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Title: MERCURY ACCUMULATION IN FISH FROM COTTAGE GROVE RESERVOIR AND ITS TRIBUTARIES

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A fish sampling program was initiated at Cottage Grove Reservoir in June of 1974 to investigate mercury accumulation in the fish. Samples were collected periodically from June to November, 1974, and from June, 1975 through January, 1976 from both the reservoir and its tributaries. Species collected included spring chinook salmon Oncorhynchus tshawytscha, rainbow trout Salmo gairdneri, cutthroat trout Salmo clarki clarki, largemouth bass Micropterus salmoides, and brown bullhead Ictalurus nebulosus.

Cutthroat trout and spring chinook salmon sampled from a tributary of Cottage Grove Reservoir in 1974 and 1975 had significantly less mercury in their muscle tissue than similar fish collected from the reservoir ($P < 0.05$).

All species of fish except the 1+ brown bullheads collected in 1974, tended to accumulate mercury with time. Many of the fish sampled had mercury levels two to three times the FDA guideline of 0.5 µg Hg/g. It also appeared that predatory fish accumulated higher mercury levels than non-predatory species.

The percent of mercury as methylmercury in all species ranged from 4.3 to 100, with most fish containing between 60% and 90% methylmercury.

Mercury uptake from the food accounted for a significant percentage of the total mercury uptake of the 0+ spring chinook collected in 1974. The average methylmercury concentration in the diet of the fish was estimated to be 0.23 µg Hg/g.

The significant difference in mercury concentration and total body burden of mercury of the spring chinook collected from the Coast Fork of the Willamette River and Cottage Grove reservoir suggested that two separate populations of chinook might exist ($P < 0.05$).

Yearling chinook salmon collected from the reservoir in the spring of 1976 with greater than 0.20 µg Hg/g in the muscle tissue had greater mortality in saltwater than the control fish which had mercury concentrations below 0.10 µg Hg/g.

Mercury Accumulation in Fish from Cottage Grove Reservoir and Its Tributaries

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INTRODUCTION

Pollution is defined by Charles Warren (1971) as "any impairment of the suitability of water for any of its beneficial uses, actual or potential, by man-caused changes in the quality of the water." During the Industrial Revolution, when people began to concentrate in the cities, and factories started to release large quantities of waste materials into the environment, pollution became a problem. At first, the major concerns were proper waste disposal and public health. Recently, interest has turned towards more subtle forms of pollution such as radioactivity, atmospheric pollution, temperature changes, and chemicals such as pesticides and heavy metals. Mercury has become one of the most extensively studied of the heavy metals.

In the 1950's methylmercury poisoning was determined to have caused the death of 46 fishermen in Minamata Bay, Japan. A similar outbreak of mercury poisoning occurred in Nigata, Japan in 1964, causing the death of six others. Many others were afflicted with neurological diseases and were left with brain damage and paralysis (Klein, 1972).

During the early 1960's, Swedish ornithologists noticed a decline in the seed-eating bird population. Upon investigation, they found high levels of mercury in the birds and many Swedish agricultural products. The use of mercury compounds in agriculture

was, therefore, greatly reduced. Soon the bird populations returned to their normal levels. In 1965, however, Swedish scientists discovered that there was an aquatic mercury problem. Analysis of Swedish fish revealed alarmingly high levels of mercury in their muscle tissue (Johnels et al., 1967). The problem was traced to the release of organic, inorganic, and metallic mercury into Swedish waters by electrolytic chlorine plants and paper mills (Buhler, 1971).

In 1970, Norvald Fimreite, a graduate student at the University of Western Ontario, collected fish from Lake St. Clair for mercury analysis. The analysis revealed extremely high levels of mercury in the fish. These findings led to the closure to fishing of many bodies of water in the Great Lakes area. Since that time, the U.S. Food and Drug Administration has passed a law stating that no fish with more than 0.5 μg Hg/g in the edible flesh shall be sold for human consumption.

The release of mercury into the environment has been attributed to several industrial sources such as chlor-alkali plants, pulp and paper mills, acetaldehyde producers, burning of fossil fuels, agricultural runoff, and gold mining. Mercury is also a naturally-occurring substance, normally existing as cinnabar (HgS) and thus can be transported through the environment by weathering, leaching, volcanic activity, dredging, and mining. The natural occurrence of mercury makes identification and control of the sources of pollution difficult.

Mercury pollution represents a hazard because of the persistence of the metal in the environment. Unlike most of the organic pollutants which are eventually broken down in nature, mercury is not destroyed by biological or chemical breakdown. Once mercury is released into the environment, it tends to remain indefinitely in the ecosystem and is available for transport throughout the environment.

Mercury was originally thought to be biologically inert and was, therefore, discharged indiscriminately into the aquatic environment. It was believed that, because of its low solubility in water, metallic mercury would settle to the bottom and would thus be unavailable for uptake by the aquatic biota. Researchers now know that inorganic mercury is rapidly converted by bacteria to methylmercury which is rapidly taken up by the aquatic organisms (Hammond, 1971). Methylmercury is far more soluble in water than inorganic mercury and is more readily absorbed by the biota due to its lipophilicity, relatively small size, and its affinity for sulfhydryl groups (Clarkson, 1971). Research by Hannerz (1968) has shown that methylmercury is absorbed by fish to a substantially greater extent than inorganic mercury. Upon absorption, methylmercury accumulates in the liver and kidney followed by redistribution to muscle tissue. Excretion of methylmercury is very slow. The biological half-life of methylmercury in rainbow trout has been reported to be greater than 200 days (Giblin and

Massaro, 1973). Inorganic mercury, on the other hand, accumulates in the liver and kidney and is rapidly excreted (Jernelov and Lann, 1971).

The aquatic mercury pollution that occurred in Sweden was attributed to the discharge of elemental, inorganic, and phenylmercury. Westöö (1966), however, reported that the mercury in fish muscle taken from Swedish water was primarily in the form of methylmercury. This indicated that either the mercury was being converted to methylmercury in the environment or that the fish themselves were methylating the mercury after uptake. Studies by Jensen and Jernelov (1969), Wood et al. (1968), and Bishop and Kirsch (1972) indicated that microbial activity in bottom sediments was the primary method by which inorganic mercury is converted to the more toxic form, methylmercury.

The accumulation of mercury in aquatic organisms, specifically fish from natural systems, has been extensively studied since the outbreak of methylmercury poisoning in Minamata Bay. Analysis of the fish taken from Minamata Bay revealed mercury concentrations exceeding 30 ppm (Celeste and Shane, 1970). Since then, mercury has been detected in organisms from all parts of the world. The background or "normal" level of mercury in fish from North America has been reported to be between 0.1 to 0.2 μg/g (Klien, 1972; D'Itrie, 1972).

Studies of reservoirs and their tributaries by Gebhardt et al. (1971), Buhler et al. (1973), and Walter et al. (1974)

have shown that fish reared in reservoirs have significantly higher mercury levels in their muscle tissue than fish reared in tributaries. This can be attributed to the particular physical and chemical properties which exist in a reservoir. Reservoirs on the average have a higher organic content in the sediment and warmer water temperatures. This affords an excellent location for methylation of mercury by bacteria. Also the relatively low flow rate through a reservoir would allow more time for fish to accumulate the methylmercury being produced.

Work by Bache et al. (1971) has shown a positive correlation between the age of a fish and its mercury content in the muscle tissue. He also reported an increase in the percent methylmercury in muscle with age. Many other scientists (Rechins and Rissor, 1975; Scott, 1974; Scott and Armstrong, 1972) have reported similar positive relationships between fish length, weight, or both and mercury concentration. In these studies length and weight were used as an index of age. Work by Walter et al. (1974) and Phillips (1975), on the other hand, showed no relationship between fish age and mercury concentration.

Differences in mercury concentration between species collected from the same location have been observed during the course of many field studies. In his study of Lake St. Clair and the St. Clair River, Bails (1970) categorized fish by their ability to accumulate mercury. Muskellunge, which are piscivorous fish,

occupied category I which had the highest mercury level. Pike, walleye, sauger, and white crappie which are also piscivorous constituted category II. Bass and perch, which are both predators, comprised category III. Bullhead and bluegill which are primarily herbivores occupied category IV which had the lowest mercury level. Walter et al. (1974) and Richins and Rissor (1975) also indicated that predatory fish tend to have higher mercury levels than nonpredatory fish. These results support the "food chain magnification" theory. That is, there is an increase in mercury levels as you progress up the food chain.

There are three primary factors which could affect the rate of mercury accumulation by fish: 1) the metabolic rate of the fish; 2) the food habits of the fish; and 3) the epithelial surface area of the fish. Many factors influence the metabolic rate of the organism and hence the rate at which it accumulates mercury. Low dissolved oxygen levels, for example, would require an organism to pump more water over the gills which in turn causes increased mercury uptake (Amend et al., 1969). Similar data has been obtained in temperature studies by Reinert et al. (1974) and MacLeod and Pessah (1973). They showed that increased temperature resulted in greater mercury uptake by fish due to increased metabolic rates.

Methylmercury can be taken up through the food or water. The efficiency of methylmercury uptake through the water via the

gills has been estimated to be 9-11% (Phillips, 1975). Efficiencies of methylmercury uptake through the food via the gut range from 10-20% for a natural food source (Archer et al., 1973), to 69-75% for a prepared laboratory diet (Phillips, 1976).

The relative contribution of mercury uptake through the food and water has been studied by many scientists. The studies of Knight and Herring (1972) on largemouth bass in Rose Barnett Reservoir and of Johnel et al. (1967) on northern pike support the food chain magnification theory. Both studies show a positive relationship between mercury concentration and trophic level and thus imply that mercury uptake through the food is most important. There are those, however, that believe mercury uptake through the water is the most important pathway. Hannerz (1968) exposed fish to methylmercury both in the food and in the water and concluded that methylmercury uptake through the food was almost insignificant compared to the accumulation through the water. Phillips (1976), in his field and laboratory studies of methylmercury uptake, found that uptake of methylmercury from the food accounted for only 4-15% of the total amount of methylmercury being accumulated. Similar work by Jernelov and Lann (1971) showed that the mercury uptake from the food contributed 60% of the total mercury accumulated.

The toxicity of mercury compounds has been known for many years. Mercury salts appear to be very toxic to fish when present in the water. The 96 hour LD_{50} of methylmercury chloride for coho salmon fingerling has been estimated to be 39 ng/g (McPherson, 1973). Death which occurs within a few days of exposure to mercury salts has usually been attributed to suffocation. Mercurial compounds have been shown to cause histological damage to gill epithelial cells and suffocation resulting from coagulation of mucus over the gills (Amend et al., 1969; Akiyama, 1970).

Another effect of metal toxicity, although not as well studied, is that of osmoregulatory disturbance in fish which have been exposed to metals in the water. Studies by Lewis and Lewis (1971) showed that the osmolality of blood in channel catfish increased in saline water and decreased in freshwater when exposed to sublethal concentrations of zinc and copper sulfate in the water. Studies by Lorz and McPherson (1976) showed that coho salmon exposed to 20 ng/g copper in the water suffered heavy mortality when placed in salt water. Prior to death, the fish exhibited severe osmoregulatory problems. Similar studies by McPherson (1973) showed that coho salmon exposed to 20 ng/g methylmercury in the water suffered similar mortality when placed in 21°/oo salt water.

Thesis Objectives

The objectives of this field study were to 1) determine the mercury level in fish from Cottage Grove Reservoir and its tributaries, 2) identify factors affecting mercury uptake in the fish, and 3) determine effects of mercury on performance of the fish during saltwater challenge.

Description of Study Area

Cottage Grove Reservoir is located 25 miles southeast of Eugene, Oregon. It was constructed in 1942 by the Army Corps of Engineers for flood control. The reservoir was formed by damming the Coast Fork of the Willamette River which has its origin in the Calapooya Mountains. Filling of the reservoir begins in February of each year and is normally completed by May. At full capacity, the reservoir holds 33,000 acre feet of water. The average depth is 35 feet with a maximum depth of 70 feet. Drawdown of the reservoir occurs by late October or November. A thermocline is usually established during the summer months.

Since 1967, the Oregon Department of Fish and Wildlife has used the reservoir to raise spring chinook salmon, Oncorhynchus tshawytscha. Chinook salmon fingerlings are planted in April and raised in the reservoir until October. At that time, that gates in the dam are opened and the reservoir is drained down to stream bed, allowing the fish to escape. The chinook travel down the

Willamette River towards the ocean and the adult fish return in May, three to four years after release. They are netted from the river and taken to a hatchery for spawning.

The Oregon Department of Fish and Wildlife also stocks the reservoir annually with 8-10 inch rainbow trout Salmo gairdneri. Other fish species inhabiting the reservoir include largemouth bass Micropterus salmoides, brown bullhead Ictalurus nebulosus, and cutthroat trout Salmo clarki clarki. The reservoir is periodically treated with rotenone and then later restocked with salmon and rainbow trout. The last treatment occurred in November, 1974.

Cottage Grove Reservoir was chosen for the study for a number of reasons. There has been extensive gold and mercury mining in the watershed of the Coast Fork of the Willamette River. Large deposits of cinnibar are located in the Calapooya and Black Butte mountain ranges. The Black Butte Mine, located on the Coast Fork of the Willamette River in the Cottage Grove Reservoir watershed, produced over 10,000 flasks of mercury during its operation. The Bohemia District, which was the most important gold mining area in the Western Cascades, is located within the watershed. The major gold mines in the area were the Champion, Musick, Helena, and the Noonday (Weissenborn, 1969). Assocated with these mines were the operation of stamp mills and the recovery of gold from the ore by amalgamation with metallic

mercury. During this process, the gold was recovered while much of the mercury was lost to the environment. It has been estimated that for every ton of ore processed, 0.2 to 0.5 ounces of mercury were lost to the river (Thomson, 1915). Previous work by Buhler et al. (1973) showed that largemouth bass and brown bullhead inhabiting the reservoir had high levels of mercury in their tissues. In addition, the Oregon Department of Fish and Wildlife was already conducting a monthly sampling program at Cottage Grove Reservoir and thus provided a convenient means of collecting the samples.

METHODS AND MATERIALS

A fish sampling program was initiated at Cottage Grove Reservoir in June of 1974 with the cooperation of the Oregon Department of Fish and Wildlife. Samples were collected monthly from June to November in 1974 and from June, 1975 to January, 1976. Species collected included spring chinook salmon, cutthroat trout, rainbow trout, largemouth bass, and brown bullhead. Fish were also periodically collected from the major tributaries above the reservoir.

