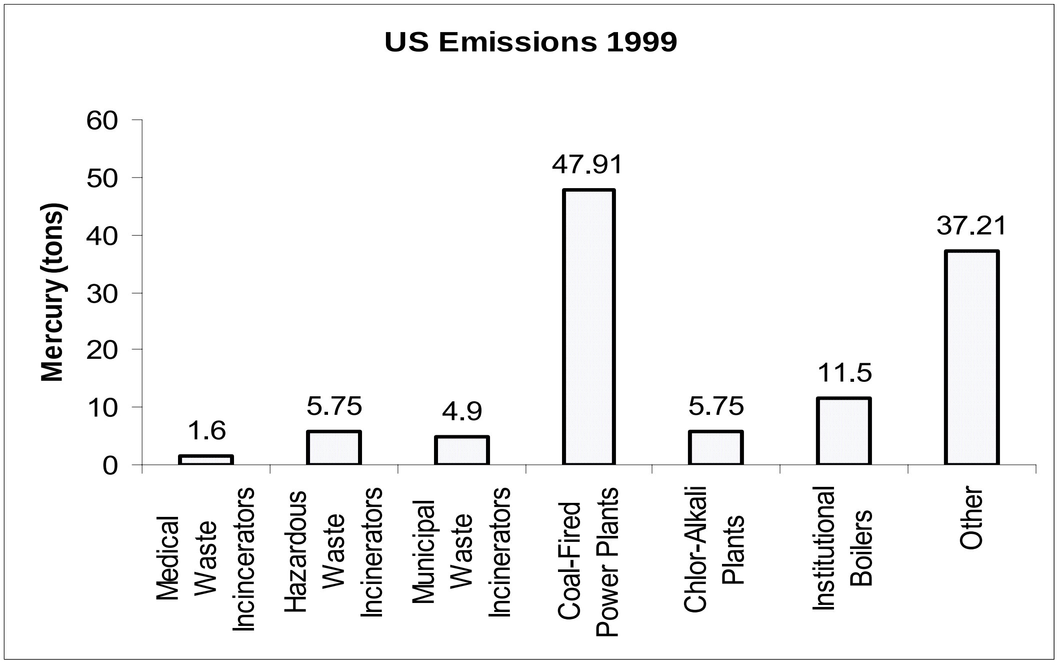

Figure 2: Anthropogenic Emissions of the United States (NEI 1999)

2.1.3 Transport and Deposition

Methyl mercury is rarely a component of mercury emissions from anthropogenic sources. Anthropogenic emissions consist mainly of a combination of elemental mercury and inorganic mercury. All three forms of mercury act differently once emitted into the atmosphere. Elemental mercury generally stays in the atmosphere for the longest amount of time, remaining suspended for up to one year traveling thousands of miles. Inorganic mercury can travel for some distance, but generally has a shorter atmospheric life, causing it to remain in the same regional (50-100 km) area it was emitted from (EPA 1997). Mercury's forms and various transport capabilities have contributed to both local and global problems.

Methyl mercury does not travel far, because it generally has only a short life span in water or air. It is most commonly found in emissions or the atmosphere close to the source; small concentrations are also found in water and sediments. However, large concentrations of methyl mercury can be found in the muscle tissue of top predator species of fish, birds and mammals.

Inorganic mercury falls out of the atmosphere in wet and dry forms. There is a 60% chance of the mercury falling on land, and a 40% chance of the mercury falling directly into a water body (Mason et al. 1994). Mercury fallout in the form of wet deposition, even on land, will eventually make its way to a water body, however, the transfer from land to water accounts for little of the inorganic mercury found within a water body (Morel et al. 1998; Sellers et al. 2001). A majority of mercury in the water, all three forms included, will become a part of the sediment composition or be ingested by fish and shellfish leaving little constant concentration of mercury within the water body (Boske et al. 2002).

Wet deposition of mercury is controlled by precipitation, and thus has similar seasonal patterns (Hoyer et al. 1995). In light of the relationship with precipitation, it is of no surprise that wet deposition accounts for three times the deposition of dry (Lamborg et al. 1995). The seasonal variation in deposition concentrations implies that there is not a constant supply of mercury deposited. This is concurrent with anthropogenic and natural sources of mercury, in which many activities are more prevalent during specific seasons or even specific conditions.

2.1.4 Species Interactions

Each species of mercury displays different characteristics and interactions with other chemical elements. In the atmosphere, the oxidation of elemental mercury to inorganic mercury is most commonly a result of an interaction with ozone (Morel et al. 1998). Once in the inorganic form, aerosols such as sea spray promote the fallout to the ground; inorganic mercury is generally found attached to dissolved organic carbon suspended within a water body. Elemental mercury is often found in the surface layer of the water, while methyl mercury is found increasing in concentration with depth (Sellers et al. 2001).

The methylation of inorganic mercury into methyl mercury is controlled by many factors in the specific water body, and therefore, a rate cannot be generalized. The most important factors are the availability of inorganic mercury within the water, and the presence of sulfate reducing bacteria (Lacerda et al. 2001). Additionally, there are many non-direct factors which have been shown to influence the rate of methylation; such as pH, temperature, salinity, organic matter (which is measured by dissolved oxygen (DO) and dissolved organic carbon (DOC) in addition to biological oxygen demand (BOD)) (Gilmour et al. 1998; Boszke et al. 2002). Wetland systems are highly efficient in producing methyl mercury (Lacerda et al. 2001; Back et al. 2002) because they generally maintain perfect conditions for maximum methylation rates.

2.2 Bioaccumulation

Diet has been shown to be the major source of mercury ingestion across multiple species (Rogers 1994). Both inorganic and methyl mercury found in the water can enter the food chain via plankton. Being characteristically soluble, methyl mercury is retained within the cell walls and is transferred up the food chain into fish and shellfish, eventually reaching top predator species such as humans. Methyl mercury accumulates through retention in the muscle tissue of animals (Morel et al. 1998). Studies have indicated that due to the bioaccumulation of mercury in tissue over time and through the food chain, age has a strong relationship with the methyl mercury concentration (Rogers 1994; Wente 2004; Stepanova and Kornov 2004). Inorganic mercury can also be transferred up the food chain, but because it is not soluble, it does not accumulate.

The water body characteristics influencing methylation of mercury play an important role in the availability of methyl mercury, yet the uptake into the food chain is controlled by slightly different factors. The biota present in the water body is strategic to estimating the amount of methyl mercury that will actually enter the food chain. Algal blooms are induced by elevated nutrient levels which often include an increase of mercury. However the methyl mercury is diluted within the large number of phytoplankton, leaving a lower concentration entering the food chain (Pickhardt et al. 1999). Algal blooms seem to be an indicator for decreased methyl mercury levels entering the food chain and zooplankton is the opposite, indicating increased methyl mercury. If the water body's biomass is dominated by zooplankton rather than phytoplankton, the water body's biota exhibits higher mercury concentrations (Stepanova and Kornov 2004).

Increased deposition of mercury into water bodies will eventually lead to an increase in methyl mercury concentrations in the biota of the water body given the right conditions. Although highly speculative and questioned, decreasing deposition is believed to decrease in concentration of methyl mercury. This has been seen to be true in the Florida Everglades (FL DEP 2003) where the Florida Department of Environmental Protection obtained measurements of mercury concentrations in a fish species (bass) and a bird (egret) on a regular basis. The trend of mercury concentration over time was seen to decline following the enforced decrease in medical waste incinerator mercury emissions. Their local finding supports that freshwater fish are more susceptible to regional (50-100 km) pollution; whereas marine fish are subject to global mercury pollution (Lipfert et al. 2005).

2.3 Health

Exposure to methyl mercury has been shown to cause health effects in fish eating birds, mammals and humans. The effects of the exposure of methyl mercury vary widely based on the specific circumstances surrounding the interaction. The neurotoxin effects of methyl mercury make overexposure dangerous.

2.3.1 Biota

Fish consuming birds and mammals display a range of health effects from exposure to methyl mercury. The range can be attributed to the amount of exposure with the most severe effects correlating with the highest exposure (Rice and Barone 2000; Chan et al. 2003). Low end of exposure effects include low reproductive success and a change in normal behaviors (Chan et al. 2003). Examples of behavior changes include flying (for birds), walking, hunting, and protection from environmental stimulus such as the sun and rain events. At the high end of exposure to methyl mercury, the observed affects for birds and fish eating mammals have been similar to what is seen in humans: these include loss of muscle coordination, tremors, spinal cord degeneration and brain lesions.

2.3.2 Human Symptoms

Overexposure of methyl mercury to humans is a result of ingestion. Most commonly, fish consumption is the source of ingestion but other sources have been documented such as the consumption of contaminated grain in Iraq. Today, the main source of overexposure is the consumption of fish and possibly fish-consuming animals as well; occurring over long periods of time. However, some isolated incidents of quickened overexposure from other methods have offered some of the first insight to the severe effects of mercury. The effects observed by humans can be seen in two groups: adults (classified as over 7 years of age) and children (those under 7 years of age) including fetuses (naturally pregnant women would fit into this category). Methyl mercury tends to build up in the brain, muscle and kidneys (Hightower and Moore 2003); these are the main areas of the human body where health effects are seen.

2.3.2.1 Isolated incidents

During the early 1930's, in the small fishing community of Minamata, Japan the local chemical plant began a manufacturing process that used mercury. The mercury was discharged into the bay; contaminating fish and shellfish, the local source of protein. After World War II (early 1950s), many dead fish were found floating in the bay; and local cats began exhibiting uncanny behavior which often led to their death. Following this was an epidemic of hearing loss, lack of comprehension, lowered motor function, and loss of coordination in children and then adults. By 1956, these symptoms were collectively given a name, called Minamata Disease; the result of mercury poisoning. In the 1970s the most devastating effects of the long term mercury exposure to the residents of Miniamata Bay became apparent; children were born with neurological and physical disorders at alarming rates.

Iraq imported grain from Mexico that was treated with mercury fungicide; this grain was intended only for planting. Yet, due to devastating harvest, people ate the pink grain and fed it to their livestock. Within months, people reported symptoms relating to nervous system damage. The political action taken to correct the problem was badly handled, resulting in the improper disposal of the contaminated grain, further contaminating fish and birds. With the people still desperate for food, fish and birds were their main staple, causing thousands of people to die from mercury poisoning and many newborns to suffer brain damage.

2.3.2.2 Children

Fetuses and children under seven years of age are more susceptible to suffer from symptoms of methyl mercury exposure. Development of the nervous system and other key functions of the body are occurring during this phase of life. As a result, there are many factors influencing the effect the methyl mercury will have. Rice and Barone (2000) have highlighted two main aspects that determine vulnerability to effects: 1) the length of exposure and 2) the actual contact point of exposure in the brain. Additionally, the timing of exposure within the development process is thought to substantially make a difference in the observed reactions (Mendola et al. 2002). While vulnerability is greatest during the pre-natal development of the brain; the brain continues to develop through puberty; thus, vulnerability to methyl mercury exposure does not end with birth (ATSDR 1999; Amler et al. 2003).

The effects of methyl mercury on children can be classified into three different categories: long term deficits, developmental delays and transient deficits (Rice and Barone 2000). Development delays and transient deficits are the most common; including learning disabilities, speech impediments, and slowed motor skills.

Long term effects of methyl mercury exposure include cerebral palsy, mental retardation and autism. Autism is the fastest growing developmental disability according to the Autism Society of America (2003). The symptoms used to diagnosis autism and methyl mercury poisoning are similar (Bernard et al. 2001; Bernard 2002), especially when considering the range of potential effects. A key factor to the link between methyl mercury exposure and autism is the inability of the autistic child to excrete the mercury naturally through the hair follicle (Holmes et al. 2003). However, it is still unknown whether this is a result of genetics or methyl mercury exposure. The increase of autism and other developmental disorders in recent years (Trasande et al. 2005), has coincided with an increase of environmental mercury. While there is not a definitive causal relationship, it does not seem to be a coincidence.

2.3.2.3 Adults

The overexposure effects of methyl mercury to adults are often short term and less detectable on a large scale. While the neurotoxin effects of mercury are not less in adults, an adult body is more capable of deterring the effects due to the obvious size which results in lower concentrations and more importantly, adult brains are fully developed. It is important to note that while the classification of adult for these purposes is older than seven years of age, and obviously a seven year old does not have a fully developed brain, the film surrounding the brain at age seven is fully developed; equaling that aspect with fully developed adult brains. Adult overexposure is associated with deficits in the neurological performance, including such behaviors as loss of fine motor skills and dexterity, lowered response inhibitions, memory loss (Yokoo et al. 2003), lowered kidney functions, slurred speech, and sight and hearing losses (ATSDR 1999). In one case, reddened skin, tremors, and ear ringing were among the observed symptoms to over exposure (Rischer 2004).

2.4 Exposure Risks

Diet is the main route of exposure to humans, through the consumption of fish. The risk from eating fish is not equal for all people. Children and pregnant woman have a higher risk than do fully developed adults. There are certain subpopulations which are more susceptible to incorporating higher levels of fish in their diet. The most important factor in mercury consumption risk is the fish species and location from which it comes. For any given location and methyl mercury availability, concentration of methyl mercury varies among fish species. The determining factor for the level of methyl mercury found in a specific fish species is its diet. The farther up the food chain, the higher the levels of methyl mercury are found. Furthermore, within a given species in a particular water body, size as a factor of age also affects the concentration of methyl mercury. The older the fish, the longer it has been storing methyl mercury in its tissue.

2.4.1 Cultural Risks

Several factors influence the amount and kind of fish consumed by humans. The culture in which people grow up plays a notable role in their diet, and thus, the consumption of fish. There are a few cultural groups of people at higher risk due to their culturally related consumption patterns. Native American tribes each have their own consumption patterns for fish often associated with special events and seasons (Peterson et al. 1994; Marien and Patrick 2001), causing a wide variety of mercury exposure. Historically, Asians and Pacific Islanders have maintained seafood and specifically fish as a main staple in their diet (Mahaffey 2004). The logic behind this cultural adaptation is likely the availability and high protein found in the catch. Recreational fishermen and their families tend to have higher exposure rates to methyl mercury (Marien and Patrick 2001), as they most often consume their catch. To the people of Louisiana cuisine, specifically Cajun cuisine, culturally defines their way of life. The availability of fresh seafood from the Gulf of Mexico and the numerous lakes, bayous and swamps has resulted in fish and shellfish to become a staple in their diet (Wilds et al. 1996).

2.4.2 Economic Risks

Beyond culture, economic factors also are associated with the amount and type of fish consumed. People associated with high economic status tend to eat top predator species

(Hightower and Moore 2003), as a result of the prices being higher. Top predator species such as swordfish have the greatest concentrations of mercury. People in low economic situations often eat more fish because it is a good source of protein, the fish consumed often comes from local water bodies and is whatever species caught. Around the world, people of lower income have been known to consume more fish where it is locally available (Louekari et al. 1994). In the United States when looking at employment status with in a specific culture group, unemployed males are known to consume more local fish (Peterson et al. 1994).

