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AVAILABILITY AND CONCENTRATION OF POLLUTANTS FROM AMERICAN FALLS RESERVOIR SEDIMENTS TO FORAGE AND PREDACEOUS FISHES

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Graduate students (James C. Kent, Gale R. Lewellen, Donald K. Campbell, and Virgil K. Moore) participated in this project and have increased their skills as aquatic biologists as well as increasing water quality problems. These students have contributed and gained from communication with EPA, U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, U.S. Geological Survey, U.S. Forest Service, Idaho Department of Fish and Game, Idaho Department of Health, and Idaho Power Company. They have presented their findings at regional meetings--American Fisheries Society (1974, 1975, 1976) and Idaho Academy of Science (1976).

All of the above-mentioned governmental agencies have an interest in this project as the findings relate to their management of environmental health, regulation of water quality, and protection of the sport fishery.

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INTRODUCTION

OBJECTIVES

An earlier report by the Idaho Health Department and Idaho Fish and Game Department indicated that American Falls Reservoir was polluted by mercury levels which constituted a threat to the ecosystem and public health (1,2). These findings resulted in a news release (Idaho State Journal, January 19, 1972) advising healthy adults not to eat more than one-half pound per week of fish from American Falls Reservoir and that pregnant women and children should completely avoid eating reservoir fishes. Subsequently the presence of dangerous levels of mercury in yellow perch (Perca flavescens), carp (Cyprinus carpio), and black bullhead (Ictalurus melas) was confirmed (3,4). The presence in American Falls Reservoir and resulting environmental threat of pollutants other than mercury had not been investigated.

The objectives of this project were: (1) Determination of predominant chlorinated bydrocarbon and heavy metal residues in American Falls Reservoir sediment, water, the dominant detritus-feeding "rough" fish, and dominant predaceous "game" fishes; (2) Correlation of the ecology of the abundant forage fish with the distribution and concentration of pollutants; (3) Determination of the effect of sediment drying, as well as variation in water temperature, pH, and dissolved oxygen on the stability and adsorption of these pollutants in the sediments; and to (4) Compare reservoir concentrations of organochlorines and heavy metals to standards established to protect aquatic biota and public health.

Elevated levels of mercury, cadmium, and chlorinated hydrocarbons have been identified in fish, sediment, and water. The levels present exceed those at which protection of aquatic species is recommended by the U.S. Environmental Protection Agency (EPA). The source of these pollutants remains to be identified as does their potential to measurably degrade the health, growth, and reproductive success of the reservoir fishery.

Four years ago all Utah sucker (Catostomus ardens) sampled from American Falls Reservoir contained less than 0.15 ug/kg mercury (3). The mean value in 1975 was 0.37 g/kg. This increase in contamination may threaten the reservoir population of this important prey species. If their reproductive success has been impaired a severe reservoir, construction-associated, drawdown in 1976 may have lasting effects. While water and sediment levels have remained relatively stable the availability of contaminated sediment to the detrital-feeding sucker may have increased as a result of the previous extreme drawdowns of recent years. Wind action on the shallow waters and recurrent drying may effectively increase introduction of pollutants into the reservoir food web.

ORGANOCHLORINES

Pesticides may enter the aquatic environment from the atmosphere, with industrial effluents, with silt and sediment in runoff waters, and from direct application. The major source of contamination is probably runoff from irrigation and flooding of agricultural lands. Laboratory and field data indicate that pesticides are readily adsorbed on particulate matter and are carried in the runoff water to the aquatic environment where they are concentrated in the sediment (5). Seasonal increases in pesticide residues that coincide with peak periods of agricultural uses have been reported (6,7). It has been stated elsewhere, however, that only a small portion of the residues in fresh water are via drainage or runoff from agricultural lands (8).

Adsorption to suspended particulate matter places the compounds in a finely dispersed and available form (9). Adsorption on the sediment facilitates the transfer of pesticides to the benthic invertebrates and other silt-dwelling organisms and in turn to fish. This can lead to the elimination of invertebrate populations and subsequently starve the fish who feed on those invertebrates.

Recent discovery of the presence of PCB's (polychlorinated biphenyl's) in the aquatic environment has generated a great deal of public concern. PCB's have become ubiquitous in world ecosystems in quantities similar to those of DDT (10). These industrial chemicals and their escape into the aquatic environment present a serious problem. Both salmon (Salmo salar) and striped bass (Morone saxatilis) from the upper Hudson River and Lake Ontario contained PCB's in concentrations from 5 to 20 mg/kg, well above the 2 mg/kg Canadian limit for edible fish (11).

Health problems associated with PCB's in the environment have been established. Investigations have shown that PCB's interfere with reproduction in rodents, fish, fowl, and primates. Animals fed PCB's develop intestinal ailments, enlarged livers, gastro-intestinal lesions, and abnormalities in the lymphatic system (11). PCB toxicity has been described in man. In 1968, 1,291 Japanese exhibited the same effects shown in laboratory animals when they consumed cooking oil which had been contaminated with PCB's (11).

These chemicals may enter the aquatic environment in a fashion similar to other chlorinated hydrocarbons, i.e., direct application or adsorbed on particulate matter in runoff. Silt laden with either pesticides or PCB's is carried by the current until it is deposited in slow-moving waters. Such is the case in reservoirs, where contaminated silt accumulates on the bottom. Forage fishes, such as the Utah sucker, are vulnerable to this accumulation in the sediment.

Research indicates that determination of pesticides in water alone is an inadequate measure for determining the safety of a fish population in a given habitat (12). Keith's studies emphasized the need to analyze both water and sediment samples (13). These values can be combined with other biological information such as fish residue values to give a good pesticide-pollution index (14).

MERCURY, ARSENIC, AND CADMIUM

The significance of heavy metals as pollutants of aquatic ecosystems has received greater attention since the discovery of mercury as the causative agent in "Minamata Disease." Approximately 10,000 residents of the eastern shore of the Shiranui Sea near Minamata, Japan have suffered from central nervous system degeneration induced by consumption of mercury contaminated fishes (15).

The potential hazards that can arise from continual deposition of heavy metals in lakes and rivers require detailed investigation of their toxicity and accumulation in aquatic organisms. While mercury has received the most attention, other metals, such as arsenic and cadmium, also contribute to the pollution of aquatic ecosystems.

Since the "Minamata incident," excessive amounts of mercury have been discovered in the aquatic habitat of other areas of the world. In 1970 the discovery of sizable quantities of mercury in Lake St. Clair and the Detroit River resulted in a ban on the sale of commercial catches of fish from these waters (16). Elevated mercury levels were also found in 10 species of fish from the Saskatchewan River (17). Fish sold from this area were restricted to those containing less than 0.5 mg/kg mercury. Over a three to four month period one million pounds of fish were destroyed. In December 1970, two and one-third million cans of tuna were confiscated because one percent had a mercury content above the Food and Drug Administration (FDA) standard of 0.5 mg/kg. More recent studies of fishes from Idaho, California, Oregon, and Washington revealed maximum levels up to 1.9 mg/kg mercury (18).

Even though widespread pollution of the aquatic environment by cadmium has not been reported, incidents of cadmium pollution have been found. In 1970 the Japanese proved that cadmium was the cause of the disease "itai-itai." It was contracted by eating rice that had been irrigated with river water polluted by runoff from a cadmium mine (16). Cadmium is present in natural waters in very low amounts (19). A nationwide survey of 720 lakes and rivers in the United States revealed that only 4% of the samples were greater than 0.01 mg/l (20). Little data are available on cadmium residues in freshwater fish. Fishes from 49 freshwater sources in New York had an average concentration of 0.02 mg/kg or below. A mean value of 0.09 mg/kg was found in four species of fish from the Great Lakes (21). Cadmium is a byproduct of zinc, lead, and copper smelting as well as several other industrial processes. Phosphate fertilizers contain 50 to 170 mg/kg cadmium (22). Waters located in phosphate mining and processing areas in Idaho, as well as downstream reservoirs, should be monitored for potential cadmium pollution.

It is not known whether man's contribution has significantly increased the levels of cadmium in the ocean. Sea water contains 0.1 mg/l cadmium (23). Marine organisms, particularly molluscs, concentrate cadmium from very low levels. The cadmium is concentrated in the calcareous tissues and in the viscera (24). Fishes from the North Atlantic contained cadmium levels from less than 0.1 to 2.1 mg/kg. In herring, cod, and whiting from the coastal area of southern Norway, cadmium concentrations ranged from 0.002 to 0.12 mg/kg.

Arsenic was found in less than 6% of water sampled in 1962 by the Federal Water Quality Administration. Four percent of the samples from Lake Erie had an average of 0.038 mg/l arsenic (16). Accumulation of arsenic in aquatic organisms has not been well documented. Fishes of the North Atlantic contain concentrations of arsenic from less than 1.0 to 19.0 mg/kg (22). Mean values of .006 to .08 mg/kg were found in 15 species of fish from the Great Lakes (21). Poisoning from high levels of arsenic in water are rare; however, such poisonings have occurred in New Zealand (25).

Arsenic occurs in nature in small amounts in the elemental form; it is found mostly as arsenides of metals or as pyrites. Copper, lead, zinc, and tin ores contain arsenic and it can enter the aquatic habitat in effluent from their processing. The major use of arsenic has been as a pesticide and wood preservative. It has been used in Southern Idaho to kill potato vines prior to harvest. It has been replaced, for the most part, by the more popular organochlorines, organophosphates, and burning of potato vines. In waters carrying or in contact with natural colloidal materials, the dissolved arsenic content may be decreased to a low level by adsorption.

All of these metals may attain high concentrations in aquatic habitats. Reservoirs are particularly prone to act as a "trap" for silt and suspended particulate matter in runoff. Biomagnification by fishes may occur, rendering them unfit for consumption. Such has been the case in Idaho. In 1970 the Idaho Health Department collected 160 fish from Idaho waters and analyzed them for mercury content. Approximately 19% of the fish collected exceeded the FDA standard of 0.5 mg/kg. Thirty percent of the fish taken from American Falls Reservoir had levels exceeding 0.5 mg/kg. Similar mercury concentrations were found in fish taken from other impoundments on the lower and middle Snake River (1). Further investigations in 1971 found a mean of 0.88 mg/kg with 57% of the total sample at or above 0.5 mg/kg. Rainbow trout (Salmo gairdneri) in American Falls Reservoir had a mean value of 0.33 mg/kg with a maximum of 0.91 mg/kg. Elevated levels were also detected in brown trout (Salmo trutta) and cutthroat trout (Salmo clarki). Yellow perch from the reservoir had concentrations in muscle tissue of 0.09 to 0.84 mg/kg (2). Mercury concentration in American Falls Reservoir fishes has been a problem. Has mercury continued to be accumulated in the reservoir and are other metals, such as arsenic and cadmium, also being transported into the reservoir and accumulated by the sediment and fishes?

AVAILABILITY OF POLLUTANTS FROM RESERVOIR SEDIMENTS

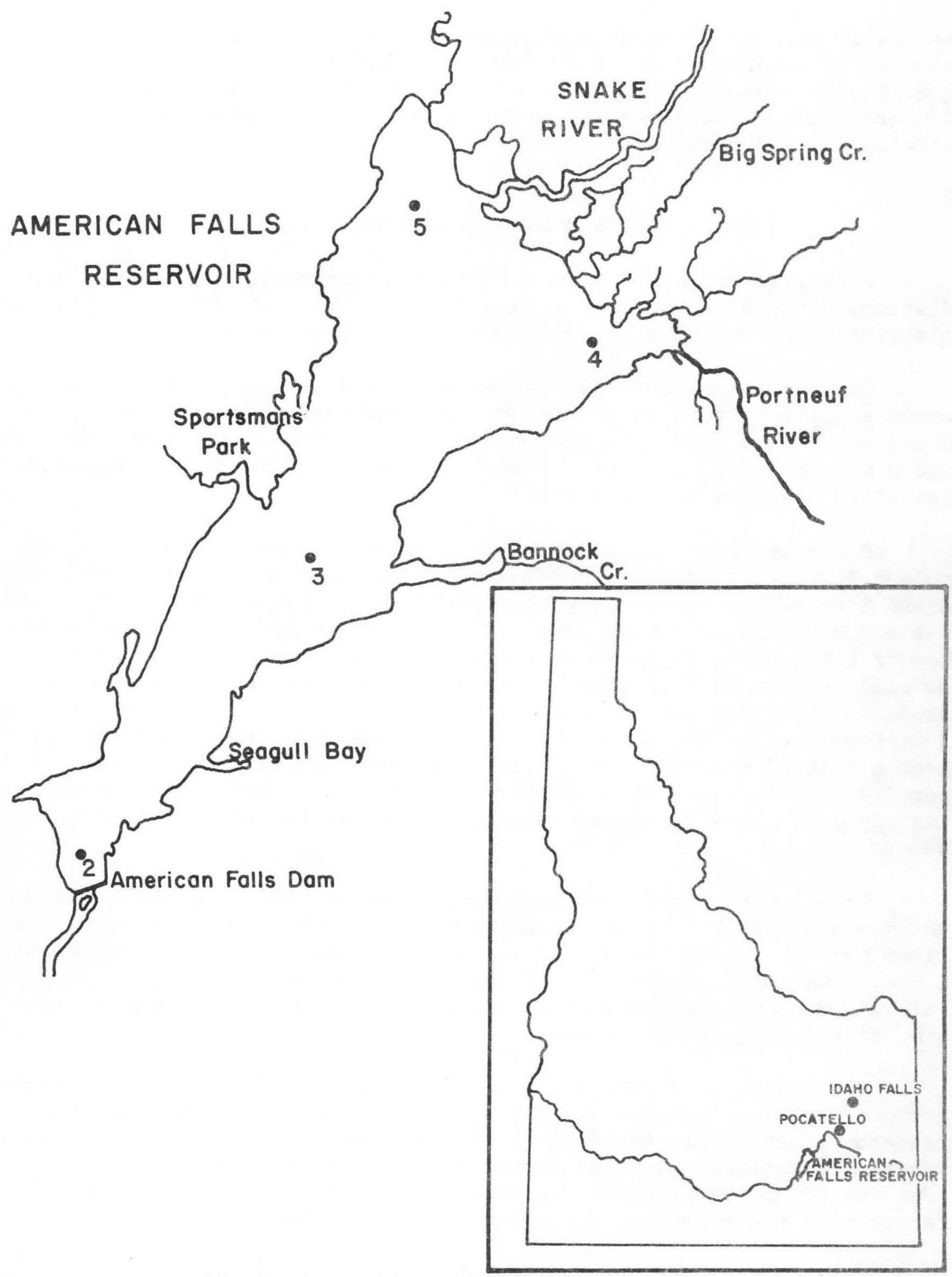
The effect of exposure of bottom deposits to drying, as well as variation in water temperature, pH, and dissolved oxygen on the stability and adsorption of reservoir sediment contaminants is unclear. A judgment of the toxicity of a given water and/or sediment with its unique combination of pollutants and interacting physical, chemical, and biological factors can best be based on a study of that specific environment (26, 27).

An attempt has been made to better understand how reservoir manipulation might affect the availability of toxic contaminants associated with sedimentary deposits.

DESCRIPTION OF THE STUDY AREA

American Falls Reservoir is located on the Snake River in Southeastern Idaho downstream from Idaho Falls and Pocatello (Fig. 1.). The reservoir has a capacity of approximately 2.0×10^9 cubic meters (1.7×10^6 acre feet) when full and a surface area of 22,663 hectares (ha). The reservoir is 35 km long and varies in width from 1.6 km at the dam to 16 km at the upper end. It has shoreline of 249 km and a maximum depth of 21 meters (28). During this study the maximum storage capacity was reduced by 34% because of structural deterioration of the dam. A new dam is currently under construction with the present dam serving as its core.

The upper Snake and Portneuf River watersheds are the major sources of reservoir waters; however, Big Spring Creek and several smaller springs contribute as much as 22% of the reservoir inflow (Fig. 1 and Table 1).



1. Location of American Falls Reservoir and sites from which samples were collected for chlorinated hydrocarbon and heavy metal analysis.

Reservoir storage provides irrigation for 3.6×10^5 ha and the powerhouse has a generating capability of 18,000 kw. A highly successful, diversified agriculture has developed during the half century since irrigation has been intensified. The principal crops grown in this area are cereals, potatoes, beans, sugar beets, alfalfa hay and pasture.

METHODS OF COLLECTION

Fish were collected from the reservoir by four techniques: electrofishing, otter trawl, gill net, and creel census. Of the techniques employed electrofishing and otter trawling were most extensively used.

Travel on the reservoir was accomplished in an open-decked Kenner Ski-Barge equipped with a 50 HP Mercury outboard motor with a 20 HP Mercury outboard motor as a back-up. The boat displaced very little water and sampling could be completed in 30 cm of water. It was outfitted with removable booms for electrofishing and trawling.

Electrofishing equipment was a 1500 watt portable AC-DC generator. A pulsed DC voltage was used. The amperage used during sampling varied between 4 and 8 amps, but was usually maintained at 6-7 amps. The positive electrode was a 5 cm diameter copper tube 1.2 m long suspended from two booms off the bow of the boat by light gauge chain. The negative electrode consisted of several lengths of 5 cm diameter flexible aluminum conduit 1.2 m long. The negative electrode was suspended from the port side of the bow. A "dead-man's" foot-pedal switch was used so that one person could shock and dip fish while a second piloted the boat. Electrofishing was used to sample fishes in the upper 2 m of water. In turbid waters the effective depth was decreased to approximately 1 m. This technique was very effective in sampling fish in shallow waters.

Trawling was used to sample deeper waters. Effectiveness was enhanced by the drawdown of the reservoir as the summer progressed. The otter trawl utilized had a 2.5 m wing span and the vertical span of the net was approximately 1.5 m. The top, forward edge of the trawl was equipped with floats. Depth was maintained by the weighted otter boards and a chain interlaced through the bottom, forward edge of the trawl.

Each trawl or shocking run was 30 minutes. The following data were collected: species, length, weight, sex (if possible), as well as stomachs of predatory fish. Selected fish were preserved for later reference and an ISU museum collection. Fish and stomachs were preserved in 10% formalin and later transferred to 40% propanol or isopropanol. The vast majority of the fish were returned to the reservoir following data collection.

Stomach analysis was carried out during the winter. The wet weight, volume, and index of fullness (an arbitrarily derived scale for ranking the degree of fullness) were recorded for each fish as well as locality, time of capture, means of capture, and associated physical parameters (temperature and dissolved oxygen). Each food item was classified to Family or Genus when possible. Those food items too far digested for probable Family identification were classified as low as possible, usually Class or Order.

Table 1. Inflow Source for American Falls Reservoir in 1969 (29).

Contributing Source	Minimum Inflow (July) Volume (c.f.s.)	Percent of Total	Maximum inflow (June) Volume (c.f.s.)	Percent of Total
Snake River	955	29	6,287	69
Portneuf River	4	0	605	7
Big Spring Creek	455	14	466	5
Danielson Creek	63	2	49	1
Jimmy Drinks Creek	22	1	28	0
Bannock Creek	47	1	43	1
Other measured springs	297	9	285	3
Other sources	1,433	44	1,415	15
Total Inflow	3,268	100	9,178	100

Fish from each species were divided into size classes based on abundance (see Appendix II). A species diversity index was applied to each sampling station by collection period (see Appendix I). The equation used to derive the index was that of Shannon-Weaver:

$$d = - (n_i/n) \log_2 n_i/n$$

As with any biological index, its significance is limited by the natural history of the area to which it is being applied. It, therefore, only has meaning when taken in context of the whole area.

RELATIVE ABUNDANCE OF FISHES

Several species of fish are present in the reservoir. Native game fish present are the cutthroat trout* and mountain whitefish (Prosopium williamsoni)**. Game fish which have been introduced include rainbow trout**, brown trout*, kokanee (Oncorhynchus nerka)*, yellow perch***, white crappie (Pomoxis annularis**, black crappie (Pomoxis nigromaculatus)***, largemouth bass (Micropterus salmoides) ***, and the black bullhead (Ictalurus melas)***. Native non-game species include the Utah sucker***, Utah chub (Gila atraria)***, longnose dace (Rhinichthys cataractae)**, speckled dace (Rhinichthys osculus)**, and sculpin (Cottus sp.)***, as well as introduced redside shiner (Richardsonius balteatus)***, mirror and common carp***, and fathead minnow (Pimephales promelas)*. Carp and sucker are harvested commercially and sold for human consumption and as a fish food component. The relative abundance of fishes collected in 1975 is shown in Table 2.

