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ECOLOGICAL SURVEY OF THE HUDSON RIVER

Progress Report Number 2
PH 86-65-Neg. 141

December 23, 1966

New York University Medical Center
New York, N.Y. 10016

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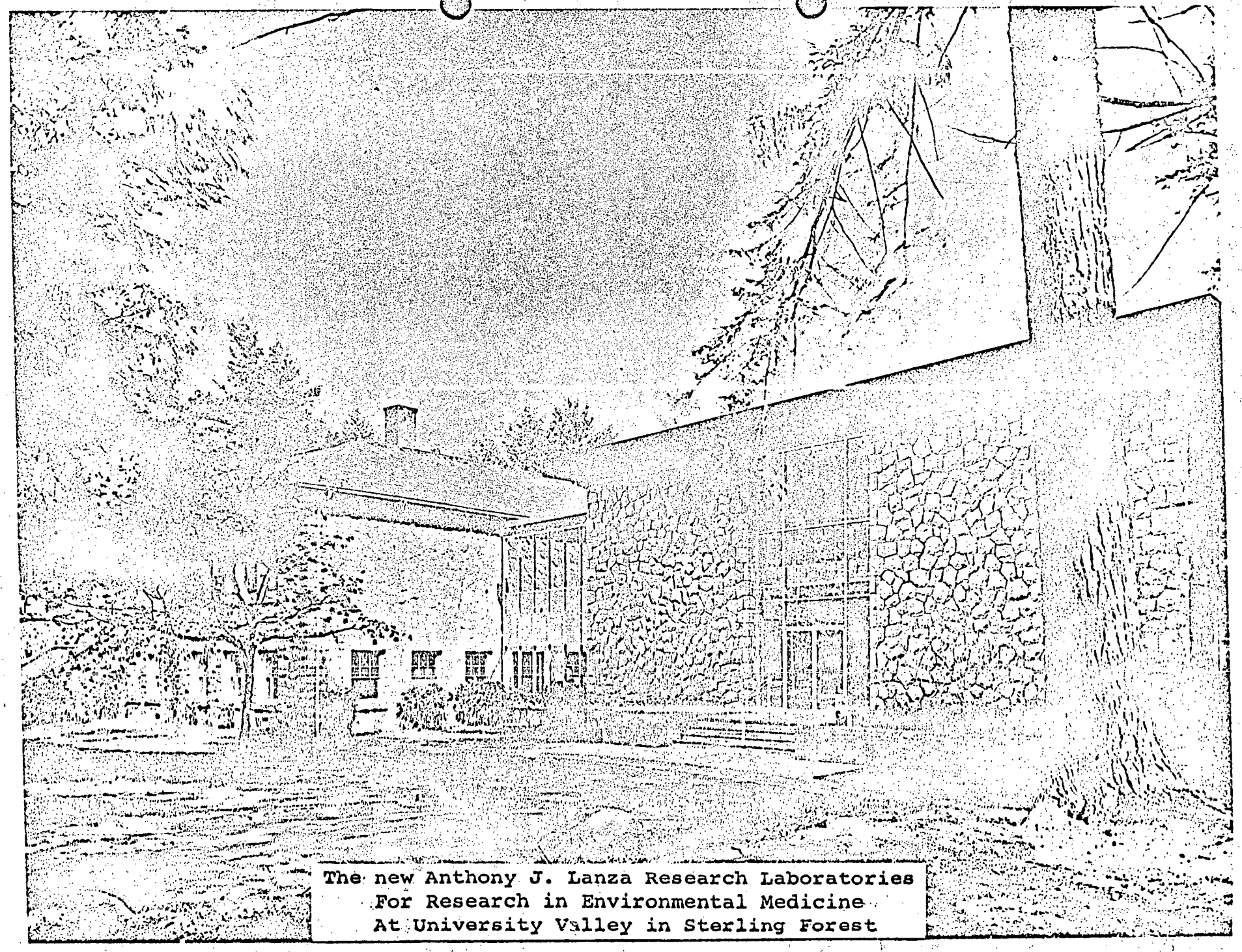