Fish were obtained from the reservoir using variable mesh experimental gill nets, monofilament gill nets, trap nets, hook and line, and with the use of a downstream migrant trap which was fished in the fall of both years to monitor the release of the spring chinook as they left the reservoir. In November of 1974, the reservoir was chemically treated with rotenone thus allowing the collection of fish with dip nets. Fish were collected from the tributaries using an electro-shocker and a variable mesh experimental gill net.

Fish samples were immediately placed in plastic bags and stored on ice for transport back to the laboratory where they were frozen and stored until they could be analyzed.

Concurrent with the fish sampling in the reservoir, limited limnological data was obtained. The temperature profile of the reservoir was determined using an electronic thermometer. The

dissolved oxygen profile was determined using a Kimmer water sampler to collect the water samples and a Hach Kit to calculate the dissolved oxygen levels. The dissolved oxygen and temperature values were obtained during midday.

In April, 1976, one year old spring chinook salmon were collected alive from Cottage Grove Reservoir to be used in a salt water tolerance study. At the same time, spring chinook salmon from the Sandy Fish Hatchery were obtained to serve as controls. Both groups of fish were from the same stock and the same age. The fish were brought back to the laboratory and held in fresh water tanks at the Oregon State University Department of Fisheries and Wildlife's holding facility at Smith Farm.

The fish were kept in fresh water for 10 days to simulate the shortest time it would take the salmon to migrate from Cottage Grove Reservoir to the ocean (Smith, 1978). The salt water tolerance of the fish was then determined by placing two fish from Cottage Grove and two hatchery fish directly into aquaria containing 0, 16.6, 20.5, 25.8, and 33.7°/oo salt water. Due to the limited number of fish available from Cottage Grove Reservoir, only one fish was placed in the 0°/oo and 33.7°/oo tanks. The fish were observed for signs of stress and mortality for 108 hours. At the end of 108 hours, the experiment was terminated and the remaining fish were killed and frozen in preparation for mercury analysis.

Prior to analysis, the fish collected from Cottage Grove Reservoir were identified, aged, measured to the nearest millimeter (fork length), and weighed to the nearest 0.1 g. The age of the fish was determined by scale and vertebrae analysis, and length frequency plots. The spring chinook were also eviscerated, and the stomach and intestine were kept for subsequent analysis of feeding habits and determination of mercury levels in their food.

Laboratory analysis of fish samples from 1974 involved total mercury determinations following the tissue digestion procedure described by the Analytical Methods Committee (1960). This procedure involved removing 5-10 g. of muscle tissue from below the dorsal fin of the fish and weighing it to the nearest 0.01 g. The tissue was then placed in a flask and concentrated nitric acid was added. The solution was brought to a boil and then removed from the heating block. Nitric acid was again added, and the solution was allowed to reflux. A 30% solution of hydrogen peroxide was then added, and the solution was allowed to boil. Upon cooling, the solution was filtered through glass wool and diluted to a known volume.

The mercury analysis was done according to the procedure described by Jeffeus (1970) on a Perkin-Elmer Coleman Model 50 mercury analyzer. A sample was injected into a bubbling flask containing a basic solution of stannous chloride. Under these

conditions, the ionic mercury in solution was converted to metallic mercury. The metallic mercury vapor was swept through the absorption cell in the analyzer, and the percent absorption was recorded. The percent absorption is proportional to the mercury content.

Total and methylmercury determinations were performed on fish taken in 1975. The digestion procedure used for these determinations was that of Giovanoli-Jakubczak et al. (1974). One to two grams of tissue was added to a test tube and 2 ml. of 10 N sodium hydroxide was added. The sample was then heated to 90°C for 10 minutes, and was then made up to volume using a 1% solution of sodium chloride. Total, inorganic, and organic (methylmercury) mercury levels were determined with the Coleman Model 50 mercury analyzer using the method described by Magos and Clarkson (1972). This method depends upon the differential reduction of inorganic mercury by stannous chloride and organic mercury by stannous chloride and cadmium chloride. Thus, inorganic mercury could be determined on the same sample using stannous chloride and cadmium chloride as a reductant. Organic mercury levels were calculated by subtracting the inorganic mercury values from the total mercury values. All organic mercury was considered to be methylmercury. Recovery for total, inorganic, and methylmercury was determined to be quantitative following addition of known amounts of the various forms of mercury.

The stomach contents of the spring chinook were identified, separated, dried, and weighed to obtain information on the salmon's

feeding habits, The stomach contents were digested and analyzed for total and methylmercury.

The data were analyzed using an analysis of variance, F test, and a student's "t" test.

RESULTS

1974 Sampling

Spring Chinook Salmon

Two age classes of spring chinook were collected during 1974: 1) 0+ age fish; and 2) 1+ age fish. The 0+ fish (i.e., 1973 brood) were hatched in the winter of 1973 and stocked in the reservoir as fingerling in April of 1974. The 1+ fish (i.e., 1972 brood) were hatched in the winter of 1972 and planted as fingerling in 1973. The 1972 brood that did not migrate out of the reservoir during the fall of 1973 spent the winter in the reservoir and were thus available for collection during 1974 as 1+ fish. The two age classes can be easily distinguished by size differences.

0+ fish were collected and analyzed for mercury during all of the months sampled while 1+ fish were collected during all the months except October (Appendix 1).

The 0+ chinook sampled exhibited a linear increase in mercury content with time ($r^2 = 0.553$; significant at the 99% level). The highest mercury concentration observed for a 1+ chinook was 0.49 µg Hg/g (Figure 1 and Appendix 1).

In November, during the chemical treatment of the reservoir, 0+ spring chinook were collected from the downstream migrant trap (i.e., representing the fish population in the reservoir) and from the Coast Fork of the Willamette River above the reservoir). The mercury

concentrations found in the fish from the Coast Fork were significantly lower than those found in the 0+ fish taken from the reservoir (0.54 µg Hg/g versus 0.68 µg Hg/g, respectively; t value = 2.16; 22 df; significant at the 95% level).

A study of the food habits of both the 0+ and 1+ spring chinook was conducted in 1974. Since most of the fish collected were caught in gill nets, and fish are known to regurgitate their stomach contents after capture, many of the stomachs examined were found to be empty. In addition, the gill nets were fished for 24 hours, and thus many food items were digested to the point that identification was impossible.

Those samples that were discernable indicated that the 0+ and 1+ fish fed on similar items and are opportunistic in their feeding habits (Appendix 2). There appears to be only one discernable difference in their food habits. During August and September, the stomachs of two 1+ chinook contained the remains of fish. At no time, however, were the stomachs of the 0+ chinook observed to contain fish, probably because they were too small to prey upon other fish.

The stomach contents collected each month were pooled together for determination of total and methylmercury concentrations (Appendix 3). The average total mercury content of the food organisms in 1974 was 1.78 µg Hg/g on a dry weight basis. The average methylmercury concentration was 1.15 µg Hg/g. Based on these figures, it was determined that 66.3% of the mercury in the fish's diet was in the form of methylmercury.

Rainbow Trout

Rainbow trout from two different age classes (i.e., 1+ and 2+) were collected from the reservoir during 1974.

The 1+ rainbow trout exhibited a linear increase in mercury concentration with time (r^2= 0.823; significant at the 99% level). Too few 2+ fish were taken in 1974 for statistical analysis but during both the months that they were sampled, the 2+ fish had a higher average mercury concentration than the 1+ fish taken during the same months. The highest mercury concentration found in a 1+ rainbow was 0.48 µg Hg/g while the highest concentration found in a 2+ was 0.36 µg Hg/g (Figure 2; Appendix 4).

Cutthroat Trout

Three age classes of native cutthroat trout were collected from the reservoir in 1974 (i.e., 0+, 1+, and 2+). The chemical treatment of the reservoir in November allowed the only opportunity to collect all three age classes of fish at the same time.

The mercury concentration in cutthroat trout collected in November increased linearly with the age of the fish (r^2= 0.663; significant at the 99% level). The highest mercury concentration recorded was 1.36 µg/g in a 2+ cutthroat taken in November (Figure 3; Appendix 5).

The 1+ cutthroat showed a linear increase in mercury concentration over the period sampled (r^2= 0.569; significant at the 99% level).

This would seem logical based on the previous data showing mercury accumulation with age, since age is just a function of time (Figure 4).

During the month of August, the Coast Fork of the Willamette River was sampled above the reservoir and three 1+ cutthroat trout were collected and analyzed for mercury (Appendix 5). The average mercury concentration in the fish collected from the river was 0.19 µg/g. The mercury concentration in the one 1+ cutthroat sampled in August from the reservoir was 0.26 µg/g. While this is in no way conclusive, it does concur with the previous data which indicated that fish found in the tributaries did not contain as much mercury as similar fish which were collected from the reservoir.

Largemouth Bass

Four age classes of largemouth bass (i.e., 0+, 1+, 2+, and 3+) were obtained from the reservoir in 1974. The 0+ age class fish were the only ones to be sampled on more than two different occasions. The mercury concentration of the 0+ fish increased linearly with time (r^2= 0.314; significant at the 99% level). The highest mercury concentration observed was 0.74 µg/g in a 0+ fish collected in November (Figure 5; Appendix 6).

In November, all four age classes of fish were collected from the reservoir. The data on the mercury concentration versus age of the fish were fit to a quadratic equation ($y = -.184x^2 + .714x + .573$). Analysis of variance gave an r^2 of 0.676; significant at the 99%

level. It appears that the mercury concentration reaches a maximum at approximately two years of age. The small number of 2+ and 3+ bass makes it difficult to define the curve with much precision. Of all the bass collected in November, only 18% had mercury levels below the FDA's limit of 0.5 µg Hg/g (Figure 6; Appendix 6).

Brown Bullhead

Brown bullhead from four age classes (i.e., 0+, 1+, 2+ and 3+) were collected and analyzed for mercury in 1974 (Appendix 7). Mercury concentration versus time for the 0+ bullheads is shown in Figure 7. Analysis of the data indicated that there is a significant linear correlation between mercury content and time for the 0+ bullhead (r^2= 0.555; significant at the 95% level).

There was, however, no apparent relationship between mercury concentration and time for 1+ brown bullhead sampled in 1974.

All four age classes of brown bullheads were collected from the reservoir during November, 1974. Analysis of the data indicated that no apparent correlation exists between the fish's age and mercury content for bullheads collected in November.

Studies by many scientists have shown a positive correlation between mercury concentration and fish weight. In most cases these studies involved more than one age class and thus they were observing changes in mercury concentration due to both age and weight variations. The large number of 1+ brown bullheads collected in November

allowed the investigation of variations in mercury concentration with weight within a single age class. A study of this relationship showed the lack of a significant correlation. The correlation coefficient was only 0.046.

1975 Sampling

Spring Chinook Salmon

Spring chinook salmon were again sampled from the reservoir in 1975 and analyzed for total and methylmercury (Appendix 10). 0+ fish were collected during every month sampled, while 1+ fish were collected from June to November. The 1+ fish taken in 1975 were the 0+ fish that did not migrate out of the reservoir in 1974. Also collected in 1975 was a 2+ fish. This fish was planted in 1973 and thus had not migrated out of the reservoir during 1973 and 1974. Two returning adult spring chinook were also collected in 1975. These fish had migrated out of the reservoir as 0+ fish, spent three years in the ocean, and then returned to spawn as four year olds.

The 0+ chinook collected in 1975 did not exhibit a linear correlation between time and mercury concentration as was seen in the 0+ chinook collected in 1974. The data for the fish collected in 1975 were fit to a fourth degree polynomial ($y= -.002x^4 + .087x^3 + 1.252x^2 + 7.854x - 17.936$). Analysis of variance gave an r^2 of 0.419 which is significant at the 99% level.

The 1+ spring chinook collected in 1975 exhibited a linear increase in mercury concentration with time ($r^2 = 0.378$; significant at the 99% level). The highest concentration recorded was 0.96 µg Hg/g from a 1+ fish collected in October (Figure 8b).

Another way of expressing mercury accumulation by fish besides concentration (µg Hg/g) is to report the total body burden (µg Hg). In some cases the total body burden of mercury is of more interest than its concentration. The total body burden is not affected by the positive or negative growth of the fish and therefore accurately indicates whether the quantity of mercury in the fish is increasing or decreasing.

The 0+ fish collected from the reservoir in November of 1974 had an average total body burden of 21.4 µg Hg while the 0+ collected from the tributaries in November of 1974 had a significant lower average total body burden of 14.6 µg Hg ($t = 2.35$, 22 df, significant at the 95% level). In June of 1975, the 1+ chinook collected from the reservoir had an average body burden of only 9.1 µg Hg (Appendix 11). Thus, there appeared to be a drastic decline in the total mercury content of these fish during the winter.

The uptake of methylmercury for both the 0+ and 1+ spring chinook appeared similar to their respective uptake of total mercury. A plot of the methylmercury concentration versus time for both the 0+ and 1+ fish followed the same pattern of uptake as did their total mercury concentration (Figures 8 and 9). The highest methylmercury concentration recorded in a 0+ salmon was 0.49 µg/g in a fish collected in

December. The highest concentration observed in a 1+ salmon was 0.68 µg/g in a fish collected in October. The average percent methylmercury content (mean ± S.D.) of the 0+ fish was 81.4 ± 11.9% while the 1+ fish had an average of 75.5 ± 17.2%.

The food habits of the 0+ and 1+ chinook were again investigated in 1975 (Appendix 12). Both age classes appeared to be feeding on anything available to them. Neither the 0+ or 1+ fish were observed to prey upon other fish. The only difference observed was the higher percentage of zooplankton taken by the 0+ fish compared to the 1+ fish. The average mercury content of the food organisms taken by the salmon in 1975 was 1.47 µg/g. The average methylmercury concentration was 1.18 µg/g. From these data it was determined that 78.8% of the mercury in the fish's diet was in the methylmercury form (Appendix 13).

Rainbow Trout

Due to the chemical treatment in November of 1974, no holdovers (i.e., 2+) fish were collected from the reservoir in 1975. Therefore, only the 1+ rainbow trout which were planted in April of 1975 were collected and analyzed for mercury. Analysis of the data indicated that there was no apparent correlation between mercury concentration and time for the 1+ trout sampled. The highest concentration of mercury observed was 0.24 µg/g in a fish collected in October. The average percent methylmercury content in 1+ rainbow trout was 67.5% (Figure 10; Appendix 14).