2.5 Policy

The recognition of the mercury problem by federal agencies in the United States has prompted policy actions to reduce the exposure risk. In addition to the federal response, many state and local governments and agencies have also taken policy related steps to deter certain aspects of the problem.

2.5.1 Federal Level

Mercury regulations began in the early 1990's, concentrating on non-point sources. Bans on disposal of products containing high levels of mercury into land fills and fungicides containing mercury (Sznopek and Goonan 2000) was seen as the first step. By reducing the input of mercury into the landfill, the chance of the mercury thus entering the environment was reduced. The Mercury-Containing and Rechargeable Battery Management Act also known as the Battery Act of 1996, set to phase out the mercury addition to batteries, and called for the appropriate disposal methods to be indicated on the packaging.

2.5.1.1 Point Sources

The emissions of mercury into the environment are regulated through the medium of which they are emitted. The Clean Air Act (CAA), the Clean Water Act (CWA), and the Resource Conservation and Recovery Act (RCRA) all set forth provisions to regulate mercury from specific sources. Land Disposal Restrictions Regulations set for by 40 CFR Part 268 under RCRA, requires a set level of treatment conditions for hazardous wastes containing mercury, prior to disposal. The Total Maximum Daily Load (TMDL) Regulations and Guidance under the CWA in conjunction with the water quality criteria set for methyl mercury, set maximum discharge for any given water body, by any point source.

The CAA, has set forth the procedure for the regulation of multiple sources of mercury. Solid Waste Combustion Rules, CAA section 129, set regulatory guidelines for municipal waste, medical waste, and industrial waste incinerators. Hazardous waste incinerators are also regulated for mercury, under the Reduction of Toxic Air Emissions from Combustion Sources that Burn Hazardous Waste. The regulation of Mercury Cell Chlor-Alkali Plants Final Rule was issued in December 2003, regulating a major source of air emissions of mercury from this specific industry.

The Clean Air Mercury Rule of 2005 set forth regulations for the largest anthropogenic point source of mercury emissions. This rule issued a plan of action to reduce mercury emissions from coal-fired power plants, through a cap and trade program. Each state is given a maximum emissions target for the coal fired power plants, and has the flexibility to decide how to reach the target cap. The full implementation of this rule, set to be reached in 2012 will reduce this source of emissions by 21% (Reppert 2005).

2.5.2 State Level

Some states have taken a more progressive step towards reducing the increased input of mercury to the environment from anthropogenic sources. Medical and municipal waste incinerators were regulated in the state of Florida prior to the regulation on the federal level. Florida, recognizing the sources of their mercury problem, took action, and saw dramatic improvement in deposition. In 1997, a conference of New England Governors (with the addition of New Jersey and New York State) and Eastern Canadian Premiers implemented a groundbreaking regional Mercury Action Plan (MAP) (Smith and Trip 2005). The MAP included reductions in emissions, safe waste management, education, and research including a regional task force; in an attempt to curb the exposure risk to mercury.

2.5.3 Consumption Advisories

The Food and Drug Administration in coordination with the Environmental Protection Agency and the Agency for Toxic Substances and Disease Registry set a safe limit of mercury consumption of 30 μg per day. This limit was based on the reference dose found in rats and converted to the average consumer weight of 70kg (about 154 lbs). The reference dose is a cutoff point which greater than is likely to observe more severe symptoms (ASTDR 1999). The announcement of the safe limit prompted the issuance of consumption advisories on specific water bodies known to have unsafe levels of mercury. Fish advisories have increased in number throughout the United States (Knuth 1994). This increase can be partially explained by the increased testing of water bodies and partially by the increasing levels of deposition.

Advisories are announced on state levels, and differ from one another based on the actual risks. Advisories may be for any species in a specific water body, or for a specific species. The advisory could contain specific information about the size of species that are acceptable to eat, and even different consumption suggestions for children and adults. Often the advisories not only suggest a limit to the amount of fish eaten from a water body, but often suggest limiting overall fish consumption from a range of water bodies. In some highly polluted areas, it is not safe to eat any amount of any of the fish species.

Suggestions for portion size are also given in a consumption advisory; and are equally important as how often and what species of fish to eat. If the portion size eaten is much larger that that suggested in the advisory, it will reduce the frequency of which one should consume the fish.

General consumption advisories have been placed on specific fish bought rather than fished out of a water body. It is suggested that pregnant women do not consume any amount of swordfish, tile fish, shark or king mackerel; as these species are top predator species that have much higher concentrations than any other species (EPA 1997). Additionally suggestions are made to diversify the type of fish eaten, in other words it is better to not eat the same species every time.

Louisiana has multiple agencies that cooperate to set the fish consumption advisories; the Department of Health and Hospitals (DHH), Department of Environmental Quality (DEQ), the Wildlife and Fisheries Department (LWFD), and the Agriculture and Forestry Department (LAFD). Currently, 49 of Louisiana’s 64 parishes contain freshwater body advisories, in addition to the entire Gulf Coast holding advisories for specific species. The specific advisories can be found in Appendix A, from the latest update given in July 2004, issued by the DHH.

CHAPTER THREE: DATA AND METHODS

This study follows the structure of a study conducted in Texas that associated environmental mercury with special education (Palmer et al. 2006). Similarly, school districts serve as the sample for comparison between special educational needs and mercury; taking into account external influences such as ethnicity, wealth, and urbanization. This study uses multiple regression to define the relationship between mercury exposure and special education for the Louisiana public schools, as a sample of Louisiana's entire population. Difference between this study and Palmer et al.'s (2006) study were based on local knowledge of mercury issues in an effort to improve chances to find a similar association between mercury and special education in Louisiana. The major differences included additional mercury variables, socioeconomic variables, and a differenct regression method. The statistical methods used on the Louisiana public school sample consist of Pearson's correlation, and multiple regression. The multiple regression is assessed for significance for the 59 values representing 59 parishes of the sample, using F-ratios, p-values, and t-statistics all calculated through the Minitab statistical software.

3.1 Data

3.1.1 Mercury Data

As part of the Community Right to Know Act, the EPA collects emissions data from industries, and makes the information available through their Toxic Release Inventory (TRI) explorer, found on their website: http://www.epa.gov/TRI. Each facility self reports the amount of emissions of numerous hazardous chemicals in pounds for the entire year. For this study, the total air emissions within each parish were calculated by adding the individual facility emitters. The reported total is in pounds and includes mercury and mercury compounds. Forty-eight facilities in 20 parishes reported emitting mercury or mercury compounds during the year 2002.

The Louisiana Department of Environmental Quality (LA DEQ) began taking measurements of the mercury concentration found in fish in numerous local water bodies throughout the state in 1997. The species, weight and length were recorded for each testing site in addition to the number of fish caught and the concentration of mercury measured in parts per million. The raw data used in this study can be found on the DEQ website, as part of the Mercury Initiative Report (LA DEQ 2005). Seven thousand six hundred and seventy-two samples recorded were matched to the parish in which they occurred. The samples were located in 59 of Louisiana's parishes in 500 water bodies, and along the gulf coast. An average concentration in parts per million of all fish (from the 7,652 samples) and largemouth bass (containing 2,358 samples) specifically in each of the 59 parishes was recorded and used for the variables: all fish mercury concentration and largemouth bass mercury concentration.

3.1.2 Public Education Data

The Louisiana Department of Education retains information for all public schools accessible on their website (LDE 2002). In 2002, there were 66 school districts in the state, 62 of which contained entire parishes. Bogalusa and Monroe cities held their own districts, while the parishes that they reside in, Washington and Ouachita, respectively; hold the two remaining districts, accounting for the entire parish minus the city. For the purposes of comparison with the mercury concentration data, the two city-wide districts were combined with their parish counterparts, leaving 64 school districts datasets. Each parish school district dataset consists of the following variables: total student population, disadvantaged population, and special education population. The students disadvantaged are defined by the combined number of students enrolled in the free or reduced lunch program. The count of students classified as receiving special education was broken down into the following categories: autism, learning disabilities, and developmental delay and was obtained from the Special Education Profiles (LDE 2002a). In addition a fourth category of other special education students was created, consisting of the total special education count minus the subsets of autism, learning disabilities and developmental delays.

3.1.3 Census Data

Socioeconomic and demographic information at the parish level was obtained from the census bureau's Quick Find database (US Census 2000). The data obtained for this study consists of population density, per capita income, ethnic composition, and percent of the population below poverty, percent of the population of high school graduates. The ethnicities specifically were European descent, labeled white; and a composite group consisting of Native Americans, Pacific Islanders and Asians; this grouping was labeled culture. The other ethnic groups of black, Hispanic, and other; were not included in this study because there is no evidence that their cultural diets influence fish consumption.

3.2 Statistical Methods

This study looked at four dependent and nine independent variables. All of the variables are recorded as continuous ratio numbers, and are described in Table 1.

3.2.1 Descriptive Statistics

Descriptive statistics for each dependent and independent variable was calculated to include mean, median, minimum, maximum, standard deviation, and standard error. The

Table 1: Variable Description

Dependence	Variable	Units Measured In	Variable Name
Dependent	Autism	Percentage	Autism
Dependent	Developmental Delay	Percentage	Develop
Dependent	Learning Disorders	Percentage	LD
Dependent	Other Special Education	Percentage	Other Sp
Independent	Mercury Air Emissions	Pounds	Emissions
Independent	Mercury Concentration in All Fish	Parts Per Million	AllFish
Independent	Mercury Concentration in Largemouth Bass	Parts Per Million	Bass
Independent	Population European Descent	Percentage	White
Independent	Culture ethnicity Population	Percentage	Culture
Independent	At Risk Student Population	Percentage	Disadv
Independent	Per Capita Income	Dollars	PCI
Independent	Below Poverty	Percentage	Poverty
Independent	Population Density	People per Square Mile	Pop Den
Independent	High School Diploma	Percentage	HS Grad

purpose of obtaining this information is to provide interpretable and comparable information about the variables at a glance by describing the location and dispersion on the data. Additionally, the descriptive statistics help to determine the normality of the variables, which is essential to continuing the statistical anaylsis.

Mean and median both describe aspects of location; both are given as a single number to represent the data set. The mean represents the central tendency of the data, and is calculated by the sum of all values divided by the number of observed values. The median, also represented by a single number for each variable, is defined as the middle point of the dataset. This means of data in chronological order; 50% falls above and 50% below the median. The median is calculated by dividing the range by two; the range is defined as the largest minus the smallest variable. For a normal distribution, of which most statistical methods are based on, the mean and median of a data set should be close to one another.

Dispersion of the data, also referred to as the data's variability is important to understand how the data is distributed. The variance is a measure of the distance between each value and the mean. The square root of the variance is the standard deviation, and it most commonly used to describe the dataset's variability. In a normally distributed data set, 68% of the data's variability is located within one standard deviation of the mean, and 95% is found within two standard deviations. The standard error of the mean is another measure of variability, similar to that of the standard deviation. However, the standard error of the mean, describes how much dispersion there is in the sampling of the mean compared to the population mean.

3.2.2 Correlation

The linear relationship between two variables can be measured with a correlation coefficient. Pearson's correlation coefficient is specifically designed to determine the strength of the relationship for interval and ratio data. Expressed as 'r', Pearson's correlation coefficient falls within the range -1 to 1. When r = 0, there is no linear relationship between the two variables. As r gets closer to 1, a stronger positive linear relationship is found between the variables, and conversely, the closer r is to -1 indicates a strong negative relationship between the variables. A positive relationship indicates that as one variable increases, the second variable also increases; a negative relationship indicates that as one variable increases the second decreases.

For two variables x and y, the formula to calculate Pearson's correlation coefficient, is given as follows:

$$r = \frac{\Sigma(x-\mu_x)(y-\mu_y)}{(n-1)s_x s_y}$$

where μ is the mean of the variable, ‘n’ is the sample size, and s is the standard deviation for the variable.

The correlation coefficient gives an indication of the strength of the linear relationship between two variables, but it is unknown whether or not the relationship is significant or if it occurs just by chance. With this uncertainty in mind, a critical correlation table has been constructed through the distribution of different sample sizes. The critical value (r_c) states that for a given sample size and confidence level (denoted by α), the correlation is significant if larger than the critical value. For this data set with n=59, the critical values are as follows:

$$\alpha = 5\%;\ r_c = 0\ .273$$

$$\alpha = 1\%;\ r_c = 0.354$$

Beyond the significance of a correlation, a p-value is associated with each correlation coefficient. The p-value is the actual α value, which gives the actual probability that the correlation calculated could be attributed to chance of the sample, rather than an actual relationship between the variables. As with significance of a correlation, the p-value is calculated for the desired confidence level, which was set at 95% for this study (α= .05; or indicating a 5% chance of error).

3.2.3 Multiple Regression

Correlation defines the strength of the relationship between variables, and regression defines the functional relationships between the variables. The mathematical equation can be used for prediction. For two variables, one dependent (y) and one independent (x); a regression equation looks like this:

$$y = \beta_o + \beta_1 x_1\ ;$$

where β_o is a constant, and β_1 is the coefficient of the x variable. The constant represents the y-intercept for the linear equation, and the coefficient for the x variable tells how much of a change in the x value is needed to change the y variable. With multiple independent variables, the equation follows the same pattern, and looks like this:

$$y = \beta_o + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \ldots + \beta_n x_n$$

for n independent variables.

Beyond the mathematical equation regression gives, it is important to know the how well it captures the relationship between the variables and what it means. In statistical software programs, when multiple regression is run, there is a lot of information given in the output that allows assessment to be made as to how well the predictive equation works. 'R^2' represents the amount of variability accounted for by the independent variables for a given predictive equation, and 'adjusted R^2' represents the accountability of the equations variability of the actual population. Based on correlations between the variable, an 'F-ratio' value gives the strength of the entire relationship; the F-ratio is calculated as such:

$$F= \frac{r^2/u}{(1-r^2)/v}$$

where u is degrees of freedom for the numerator: based on the number of treatments minus 1; and v is the degrees of freedom for the denominator: based on the number of subjects minus 2. The significance is then compared to critical values, based on the degrees of freedom for the denominator and numerator. If the f-ratio is above the critical value, than it is significant at that confidence level; table 2 is a portion of a critical value table where the degrees of freedom for the denominator is 40.