The new Anthony J. Lanza Research Laboratories
For Research in Environmental Medicine
At University Valley in Sterling Forest

Division of Radiological Health
Bureau of State Services
United States Public Health Service

Contract PH 86-65-Neg. 141

ECOLOGICAL SURVEY OF THE HUDSON RIVER

Progress Report Number 2

Period Covered February 1, 1965 - January 31, 1966

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December 20, 1966

Table of Contents

	Page
SUMMARY	i
INTRODUCTION	1-1
BIOLOGICAL STUDIES	
(Distribution and Abundance of Fishes Along the Shores of the Hudson River, New York, During the Summer of 1965) Alfred Perlmutter, Eugene E. Schmidt, and Eugene Leff	
Introduction	2-1
Results	2-8
Conclusions	2-19
GEOLOGICAL STUDIES (Sedimentary and Geological Studies) Alistair W. McCrone, Charles T. Schafer, Dennis Weiss, and Robert Koch	
Introduction	3-1
Hydrography of the Hudson River	3-5
Bottom Sediments	3-8
Conclusions	3-18
RADIOLOGICAL STUDIES Frank Cosolito, Dale W. Bath, Harold T. Peterson, and Norman Cohen	
Radiological Techniques	4-1
Radiological Findings	4-7
Comparative Study of Radionuclide Concentrations for 1964 Versus 1965	4-16
APPENDIX 1	A-1
APPENDIX 2	B-1
APPENDIX 3	C-1
APPENDIX 4	D-1
ACKNOWLEDGEMENTS	E-1

Summary

The ecological survey of the Hudson River was expanded during the summer of 1965, and reached from Dobbs Ferry to Catskill. Portions of the neighboring watershed have also been included.

Eighteen species of fish are found to predominate in the Hudson River. The spottail shiner is the most abundant species followed closely by the freshwater killifish. Four species in close competition as the next most abundant are the white perch, saltwater killifish, common silversides and Johnny darter. For each of the eighteen species which predominate data is presented in terms of catch per 100,000 square feet for quantitative comparison. In addition, the catch of most species has been further divided into a 0 + (young-of-the-year) group and a 1 +> (one year and older) group. This categorization is based on length frequencies and information previously gathered on length-age distributions.

It has been found that fish above Poughkeepsie were larger than those in the south in June and July but not in August. Whether this difference was due to earlier spawning or more favorable environmental conditions in the freshwater reaches is not yet known.

The hydrography and sediments of the river have been studied during July and August in a 30-mile section between Poughkeepsie and Stony Point. Vertical temperature profiles show temperature

differences in the order of only 1°C between top and bottom waters. The pH of river water at 31 stations was found to average 6.7 with a range of 5.4 to 8.1. Data on conductivity and composition of water samples from 14 stations is also presented.

Channel muds were found to be mostly clayey silts containing 5 to 6 % organic matter. Chlorite and illite are the dominant clay minerals with quartz, and other finely fragmented minerals also being present.

In contrast with ordinary soils, substantial amounts of Ca^{++}, Mg^{++}, Na^{+} and K^{+} in the muds are organic bound. The muds, however, contain insufficient amounts of these (and other minor ions) to drive out H^{+} which occupies more than 2/3 of cation exchange sites. The easily-oxidizable organic fraction of the muds was found to account for about 3/4 of the total cation exchange capacity.

The exchangeable manganese levels in the muds were found to be substantially higher than in ordinary subaerial soils. Despite the large amounts of sodium supplied daily by tidal inflow, more manganese than sodium was present in the muds. In light of the constant supply of sodium to the waters south of Newburgh the deficiency of sodium in the muds is particularly striking.