Cutthroat Trout

Two age classes of cutthroat trout were collected from the reservoir in 1975 (0+ and 1+). The 2+ and 3+ fish were eliminated during the treatment in 1974. The 1+ cutthroat trout were collected and analyzed for mercury during every month except September (Appendix 15). Unfortunately, there were only two months when more than one fish could be collected. Therefore, no relationship between mercury concentration and time could be determined. The highest concentration found was 0.346 µg/g. The average percent methylmercury content was 63.8%.

The 0+ fish were only collected during the months of October (Appendix 15). The highest concentration obtained was 0.18 µg/g. The three mercury concentrations obtained for the 0+ fish were all lower than the mercury concentration of the one 1+ cutthroat collected in October.

During August of 1975, 1+ cutthroat trout were collected from the Coast Fork of the Willamette River as well as the reservoir itself. The average mercury concentration of the fish collected from the river was 0.08 µg/g while those from the reservoir contained 0.26 µg/g. Here again, the fish collected from the tributary had a significantly lower mercury level than those fish taken from the reservoir ($t = 5.57$ 8 df; significant at the 99% level).

Brown Bullhead

Due to the chemical treatment in 1974, few 0+ and 1+ fish and no 2+ or 3+ fish were collected in 1975 (Appendix 16). The small number of fish taken made it impossible to observe any changes in mercury concentration with time for either the 0+ and 1+ fish.

Largemouth Bass

The largemouth bass population was significantly reduced due to the treatment, and thus no largemouth bass were collected in 1975.

1976 Sampling

Salt Water Tolerance Study

The fish used in the salt water tolerance test were observed for 108 hours for mortality and signs of stress. It was believed that any osmoregulatory problems would occur within this period. At the end of 108 hours, one reservoir fish in the 25.8°/oo and one reservoir fish in 20.5/oo had died. No control fish died. Also, one reservoir fish in 16.6°/oo was floating belly-up on the surface near death. A sub-sample of the fish used in the experiment was analyzed for mercury, and the results are shown in Appendix 19. As can be seen, there is a significant difference in the mercury content between the reservoir fish which survived the salt water experiment and those that did not

[($t = 3.95^2$ df; significant at the 90% level); based on a modified student's "t" test for unequal variances].

DISCUSSION

Field studies by Phillips (1976) involving the study of mercury uptake by rainbow trout in Oregon's Antelope Reservoir determined that the mercury uptake rate could be divided into three distinct phases: 1) a rapid, almost linear phase; 2) a point of rapid decrease in the rate of mercury accumulation; and 3) a phase during which the mercury concentration increases very slowly or remains constant. It is believed that mercury accumulation proceeds rapidly initially due to the excess of methylmercury binding sites. At some point, mercury accumulation would decrease as the binding sites become saturated (Phillips, 1976).

The major assumption that must be made so that mercury accumulation would proceed as described by Phillips is that the fish's exposure to methylmercury remains fairly constant. This is very unlikely in a reservoir such as Cottage Grove since it is maintained for flood control and is thus filled and emptied on a yearly cycle. The whole physical and chemical nature of the reservoir is constantly changing; thus, it is difficult to assume that the fish are exposed to a constant level of methylmercury throughout the year. Conditions during the late summer (i.e., low dissolved oxygen levels, high temperatures, etc.) may cause more methylmercury to be produced, or the fish may prey upon organisms containing a higher mercury content, thus upsetting the mercury equilibrium. Variations in methylmercury availability might account for the fact that fish from Cottage Grove Reservoir did

not follow the mercury uptake pattern described by Phillips. In fact, the mercury content of all species collected in 1974 from Cottage Grove Reservoir, except the 1+ brown bullhead, increased linearly throughout the sampling period.

Data gathered for all fish species indicated that the percent methylmercury of total mercury in the muscle tissue ranged from 4.3 to 100 percent with a majority of the fish having between 60 and 90 percent methylmercury. This is consistent with studies by Westöö (1973) in which the percent methylmercury in Swedish fish were found to range from 81 to 98.

Studies by Bache et al. (1971) have shown that the proportion of methylmercury to total mercury in lake trout increased with age. In the present study, however, there did not appear to be any discernable difference between the percent methylmercury content of 0+ and 1+ chinook. The average percent methylmercury content of the 0+ fish was 81.4 ± 11.9% while the 1+ fish had an average of 75.5 ± 17.2%.

Cutthroat trout and spring chinook sampled from the Coast Fork of the Willamette contained significantly less mercury than similar fish collected from the reservoir (based on student's "t" test of data on chinook collected in November, 1974 and cutthroat trout collected in August, 1974 and 1975). Studies by Gebhards et al. (1971), Buhler et al. (1973), and Walters, et al. (1974) have shown similar relationships between mercury concentration found in fish from reservoir and their respective tributaries.

One of the original objectives of this study was to investigate if differences in physical conditions (i.e., mercury and organic content of the sediment, water temperature, and dissolved oxygen) between the reservoir and its tributaries did exist and determine what effects these differences might have on the rate of mercury uptake by the fish. Due to limited equipment and time, only preliminary dissolved oxygen and temperature readings were obtained during the study (Tables 8, 9, 17, and 18). Due to the lack of data nothing definite can be stated about differences in temperature and dissolved oxygen between the reservoir and the Coast Fork of the Willamette.

The chemical treatment of the reservoir in November, 1974, and the subsequent collection of a large number of fish, allowed the opportunity to observe differences in mercury levels between species (Appendixes 1, 4, 5, 6, and 7). The most predaceous fish sampled from Cottage Grove Reservoir, the largemouth bass, had the highest average mercury concentrations for the 1+, 2+, and 3+ year classes. This is in agreement with other studies which have shown that predatory fish tend to accumulate higher levels of mercury than non-predatory species. The higher mercury levels in predatory fish is attributed to the accumulation of mercury in the prey species as you proceed up the food chain (i.e., each predator species concentrates mercury in its tissues as it consumes its prey and thus the higher a species is on the food chain the higher the mercury levels would be in its prey). This process is known as "food chain magnification".

In the 0+ year class, however, the chinook salmon was the species with the highest average mercury concentration. It may be that due to the small size of 0+ fish, none of the species were able to function as true "predators" and thus the "food chain magnification theory" would not apply to the 0+ fish.

The "food chain magnification theory" would also predict that the least predaceous species, the brown bullhead, should have the lowest mercury concentration. Field studies by Bails (1970) have shown that herbivores like bullheads tend to accumulate lower levels of mercury than the more predatory species. The brown bullhead collected from Cottage Grove Reservoir, however, had mercury levels similar to the cutthroat and rainbow trout. Thus the "food chain magnification theory" does not adequately explain the differences in mercury levels between species. These differences are probably due to a combination of factors (i.e., species differences in: 1) food habits, 2) metabolic rates, and 3) distribution within the reservoir.

Information on the methylmercury concentration of the stomach contents of the 0+ spring chinook collected during 1974 was used to evaluate the relative contribution of mercury uptake through the food. Food consumption rates for the 0+ fish were obtained by first estimating the monthly growth rates of the fish collected. The growth rate was determined by dividing the monthly change in weight by the average weight during the month (Appendix 1). The growth rates ranged from 1.5% of body weight in July to -0.5% in October.

The food consumption rates were then estimated from laboratory studies by Averett (1969) on food consumption rates versus growth rate relationships. Estimated food consumption rates ranged from 55 mg/g/day in July to 10 mg/g/day in October.

According to studies by Jernelov and Lann (1971) methylmercury is the only form of mercury which is readily absorbed and stored. As reported, the average methylmercury content of the fish's diet was 1.152 µg Hg/g. Thus, the maximum methylmercury consumption rate would be 63.4 ng Hg/g/day while the minimum would be 10.5 ng Hg/g/day.

Based on research by Jernelov (1972) and Archer et al. (1973) the efficiency of methylmercury retention from a "natural" diet by fish is between 10-20%. Using an average of 15% efficiency of absorption, the maximum methylmercury accumulation rate would be 0.0095 µg Hg/g/day and 0.0016 µg Hg/g/day at the minimum.

From Figure 1, the mercury uptake rate for 0+ chinook was estimated to be 0.0041 µg Hg/g/day. Based on the data gathered, mercury uptake from the food accounted for a minimum of 25% (in October) and a maximum of 100% (in July) of the total mercury uptake for the 0+ spring chinook collected in 1974. Due to the number of assumptions and estimations made in calculating the percent methylmercury uptake, the actual values of 25% (minimum) and 100% (maximum) must be critically evaluated. The data does, however, indicate that methylmercury uptake through the food does account for a significant percentage of the total methylmercury uptake for the 0+ chinook sampled in 1974. Work by Phillips (1976), Jernelov and Lann (1971), and Fagerstrom and

Asell (1973), however, has indicated that mercury uptake through the food is negligible. In their studies, the methylmercury content of the food organisms were 0.01, 0.07, and 0.12 µg Hg/g, respectively, and the percent methylmercury in the diet ranged from 1-20%. In our studies, the average methylmercury content of the fish's diet was estimated to be 0.23 µg Hg/g (e.g., based on a dry weight concentration of 1.15 µg Hg/g and 80% water content of food organisms). The percent methylmercury was 63.4%. The significantly higher methylmercury content of the food organisms in Cottage Grove Reservoir compared to those levels found during similar experiments would explain why food accounted for a greater percentage of the total mercury uptake in our study.

The data showing a significant difference in the mercury concentration and total body burden of spring chinook collected from the Coast Fork of the Willamette River and the reservoir suggests that two separate populations of chinook might exist in the system (i.e., those rearing in the tributaries and those rearing in the reservoir). We believe that when the spring chinook are planted in the reservoir, some of the fish migrate up into the tributaries while a majority of the fish stay in the reservoir. These two "populations" remain separate throughout most of the summer, although there is probably some exchange between the two populations. In the fall the reservoir is evacuated, and the fish rearing in the reservoir migrate out. When the reservoir is brought back to minimum pool, the chinook inhabiting

the tributaries drop down into the reservoir to fill the void. They spend the winter in the reservoir and become the 1+ fish sampled the following year.

The existence of two populations of chinook would help to explain the drastic decline in the total body burden of mercury between November, 1974, and June, 1975 (Appendix 11). Knowing that the biological half-life of methylmercury in the body was approximately 200 days it seems unlikely that the total mercury body burden of the fish could decrease from 21.4 µg in November to 9.1 µg in June. That would mean that the fish could not accumulate any mercury during the seven month period from November to June. We believe that the fish sampled in November (total body burden of mercury = 21.4 µg) were from the population which had reared in the reservoir, while the fish collected in June (total body burden of mercury = 9.1 µg) were from the population which had reared in the tributaries the year before and had subsequently spent the winter in the reservoir.

A reduction in the total body burden of mercury from 14.6 (i.e., the body burden of 0+ chinook collected from the Coast Fork of the Willamette in November) to 9.1 µg in seven months could be explained by changes in the chemical and physical properties of the system during that period. The cooler water temperature and high flow rates in the reservoir would not be suitable conditions for methylmercury production. This lower exposure rate would allow the fish to excrete more mercury than it is ingesting, thus the total body burden would decrease.

There are two other hypotheses which might explain the decline in the total body burden of mercury in chinook between November, 1974 and June, 1975. Both hypotheses are bases on a model involving a single population of spring chinook inhabiting the reservoir.

The first hypothesis assumes that in the fall the fish with high levels of mercury would migrate out of the reservoir, while the fish with low mercury concentrations would remain. The following spring when the population from the reservoir was sampled and analyzed for mercury the total body burden of the "remaining" population would be lower than the level found the previous fall. This hypothesis seems unlikely based on the work of Lorz and McPherson (1976). In this study it was determined that exposure to metals such as copper reduces the fish's migratory responses.

The other hypothesis assumes that the spring chinook migrating out of the reservoir in the fall had mercury levels similar to those remaining in the reservoir (i.e., both migrating and nonmigrating groups had approximately normally distributed mercury concentrations). During the winter the fish with the highest mercury concentrations would suffer a higher mortality than fish with low mercury levels.

When the fish are sampled the following spring the "remaining" population would have a lower total body burden then the population sampled the previous fall. A situation similar to this involving DDT residues in fish has been observed.

Based on the available data it is impossible to determine which, if any, of the three hypotheses is correct. The original hypothesis that the decline in total body burden of mercury can be attributed to the existence of two separate populations of spring chinook in the system appears to be the most plausible for it incorporates the data already presented which showed that there was a statistically significant difference in mercury levels between fish collected from the reservoir and those collected from the Coast Fork of the Willamette River.

The erratic increases and decreases in the mercury concentration of the 0+ chinook sampled in 1975 (Figure 8a) might also be explained by the existence of two populations of chinook salmon that contain different mercury levels. The average mercury concentration of the fish sampled would be influenced by the relative number of fish collected from each population. The fluctuations in the average mercury concentrations for the 0+ fish collected in 1975 might reflect the sporadic occurrence of fish from the tributaries swimming into the reservoir and being included in the sample of the "reservoir" population.

The data showing that the chinook which had mercury concentrations greater than 0.20 µg/g mercury suffered higher mortality in salt water than the control fish with mercury concentrations below 0.1 µg/g has significant management applications if further tests support this data.

Since the beginning of the salmon rearing program in Cottage Grove Reservoir in 1967, the number of returning adults has been small. Fall Creek reservoir which is located in the Middle Fork of the Willamette River has also been used by the Fish Commission to rear chinook. Every year similar number of smolts are released from Fall Creek and Cottage Grove Reservoirs, but the return of adults to Fall Creek has always been significantly greater than the return of adults to Cottage Grove.

Based on the data gathered in 1974 and 1975, it appears that almost all of the spring chinook migrating out of Cottage Grove Reservoir in the fall have mercury concentrations greater than the 0.20 µg/g mercury--a concentration which has been shown to affect the salt water survival. It is, therefore, possible that the lower returns to Cottage Grove Reservoir could be due to severe mortality of the smolts as they enter salt water. Since the conclusion of this study, the Oregon Department of Fish and Wildlife has terminated their chinook rearing program at Cottage Grove Reservoir. Possible problems with mercury accumulation in the chinook smolts was one of several reasons that the project was cancelled.

Figure 1. The relationship between the mercury concentration in muscle (µg Hg/g), mean ± S.D., and time (months) for spring chinook salmon collected from Cottage Grove Reservoir during 1974 (for 0+ fish $r^2 = 0.829$, significant at 99% level; for 1+ fish $r^2 = 0.553$, significant at 99% level).