In cases with multiple independent variables, it is often true that not all of the variables are significant in the predictive equation. The variables that should be included are often

Table 2: Critical Values for F-Ratio (Keppel and Zedeck 1989)

Degrees of Freedom for the numerator

α	1	2	3	4	5	6	7	8
0.25	1.36	1.44	1.42	1.4	1.39	1.37	1.36	1.35
0.1	2.84	2.44	2.23	2.09	2	1.93	1.87	1.79
0.05	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18
0.025	5.42	4.05	3.46	3.13	2.9	2.74	2.62	2.53
0.01	7.31	5.18	4.31	3.83	3.51	3.29	3.12	2.99
0.001	12.6	8.25	6.6	5.7	5.13	4.73	4.44	4.21

Chosen by their individual significant correlation with the dependent variable. Additionally a t-statistic can be calculated for each variable; when adding variables to the regression equation the t-statistic indicates how well the individual variable adds to the strength of the overall equation. However, there are cases in which a non-significant variable can add more accountability in the regression equation, and at other times, the logic behind the research requires a variable to be included even if in the sample it is not significant (Keppel and Zedeck 1989).

One way to obtain the best combination of variables to account for the most variability of the equation, is to let the statistical software look at the interrelationships between all variables and different subsets of variables. Called ‘best subset’ in Minitab, the software starts with a single variable that accounts for the most variability, then adds and subtract variables in an attempt to progressively increase the variability accounted for, until all variables have been added. The t-statistic is used in determining whether or not to keep a variable in the regression equation.

3.3 Methodology

The values for each variable were combined to in order to have one value for each parish. Mercury concentration variables, in addition to some of the school district data was obtained through such a combination. The school data was given as a count, such as the number of developmental disorders and disadvantaged within the school district. These data were converted to represent a percentage for the value in order to have compatibility with other data. The given emissions in pounds were transformed by taking the log of the data in an attempt to normalize distribution of the emissions variable.

The statistical software Minitab Student Version 12 was used for the statistical analysis. The descriptive statistics were obtained and recorded; followed by a correlation matrix, which used Pearson's correlation and recorded the correlation coefficient and associated p-value between each variable. Best subset regression was then run for each dependent variable. Based on the results of the best subset regression, three subsets for each dependent variable were chosen to use for multiple regression. The criteria used in choosing the subsets required that at least one of the three mercury variables was included, followed by the following three attributes: 1) highest R^2 2) highest adjusted R^2 and 3) the best combination, of R^2 and adjusted R^2. From the subsets, multiple regression was run twelve times; three times for each dependent variable based on the subsets.

As an attempt to adjust for Type I Errors (Hoyle 1999), baseline data was obtained by analyzing some unrelated variables. Four dependent variables which were seemingly unrelated included average teacher salary (salary), population of students within each district (count), average daily attendance rate (attend), and graduation rate (grad). In addition, eight random variables composed of 59 random values provided by Microsoft Excel random number generator were used. Four of the random variables were considered dependent, and four were independent variables. The correlation and multiple regression analysis were run in the same manner as the variables of concern. The seemingly unrelated variables were also correlated and tested through subset and multiple regressions for use in comparison with the results of the original variables of concern for this study.

CHAPTER FOUR: RESULTS

4.1 Descriptive Statistics

The minimum (min), maximum (max), mean, median, standard deviation (stdev) and standard error of the mean (se mean) was computed for each of the thirteen variables. Each variable consists of 59 values coinciding with the 59 parishes that made up the sample set of the population. The descriptive statistics are found in Table 3.

Table 3: Descriptive Statistics of All Variables

Variable	Min	Max	Mean	Median	StDev	SE Mean
Autism	0	0.4935	0.1578	0.1657	0.0976	0.0127
LD	2.353	8.307	5.104	5.21	1.339	0.174
Develop	0.01	5.363	1.361	1.275	0.952	0.124
Other Sp	2.78	11.394	6.767	6.659	1.614	0.21
AllFish	0.119	0.8953	0.3894	0.3911	0.164	0.0213
Bass	0.1498	0.9297	0.4433	0.4315	0.1887	0.0246
White	3.58	93.61	53.02	55.19	20.81	2.71
Culture	0	19.173	1.576	0.54	2.914	0.379
Disadv	30.59	89.5	62.62	53.7	12.63	1.64
PCI	9629	22514	14831	14381	2479	323
Poverty	9.7	49.5	21.773	21.2	6.455	0.84
Pop Den	7.6	2864.3	171.8	53.3	426.6	55.5
HS Grad	53.3	83.9	69.798	69.1	7.197	0.937
Emissions	-1.523	3.235	0.431	0	0.935	0.122

4.2 Correlation

Pearson’s correlation was determined for each variable pair with all thirteen variables, through Minitab. The output consisted of Pearson’s correlation coefficient, r, and associated p-value; which can be found in table 4. For a sample size of 59, the critical value for 95% confidence level is 0.273 and 99% confidence is 0.354; correlations that did not fall within the confidence level will not be addressed in detail. The eight random number variables were correlated with the thirteen original variables, and three sets in the matrix of 78 pairs were found to be significant at the 95% confidence level. The four seemingly unrelated variables were also correlated, and were found to have some relationship with the independent socioeconomic variables, and can be found in Appendix B

4.2.1 Autism

Five of the independent variables were not found within the confidence level when correlated to autism; they are mercury emissions, European descent percentage, culture percentage, below poverty percentage; and percent disadvantaged. Bass mercury concentration has a 95% confidence level, with a Pearson's correlation coefficient of -0.284. The corresponding p-value of 0.029 indicates that there was a 2.9% chance that the negative correlation between bass and autism was by chance. High school graduates correlated positively with 95% confidence level with an r value of 0.328 and a p-value of 0.011. This indicates that the correlation has only a 1.1% chance of occurring due to chance.

Three independent variables were found to be significantly correlated to autism at the 99% confidence level: all fish concentration (AllFish), per capita income (PCI) and population density (Pop Den). All fish concentration correlated with an r value of -0.466 and a p-value of 0; implying the negative relationship has a 0% chance of this relationship occurring due to chance. The per capita income had an r value of 0.426 with a p-value of 0.001; indicating the positive relationship has a 0.1% chance of occurring due to chance. Population density had a p-value of 0, with an r of 0.526, implying that there was 0% chance of the positive relationship having occurred by chance.

4.2.2 Learning Disabilities

There were no correlations between learning disabilities (LD) and the ten independent variables, or amongst the other dependent variables, that fell in with the set confidence levels.

Table 4: Pearson's Correlation and Associated P-value;
The top number indicated the r value, and bottom is p-value.
bold indicates 95% confidence level & *italicized and underlined* indicates 99% confidence

		Dependent				Indpendent								
		Autism	LD	Develop	Other Sp	AllFish	Bass	White	Culture	Disadv	PCI	Poverty	Pop Den	HS Grad
Dependent	LD	-0.014 0.915												
	Develop	-0.231 0.078	0.217 0.099											
	Other Sp	**0.283** 0.030	0.046 0.732	-0.129 0.239										
Independent	AllFish	*-0.466* 0.000	0.049 0.715	0.033 0.804	-0.134 0.312									
	Bass	**-0.284** 0.029	0.019 0.889	-0.111 0.402	0.063 0.635	*0.680* 0.000								
	White	-0.194 0.141	0.074 0.578	-0.183 0.166	-0.188 0.153	0.180 0.172	0.201 0.126							
	Culture	0.157 0.234	0.159 0.230	-0.091 0.494	0.000 0.998	-0.222 0.091	-0.161 0.224	0.084 0.529						
	Disadv	-0.034 0.797	-0.039 0.767	0.126 0.343	0.234 0.074	-0.052 0.694	-0.181 0.171	*-0.762* 0.000	-0.078 0.556					
	PCI	*0.426* 0.001	-0.023 0.865	**-0.316** 0.015	0.041 0.758	-0.126 0.343	0.066 0.621	0.238 0.070	0.206 0.117	*-0.624* 0.000				
	Poverty	-0.165 0.213	-0.043 0.745	**0.289** 0.026	0.081 0.540	0.021 0.874	-0.115 0.386	*-0.621* 0.000	-0.196 0.136	*0.773* 0.000	*-0.797* 0.000			
	Pop Den	*0.526* 0.000	-0.242 0.065	**-0.328** 0.011	0.082 0.537	-0.195 0.139	-0.057 0.670	**-0.341** 0.008	0.078 0.559	0.117 0.376	*0.434* 0.001	-0.080 0.548		
	HS Grad	**0.328** 0.011	-0.017 0.899	-0.165 0.213	-0.098 0.459	0.067 0.613	0.152 0.250	0.125 0.344	0.103 0.437	*-0.462* 0.000	*0.777* 0.000	*-0.671* 0.000	**0.339** 0.009	
	Emissions	-0.046 0.730	0.033 0.805	-0.037 0.784	0.178 0.178	0.006 0.962	0.004 0.978	-0.241 0.066	-0.040 0.766	0.229 0.081	0.098 0.461	-0.023 0.862	0.053 0.688	0.120 0.366

4.2.3 Developmental Delay

Seven of the independent variables were found to not be significantly correlated to the dependent variable developmental delay. Yet, three variables were at the 95% confidence level: per capita income (PCI), population density (Pop Den) and percent below poverty (Poverty). Per capita income was negatively correlated with an r of -0.316 and a p-value of 0.015, indicating that there was a 1.5% chance that the relationship occurred due to chance. Population density has an r of -0.328 with a corresponding p-value of 0.011; indicating that the negative relationship had a 1.1% chance of resulted due to chance. Poverty was correlated with an r of 0.289 and a p-value of 0.026; indicating a 2.6% chance that the positive relationship was a result of chance.

4.2.4 Other Special Education

No correlation that occurred between other special education (Other Sp) data and the nine independent variables was found within the determined confidence levels. However, there was a significant correlation with autism, at the 95% confidence level. The correlation value of r=0.283 carries a p-value of 0.030; indicating a 3% chance of the correlation occurring by chance.

4.2.5 Independent Variables

There were twelve significant correlations between independent variables, ten of which occurred at the 99% confidence level, leaving two to occur at the 95% confidence level. The Pearson correlation coefficient values (r) can be found in Table 3, with the p-value for each correlation in found in parentheses. The correlation pairs with 95% confidence are denoted with an asterisk, with remaining being confident at the 99% level.

Table 5: Independent Correlations
* 95% Confidence Level; no * indicates 99% Confidence Level

Variable Pair	Correlation Coefficient	P-value
All Fish & Bass	0.68	0.0
White & Disadv	-0.762	0.0
White & Poverty	-0.621	0.0
White & Pop Den	-0.341 *	0.008
Disadv & PCI	-0.624	0.0
Disadv & Poverty	0.773	0.0
Disadv & HS Grad	-0.462	0.0
PCI & Poverty	-0.797	0.0
PCI & Pop Den	0.434	0.0
PCI & HS Grad	0.777	0.0
Poverty & HS Grad	-0.671	0.0
Pop Den & HS Grad	0.339 *	0.009

4.3 Regression

The randomly generated independent variables had no significant effect on the multiple regression of the four original dependent variables. The four dependent randomly generated variables in addition to the two seemingly unrelated variables were tested through multiple regression using the original independent variables. Three out of four of the dependent randomly generated variables and average daily attendance yielded results significant at the 75% confidence level, which is less than the accepted significance used for this study. The other random variable and graduation rate was found to be not significant at all; the full regression analysis of these variables can be found in Appendix B. The two seemingly unrelated variables, count and salary, were found to be significantly related to multiple socioeconomic independent variables, and were not analyzed with regression because of this close, confounding relationship.

For each of the four dependent variables, the independent variables chosen to run in regression, came from the best subsets regression. Three subsets were chosen for each variable and were selected by the subset with the highest adjusted R-square value, the subset with the highest R-square followed by the subset which included the highest combination of adjusted r-square and r-square. The subset selection was also stipulated by having to contain at least one mercury variable, as mercury is the key independent variable this study was concerned with. The full subset results can be found in Appendix C. A comparison of the regression results can be seen in Table 5.

4.3.1 Autism

Nine independent variables: mercury air emissions in pounds (Emissions), all fish mercury concentration (AllFish), largemouth bass mercury concentration (Bass), percent European descent (White), percent disadvantaged (Disadv), per capita income (PCI), percent below poverty (Poverty), population density (Pop Den), and high school graduate percentage (HS Grad) were contained in the subset with the best R-square. The regression equation accounts for 49.4% of the samples variability (R-square) and 40.1% of the population’s variability (adjusted R-square) as follows:

$$\begin{gathered}\text{Autism} = -0.378 - 0.217\,\text{AllFish} - 0.0199\,\text{Bass} + 0.00042\,\text{White} + 0.00138\,\text{Disadv} \\ + 0.000016\,\text{PCI} + 0.00364\,\text{Poverty} + 0.000055\,\text{Pop Den} + 0.00277\,\text{HS Grad}\end{gathered}$$

This regression equation has a significance level of 99.9% with an f-ratio of 5.31. The regression equation implies that all fish mercury concentration carries the most weight followed by largemouth bass mercury concentration, and as either variable increases, autism

Table 6: Regression Equations

Dependent Variable	Function	Significance	R-square	Adjusted R-square	Multiple Regression Equation
Autism	Allfish, Pop Den, HS Grad	99.9%	46%	43%	0.0169 - 0.244AllFish +0.000084Pop Den + 0.00314HS Grad
Autism	Allfish, White, Disadv, PCI, Poverty, Pop Den, HS Grad, Bass, Emissions	99.9%	49.40%	40.10%	- 0.378 + 0.00042White + 0.00138Disadv + 0.000016PCI + 0.00364Poverty + 0.000055Pop Den + 0.00277HS Grad - 0.217Allfish - 0.0141Emissions - 0.0199Bass
Autism	Emissions, Allfish, PCI, Poverty, Pop Den, HS Grad	99.9%	48.70%	42.80%	- 0.204 - 0.0111Emission - 0.233Allfish + 0.000012PCI + 0.00361Poverty + 0.000063Pop Den + 0.00269HS Grad
Developmental Delay	Allfish, Bass, White, Disadv, PCI, Pop Den, HS Grad, Poverty	95%	28.60%	17.20%	5.53 + 0.48Allfish - 0.816Bass - 0.0236White - 0.0393Disadv - 0.000153PCI - 0.0007Pop Den + 0.0240HS Grad + 0.0194Poverty
Developmental Delay	Bass, White, Disadv, PCI, Pop Den	95%	19.90%	26.80%	7.66 - 0.413Bass - 0.0269White - 0.0398Disadv - 0.00014PCI - 0.000698Pop Den
Developmental Delay	Allfish, Bass, White, Disadv, PCI, Pop Den, HS Grad	95%	28.40%	18.50%	6.88 + 0.53Allfish - 0.813Bass - 0.0266White - 0.0402Disadv - 0.000183PCI - 0.000667Pop Den + 0.0201 HS Grad
Other Special Education	Allfish, Bass, Disadv, PCI, Pop Den, HS Grad, White, Culture	90%	25.40%	13.40%	-2.38 - 2.91Allfish + 2.93Bass + 0.0968Disadv + 0.000501PCI - 0.000787Pop Den - 0.0720HS Grad + 0.0128White - 0.0412Culture
Other Special Education	Allfish, Bass, Disadv, PCI, Pop Den, HS Grad	95%	24.20%	15.50%	0.22 - 2.62Allfish + 2.95Bass + 0.0763Disadv + 0.000465PCI - 0.000816Pop Den - 0.0759HS Grad
Other Special Education	Allfish, Bass, White, Disadv, PCI, Pop Den, HS Grad	95%	24.90%	14.60%	-1.94 - 2.78Allfish + 2.97Bass + 0.0111White + 0.0933Disadv + 0.000482PCI - 0.000768Pop Den - 0.0715HS Grad

is expected to decrease. A large increase in any of the remaining variables, percent European descent, percent disadvantaged, per capita income, percent below poverty, population density or high school graduate percentage, will lead to an increase in occurrence of autism.