In general the river bottom muds appear to be capable of absorbing tremendous quantities of chemical pollutants. More research is needed to determine the ionic concentrations in river

water and other geologic mechanisms required to effect fixation of pollutant ions in the muds.

The quantities of radioactive substances discharged into the river by industrial plants are small compared to fallout from past nuclear weapons tests. Radioactive pollution from all sources including fallout is minimal, and naturally occurring K-40 has been found to constitute the principle activity in Hudson River water, sediments, fish, and vegetation. Levels of Mn-54 activity appeared to be almost as high as K-40 activity in vegetation. For 75 samples of vegetation the mean K-40 concentration was 3.2 pCi/gm of wet weight and that of Mn-54 was 1.2 pCi/gm of wet weight. Analysis of the data shows, however, that 63% of the total Mn-54 activity occurred in only 7 samples. These samples are representative of only two species of aquatic vegetation; i.e., Chara sp. an aquatic algae found to a limited extent in the river and Potomogeton crispus a higher aquatic found at two sites on the river (II-W-1 and II-W-2). Investigation of these species has shown them to be manganese concentrators which contain approximately 10% stable manganese in their ash. The higher specific activity of Mn-54 in these 2 species (approximately 3 to 4 times that of other vegetation) can thereby be explained by their higher utilization of manganese.

Statistical comparisons of radionuclide concentrations in 1964 and 1965 have shown the data to be reproducible. Potassium

appears as the best estimator of reproducibility in sampling techniques. The mean concentrations of K-40 in various categories of samples were identical for both years at the $\alpha = 0.05$ level of significance. Most other nuclides are present in insufficient amounts for the sample sizes utilized to facilitate valid statistical comparisons. The data can be used, however, to indicate increasing or decreasing trends in the environmental burden.

In conclusion the most important fact that can be noted from the tabulated radiological data is that the concentrations of the man-made radionuclides are many orders of magnitude below the levels that would be regarded as having public health significance.

INTRODUCTION

Investigation of the ecology of the Hudson River was initiated in the Summer of 1964 by the Institute of Environmental Medicine in collaboration with the Departments of Biology and Geology of the Graduate School of Arts and Sciences. Financial support was provided by a grant from the Division of Radiological Health of the United States Public Health Service. The results of the study through January 31, 1965 have been previously reported in Progress Report No. 1 (1), and continued support has made possible additional surveys in the Summers of 1965 and 1966. This report discusses the progress made through the Summer of 1965, during which period support was again received from the Division of Radiological Health. The 1966 survey was also supported by the Institutes Core Grant from the Bureau of States Service and the National Cancer Institute.

The original objective of these studies was to obtain quantitative information concerning the manner in which radionuclides introduced into the river find their way to man. Fundamental to such an inquiry is the documentation of the radiation background so that the magnitude of changes in the river may be gauged. The studies to be described were designed to provide basic information about the behavior of radioactive materials introduced into the river. The findings are also proving applicable to the behavior of other pollutants

as well. Indeed, the study has been expanded during 1966, with support from New York State, to the behavior of non-radioactive pollutants. However, the 1965 survey, which was the subject of this report was limited to radioactive pollution.

The Hudson River was historically one of the principle causes for the commercial development of New York City. It has today an increasingly important role in sustaining the economy which it was responsible for developing. The river and its tributaries support a wide variety of industrial plants, among which are the General Electric Company's Atomic Power Laboratory and the Consolidated Edison Nuclear Power Plant. These plants discharge minor quantities of radioactive substances into the Hudson River, and though their present amounts are small in comparison to fallout from weapons tests, studies of the behavior of effluents from these plants can serve to forecast the results of future developments in the area (see Table 1). Among other possible sources that contribute radioactive effluents to the river are hospitals and research laboratories.