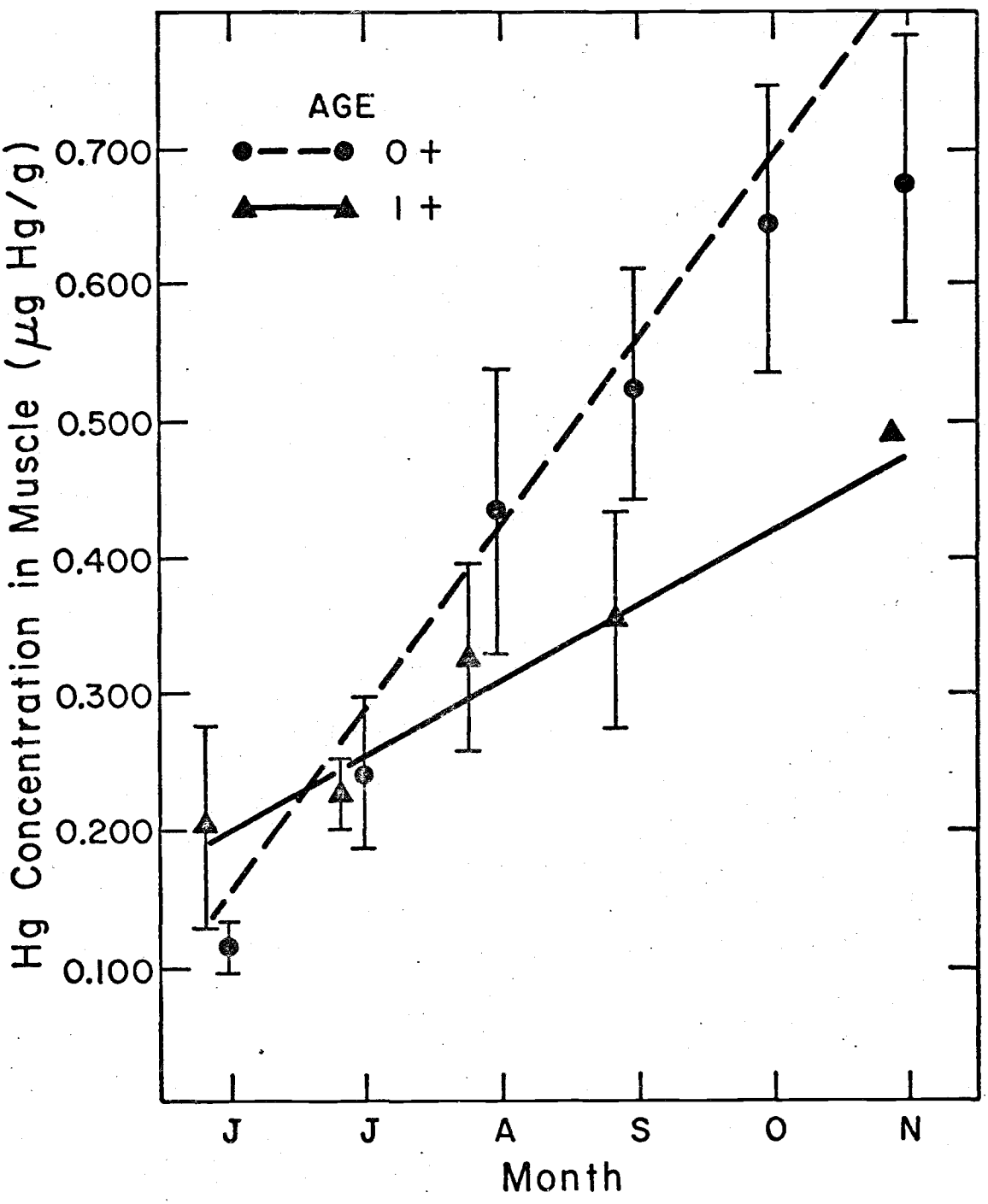

AGE
0 +
1 +
0.700
0.600
0.500
0.400
0.300
0.200
0.100
Hg Concentration in Muscle (μg Hg/g)
J
J
A
S
O
N
Month

Figure 2. The relationship between the mercury concentration in the muscle (µg Hg/g), mean ± S.D. and time (months) for rainbow trout collected from Cottage Grove Reservoir during 1974 (for 1+ fish $r^2 = 0.823$, significant at 99% level).

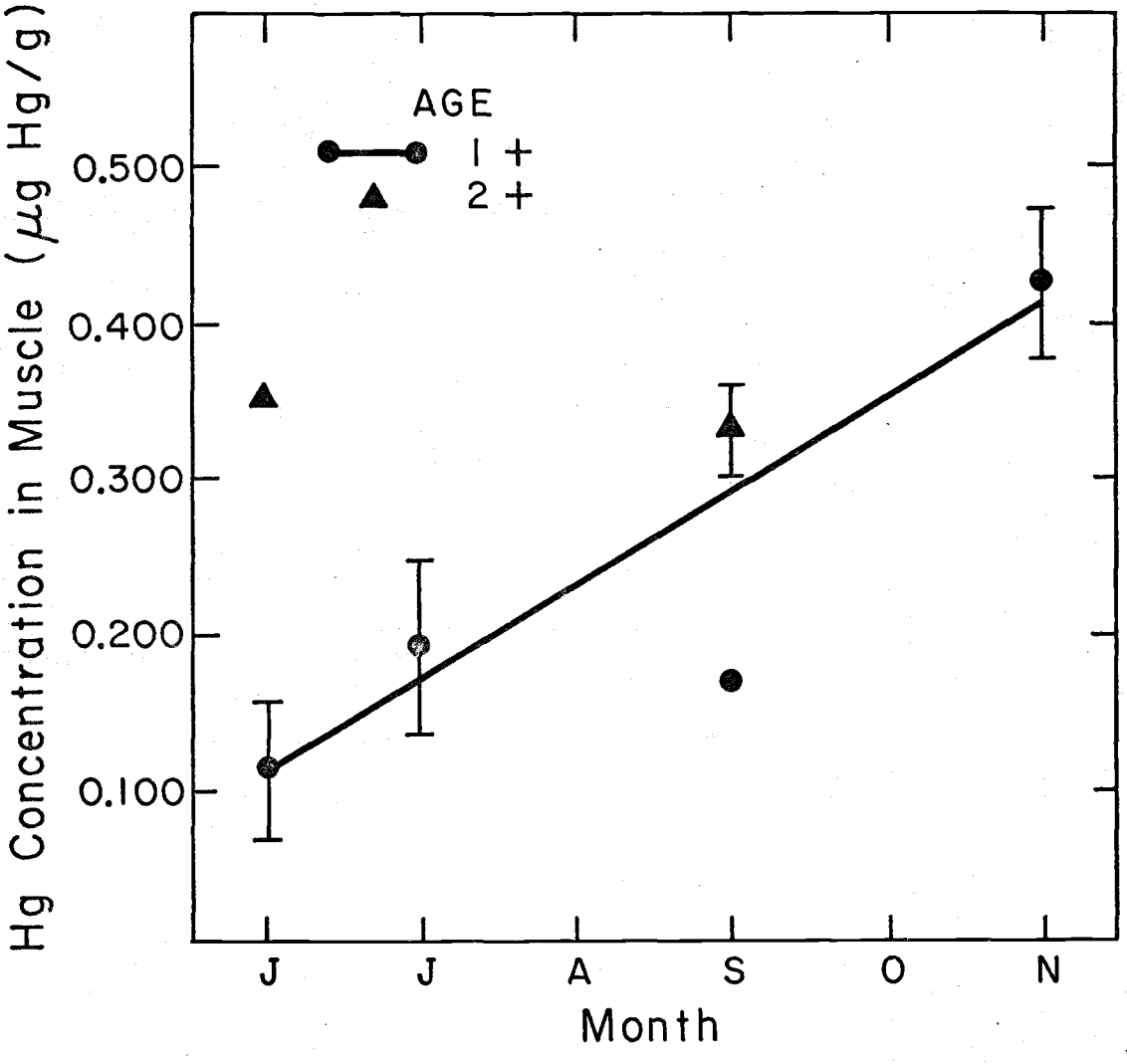

AGE
1 +
2 +
0.500
0.400
0.300
0.200
0.100
Hg Concentration in Muscle (μg Hg/g)
J
J
A
S
O
N
Month

Figure 3. The relationship between the mercury concentration in the muscle (μg Hg/g) and age (years) of the fish for cutthroat trout collected from Cottage Grove Reservoir during November, 1974 (r^2 = 0.663, significant at 99% level).

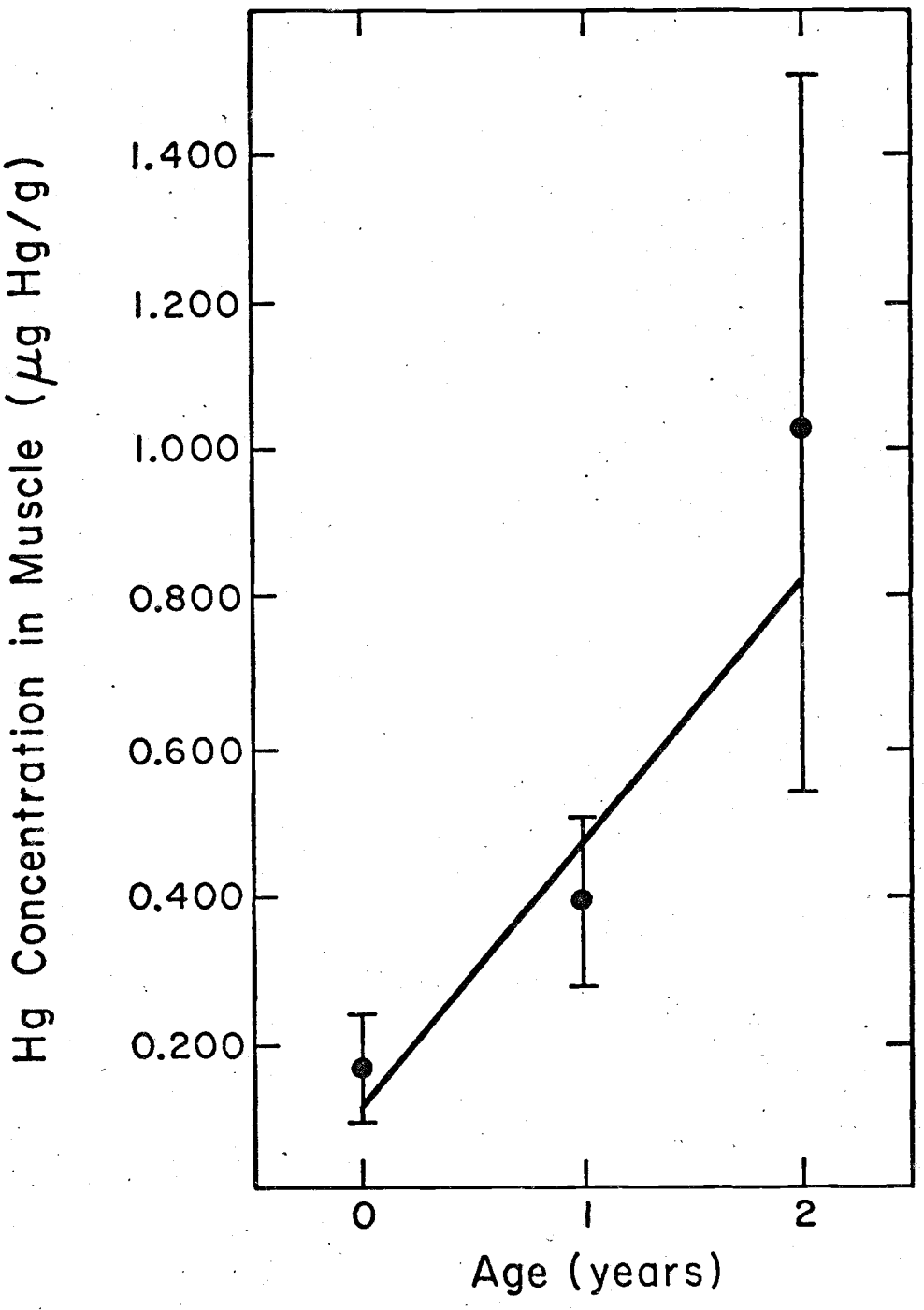

Hg Concentration in Muscle (μg Hg/g)
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0
1
2
Age (years)

Figure 4. The relationship between the mercury concentration in muscle (µg Hg/g), mean ± S.D. and time (months) for 1+ cutthroat trout collected from Cottage Grove Reservoir during 1974 (r^2 = 0.569, significant at 99% level).