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* rarely collected
** uncommonly collected
*** commonly collected

The trout fishery in American Falls Reservoir is the result of immigration from upstream sources and an annual planting of rainbow trout by the Idaho Fish and Game Department (IFG). From 1963 to 1973 an average of 65,000 trout were planted in the reservoir. In 1974 the number dropped to 50,000 (30). Peak fishing pressure occurs during June and July when a large number of anglers troll. From late August to December a small number of anglers are normally present near the dam. Ice fishing occurs from January to March. Yellow perch are an important component of the ice-fishing catch. From April to May the pressure slowly increases. There are no precise estimates of angling pressure at the reservoir; however, it has been estimated that fishing time is between 15,000 and 25,000 angler days and between 45,000 and 75,000 angler hours annually (30).

Table 2. Relative abundances of fishes in American Falls Reservoir in 1975.* Fish were collected by electrofishing, otter trawl and gill net (one occasion). Selectivity of gear did not allow capture of trout (see methods).

Fish Species	Total Captured	% of All Fish Captured
Catostomus ardens Utah sucker	4728	41.3
Gila atraria Utah chub	957	8.4
Perca flavescens Yellow perch	1970	17.2
Cyprinus carpio Carp	713	6.2
Richardsonius balteatus Redside shiner	247	2.2
Pomoxis nigromaculatus Black crappie	472	4.1
Ictalurus melas Black bullhead	2165	18.9
Prosopium williamsoni Mountain whitefish	14	0.1
Cottus spp. Sculpin	170	1.5
Pimephales promelas Fathead minnow	1	0.1
Micropterus salmoides Largemouth bass	1	0.1
TOTAL	11438	100.0

* see Appendix II for data used to compute the relative abundances.

DISTRIBUTION AND FOOD HABITS OF FISHES

Distributional data were collected to answer the following questions: (1) What are the distributional interrelationships (especially predator and prey species) of American Falls Reservoir fishes; and (2) Are there significant migrations of fishes between areas of the reservoir? Gear selectivity and relatively low density populations did not allow an adequate sampling of reservoir trout populations. Relative abundance by collecting station is presented in Table 3. Food item selection is summarized in Table 4. A critique of each sampling area follows:

Spring Hollow. This area is located approximately 2 km north of the American Falls Dam (Figure 2). It is fed by a small spring whose natural flow is interrupted by a highway; water now flows through a culvert. It is a narrow inlet with a sandy beach on one shore and vegetation covering the other. Large rocks make up the end of the inlet where the stream enters. The area was observed during a reconnaissance survey in early June and the only fish seen were two large carp and three Utah suckers. However, on July 15, nearly 700 fish of 8 species were collected (see Appendix Ia). The vast majority of these were fingerling (sucker, carp, perch and crappie) indicating that adults had migrated into the area to spawn. Though total numbers of fish diminished, the diversity of the area continued to increase through the summer. Stomach analysis of the predaceous black bullhead from the area showed that fry and fingerlings of suckers and possibly perch were being utilized as a food source (Table 4-1). Adult perch were uncommon in the area. As the reservoir was drawn down through the summer the water level in Spring Hollow continued to fall until there was only the small creek running through the Hollow.

Spring Hollow is used primarily as a spawning ground for a variety of fishes and subsequently supplies forage for at least one predatory fish. A variety of birds, including Western grebes, great blue heron, California and Franklin gulls, also utilize the area indicating that it also provides forage for the avian community of the reservoir.

Marmot Bay. This area is located approximately 3 km north of the dam. It is protected from much of the turbulence and wave action of the main reservoir, which occurs quite regularly through the summer months, by a basalt outcropping. It was chosen for its variety of shore line which changes from basalt boulders to a pebble beach to sand to muck. There is an agricultural drain culvert emptying waste water into the bay. The littoral zone is narrow, descending rapidly to a depth of approximately 4-5 meters several meters from shore. A maximum mid-bay depth of 11 m was recorded in July.

Like Spring Hollow, this area had little fish life in June but increased in July. Suckers, perch, and bullhead utilized the area for spawning. There appeared to be two distinct hatches of suckers in July and September. Perch fry were found in July and bullhead fry in September, coinciding with the sucker hatch. Migration out of the bay occurred following spawning for both predator fish, although the sucker population remained reasonably high.

The majority of fish were captured in and around the rocks. Very few were taken along the beach area although several large suckers were taken near the agricultural waste inlet.

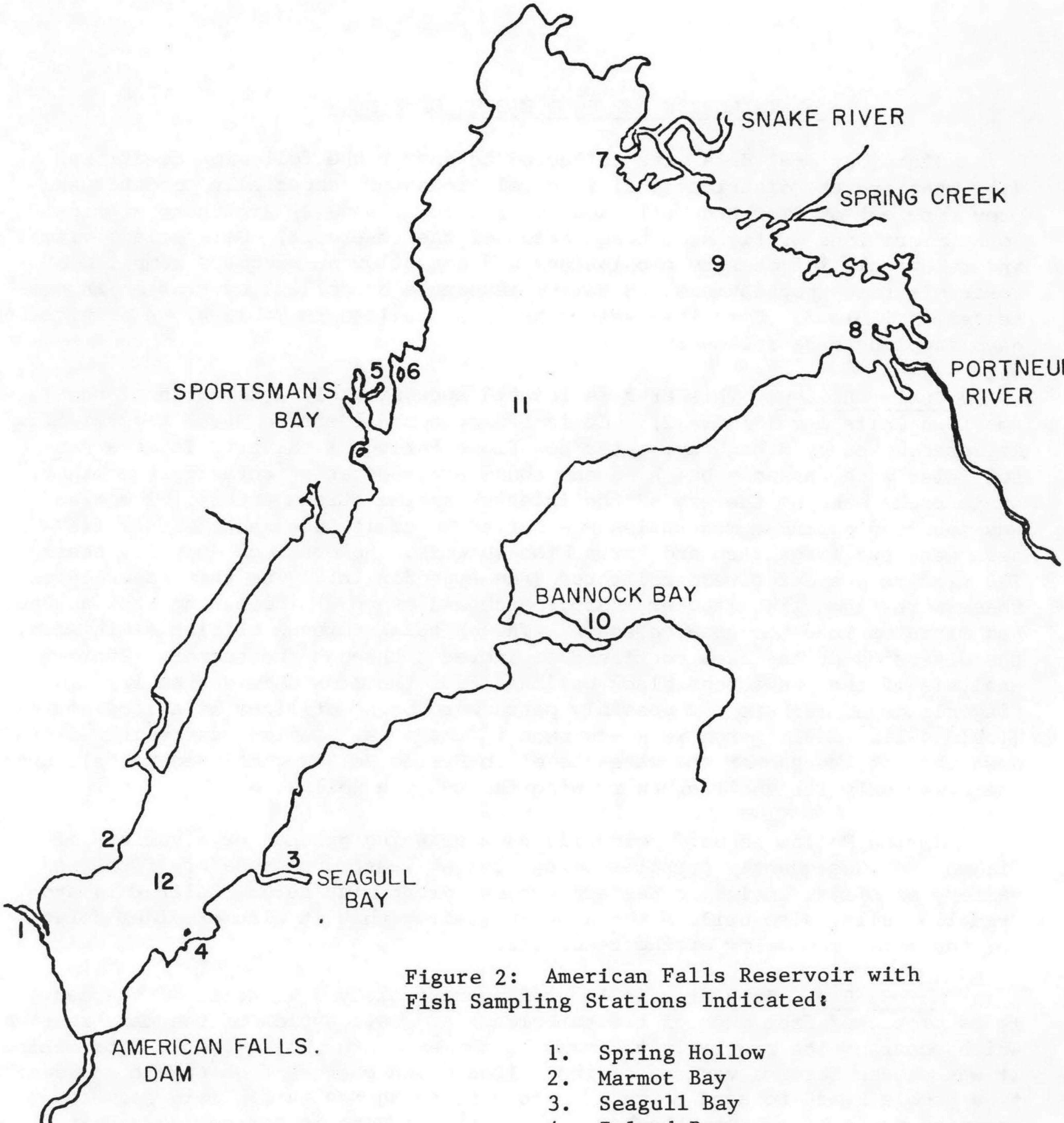


Figure 2: American Falls Reservoir with Fish Sampling Stations Indicated:

1. Spring Hollow
2. Marmot Bay
3. Seagull Bay
4. Island Bay
5. Sportsman's Bay
6. Scout Island
7. Snake River Delta
8. Portneuf River Area
9. Upper End: Snake to Portneuf
10. Bannock Bay
11. Midwater Upper End
12. Midwater Lower End

2. American Falls Reservoir with Fish Sampling Stations Indicated.

Table 3. Total numbers of each species at each collecting station in American Falls Reservoir 1975. Where a species comprised greater than 10% of the catch the percentage is included in parentheses.

	COLLECTING STATION						
FISH SPECIES	SPRING HOLLOW	MARMOT BAY	SEAGULL BAY	ISLAND BAY	MIDWATER LOWER END	MIDWATER UPPER END	SPORTSMAN'S BAY
Catostomus ardens Utah sucker	904(67)	1375(49)	459(23)	220(65)		24(71)	472(25)
Gila atraria Utah chub	40	135	109	30		2	98
Perca flavescens Yellow perch	145	372(13)	168	46		6	389(21)
Cyprinus carpio Carp	100	39	275(14)	33		2	67
Richardsonius balteatus Redside shiner	84	24	3	1			64
Pomoxis nigromaculatus Black crappie	51	23	93	10			227(12)
Ictalurus melas Black bullhead	20	679(24)	920(45)	1			518(28)
Prosopium williamsoni Mountain whitefish	6		1				
Cottus spp. Sculpin	4	118	1				23
Salmo gairdneri Rainbow trout		12					
Salmo clarki Cutthroat trout		1					
Pimephales promelas Fathead minnow	1						
Micropterus salmoides Largemouth bass							1
TOTALS (Station)	1355	2778	2029	341		34	1859

Table 3. (Continued)

FISH SPECIES	COLLECTING STATION SCOUT ISLAND	SNAKE RIVER DELTA	PORTNEUF RIVER	UPPER END SNAKE TO PORTNEUF	BANNOCK BAY
Catostomus ardens Utah sucker	478(43)	300(44)	131(34)	5	360(43)
Gila atraria Utah chub	375(34)	10	92(24)	1	65
Perca flavescens Yellow perch	110	343(50)	42(11)	30(81)	319(38)
Cyprinus carpio Carp	78	13	97		9
Richardsonius balteatus Redside shiner	32	6	9	1	23
Pomoxis nigromaculatus Black crappie	6		9		53
Ictalurus melas Black bullhead	12	1	1		13
Prosopium williamsoni Mountain whitefish		6	1		
Cottus spp. Sculpin	14	6	1		3
Salmo gairdneri Rainbow trout					
Salmo clarki Cutthroat trout					
Pimephales promelas Fathead minnow					
Micropterus salmoides Largemouth bass					
TOTALS	1105	685	383	37	845

Table 4-1. Food item preference of three predatory fishes of American Falls Reservoir -- Rainbow Trout (*Salmo gairdneri*), black bullhead (*Ictalurus melas*), and yellow perch (*Perca flavescens*). These species were collected during regular sampling in 1974 and 1975, by methods previously mentioned. (Techniques in the summer of 1975 allowed the more efficient capture of catfish and perch - see methods). In the table, N = species sample size; n = number of fish of the species containing the food item; % = the percentage of fish of the species containing the food item.

	RAINBOW TROUT				BLACK BULLHEAD				YELLOW PERCH			
FOOD ITEM[1]	1974 (N=13)[2]		1975 (N=17)[3]		1974 (N=2)[2]		1975 (N-29)[4]		1974 (N=2)[2]		1975 (n=36)[4]	
	n	%	n	%	n	%	n	%	n	%	n	%
Pisces	3	23.1	1	5.9			4	13.8	1	50.0	9	25.0
Catostomus ardens	1	7.7					13	44.8	1	50.0	8	22.2
Cyprinius carpio												
Pomoxis nigromaculatus	7	53.8										
Perca flavescens	5	38.5										
Gila atraria	1	7.7					1	3.4				
Annelida			1	5.9			1	3.4			1	2.8
Hirudinea			1	5.9								
Cladocera	3	23.1	1	5.9	1	50.0	3	10.4			2	5.6
Daphnia spp.	5	38.4	12	70.6	1	50.0	2	6.9			6	16.7
Leptodora spp.			12	70.6	1	50.0	2	6.9				
Bosmina spp.											2	5.6
Conchostraca			3	17.6								
Malacostraca												
Hyalela spp.			3	17.6			1	3.4			1	2.8
Gammarus spp.			1	5.9								
Insecta							5	17.2			5	13.9
Ephemeroptera	1	7.7					3	10.4			2	5.6
Odonata			1	5.9			1	3.4			2	5.6
Plecoptera	1	7.7										
Hemiptera					1	50.0						
Corixidae	1	7.7					2	6.9	1	50.0	3	8.3
Coleoptera												
Dytiscidae							2	6.9				
Hydrophilidae	1	7.7					1	3.4			1	2.8

Table 4-1 (Continued)

FOOD ITEM [1]	RAINBOW TROUT 1974 (N=13) [2]		RAINBOW TROUT 1975 (N=17) [3]		BLACK BULLHEAD 1974 (N-2) [2]		BLACK BULLHEAD 1975 (N=29) [4]		YELLOW PERCH 1974 (N=2) [2]		YELLOW PERCH 1975 (N=36) [4]	
	n	%	n	%	n	%	n	%	n	%	n	%
Tricoptera												
Hydropsyche sp.			3	17.6							1	2.8
Diptera			1	5.9								
Chironomidae												
Larvae	2	15.4	8	47.1	2	100.0	19	65.5	1	50.0	18	50.0
Pupae	1	7.7	8	47.1	2	100.0	9	31.1				
Simulidae			1	5.9			2	6.9				
Mollusca							2	6.9				
Lymnea spp.							2	6.9				
Physa spp.							1	3.4				
Gyranulus spp.							2	6.9				
Annicola spp.							1	3.4				
Sphaeridae							1	3.4				
Acarina							2	6.9				
Detritus			3	17.6			18	62.1			17	47.2
Sand--dirt							5	17.2				
Other:												
Corn	3	23.1	2	11.8								
Salmon eggs			1	5.9								

[1] Due to digestion, several items could not be identified beyond "class" or "order". They have been included as such.
[2] Collected July and August 1974.
[3] Collected January, February, July 1975.
[4] Collected June - October, 1975.

Table 4-2. Food item preference of two predatory fishes of American Falls Reservoir. -- Cutthroat trout (*Salmo clarki*) and black crappie (*Pomoxis nigromaculatus*). The sample sizes are small due to a small population or gear selectivity (see text). In the table, N + species sample size; X = presence of food item.

FOOD ITEM[1]	CUTTHROAT TROUT 1974 (N=1)[2]	CUTTHROAT TROUT 1975 (N=1)[3]	BLACK CRAPPIE 1974 (N=1)[2]	BLACK CRAPPIE 1975 (N=1)[3]
Pisces			X	
Catostomus ardens				X
Pomoxis nigromaculatus	X			X
Perca flavescens				X
Cladocera				
Daphnia spp.	X	X		
Leptodora spp.		X		X
Malacostraca				
Hyalella spp.		X		
Diptera		X		
Chironamidae				
Larvae		X	X	
Pupae		X		
Insecta				X
Detritus			X	

[1] Due to digestion, several items could not be identified beyond "class." They have been included as such.
[2] Collected August, 1974.
[3] Collected July, 1975.

The only trout obtained during the study came from this area. Three fishermen had caught 12 rainbow and 1 cutthroat trout trolling in the vicinity of the bay. Though none of the fish contained fish food items, they were present at the time of the July sucker and perch hatch and thus could have utilized this food resource.

Catfish taken from this area at this time also did not contain any fish in their stomachs; like the trout they contained large numbers of cladocerans and Chironomidae (Table 4-1). This may be because forage fish are able to obtain protective cover in the rocky-shore line habitat.

Seagull Bay. Seagull Bay is located on the southern shore of the reservoir and provides one of three boat accesses to the reservoir. It is the only location having full-time residents during the summer months and these persons provided much information concerning water level fluctuations and fish kills through the study period. It is a narrow bay fed by a small stream at its southern end.

This area provided the most diverse habitat of the stations in the lower (southeast) end of the reservoir and this was reflected in the diversity of species present. The stream end of the bay, at high water, was a shallow marsh which provided spawning habitat for carp. Catfish also utilized the area for spawning at the end of July. The fry and fingerlings of perch, suckers, chubs, and crappie were all found in the bay.

Perch and catfish analyzed for food items showed a preference for sucker fry and fingerlings, and to a lesser degree, chub fingerling. Other major food items included Chironomidae, Corixidae, and Cladocera (Table 4-1).

Seagull bay, in addition to having a diverse fish population, also harbored fish-eating birds which included great blue heron, California and Franklin gulls.

Island Bay. This collecting station is a large bay approximately half way between the American Falls Dam and Seagull Bay on the south side of the reservoir. It is characterized by a large aquatic macrophyte population along its eastern shore where a small creek empties into the bay, a long sandy beach along the southern shore, and at high water a small island in its center. Sand is the primary bottom substrate throughout the area, changing to a relatively firm muck within the boundaries of the aquatic plants. The channel separating the island from the mainland was 4 m deep at high water and affords habitat for aquatic plants.

This area was not very productive from a fishery standpoint, most likely due to the large areas devoid of any protective cover. Though a few fish were taken in open water by electro-fishing, the majority of fishes were taken in the areas of vegetation.

Very few predatory fish were captured. Although many perch were collected, no adults (> 150mm) were observed. Only one bullhead was collected. Stomach analysis showed that sucker fingerlings were being consumed as well as a large number of Chironomidae and detrital material (Table 4-1).

The diversity of fishes in the area increased as the summer progressed before falling to zero with late summer reservoir drawdown. It does not appear to be a major spawning area and those fishes inhabiting it are probably transitory.

Bird life in the area was sparse which could be interpreted as a reflection of the fish population.

Sportsman's Bay (Big Hole by U.S.G.S.). Sportsman's Bay is located approximately midway along the north side of the reservoir. This is the second of the three boating accesses to the reservoir. Its proximity to Aberdeen (3km) causes this area to be used more by the public for boating, fishing, and hunting activities. It is also utilized in the winter for ice fishing. This is the only access that was functional throughout the entire collecting period.

Sportsman's Bay presents a variety of habitats for fishes. It is fed by many springs located along each "finger" of the bay. Marshy areas of clean water offer spawning grounds for many species (perch, sucker, chub, crappie, carp, shiners, catfish--see Appendix II). Moving from the marshy areas toward the main body of the bay are basalt cliffs. The channel along the cliffs was 4.5-5.8 m at high water. The cliff area, with associated springs and marshes, offers a diverse range of habitats which is reflected in the number of species captured.

Black bullhead and yellow perch stomach contents indicated that a variety of organisms (molluscs, insects, cladocerans, detritus) were consumed, but of the available fish, only sucker fry and fingerling were selected (Table 4-1).

The avian population in this area is large. In excess of 10,000 gulls nests on Seagull Island adjacent to the bay. In addition, great blue heron, black-crested night heron and Caspian tern were observed.

Scout Island. This area is located less than 1 km northwest of Sportman's Bay and was selected because of the presence of many springs flowing into the channel surrounding the island.

The channel in areas trawled varied from 3-5 m deep until reservoir drawdown. Like Sportsman's, basalt cliffs were present. These were on the mainland shore to the island's west and along the southern shore of the island itself. The remainder of shoreline consisted of grassy marsh-type areas and sand, and mud beaches. The beaches and cliffs were the shocking stations.

Fishes present were primarily prey species (see Appendix I-f). Numbers in each size class indicated that it was primarily a spawning and rearing area. Very few adults of any species were captured.

Predatory species were not plentiful. Only one adult perch and 3 catfish were taken. The perch contained only chironomids, although it was captured with forage fishes. The catfish were feeding on sucker fry and fingerling as well as cladocerans, chironomids, other insects (too far digested to be positively identified), and detritus (Table 4-1).

The bird population in the vicinity of Scout Island was slightly more diverse. In addition to those previously mentioned were white pelicans and cormorants.

Snake River Delta. This collecting station was located at the upper end of the reservoir, approximately 34 km from the dam at high water. This end of the reservoir is hard to sample because of currents, turbidity, submerged trees, and as the summer progresses and drawdown continues, shallow water.

The final collection in the delta area was made in 1-1.5 meters of water, 0.5-1 km NW of Scout Island due to drawdown. Heavy mud and sands bars and shallow water (< .2m) prevented sampling in the original area. Previously, depths were 2 to 6 meters near the mouth of the Snake River. Sampling indicated that fishes did not congregate in this area except in September when drawdown had a concentrating effect on the population. This was evident in all sampling areas at the upper end of the reservoir. Whitefish were collected in this area. Relative abundance changed slightly; however, suckers continued to be the dominant species. No predatory fish were collected for stomach contents from this area.