An increasing demand for water combined with insufficient rain-fall in the past five years have made it necessary to consider the river as a potential source of water for domestic as well as industrial uses, thus adding additional importance to knowledge of the ecology of the Hudson River and its watershed. This knowledge must be accumulated so that it can be used to the best advantage of the population and the industries that use the river. It would be unforgivable

Table 1

SOURCES OF MAN-MADE RADIOACTIVITY IN THE HUDSON RIVER

Curies [1]

Nuclide	Fallout From Nuclear Weapons Tests [2]	K.A.P.L. (6/62-1/66)	Con. Ed. (8/62-1/66)
Sr-90	18	8.5	
Cs-137	21	20.4	
Ce-144	200	12.1	
Mn-54	25		0.26
Fe-55	42		
Co-60			0.66
H-3			491 [3]
Others [4]		36.1	38.9

(1) KAPL and Con. Ed. data are uncorrected for decay and are given as reported. Fallout data is from HASL Quarterly Report No. 165 at Westwood, New Jersey Station, corrected for decay to June, 1965.

(2) Hudson River Area taken as 100 square miles.

(3) For 1965 only.

(4) All other nuclides having half-lives greater than 1 day.

if the river became contaminated by radioactive substances to the point where the public health was affected. On the other hand, it would be a loss to the community if the capacity of the river to receive radioactive wastes safely was underestimated--or if public misapprehension denied the use of the river for the discharge of radioactive wastes in amounts well below those that could possibly have a deleterious effect.

The data accumulated during the past two years gives reason for optimism of achieving the eventual objective of this ecological study. It should in time become possible to observe patterns which explain the behavior of radionuclides introduced into a river system. Ultimately mechanisms can be postulated to predict the fate of radionuclides introduced into the Hudson River and its watershed.

Presently, we are in the process of expanding our research area throughout the length of the river and into its watershed. The pilot study of the Hudson River took place in the Summer of 1964 when a series of twelve sampling stations in a region extending 39 miles, provided sufficient background data for the establishment of a broader sampling network along the river. This study was also fundamental to the establishment of sampling and sample processing techniques. The biological aspects of the 1964 survey were mainly qualitative yet sufficient quantitative data was

obtained regarding radionuclide concentration to enable us to make statistically valid comparisons between some of the levels observed in 1964 and 1965.

In 1965 four sampling stations, located on the East side of the river, were discontinued and five additional stations were added on the West side of the river. The changes in collection sites may be seen in Figure 1, page 2-33, which shows the 1964 and 1965 sampling networks. These changes served the purpose of allowing us to expand the survey without expending an unwarranted amount of additional effort. Because of transportation problems it was difficult to sample the East side of the river and simultaneously expand the range of the study. By dropping the four stations on the East side we were able to expand the survey to a 90 mile stretch of river ranging from Catskill, New York to Dobbs Ferry, New York. The results of the survey indicate that significant differences do not exist between the East and West river banks.

The survey performed during the Summer of 1965 added substantially to our knowledge of the Hudson River. In both the biological and geological studies considerable effort was made to quantitate the data. A measure of the relative abundance for each species of fish collected was devised and length-frequency distributions were compiled. This data will serve as a standard for comparison that may

help to reflect changes in the environment in subsequent years.

The geological survey was expanded in 1965 to include studies of general cation exchange phenomena in the mineral-organic sedimentary aggregates, to document changes in river hydrography and sediments, and to study the geochemistry of the sediments. The information sought is fundamental to the understanding of the sediment's capacity to absorb pollutants.

The principle findings of the 1965 survey are reported under the headings of Biological, Geological and Radiological studies.

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1 Eisenbud, M., Perlmutter, A., and McCrone, A.W., Radioecological study of the Hudson River, Progress Report No. 1, Div. Radiological Health, U.S. Public Health Service Contract PH-86-64-neg. 141, Wash., D.C., 1964.