The subset that had the largest adjusted R-square value of 43.0% was obtained with the independent variables all fish mercury concentration (AllFish), population density (Pop Den) and high school graduate percentage (HS Grad); giving the following predictive equation:

$$\text{Autism} = 0.0169 - 0.244\ \text{AllFish} + 0.000084\ \text{Pop Den} + 0.00314\ \text{HS Grad}$$

The R-square for this equation is 46%, implying that 46% of the variation is accounted for by the variables in the equation. The adjusted R-square value is 43%, indicating that the variables in this equation account for 43% of the variation in autism in the entire population. The f-ratio for this entire equation is 15.61, giving the equation a significance level of 99.9%. The regression equation also implies that all fish mercury concentration has the most weight in changing percent of autism; an increase in all fish mercury concentration should yield a decrease in autism, if the other variables remain the same. Similarly, increasing population density or high school graduate percentage will increase autism, but it would take a larger increase of the variables to see changes in autism.

The best combination subset for R-square and adjusted R-square included seven independent variables: mercury air emissions in pounds (Emissions), all fish mercury concentration (AllFish), per capita income (PCI), percent below poverty (Poverty), population density (Pop Den) and high school graduate percentage (HS Grad); account for 48.7% of the sample variation (R-square) and 42.8% of the population variation (adjusted R-square). The regression equation is given as follows:

$$\text{Autism} = -0.204 - 0.233\ \text{AllFish} - 0.0111\ \text{Emissions} + 0.000012\ \text{PCI} + 0.00361\ \text{Poverty} + 0.000063\ \text{Pop Den} + 0.00269\ \text{HS Grad}$$

The regression equation has an f-ratio of 8.23, indicating a significance level of 99.9%. The regression equation implies that for an increase in autism to occur, the mercury concentration of all fish would decrease and the other variables would increase.

4.3.2 Learning Disability

The best subsets for learning disability did not yield significant results when testing the f-ratio. At best, R-square accounted for 10.1% of the variability, and the adjusted R-square accounted for 5.8% of the population's variability, but did not include a mercury variable (concentration in all fish or largemouth bass). The subset with the highest adjusted R-square that contained a mercury variable accounted for only 1.6% of the population's variability. With no combination of variables having significance in a regression equation or correlations; there is nothing further to report on for learning disabilities.

4.3.3 Developmental Delay

The subset which accounted for the highest sample variability (R-square) in developmental delay contained eight independent variables; all fish mercury concentration (AllFish), mercury concentration in largemouth bass (Bass), percent European descent (White), disadvantaged percentage (Disadv), per capita income (PCI), population density (Pop Den), high school graduate percentage (HS Grad), and percent below poverty has an R-square of 28.6% with an adjusted R-square of 17.2%. The following regression equation was 95% significant, with an f-ratio of 2.50;

$$\text{Develop} = 5.53 + 0.48\ \text{AllFish} - 0.816\ \text{Bass} - 0.0236\ \text{White} - 0.0393\ \text{Disadv} - 0.000153\ \text{PCI} - 0.000700\ \text{Pop Den} + 0.0240\ \text{HS Grad} + 0.0194\ \text{Poverty}$$

This equation implies that mercury concentration in largemouth bass will account for the largest changes in developmental delay, followed by all fish mercury concentration, high school graduate percentage, percent disadvantages, percent below poverty, population density, and per capita income respectively. An increase in all fish mercury concentration, high school graduate percentage or percent below poverty will increase developmental delay percentage; while an increase in largemouth bass mercury concentration, percent white, percent disadvantaged or per capita income will decrease the percentage of developmental delay.

Five independent variables; largemouth bass mercury concentration (Bass), percent European descent (White), percent disadvantaged (Disadv), per capita income (PCI) and population density (Pop Den) together obtained the highest adjusted R-square value of 19.9%, with an R-square of 26.8%. The regression equation is as follows:

$$\text{Develop} = 7.66 - 0.413\ \text{Bass} - 0.0269\ \text{White} - 0.0398\ \text{Disadv} - 0.000140\ \text{PCI} - 0.000698\ \text{Pop Den}$$

The equation accounting for 19.9% of the population's variability is significant at the 99% level, with an f-ratio of 3.88. The regression equation implies that mercury concentration in largemouth bass carries most of the weight, and will account for most of the change in developmental delay percentage. As the variables increase, it is expected that developmental delay percentage will decrease accordingly.

The best combination of variables that gave the highest combination of adjusted R-square and R-square accountability measures contains seven independent variables: mercury concentration found in all fish (AllFish), largemouth bass mercury concentration (Bass), percent European descent (White), percent disadvantaged (Disadv), per capita income (PCI), population density (Pop Den) and high school graduate percentage (HS Grad). These variables in the following regression equation:

$$\text{Develop} = 6.88 + 0.53\ \text{AllFish} - 0.813\ \text{Bass} - 0.0266\ \text{White} - 0.0402\ \text{Disadv} - 0.000183\ \text{PCI} - 0.000667\ \text{Pop Den} + 0.0201\ \text{HS Grad}$$

accounted for 28.4% of the samples variability (R-square) and 18.5% of the populations variability (adjusted R-square); at a 95% significant level with an f-ratio of 2.88. The regression equation predicts that largemouth bass mercury concentration has the most weight, followed by all fish mercury concentration, then percent disadvantaged, percent white, high school graduate percent, population density and per capita income respectively. As all fish mercury concentration and high school graduate percent increases, developmental delay percent is expected to increase as well; however, an increase in largemouth bass mercury concentration, percent white, percent disadvantaged, per capita income or population density should yield a decrease in percent of developmental delay.

4.3.4 Other Special Education

The highest R-square accounts for 25.4% of the variability of other special education (Other Sp), and accounts for 13.4% of the population's variability from a subset containing eight variables: all fish mercury concentration (AllFish); largemouth bass mercury concentration (Bass); percent disadvantaged (Disadv); per capita income (PCI); population density (Pop Den); high school graduate percentage (HS Grad); and percent cultural (Culture). The regression equation is as follows:

$$\text{Other Sp} = -2.38 - 2.91\ \text{AllFish} + 2.93\ \text{Bass} + 0.0968\ \text{Disadv} + 0.000501\ \text{PCI} - 0.000787\ \text{Pop Den} - 0.0720\ \text{HS Grad} + 0.0128\ \text{White} - 0.0412\ \text{Culture}$$

The f-ratio for the previous equation is 2.12, which is 90% significant. This equation predicts an increase in other special education when all fish mercury concentration, population density, high school graduate percent or percent culture decreases, with all fish having the more weight than the others. Additionally, overall largemouth bass mercury concentration has the highest strength in changing other special education, as other special education percentage will increase as largemouth bass does. Similarly, percent disadvantaged, per capita income and percent white also will increase other special education as they increase, but to lesser degrees.

Six independent variables that account for most of the population's variability with an adjusted R-square of 15.5%; all fish mercury concentration (AllFish), largemouth bass mercury concentration (Bass), percent disadvantaged (Disadv), per capita income (PCI), population density (Pop Den) and high school graduate percentage (HS Grad) account for an R-square of 24.2% of the sample's variability. The f-ratio for the equation as a whole is 2.77, which is 95% significant. The equation is as follows:

$$\text{Other Sp} = 0.22 - 2.62\ \text{AllFish} + 2.95\ \text{Bass} + 0.0763\ \text{Disadv} + 0.000465\ \text{PCI}$$
$$- 0.000816\ \text{Pop Den} - 0.0759\ \text{HS Grad}$$

This regression equation predicts that largemouth bass and then all fish mercury concentrations have the strongest relationship with other special education. Increases in largemouth bass, percent disadvantaged or per capita income will increase the percentage of other special education; on the other side, increasing all fish mercury concentration, population density or high school graduate percentage will decrease the percentage of other special education.

The combination of the following seven variables: all fish mercury concentration (AllFish), largemouth bass mercury concentration (Bass), percent European descent (White), percent disadvantaged (Disadv), per capita income (PCI), population density (Pop Den) and high school graduate percentage (HS Grad) give the best combined account of variability. Accounting for 24.9% of the samples variability (R-square), and 14.6% of the population's variability (adjusted R-square); the regression equation is as follows:

$$\text{Other SpEd} = -1.94 - 2.78\ \text{AllFish} + 2.97\ \text{Bass} + 0.0111\ \text{White} + 0.0933\ \text{Disadv}$$
$$+ 0.000482\ \text{PCI} - 0.000768\ \text{Pop Den} - 0.0715\ \text{HS Grad}$$

This equation is significant at the 95% level with an f-ratio of 2.41. The regression equation indicates that largemouth bass mercury concentration has the most weight, followed by all fish mercury concentration; meaning that it only takes a small change in largemouth bass or all fish mercury concentrations to greatly change the other special education percentage. With an increase in any of the following variables; largemouth bass mercury concentration, percent European descent, percent disadvantaged, or per capita income; other special education percent is expected to increase. Yet, an increase in all fish mercury concentration, population density or high school graduate percentage, and other special education percentage is expected to decrease.

CHAPTER FIVE: DISCUSSION

5.1 Statistical Considerations

In this study, correlation and regression do not provide evidence of causality between mercury and developmental disorders. The strength of a relationship between variables can be determined statistically, relative to the level of Type I Error the analyst is willing to accept. In many cases, including this study, a 5% error or less is acceptable. Being able to confirm or reject the existence of a relationship based on a predefined level of confidence allows scientific investigators to unravel uncertainties surrounding complex relationships. With respect to this study, which seeks to associate mercury poisoning and developmental disorders, correlation and regression supply a starting point from which further investigations might begin.

The assumed association between mercury and developmental disorders has been acknowledged by the shared symptoms between developmental disorders and mercury poisoning and increasing exposure to mercury. Both correlation and regression are suited to examine the suspected relationship for strength and validity, where significant results provide confidence that there is a high likelihood of a relationship. While the determined existence of a relationship is not definitive, it does provide a cutoff point where associations occurring below a specified confidence level are considered less significant. Such associations can be more accurately defined as not having a strong relationship and either should be disregarded or re-examined with other factors if other information offers incentive to identify the relationship.

The significance alone of a relationship does not always imply a valid association, in light of the inherent probability of errors associated with correlation. Relationships can be tested against randomly generated variables and against variables that have no known influences by the variables of concern to set a baseline for comparison of significance. The expectation is that these baseline tests will be less significant than the relationships found when using the variables of concern. The results for the random variables, give more reassurance that the results of the original analysis can be considered to have not occurred as a result of chance or error. The random variable correlation in this study indicated that chance associations are expected to occur 1.7% of the time for variables with 59 values. The analysis of concern found a much larger ratio of significant association than 1.7%, indicating that error was minimal, though present. Although there were some significant findings associated with the regression models of the random variables, the level of significance was less than required for the study, and far less than that of the observed significance with the variables of concern. Upon further investigation of the seemingly unrelated variables (salary, student count, average daily attendance, and graduation rate); it was determined that teachers salary and student count were not completely unrelated to the independent variables, thus were inadequate indicators for determining random background errors. Average daily attendance and graduation rates are unrelated to the socioeconomic variables in Louisiana, and yielded insignificant regression equations.

5.2 Study Findings

The results do not support the hypothesis, which states that increases in developmental disorders are associated with increasing mercury concentrations found in fish. At best, regression accounted for half of the variability within the dataset, but there was not a constant relationship found with mercury. Yet, with the exception of the learning disabilities, the dependent variables did have significant regression equations

One possible reason for a mercury-developmental disorder pattern anomaly is a potential disconnect between fish consumption during the most critical time periods for brain development, and the symptoms recorded as special educational needs could be a possible reason for pattern failure. For the most part, mercury concentration recorded from the fish was an average, spanning over at most five years. The students ranged in age from three to twenty-one years of age. Given the assumption that critical brain functions are developed by age seven, there is a disconnection between fish concentrations and special education needs for students over six years of age. For these older children (over six years old), the concentrations of mercury within the fish in their local region is unknown. An educated guess could be made concerning the levels of mercury found in specific water bodies using current trends, but even with complete data for more recent years, this method carries a great deal of uncertainty.

Beyond observing that there is uncertainty in the actual concentration found in local fish during critical development, a second discussion item can be found in the amount of fish consumption. Although generalities have been made concerning specific social and economic groups, these are just assumptions and have not been largely tested. Additionally, it has been suggested that the eating habits of children are quite different from that of adults (Amler et al. 2003). Many children do not like to eat fish in the same manner that adults do, and therefore exposure may be limited after birth. Within Louisiana, these assumptions have not been looked at; even though it is a culture where fish is a staple of cooking. Louisiana is likely to influence the socioeconomic and age groups in different ways than might be found elsewhere. It is important and probably necessary to determine the strongest influences on the diet of the different groups in Louisiana, in order to make assumptions and potentially predict the most vulnerable groups.

The large size of the parish wide average for all variables may not be an accurate source of what occurs within the parish as a whole. Population centers in each parish are likely to account for the majority of variability, while skewing the data. There are three main areas of high variability when looking at the parish average; socioeconomic, fish source, and mercury concentration within water bodies. There are likely to be regions of a parish where similar groups of people are more concentrated that may be more likely to fish from local water bodies, or be inclined to eat more fish in general. Secondly, within population centers, it is more likely that fish consumed originated in a store; where the water body that the fish originated from is likely not local and usually unknown to the consumer. Store bought fish is also likely to occur of middle class economic groups. Rural communities likely have better access to local water bodies and residents might be more inclined to fish for themselves. Lastly, the variability of the water bodies used for the parish wide average is also important, for some water bodies could have extremely high mercury concentrations, but be remote with little fishing occurring, or in close proximity with low mercury concentrations.