The delta area was frequented by several thousand white pelicans, as well as gulls and cormorants.

Portneuf River. Like the Snake River, the Portneuf River sampling area was 34 km from the dam and opposite the Snake River. The sampling area was located near the junction of the river and reservoir. The area was easy to sample as the river channel is well defined by a large aquatic macrophyte growth along the channel borders because of shallow waters.

The efficiency of shocking in this area was impaired by the extremely dense macrophyte cover. Many fish may have been shocked and not collected.

The diversity of fishes collected increased as the summer progressed. The presence of fry and fingerling suggest that the area may be used as spawning grounds or simply protective cover by perch, crappie, sucker, chub, and carp. Only one black bullhead was observed in this area throughout the summer. Stomach analysis showed that it had been feeding on chironomids, molluscs, insects (Ephemeroptera), and fish (could not be positively identified). Perch analyzed for food habits contained sucker fry and fingerling, chironomids, Hyalella spp. and Ephemeroptera (Table 4-1).

The bird life at this area was the most diverse of any area sampled. Observed were great blue heron, gulls, cormorants, black-crested night heron, white pelican, snowy egret, and a variety of ducks.

Upper End: Snake to Portneuf. This area was located at the extreme upper end of the reservoir and, as the name implies, was between the Snake and Portneuf rivers. The physical and aquatic environment at this station reflected that of both of the above areas and water conditions and levels were similar. Only open water was sampled by trawling .25 to .5 km from shore.

Few fish were collected. Those fish taken were fry and fingerling, indicating that larger fish were avoiding the trawl or that they were simply not present. No large predators were collected. The number of fish taken indicates that this vicinity was of limited use.

The bird population was similar to that of the Portneuf and Snake River area. Their presence possibly indicates that fish were present closer to shore than in the area sampled.

Bannock Bay. Bannock Bay is located midway along the length of the reservoir's southern shore. It is fed by a large creek (Bannock Creek) that drains an agricultural area. It is a large bay with a mud bottom near the stream inlet and rock substrate as one nears the mouth of the bay.

It was not included in the original sampling scheme; however, collections began in mid-July after eliminating the two midwater stations in the upper and lower ends.

The diversity was high at the initial sampling in July but was quite low in August. The July collections indicated that the area had been utilized as a spawning area for several species--perch, sucker and crappie. Stomach analysis of the perch present indicated that they were feeding on sucker fry, cladocerans, chironomids, and detritus (Table 4-1). No catfish stomachs were taken for analysis; however, adults were present at this time also and could have utilized the forage fish.

Those birds observed were California and Franklin gulls, as well as great blue heron.

Midwater Stations-Upper and Lower Ends. These two stations were chosen to determine what fishes if any were present in the deeper section of the reservoir. Their locations are indicated on Fig. 2. No fish were collected. Both of these were sampled only once and dropped as collecting stations, with the addition of Bannock Bay and resulting time limitations.

Major Fishes

Utah sucker. Suckers are by far the most numerous fish in the reservoir and constitute a major food source for predatory fishes of the reservoir. During the study large numbers of adult fish were found dead in all portions of the reservoir in early July, before any algal bloom of consequence occurred. At this time most adults taken were in poor condition, having fungus-like ulcerations on their heads, eyes, nostrils and where scales were missing. The extent of the problem could not be attributed solely to spawning activities as was suggested (personal communication), but was indicative of other undefined problems. Unfortunately no work was done to determine the exact cause of this phenomenon. As the summer progressed, following a large "die-off", fewer suckers were captured having the ulcerations.

Perch. Perch are widespread throughout the reservoir but appear to favor protected areas with plant cover. Several perch captured in July and August also had the ulcerations exhibited by the suckers. Incidence of ulcerations again decreased as the summer drew to an end. As reservoir dissolved oxygen (D.O.) levels fall from late June to September, perch migrate through the dam penstocks into the forebay area and create a fishery in this area.

Carp. A wide-ranging species in the reservoir, adult carp were captured in all areas except the midwater station in the lower end. Carp were observed spawning in all shallow areas during the late summer. Adult carp also demonstrated the ulceration pattern described above.

Utah chub. This species is also widespread throughout the reservoir. Few adults were taken by trawl or electrofishing. Chub are present in large numbers and can most easily be sampled using gill and trammel nets.

Catfish. This species was present at most areas but was primarily found in water deeper than 3 m and near concentrations of forage fish. Catfish fry were observed in late July and August. Ulcerations were exhibited by some adults captured and followed the same course as the other fishes.

Crappie. Only 2 adults were taken through the collection period. Many fry and fingerling were collected indicating a potential for an improved crappie fishery in the future.

Trout. Trout are stocked on a put-and-take basis by the Idaho Fish and Game Department with no indication of natural reproduction within the reservoir. Some downstream migration may occur from above the reservoir. As reservoir D.O. levels drop in late June, trout leave the reservoir by passing through the dam and create a very popular fishery in the forebay.

Previously unreported fishes in American Falls Reservoir. A fathead minnow (*Pimephales promelas*) was taken at Spring Hollow on July 28, 1975 between 2100-2130 by electrofishing. Only one individual was captured during the study. The minnow, 50 mm long and weighing 2 gms, was preserved and retained in the ISU museum collection.

One largemouth bass (*Micropterus salmoides*) was also collected during the study. It was captured between 1100-1130 at Sportsman's Bay August 29, 1975 by electrofishing. It was present with perch, carp, sucker, and crappie fingerling and adults. The bass was 80 mm long and weighed 12 gms. Bass have not been planted by the Idaho Department of Fish and Game (John Heimer, personal communication, 1975).

Some ecological observations based on the 1974 field season.

One of the project objectives was to correlate the ecology of reservoir fishes with water quality--including dissolved oxygen and temperature. Possible D.O.-related distribution patterns included the following. A general lack of activity of all fishes, both game and nongame, is common when dissolved oxygen is less than 4.5 mg/l. Trout feeding is apparently curtailed following a drop in D.O. Trout feeding and movement increase when D.O. levels increase to greater than 6 mg/l. When D.O. is adequate and water temperature is 16 to 21^{o} C maximum "rough" fish activity occurs at sunset, with lowest activity at sunrise. Chub, bullhead, and perch are generally found in areas that exceed 6 mg/l, but tolerate 4 to 6 mg/l. Utah sucker were collected from water with D.O. as low as 0.6 mg/l.

Sucker inhabit all depths of the reservoir, while most common near the bottom. Chub are most common at the surface and were not collected in more than 10 m of water. Sucker and chub were both most abundant near shore, but were also found in open water. Chub avoid or move out of shallow areas after a rapid drop in water temperature, while sucker distribution is unaffected. Neither species appeared adversely affected by temperature extremes between May and October in 1974 (7.5 to 21^{o} C). High water conditions, sufficient D.O., and water temperature, apparently provided a suitable environment for crappie, perch, chub, and sucker reproduction. Fisherman success was extremely low during 1974. Most trout caught were hatchery plants and overall reservoir conditions seemed unfavorable for trout production.

THE ACCUMULATION AND DISTRIBUTION OF ORGANOCHLORINES AND SOME HEAVY METALS IN AMERICAN FALLS RESERVOIR

ORGANOCHLORINES

Methods of Study

Four stations (Fig. 1) were selected, from which water and sediment samples were collected. Fish samples were not confined to these stations. Water samples were collected from the mud-water interface using a Van Dorn water bottle. The water sample was brought to the surface and placed in a one-gallon glass jar which was then sealed with a lid lined with aluminum foil. Sediment samples were placed in one-quart glass jars which were then sealed with aluminum foil. Water and sediment samples were frozen for 8 to 9 months until analyses were performed.

The six species of fish collected for residue analysis were Utah chub, yellow perch, black crappie, black bullhead, carp, and the predominant forage fish, the Utah sucker. Whole fish were frozen except for large suckers, where sections of epaxial muscle were taken just anterior to the dorsal fin. Fish samples were wrapped in aluminum foil and frozen.

Pesticide separation was accomplished by using the Hesselberg and Johnson technique (31). Sulfur interferences in sediment samples were removed by the addition of copper. In samples where PCB's and other chlorinated hydrocarbons were present, separation was accomplished using the method described in the Manual of Analytical Methods (32).

Analyses were performed using a Hewlett-Packard, Series 7400 gas chromatograph (GC) with an electron-capture detector. The operating conditions were as follows:

Column: 6-ft glass, packed with 1.5% SP-2250/
1.95% SP-2401 on 100/120 Supelcon
AW-DMCS

Temperature: Column 200°C
Detector 210°C
Injector 220°C

Carrier gas: Nitrogen at a flow of 25 ml/min

Volume injected: Approximately 5 μl of extract

Each sample was analyzed for endrin, aldrin, dieldrin, heptachlor, heptachlor epoxide, lindane, DDT, DDE, DDD, and PCB's. Quantitative analysis was accomplished by using the internal standardization technique. Qualitative analysis was achieved by using two separate chromatography columns and thin layer chromatography. Recovery was 71 to 98 percent. Residue values were not corrected for percent recovery. Quantitative and qualitative analysis for PCB's was performed by matching the unknown peaks on the chromatogram to the nearest commercial preparation and measuring the areas of four corresponding peaks (33). Area measurements were made by an electronic integrator. Linear regression was used in the analysis of data (34).

Results and Discussion

Only four organochlorides were detected in American Falls Reservoir. DDE and DDD were found in all fish and sediment samples (Table 5 and 6). Dieldrin was found in only two species and polychlorinated biphenyls (PCB) were present in only one species (Table 6). PCB's were also detected in the sediments (Table 5).

Water. None of the water samples contained measurable quantities of organochlorines. This is to be expected because of the low solubility of these compounds: 3.4μg/l DDT (35), 12.5μg/l dieldrin (36), and 100 to 1000μg/l PCB's, depending on the formulation (37). Residues in the reservoir are bound to the sediment and not associated with the water phase.

Sediment. Residues in the reservoir sediments are low and are bound tightly on soil particles, as expected in sediments which are composed of organic muck (38, 39). DDE and DDD were detected in all samples analyzed. The concentration varied with reservoir sampling stations. Sample areas 4 and 5 (Figure 1) have a larger concentration of DDE and DDD. These two areas are exposed to more turbulence and do not develop anaerobic conditions. The reverse is true for areas 2 and 3 where anaerobic conditions develop and DDD is present in larger amounts (Table 5).

EPA has found a similar distribution in areas 2 and 3 (personal communication); they did not sample areas 4 and 5. DDT and BHC break down rapidly in bottom sediments (39, 40). Degradation is probably achieved via reductive dechlorination by anaerobic bacteria (40). Consequently, bacteria in reservoirs are important in the degradation and removal of certain pesticides from the aquatic ecosystem. PCB's were not as ubiquitous as DDD and DDE in reservoir sediments and were found in only two of the four areas sampled.

Fish. Although all fish sampled had organochlorines present, the type and quantity varied considerably between species (Table 6). DDE and DDD were found in all species sampled. Dieldrin appeared only in the yellow perch and black bullhead. The ten perch analyzed were of varying size classes with the greatest concentrations of DDE, DDD and dieldrin being found in the larger fish (Fig. 3). Since the yellow perch and black crappie have similar diets, it is interesting that no dieldrin residues were detected in the black crappie (Table 6). Dieldrin was not detected in sediment from the areas sampled (Table 5). Sediment analysis of EPA in 1973 did indicate the presence of dieldrin in one of the six areas which they sampled (personal communication). Dieldrin exposure may be dependent upon the area which the fish have inhabited.

Utah sucker contained the highest concentration of organochlorines (Table 6), and was the only species to contain PCB's. PCB's were not found in suckers less than two years old (Table 7).

Table 5. Concentration of organochlorines in American Falls Reservoir sediments.

Area	n 1/	µg/kg (ppb--wet wgt--sediments DDD	DDE	PCB
2	3	1.55 2/ (1.42-1.79)	1.46 (1.18-1.73)	22.65 3/
3	3	1.04 (0.79-1.31)	2.13 (1.69-2.53	ND 4/
4	3	1.64 (0.53-3.60)	2.18 (1.09-3.80)	ND
5	3	1.68 (0.81-1.96	2.21 (0.45-2.79)	28.74 5/ (24.02-33.46)

1/ Sample size

2/ Mean (Range)

3/ Detected in a single sample

4/ Not detected

5/ Detected in only 2 of 3 samples

Table 6. Chlorinated hydrocarbon residues in American Falls Reservoir fishes greater than 2 years old.

Species	n[1/]	Flesh residue--µg/kg (ppb)--wet weight DDE	DDD	Dieldrin	PCB's
Catostomus ardens	14	28.4 ± 6.8[2/] (1.1-82.1)[3/]	187.4± 68.6 (13.9-781.7)	ND	671.7± 89.0 (0-1144)
Gila atra	5	65.4 ± 15.4 (31.5-104.8)	42.8 ± 17.0 (12.1-86.8)	ND	ND
Cyprinus carpio	5	42.1 ± 14.0 (15.6-91.8)	37.6 ± 21.6 (9.3-122.4)	ND	ND
Pomoxis nigromaculatus	20	20.7 ± 4.0 (3.0-67.2)	14.0 ± 3.1 (2.0-52.3)	ND	ND
Perca flavescens	10	14.7 ± 7.8 (2.3-28.6)	5.7 ± 3.6 (1.2-13.4)	34.4 ± 3.2 0-160.4)	ND
Ictalurus melas	10	9.5 ± 2.1 (1.0-22.6)	5.1 ± 1.4 (0.9-14.0)	11.0 ± 6.6 (0-48.4)	ND

1/ Sample size

2/ Mean ± standard error

3/ Range

4/ Not detected

Table 7. Chlorinated hydrocarbons in American Falls Reservoir *Catostomus ardens* by age group.

Age (yrs.)	n[1]	Flesh residue-μg/kg(ppb)-wet wgt. DDE	DDD	PCB's
< 2	6	5.4 ± 1.2[2] (1.5-8.0)[3]	3.0 ± 1.1 (0-7.8)	ND
2-3	6	12.2 ± 2.9 (1.1-19.3)	43.0 ± 7.7 (13.9-71.4)	570 ± 156 (0-1029)
> 3	8	40.5 ± 9.8 (3.3-82.1)	295.6 ± 106.5 (23.4-781.7)	748 ± 104 (179-1144)

1/Sample site

2/Mean ± Standard Error

3/Range

4/Not Detected

Table 8. Concentrations of organochlorines in whole fishes from American Falls Reservoir.

Species	n[1/]	µg/kg-whole fish-wet weight	
		DDE	DDD
Ictalurus melas	39	88.9[2/] (±11.6)[3/]	127.0 (± 26.7)
Catostomus ardens	81	68.7 (± 9.8)	51.6 (± 5.9
Pomoxis nigro-maculatus	18	75.0 (± 4.1)	37.2 (± 3.6)
Perca flavescens	30	50.7 (± 2.6)	42.9 (± 3.2)
Gila atraria	11	51.0 (± 5.9)	29.6 (± 2.8)

1/ Sample size

2/ Mean

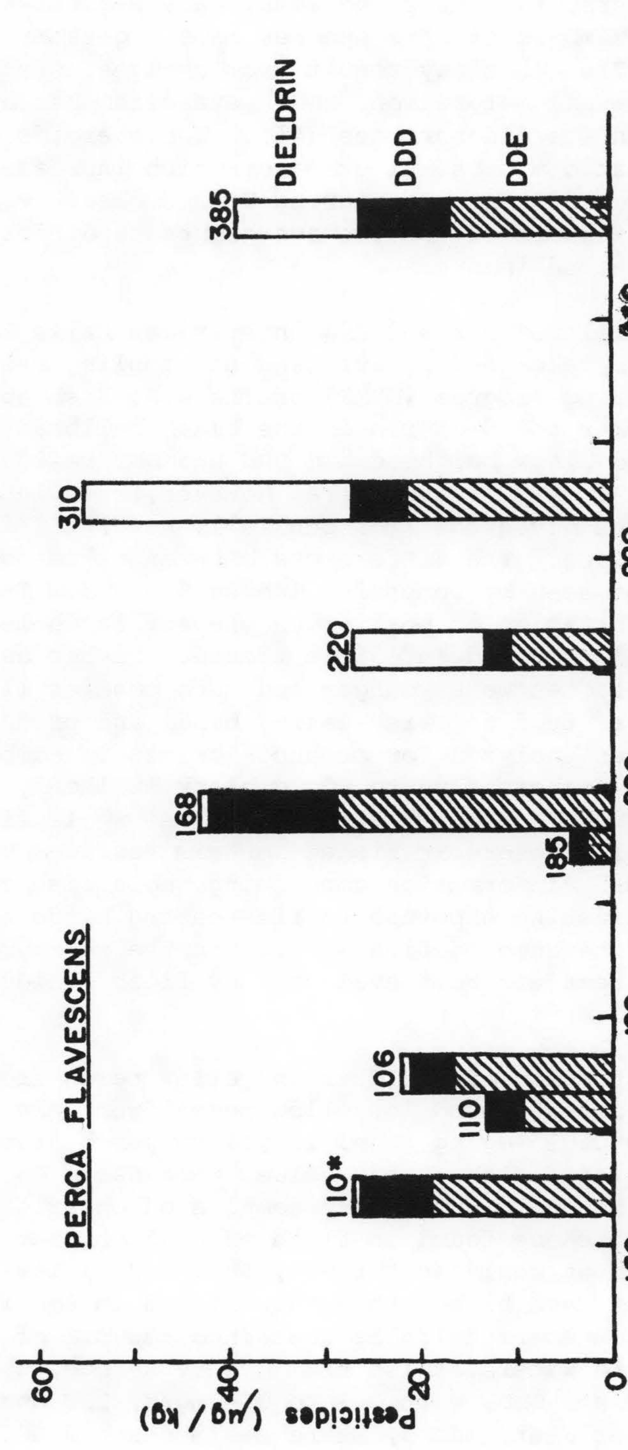
3/ Standard Error

Young suckers, two years and less, have a greater concentration of DDE than DDD; older members of this species have a greater concentration of DDD than DDE (Table 7). This may result from changes associated with steroid metabolism and sexual maturation. DDT metabolism has been increased by injecting rats with steroid hormones (41). The steroids induce the synthesis of non-specific hepatic microsomal oxidases which increase the metabolism of DDT. Similar action could occur in maturing Utah sucker. Variation may also exist as a result of exposure of the two age groups to different concentrations of DDE and DDD in the sediments.