DISTRIBUTION AND ABUNDANCE OF FISHES ALONG THE SHORES OF THE HUDSON RIVER, NEW YORK, DURING THE SUMMER OF 1965

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Eugene E. Schmidt
Eugene Leff

The Hudson River has supported an active commerce and commercial fisheries since its discovery, and over the years has served as a disposal area for the sewage of towns and cities along its course. Its waters also have been used to some extent for recreational purposes such as swimming, fishing and boating, and to a lesser degree for drinking and as a coolant in power and other industrial plants.

At present, after a period of neglect extending back to colonial days, attention has been focused on the Hudson River as a regional resource. The awakened interest has been stimulated by problems arising from a rapid increase in population in the vicinity of the river and technological developments in industry and agriculture. These have resulted in qualitative and quantitative changes in pollutants entering the river which could affect the aquatic biota, including the fishes. At the same time, the need for water of high quality for domestic and industrial use has increased. Further, with an ever increasing population, development of the river as a recreational area becomes imperative.

Unquestionably, further development of the Hudson River as a regional resource will entail multiple utilization. A

program for optimum multiple utilization of the river's resources will require information from many disciplines including among others the biological, economic and social. Information on the fish and fisheries of the Hudson River is fragmentary and discontinuous. The most comprehensive reports on the subject are the biological studies of the Hudson River watershed made in the summers of 1932, 1934 and 1936 by the State of New York Conservation Department (1933, 1935, 1937). These surveys are limited to information in the few years in which they were conducted. More continuous information, particularly on the commercial fishes and fisheries of the river are contained in annual reports of the fishery statistics of the United States compiled by the Fish and Wildlife Service (Fiedler, 1932-1941 and 1942-1945; Anderson et. al., 1946-1957; Power, 1958-1963). Individual studies have been made on certain phases of some species, notably the shad (Talbot, 1954) and the striped bass (Rathjen and Miller, 1957).

This portion of the study has been concerned mainly with a single aspect, the biota of the river, with particular emphasis on the fishes. Our objective was to determine in greater detail their distribution, size and age composition and abundance for use as a measure of the effects of urban, agricultural and industrial pollutants on the fish populations.

The surveys of the New York State Conservation Department and our own observations indicate that the young-of-the-year fishes of many species are heavily concentrated along the shores of the river. Since these would most likely be the product of local spawning and resident in the area of birth for a large part of the period studied, we felt that they would be better indicators of annual fluctuations in pollution than older fishes. The older fishes found in the more offshore and deeper water of the river would consist of a mixture of year classes to be composed of both resident and immigrant fishes of unknown and changing proportions.

During the summer of 1964, a preliminary ecological study of the Hudson River was carried out in the area from Dobbs Ferry to Poughkeepsie (Eisenbud et. al., 1965). Sampling of the fish population was accomplished by seining along the shores at localities on the river suitable for the purpose. Twelve sampling stations were established, eight on the west side and four on the east side of the river (Figure 1). Collections were made from June 23rd through August 12th. Included with the fish were samples of other organisms namely invertebrates and aquatic plants.

In the 1964 study, sampling was qualititive with no

attempt made to determine the relative abundance of the fish by locality, species or age group. The primary purpose of this initial investigation was to obtain large enough samples of the major species of fishes and associated biota in the area below Poughkeepsie to elucidate the relationship between the levels of radioactivity in the various portions of the ecosystem. While accomplishing this primary purpose, considerable data was obtained on the general distribution of various organisms, particularly the fishes along the shores.

Eleven species of fish were most frequently caught in the seines throughout the area studied. There were the striped bass, Roccus saxatilis; white perch, Roccus americanus; saltwater killifish, Fundulus heteroclitus; freshwater killifish, Fundulus diaphanus; shad, Alosa sapidissima; alewife, Alosa pseudoharengus; blueback herring, Alosa aestivalis; common sunfish, Lepomis gibbosus; Johnny darter, Etheostoma nigrum; spottail shiner, Notropis hudsonius and common silverside, Menidia menidia. In addition, twenty-two other species of fishes were taken occasionally at the various stations.