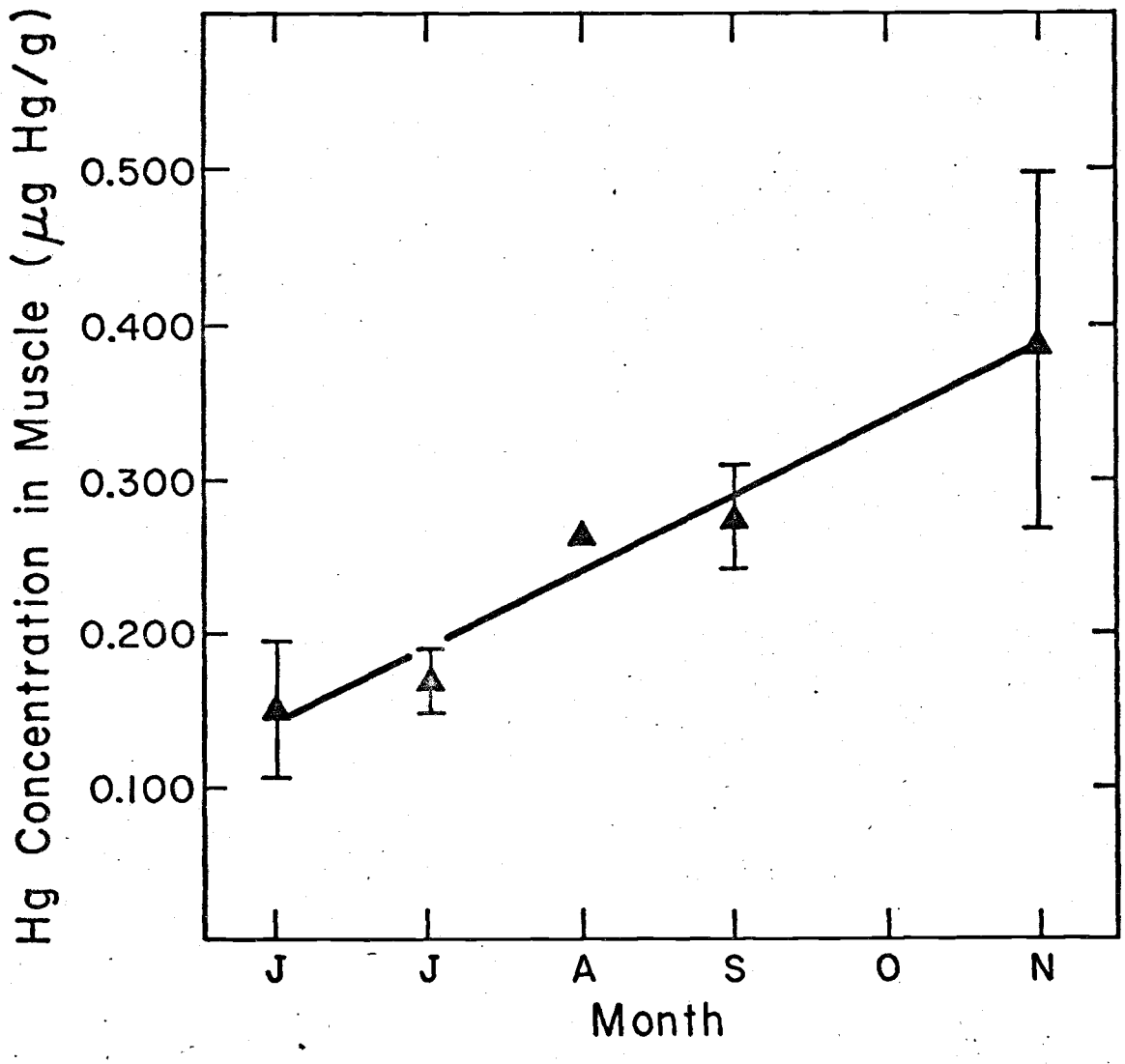

Hg Concentration in Muscle (μg Hg/g)
0.500
0.400
0.300
0.200
0.100
J
J
A
S
O
N
Month

Figure 5. The relationship between the mercury concentration in muscle tissue (μg Hg/g) mean ± S.D. and time (months) for 0+ largemouth bass collected from Cottage Grove Reservoir during 1974 (r^2 = 0.314, significant at 99% level).

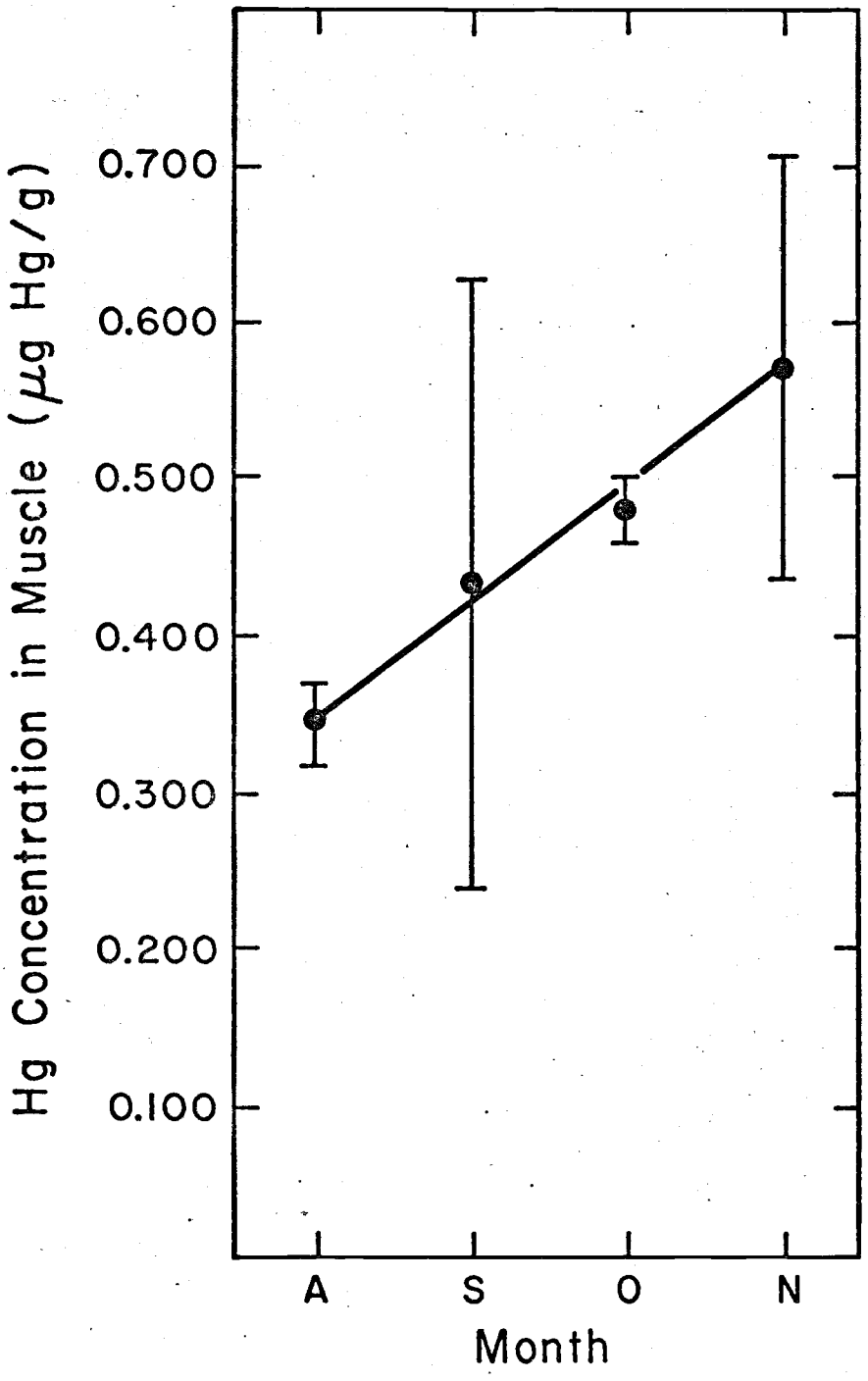

Hg Concentration in Muscle (μg Hg/g)
0.700
0.600
0.500
0.400
0.300
0.200
0.100
A
S
O
N
Month

Figure 6. The relationship between the mercury concentration in muscle tissue (µg Hg/g) and age (years) of the fish for largemouth bass collected from Cottage Grove Reservoir during November, 1974 ($r^2 = 0.676$, significant at 99% level).

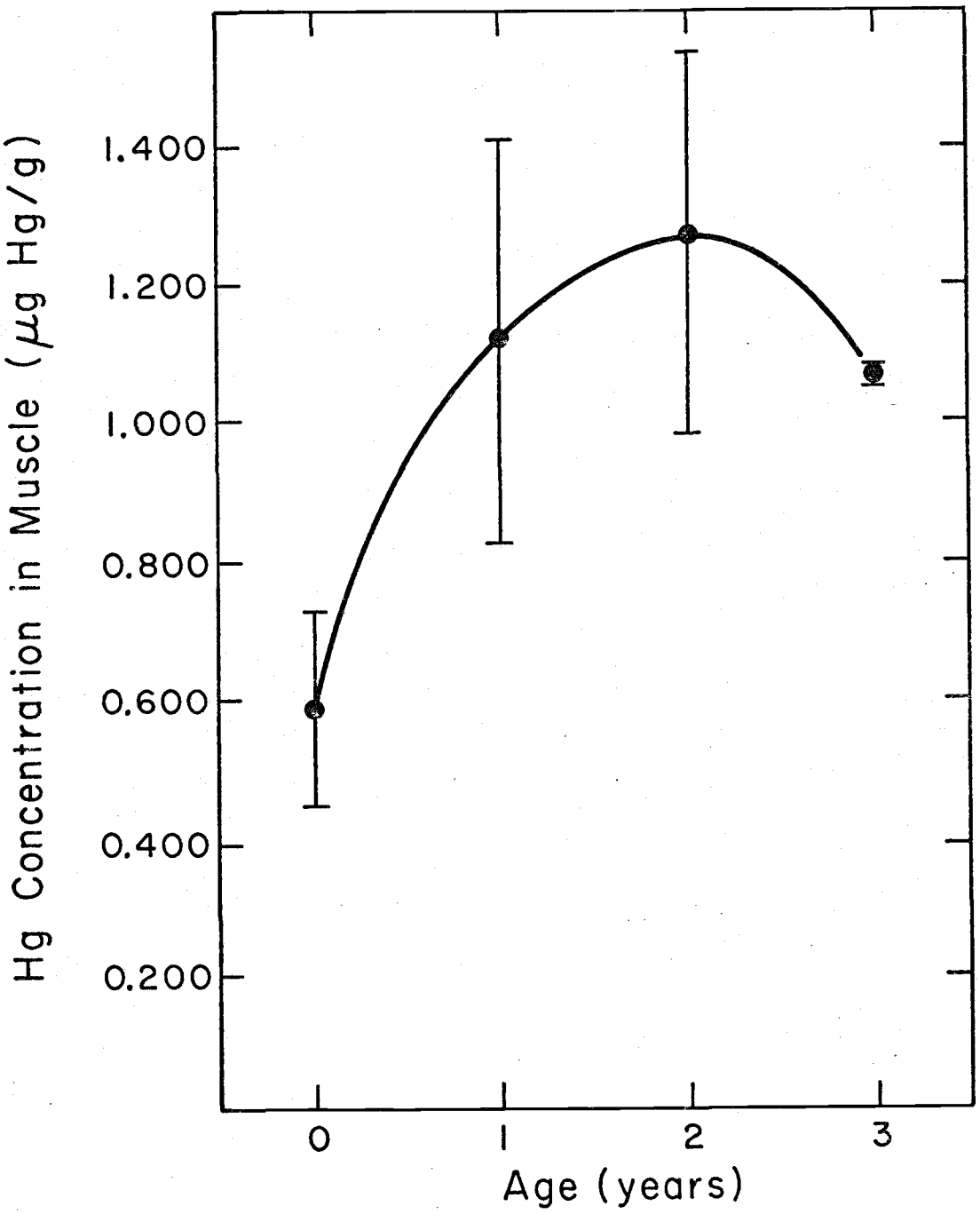

Hg Concentration in Muscle (μg Hg/g)
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0
1
2
3
Age (years)

Figure 7. The relationship between the mercury concentration in muscle tissue (μg Hg/g), mean ± S.D. and time (months) for 0+ brown bullhead collected from Cottage Grove Reservoir during 1974 (r^2= 0.555, significant at 95% level).

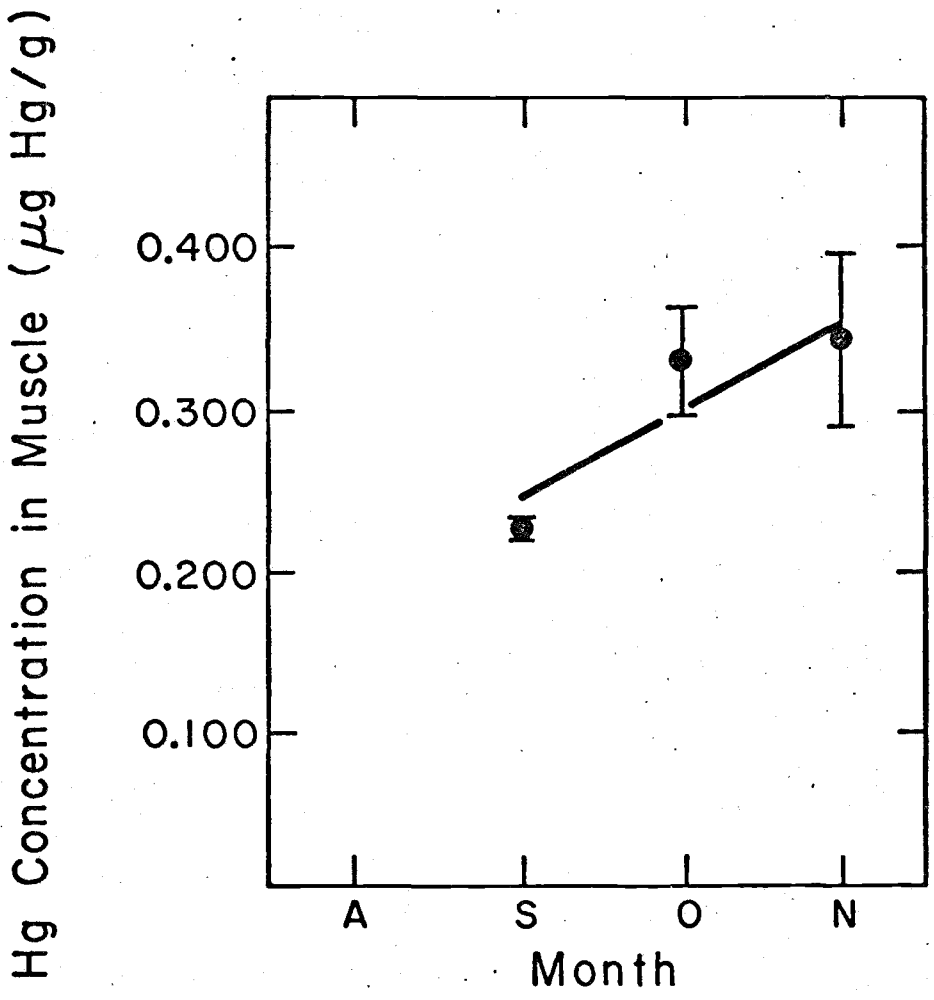

Hg Concentration in Muscle (μg Hg/g)
0.400
0.300
0.200
0.100
A
S
O
N
Month

Figure 8. (a) The relationship between the mercury concentration in the muscle (µg Hg/g), mean ± S.D. and time (months) for 0+ spring chinook collected from Cottage Grove Reservoir during 1975 and 1976 (r^2 = 0.419, significant at 99% level).

(b) The relationship between the mercury concentration in the muscle (µg Hg/g), mean ± S.D. and time (months) for 1+ spring chinook collected from Cottage Grove Reservoir during 1975 and 1976 (r^2 = 0.378, significant at 99% level).