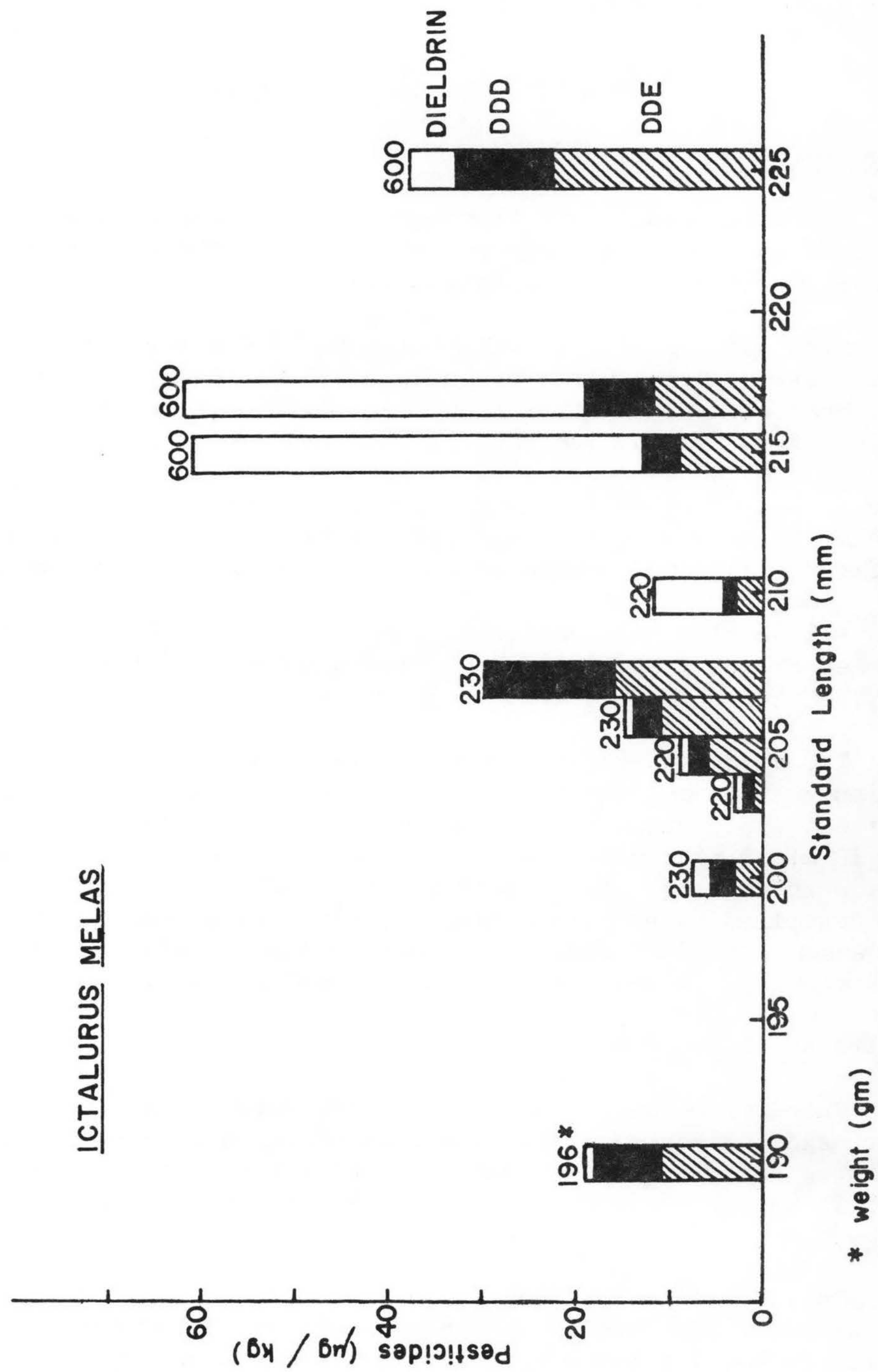
Residue levels of DDE and DDD in American Falls Reservoir suckers and yellow perch from lakes and rivers used as sampling stations in the National Pesticide Monitoring Program (NPMP) of the U.S. Fish and Wildlife Service (45), PCB's in the sucker and dieldrin in the black bullhead were also similar. Black crappie and black bullhead had DDE and DDD residues lower than those found by the NPMP. NPMP values were, however, calculated on a whole fish basis. The values given for American Falls Reservoir fishes are based on edible muscle tissue. The differences between values obtained for whole fish and muscle can be seen by comparing Tables 6 and 8. In all species except the sucker the concentration of pesticides present in whole fish are greater than those concentrations found in edible tissue. Fishes used in the determination of whole fish residues were younger and much smaller (1 to 10 g). Fishes of this size serve as food for fish-eating birds and predatory game fish in the reservoir. Fishes analyzed for organochlorines in edible tissue ranged from 21 to 2112 g for suckers, 196 to 600 g black bullhead, 60 to 385 g for yellow perch, and 260-690 g for black crappie. These whole fish samples indicate that American Falls Reservoir fishes contain residues which may exceed those found by the NPMP. Information concerning whole fish concentrations is most important in evaluating exposure to fish-eating birds and possible effects on survival and maintenance of fish species in the reservoir. The human and public health threat are best evaluated by flesh residues and have been emphasized here.

The concentration of dieldrin in yellow perch from American Falls Reservoir was equal to that found in yellow perch from Lake Huron (43) and exceeded values (0.001 to 0.015 mg/kg found in yellow perch from lakes and streams in Ontario, Canada (44). Lake Huron values were based on whole fish samples. DDT metabolites found in whole body samples of Ontario suckers were in quantities similar to those found in flesh of suckers from American Falls Reservoir. The average sediment residues for DDE, DDD, and dieldrin in Ontario waters were for the most part much higher than those found in American Falls Reservoir, yet suckers taken from American Falls contained amounts of DDE and DDD equal to those from Ontario waters. Fish from McNary Refuge, Washington contained 0.7 to 6.4 mg/kg DDT and DDD, with 0.1 to 0.4 mg/kg DDT and DDD in associated sediments; at Deer Flat, Idaho, where sediments had 68.0 to 94.0 mg/kg DDD, the maximum for fish was 0.2 mg/kg DDD (45). In a third reservoir (Tuttle Creek, Kansas), while no DDT, DDE, DDD, or dieldrin was found in the sediments, they were present in the fish with a maximum of 0.17 mg/kg DDT and 0.17 mg/kg dieldrin (46). There appears to be no simple correlation between sediment residue and bio-concentration in fishes.

Gravid black bullhead from the reservoir contained greater concentrations of pesticides (Fig. 4), particularly dieldrin, than other bullheads sampled. There was a highly significant correlation ($P < .01$) between dieldrin and condition factor and a significant correlation ($P < .05$) between the weight of



3. Chlorinated hydrocarbon residues in yellow perch versus standard length.



4. Chlorinated hydrocarbons in black bullhead versus standard length.

this species and dieldrin concentration. The larger weight and condition factors were the result of mature gonads.

MERCURY, ARSENIC, AND CADMIUM

Methods of Study

Sediment, water, and fish samples were collected as described previously from four areas of the reservoir to determine the distribution and quantity of cadmium, arsenic, and mercury (Figure 1).

Five species of fish were collected for heavy metal analysis: rainbow trout, yellow perch, black crappie, black bullhead, and the predominant forage fish, Utah sucker. Rainbow trout were difficult to collect. Those samples obtained from sports fishermen limited the amount of tissue available for analysis. Rainbow trout were, therefore, analyzed only for mercury and arsenic. Whole fish were collected except for rainbow trout and the larger suckers where large sections (> 20 g.) of epaxial muscle were taken just anterior to the dorsal fin. Fish samples were wrapped in aluminum foil and frozen.

All samples were analyzed using a Varian 1200 atomic absorption spectrophotometer with a Model 63 carbon rod atomizer and the Model 64 As/Se/Hg Analysis Kit. A Neff 401 recorder was used to record the results.

The vapor generation technique was used for the determination of mercury in fish, water, and sediments (47). Lead and cadmium in water were determined by direct application to the carbon rod unit. Fish samples (.5g) were digested with 10 ml of nitric acid and analyzed directly on the carbon rod (48). Sediment samples (.5g) were digested with 10 ml of nitric acid and diluted to 20 ml with distilled water before analysis directly on the carbon rod. Quantification was by standard addition technique (49). Values were not corrected for percent recovery. Linear regression was used in analysis of data (34).

Results and Discussion

Cadmium, mercury, and arsenic were determined in this study for fish, water, and sediments. These analyses contribute to a more complete picture of the total contamination of American Falls Reservoir. Cadmium and mercury were found in water, sediment, and fish. Arsenic was found only in the water and sediment.

Mercury concentrations in water varied at each sample site (Table 9). The maximum value found in a water sample was 1.78 μg/l. The Idaho Health Department found a maximum of 1.8 μg/l and Runyan found 1.3 μg/l (3). Analysis of 73 rivers in the United States found 27 contained mercury, with a range of 0.1 to 1.0 μg/l (50). Ground waters have been found to contain from 0.02 to 0.07 μg/l (51). Mean values of mercury in American Falls Reservoir ranged from 0.70 to 1.02 μg/l. These values are above the 0.03 μg/l level presumed to be the mean natural mercury content for uncontaminated water (52). They also exceed Federal criteria of 0.05 μg/l (37).

Cadmium concentrations from 1.0 to 24.5 μg/l were found in American Falls Reservoir. Analysis of 720 lakes and rivers revealed that 41 percent had concentrations from 1 to 10 μg/l and 4% of the waters sampled ranged from 12 to 130 μg/l (20). Values in American Falls Reservoir were similar to those in Foundry

Table 9. Heavy metals in American Falls Reservoir water and sediment.

Area		n	Mercury	Cadmium	Arsenic
2	Water 1/	3	0.72 3/ (0.25-1.52)	9.23 (6.42-11.26)	12.60 (1.50-33.0)
	Sediment 2/	3	0.35 (0.21-0.42)	0.62 (0.60-0.64)	2.02 (1.57-2.40)
3	Water	3	0.70 (0.45-1.20)	14.64 (6.62-24.47)	15.67 (3.0-25.50)
	Sediment	3	0.49 (0.42-0.53)	0.39 (0.36-0.64)	1.83 (1.38-2.20)
4	Water	3	1.02 (0.55-1.78)	6.64 (1.67-10.63)	16.50 (3.50-30.50)
	Sediment	3	0.53 (0.21-0.95)	0.43 (0.14-0.72)	1.56 (1.40-1.75)
5	Water	3	1.02 (0.30-1.47)	5.95 (1.0-9.67)	4.67 (3.0-8.0)
	Sediment	3	0.32 (0.32-0.32)	0.94 (1.64-1.24)	1.38 (1.36-2.04)

1/ μg/l

2/ mg/kg

3/ mean (range)

	Mercury	Cadmium	Arsenic
Environmental threat in excess of EPA standard for water	0.05 μg/l	3.0 μg/l	10.0 μg/l

Cove, Hudson River, a known recipient of cadmium waste. Concentrations in Foundry Cove ranged from 5 to 26 μg/l (19). The National Academy of Sciences considered 3.0 μg/l harmful to aquatic life (37).

Arsenic compounds have been found to occur naturally in some waters of the Western states (53). In American Falls Reservoir, arsenic concentrations ranged from 1.50 to 33.0 μg/l (Table 9). Water in Kansas contained 2.6 μg/l arsenic, while in Lake Erie and the St. Lawrence River concentrations of 0.038 and 0.058 μg/l, respectively, were found (16, 53).

Arsenic concentrations in American Falls Reservoir sediment ranged from 1.36 to 2.40 mg/kg. Pita and Hyne (1975) studied the deposition of heavy metals in a reservoir and noted that they were adsorbed on suspended materials and carried by water flowing through the reservoir. The higher concentrations were found in the deeper water sediments (54). Only arsenic in American Falls Reservoir exhibits this type of distribution. Mercury and cadmium in sediments were not depth dependent.

Heavy metals are adsorbed on particulate matter and their concentration in water may be correlated with the degree of turbidity (54). The correlation between turbidity and heavy metal concentration in American Falls Reservoir water is illustrated in Figures 5, 6, and 7. Only arsenic exhibited a significant ($P < .05$) correlation.

Levels of heavy metals present in water may not indicate the total amount present in the aquatic system. No correlation is usually found between the concentration of heavy metals in sediment and the associated water column (19, 55, 56). Mercury, cadmium, and arsenic levels in the sediment of American Falls Reservoir were 300 to 700, 26 to 160, and 80 to 400 times greater, respectively, than amounts present in the associated water. Linear regression analysis indicated no significant $P < .05$) relationship.

Background levels of mercury in fish have been generally accepted as being less than 0.2 mg/kg (52). Mean values of mercury for reservoir yellow perch, black bullhead, and hatchery stocked trout did not exceed this value. Utah sucker, black crappie and larger rainbow trout have mean values greater than 0.2 mg/kg (Table 10). The mean value of mercury for all fishes from American Falls Reservoir was 0.31 mg/kg. Thirteen percent of the Utah suckers, 21% of the black crappie, and the large rainbow trout exceeded the FDA standard of 0.5 mg/kg for fish flesh (18). Mercury concentrations for hatchery trout and yellow perch from American Falls Reservoir were similar to those found in 1971 (3); however, concentrations found in suckers increased from 0.11 to 0.37 mg/kg and black bullhead concentrations decreased from 0.36 to 0.1 mg/kg.

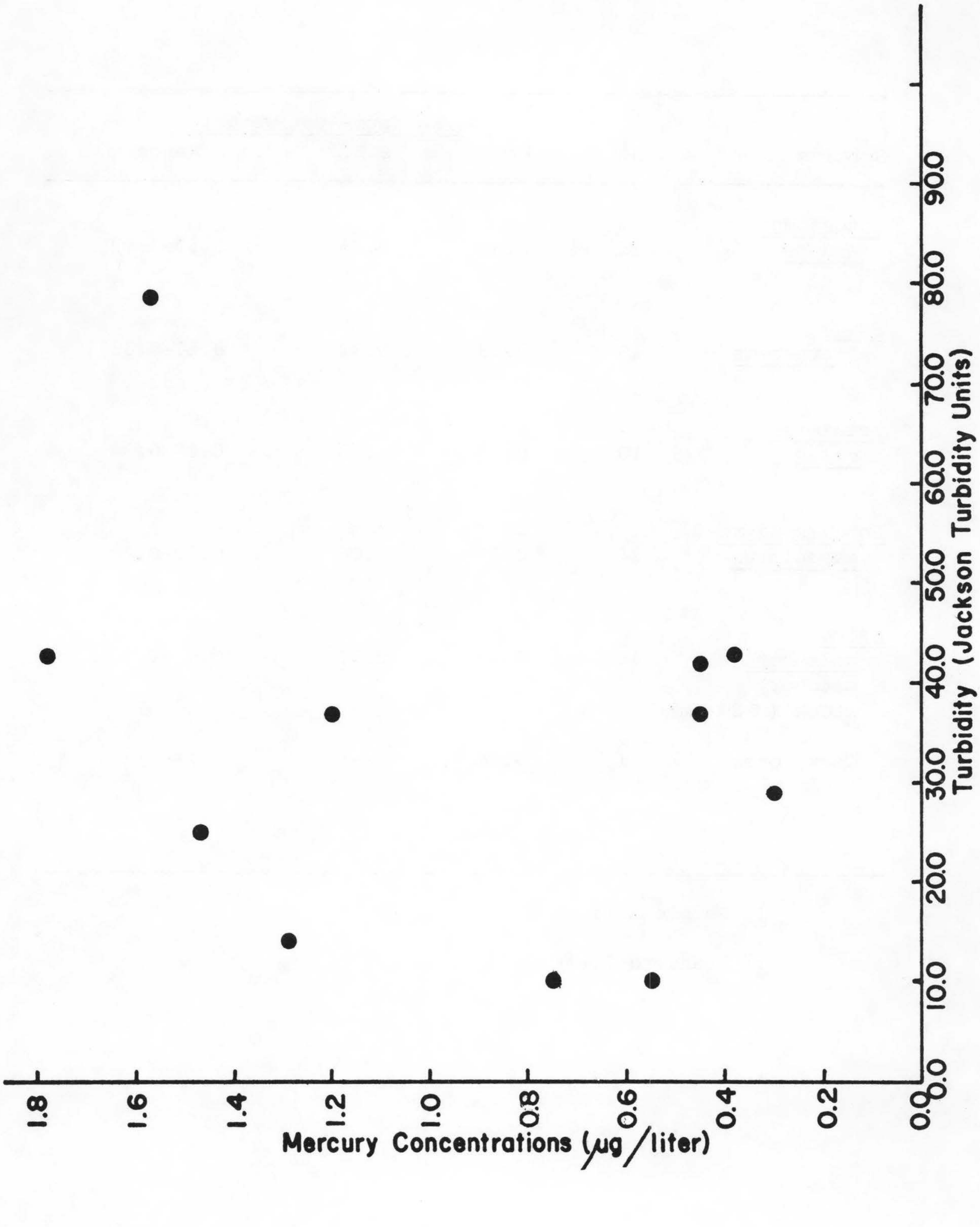
Accumulation of mercury by fishes may or may not be directly correlated with age, length, or weight. Positive correlations between mercury concentration and all of the above factors have been reported by various authors (55, 57, 58, 59). Runyan reported no correlation between weight and mercury concentration in rainbow trout from American Falls Reservoir, but a significant correlation at the .05 level between length and mercury concentration (3). Jarmon found a positive correlation between mercury concentration in muscle and age and length for yellow perch from American Falls and Weston Reservoirs (4). Other authors have reported no correlation between either weight or length and concentration of mercury (17, 57). There was no significant correlation between weight, age, length, or condition factor and mercury concentration for any species analyzed in this study. Fish of the same size and species, with identical

Table 10. Mercury in American Falls Reservoir fishes.

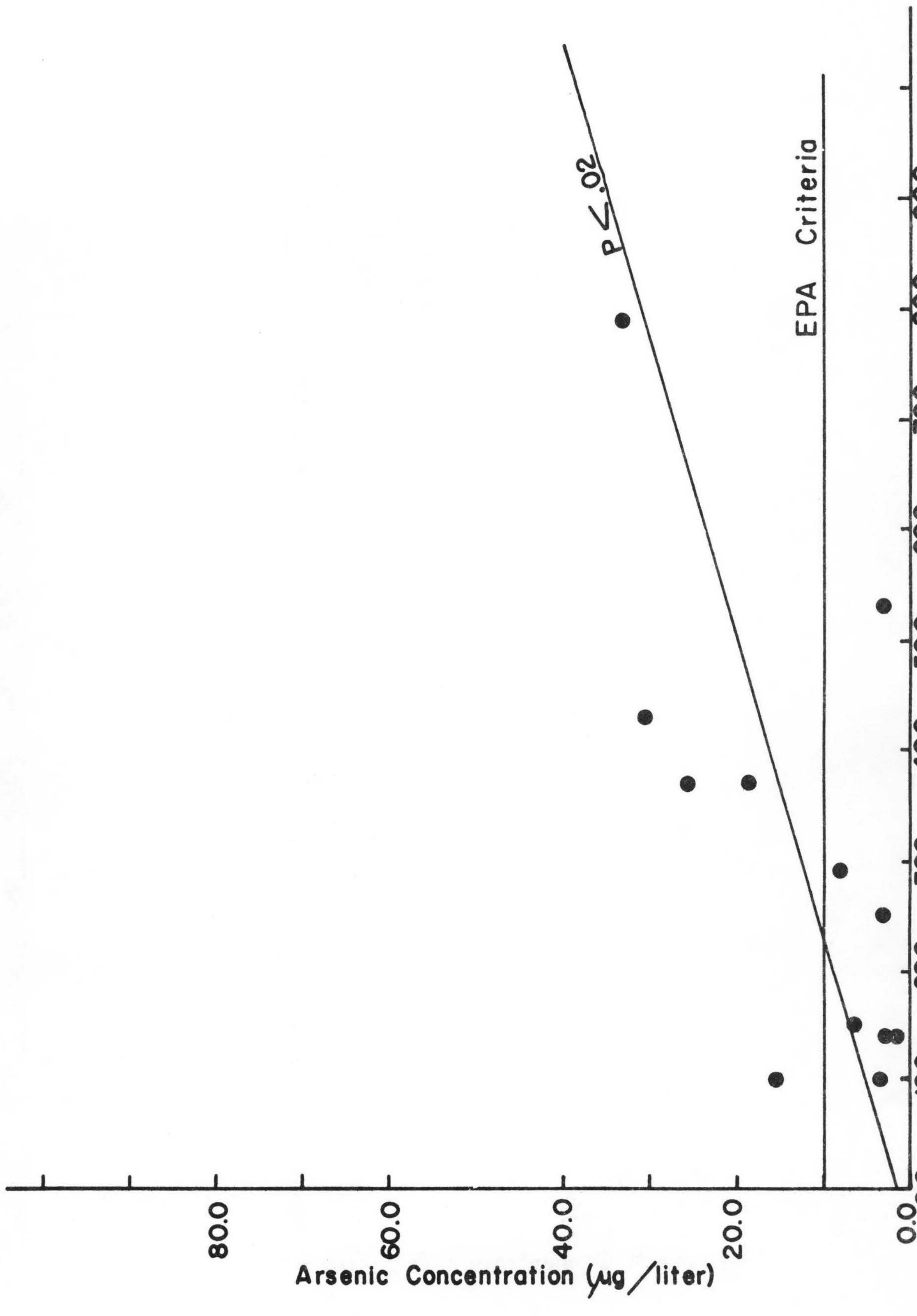
Species	n[1]	mg/kg (ppm--wet weight Mean	S.E.[2]	Range
Catostomus ardens	15	0.37	0.06	0.10-0.82
Perca flavescens	10	0.19	0.02	0.11-0.33
Ictalurus melas	10	0.17	0.03	0.10-0.34
Pomoxis nigro-masculatus	14	0.37	0.06	0.12-0.80
Salmo gairdneri Hatchery stock (< 20 cm)	16	0.13	0.02	0.05-0.30
Carry over	1	0.64	--	--