Knowing that different species will have different average mercury concentrations as a result of the location within the local food chain, largemouth bass was taken out of the inclusive all fish category in an attempt to control some variability. Each site tested had a range of species collected, and the only consistency amongst all water bodies was largemouth bass. There is some variability expected between sites as previously mentioned, methyl mercury availability is based on specifics characteristics within a water body. It is interesting to note the different effects the mercury variables all fish and largemouth bass had in the regression equations. For other special education, all fish mercury concentration has a negative impact while largemouth bass mercury concentration has a positive impact. The opposite occurred with developmental delay where all fish mercury concentration has the positive impact and mercury concentration of largemouth bass impacted developmental delay negatively. Considering autism, both all fish and largemouth bass mercury concentrations have a negative impact. It is difficult to account for the discrepancies that these two independent variables have on the dependent variables. A potential connection might be the consumption pattern of certain fish over others, but there is not sufficient data here to support or deny this idea. This aspect is most puzzling, and yet truly significant to the relationship with special education needs and mercury. Statistically looking at the two mercury variables, a strong correlation was found between them, which should that they would have similar impacts. Furthermore, both all fish and largemouth bass mercury concentrations were negatively correlated to the dependent variables (special education needs). This suggests the importance of the socioeconomic variables within the regression equation, but does not account for the discrepancy between positive or negative impacts.

The lack of significance in correlation and regression attempts for learning disabilities is most likely attributed to the widespread potential causes and different levels of the disorder. The inconclusiveness of all specified learning disabilities used for the study may have too many unknown confounding variables to accurately make predictions to capture the entire picture. This is true for the other special education category, and even to a degree for autism and developmental delay. The large inclusive design of these categories may be too large for the purposes of this type of linkage. In general, the symptoms of mercury are widespread in severity, attributed by the amount of mercury exposure. The breakdown to severity level of these larger categories may yield more appropriate comparisons between special education needs and mercury concentrations.

Autism was found to be the most predictable dependent variable, with the best account of variability, of around 48%, and significant within the 99.9% confidence level for all regression attempts. However, as previously mentioned the regression equations do not seem to agree with what was hypothesized to occur; specifically that increased levels of mercury would yield an increase in autism Additionally, the results do not agree with the Texas study (Palmer et al. 2006), of which this study was based on. As indicated by the Palmer et al. (2006) study autism was expected to increase with increase in mercury emissions; however this was not the case in this study. The regression equations and correlations show that there is a negative relationship between autism and mercury, whether looking at all fish or largemouth bass mercury concentrations, or emissions. The fact that the correlations and regressions were significant to the level that they are indicates that this relationship should be looked at more closely to develop stronger predictability measures. The current statistical relationship is not consistent with the other data relationships that are known between mercury and autism, but creates an opposite relationship, suggesting that further study should be made. Autism itself occurs with less of a range due to all levels of autism residing on the severe side of the scale, therefore is less variable than the other special educational needs variables, and has recently increased at such remarkable rates that the relationship is becoming of increasingly importance. More study is necessary to find logical predictive variables, and even a better idea of whether environmental or genetic factors have greater influence.

5.3 Comparison of Texas and Louisiana Studies

This study of mercury and developmental disorders in Louisiana was inspired by a similar ecological study in Texas (Palmer et al. 2006). The Texas study was one of the first of its kind, establishing a relationship in Texas between mercury air emissions with the prevalence of autism and special education at the school district and county level. Louisiana has a high level of mercury consumption advisories along with increasing special educational needs, suggesting a similar association might exist. Because this study was inspired by the Texas example, it is important to understand the similarities and differences between the studies completed for Texas and Louisiana. Although the results of the two similar ecological studies did not agree, both were considered statistically significant. Knowledge of the methods, data type and study area of the two studies are fundamental in comparing the differences, and may provide insight to the discrepancies around the results.

The methods used in Louisiana and Texas were different, although the objectives and hypotheses were similar. Palmer et al. (2006) used multilevel Poisson regression to predict autism and special education in schools at the county level by mercury emissions. Four separate models were generated, based on two dependent variables, autism, and special education. Subsequent models allowed for autism and special education to act as covariates for each other; given by a function of the pounds of mercury released. Socioeconomic factors were used to adjust this relationship, such as district wealth, percent disadvantaged and urbanicity. The choice for Poisson regression in Texas was well-suited with the data coming from 1154 school districts nested within 254 counties. The multiple regression model used for Louisiana considered four dependent variables related to special education needs and used mercury concentrations found in fish, in addition to emissions released.

Louisiana having roughly the same number of school districts as parishes can be analyzed using multiple regression, accounting for socioeconomic variables in addition to mercury. This was felt to be important, as the influential factors associated with developmental disorders, and consumption of fish, are uncertain. By suggesting potential influential factors and analyzing the influences using statistical methods, more certainty around the potential influential variables can be found. The multiple regression models can account for multiple influential factors better than a Poisson model. Although the dispersion on the county (parish) level is not accounted for with multiple regression, as it is with Poisson regression. Both models are on the ecological level, and can not be used to assess individual's risk to the effects of mercury.

The alternate methods, while yielding different results were both significant in the relationships found between mercury and autism. The Texas study (Palmer et al. 2006) results indicated that autism would increase by 61% for every 1000 lbs of mercury emitted on the county level. Socioeconomic influences were also investigated and revealed that district wealth significantly increased the rate of autism, and European descent and economic disadvantage were inversely related to autism rates. The results showed that increased autism rates accounted for the positive association between environmental mercury and special education rates. The results in Louisiana were different from that of Texas, and even amongst the dependent variables. The basic relation found between autism and mercury, was negative, indicating an increase in mercury yields a decrease in autism. Special education and developmental delay had interesting relations with mercury. The two mercury variables, representative of all fish species and largemouth bass, did not relate the same to the dependent variables, and in fact were opposite of each other when looking between developmental delay and other special education.

It is important to note some basic differences between the states of Texas and Louisiana that could affect the outcomes of similar studies. Texas is five times larger than Louisiana, in both population and land area. There are more school districts and counties in Texas than Louisiana, which increases the number of values available for each variable. This indicates that the Texas study was based on a larger subpopulation group which could account for some significance on its own. Texas is the 4th largest emitter of mercury emissions, while Louisiana yields much lower emissions. The geography of Texas is very different from that of Louisiana. Texas has a vast coast line along both the Pacific Ocean and the Gulf of Mexico. Texas's inland is characteristically dry with only 2.5% water cover; while Louisiana is characteristically wet, with 16% water cover. These geographic characteristics are important when considering transport and deposition of mercury. Generally speaking, the majority of mercury in local water bodies is accounted for by local emissions. Yet, local emissions do not account for all potential depositional sources. This is confirmed when comparing the water body advisories for mercury consumption between the two states. Louisiana has advisories within 77% of parishes while less than 4% of the counties in Texas have advisories for mercury consumption.

5.4 Implications

There is no question that overexposure to mercury causes severe health problems, but there are uncertainties surrounding a direct link between exposure and the effects. This study attempted to find a relationship between mercury concentrations in fish, and four types of disorders found with school age children in Louisiana. Autism, learning disorders, and developmental delay, all share the same symptoms as overexposure of mercury to a developing brain; and even without a direct causal link, the evidence supports a relationship (Rice and Barone 2002). The most damaging exposure to mercury occurs pre-natal, while the brain is developing critical components. The methyl mercury consumed by the mother during pregnancy passes along to the unborn child via the placenta, where the methyl mercury accumulates in the developing brain. The brain is so complex in the stages of development, that the timing of development of specific aspects is still a mystery to science, causing each case of development to have a unique timeline. Two factors affect the damage that could occur as a result of mercury exposure timing and concentration of methyl mercury exposure to the brain. These factors are the primary reason why the symptoms and affects of over-exposure to methyl mercury are so vast. Many of the symptoms, such as developmental delay, poor motor skills, few points lost of IQ; may not be seen as a problem, as we understand that all children develop a little differently. This results in some children just being extra clumsy, or some may not be great at spelling or math; all of these by themselves do not present a problem, and may be grown out of in time; making a connection to mercury exposure increasingly difficult. The continued exposure after birth via breast milk and then consumption by the individual continue to affect the level of mercury exposure. This affects the symptoms experienced; the ambiguous levels of exposure and levels of severity make it difficult to analyze these data within all special educational needs category.

Beyond fish consumption, there are other potential factors that could result in exposure to mercury that have been used for evidence of mercury causing neurological disorders. These other sources have not been found to be an important linking factor to mercury exposure when compared to fish consumption. Additionally, these sources as exposure risks are decreasing, and are only mentioned for thoroughness. Amalgams contain mercury, and can be a source of mercury in the body through the inhalation of mercury from the amalgam in our teeth fillings; being potentially dangerous the mercury in the amalgam is being phased out. Thimerosal found in many common vaccines such as measles-mumps-rubella (MMR), flu, and RH immunoglobulin; contains organic ethyl mercury. Newborns often receive multiple doses of the Thimerosal containing vaccinations to prevent disease. While there is proven link between Thimerosal and neurological disorders, the recent awareness by scared parents, has prompted the mercury concentrations to be reduced in some of the vaccines; a lower amount of mercury contained in Thimerosal is available for the MMR and flu shots (US FDA 2005). Currently, there is some thought surrounding the potential overdose of mercury in some cases where in-uterus exposure occurred and then the vaccines administered only added to the existing problem. Additionally, small amounts of inorganic mercury may be inhaled by those living in close proximity to a point source of air pollution, such as an incinerator or a coal fired power plant, or occupationally; but neither has been found to be of significant risk.

As the main source of methyl mercury in the human body, fish consumption as a whole has been increasing in the United States, inevitably causing an increase in mercury concentrations for fish eaters (USDA 2005). This was confirmed by a recent study collecting hair samples to test for mercury, and found that 1 out of 5 women had levels higher than the EPA recommends as safe (Patch et al. 2005). While people are consuming more fish, the methyl mercury concentration in fish is also increasing, as a result of the increasing mercury deposition.

There is no doubt mercury emissions are a global issue, countries all over the world are sources of anthropogenic atmospheric emissions and deposition occurs in places far removed from anthropogenic sources (Shuster et al. 2002). There is some controversy over the source of deposition that has led to a lack of responsibility taken to lower emissions. Freshwater deposition is most likely a result of local or at least regional emissions; so it only makes sense, that the first step in fixing the problem is to reduce local emissions as much as possible, and when that is accomplished work on solving the global problem. The technology exists for the reduction of emissions in the United States by 90-95% from coal fired power plants (Bustard et al. 2002; Renniger et al. 2004), and costs no more than a couple of dollars a month per household (NWF 2004). This is considered economically sound when comparing the cost to prevent methyl mercury effects with the lifetime costs of dealing with the symptoms from over exposure to methyl mercury, ranging from $8.7 billion to $90 billion per year (Trasande et al. 2005; ASA 2003). The choice should be clear, even if only as a precautionary measure until the causal links are supported.

5.5 Future Research

As a good starting point, this study should be expanded to provide more specific and significant relationships. As suggested earlier in this discussion, further study might focus on comprehending the variability to be accounted for. Reducing the value size from parish to community is the first step in reducing variability of the data, and providing an in depth look at the relationships. Secondly, the breakdown of special educational needs categories into multiple levels of severity might provide additional insight and might be a viable option for future work.

Specific data on fish consumption with mercury concentration is essential to develop further relationships between mercury and special education issues. A personal consumption history for a sample of the population in addition to samples of the source of the fish is suggested as a next step to further create a significant predictive relationship. The extra work of taking a sample and comparing it to the community sized assumptions would be extremely beneficial to understanding important linkages. Additionally, taking individual people's dietary and other relevant life history aspects would allow for a control of non-special educational needs to be assessed with special education needs.

CHAPTER SIX: SUMMARY

Recent rises in the number of students with special education needs, specifically autism and learning disorders, have prompted researchers to look into possible reasons for this increase. Environmental factors, especially mercury, have been known to induce negative health affects on some people exposed. The developing mind, found primarily in children under seven including unborn fetuses, is susceptible to the damaging effects of mercury exposure. Potential results of mercury exposure include slow development, autism, cerebral palsy, learning disorders, among many other neurological disorders.

The major source of mercury exposure is through consumption of contaminated fish. Certain groups of people tend to ingest more fish in their diet as a result of cultural or economic status. Native Americans, Asians, Islanders, coastal inhabitants and especially Louisianans consider fish a main staple in their diet. Both poor and wealthy people also tend to consume more fish, because fish are readily available in local water bodies cheaply, and high value species are regarded as a status symbol. Forty-nine of the sixty-four parishes in Louisiana have issued water body advisories to limit consumption of fish due to mercury contamination. Approximately 500 water bodies in Louisiana have been host to fish tested for mercury levels, of numerous species.

Three mercury variables, all fish species and largemouth bass concentrations, in addition to air emissions; census data of the parishes, and school statistics including counts of special educational needs students; was used to find a relationship between mercury and special education needs in Louisiana. The significance of the results is indicates that these variables may be important in determining the complicated relationship between mercury and developmental disorders. The low variability, however, indicates that our current assumptions are not enough to wholly ascertain these relationships. These results can be seen as a starting point for future research to effectively discern the relationship, with the intention of preventing as many of the disorder diagnoses as possible.

The most efficient way to reduce the mercury exposure risk is to reduce emissions from anthropogenic sources. The largest anthropogenic contributor to mercury emissions in the United States is coal-fired power plants, accounting for 42% of the emissions. The remainder of the controllable sources individually account for less than 10%, each and are already being phased out as efficiently as possible. With the existing legislation, coal-fired power plants will continue to be the largest source of mercury emissions with no end in sight.

In conclusion, with Louisiana facing higher risks to mercury consumption as a result of culturally related fish consumption, and high rates of special educational needs; the relationship between mercury and developmental disorders should be identified. While the confounding variables of this study did not define a strong general relationship linking mercury to developmental disorders; it did provide evidence that a relationship exists between some socioeconomic variables and some developmental disorders and opened up questions to be answered in future research. Efforts in future studies should focus on defining the association between mercury and our children's health. It is essential to control the anthropogenic sources of mercury now, to protect the thousands of children born every year from mercury poisoning. The reduced health of our children and loss income potential from diminished mental capacity has a higher cost than that of reducing emissions; leaving the decision as to which cost society is willing to burden. Continuing the status quo with minimum reductions from the largest direct source, the contamination of fish and shellfish is only going to increase; as global and local emissions rise.