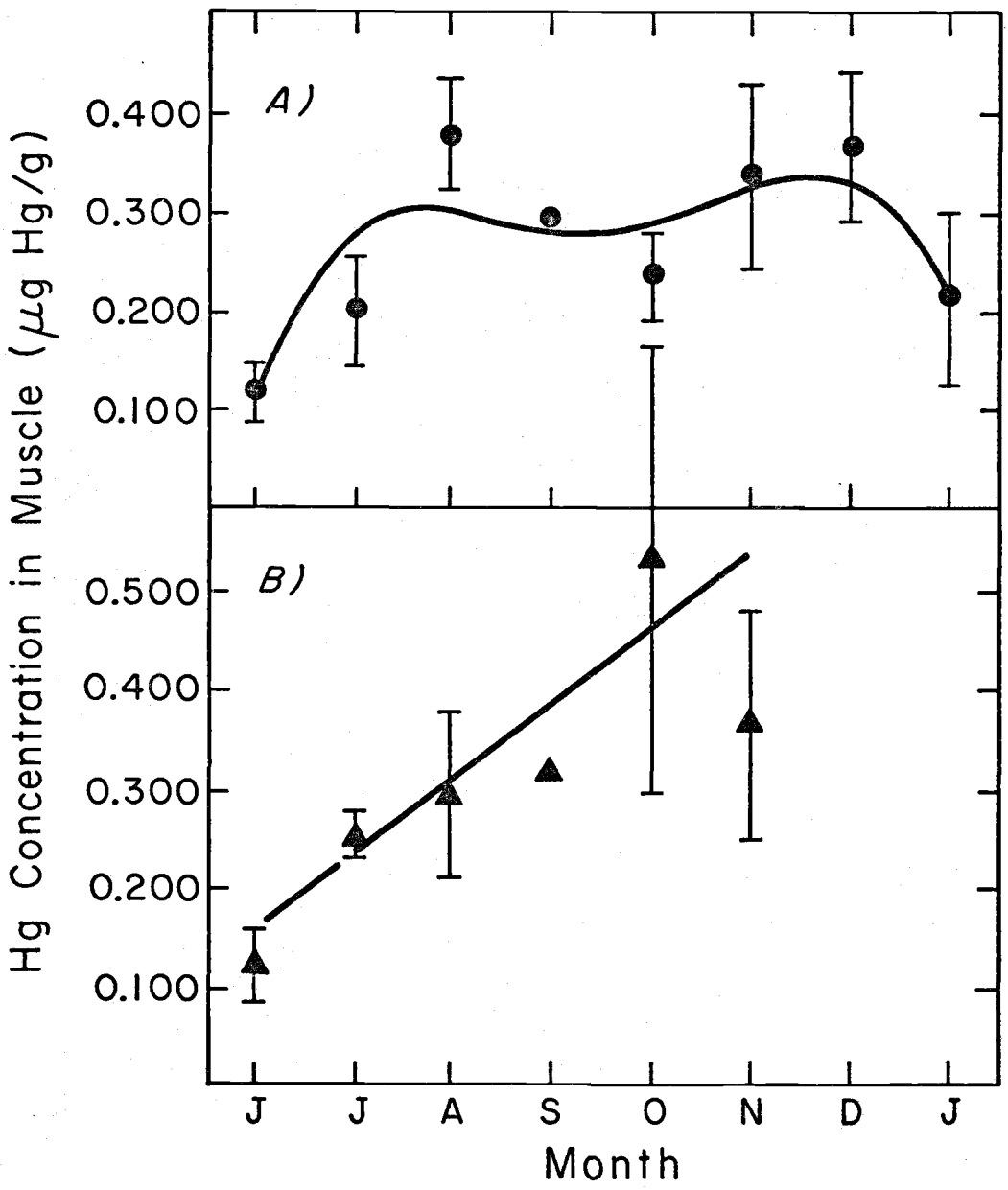
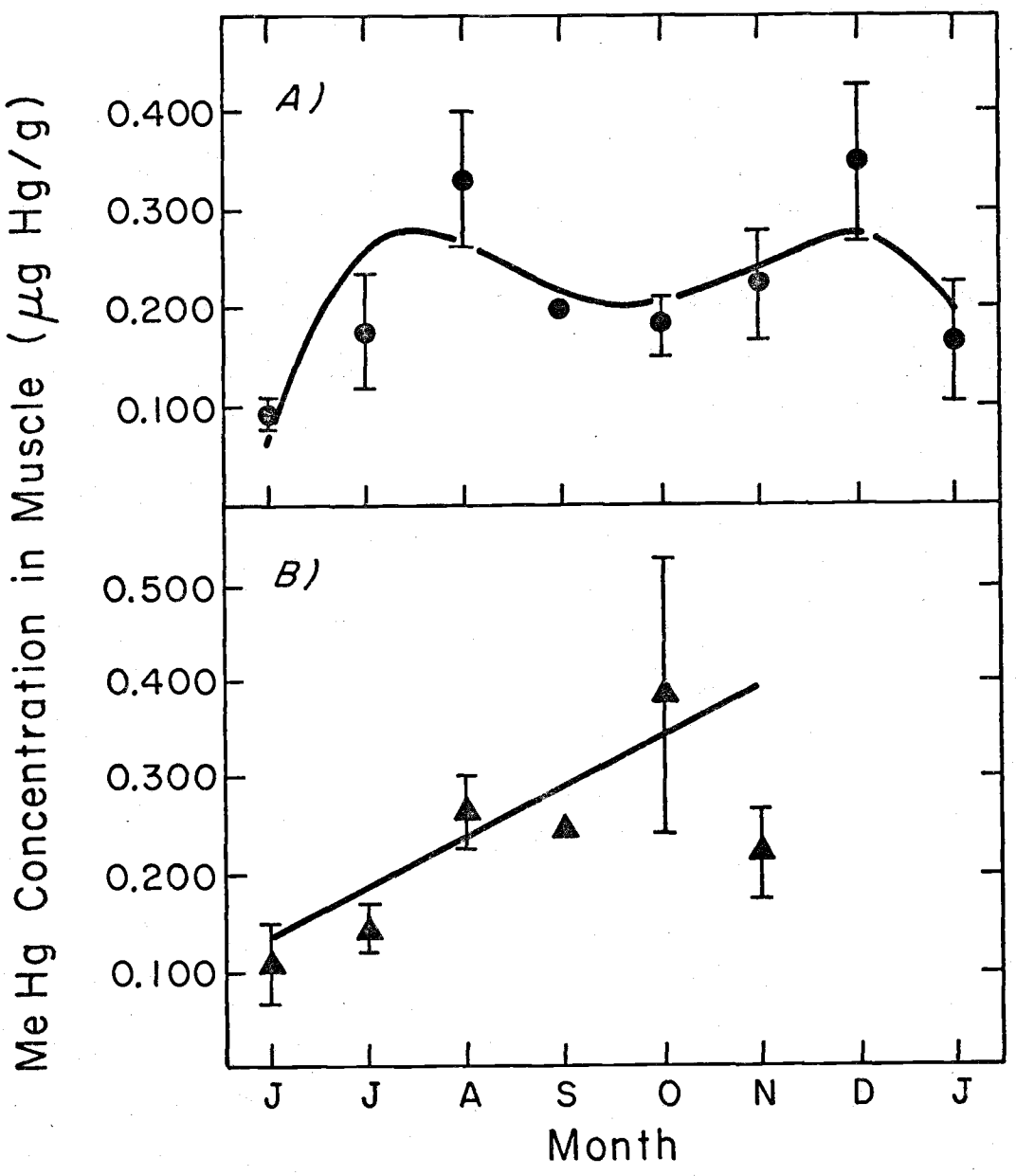

A)
B)
0.400
0.300
0.200
0.100
0.500
0.400
0.300
0.200
0.100
Hg Concentration in Muscle (μg Hg/g)
J
J
A
S
O
N
D
J
Month

Figure 9. (a) The relationship between the methylmercury concentration in muscle tissue (μg Hg/g), mean ± S.D. and time (months) for 0+ spring chinook salmon collected from Cottage Grove Reservoir during 1975 and 1976.

(b) The relationship between the methylmercury concentration in muscle tissue (μg Hg/g), mean ± S.D. and time (months) for 1+ spring chinook collected from Cottage Grove Reservoir during 1975 and 1976.


A)
B)
0.400
0.300
0.200
0.100
0.500
0.400
0.300
0.200
0.100
J
J
A
S
O
N
D
J
Month
Me Hg Concentration in Muscle (μg Hg/g)

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APPENDICES

APPENDIX I. TOTAL MERCURY CONCENTRATION OF MERCURY IN LATERAL MUSCLE TISSUE FROM SPRING CHINOOK SALMON COLLECTED FROM COTTAGE GROVE RESERVOIR AND THE COAST FORK OF THE WILLAMETTE RIVER DURING 1974.

Date	Locality	Age	Length[1] (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.
06/13	Cottage Grove Reservoir	0+	11.7	20.2	0.12	
			11.4	24.4	0.14	
			11.2	23.8	0.13	
			11.4	24.5	0.11	
			10.2	20.0	0.11	
			10.0	18.1	0.09	
			10.6	19.3	0.12	0.11 ± 0.02
			10.7	16.5	0.11	
			9.8	12.2	0.09	
			11.5	19.0	0.09	
			11.7	20.1	0.10	
			13.1	10.0	0.12	
			10.1	15.7	0.12	
			12.0	22.2	0.09	
06/13	Cottage Grove Reservoir	1+	16.4	49.8	0.15	
			16.0	64.5	0.16	
			16.9	80.3	0.24	
			16.3	64.6	0.20	
			16.9	62.1	0.29	0.21 ± 0.07
			15.4	59.5	0.18	
			17.8	83.5	0.22	
			13.4	52.1	0.17	
			17.0	68.9	0.25	
			16.8	61.5	0.12	
			18.0	64.4	0.37	
			17.6	73.3	0.14	

APPENDIX I. (CONT'D)

Date	Locality	Age	Length[1] (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.
07/08	Cottage Grove Reservoir	0+	10.1	20.0	0.22	
			11.7	20.0	0.21	0.24 ± 0.05
			12.9	24.5	0.27	
			11.8	24.0	0.18	
			10.2	14.0	0.32	
07/08	Cottage Grove Reservoir	1+	17.2	80.6	0.24	
			15.3	73.2	0.23	
			16.5	80.2	0.19	
			16.7	86.0	0.21	
			16.1	66.6	0.27	0.23 ± 0.02
			15.8	78.5	0.23	
			15.5	53.4	0.20	
			18.0	80.7	0.24	
			15.4	55.8	0.22	
			17.0	78.0	0.24	
08/14	Cottage Grove Reservoir	0+	12.5	38.5	0.54	
			12.4	33.5	0.51	
			13.1	35.0	0.53	
			12.8	33.5	0.43	0.44 ± 0.11
			12.3	31.4	0.19	
			13.5	37.3	0.43	
			14.8	38.3	0.40	
			14.2	38.5	0.48	
			13.0	36.6	0.41	

APPENDIX I. (CONT'D)

Date	Locality	Age	Length[1] (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.
08/14	Cottage Grove Reservoir	1+	16.6	72.5	0.37	
			17.5	84.3	0.38	
			18.9	120.9	0.31	
			16.2	73.4	0.31	
			17.0	55.0	0.25	
			18.2	74.1	0.34	
			16.5	69.9	0.28	
			17.9	90.8	0.48	0.33 ± 0.07
			17.8	63.7	0.24	
			16.7	64.1	0.31	
09/12	Cottage Grove Reservoir	0+	13.0	42.5	0.59	
			14.2	36.5	0.57	
			13.9	32.5	0.49	
			14.3	44.0	0.58	
			11.6	23.4	0.80	
			14.9	41.5	0.56	
			15.0	47.5	0.59	
			11.2	18.0	0.43	0.55 ± 0.87
			11.5	22.5	0.46	
			13.0	31.0	0.63	
			15.5	48.5	0.51	
			12.0	34.5	0.63	
			14.0	45.5	0.55	
			16.0	48.0	0.50	
			14.2	37.6	0.57	
			14.5	33.8	0.59	
			9.1	16.1	0.54	
			10.1	11.8	0.39	

APPENDIX I. (CONT'D)

Date	Locality	Age	Length[1] (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.
09/12 (cont'd)	Cottage Grove Reservoir	0+	14.2	38.6	0.45	
			12.0	23.5	0.58	
			10.8	23.3	0.60	
09/12	Cottage Grove Reservoir	1+	16.2	68.0	0.38	
			16.4	56.8	0.32	0.36 ± 0.07
			19.0	83.0	0.28	
			16.8	79.5	0.45	
10/27	Cottage Grove Reservoir	0+	14.0	38.5	0.49	
			14.0	31.5	0.52	
			14.0	33.1	0.72	
			14.6	35.0	0.63	
			15.0	40.7	0.57	0.65 ± 0.11
			14.0	34.4	0.64	
			13.0	28.1	0.56	
			14.0	29.2	0.70	
			13.4	27.0	0.76	
			13.4	25.3	0.61	
			14.2	34.5	0.82	
			13.9	30.3	0.77	
11/23	Cottage Grove Reservoir	0+	15.1	28.7	0.74	
			14.3	29.1	0.78	
			10.8	17.4	0.40	
			14.6	35.6	0.64	
			14.5	34.3	0.71	
			14.7	33.5	0.63	0.68 ± 0.11

APPENDIX I. (CONT'D)

Date	Locality	Age	Length[1] (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.
11/23 (cont'd)	Cottage Grove Reservoir	0+	15.0	38.9	0.69	
			14.0	31.3	0.73	
			14.4	31.4	0.72	
			13.8	31.2	0.75	
11/23	Coast Fork	0+	14.8	33.9	1.02	
			12.2	21.3	0.62	
			15.5	36.9	0.49	
			9.2	10.0	0.28	
			8.1	9.8	0.42	
			14.2	26.6	0.50	0.54 ± 0.18
			14.6	29.3	0.52	
			8.4	12.8	0.34	
			14.0	27.6	0.69	
			15.2	34.9	0.58	
			14.9	33.1	0.59	
			16.0	35.6	0.65	
			11.0	16.4	0.37	
			14.2	24.6	0.45	
11/23	Cottage Grove Reservoir	1+	18.0	56.3	0.49	0.49

[1] *Fork length.*

APPENDIX II. THE 1974 FOOD HABIT STUDY OF 0+ AND 1+ SPRING CHINOOK SALMON FROM COTTAGE GROVE RESERVOIR.