1/ Sample size

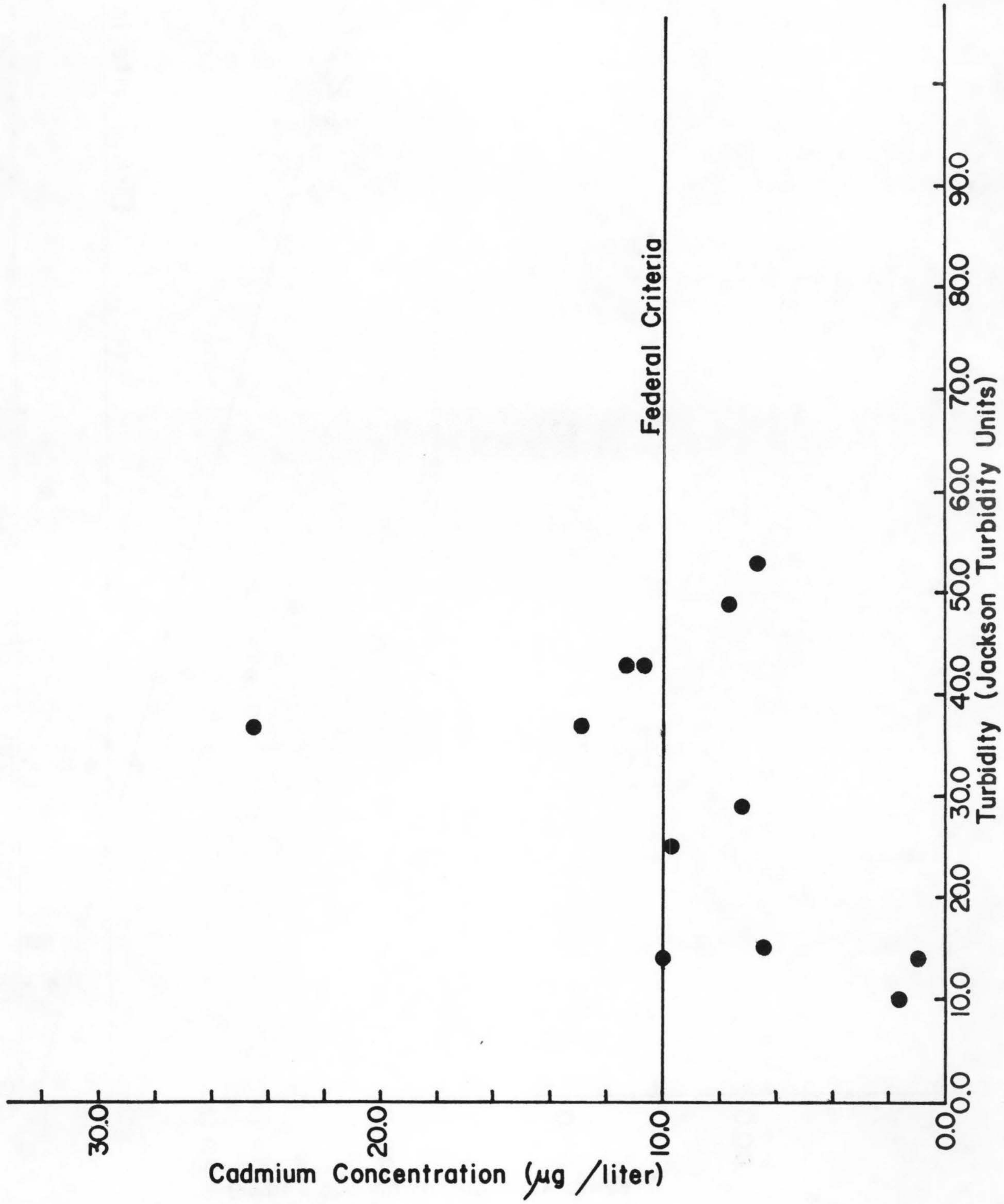
2/ Standard Error



5. Correlation between mercury concentration and turbidity of water in American Falls Reservoir.



6. Correlation between arsenic concentration and turbidity of water in American Falls Reservoir.



7. Correlation between cadmium concentration and turbidity of water in American Falls Reservoir.

exposure, have shown maximum concentrations up to 10 times the minimum (60). Chronic exposure to low levels of mercury has resulted in fishes acquiring about the same tissue concentrations regardless of size (61). It appears, therefore, that the conditions at the time of exposure are more influential than age, weight, length, condition factor, or environmental concentration.

Cadmium present in the reservoir does not seem to be concentrated in fish as readily as mercury (Table 11). Cadmium is not as easily mobilized from the sediments as mercury. The high calcium carbonate, hard water of American Falls Reservoir may cause cadmium to precipitate out (62) and collect in the bottom sediment, probably causing exposure to be dependent upon ingestion of contaminated fish or particulate matter.

The mean values for cadmium in American Falls Reservoir fishes are higher than those reported elsewhere. In the Illinois River where sediments had an average of 2.0 mg/kg cadmium, fishes contained 0.03 mg/kg (56). Larger concentrations of cadmium, ranging from 0.06 to 1.4 mg/kg were found in Great Lakes fishes (21). Black bullhead, black crappie, and yellow perch from New York waters had levels of 0.01 to 0.05 mg/kg (63). There was no correlation between size and cadmium concentration in fishes analyzed from American Falls Reservoir.

Arsenic was not found in fishes from American Falls Reservoir. Accumulation may be dependent upon the valence state of arsenic. Arsenate (pentavalent) is excreted rapidly through the kidneys and probably does not accumulate in the tissues. Fish collected from a lake 21 days after application of arsenic showed no significant increase in arsenic accumulation, although water concentrations reached a maximum of 7.0 mg/l (64).

Table 11. Cadmium in American Falls Reservoir fishes.

Species	n 1/	mg/kg (ppm)--wet weight Mean	S.E. 2/	Range
Catostomus ardens	16	0.19	±0.04	0.08-0.60
Perca flavescens	9	0.23	±0.03	0.14-0.44
Ictalurus melas	10	0.15	±0.05	0.04-0.30
Pomoxis nigromaculatus	16	0.19	±0.03	0.03-0.45

1/Sample size

2/Standard Error

THE AVAILABILITY OF ORGANOCHLORIDES, MERCURY, ARSENIC, AND CADMIUM FROM THE SEDIMENTS OF AMERICAN FALLS RESERVOIR

METHODS OF STUDY

Sediment samples were collected from American Falls Reservoir using an Ekman dredge. The samples were placed in one-quart glass jars and sealed. The sediments were returned to the laboratory where they were drained of excess water and allowed to air dry. After drying, the sediment samples were placed in a blender and thoroughly mixed. A 100 g sediment sample was placed in a 3.8 l glass jar and 3.5 l of distilled, deionized water was added. Three groups, consisting of nine samples each, were utilized. Each group of samples had a different water temperature, $8 \pm 1^{o}C$, $12 \pm 1^{o}C$, and $25 \pm ^{o}C$. The nine samples in each group were divided into three subgroups. Each of these subgroups were adjusted to a particular pH. The pH values were $6.2 \pm .1$, $7.5 \pm .1$, and $8.9 \pm .1$. The pH was adjusted with 1N HCl and 1N NaOH. The range of chemical parameters used here were within the range of those found in American Falls Reservoir. Water samples (140 ml) were taken from each jar at 1, 12, and 24 hours after the start of the experiment for analysis of mercury, cadmium, and arsenic. The methods utilized in analysis of these water and sediment samples were described previously. Temperature, dissolved oxygen, and pH were monitored throughout the experiment.

RESULTS AND DISCUSSION

Organochlorides

No organochlorides were released from the manipulated sediment. Very low concentrations were present in the sediment (3.0 ng/g total DDT metabolites). The relative insolubility of these compounds provides an explanation. Organochlorines found in the water column are for the most part bound to suspended particulate material.

Mercury

Mercury was released from all manipulated sediment samples. Sediment incubated at 25^{o} C released significantly more mercury than at 8^{o} C (Table 12). Filtering the exposed water after 24 hours incubation had no clear effect on mercury measurements. There was no apparent pH effect. The higher temperature may increase bacterial action in the sediment and result in increased methylation and availability of soluble mercury. After 24 hours incubation at 25^{o} C, DO had decreased from 8.75 to 4.20 mg/l at the surface. Anaerobic conditions may have existed at the sediment-water interface. These conditions (temperature and dissolved oxygen) are comparable to summer reservoir conditions. The results of other investigations of the relationship of mercury availability and dissolved oxygen exposure are unclear. An increase in aeration and nutrients has been reported to increase the availability of mercury from sediments (27). More recently anaerobic conditions have been shown to favor the release of mercury from sediments (65). Other studies have utilized sediment to which a relatively high known amount of mercury was added (65, 66). In the present study much

Table 12. Mercury and cadmium in water above reservoir sediments. Sediment contained 210 ng/g mercury and 1,600 ng/g cadmium. Cadmium was not detectable after 12 hours nor in filtered samples. Turbidity during the sediment incubation is also shown. Three replicates were run at each pH; the range of values is in parentheses.

Conditions Temp. & Dissolved Oxygen	Time Hours	Mercury (ng/l)			Cadmium (ng/l)			Turbidity (JTU)
	pH	8.9	7.5	6.2	8.9	7.5	6.2	7.5
25°C	1	3.5	2.2	3.2	6.0	9.0	10.0	11.7
		(3.0-4.5)	(2.2-2.2)	(2.2-4.5)	(5.0-7.0)	(1.0-25)	(3.0-15)	(10-14)
8.75 to 4.25 1/ mg/l	12	1.0	0.8	0.8				5.0
		(0.8-1.5)	(0.8-0.8)	(0.8-0.8)				(4-6)
	24	0.8	0.8	1.5				2.3
		(0-1.5)	(0.-1.5)	(1.5-1.5)				(2-3)
12°C	1	1.3	1.0	4.2	0	0	0	28.3
		(1.0-1.5	(0.8-1.5)	(1.5-9.3)				(12-50)
	12	0.8	0.7	1.1				11.3
		(0.8-0.8)	(0.4-1.0)	(0.8-1.5)				(8-17)
9.04 to 7.76 mg/l	24	2.4	1.4	2.4				5.3
		(0.8-4.0)	(0.8-2.3)	(1.0-4.5)				(4-7)
	24 2/	1.1	1.3	0.8				
		(0.8-1.5)	(1.0-1.5)	(0.4-1.5)				
	24 2/	1.2	1.4	1.2				
		(0.8-1.5)	(1.0-1.8)	(0.8-1.5)				
8°C	1	0.7	0.6	0.3	3.3	0	1.0	24.3
		(0.5-1.0)	(0.6-0.6)	(0.-0.6)	(0-5.0)			(0.2.0)
	12	0.6	1.0	0.7				6.0
9.06 to 10.0 mg/l		(0.3-1.0)	(0.6-1.4)	(0-1.4)				(3-9)
	24	0.4	0.4	0.4				3.7
		(0.3-0.6)	(0-1.0)	(0.3-0.6)				(2-5)
	24 2/	0.7	0.9	0.6				
		(0.6-1.0)	(0.6-1.0)	(0.3-1.0)				

1/ dissolved oxygen at initiation and 24 hours

2/ sample filtered prior to analysis

lower environmental levels were investigated. Mercury found in American Falls Reservoir sediments are bound to the sediment and may react differently from added unbound mercury.

Arsenic

The sediments utilized in these experiments contained 7,900 ng/g arsenic. No arsenic was released from the sediment into the associated water. That arsenic concentration in unfiltered reservoir water samples is directly correlated with the turbidity of the sample was shown earlier in this report (Figure 6).

Cadmium

Water levels of cadmium are also dependent on suspended sediment. cadmium was not detectable after filtration or in unfiltered samples after one hour when turbidity decreased (Tables 12). Cadmium was present in the manipulated sediment at 1,600 ng/g. The affinity of cadmium for reservoir and estuarine sediments and their role in mobilizing the cadmium in the ecosystem has previously been reported (55, 67). No conclusion could be made regarding the potential of temperature, pH, or dissolved oxygen to alter the availability of cadmium.

SUMMARY AND CONCLUSIONS

ORGANOCHLORINES

Organochlorines in American Falls Reservoir sediments are accumulated in fishes of the reservoir. Consumption of these fishes may be a health hazard to sports fishermen and their families. Suckers sold for human consumption contain residues of PCB's and DDT metabolites at levels which are considered hazardous by the Environmental Protection Agency. A more intensive sampling program is needed to indicate if there is a need to prohibit the use of suckers and other fishes from American Falls Reservoir for human consumption.

Chlorinated hydrocarbon residues in American Falls Reservoir did not exceed FDA recommended standards of 5 mg/kg DDT, .3 mg/kg dieldrin, and 2 mg/kg for PCB's. In the larger suckers, total DDT metabolites approach 1 mg/kg. These suckers are the ones which are harvested and sold for human consumption. At this level EPA has recommended that precautionary measures should be taken to avoid endangering the health of those who consume them (37). The continued marketing of a commercial catch of suckers from this reservoir should receive close surveillance and evaluation.

The white sucker has been shown to be among the most susceptive species to DDT (68). These fish are usually found in large numbers in disturbed habitats, such as reservoirs, where an abundance of detrital food sources are found. Fry of such forage fish are an important part of the diet of the game fishes of American Falls Reservoir. Maintenance of the sports fishery is dependent on an adequate forage fish population. Bioaccumulation of pollutants by the adults could affect the reproductive success or the survival of the adults, and could result in a decrease in available prey for game fishes. Effects on fry can produce morphological and behavioral changes which may result in increased predation. These fry also contribute to biomagnification in the food chain, with higher concentrations of chlorinated hydrocarbons being found in the game species which consume them.

The FDA maximum allowable limit for PCB's is 2 mg/kg. EPA has recommended that PCB concentrations in any sample consumed by any bird or mammal be no greater than 0.5 mg/kg (37). The U.S. Fish and Wildlife Service regards the presence of 0.5 mg/kg in a fish as an indication of a pollution problem (69). Average concentration for suckers from American Falls Reservoir was 0.67 mg/kg. Consumption of fishes from the reservoir may present a problem to their predators.

The problem of egg shell thinning in birds which consume contaminated food sources is well documented. The concentration of DDT residues in carnivorous birds is 10 to 100 times those in the fish they consume (70). Eagles eating fish with hundredths to tenths of mg/kg PCB, had muscle concentrations from 150 to 240 mg/kg (71). It seems apparent that fish-eating birds at American Falls Reservoir could accumulate dangerous levels of chlorinated hydrocarbons.

The Utah sucker is the predominant forage fish in the reservoir and is an essential part of the diet of many species of game fish, as well as fish-eating birds. The reproductive success of the sucker is important in maintaining a stable community structure. Organochlorine residues are higher in the Utah sucker than in other species of the reservoir; they contain DDT metabolites and PCB's in high concentrations. Although no PCB's were found in American Falls Reservoir water, and large numbers of Utah sucker do not spawn in the reservoir where PCB's have been found, the possible effects of PCB's on their reproduction are not negated.

The continuance of a sports fishery in American Falls Reservoir is dependent upon the reproductive success of all reservoir fish populations. Organochlorines are concentrated in the gonads. Concentration of pesticides by prey species may affect their reproductive success. Chlorinated hydrocarbon residue levels in American Falls Reservoir prey species appear to justify this concern.

The presence of organochlorines places stress upon the fishes and affects the health and behavior of the fish species. Certain environmental parameters, especially temperature, add to the problem (72). DDT toxicity increases with decreasing temperature (72, 73). This presents a paradoxical situation. Most fish seek colder water where sufficient oxygen content is present, increasing the toxicity of DDT. On the other hand DDT (50 μg/kg has been found to affect the thermo-regulatory ability of fish and cause them to seek warmer temperatures, placing additional stress on the fish (74).

During the summer of 1975, 75% of the suckers collected had fungus-like growths on their heads or sides. Similar symptoms developed with exposure of pinfish to 5 μg/l of the PCB Arochlor 1254 (71). After these fish were returned to flowing water free from PCB's, most died. Much higher concentrations were found in the larger sucker of American Falls Reservoir than in the experimentally exposed pinfish. Although the PCB's in the reservoir were not demonstrated to have directly caused the lesions and fungus-like growths (ulcerations) on the sucker, it is a possible explanation. The mortality associated with this fungus infection may also ultimately affect the structure of the reservoir community.

MERCURY, ARSENIC, AND CADMIUM

Consumption of fish from American Falls Reservoir presents a health problem. Mercury concentrations in suckers, black crappie, and large rainbow trout exceed the FDA standard of 0.5 mg/kg (Table 10). The Idaho Health Department issued the following warning concerning consumption of fish from waters known to be contaminated with mercury: (1) that persons not eat more than ½ pound of fish per week from Idaho waters; (2) that pregnant women, infants, and young children not eat fish taken from waters known to be contaminated with mercury; and (3) catfish, yellow perch, and suckers taken from the Snake River between American Falls Reservoir and Hells Canyon should not be eaten. The World Health Organization has suggested that maximum daily intake of cadmium be 70 μg/day (75). Daily intake of cadmium from food sources averages 50 μg/day in the U.S.A. (75) and the FDA has stated that at this level "we may have reached the safe upper limit for cadmium" (76). Consumption of fishes from American Falls Reservoir would increase daily intake of cadmium in excess of the 70 μg/day limit.

Although consumption of fishes contaminated with heavy metals may lead to no immediate adverse effects heavy metals are concentrated in vital organs of the body. Large amounts are usually found in the kidneys and may result in renal dysfunction. Other effects of mercury and cadmium accumulation are well documented (75, 77, 78).

Mercury accumulation in water, sediment, and trout, as well as other species of game fish, had previously been determined (3). The U.S. Environmental Protection Agency (personal communication) determined the concentration of arsenic, mercury, and cadmium in water. These reports were based on analysis of one contaminant and one component of the aquatic ecosystem, respectively. In determining contamination of an aquatic ecosystem by heavy metals all components (water, sediments, and fauna) should be analyzed. This gives a complete picture of the total contamination of the system. Examination of only one contaminant does not properly reveal the hazards to the aquatic ecosystem. Synergistic effects could render a "safe" level of one contaminant lethal and result in the decline and elimination of certain species.

The significance of accumulation of heavy metals in fishes in American Falls Reservoir and subsequent effects on their survival and reproductive success is unknown. There is a higher concentration of heavy metals in the kidney, liver, gonads and gills than in muscle tissue. Large amounts of mucus are produced and suffocation results due to coagulation of the mucus by mercury. Epithelial necrosis and hyperplasia in the gills has been observed in fish exposed to mercury (79). Mercury present in the body of fishes acts as a neurotoxin; lesions usually develop in the neurological system, resulting in death (80).

Suffocation of adult fishes and fry by coagulation of gill mucus caused by heavy metals may contribute to a declining population; however, the accumulation of heavy metals in the gonads may be more important. Little information exists on the effects of heavy metals on the developmental stages of fishes. Exposure to cadmium inhibited red blood cell circulation in embryo of the fathead minnow (81). Laboratory animals exposed to cadmium developed damage to the reproductive organs and central nervous system, birth defects, life shortening, and inhibition of growth (62). Similar effects may occur in fish.

There is a need to evaluate the effects of heavy metal accumulation on all the life stages of fish. Highest concentrations of cadmium are located in the liver and kidney where enzymatic processes are inhibited. Oxidative phosphorylation, a key enzyme-mediated process by which high-energy phosphate bonds are formed, was completely halted by a concentration of 0.67 mg/kg cadmium (82). Kidney dysfunction results from this exposure (75). Lesions in the intestine and kidney result from cadmium exposure. The rate and degree of the lesions are significantly affected by pH, salinity, oxygen, and temperature of the water (83). In sufficient concentrations, cadmium may exert its toxic effects on fish by coagulation of external gill mucus, causing anoxia, as well as altered salt balance and secretion of waste products (84). Little is known about the effects of arsenic in fish. Arsenic is also an enzyme inhibitor. Effects similar to those of cadmium could result from exposure to arsenic.

Mercury and cadmium accumulation in fishes from American Falls Reservoir exceeds human health standards set by FDA and WHO. Consumption of fishes from the reservoir may endanger the health of the consumers of the commercial catch, as well as the sports fishermen and their families. The stocking of rainbow trout annually is important to the sports fishery of the reservoir, since fishermen fish almost exclusively for these trout. Trout, therefore, serve as a source of cadmium and mercury to fishermen. Further utilization of American Falls Reservoir as a sports fishery should subsequently not be encouraged and perhaps should be restricted. There appears to be good cause to warn all consumers of reservoir fishes, whether sport or commercially caught, of the hazards associated with their consumption. A warning was issued by the Idaho Health Department in 1971 based on dangerous levels of mercury. Analyses performed on the flesh of fishes collected from American Falls Reservoir in the past few years indicates that mercury residues have increased and that they are accompanied by levels of cadmium, and chlorinated hydrocarbons that warrant concern. Another attempt at public education is perhaps warranted.