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APPENDIX A: LOUISIANA CONSUMPTION ADVISORIES

LOCATION	BOUNDARIES	PARISH	WOMEN OF CHILDBEARING AGE AND CHILDREN UNDER 7	OTHER ADULTS AND CHILDREN OVER THE AGE OF 7
Amite River Drainage Basin	Amite River form the Mississippi State Line to its confluence with Lake Maurepas, Colyell Creek, the Amite River Diversion Canal and Petite Amite Rive	East Feliciana, St. Helena, East Baton Rouge, Livingston and Ascension	Limit bigmouth buffalo, largemouth bass, spotted bass, white crappie, freshwater drum, and bowfin. Limit consumption to no more than 1 meal per month combined.	Limit bigmouth buffalo, largemouth bass, spotted bass, white crappie, freshwater drum, and bowfin. Limit consumption to no more than 4 meals per month combined.
Bayou Bartholomew	Bayou Bartholomew from the LA/AR state line to its confluence with the Ouachita River	Morehouse	No bowfin; Limit other fish species to no more than 1 meal per month combined	No bowfin; Limit other fish species to no more than 4 meals per month combined
Bayou Bonne Idee	Bayou Bonne Idee from its headwaters near Jones, LA to its confluence with the Boeuf River east of Oak Ridge	Morehouse	No bowfin; Limit largemouth bass and freshwater drum consumption to no more than 1 meal per month combined	No bowfin; Limit largemouth bass and freshwater drum consumption to no more than 4 meals per month combined
Bayou De Loutre and Associated Lakes	Bayou De Loutre from the AK/LA state line to its confluence with the Ouachita River Including Phillips, Hatley and Hudson Lakes	Union	No consumption of any species.	Limit consumption of all species to no more than 2 meals per month combined.
Bayou des Cannes	Bayou des Cannes from its origin near Ville Platte to its confluence with Mermentau	Acadia, Evangeline	Limit bowfin, black crappie, and freshwater drum to no more than 1 meal per month combined.	Limit bowfin, black crappie, and freshwater drum to no more than 4 meals per month combined.
Bayou DeSiard	Bayou DeSiard from its headwaters to its confluence with the Ouachita River	Ouachita	No bowfin; Limit other fish species to no more than 1 meal per month combined	No bowfin; Limit other fish species to no more than 4 meals per month combined
Bayou Liberty	The entire length of Bayou Liberty	St. Tammany	Limit largemouth bass, spotted bass, black crappie, freshwater drum, and bowfin consumption to no more than 1 meal per month combined.	Limit largemouth bass, spotted bass, black crappie, freshwater drum, and bowfin consumption to no more than 4 meals per month combined.

Bayou Louis	Bayou Louis from its headwaters to its confluence with the Ouachita River including Lake Louis (Lovelace Lake)	Catahoula	No bowfin; Limit other fish species to no more than 1 meal per month combined	No bowfin; Limit other fish species to no more than 4 meals per month combined
Bayou Plaquemines Brule	Bayou Plaquemine Brule from its origin near Opelousas to its confluence with the Mermentau River	Acadia, St. Landry	No bowfin; Limit largemouth bass, crappie, or freshwater drum to no more than 1 meal a month combined.	Limit bowfin to 2 meals per month; Limit largemouth bass, crappie, or freshwater drum to no more than 4 meals a month.
Bayou Queue De Tortue	Bayou Queue de Tortue from its headwaters near Cankton, LA to its confluence with the Mermentau River east of Lake Arthur, LA	Acadia, Lafayette, and Vermillion	Limit bowfin consumption to no more than 1 meal per month.	Limit bowfin consumption to no more than 4 meals per month.
Big Alabama Bayou	The entire length of Big Alabama Bayou, from the boat landing at Hwy 975 to near the Atchafalaya River Pilot Channel	Pointe Coupee, Iberville, and St. Martin	Limit Consumption of all species to no more than 1 meal per month combined.	Limit consumption of all catfish species to no more than 2 meals a month; Limit consumption of all other species to 4 meals a month combined.
Black Bayou Lake	Black Bayou Lake Only	Ouachita	No bowfin consumption.	Limit bowfin consumption to 1 meal a month.
Black Lake	Black Lake Only	Natchitoches	No bowfin consumption; Limit largemouth bass, white bass, crappie or freshwater drum to no more than 1 meal a month combined.	Limit bowfin to 2 meals per month; Limit largemouth bass, white bass, crappie, or freshwater drum to no more than 4 meals a month.
Blind River	The Blind River Only	St. James, Ascension, Livingston, St. John the Baptist	Limit bowfin consumption to no more than 1 meal per month.	Limit bowfin consumption to no more than 4 meal per month.
Boeuf River	The Boeuf River from the confluence with Lake Lafourche to the confluence with Ouachita River	Caldwell, Franklin, Richland, and Catahoula	No bowfin; Limit other fish species to no more than 1 meal per month combined	No bowfin; Limit other fish species to no more than 4 meals per month combined
Bogue Chitto River	The Bogue Chitto River from MS/LA state line to the Pearl River Navigation Canal	St. Tammany, Washington	Limit all bass species or bowfin to no more than 1 meal per month combined.	Limit all bass species or bowfin to no more than 4 meals per month combined.

Bogue Falaya and Tchefuncte Rivers	The Bogue Falaya from its headwaters to its confluence with the Tchefuncte and the Tchefuncte from its headwaters to Lake Pontchartrain	Washington, St. Tammany and Tangipahoa	No largemouth bass or crappie; Limit freshwater drum, spotted bass or catfish to no more than 1 meal a month combined.	Limit largemouth bass or crappie to no more than 2 meals a month combined; Limit freshwater drum, spotted bass or catfish to no more than 4 meals a month combined.
Calcasieu River Drainage Basin	Calcasieu River from Hwy 26 to the Saltwater Barrier north of Charles Lake, the West Fork Calcasieu River, Houston River, Hickory Creek, Beckwith Creek, English Bayou and Little River	Calcasieu, Jefferson Davis, and Allen	No largemouth bass, bowfin or freshwater drum consumption.	Limit largemouth bass, bowfin or freshwater drum consumption to no more than 2 meals per month combined.
Chicot Lake	Chicot Lake only	Evangeline	No bowfin consumption; Limit largemouth bass to no more than 1 meal a month.	Limit consumption of bowfin to no more than 2 meals a month; Limit consumption of largemouth bass to no more than 4 meals a month.
Cheniere (Brake) Lake	Cheniere (Brake) Lake Only	Ouachita	No consumption of bowfin; Limit largemouth bass to no more than 2 meals per month.	Limit consumption of bowfin to no more than 2 meals a month; Limit consumption of largemouth bass to no more than 4 meals a month.
Corney Lake	Corney Lake Only	Claiborne	Limit largemouth bass or bowfin to no more than 1 meal per month.	Limit largemouth bass or bowfin to no more than 4 meals per month.
Grand Bayou Reservoir	John K. Kelley- Grand Bayou Reservoir	Red River	No bowfin consumption; Limit largemouth bass to no more than 1 meal a month.	Limit bowfin or largemouth bass to 2 meals a month.
Gulf of Mexico	Gulf of Mexico off all coastal parishes.	Coastal Parishes	Limit consumption to 1 meal per month for King Mackerel 39 inches or less in total length.	Limit consumption to 4 meals per month for King Mackerel 39 inches or less in total length.
Gulf of Mexico	Gulf of Mexico off all coastal parishes.	Coastal Parishes	No consumption of King Mackerel greater than 39 inches total length.	No consumption of King Mackerel greater than 39 inches total length.

Henderson Lake Area	Henderson Lake, Lake Bigeux, and all water within the area bounded on the north of the St. Landry/ St. Martin Parish line, on the east by the West Atchafalaya River levee, on the south by Hwy 3177 and on the west by the West Atchafalaya Basin Levee	St. Martin	Limit largemouth bass, crappie or freshwater drum to no more than 1 meal per month.	Limit largemouth bass, crappie or freshwater drum to no more than 4 meals per month.
I-10 Canal and Work Canal	The canal that is between the Interstate 10 bridges (between Whiskey Bay and Ramah), and the canal known as Work Canal, which runs north to south and intersects I-10 Canal.	Iberville	Limit largemouth bass, black crappie, and bowfin consumption to no more than 1 meal per month combined.	Limit largemouth bass, black crappie, and bowfin consumption to no more than 4 meals per month combined.
Ivan Lake	Ivan Lake Only	Bossier	No consumption of bowfin; Limit largemouth bass to no more than 1 meal per month.	Limit consumption of bowfin to no more than 2 meals a month; Limit consumption of largemouth bass to no more than 4 meals a month.
Kepler Creek Lake	Kepler Creek Lake only	Bienville	No bowfin consumption.	Limit bowfin consumption to 1 meal a month.
Lake Vernon	Lake Vernon only	Vernon	Limit largemouth bass, flathead catfish, redear or bluegill sunfish to no more than 1 meal a month.	Limit largemouth bass, flathead catfish, redear or bluegill sunfish to no more than 4 meals a month.
Little River/Catahoula Lake Area	Catahoula Lake, Little River, Old River, Black River, Saline Lake, Larto Lake (Saline-Larto Complex), Shad Lake, and Associated Water Bodies	Avoyelles, Catahoula, Concordia, Grant, LaSalle, and Rapides	No largemouth bass, white bass, freshwater drum, flathead catfish or bowfin consumption; Limit white crappie to no more than 2 meals per month combined.	Limit largemouth bass, white bass, freshwater drum, flathead catfish or bowfin consumption to no more than 2 meals per month; Limit white crappie to no more than 4 meals per month combined.
Ouachita River	LA/AK border to the confluence of the Tensas River including any lakes that are inside the levee system or within the Ouachita River floodplain.	Ouachita, Union, Morehouse, Caldwell, and Catahoula.	No bowfin consumption; Limit other species to no more than 1 meal per month combined.	No bowfin consumption; Limit other species to no more than 4 meals per month combined.

Pearl River	The entire length of the Pearl River	St. Tammany, Washington	No bowfin consumption; Limit bass, bigmouth buffalo, or freshwater drum to no more than 1 meal a month combined.	No bowfin consumption; Limit bass, bigmouth buffalo, or freshwater drum to no more than 4 meal a month combined.
Seventh Ward Canal	The Seventh Ward Canal (Southwest of Abbeville)	Vermillion	Limit bowfin, flathead catfish, white crappie, or freshwater drum to no more than 1 meal a month combined.	Limit bowfin, flathead catfish, white crappie, or freshwater drum to no more than 4 meals a month combined.
Tangipahoa River	The Tangipahoa River from the LA/MS state line to Lake Pontchartrain	Tangipahoa	Limit bowfin, flathead catfish, largemouth bass, spotted bass, or freshwater drum to no more than 1 meal a month combined.	Limit bowfin, flathead catfish, largemouth bass, spotted bass, or freshwater drum to no more than 4 meals a month combined.
Tew Lake	Tew Lake Only	Catahoula	Limit bowfin consumption to no more than 1 meal per month.	Limit bowfin consumption to no more than 4 meals per month.
Tickfaw River Area	The Tickfaw River (from MS/LA state line to Lake Maurepas), the Blood River, Natalbany River, Lizard Creek, and Ponchatoula Creek	St. Helena, Tangipahoa, and Livingston	Limit freshwater drum, largemouth bass, bowfin, and white crappie to no more than 1 meal per month combined.	Limit freshwater drum, largemouth bass, bowfin, and white crappie to no more than 4 meals per month combined.
Toledo Bend Reservoir	The entire reservoir	DeSoto, Sabine	No consumption of bowfin; Limit consumption of largemouth bass and freshwater drum to no more than 1 meal per month combined.	Limit bowfin consumption to no more than 2 meals per month combined; Limit consumption of largemouth bass and freshwater drum to no more than 4 meals per month combined.

Source: Louisiana Department of Health and Hospitals, Office of Public Health, http://www.oph.dhh.state.la.us/environmentalepidemiology/healthfish/index.html ; updated July 1, 2004.

APPENDIX B: RANDOM AND UNRELATED VARIABLE ANALYSIS

Cell contents: Correlation
P-value

	Rand 1	Rand 2	Rand 3	Rand 4	Rand 5	Rand 6	Rand 7	Rand 8
Autism	-0.1	0.157	-0.119	0.055	-0.191	-0.075	0.041	-0.057
	0.451	0.234	0.369	0.677	0.148	0.572	0.76	0.666
LD	-0.111	-0.024	0.022	-0.092	-0.067	-0.217	0.015	-0.18
	0.402	0.857	0.867	0.489	0.615	0.098	0.908	0.174
Develop	-0.164	-0.226	0.258	0.008	0.04	0.06	-0.179	0.085
	0.215	0.086	0.48	0.951	0.766	0.649	0.175	0.174
Other Sp	0.029	0.135	0.013	-0.006	-0.015	-0.191	-0.09	0.048
	0.826	0.307	0.923	0.963	0.912	0.147	0.497	0.718
AllFish	**0.286**	-0.069	0.061	0.069	-0.167	-0.046	-0.069	0.078
	0.028	0.602	0.645	0.605	0.206	0.73	0.605	0.556
Bass	0.223	0.036	0.031	-0.159	0.02	0.034	-0.186	-0.062
	0.09	0.785	0.813	0.23	0.88	0.797	0.158	0.641
White	-0.027	0.02	-0.031	0.044	-0.078	0.224	0.061	-0.034
	0.841	0.883	0.818	0.742	0.559	0.088	0.649	0.796
Culture	-0.143	0.093	-0.133	0.229	-0.212	-0.007	0.029	-0.187
	0.28	0.485	0.317	0.081	0.108	0.958	0.828	0.157
Disadv	0.191	0.018	-0.065	-0.037	0.096	-0.172	0.18	0.105
	0.147	0.892	0.624	0.78	0.469	0.193	0.172	0.428
PCI	-0.1	-0.025	0.053	0.048	-0.163	0.187	0.001	-0.152
	0.453	0.829	0.691	0.72	0.218	0.157	0.993	0.249
Poverty	0.044	0.005	0.021	-0.263	0.157	-0.263	0.059	0.26
	0.741	0.973	0.876	0.044	0.245	0.044	0.657	0.047
Pop Den	0.096	0.161	-0.006	-0.052	0.109	-0.163	-0.017	0.165
	0.469	0.224	0.963	0.695	0.413	0.217	0.899	0.211
HS Grad	-0.052	-0.156	-0.067	-0.002	-0.01	0.071	0.096	-0.131
	0.695	0.238	0.615	0.986	0.94	0.594	0.468	0.321

Cell contents: Correlation
P-value

	SALARY	COUNT	ATTEND	GRAD
AllFish	-0.108 0.414	-0.146 0.269	0.137 0.3	-0.059 0.655
Bass	0.089 0.504	0.054 0.683	-0.152 0.25	-0.271 0.038
White	0.095 0.472	-0.188 0.154	-0.162 0.22	0.081 0.543
Culture	-0.054 0.684	0.12 0.367	-0.043 0.747	0.041 0.756
Disadv	-0.361 0.005	-0.126 0.34	0.202 0.125	-0.048 0.717
PCI	0.567 0	0.633 0	-0.241 0.066	-0.04 0.765
Poverty	-0.529 0	-0.272 0.038	0.167 0.207	-0.091 0.492
Pop Den	0.253 0.054	0.829 0	-0.156 0.237	-0.21 0.11
HS Grad	0.525 0	0.544 0	-0.141 0.287	0.024 0.856