Date collected	1+	Food item	% of total diet	0+	Food item	% of total diet
June 1974	(12)[2]	formicidae	8.7	(14)	hemiptera	<1.0
		coleoptera	<1.0		unidentified	100.0
		zooplankton	1.2			
		pleidae	6.1			
		curculianidae	1.9			
		cynipidae	4.6			
		unidentified	61.7			
		chironomidae	0.3			
		cryptotermes	15.5			
July 1974	(10)	diptera	<1.0	(5)	--	
		unidentified	36.5			
		chironomidae	<1.0			
		zygoptera	31.3			
		coleoptera	<1.0			
		pleocoptera	32.2			
August 1974	(10)	chironomidae	2.2	(9)	zooplankton	6.0
		clams	<1.0		vegetation	55.5
		zooplankton	4.2		heleidae	<1.0
		unidentified	1.4		clams	<1.0
		fish	92.3		unidentified	35.7
		heleidae	<1.0		chironomidae	<1.0
					tipulidae	2.8
					leptoceridae	<1.0

APPENDIX II. (CONT'D)

Date collected		1+ Food item	1+ % of total diet		0+ Food item	0+ % of total diet
September 1974	(4)[2]	fish	61.8	(21)	unidentified	80.4
		diptera	5.0		zooplankton	19.6
		coleoptera	13.7		diptera	<1.0
		unidentified	<1.0			
October 1974	(0)	--		(12)	unidentified	98.0
					pleidae	<1.0
					chironomidae	2.1
					diptera	<1.0
November 1974	(1)	chironomidae	<1.0	(10)	nemouridae	38.6
					chironomidae	3.7
					tipulidae	4.2
					simulidae	2.9
					unidentified	50.7
					dytiscidae	<1.0

[2] *Quantity in ( ) indicates number of stomachs examined.*

APPENDIX III. TOTAL AND METHYLMERCURY CONCENTRATION (µG HG/G) AND PERCENTAGE METHYLMERCURY OF THE STOMACH CONTENTS OF 0+ AND 1+ SPRING CHINOOK COLLECTED DURING 1974.

Date	Total Hg concentration (µg Hg/g)	Methylmercury concentration (µg Hg/g)	Percentage methylmercury
June	0.88	0.44	49.9
August	3.90	2.46	63.9
September	1.60	0.69	42.8
October	0.94	0.94	100.0
November	1.65	1.24	75.0
AVERAGE	1.78	1.15	66.3

APPENDIX IV. TOTAL MERCURY CONCENTRATION IN LATERAL MUSCLE TISSUE FROM RAINBOW TROUT COLLECTED FROM COTTAGE GROVE RESERVOIR DURING 1974.

Date	Age	Length[3] (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.
06/13	1+	21.5	138.0	0.10	
		20.9	128.0	0.06	
		21.8	134.0	0.05	
		25.0	250.0	0.16	0.12 ± 0.05
		26.0	227.0	0.10	
		24.1	202.8	0.18	
		24.7	170.2	0.16	
		27.4	250.0	0.11	
06/13	2+	36.0	>600.0	0.36	0.36
07/08	1+	27.0	352.0	0.22	
		25.0	313.0	0.18	0.19 ± 0.06
		22.0	216.0	0.25	
		23.0	256.0	0.12	
09/12	1+	26.5	240.5	0.17	0.17
09/12	2+	20.0	377.5	0.35	0.33 ± 0.03
		33.0	372.5	0.31	
11/23	1+	25.0	217.0	0.37	
		24.0	220.0	0.40	0.43 ± 0.05
		25.0	206.0	0.48	
		25.0	219.0	0.45	

[3] *Fork length.*

APPENDIX V. TOTAL MERCURY CONCENTRATION IN LATERAL MUSCLE TISSUE FROM CUTTHROAT TROUT COLLECTED FROM COTTAGE GROVE RESERVOIR AND THE COAST FORK OF THE WILLAMETTE RIVER DURING 1974

Date	Locality	Age	Length[4] (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.
06/13	Cottage Grove Reservoir	1+	19.0	117.5	0.18	0.15 ± 0.04
			17.0	79.5	0.12	
07/08	Cottage Grove Reservoir	1+	22.0	169.0	0.18	0.17 ± 0.02
			19.5	103.0	0.16	
08/14	Cottage Grove Reservoir	1+	19.5	143.0	0.26	0.26
09/12	Coast Fork	1+	14.8	70.0	0.24	
			17.3	90.0	0.14	0.19 ± 0.05
			14.3	49.0	0.19	
09/12	Cottage Grove Reservoir	1+	17.0	88.0	0.24	
			18.8	70.0	0.25	
			16.2	53.0	0.27	
			17.6	88.0	0.26	0.28 ± 0.04
			20.0	92.0	0.30	
			16.2	50.5	0.24	
			17.0	72.0	0.29	
			23.5	166.5	0.35	
			18.3	104.5	0.29	

APPENDIX V. (CONT'D)

Date	Locality	Age	Length[4] (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.
11/23	Cottage Grove Reservoir	0+	11.5	17.0	0.29	
			11.0	15.6	0.17	
			13.5	30.5	0.12	0.16 ± 0.07
			12.5	20.8	0.10	
			14.5	29.0	0.18	
			12.3	30.5	0.12	
11/23	Cottage Grove Reservoir	1+	22.0	134.5	0.43	
			15.0	53.6	0.29	
			15.0	31.6	0.39	
			17.0	73.0	0.50	0.39 ± 0.11
			16.3	58.5	0.42	
			13.6	29.0	0.24	
			18.0	68.5	0.56	
			17.0	41.1	0.26	
11/23	Cottage Grove Reservoir	2+	29.5	428.0	0.58	1.02 ± 0.48
			38.0	>600.0	1.36	

[4] *Fork length.*

APPENDIX VI. TOTAL MERCURY CONCENTRATION IN LATERAL MUSCLE TISSUE FROM LARGEMOUTH BASS COLLECTED FROM COTTAGE GROVE RESERVOIR DURING 1974.

Date	Age	Length[5] (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.
08/14	0+	8.4	13.9	0.35	
		8.9	10.7	0.37	0.34 ± 0.03
		8.6	10.5	0.31	
09/12	0+	9.6	14.0	0.49	
		8.0	12.0	0.44	
		8.1	14.0	0.41	0.43 ± 0.19
		5.6	3.4	0.15	
		5.3	3.3	0.69	
09/12	1+	12.0	48.5	0.55	0.55
10/27	0+	9.0	10.3	0.45	
		6.5	6.6	0.49	0.48 ± 0.02
		8.0	6.6	0.50	
		8.2	8.1	0.46	
11/23	0+	8.9	10.8	0.46	
		8.6	9.6	0.74	
		9.2	11.9	0.60	
		10.0	15.3	0.46	
		8.2	8.5	0.69	
		9.0	11.7	0.56	0.57 ± 0.13
		10.6	13.9	0.44	
		8.8	9.5	0.81	
		8.8	10.1	0.57	
		10.2	12.1	0.59	
		10.2	15.1	0.38	
11/23	1+	16.2	58.0	1.03	
		20.5	147.2	1.06	
		18.8	88.5	1.08	
		18.6	101.2	0.55	
		19.5	121.2	1.15	1.11 ± 0.29
		19.8	161.6	1.14	
		18.1	112.7	1.23	
11/23	2+	24.0	375.0	1.05	1.24 ± 0.28
		25.0	413.3	1.44	
11/23	3+	37.5	>600.0	1.07	1.06 ± 0.02
		33.0	>600.0	1.05	

[5] *Fork length.*

APPENDIX VII. TOTAL MERCURY CONCENTRATION IN LATERAL MUSCLE TISSUE FROM BROWN BULLHEAD COLLECTED FROM COTTAGE GROVE RESERVOIR DURING 1974

Date	Age	Length[6] (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.
08/14	1+	22.0	195.0	0.25	
		19.0	186.5	0.37	0.26 ± 0.08
		16.0	90.3	0.24	
		17.0	98.5	0.17	
09/12	0+	10.5	15.5	0.22	0.23 ± 0.01
		10.0	15.0	0.23	
09/12	1+	22.5	489.0	0.42	0.31 ± 0.16
		16.0	110.0	0.20	
10/27	0+	9.2	10.1	0.35	
		14.3	4.5	0.31	0.33 ± 0.03
10/27	1+	20.0	110.0	0.22	
		23.0	227.0	0.48	0.35 ± 0.18
11/23	0+	8.5	12.2	0.32	
		9.2	11.8	0.31	
		8.5	7.8	0.31	0.34 ± 0.05
		7.2	6.6	0.41	
11/23	1+	20.5	114.4	0.32	
		19.2	86.2	0.29	
		17.5	68.8	0.27	
		20.5	101.5	0.22	
		18.3	97.0	0.23	
		15.1	46.4	0.41	
		18.0	79.4	0.27	
		18.5	67.9	0.68	
		18.5	90.5	0.33	
		19.5	103.8	0.54	
		20.0	112.3	0.33	
		23.0	165.6	0.32	
		20.0	106.5	0.20	
		19.3	98.7	0.40	
		23.0	163.8	0.31	
		21.0	140.6	0.27	0.30 ± 0.10
		19.0	94.7	0.24	
		20.1	112.1	0.22	
		19.0	100.3	0.29	
		18.0	78.6	0.26	

APPENDIX VII. (CONT'D)

Date	Age	Length[6] (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.
11/23 (cont'd)	1+	20.8	123.0	0.29	
		17.0	67.1	0.24	
		14.1	38.7	0.28	
		19.0	100.8	0.20	
		20.4	112.6	0.62	
		18.3	82.0	0.33	
		22.3	137.6	0.32	
		20.0	116.6	0.37	
		20.0	144.8	0.20	
		20.5	114.3	0.20	
		21.0	113.8	0.24	
		18.0	81.8	0.21	
		17.6	75.4	0.25	
		19.5	101.3	0.34	
		20.0	124.0	0.23	
		21.0	120.1	0.27	
		17.0	65.7	0.26	
		18.5	107.0	0.33	
		17.0	68.3	0.28	
		14.0	58.2	0.21	
		15.7	46.7	0.30	
		17.5	61.8	0.27	
11/23	2+	25.5	238.5	0.28	
		25.0	240.0	0.39	
		25.0	246.1	0.35	
		24.4	224.1	0.35	
		25.0	256.0	0.29	0.33 ± 0.04
		24.0	212.3	0.35	
		24.5	213.3	0.31	
		26.8	245.1	0.28	
11/23	3+	28.0	304.2	0.37	0.42 ± 0.07
		30.0	414.0	0.47	

[6] *Fork length.*

APPENDIX VIII. THE DISSOLVED OXYGEN LEVEL OF THE EPILIMNION, THERMOCLINE, AND HYPOLIMNION OF COTTAGE GROVE RESERVOIR DURING 1974

Date	Water level	Dissolved oxygen (mg/liter)
6/12	epilimnion	10.5
	thermocline	10.5
	hypolimnion	10.5
7/9	epilimnion	10.0
	thermocline	10.0
	hypolimnion	9.0
8/13	epilimnion	9.0
	thermocline	8.0
	hypolimnion	6.0
9/10	epilimnion	10.0
	thermocline	--[7]
	hypolimnion	10.0

[7] *No well defined thermocline.*

APPENDIX IX. THE WATER TEMPERATURE OF THE SURFACE, THERMOCLINE, AND BOTTOM OF COTTAGE GROVE RESERVOIR DURING 1974

Date	Water level	Temperature °C
6/12	surface	20.5
	thermocline	16.0
	bottom	10.5
7/9	surface	20.0
	thermocline	16.0
	bottom	11.0
8/13	surface	23.0
	thermocline	18.5
	bottom	13.0
9/10	surface	21.5
	thermocline	--[8]
	bottom	21.0

[8] *No well defined thermocline.*

APPENDIX X. TOTAL MERCURY AND METHYLMERCURY CONCENTRATION AND PERCENTAGE METHYLMERCURY IN LATERAL MUSCLE TISSUE FROM SPRING CHINOOK COLLECTED FROM COTTAGE GROVE RESERVOIR DURING 1975 AND 1976

Date	Age	Length (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.	Methylmercury in muscle (µg Hg/g)	Mean ± S.D.	% Methyl-mercury	Mean ± S.D.
6/12/75	0+	10.0	13.9	0.10		0.08		79.2	
		10.5	13.0	0.11		0.07		64.5	
		12.2	28.4	0.11	0.12 ± 0.03	0.08	0.09 ± 0.02	74.5	76.0 ± 10.6
		11.0	12.9	0.10		0.10		92.2	
		11.0	--	0.17		0.12		69.5	
6/12/75	1+	17.5	80.0	0.10		0.09	0.11 ± 0.04	86.7	90.7 ± 5.6
		17.8	64.0	0.15		0.14		94.6	
7/16/75	0+	11.3	16.2	0.16		0.15		94.3	
		13.9	32.0	0.27		0.27		100.0	
		13.1	27.0	0.25		0.23		91.2	
		13.6	24.4	0.15	0.20 ± 0.06	0.12	0.17 ± 0.06	81.6	87.3 ± 16.1
		11.4	16.9	0.20		0.20		100.0	
		13.3	26.4	0.14		0.12		90.4	
		12.1	21.7	0.24		0.13		53.8	
7/16/75	1+	19.6	96.6	0.26		0.15		58.2	
		18.2	71.2	0.28		0.13		46.0	
		20.0	87.0	0.25	0.26 ± 0.02	0.10	0.15 ± 0.03	41.2	57.7 ± 12.3
		20.8	101.3	0.26		0.16		61.7	
		15.3	45.4	0.28		0.18		64.1	
		19.2	79.5	0.22		0.16		74.9	

APPENDIX X. (CONT'D)

Date	Age	Length (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.	Methylmercury in muscle (µg Hg/g)	Mean ± S.D.	% Methyl-mercury	Mean ± S.D.
8/14/75	0+	12.1	20.5	0.46		0.46		100.0	
		12.3	26.0	0.40		0.35		87.6	
		12.4	30.0	0.28		0.18		65.6	
		11.8	26.5	0.30		0.28		91.1	
		12.8	29.0	0.35	0.38 ± 0.06	0.33	0.33 ± 0.07	93.9	86.9 ± 10.6
		13.5	28.3	0.41		0.39		95.3	
		12.9	28.3	0.43		0.32		73.7	
		13.0	28.9	0.40		0.33		81.4	
		13.5	25.7	0.38		0.33		86.6	
		10.5	14.8	0.36		0.34		93.7	
8/14/75	1+	22.0	223.5	0.38		0.38		100.0	
		19.4	63.4	0.24		0.19		78.5	
		18.9	89.0	0.22		0.17		75.1	
		18.0	91.5	0.24		0.15		64.7	
		19.0	86.5	0.32	0.29 ± 0.09	0.32	0.27 ± 0.04	100.0	87.9 ± 15.4
		20.2	99.8	0.30		0.30		100.0	
		18.0	97.0	0.49		0.49		100.0	
		18.3	77.4	0.19		0.12		64.9	
		19.0	70.1	0.26		0.26		98.1	
		19.0	70.5	0.31		0.31		97.8	
9/25/75	0+	14.2	32.0	0.29	0.29	0.20	0.20	67.7	67.7
9/25/75	1+	19.8	75.0	0.32	0.32	0.25	0.25	78.2	78.2