AVAILABILITY OF POLLUTANTS FROM RESERVOIR SEDIMENTS

It should be recognized that the chemical and physical characteristics of aquatic ecosystems may limit, enhance, or modify the availability, uptake by, and toxicity of heavy metals to fishes. Methylation of mercury in the sediments by bacteria is a critical step in increasing mercury availability to fish. Practically all mercury in fish is methylmercury (18). Mobilization and methylation from sediment is dependent on several factors. Low concentrations in the sediment are mobilized and methylated faster than higher concentrations. These processes occur more readily in aerobic than in anaerobic conditions. The addition of the nutrients carbon, phosphate, nitrogen and other trace elements also increases the rate of methylation, presumably by stimulating an increase in methylating bacteria (27, 82). Methylmercury is easily absorbed through the gills. Mercury may be present in several inorganic forms. The amount of inorganic mercury in the water and absorbed by fish is pH dependent. In alkaline conditions, as in American Falls Reservoir, inorganic mercury is readily released from the sediment into the water (82). Inorganic mercury is not readily absorbed by fish from water with a high pH. Halides, such as florides, in American Falls Reservoir water might form complexes with inorganic mercury facilitating its absorption by fish. Sulfides also increase the uptake of inorganic mercury (82). Since hydrogen sulfide develops in the anerobic bottom waters of the reservoir, it may be brought up to the surface waters when overturn occurs in autumn, facilitating absorption of inorganic mercury. Inorganic mercury can also be methylated in the fish (85). Increased temperature increases the uptake of both organic and inorganic mercury (86, 87). In rainbow trout lethal levels of mercury decrease with increased water temperature, chloride ion content, or with a decrease in oxygen (88).

The "hard water" of American Falls Reservoir decreases the availability and toxicity of cadmium by precipitating it out as cadmium carbonate. Precipitation would result in decreased levels of cadmium in water and an underestimation of the amount of cadmium present in the reservoir, if only water samples were utilized. In the presence of zinc, cadmium toxicity is increased (89). Zinc values for rainbow trout, Utah sucker, yellow perch, and bullhead taken from American Falls Reservoir were as high as 12.8, 9.2, 11.4, and 1.05 mg/kg, respectively (90). Absorption of cadmium together with zinc will result in lower toxicity levels than reported from acute toxicity tests with cadmium alone. In the low oxygen and anaerobic waters of the reservoir, arsenate may be converted to arsenite, the more lethal form of arsenic (53). Modification of toxicity by chemical and physical parameters points out the need to redefine "safe" levels in aquatic environments. Each aquatic system is unique and "safe" levels of contaminants should be determined which reflect the characteristics of the system.

The present experimental design proved inadequate to measure altered availability of the pollutants present in American Falls Reservoir with the possible exception of mercury. Further investigation is desirable.

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APPENDIX I

Species Abundances and Diversity by Collection Station and Period

Appendix I-a. Species abundance and diversity at Spring Hollow in the lower end of American Falls Reservoir by collecting period

FISH SPECIES	6/26	7/15	7/16	7/28	8/13	10/10
	COLLECTING DATE 1975					
Catostomus ardens Utah sucker	3	565	186	97	53	*
Gila atraria Utah chub	0	20	6	2	12	*
Perca flavescens Yellow Perch	0	48	45	18	34	*
Cyprinus carpio Carp	1	28	19	22	30	*
Richardsonius balteatus Redside shiner	0	27	3	0	54	*
Pomoxis nigromaculatus Black crappie	0	0	17	12	22	*
Ictalurus melas Black bullhead	0	4	9	7	0	*
Prosopium williamsoni Mountain whitefish	0	3	0	3	0	*
Cottus spp. Sculpin	0	1	0	3	0	*
Salmo gairdneri Rainbow trout						
Salmo clarki Cutthroat trout						
Pimephales promelas Fathead minnow	0	0	0	1	0	*
Micropterus salmoides Largemouth bass						
TOTAL NUMBER FISH	4	696	285	165	205	
TOTAL NUMBER SPECIES	2	8	7	9	6	
SPECIES DIVERSITY INDEX	0.81	1.12	1.67	1.99	2.43	

*Reservoir drawn down to a level such that area was not accessible with sampling equipment utilized.

Appendix I-b. Species abundance and diversity at Marmot Bay in the lower end of American Falls Reservoir by collecting period.

FISH SPECIES	COLLECTING DATE 1975 6/26	7/15	7/16	7/29	8/13	9/19	10/10
Catostomus ardens Utah sucker	18	401	218	61	127	350	200
Gila atraria Utah chub	0	0	0	2	109	14	10
Perca flavescens Yellow perch	0	3	302	13	6	38	10
Cyrinus carpio Carp	3	7	1	0	4	4	20
Richardsonius balteatus Redside shiner	0	5	2	4	3	0	10
Pomoxis nigromaculatus Black crappie	0	1	0	2	0	0	20
Ictalurus melas Black bullhead	0	0	11	2	53	603	10
Prosopium williamsoni Mountain whitefish							
Cottus spp. Sculpin	0	6	107	0	4	1	0
Salmo gairdneri Rainbow trout	0	0	12	0	0	0	0
Salmo clarki Cutthroat trout	0	0	1	0	0	0	0
Pimephales promelas Fathead minnow							
Micropterus salmoides Large mouth bass							
TOTAL NUMBER FISH	21	423	654	84	306	1010	280
TOTAL NUMBER SPECIES	2	6	8	6	7	6	7
SPECIES DIVERSITY INDEX	0.59	0.40	1.73	1.35	1.84	1.28	1.58

*Reservoir drawn down to a level such that area was not accessible with sampling equipment utilized.

Appendix I-c. Species abundance and diversity at Seagull Bay in the lower end of American Falls Reservoir by collecting period.

FISH SPECIES	COLLECTING DATE 1975						
	6/26	7/14	7/15	7/31	8/1	8/13	9/19
Catostomus ardens Utah sucker	58	61	46	64	113	117	*
Gila atraria Utah chub	1	6	15	5	1	81	*
Perca flavescens Yellow perch	33	7	38	31	23	36	*
Cyprinus carpio Carp	14	89	44	6	16	106	*
Richardsonius balteatus Redside shiner	0	2	0	1	0	0	*
Pomoxis nigromaculatus Black crappie	0	0	0	16	0	77	*
Ictalurus melas Black bullhead	3	0	1	401	404	111	*
Prosopium williamsoni Mountain whitefish	0	0	0	1	0	0	*
Cottus spp. Sculpin	0	0	1	0	0	0	*
Salmo gairdneri Rainbow trout							
Salmo clarki Cutthroat trout							
Pimephales promelas Fathead minnow							
Micropterus salmoides Large mouth bass							
TOTAL NUMBER FISH	109	165	145	525	557	528	
TOTAL NUMBER SPECIES	5	5	6	8	5	6	
SPECIES DIVERSITY INDEX	1.59	1.46	1.99	1.23	1.16	2.50	

*Reservoir drawn down to a level such that area was not accessible with sampling equipment utilized.

Appendix I-d. Species abundance and diversity at Island Bay in the lower end of American Falls Reservoir by collecting period.

FISH SPECIES	COLLECTING DATE 1975 6/26	7/14	7/16	8/1	10/10
Catostomus ardens Utah sucker	0	173	27	20	0*
Gila atraria Utah chub	0	22	7	1	0*
Perca flavescens Yellow perch	0	32	2	12	0*
Cyprinus carpio Carp	0	11	11	10	1*
Richardsonius balteatus Redside shiner	0	0	0	0	0*
Promoxis nigromaculatus Black crappie	0	0	0	10	0*
Ictalurus melas Brown bullhead	0	0	1	0	0*
Prosopium williamsoni Mountain whitefish					
Cottus spp. Sculpin					
Salmo gairdneri Rainbow trout					
Salmo clarki Cutthroat trout					
Pimephales promelas Fathead minnow					
Micropterus salmoides Large mouth bass					
TOTAL NUMBER FISH	0	239	48	53	1
TOTAL NUMBER SPECIES	0	5	5	5	1
SPECIES DIVERSITY INDEX	0	1.28	1.67	2.03	0

*Reservoir drawn down to a level such that area was not accessible with sampling equipment utilized. However, the collection was made in the main reservoir adjacent to the original area.

Appendix I-e. Species abundance and diversity at Sportsman's Bay in the upper end of American Falls Reservoir by collecting period.

FISH SPECIES	COLLECTING DATE 1975 6/24	7/7	7/9	7/21	7/22	8/6	8/29	10/10
Catostomus ardens Utah sucker	25	24	50	121	26	146	29	51
Gila atraria Utah chub	9	45	10	3	10	20	0	1
Perca flavescens Yellow perch	7	8	52	38	21	45	187	31
Cyprinus carpio Carp	0	0	2	2	10	16	33	4
Richardsonius balteatus Redside shiner	42	0	0	5	1	6	0	10
Pomoxis nigromaculatus Black crappie	1	1	0	12	51	116	15	31
Ictalurus melas Brown bullhead	0	6	7	2	0	3	0	500
Prosopium williamsoni Mountain whitefish								
Cottus spp. Sculpin								23
Salmo gairdneri Rainbow trout								
Salmo clarki Cutthroat trout								
Pimephales promelas Fathead minnow								
Micropterus salmoides Largemouth bass	0	0	0	0	0	0	1	0
TOTAL NUMBER FISH	84	84	121	183	119	352	265	651
TOTAL NUMBER SPECIES	5	5	5	7	6	7	5	8
SPECIES DIVERSITY INDEX	1.74	1.67	1.68	1.50	2.10	2.03	1.34	1.32

*Reservoir drawn down to a level such that area was not accessible with sampling equipment utilized.

Appendix I-f. Species abundance and diversity at Scout Island in the upper end of American Falls Reservoir by collecting period.

FISH SPECIES	COLLECTING DATE 1975 6/24	7/7	7/9	7/21	7/22	8/6	8/29	9/19
Catostomus ardens Utah sucker	2	29	121	17	17	41	251	*
Gila atraria Utah chub	0	12	275	5	44	9	30	*
Perca flavescens Yellow perch	0	16	28	6	9	18	33	*
Cyprinus carpio Carp	1	0	0	1	0	36	40	*
Richardsonius balteatus Redside shiner	0	0	2	18	3	4	5	*
Pomoxis nigromaculatus Black crappie	0	0	0	0	0	2	4	*
Ictalurus melas Black bullhead	0	0	1	1	0	0	10	*
Prosopium williamsoni Mountain whitefish								
Cottus spp. Sculpin	1	0	2	0	0	11	0	*
Salmo gairdneri Rainbow trout								
Salmo clarki Cutthroat trout								
Pimephales promelas Fathead minnow								
Micropterus salmoides Largemouth bass								
TOTAL NUMBER FISH	4	57	429	48	73	121	373	
TOTAL NUMBER SPECIES	3	3	6	6	4	7	7	
SPECIES DIVERSITY INDEX	1.50	1.48	1.28	2.01	1.49	2.31	1.63	

*Reservoir drawn down to a level such that this station was dry. No collection was attempted.

Appendix I-g. Species abundance and diversity at Snake River Delta in the upper end of American Falls Reservoir by collecting period.

FISH SPECIES	COLLECTING DATE 1975 7/9	7/10	7/21	7/22	9/19
Catostomus ardens Utah sucker	15	12	10	14	249
Gila atraria Utah chub	0	0	0	0	10
Perca flavescens Yellow perch	0	0	0	0	343
Cyprinus carpio Carp	2	1	10	0	0
Richardsonius balteatus Redside shiner	2	1	2	1	0
Pomoxis nigromaculatus Black crappie					
Ictalurus melas Black bullhead	0	0	1	0	0
Prosopium williamsoni Mountain whitefish	4	1	0	1	0
Cottus spp. Sculpin					6
Salmo gairdneri Rainbow trout					
Salmo clarki Cutthroat trout					
Pimephales promelas Fathead minnow					
Micropterus salmoides Largemouth bass					
TOTAL NUMBER FISH	23	15	23	16	598
TOTAL NUMBER SPECIES	4	4	4	3	4
SPECIES DIVERSITY INDEX	1.45	0.83	1.55	0.67	1.15

Appendix I-h. Species abundance and diversity at Portneuf River Area in the upper end of American Falls Reservoir by collecting period.

FISH SPECIES	COLLECTING DATE 1975 7/2	7/4	7/7	7/10	7/21	7/22	10/10
Catostomus ardens Utah sucker	21	33	16	23	3	15	20
Gila atraria Utah chub	12	34	12	4	3	10	17
Perca flavescens Yellow perch	6	0	5	5	1	10	15
Cyprinus carpio Carp	1	0	60	14	1	16	5
Richardsonius balteatus Redside shiner	0	0	0	0	0	0	9
Pomoxis nigromaculatus Black crappie	0	0	0	1	0	8	0
Ictalurus melas Black bullhead			1				
Prosopium williamsoni Mountain whitefish							
Cottus spp. Sculpin							
Salmo gairdneri Rainbow trout							
Salmo clarki Cutthroat trout							
Pimephales promelas Fathead minnow							
Micropterus salmoides Largemouth bass							
TOTAL NUMBER FISH	40	67	94	47	8	59	68
TOTAL NUMBER SPECIES	4	2	5	5	4	5	7
SPECIES DIVERSITY INDEX	1.55	1.00	1.52	1.79	1.81	2.27	2.34

Appendix I-i. Species abundance and diversity at Upper End from the Snake River to the Portneuf River of American Falls Reservoir by collecting period.

FISH SPECIES	COLLECTING DATE 1975 7/4	7/9	7/10	7/21
Catostomus ardens Utah sucker	0	4	1	0
Gila atraria Utah chub	0	0	1	0
Perca flavescens Yellow perch	26	1	2	1
Cyprinus carpio Carp				
Richardsonius balteatus Redside shiner		1		
Pomoxis nigromaculatus Black crappie				
Ictalurus melas Black bullhead				
Prosopium williamsoni Mountain whitefish				
Cottus spp. Sculpin				
Salmo gairdneri Rainbow trout				
Salmo clarki Cutthroat trout				
Pimephales promelas Fathead minnow				
Micropterus salmoides Largemouth bass				
TOTAL NUMBER FISH	26	6	4	1
TOTAL NUMBER SPECIES	1	3	3	1
SPECIES DIVERSITY INDEX	0	1.25	1.50	0

Appendix I-j. Species abundance and diversity at Bannock Bay in the upper end of American Falls Reservoir by collecting period.

FISH SPECIES	COLLECTING DATE 1975 7/21	7/22	8/29
Catostomus ardens Utah sucker	23	227	110
Gila atraria Utah chub	25	36	4
Perca flavescens Yellow perch	30	281	8
Cyprinus carpio Carp	1	4	4
Richardsonius balteatus Redside shiner	1	22	0
Pomoxis nigromaculatus Black crappie	28	25	0
Ictalurus melas Black bullhead	2	6	5
Prosopium williamsoni Mountain whitefish			
Cottus spp. Sculpin	1	0	2
Salmo gairdneri Rainbow trout			
Salmo clarki Cutthroat trout			
Pimephales promelas Fathead minnow			
Micropterus salmoides Largemouth bass			
TOTAL NUMBER FISH	111	601	133
TOTAL NUMBER SPECIES	8	7	6
SPECIES DIVERSITY INDEX	2.25	1.77	.87

Appendix I-k. Species abundance and diversity at Lower and Upper End of American Falls Reservoir by collecting period.

FISH SPECIES	LOWER END 7/14/75	UPPER END 7/10/75
Catostamus ardens Utah sucker	0	24
Gila atraria Utah chub	0	2
Perca flavescens Yellow perch	0	6
Cyprinus carpio Carp	0	2
Richardsonius balteatus Redside shiner	0	0
Pomoxis nigromaculatus Black crappie	0	0
Ictalurus melas Black bullhead	0	0
Prosopium williamsoni Mountain whitefish	0	0
Cottus spp. Sculpin	0	0
Salmo gairdneri Rainbow trout	0	0
Salmo clarki Cutthroat trout	0	0
Pimephales promelas Fathead minnow	0	0
Micropterus salmoides Largemouth bass	0	0
TOTAL NUMBER FISH	0	34
TOTAN NUMBER SPECIES	0	4
SPECIES DIVERSITY INDEX	0	1.28

Appendix I - 1: Additional species captured in American Falls Reservoir 1975. Sample sizes do not permit a distribution survey.

species	number captured	location	date
Salmo gairdneri Rainbow trout--hatchery	12 length 256-320 mm weight 485-800 gm	Marmot Bay	7-16
Salmo clarki Cutthroat trout--native	1 length 275 mm weight 390 gm	Marmot Bay	7-16
Pimephales promelas Fathead minnow	1 length 50 mm weight 2 gm	Spring Hollow	7-28
Micropterus salmoides Largemouth bass	1 length 80 mm weight 12 gm	Sportsman's Bay	8-29

APPENDIX II

Species Distribution by Station, Period and Size Class

Collection Date		Spring Hollow		Marmot Bay		Seagull Bay		Island Bay	
June	24								
June	26	---	---	---	113	---	177	---	---
		15.0	---	16.5	---	16.0	---	---	---
		7.6	---	10.0	---	9.8	---	---	---
July	2								
July	4								
July	7								
July	9								
July	10								
July	14					4	96	1-4	---
						25.0	22.0	21.0	21.0
						7.0	5.4	7.0	7.0
July	15	5.5	---	9-11	---	5	150		
		23.5	21.0	22.5	21.0	24.0	20.0		
		7.0	7.0	8.0	7.0	8.0	3.2		
July	16	5	---	14	---			2-3	200
		24.2	19.5	19.5	17.0			21.5	21.0
		7.0	4.0	6.0	1.2			8.0	7.0
July	21								
July	22								
July	28	3.2	---						
		24.2	22.0						
		12.0	8.0						
July	29			9	---				
				22.0	21.0				
				10.0	6.0				
July	31					---	---		
						22.0	21.0		
						8.0	8.0		
August	1					as above		---	---
								---	---
								---	---
August	6								
August	13	---	---	10	---	2	---		
		24.5	24.5	24.0	21.0	23.0	21.0		
		10.0	---	8.0	8.0	10.0	8.0		
August	29								
Sep	19			---	---				
				---	---				
				---	---				
Oct	10			2	---			---	---
				14.0	---			15.0	---
				14.0	8.5			8.0	---

Appendix II. Selected Physical Parameters of American Falls Reservoir by sampling station, 1975. The Key below refers to depth (D), secchi disk visibility (S), temperature on the surface (T_s) and bottom (T_b) and dissolved oxygen on the surface (DO_s) and bottom (DO_b). Dashes indicate no measurment taken.

Key

D	S
T_s	T_b
DO_s	DO_b

Example

5.5	---
23.5	21.0
7.0	7.0

where temperature (T) = degrees centigrade
depth (D) = meters
secchi disk visibility = centimeters
dissolved oxygen (DO) = milligrams per liter

COLLECTION DATE		Sportsmans Bay		Scout Island		Snake River Delta		Portneuf River Area	
JUNE	24	---	---	3	---				
		---	---	17.6	---				
		---	---	9.8	---				
	26								
JULY	2							1	10
								22.5	---
								---	---
	4							---	---
								25.5	21.0
								10.0	11.8
	7	5.8	250	3	---			.2-1.	---
		26.0	17.0	24.0	---			24.0	---
		10.5	4.2	10.6	---			---	---
	9	4.7	280	5	---	0-2	---		
		23.0	22.2	---	---	---	---		
		9.0	---	12.0	9.8	7.4	---		
	10					---	---	1.3	57
						---	---	---	---
						8.0	---	7.0	---
	14								
	15								
	16								
	21	4.5	---	4.5	100	---	---	---	---
		23.0	---	23.5	23.0	---	---	22.0	---
		8.0	---	9.0	9.0	---	---	8.0	---
	22	5	---	3	---	---	---	---	---
		---	---	---	---	---	---	---	---
		10.0	---	10.0	6.0	8.0	---	10.0	13.0
	28								
	29								
	31								
AUGUST	1								
	6	---	---	5	90				
		24.0	---	23.5	20.0				
		11.0	---	13.0	8.0				
	13								
	29	---	---	---	---				
		22.0	---	20.0	---				
		11.0	---	10.0	---				
SEP	19					0-1	---		
						14.0	---		
						10.0	---		
OCT	10	---	---					1	---
		11.0	---					12.0	---
		13.0	11.0					8.5	---

within vegetation (13.0, July 22, Portneuf River Area)

Appendix II.3: Selected Physical Parameters of American Falls Reservoir by sampling station, 1975.