During the summer of 1965, the investigation was expanded to include a section of the Hudson River above Poughkeepsie. To accomplish this with the facilities

available, all collecting sited on the east side of the river and Stations I W 1, I W 4, II W 3 and III W 1 on the west side of the river were dropped. A new station II W 2 A was added on the west side in the sector below Poughkeepsie at Cornwall. Four new stations were added on the west side of the river in the sector above Poughkeepsie. These were I V W 1, located one-quarter mile north of Esopus Meadows. Point in the town of Esopus; I V W 2, a cove at Ulster Landing; I V W 3, 1500 feet W.N.W. of Esopus Creek Inlet; I V W 4, the cove 1000 feet south of Smith Landing at Cementon (Figure 1). Also in the 1965 study, collections were quantitated.

Every station was visited five times in the period from June 21st through August 16, 1965; in June on one day during the interval June 21,22; in July on one day each during the intervals July 6-7 and July 19-20; and in August on one day each during August 2-4 and August 16-17. A fifty foot nylon seine of the following specifications was employed to collect the fish. The mesh size was 3/8 of an inch while the top and bottom lines were made of $\frac{1}{4}$ inch polypropylene. The former had plastic floats $2\frac{1}{2}$ inches in diameter and $\frac{1}{2}$ inch thick every 15 inches while the latter had a number 9 oblong lead every 15 inches. Centrally located in the body of the net was a pocket of the

same material as the net. The pocket was 4 by 4 feet at its attachment and extended back for 6 feet.

The net was set at each station according to fixed procedure. It was pulled out into the water perpendicular to the shore until a depth of about 4 feet was reached. The distance to this depth from the shoreline varied from station to station and changed with the tide. Measurements were made in multiples of 25 feet and ranged from 25 to 100 feet. At the prescribed position, the net was stretched parallel to the shore and then hauled to the beach. The product of the distance from the shore where the net was set and the length of the net is taken as the area seined. Slight changes in these parameters occasionally were incurred because of obstructions. The number of tows made at a station at a particular time was dependent on the extensiveness of the shore area suitable for seining and this varied according to tide. Table 1 summarizes the number of tows made at each station and the computed total area seined. The average total area seined per individual station for the entire period studied was 40,908 square feet and ranged from 12,925 square feet at II W 2 to 57,500 square feet at IV W 2. The average number of tows made at the individual stations for the period under study was 13 with a range of 11 to 16.

The lengths of each species of fish taken at Stations I W 3, II W 1, II W 2A and III W 2 were pooled and the composite length frequency considered as indicative of the size composition of these fish in the euryhaline environment below Poughkeepsie. Similarly, lengths of each species taken at Stations IV W 1, IV W 2, IV W 3 and IV W 4 were combined and the pooled frequency taken as indicative of these fishes in the freshwater environment above Poughkeepsie. Further, the combined frequencies by species for the areas below and above Poughkeepsie were determined, when possible, for two time periods, namely June-July (Period 1) and August (Period 2).

From these length frequencies and information on length-age distributions of Hudson River fishes obtained in the 1964 study (Eisenbud et. al., 1965), the catch of most species could be divided into two age categories; a 0+ (young-of-the year) group and a 1+ (one year and older) group. This information was then correlated with field data on the extent of area seined. An arbitrary relative catch per unit of area figure, the number of fish caught in each of the two age categories per 100,000 square feet of shore area seined was calculated for each station, throughout the collecting season. This measure of relative abundance and availability was also calculated for each species for the entire collecting period and for the whole river by taking the average of the catch per 100,000 square feet of shore

area seined obtained for all nine stations.