APPENDIX X. (CONT'D)

Date	Age	Length (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.	Methylmercury in muscle (µg Hg/g)	Mean ± S.D.	% Methyl-mercury	Mean ± S.D.
10/10/75	0+	14.2	31.0	0.22		0.16		69.8	
		14.2	31.5	0.19		0.16		83.2	
		14.3	31.9	0.18		0.14		77.8	
		14.0	28.6	0.29	0.24 ± 0.04	0.20	0.18 ± 0.03	71.6	76.8 ± 12.1
		15.0	36.7	0.28		0.20		72.6	
		14.7	35.1	0.22		0.22		100.0	
		14.3	32.3	0.27		0.17		62.6	
10/10/75	1+	17.5	52.2	0.36		0.34		95.8	
		19.5	58.7	0.57		0.40		70.8	
		20.8	93.8	0.96		0.68		70.3	
		18.2	60.4	0.45		0.28		63.4	
		18.5	60.7	0.54	0.53 ± 0.22	0.36	0.38 ± 0.14	67.2	73.4 ± 11.1
		17.2	55.0	0.34		0.23		66.0	
		16.0	46.0	0.38		0.33		86.0	
		20.0	74.6	0.36		0.28		77.2	
		17.8	50.7	0.83		0.53		63.5	
11/7/75	0+	15.6	34.6	0.35		0.25		71.1	
		12.0	21.0	0.23		0.19		81.9	
		14.4	33.2	0.30		0.26		89.2	
		14.9	36.5	0.27		0.20		74.8	
		14.8	30.6	0.24		0.21		87.0	
		13.9	34.0	0.23		0.16		68.3	
		14.1	30.9	0.29		0.21		70.1	
		10.9	13.3	0.46	0.34 ± 0.09	0.32	0.22 ± 0.06	69.0	58.9 ± 17.8
		9.0	8.5	0.34		0.26		75.7	
		10.6	11.0	0.33		0.23		70.3	
		15.1	27.5	0.47		0.29		62.1	

APPENDIX X. (CONT'D)

Date	Age	Length (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.	Methylmercury in muscle (µg Hg/g)	Mean ± S.D.	% Methyl-mercury	Mean ± S.D.
11/7/75 (cont'd)	0+	13.0	19.8	0.30		0.25		82.3	
		9.1	8.1	0.53		0.19		36.6	
		10.0	10.5	0.35		0.09		26.0	
11/7/75	1+	22.0	88.3	0.28	0.36 ± 0.12	0.19	0.22 ± 0.05	66.2	61.6 ± 6.6
		20.0	70.3	0.45		0.25		56.9	
11/7/75	Adult	--	--	0.10	0.09 ± 0.02	--		--	
		--	--	0.08		--		--	
12/17/75	0+	10.2	10.6	0.33		0.30		92.7	
		11.5	15.6	0.50		0.49		98.2	
		10.7	12.5	0.31	0.37 ± 0.08	0.29	0.35 ± 0.08	96.1	94.7 ± 3.4
		12.0	18.7	0.38		0.37		96.8	
		10.5	12.3	0.33		0.29		89.9	
1/8/76	0+	11.0	20.5	0.11		0.09		83.9	
		12.0	23.0	0.26	0.21 ± 0.09	0.18	0.16 ± 0.06	71.1	77.5 ± 9.1
		12.0	17.5	0.27		0.21		78.6	

APPENDIX XI. THE TOTAL BODY BURDEN OF MERCURY FROM 0+ SPRING CHINOOK COLLECTED IN NOVEMBER 1974, AND 1+ CHINOOK COLLECTED IN JUNE 1975.

Date	Locality	Age	Total body burden of mercury (µg)	Mean ± S.D.
10/74	Cottage Grove Reservoir	0+	21.15	
			22.61	
			7.01	
			22.64	
			24.46	21.4 ± 5.31
			21.17	
			26.72	
			22.72	
			22.51	
			23.24	
10/74	Coast Fork	0+	34.58	
			13.10	
			18.08	
			2.84	
			4.16	
			13.35	
			15.18	14.63 ± 8.78
			4.34	
			18.91	
			20.38	
			19.56	
			23.14	
			6.04	
			11.09	
6/75	Cottage Grove Reservoir	1+	6.26	9.09 ± 3.98
			11.90	

APPENDIX XII. THE 1975 FOOD HABIT STUDY OF 0+ AND 1+ SPRING CHINOOK SALMON FROM COTTAGE GROVE RESERVOIR.

Date collected	1+		0+	
		Food item		Food item
June 1975	(2)[9]	unidentified	(5)	zooplankton
		chironomidae		unidentified
July 1975	(6)	chironomidae	(7)	unidentified
		unidentified		vegetation
		clams		chironomidae
August 1975	(10)	unidentified	(10)	unidentified
		chironomidae		zooplankton
		simulidae		pleidae
September 1975	(1)	chironomidae	(1)	zooplankton
		orthoptera		chironomidae
October 1975	(9)	unidentified	(7)	unidentified
		aniseptera		
		coleoptera		
		vegetation		
		cryptotermes		
		curculianidae		
		formicidae		

Date collected	1+ % of total diet	0+ % of total diet
June 1975	100.0 <1.0	100.0 <1.0
July 1975	<1.0 <1.0 100.0	98.7 1.3 <1.0
August 1975	57.1 42.9 <1.0	<1.0 64.3 35.7
September 1975	<1.0 <1.0	91.7 8.3
October 1975	43.6 20.1 10.8 <1.0 23.5 <1.0 <1.0	<1.0

APPENDIX XII. (CONT'D).

Date collected		1+ Food item	1+ % of total diet		0+ Food item	0+ % of total diet
November 1975	(2)	zygoptera	76.7	(14)	zygoptera	35.7
		pleidae	16.3		unidentified	21.4
		cryptotermes	7.1		vegetation	<1.0
					coleoptera	42.9
					diptera	<1.0
					dytiscidae	

[9] *Quantity in ( ) indicates number of stomachs examined.*

APPENDIX XIII. TOTAL AND METHYLMERCURY CONCENTRATION (µG HG/G) AND PERCENTAGE METHYLMERCURY OF THE STOMACH CONTENTS OF 0+ AND 1+ SPRING CHINOOK COLLECTED DURING 1975.

Date	Total Hg concentration (µg Hg/g)	Methylmercury concentration (µg Hg/g)	Percentage methylmercury
June	1.47	1.47	100.0
July	2.32	2.03	87.5
August	1.68	0.63	37.5
September	1.81	1.81	100.0
October	0.88	0.57	64.5
November	0.66	0.55	83.4
	1.47	1.18	78.8

APPENDIX XIV. TOTAL MERCURY AND METHYLMERCURY CONCENTRATION AND PERCENTAGE METHYLMERCURY IN LATERAL MUSCLE TISSUE FROM 1+ RAINBOW TROUT COLLECTED FROM COTTAGE GROVE RESERVOIR DURING 1975.

Date	Length (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.	Methylmercury in muscle (µg Hg/g)	Mean ± S.D.	% Methyl-mercury	Mean ± S.D.
6/12/75	25.2	226.0	0.07	0.07	--		--	
7/16/75	25.2	193.5	0.23				4.3	
	24.0	173.3	0.16		0.08		46.9	
	26.0	260.2	0.14	0.18 ± 0.05	0.05	0.07 ± 0.09	35.8	38.5 ± 39.2
	25.0	206.3	0.22		0.22		100.0	
	26.0	234.7	0.13		0.01		5.3	
8/14/75	29.0	247.0	0.13		0.10		74.6	
	24.0	157.0	0.13	0.15 ± 0.03	0.13	0.13 ± 0.02	100.0	84.2 ± 11.0
	28.5	242.0	0.18		0.15		82.0	
	24.0	172.5	0.16		0.13		80.1	
10/10/75	26.0	189.9	0.21	0.23 ± 0.02	0.15	0.15 ± 0.00	71.1	47.0 ± 5.9
	26.0	177.2	0.24		0.15		62.8	

APPENDIX XV. TOTAL MERCURY AND METHYLMERCURY CONCENTRATION AND PERCENTAGE METHYLMERCURY IN LATERAL MUSCLE TISSUE FROM CUTTHROAT TROUT COLLECTED FROM COTTAGE GROVE RESERVOIR AND THE COAST FORK OF THE WILLAMETTE RIVER DURING 1975.

Date	Locality	Age	Length (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.	Methyl-mercury in muscle (µg Hg/g)	Mean ± S.D.	% Methyl-mercury	Mean ± S.D.
6/12/75	Cottage Grove Reservoir	1+	20.0	85.2	0.11	0.11	--		--	
7/16/75	Cottage Grove Reservoir	1+	21.0	140.7	0.32		0.32		100.0	
			20.0	89.1	0.31		0.15		48.4	
			20.0	140.6	0.23	0.28 ±	0.11	0.18 ±	47.8	63.2 ±
			20.0	142.5	0.24	0.04	0.20	0.08	80.4	23.0
			20.5	109.2	0.29		0.12		40.1	
			21.8	105.4	0.30		0.18		62.2	
8/14/75	Cottage Grove Reservoir	1+	25.2	220.0	0.35		0.24		68.5	
			21.0	108.0	0.22		0.22		100.0	
			17.4	68.9	0.30	0.26 ±	0.30	0.23 ±	100.0	89.6 ±
			16.0	52.1	0.19	0.06	0.19	0.04	100.0	14.7
			22.0	126.5	0.25		0.20		79.6	
8/11/75	Coast Fork Willamette	1+	12.3	20.3	0.11					
			13.1	26.4	0.12					
			14.0	32.6	0.09	0.08 ±				
			18.0	64.7	0.05	0.03				
			13.3	25.0	0.05					
10/10/75	Cottage Grove Reservoir	0+	16.0	42.0	0.18		0.15		83.5	
			14.1	28.0	0.13	0.12 ±	0.08	0.09 ±	58.0	58.3 ±
			15.5	34.5	0.06	0.06	0.04	0.05	63.5	13.4

APPENDIX XV. (CONT'D).

Date	Locality	Age	Length (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.	Methyl-mercury in muscle (µg Hg/g)	Mean ± S.D.	% Methyl-mercury	Mean ± S.D.
10/10/75	Cottage Grove Reservoir	1+	19.1	73.8	0.31	0.31	0.21	0.21	58.6	58.6
11/7/75	Cottage Grove Reservoir	1+	17.3	51.3	0.27	0.27	0.27	0.27	100.0	100.0

APPENDIX XVI. TOTAL MERCURY AND METHYLMERCURY CONCENTRATION AND PERCENTAGE METHYLMERCURY IN LATERAL MUSCLE TISSUE FROM BROWN BULLHEAD COLLECTED FROM COTTAGE GROVE RESERVOIR DURING 1975.

Date	Age	Length (cm)	Weight (grams)	Total Hg in muscle (µg Hg/g)	Mean ± S.D.	Methylmercury in muscle (µg Hg/g)	Mean ± S.D.	% Methyl-mercury	Mean ± S.D.
7/16/75	1+	17.0	61.2	0.25		0.18		69.6	
		15.5	58.0	0.08		0.08		100.0	
		12.0	54.7	0.29		0.22		78.6	
		17.5	92.7	0.20	0.23 ± 0.11	0.10	0.16 ± 0.05	50.0	75.1 ± 21.6
		17.0	89.2	0.23		0.20		85.2	
		18.0	196.6	0.14		0.14		97.2	
		16.0	57.0	0.41		0.19		44.9	
8/14/75	1+	12.0	43.5	0.16	0.25 ± 0.11	0.13	0.22 ± 0.12	76.3	84.3 ± 11.3
		17.0	72.1	0.35		0.30		92.3	
10/10/75	0+	6.2	--	0.26		--		--	
		6.0	--	0.30	0.27 ± 0.02	--		--	
		7.6	--	0.25		--		--	
		4.5	--	0.26		--		--	
10/10/75	1+	13.5	32.3	0.20	0.20	0.16	0.16	76.4	76.4

APPENDIX XVII. THE DISSOLVED OXYGEN LEVEL OF THE EPILIMNION, THERMOCLINE, AND HYPOLIMNION OF COTTAGE GROVE RESERVOIR DURING 1975.

Date	Water level	Dissolved oxygen (mg/liter)
5/27	epilimnion	12.0
	thermocline	11.0
	hypolimnion	11.5
6/11	epilimnion	12.0
	thermocline	12.0
	hypolimnion	11.0
7/15	epilimnion	10.0
	thermocline	12.0
	hypolimnion	8.0
8/13	epilimnion	10.0
	thermocline	10.0
	hypolimnion	10.0

APPENDIX XVIII. THE WATER TEMPERATURE OF THE SURFACE, THERMOCLINE, AND BOTTOM OF COTTAGE GROVE RESERVOIR AND THE COAST FORK OF THE WILLAMETTE RIVER[10] DURING 1975.

Date	Water level	Temperature °C
Cottage Grove Reservoir		
5/27	surface	17.0
	thermocline	14.0
	bottom	9.5
6/11	surface	22.0
	thermocline	16.0
	bottom	10.5
7/15	surface	22.5
	thermocline	17.0
	bottom	10.5
8/13	surface	23.0
	thermocline	18.0
	bottom	12.5
Coast Fork of the Willamette River		
June		13.0
July		17.5
August		17.3
September		16.3
October		12.4

[10] *Temperature given is the average of the daily water temperatures of the Coast Fork.*

APPENDIX XIX. MERCURY CONCENTRATION (µG HG/G) IN 1+ CHINOOK SALMON FROM COTTAGE GROVE RESERVOIR IN THE SANDY RIVER HATCHERY USED IN THE SALTWATER MORTALITY STUDY.

Hatchery	Reservoir	
	Survived	Died
0.08	0.08	0.22
0.06	0.07	0.33
0.01	0.08	0.19[11]
0.02	$\bar{x}$ = 0.08 ± 0.01	$\bar{x}$ = 0.25 ± 0.07
0.07		
0.07		
$\bar{x}$ = 0.05 ± 0.03		

[11] *Fish found floating belly-up at end of experiment considered dead.*