COLLECTION DATE		UPPER END SNAKE TO PORTNEUF		BANNOCK BAY		OTHER: MIDWATER LOWER END		OTHER: MIDWATER UPPER END	
JUNE	24								
JUNE	26								
JULY	2							7 16.2 ---	--- --- ---
JULY	4	6.2 26.0 9.0	--- 20.0 15.4						
JULY	7								
JULY	9	4 --- 7.4	--- --- 5.8						
JULY	10	2.6 --- 7.0	80 --- 8.0					4 --- 12.5	105 --- 4.0
JULY	14					15 23.0 7.0	--- 16.0 2.0		
JULY	15								
JULY	16								
JULY	21	2.0 24.0 9.2	40 22.5 7.2	2 24.0 9.0	35 23.0 8.0				
JULY	22			3 22.0 6.0	44 --- 4.0				
JULY	28								
JULY	29								
JULY	31								
AUGUST	1								
AUGUST	6								
AUGUST	13								
AUGUST	29			--- 23.5 8.0	--- --- ---				
SEP	19								
OCT	10								

Collection Date		Spring Hollow	Marmot Bay	Seagull Bay	Island Bay
June	24				
June	26	B 3 0 0 0 3	C 18 0 9 5 4	C 58 0 52 2 4	C 0 0 0 0 0
July	2				
July	4				
July	7				
July	9				
July	10				
July	14			B 61 20 26 3 12	C 173* 100* 61 1 11
July	15	B 565* 100* 452 3 10	C 401* 0 400* 1 0	C 46 0 42 2 2	
July	16	C 186 40 141 3 2	C 218* 10 200 6 2		B 27* 10* 7 0 10
July	21				
July	22				
July	28	D 97 0 91 4 2			
July	29		A 61* 10* 46 4 1		
July	31			D 64 0 63 1 0	
August	1			A 113 0 110 1 2	A 20* 10* 4 0 6
August	6				
August	13	C 53 0 48 3 2	C 127 0 122 4 1	B 117 0 117 0 0	
August	29				
Sep	19		C 350 0 350 0 0	+	
Oct	10	+	C 200 0 200 0 0		C 0 0 0 0 0

* estimate, based on observation

+ reservoir level too low for sampling

Appendix II-a.1: The distribution of Catostomus ardens in American Falls Reservoir by sampling station, 1975. The Key below refers to the time period of collection (T), total number of fish captured (n), and the numbers captured in each size class (I, II, III, IV).

Key

T	n
I	II
III	IV

Example

B	61
20	26
3	12

T=time period of collection
A= 0001-0600
B= 0601-1200
C= 1201-1800
D= 1801-2400

n=total number captured
I= size class 15-20 mm
II= size class 21-100 mm
III= size class 101-200 mm
IV= size class 201-515 mm

Appendix II-a.2: The distribution of Catostomus ardens in American Falls Reservoir by sampling station, 1975.

COLLECTION DATE		SPORTSMANS BAY		SCOUT ISLAND		SNAKE RIVER DELTA		PORTNEUF RIVER AREA	
JUNE	24	C 0 3	25 21 1	C 0 0	2 0 2				
	26								
JULY	2							C 0 1	21 5 15
	4							D 0 0	33 0 33
	7	C 5 2	24 17 0	B 0 10	29 13 6			B 0 1	16* 5 10*
	9	B 0 8	50 37 5	C 0 21	121 95 5	C 9 0	15 0 6		
	10					B 0 0	12 7 5	B 4 3	23 0 16
	14								
	15								
	16								
	21	B 100* 0	121* 21 0	B 10* 0	17* 7 0	B 0 0	10* 0 10*	C 0 0	3 0 3
	22	C 10* 0	26* 16 0	C 10* 0	17* 6 1	C 10* 0	14 4 0	C 10* 0	15* 1 4
	28								
	29								
	31								
AUGUST	1								
	6	D 25 5	146* 115* 1	D 10* 0	41* 30 1				
	13								
	29	B 0 0	29 25 4	C 0 0	251* 248* 3				
SEP	19			†		C 0 2	249 246 1		
OCT	10	B 0 0	51* 50* 1					C 0 3	20 14 3

* estimate, based on observation

† reservoir level too low for sampling

Appendix II-a.3: The distribution of <u>Catostomus</u> <u>ardens</u> in American Falls Reservoir by sampling station, 1975.

COLLECTION DATE		UPPER END SNAKE TO PORTNEUF	BANNOCK BAY	OTHER: MIDWATER LOWER END	OTHER: MIDWATER UPPER END
JUNE	24				
JUNE	26				
JULY	2				— — — — — —
JULY	4	C 0 0 0 0 0			
JULY	7				
JULY	9	C 4 0 0 0 4			
JULY	10	B 1 0 0 0 1			C 24 0 2 3 19
JULY	14			C 0 0 0 0 0	
JULY	15				
JULY	16				
JULY	21	C 0 0 0 0 0	C 23 0 19 0 4		
JULY	22		B 227 0 225 0 2		
JULY	28				
JULY	29				
JULY	31				
AUGUST	1				
AUGUST	6				
AUGUST	13				
AUGUST	29		C 110 0 109 0 1		
SEP	19				
OCT	10				

* estimate, based on observation

reservoir level too low for sampling

Month	Collection date	Spring Hollow	Marmot Bay	Seagull Bay	Island Bay
June	24				
June	26	B 0 / 0 0 / 0 0	C 0 / 0 0 / 0 0	C 1 / 0 0 / 1 0	C 0 / 0 0 / 0 0
July	2				
July	4				
July	7				
July	9				
July	10				
July	14			B 6 / 0 5 / 1 0	C 22 / 0 22 / 0 0
July	15	B 20 / 2 18 / 0 0	C 0 / 0 0 / 0 0	C 15 / 0 14 / 1 0	
July	16	C 6 / 0 6 / 0 0	C 0 / 0 0 / 0 0		B 7 / 0 7 / 0 0
July	21				
July	22				
July	28	D 2 / 0 2 / 0 0			
July	29		A 2 / 0 1 / 1 0		
July	31			D 5 / 5 0 / 0 0	
August	1			A 1 / 0 1 / 0 0	A 11* / 10* 0 / 0 1
August	6				
August	13	C 12 / 11 1 / 0 0	C 109* / 100* 9 / 0 0	B 81 / 76 5 / 0 0	
August	29				
Sep	19		C 14 / 10 1 / 1 2	+	
Oct	10	+	C 10* / 10* 0 / 0 0		C 0 / 0 0 / 0 0

* estimate, based on observation

+ reservoir level too low for sampling

Appendix II-b.1: The distribution of Gila atraria in American Falls Reservoir by sampling station, 1975. The Key below refers to the time period of collection (T), total number of fish captured (n), and the number captured in each size class (I, II, III, IV).

Key

T	n
I	II
III	IV

Example

A	2
0	1
1	0

T = time period of collection
A = 0001-0600
B = 0601-1200
C = 1201-1800
D = 1801-2400

n = total number captured
I = size class 21-50 mm
II = size class 51-100 mm
III = size class 101-165 mm
IV = size class 166-266 mm

Appendix II-b.2: The distribution of Gila atraria in American Falls Reservoir by sampling station, 1975.

Collection date		Sportsmans Bay		Scout Island		Snake River Delta		Portneuf River Area	
June	24	C	9	C	0				
		0	4	0	0				
		4	1	0	0				
	26								
July	2							C	12
								0	1
								0	11
	4							D	34
								0	0
								0	34
	7	C	45	B	12			B	12
		7	35	0	12			0	9
		3	0	0	0			1	2
	9	B	10	C	275	C	0		
		0	10	126	146	0	0		
		0	0	3	0	0	0		
	10					B	0	C	4
						0	0	0	1
						0	0	2	1
	14								
	15								
	16								
	21	B	3	B	5	C	0	C	3
		0	3	0	5	0	0	0	1
		0	0	0	0	0	0	0	2
	22	C	10*	C	44	C	0	C	10*
		10*	0	0	42	0	0	10*	0
		0	0	2	0	0	0	0	0
	28								
	29								
	31								
August	1								
	6	D	20	D	9				
		6	12	6	2				
		2	0	1	0				
	13								
	29	B	0	C	30				
		0	0	30	0				
		0	0	0	0				
Sep	19			†		C	10*		
						10*	0		
						0	0		
Oct	10	B	1					C	17
		1	0					4	0
		0	0					2	11

* estimate, based on observation

† reservoir level too low for sampling

Appendix II-b.3: The distribution of <u>Gila</u> <u>atraria</u> in American Falls Reservoir by sampling station, 1975.

COLLECTION DATE		Upper End Snake to Portneuf		Bannock Bay		Other: Midwater Lower End		Other: Midwater Upper End	
JUNE	24								
JUNE	26								
JULY	2								
JULY	4	C 0 0	0 0 0						
JULY	7								
JULY	9	C 0 0	0 0 0						
JULY	10	B 0 0	1 0 1					C 2 0	2 0 0
JULY	14					C 0 0	0 0 0		
JULY	15								
JULY	16								
JULY	21	C 0 0	0 0 0	C 0 0	25 25 0				
JULY	22			B 0 1	36 35 0				
JULY	28								
JULY	29								
JULY	31								
AUGUST	1								
AUGUST	6								
AUGUST	13								
AUGUST	29			C 4 0	4 0 0				
SEP	19								
OCT	10								

Month	Collection Date	Spring Hollow	Marmot Bay	Seagull Bay	Island Bay
June	24				
	26	B 0 0 0 0 0	C 0 0 0 0 0	C 33 0 25 2 6	C 0 0 0 0 0
July	2				
	4				
	7				
	9				
	10				
	14			B 7 5 2 0 0	C 32 1 31 0 0
	15	B 48 33 14 1 0	C 3 0 3 0 0	C 38 4 32 1 1	
	16	B 45 24 21 0 0	C 302 300 2 0 0		B 2 1 1 0 0
	21				
	22				
	28	D 18 4 8 5 1			
	29		A 13 0 12 1 0		
	31			D 31 1 30 0 0	
August	1			A 23 0 22 1 0	A 20* 10* 2 0 0
	6				
	13	C 34 0 26 6 2	C 6 0 5 1 0	B 36 0 34 2 0	
	29				
Sep	19		C 38 0 37 1 0	†	
Oct	10	†	C 10* 0 10* 0 0		C 0 0 0 0 0

* estimate, based on observation

† reservoir level too low for sampling

Appendix II-c.1: The distribution of Perca flavescens in American Falls Reservoir by sampling station, 1975. The Key below refers to the time period of collection (T), total number of fish captured (n), and the number captured in each size class (I, II, III, IV).

Key

T	n
I	II
III	IV

Example

B	7
5	2
0	0

T = time period of collection
- A = 0001-0600
- B = 0601-1200
- C = 1201-1800
- D = 1801-2400

n = total number captured
- I = 19-40 mm
- II = 41-100 mm
- III = 101-150 mm
- IV = 151-225 mm

Appendix II-c.2: The distribution of *Perca flavescens* in American Falls Reservoir by sampling station, 1975.

COLLECTION DATE		SPORTSMANS BAY		SCOUT ISLAND		SNAKE RIVER DELTA		PORTNEUF RIVER AREA	
JUNE	24	C	7	C	0				
		0	7	0	0				
		0	0	0	0				
	26								
JULY	2							C	6
								3	2
								0	1
	4							D	0
								0	0
								0	0
	7	C	8	B	16 *			B	5
		3	5	10 *	5			0	4
		0	0	0	1			0	1
	9	B	52	C	28	C	0		
		0	50	8	19	0	0		
		0	2	0	1	0	0		
	10					B	0	B	5
						0	0	0	4
						0	0	0	1
	14								
	15								
	16								
	21	B	38	B	6	B	0	C	1
		22	14	4	2	0	0	0	1
		2	0	0	0	0	0	0	0
	22	C	21	C	9	C	0	C	0
		16	5	8	1	0	0	0	0
		0	0	0	0	0	0	0	0
	28								
	29								
	31								
AUGUST	1								
	6	D	45	D	18				
		0	33	0	12				
		11	1	5	1				
	13								
	29	B	187	C	33				
		0	170	0	27				
		17	0	6	0				
SEP	19			†		C	343		
						0	328		
						14	1		
OCT	10	B	31					C	15
		0	31					0	12
		0	0					3	0

* estimate, based on observation

† reservoir level too low for sampling

Appendix II-c.3: The distribution of <u>Perca flavescens</u> in American Falls Reservoir by sampling station, 1975.

COLLECTION DATE		UPPER END SNAKE TO PORTNEUF		BANNOCK BAY		OTHER: MIDWATER LOWER END		OTHER: MIDWATER UPPER END	
JUNE	24								
	26								
JULY	2							 	
	4	C 22 0	26 4 0						
	7								
	9	C 1 0	1 0 0						
	10	B 0 0	2 2 0					C 0 0	6 6 0
	14					C 0 0	0 0 0		
	15								
	16								
	21	C 0 0	1 1 0	C 0 0	30 28 2				
	22			B 250 1	281 29 1				
	28								
	29								
	31								
AUGUST	1								
	6								
	13								
	29			C 0 0	8 8 0				
SEP	19								
OCT	10								

COLLECTION DATE		AREA: SPRING HOLLOW		MARMOT BAY		SEAGULL BAY		ISLAND BAY	
JUNE	24								
	26	B	1	C	3	C	14	C	0
		0	1	0	2	0	5	0	0
		0	0	0	1	0	9	0	0
JULY	2								
	4								
	7								
	9								
	10								
	14					B	89	C	11
						0	7	0	1
						1	81	0	10
	15	B	28	C	7	C	44*		
		2	22	0	7	0	34		
		0	4	0	0	0	10 *		
	16	C	19	C	1			B	11
		6	13	0	1			0	0
		0	0	0	0			0	11
	21								
	22								
	28	D	22						
		6	13						
		2	1						
	29			A	0				
				0	0				
				0	0				
	31					D	6		
						6	0		
						0	0		
AUGUST	1					A	16	A	10*
						14	0	10*	0
						0	2	0	0
	6								
	13	C	30	C	4	B	106		
		0	28	0	3	100	6		
		0	2	0	1	0	0		
	29								
SEP	19			C	4	†			
				4	0				
				0	0				
OCT	10	†		C	20*			C	1
				10*	10*			0	0
				0	0			0	1

* estimate, based on observation

† reservoir level too low for sampling

Appendix II-d.1: The distribution of *Cyprinus carpio* in American Falls Reservoir by sampling station, 1975. The Key below refers to the time period of collection (T), total number of fish captured (n), and the number captured in each size class (I, II, III, IV).

Key

T	n
I	II
III	IV

Example

C	4
O	3
O	2

T = time period of collection
A = 0001-0600
B = 0601-1200
C = 1201-1800
D = 1801-2400

n = total number captured
I = size class 19-70 mm
II = size class 71-200 mm
III = size class 201-400 mm
IV = size class 401-660 mm

Appendix II-d.2: The distribution of *Cyprinus carpio* in American Falls Reservoir by sampling station, 1975.

COLLECTION DATE		SPORTSMANS BAY		SCOUT ISLAND		SNAKE RIVER DELTA		PORTNEUF RIVER AREA	
JUNE	24	C 0 0	0 0 0	C 0 0	1 0 1				
	26								
JULY	2							C 0 0	1 0 1
	4							D 0 0	0 0 0
	7	C 0 0	0 0 0	B 0 0	0 0 0			B 0 0	60 0 60
	9	B 0 1	2 1 0	C 0 0	0 0 0	C 0 0	2 0 2		
	10					B 0 0	1 0 1	B 0 0	14* 10* 4
	14								
	15								
	16								
	21	B 2 0	2 0 0	B 0 0	1 0 1	C 0 0	10* 0 10*	C 0 0	1 0 1
	22	C 10* 0	10* 0 0	C 0 0	0 0 0	C 0 0	0 0 0	C 13 0	16 0 3
	28								
	29								
	31								
AUGUST	1								
	6	D 16 0	16 0 0	D 34 0	36 2 0				
	13								
	29	B 26 0	33 5 2	C 38 0	40 2 0				
SEP	19			†		C 0 0	0 0 0		
OCT	10	B 3 0	4 1 0					C 4 0	5 1 0

* estimate, based on observation

† reservoir level too low for sampling

Appendix II-d.3: The distribution of _Cyprinus carpio_ in American Falls Reservoir by sampling station, 1975.

COLLECTION DATE		UPPER END SNAKE TO PORTNEUF		BANNOCK BAY		OTHER: MIDWATER LOWER END		OTHER: MIDWATER UPPER END	
JUNE	24								
	26								
JULY	2								
	4	C 0 0	0 0 0						
	7								
	9	C 0 0	0 0 0						
	10	B 0 0	0 0 0					C 0 0	2 0 2
	14					C 0 0	0 0 0		
	15								
	16								
	21	C 0 0	0 0 0	C 0 0	1 0 1				
	22			E 1 0	4 1 2				
	28								
	29								
	31								
AUGUST	1								
	6								
	13								
	29			C 4 0	4 0 0				
SEP	19								
OCT	10								

COLLECTION DATE		SPRING HOLLOW	MARMOT BAY	SEAGULL BAY	ISLAND BAY
JUNE	24				
	26	B, 0 / 0, 0 / 0	C, 0 / 0, 0 / 0	C, 0 / 0, 0 / 0	C, 0 / 0, 0 / 0
JULY	2				
	4				
	7				
	9				
	10				
	14			B, 2 / 2, 0 / 0	C, 1 / 0, 1 / 0
	15	B, 27 / 27, 0 / 0	C, 5 / 4, 1 / 0	C, 0 / 0, 0 / 0	
	16	C, 3 / 3, 0 / 0	C, 2 / 0, 2 / 0		B, 0 / 0, 0 / 0
	21				
	22				
	28	D, 0 / 0, 0 / 0			
	29		A, 4 / 2, 2 / 0		
	31			D, 1 / 1, 0 / 0	
AUGUST	1			A, 0 / 0, 0 / 0	A, 0 / 0, 0 / 0
	6				
	13	C, 54 / 16, 28 / 0	C, 3 / 1, 2 / 0	B, 0 / 0, 0 / 0	
	29				
SEP	19		C, 0 / 0, 0 / 0	†	
OCT	10	†	C, 10* / 0, 10* / 0		C, 0 / 0, 0 / 0

* estimate, based on observation

† reservoir level too low for sampling

Appendix II-e.1: The distribution of Richardsonius balteatus in American Falls Reservoir by sampling station, 1975. The Key below refers to the time period of collection (T), total number of fish captured (n), and the number captured in each size class (I, II, III).

Key

T	n
I	II
III	/////

Example

C	5
4	1
0	/////

T = time period of collection
- A = 0001-0600
- B = 0601-1200
- C = 1201-1800
- D = 1801-2400

n = total number captured
- I = size class 21-50 mm
- II = size class 51-100 mm
- III = size class 101-116 mm

Appendix II-e.2: The distribution of Richardsonius balteatus in American Falls Reservoir by sampling station, 1975.

Collection date		Sportsmans Bay		Scout Island		Snake River Delta		Portneuf River Area	
June	24	C / 42 / 0	42 / 0 / ////	C / 0 / 0	0 / 0 / ////				
June	26								
July	2							C / 0 / 0	0 / 0 / ////
July	4							D / 0 / 0	0 / 0 / ////
July	7	C / 0 / 0	0 / 0 / ////	B / 0 / 0	0 / 0 / ////			B / 0 / 0	0 / 0 / ////
July	9	B / 0 / 0	0 / 0 / ////	C / 2 / 0	2 / 0 / ////	C / 0 / 0	2 / 2 / ////		
July	10					B / 0 / 0	1 / 1 / ////	B / 0 / 0	0 / 0 / ////
July	14								
July	15								
July	16								
July	21	B / 0 / 1	5 / 4 / ////	B / 16 / 0	18 / 2 / ////	C / 0 / 2	2 / 0 / ////	C / 0 / 0	0 / 0 / ////
July	22	C / 1 / 0	1 / 0 / ////	C / 2 / 0	3 / 1 / ////	C / 1 / 0	1 / 0 / ////	C / 0 / 0	0 / 0 / ////
July	28								
July	29								
July	31								
August	1								
August	6	D / 4 / 0	6 / 2 / ////	D / 2 / 0	4 / 2 / ////				
August	13								
August	29	B / 0 / 0	0 / 0 / ////	C / 1 / 0	5 / 4 / ////				
Sep	19			+		C / 0 / 0	0 / 0 / ////		
Oct	10	B / 9 / 0	10 / 1 / ////					C / 6 / 0	9 / 3 / ////

+ reservoir level too low for sampling

Appendix II-e.3: The distribution of Richardsonius balteatus in American Falls Reservoir by sampling station, 1975.