Cell contents: Correlation
P-value

	RAND 1	RAND 2	RAND 3	RAND 4	RAND 5	RAND 6	RAND 7
RAND 2	-0.1 0.939						
RAND 3	-0.218 0.098	-0.296 0.023					
RAND 4	-0.055 0.678	0.204 0.121	-0.028 0.834				
RAND 5	-0.083 0.534	0.103 0.437	0.089 0.501	-0.143 0.279			
RAND 6	-0.018 0.89	0.117 0.377	-0.205 0.118	-0.118 0.373	0.047 0.725		
RAND 7	-0.07 0.601	-0.087 0.513	0.119 0.368	0.034 0.799	0.18 0.171	-0.003 0.981	
RAND 8	-0.06 0.654	-0.04 0.763	0 0.998	0.124 0.35	-0.268 0.04	0.139 0.295	-0.32 0.013

```
Regression Analysis
The regression equation is
RAND 5 = 0.923 - 0.729 AllFish + 0.411 Bass + 0.0108 Poverty - 0.00466 Disadv
         -0.000014 PCI - 0.0191 Culture
 Predictor   Coef          StDev        T       P
 Constant        0.9227        0.558     1.65   0.104
 AllFish        -0.7287       0.2965    -2.46   0.017
 Bass            0.4105        0.255     1.61   0.113
 Poverty        0.01081      0.01095     0.99   0.328
 Disadv       -0.004664     0.004351    -1.07   0.289
 PCI         -1.381E-05    0.0000235    -0.59   0.559
 Culture       -0.01911       0.0124    -1.54   0.129
S = 0.2612     R-Sq = 18.0%     R-Sq(adj) = 8.5%

Analysis of Variance
Source            DF       SS          MS         F      P
Regression         6    0.77740     0.12957     1.90   0.098
Residual Error    52    3.54750     0.06822
Total             58    4.32490

Source      DF     Seq SS
AllFish      1    0.12059
Bass         1    0.14397
Poverty      1    0.22096
Disadv       1    0.09895
PCI          1    0.03090
Culture      1    0.16203

The regression equation is
RAND 6 = 1.17 - 0.182 AllFish - 0.00617 Disadv -0.000062 PCI - 0.00923 Poverty
         +0.000114 Pop Den + 0.0127 HS Grad

 Predictor   Coef          StDev          T       P
 Constant        1.1673         0.668     1.75   0.086
 AllFish        -0.1815        0.1951    -0.93   0.356
 Disadv       -0.006169      0.004107     -1.5   0.139
 PCI         -6.239E-05    0.00002985    -2.09   0.042
 Poverty      -0.009227      0.009993    -0.92    0.36
 Pop Den     0.00011418    0.00009674     1.18   0.243
 HS Grad       0.012675      0.007031      1.8   0.077
S = 0.2283     R-Sq = 16.8%     R-Sq(adj) = 7.2%
Analysis of Variance
Source            DF       SS         MS         F      P
Regression         6    0.54695    0.09116    1.75   0.128
Residual Error    52    2.70932    0.05210
Total             58    3.25626
```

```
Source      DF     Seq SS
AllFish      1    0.00685
Disadv       1    0.22985
PCI          1    0.00156
Poverty      1    0.05628
Pop Den      1    0.08308
HS Grad      1    0.16933
```

The regression equation is
RAND 7 = 0.560 -0.000026 PCI - 0.00930 Poverty + 0.00904 HS Grad - 0.340 Bass

```
Predictor   Coef          StDev          T        P
Constant        0.5597       0.6437     0.87    0.388
PCI         -2.585E-05    0.0000287     -0.9    0.372
Poverty      -0.009299     0.009335       -1    0.324
HS Grad        0.00904     0.008083     1.12    0.268
Bass             -0.34       0.1939    -1.75    0.085
S = 0.2734     R-Sq = 9.2%     R-Sq(adj) = 2.5%
```

Analysis of Variance

```
Source             DF        SS         MS          F       P
Regression          4     0.41026    0.10257     1.37    0.256
Residual Error     54     4.03624    0.07475
Total              58     4.44650
Source      DF     Seq SS
PCI          1    0.05251
Poverty      1    0.07171
HS Grad      1    0.05611
Bass         1    0.22994
```

Regression Analysis
The regression equation is
RAND 8 = 0.985 + 0.507 AllFish - 0.366 Bass - 0.0186 Culture +0.000037 PCI
+0.000095 Pop Den - 0.0153 HS Grad

```
Predictor   Coef          StDev          T        P
Constant        0.9852       0.3635     2.71    0.009
AllFish         0.5066       0.3116     1.63     0.11
Bass           -0.3662       0.2597    -1.41    0.165
Culture       -0.01861       0.0126    -1.48    0.146
PCI         0.00003681   0.00002466     1.49    0.142
Pop Den     0.00009474   0.00009255     1.02    0.311
HS Grad      -0.015265     0.008036     -1.9    0.063
S = 0.2670     R-Sq = 14.1%     R-Sq(adj) = 4.1%
```

Analysis of Variance

```
Source             DF        SS          MS          F       P
Regression          6     0.60635     0.10106     1.42    0.226
```

```
Residual Error   52     3.70639    0.07128
Total            58     4.31273
Source      DF    Seq SS
AllFish      1    0.02644
Bass         1    0.10660
Culture      1    0.13340
PCI          1    0.02008
Pop Den      1    0.06265
HS Grad      1    0.25718

The regression equation is
ATTEND = 1.97 + 0.435 AllFish - 0.340 Bass - 0.00353 White + 0.00152 Culture
         - 0.00150 Disadv -0.000026 PCI - 0.0112 Poverty -0.000029 Pop Den
         - 0.00178 HS Grad

 Predictor   Coef           StDev          T          P
 Constant        1.9738        0.7888       2.5   0.016
 AllFish         0.4353        0.1881      2.31   0.025
 Bass           -0.3405         0.155      -2.2   0.033
 White        -0.003533      0.002248     -1.57   0.123
 Culture       0.001522      0.007602       0.2   0.842
 Disadv       -0.001499      0.003825     -0.39   0.697
 PCI         -2.574E-05    0.00002333      -1.1   0.275
 Poverty      -0.011176      0.008607      -1.3     0.2
 Pop Den     -2.876E-05    0.00006739     -0.43   0.671
 HS Grad      -0.001777       0.00514     -0.35   0.731
S = 0.1583     R-Sq = 21.1%    R-Sq(adj) = 6.6%

Analysis of Variance
Source            DF        SS          MS          F       P
Regression         9     0.32812     0.03646     1.45   0.192
Residual Error    49     1.22778     0.02506
Total             58     1.55590
Source      DF    Seq SS
AllFish      1    0.02930
Bass         1    0.17462
White        1    0.03709
Culture      1    0.00001
Disadv       1    0.00296
PCI          1    0.02820
Poverty      1    0.04795
Pop Den      1    0.00499
HS Grad      1    0.00300

The regression equation is
GRAD = 0.0784 + 0.0112 AllFish - 0.0229 Bass -0.000052 White +0.000036 Culture
       -0.000018 Disadv -0.000001 PCI -0.000508 Poverty -0.000005 Pop Den
```

```
           +0.000166 HS Grad

 Predictor   Coef              StDev          T          P
 Constant         0.07841        0.04988       1.57      0.122
 AllFish          0.01117         0.0119       0.94      0.352
 Bass           -0.022869       0.009799      -2.33      0.024
 White         -0.0000523      0.0001422      -0.37      0.714
 Culture        0.0000357      0.0004807       0.07      0.941
 Disadv        -0.0000183      0.0002419      -0.08       0.94
 PCI          -0.00000101     0.00000148      -0.68      0.499
 Poverty       -0.0005082      0.0005442      -0.93      0.355
 Pop Den      -0.00000459     0.00000426      -1.08      0.286
 HS Grad        0.0001662       0.000325       0.51      0.611
S = 0.01001     R-Sq = 18.0%     R-Sq(adj) = 2.9%

Analysis of Variance
Source             DF          SS             MS             F        P
Regression          9   0.0010775     0.0001197       1.19    0.320
Residual Error     49   0.0049091   0.0001002
Total              58   0.0059865

Source       DF      Seq SS
AllFish       1   0.0000211
Bass         1   0.0005942
White         1   0.0000983
Culture       1   0.0000004
Disadv        1   0.0000048
PCI          1   0.0000148
Poverty       1   0.0002070
Pop Den        1   0.0001107
HS Grad        1   0.0000262
```

APPENDIX C: MINITAB OUTPUT

BEST SUBSET REGRESSION

Key**:**
1 Emissions
2 Allfish
3 Bass
4 White
5 Culture
6 Disadv
7 PCI
8 Poverty
9 Pop Den
10 HS Grad

Response is Autism

Variables	R2	Adj R2	1	2	3	4	5	6	7	8	9	10
1	27.7	26.4									X	
1	21.7	20.3		X								
1	18.1	16.7							X			
2	41.3	39.3		X							X	
2	35.4	33.1		X					X			
2	34.7	32.3		X								X
3	46	43		X							X	X
3	45.5	42.5		X					X		X	
3	42.8	39.7		X						X	X	
4	46.8	42.9	X	X							X	X
4	46.4	42.4		X					X	X	X	
4	46.4	42.4		X					X		X	X
5	47.6	42.7		X					X	X	X	X
5	47.6	42.7	X	X				X	X		X	
5	47.3	42.3	X	X					X	X	X	
6	48.7	42.8	X	X					X	X	X	X
6	48.5	42.6	X	X				X	X		X	X
6	48	42	X	X		X			X		X	X
7	49.1	42.2	X	X				X	X	X	X	X
7	48.8	41.8	X	X	X				X	X	X	X
7	48.7	41.7	X	X		X			X	X	X	X
8	49.3	41.2	X	X			X	X	X	X	X	X
8	49.2	41.1	X	X	X			X	X	X	X	X
8	49.2	41	X	X			X	X	X	X	X	X
9	49.4	40.1	X	X	X	X		X	X	X	X	X
9	49.3	40	X	X		X	X	X	X	X	X	X
9	49.2	39.9	X	X	X		X	X	X	X	X	X
10	49.4	38.9	X	X	X	X	X	X	X	X	X	X

Response is LD

Variables	R2	Adj R2	1	2	3	4	5	6	7	8	9	10
1	5.8	4.2									X	
1	2.5	0.8					X					
1	0.5	0				X						
2	9	5.8					X				X	
2	6.7	3.3							X		X	
2	6.3	3									X	X
3	9.3	4.4					X		X		X	
3	9.3	4.4					X				X	X
3	9.3	4.3	X				X				X	
4	9.9	3.2					X	X	X		X	
4	9.7	3				X	X		X		X	
4	9.6	2.9	X				X		X		X	
5	10.1	1.6		X			X	X	X		X	
5	10	1.5			X		X	X	X		X	
5	10	1.5		X		X	X		X		X	
6	10.1	0		X		X	X	X	X		X	
6	10.1	0	X	X			X	X	X		X	
6	10.1	0		X			X	X	X	X	X	
7	10.2	0	X	X		X	X	X	X		X	
7	10.1	0		X	X	X	X	X	X		X	
7	10.1	0		X		X	X	X	X	X	X	
8	10.2	0	X	X	X	X	X	X	X		X	
8	10.2	0	X	X		X	X	X	X		X	X
8	10.2	0	X	X		X	X	X	X	X	X	
9	10.2	0	X	X	X	X	X	X	X		X	X
9	10.2	0	X	X	X	X	X	X	X	X	X	
9	10.2	0	X	X		X	X	X	X	X	X	X
10	10.2	0	X	X	X	X	X	X	X	X	X	X

Response is Develop

Variables	R2	Adj R2	1	2	3	4	5	6	7	8	9	10
1	10.7	9.2									X	
1	10	8.4							X			
1	8.4	6.8								X		
2	20.5	17.7				X					X	
2	17.7	14.8								X	X	
2	14.5	11.4							X		X	
3	22	17.8				X		X			X	
3	21	17.2	X			X					X	
3	26.2	16.7				X					X	
4	24.6	20.7			X	X		X	X		X	
4	22.8	19				X		X		X	X	
4	27	17.1	X			X		X			X	
5	26.8	20.1				X		X	X		X	X
5	26.2	19.9				X		X	X		X	
5	28	19.2			X	X	X	X	X		X	
6	27.5	19.7				X		X	X		X	X
6	27.2	19.2			X	X		X	X		X	

6	28.4	18.8		X	X	X		X	X	X	X	X
7	28.3	18.5				X		X	X		X	X
7	28	18.4		X	X	X		X	X	X	X	X
7	28.6	18.1	X		X	X		X	X		X	X
8	28.4	17.2		X	X	X		X	X	X	X	X
8	28.6	16.9		X	X	X	X	X	X		X	X
8	28.6	16.9	X	X	X	X		X	X		X	X
9	28.6	15.5		X	X	X	X	X	X	X	X	X
9	28.6	15.5	X	X	X	X		X	X	X	X	X
9	28.4	15.2	X	X	X	X	X	X	X		X	X
10	28.6	13.8	X	X	X	X	X	X	X	X	X	X

Response is Other SpEd

Variables	R2	Adj R2	1	2	3	4	5	6	7	8	9	10
1	5.5	3.8						X				
1	3.6	1.9				X						
1	3.2	1.5	X									
2	11.2	8.1						X	X			
2	8	4.7						X		X		
2	7.1	3.8	X					X				
3	16.2	11.6						X	X			X
3	13.8	9.1		X	X			X				
3	12	8.3						X	X		X	
4	18.8	12.8			X			X	X			X
4	18.2	12.1						X	X		X	X
4	17.5	11.4		X	X			X	X			
5	21.6	14.2		X	X			X	X			X
5	20.9	13.4			X			X	X		X	X
5	20	12.5		X	X			X	X		X	
6	24.2	15.5		X	X			X	X		X	X
6	22.6	13.7		X	X	X		X	X			X
6	22.1	13.1	X	X	X			X	X			X
7	24.9	14.6		X	X	X		X	X		X	X
7	24.5	14.2		X	X		X	X	X		X	X
7	24.3	13.9	X	X	X			X	X		X	X
8	25.4	13.4		X	X	X	X	X	X		X	X
8	25	13		X	X	X		X	X	X	X	X
8	24.9	12.9	X	X	X	X		X	X		X	X
9	25.4	11.8		X	X	X	X	X	X	X	X	X
9	25.4	11.7	X	X	X	X	X	X	X		X	X
9	25.1	11.3	X	X	X	X		X	X	X	X	X
10	25.5	10	X	X	X	X	X	X	X	X	X	X