Month	Collection Date	Upper End Snake to Portneuf		Bannock Bay		Other: Midwater Lower End		Other: Midwater Upper End	
June	24								
June	26								
July	2								
July	4	C 0 0	0 0 /////						
July	7								
July	9	C 0 0	1 1 /////						
July	10	B 0 0	0 0 /////					C 0 0	0 0 /////
July	14					C 0 0	0 0 /////		
July	15								
July	16								
July	21	C 0 0	0 0 /////	C 1 0	1 0 /////				
July	22			B 18 0	22 4 /////				
July	28								
July	29								
July	31								
August	1								
August	6								
August	13								
August	29			C 0 0	0 0 /////				
Sep	19								
Oct	10								

Month	Collection Date	Spring Hollow	Marmot Bay	Seagull Bay	Island Bay
June	24				
June	26	B, 0 0, 0 0, 0	C, 0 0, 0 0, 0	C, 0 0, 0 0, 0	C, 0 0, 0 0, 0
July	2				
July	4				
July	7				
July	9				
July	10				
July	14			B, 0 0, 0 0, 0	C, 0 0, 0 0, 0
July	15	B, 0 0, 0 0, 0	C, 1 0, 1 0, 0	C, 0 0, 0 0, 0	
July	16	C, 17 0, 17 0, 0	C, 0 0, 0 0, 0		B, 0 0, 0 0, 0
July	21				
July	22				
July	28	D, 12 12, 0 0, 0			
July	29		A, 2 2, 0 0, 0		
July	31			D, 16 16, 0 0, 0	
August	1			A, 0 0, 0 0, 0	A, 10* 10*, 0 0, 0
August	6				
August	13	C, 22 22, 0 0, 0	C, 0 0, 0 0, 0	B, 77 76, 1 0, 0	
August	29				
SEP	19		C, 0 0, 0 0, 0	†	
OCT	10	†	C, 20* 10*, 10* 0, 0		C, 0 0, 0 0, 0

* estimate, based on observation

† reservoir level too low for sampling

Appendix II-f.1: The distribution of Pomoxis nigromaculatus in American Falls Reservoir by sampling station, 1975. The Key below refers to time period of collection (T), total number of fish captured (n), and the number captured in each size class (I, II, III, IV).

Key

T	n
I	II
III	IV

Example

A	2
2	0
0	0

T = time period of collection
A = 0001-0600
B = 0601-1200
C = 1201-1800
D = 1801-2400

n = total number captured
I = size class 15-49 mm
II = size class 50-99 mm
III = size class 100-199 mm
IV = size class 200-225 mm

Appendix II-f.2: The distribution of <u>Pomoxis</u> <u>nigromaculatus</u> in American Falls Reservoir by sampling station, 1975.

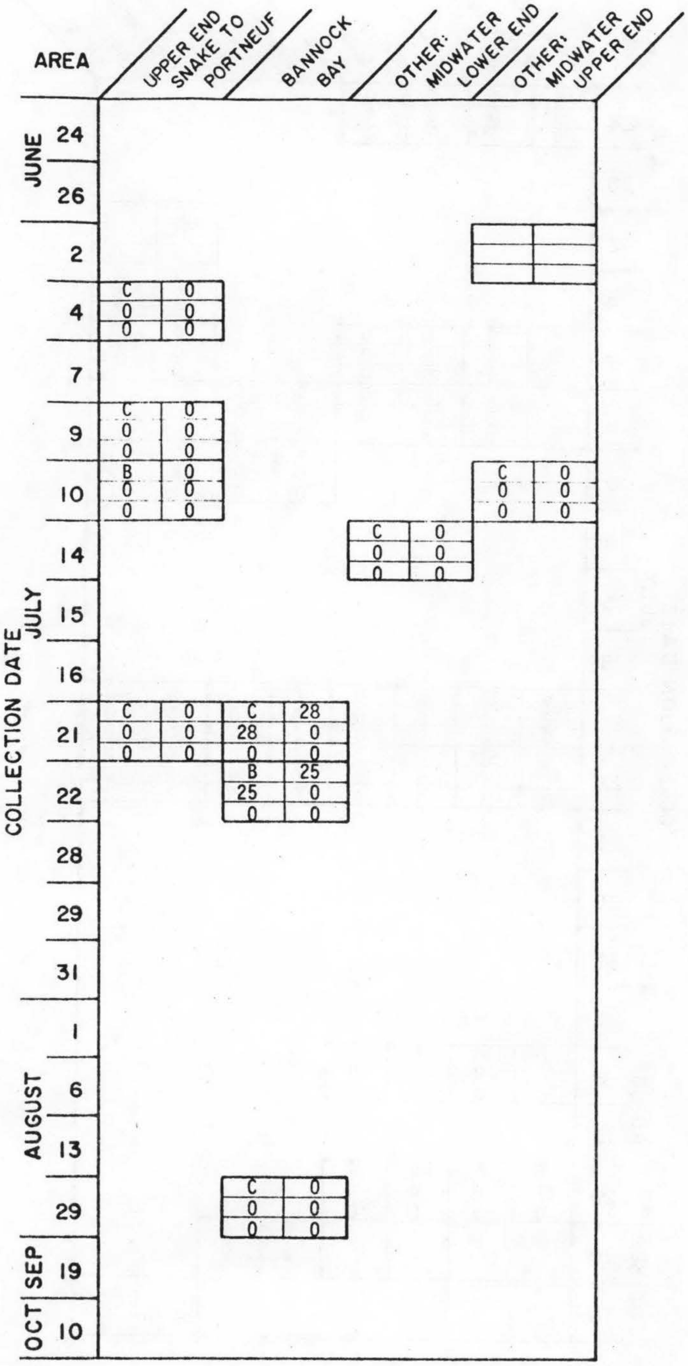
COLLECTION DATE		SPORTSMANS BAY		SCOUT ISLAND		SNAKE RIVER DELTA		PORTNEUF RIVER AREA	
JUNE	24	C 0 0	1 0 1**	C 0 0	0 0 0				
JUNE	26								
JULY	2							C 0 0	0 0 0
JULY	4							D 0 0	0 0 0
JULY	7	C 0 0	1 0 1**	B 0 0	0 0 0			B 0 0	0 0 0
JULY	9	B 0 0	0 0 0	C 0 0	0 0 0	C 0 0	0 0 0		
JULY	10					B 0 0	0 0 0	C 0 0	1 0 1
JULY	14								
JULY	15								
JULY	16								
JULY	21	B 12 0	12 0 0	B 0 0	0 0 0	C 0 0	0 0 0	C 0 0	0 0 0
JULY	22	C 51* 0	51* 0 1	C 0 0	0 0 0	C 0 0	0 0 0	C 8 0	8 0 0
JULY	28								
JULY	29								
JULY	31								
AUGUST	1								
AUGUST	6	D 116 0	116 0 0	D 2 0	2 0 0				
AUGUST	13								
AUGUST	29	B 12 0	15 3 0	C 4 0	4 0 0				
SEP	19			†		C 0 0	0 0 0		
OCT	10	B 22 0	31 9 0					C 0 0	0 0 0

* estimate, based on observation

† reservoir level too low for sampling

** observed not captured

Appendix II-f.3: The distribution of Pomoxis nigromaculatus in American Falls Reservoir by sampling station, 1975.



Collection Date	Spring Hollow	Marmot Bay	Seagull Bay	Island Bay
June 24				
June 26	B, 0 / 0, 0 / 0, 0	C, 0 / 0, 0 / 0, 0	C, 3 / 0, 0 / 0, 3	C, 0 / 0, 0 / 0, 0
July 2				
July 4				
July 7				
July 9				
July 10				
July 14			B, 0 / 0, 0 / 0, 0	C, 0 / 0, 0 / 0, 0
July 15	B, 4 / 0, 0 / 0, 4	C, 0 / 0, 0 / 0, 0	C, 1 / 0, 0 / 0, 1	
July 16	C, 9 / 0, 2 / 0, 7	C, 11 / 0, 0 / 3, 8		B, 1 / 0, 0 / 0, 1
July 21				
July 22				
July 28	D, 7 / 0, 1 / 0, 6			
July 29		A, 2 / 0, 0 / 1, 1		
July 31			A, 401* / 400*, 1 / 0, 0	
August 1			A, 404* / 400*, 0 / 0, 4	A, 0 / 0, 0 / 0, 0
August 6				
August 13	C, 0 / 0, 0 / 0, 0	C, 53 / 52, 0 / 0, 1	B, 111 / 102, 3 / 1, 3	
August 29				
Sep 19		C, 603 / 600, 2 / 1, 0	†	
Oct 10	†	C, – / –, 0 / 0, 0		C, 0 / 0, 0 / 0, 0

* estimate, based on observation

† reservoir level too low for sampling

Appendix II-g.1: The distribution of Ictalurus melas in American Falls Reservoir by sampling station, 1975. The Key below refers to the time period of collection (T), total number of fish captured (n), and the numbers captured in each size class (I, II, III, IV).

Key

T	n
I	II
III	IV

Example

C	9
O	2
O	7

T = time period of collection
A = 0001-0600
B = 0601-1200
C = 1201-1800
D = 1801-2400

n = total number captured
I = size class 11-50 mm
II = size class 51-100 mm
III = size class 101-150 mm
IV = size class 151-212 mm

Appendix II-g.2: The distribution of Ictalurus melas in American Falls Reservoir by sampling station, 1975.

COLLECTION DATE		SPORTSMANS BAY		SCOUT ISLAND		SNAKE RIVER DELTA		PORTNEUF RIVER AREA	
JUNE	24	C 0 0	0 0 0	C 0 0	0 0 0				
	26								
JULY	2							C 0 0	0 0 0
	4							D 0 0	0 0 0
	7	C 0 0	6 0 6	B 0 0	0 0 0			B 0 0	1 0 1
	9	B 0 0	7 0 7	C 0 0	1 0 1	C 0 0	0 0 0		
	10					B 0 0	0 0 0	B 0 0	0 0 0
	14								
	15								
	16								
	21	B 0 0	2 0 2	B 0 0	1 1 0	B 0 0	1 0 1	C 0 0	0 0 0
	22	C 0 0	0 0 0	C 0 0	0 0 0	C 0 0	0 0 0	C 0 0	0 0 0
	28								
	29								
	31								
AUGUST	1								
	6	D 0 0	3 3 0	D 0 0	0 0 0				
	13								
	29	B 0 0	0 0 0	C 8 2	10 0 0				
SEP	19			†		C 0 0	0 0 0		
OCT	10	B 500 0	500 0 0					C 0 0	0 0 0

† reservoir level too low for sampling

Appendix II-g.3: The distribution of <u>Ictalurus melas</u> in American Falls Reservoir by sampling station, 1975.

COLLECTION DATE		UPPER END SNAKE TO PORTNEUF	BANNOCK BAY	OTHER: MIDWATER LOWER END	OTHER: MIDWATER UPPER END
JUNE	24				
	26				
JULY	2				
	4	C 0 0 0 0 0			
	7				
	9	C 0 0 0 0 0			
	10	B 0 0 0 0 0			C 0 0 0
	14			C 0 0 0 0 0	
	15				
	16				
	21	C 0 0 0 0 0	C 2 0 0 0 2		
	22		B 6 0 0 0 6		
	28				
	29				
	31				
AUGUST	1				
	6				
	13				
	29		C 5 5 0 0 0		
SEP	19				
OCT	10				

Month	Collection Date	Spring Hollow	Marmot Bay	Seagull Bay	Island Bay
June	24				
June	26	B 0 / 0 0	C 0 / 0 0	C 0 / 0 0	C 0 / 0 0
July	2				
July	4				
July	7				
July	9				
July	10				
July	14			B 0 / 0 0	C 0 / 0 0
July	15	B 3 / 3 0	C 0 / 0 0	C 0 / 0 0	
July	16	C 0 / 0 0	C 0 / 0 0		B 0 / 0 0
July	21				
July	22				
July	28	D 3 / 3 0			
July	29		A 0 / 0 0		
July	31			D 1 / 1 0	
August	1			A 0 / 0 0	A 0 / 0 0
August	6				
August	13	C 0 / 0 0	C 0 / 0 0	B 0 / 0 0	
August	29				
Sep	19		C 0 / 0 0	†	
Oct	10	†	C 0 / 0 0		C 0 / 0 0

* estimate, based on observation

† reservoir too low for sampling

Appendix II-h.1: The distribution of Prosopium williamsoni in American Falls Reservoir by sampling station, 1975. The Key below refers to the time period of collection (T), total number of fish captured (n), and the number captured in each size class (I, II).

Key

T	n
I	II

Example

D	3
3	0

T = time period of collection
A = 0001-0600
B = 0601-1200
C = 1201-1800
D = 1801-2400

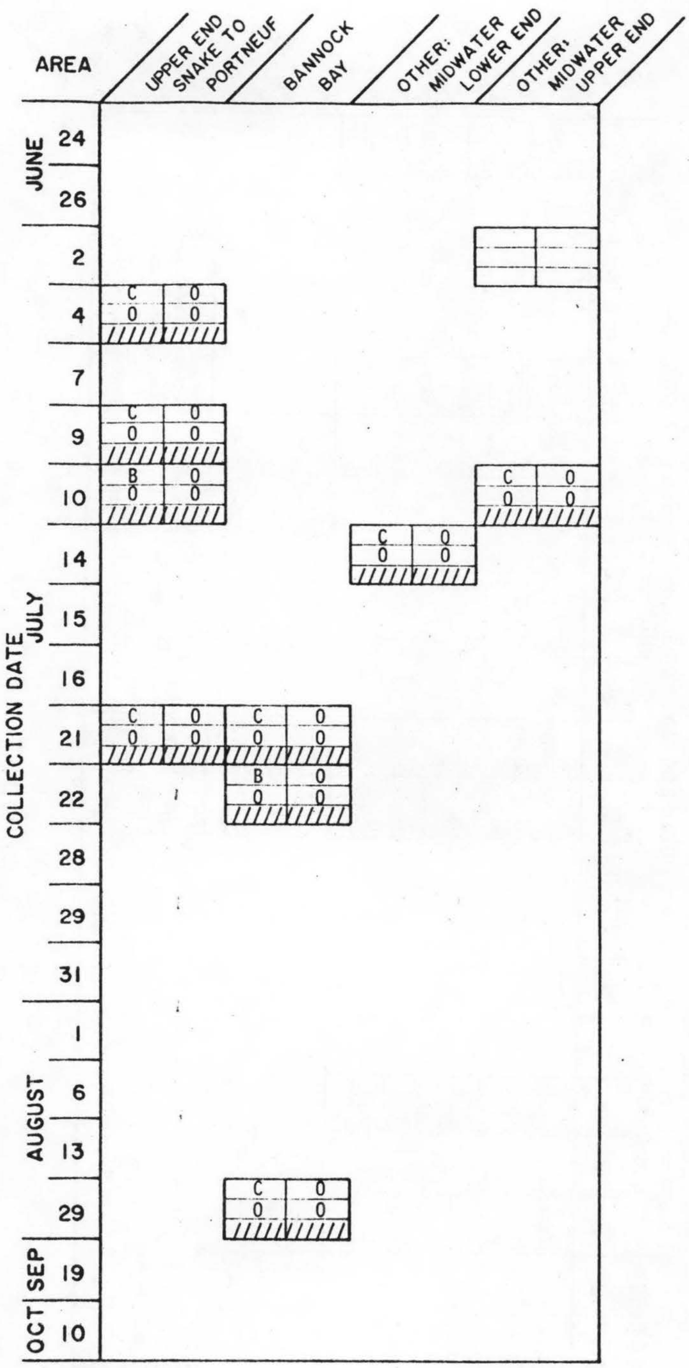
n = total number captured
I = size class 54-73 mm
II = size class 134-139 mm

Appendix II-h.2: The distribution of Prosopium williamsoni in American Falls Reservoir by sampling station, 1975.

Collection Date		Sportsmans Bay		Scout Island		Snake River Delta		Portneuf River Area	
June	24	C / 0	0 / 0	C / 0	0 / 0				
June	26								
July	2							C / 0	0 / 0
July	4							D / 0	0 / 0
July	7	C / 0	0 / 0	B / 0	0 / 0			B / 0	0 / 0
July	9	B / 0	0 / 0	C / 0	0 / 0	C / 4	4 / 0		
July	10					B / 1	1 / 0	B / 0	0 / 0
July	14								
July	15								
July	16								
July	21	B / 0	0 / 0	B / 0	0 / 0	B / 0	0 / 0	C / 0	0 / 0
July	22	C / 0	0 / 0	C / 0	0 / 0	C / 0	1 / 1	C / 0	0 / 0
July	28								
July	29								
July	31								
August	1								
August	6	D / 0	0 / 0	D / 0	0 / 0				
August	13								
August	29	B / 0	0 / 0	C / 0	0 / 0				
Sep	19			†		C / 0	0 / 0		
Oct	10	B / 0	0 / 0					C / 0	1 / 1

† reservoir level too low for sampling

Appendix II-h.3: The distribution of Prosopium williamsoni in American Falls Reservoir by sampling station, 1975.



Collection Date		Spring Hollow	Marmot Bay	Seagull Bay	Island Bay
June	24				
	26	B 0 / 0 0 / 0 0	C 0 / 0 0 / 0 0	C 0 / 0 0 / 0 0	C 0 / 0 0 / 0 0
July	2				
	4				
	7				
	9				
	10				
	14			B 0 / 0 0 / 0 0	C 0 / 0 0 / 0 0
	15	B 1 / 0 0 / 1 0	C 6 / 2 0 / 4 0	C 1 / 0 0 / 1 0	
	16	C 0 / 0 0 / 0 0	C 107* / 100* 0 / 7 0		B 0 / 0 0 / 0 0
	21				
	22				
	28	D 3 / 1 2 / 0 0			
	29		A 0 / 0 0 / 0 0		
	31			D 0 / 0 0 / 0 0	
August	1			A 0 / 0 0 / 0 0	A 0 / 0 0 / 0 0
	6				
	13	C 0 / 0 0 / 0 0	C 4 / 1 2 / 1 0	B 0 / 0 0 / 0 0	
	29				
Sep	19		C 1 / 1 0 / 0 0	†	
Oct	10	†	C 0 / 0 0 / 0 0		C 0 / 0 0 / 0 0

* estimate, based on observation

† reservoir level too low for sampling

Appendix II-i.1: The distribution of Cottus spp. in American Falls Reservoir by sampling station, 1975. The Key below refers to the time period of collection (T), total number of fish captured (n), and the number captured in each size class (I, II, III, IV).

Key

T	n
I	II
III	IV

Example

D	3
1	2
0	0

T = time period of collection
- A = 0001-0600
- B = 0601-1200
- C = 1201-1800
- D = 1801-2400

n = total number captured
- I = 9-29 mm
- II = 30-59 mm
- III = 60-99 mm
- IV = 100-150 mm

Appendix II-i.2: The distribution of Cottus spp. in American Falls Reservoir by sampling station, 1975.

Collection Date	Sportsmans Bay		Scout Island		Snake River Delta		Portneuf River Area	
June 24	C / 0 / 0	0 / 0 / 0	C / 0 / 1	1 / 0 / 0				
June 26								
July 2							C / 0 / 0	0 / 0 / 0
July 4							D / 0 / 0	0 / 0 / 0
July 7	C / 0 / 0	0 / 0 / 0	B / 0 / 0	0 / 0 / 0			B / 0 / 0	0 / 0 / 0
July 9	B / 0 / 0	0 / 0 / 0	C / 1 / 0	2 / 0 / 1	C / 0 / 0	0 / 0 / 0		
July 10					B / 0 / 0	0 / 0 / 0	C / 0 / 0	0 / 0 / 0
July 14								
July 15								
July 16								
July 21	B / 0 / 0	0 / 0 / 0	B / 0 / 0	0 / 0 / 0	B / 0 / 0	0 / 0 / 0	C / 0 / 0	0 / 0 / 0
July 22	C / 0 / 0	0 / 0 / 0	C / 0 / 0	0 / 0 / 0	C / 0 / 0	0 / 0 / 0	C / 0 / 0	0 / 0 / 0
July 28								
July 29								
July 31								
August 1								
August 6	D / 0 / 0	0 / 0 / 0	D / 5 / 0	11 / 6 / 0				
August 13								
August 29	B / 0 / 0	0 / 0 / 0	C / 0 / 0	0 / 0 / 0				
Sep 19			†		C / 0 / 0	6 / 6 / 0		
Oct 10	B / 0 / 0	23 / 23 / 0					C / 0 / 0	1 / 1 / 0

† reservoir level too low for sampling

Appendix II-i.3: The distribution of <u>Cottus</u> spp. in American Falls Reservoir by sampling station, 1975.

COLLECTION DATE		UPPER END SNAKE TO PORTNEUF		BANNOCK BAY		OTHER: MIDWATER LOWER END		OTHER: MIDWATER UPPER END	
JUNE	24								
	26								
JULY	2								
	4	C 0 0	0 0 0						
	7								
	9	C 0 0	0 0 0						
	10	B 0 0	0 0 0					C 0 0	0 0 0
	14					C 0 0	0 0 0		
	15								
	16								
	21	C 0 0	0 0 0	C 0 0	1 1 0				
	22			B 0 0	0 0 0				
	28								
	29								
	31								
AUGUST	1								
	6								
	13								
	29			C 0 0	2 2 0				
SEP	19								
OCT	10								