REGRESSION ANALYSIS

```
The regression equation is
Autism = - 0.378 - 0.0141 Emissions - 0.217 Allfish - 0.0199 Bass
           + 0.00042 White + 0.00138 Disadv +0.000016 PCI + 0.00364Poverty
           + 0.000055 Pop Den + 0.00277 HS Grad

Predictor        Coef       StDev          T        P
Constant      -0.3782      0.3783      -1.00    0.322
Emission     -0.01410     0.01200      -1.17    0.246
Allfish      -0.21745     0.08916      -2.44    0.018
Bass         -0.01985     0.07394      -0.27    0.789
White        0.000422    0.001066       0.40    0.694
Disadv       0.001381    0.001898       0.73    0.471
PCI        0.00001637  0.00001121       1.46    0.150
Poverty      0.003643    0.004138       0.88    0.383
Pop Den    0.00005476  0.00003289       1.66    0.102
HS Grad      0.002768    0.002453       1.13    0.265
S = 0.07556     R-Sq = 49.4%     R-Sq(adj) = 40.1%

Analysis of Variance
Source            DF          SS          MS         F        P
Regression         9    0.272953    0.030328      5.31    0.000
Residual Error    49    0.279721    0.005709
Total             58    0.552674

Source       DF      Seq SS
Emission      1    0.001167
Allfish       1    0.119630
Bass          1    0.001074
White         1    0.009636
Disadv        1    0.025086
PCI           1    0.087878
Poverty       1    0.004175
Pop Den       1    0.017037
HS Grad       1    0.007270

Unusual Observations
Obs   Emission     Autism         Fit   StDev Fit    Residual    St Resid
 22       0.00    0.36821     0.18538     0.01740     0.18283       2.49R
 24       0.00    0.00000     0.15772     0.01491    -0.15772      -2.13R
 25       0.00    0.49353     0.36708     0.04498     0.12645       2.08R
 34       0.77    0.36514     0.40399     0.06899    -0.03885      -1.26X

R denotes an observation with a large standardized residual
X denotes an observation whose X value gives it large influence.

The regression equation is
Autism = - 0.204 - 0.0111 Emissions - 0.233 Allfish +0.000012 PCI
           + 0.00361 Poverty +0.000063 Pop Den + 0.00269 HS Grad

Predictor        Coef       StDev          T        P
Constant      -0.2037      0.2060      -0.99    0.327
Emission     -0.01108     0.01051      -1.05    0.296
Allfish      -0.23292     0.06265      -3.72    0.000
PCI        0.00001198  0.00000922       1.30    0.200
```

```
Poverty      0.003613    0.002907       1.24    0.220
Pop Den    0.00006298  0.00002928       2.15    0.036
HS Grad      0.002689    0.002251       1.19    0.238
S = 0.07383     R-Sq = 48.7%     R-Sq(adj) = 42.8%

Analysis of Variance
Source            DF          SS          MS         F        P
Regression         6    0.269249    0.044875      8.23    0.000
Residual Error    52    0.283425    0.005450
Total             58    0.552674

Source       DF      Seq SS
Emission      1    0.001167
Allfish       1    0.119630
PCI           1    0.078326
Poverty       1    0.033428
Pop Den       1    0.028919
HS Grad       1    0.007780

Unusual Observations
Obs   Emission     Autism         Fit   StDev Fit    Residual    St Resid
 22       0.00    0.36821     0.19023     0.01516     0.17798        2.46R
 24       0.00    0.00000     0.16143     0.01342    -0.16143       -2.22R
 25       0.00    0.49353     0.34557     0.03402     0.14796        2.26R
 34       0.77    0.36514     0.41576     0.06509    -0.05062       -1.45X

R denotes an observation with a large standardized residual
X denotes an observation whose X value gives it large influence.

The regression equation is
Autism = 0.0169 - 0.244 Allfish +0.000084 Pop Den + 0.00314 HS Grad

Predictor        Coef       StDev          T        P
Constant      0.01685     0.09931       0.17    0.866
Allfish      -0.24371     0.06078      -4.01    0.000
Pop Den    0.00008412  0.00002477       3.40    0.001
HS Grad      0.003140    0.001444       2.18    0.034
S = 0.07367     R-Sq = 46.0%     R-Sq(adj) = 43.0%

Analysis of Variance
Source            DF          SS          MS         F        P
Regression         3    0.254190    0.084730     15.61    0.000
Residual Error    55    0.298483    0.005427
Total             58    0.552674

Source       DF      Seq SS
Allfish       1    0.119775
Pop Den       1    0.108733
HS Grad       1    0.025681

Unusual Observations
Obs    Allfish     Autism         Fit   StDev Fit    Residual    St Resid
 22      0.209    0.36821     0.18668     0.01444     0.18153        2.51R
 24      0.386    0.00000     0.15611     0.01217    -0.15611       -2.15R
 25      0.198    0.49353     0.34262     0.03191     0.15091        2.27R
 34      0.261    0.36514     0.42872     0.06400    -0.06358       -1.74X
```

```
R denotes an observation with a large standardized residual
X denotes an observation whose X value gives it large influence.

The regression equation is
Develp = 7.66 - 0.413 Bass - 0.0269 White - 0.0398 Disadv -0.000140 PCI
           -0.000698 Pop Den

Predictor        Coef       StDev          T        P
Constant        7.663       2.580       2.97    0.004
Bass          -0.4127      0.6058      -0.68    0.499
White       -0.026938    0.009505      -2.83    0.006
Disadv       -0.03983     0.02006      -1.99    0.052
PCI       -0.00014002  0.00008019      -1.75    0.087
Pop Den    -0.0006981   0.0003515      -1.99    0.052
S = 0.8517      R-Sq = 26.8%     R-Sq(adj) = 19.9%

Analysis of Variance
Source            DF          SS          MS         F        P
Regression         5     14.0744      2.8149      3.88    0.005
Residual Error    53     38.4493      0.7255
Total             58     52.5237

Source       DF      Seq SS
Bass          1      0.6477
White         1      1.4093
Disadv        1      0.0305
PCI           1      9.1254
Pop Den       1      2.8616

Unusual Observations
Obs       Bass     Develp         Fit   StDev Fit    Residual    St Resid
 34      0.370      0.010      -0.115       0.768       0.125       0.34X
 51      0.265      5.363       2.362       0.293       3.001       3.75R

R denotes an observation with a large standardized residual
X denotes an observation whose X value gives it large influence.

The regression equation is
Develp = 6.88 + 0.53 Allfish - 0.813 Bass - 0.0266 White - 0.0402 Disadv
           -0.000183 PCI -0.000667 Pop Den + 0.0201 HS Grad

Predictor        Coef       StDev          T        P
Constant        6.875       2.784       2.47    0.017
Allfish         0.527       1.006       0.52    0.603
Bass          -0.8127      0.8401      -0.97    0.338
White       -0.026558    0.009748      -2.72    0.009
Disadv       -0.04020     0.02033      -1.98    0.053
PCI        -0.0001831   0.0001015      -1.80    0.077
Pop Den    -0.0006670   0.0003563      -1.87    0.067
HS Grad       0.02007     0.02621       0.77    0.447
S = 0.8590      R-Sq = 28.4%     R-Sq(adj) = 18.5%

Analysis of Variance
Source            DF          SS          MS         F        P
Regression         7     14.8931      2.1276      2.88    0.013
Residual Error    51     37.6307      0.7379
Total             58     52.5237
```

```
Source       DF      Seq SS
Allfish       1      0.0573
Bass          1      1.7429
White         1      1.5731
Disadv        1      0.1896
PCI           1      8.2663
Pop Den       1      2.6312
HS Grad       1      0.4327

Unusual Observations
Obs    Allfish     Develp         Fit   StDev Fit    Residual    St Resid
 29      0.721      0.702       1.447       0.558      -0.746       -1.14X
 34      0.261      0.010      -0.096       0.777       0.106        0.29X
 51      0.235      5.363       2.296       0.302       3.067        3.81R
 59      0.209      0.865       1.480       0.571      -0.615       -0.96X

R denotes an observation with a large standardized residual
X denotes an observation whose X value gives it large influence.

The regression equation is
Develp = 5.53 + 0.48 Allfish - 0.816 Bass - 0.0236 White - 0.0393 Disadv
            -0.000153 PCI + 0.0194 Poverty -0.000700 Pop Den + 0.0240 HS
            Grad

Predictor        Coef       StDev          T        P
Constant        5.534       4.301       1.29    0.204
Allfish         0.479       1.021       0.47    0.641
Bass          -0.8162      0.8471      -0.96    0.340
White        -0.02358     0.01220      -1.93    0.059
Disadv       -0.03925     0.02063      -1.90    0.063
PCI        -0.0001526   0.0001263      -1.21    0.233
Poverty       0.01938     0.04708       0.41    0.682
Pop Den    -0.0007005   0.0003683      -1.90    0.063
HS Grad       0.02402     0.02811       0.85    0.397
S = 0.8661      R-Sq = 28.6%     R-Sq(adj) = 17.2%

Analysis of Variance
Source            DF          SS          MS         F        P
Regression         8     15.0201      1.8775      2.50    0.023
Residual Error    50     37.5036      0.7501
Total             58     52.5237

Source       DF      Seq SS
Allfish       1      0.0573
Bass          1      1.7429
White         1      1.5731
Disadv        1      0.1896
PCI           1      8.2663
Poverty       1      0.0578
Pop Den       1      2.5856
HS Grad       1      0.5475

Unusual Observations
Obs    Allfish     Develp         Fit   StDev Fit    Residual    St Resid
 31      0.171      1.123       2.674       0.401      -1.551       -2.02R
 34      0.261      0.010      -0.101       0.783       0.110        0.30X
```

```
 51       0.235      5.363       2.397       0.392       2.965        3.84R
 59       0.209      0.865       1.426       0.591      -0.561       -0.89X

R denotes an observation with a large standardized residual
X denotes an observation whose X value gives it large influence.


The regression equation is
SpEd = - 2.38 - 2.91 Allfish + 2.93 Bass + 0.0128 White - 0.0412 Culture
           + 0.0968 Disadv +0.000501 PCI -0.000787 Pop Den - 0.0720 HS
Grad

Predictor        Coef       StDev          T        P
Constant       -2.376       4.926      -0.48    0.632
Allfish        -2.909       1.774      -1.64    0.107
Bass            2.929       1.470       1.99    0.052
White         0.01284     0.01730       0.74    0.462
Culture      -0.04116     0.07209      -0.57    0.571
Disadv        0.09682     0.03608       2.68    0.010
PCI         0.0005013   0.0001807       2.77    0.008
Pop Den    -0.0007873   0.0006237      -1.26    0.213
HS Grad      -0.07201     0.04583      -1.57    0.122
S = 1.502       R-Sq = 25.4%     R-Sq(adj) = 13.4%

Analysis of Variance
Source            DF          SS          MS         F        P
Regression         8      38.299       4.787      2.12    0.051
Residual Error    50     112.728       2.255
Total             58     151.027

Source       DF      Seq SS
Allfish       1       2.702
Bass          1       6.679
White         1       5.521
Culture       1       0.001
Disadv        1       6.007
PCI           1       8.421
Pop Den       1       3.401
HS Grad       1       5.567

Unusual Observations
Obs    Allfish       SpEd         Fit   StDev Fit    Residual    St Resid
 22      0.209      9.282       6.348       0.355       2.934        2.01R
 34      0.261      6.394       6.498       1.359      -0.104       -0.16X
 41      0.423      5.763       6.185       1.290      -0.421       -0.55X
 56      0.520     11.394       8.063       0.634       3.331        2.45R

R denotes an observation with a large standardized residual
X denotes an observation whose X value gives it large influence.


The regression equation is
SpEd = 0.22 - 2.62 Allfish + 2.95 Bass + 0.0763 Disadv +0.000465 PCI
           -0.000816 Pop Den - 0.0759 HS Grad

Predictor        Coef       StDev          T        P
Constant        0.221       3.522       0.06    0.950
```

```
Allfish        -2.624       1.722      -1.52    0.134
Bass            2.950       1.451       2.03    0.047
Disadv        0.07634     0.02402       3.18    0.002
PCI         0.0004650   0.0001734       2.68    0.010
Pop Den    -0.0008158   0.0006111      -1.33    0.188
HS Grad      -0.07592     0.04476      -1.70    0.096
S = 1.483       R-Sq = 24.2%     R-Sq(adj) = 15.5%

Analysis of Variance
Source            DF          SS          MS         F        P
Regression         6      36.603       6.100      2.77    0.021
Residual Error    52     114.425       2.200
Total             58     151.027

Source       DF      Seq SS
Allfish       1       2.702
Bass          1       6.679
Disadv        1      11.401
PCI           1       5.602
Pop Den       1       3.887
HS Grad       1       6.331

Unusual Observations
Obs    Allfish       SpEd         Fit   StDev Fit    Residual    St Resid
 29      0.721      4.284       4.289       0.941      -0.005      -0.00X
 34      0.261      6.394       6.611       1.336      -0.216      -0.34X
 56      0.520     11.394       7.739       0.469       3.655       2.60R
 59      0.209      7.949       7.531       0.896       0.418       0.35X

R denotes an observation with a large standardized residual
X denotes an observation whose X value gives it large influence.


The regression equation is
SpEd = - 1.94 - 2.78 Allfish + 2.97 Bass + 0.0111 White + 0.0933 Disadv
           +0.000482 PCI -0.000768 Pop Den - 0.0715 HS Grad

Predictor        Coef       StDev          T        P
Constant       -1.943       4.835      -0.40    0.689
Allfish        -2.780       1.748      -1.59    0.118
Bass            2.966       1.459       2.03    0.047
White         0.01113     0.01693       0.66    0.514
Disadv        0.09326     0.03530       2.64    0.011
PCI         0.0004817   0.0001762       2.73    0.009
Pop Den    -0.0007683   0.0006187      -1.24    0.220
HS Grad      -0.07146     0.04551      -1.57    0.123
S = 1.492       R-Sq = 24.9%     R-Sq(adj) = 14.6%

Analysis of Variance
Source            DF          SS          MS         F        P
Regression         7      37.564       5.366      2.41    0.033
Residual Error    51     113.463       2.225
Total             58     151.027

Source       DF      Seq SS
Allfish       1       2.702
Bass          1       6.679
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White         1       5.521
Disadv        1       6.006
PCI           1       7.915
Pop Den       1       3.254
HS Grad       1       5.485

Unusual Observations
Obs    Allfish       SpEd         Fit   StDev Fit    Residual    St Resid
 29      0.721      4.284       4.428       0.969      -0.144      -0.13X
 34      0.261      6.394       6.531       1.349      -0.137      -0.21X
 56      0.520     11.394       8.006       0.622       3.388       2.50R
 59      0.209      7.949       7.257       0.992       0.691       0.62X

R denotes an observation with a large standardized residual
X denotes an observation whose X value gives it large influence.
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VITA

The author, Jessica Rury, born in Johnson City, New York, is a 2000 graduate of Binghamton High School in Binghamton, New York. She received a Bachelor of Science in Environmental Science from the University of Alabama; Tuscaloosa, Alabama, in May 2004. A graduate student of Louisiana State University; Baton Rouge, Louisiana, she will receive a Master of Science in environmental studies in May 2006; with concentrations in both planning and management, and wetland science and management.