RESULTS

Species Captured

A total of eighteen species of fishes were most common in the catch. These were the white perch, *Roccus americanus*; striped bass, *Roccus saxatilis*; shad, *Alosa sapidissima*; alewife, *Alosa pseudoharengus*; blueback herring, *Alosa aestivalis*; spottail shiner, *Notropis hudsonius*, goldfish *Carassius auratus*; carp, *Cyprinus carpio*; golden shiner, *Notemigonus crysoleucas*; saltwater killifish, *Fundulus heteroclitus*; freshwater killifish, *Fundulus diaphanus*; Johnny darter, *Etheostoma nigrum*; common sunfish, *Lepomis gibbosus*; American eel, *Anguilla rostrata*; common silverside, *Menidia menidia*; tidewater silverside, *Menidia beryllina*; bay anchovy, *Anchoa mitchilli* and the white mullet, *Mugil curema*. Appearing as rare stragglers, particularly in the area below Poughkeepsie, were the bluefish, *Pomatomus saltatrix*, the tomcod, *Microgadus tomcod*; the northern pipefish, *Syngnathus fuscus*; four-spined stickleback, *Apeltes quadracus*; hogchoker, *Trinectes maculatus*; the Atlantic needlefish, *Strongylura marina*; and the Crevalle jack, *Caranx hippos*.

Length-frequency Distributions

The length-frequency distributions of the eighteen species of fishes predominant in the catch are given in Tables 2-7. To facilitate analysis, the length frequencies have been plotted for twelve of these species which were found to be the most abundant or of economic importance or both (Figures 2-6). Where sufficient data was available, the length-frequency distribution has been given independently for the areas above and below Poughkeepsie both for the period covering the combined collections of June and July (Period 1) and the period covering the collections taken in August (Period 2). Where data was less complete for certian species, the length-frequency information for the two areas or two periods or both were combined.

An examination of this data indicates, in most species, a concentration of fishes of the smaller sizes and in the 0+ year class. In the white perch, during Period 1, the fish caught ranged in length from 10-154 mm. The 0+ age group ranging from 10-49 mm in length comprised 68 percent of the catch. In the north, the modal length was 25-29 mm compared to 20-24 mm in the south (Table 2, Figure 2). The 1+ age group ranged in length from 55-89 mm and made up 25 percent of the catch. Once again, the fish in the north appeared to be larger than those in the south. This difference in size of fish between the two areas is not evident

in Period 2.

Data on the striped bass was not extensive enough to do more than calculate a length-frequency distribution for the entire river for the total sampling period (Table 2, Figure 2). The 0+ age group ranged from 15-64 mm.

Among the herrings, only the shad was found in sufficient quantities both in the northern and southern areas to compare its size composition during the two time intervals. All the shad were young-of-the-year and ranged in length from 25-54 mm in Period 1 and 35-59 mm in Period 2 (Table 3, Figure 3). There is some suggestion that the fish in the northern area are larger than those in the south. All alewives and bluback herring were young-of-the-year.

Since relatively few alewives and blueback herring were taken below Poughkeepsie the total catch for the river was combined (Table 3, Figure 3). In Period 1, the alewives in the 0+ group were smaller than the shad and had a range of 10-59 mm but a mode at only 25-29 mm. This was also true for the blueback herring which ranged from 15-44 mm, also with a peak at only 25-29 mm. A relatively small sample of alewives caught in Period 2 were larger than shad taken in the same period. The blueback herring remained smaller than the shad.

Among the killifishes, the freshwater killifish in the 0+ age group had a modal length during Period 1 of 15-19 mm in the southern area and 20-24 mm in the northern area (Table 4, Figure 4). In Period 2, the 0+ fish in the north were also larger in size than those in the south, with a mode at 30-34 mm and 25-29 mm respectively. The length-frequency distribution for the mature fish, those 1+ and older, show the females to be larger than the males.

The saltwater killifish, unlike its related freshwater species, was found mostly below Poughkeepsie during Period 1. The 0+ fish had a modal length of 20-24 mm, during Period 1 and 25-29 mm during Period 2 (Table 5, Figure 5). Also, as in the freshwater killifish, the adult females were larger than the males.

The common silverside was caught only below Poughkeepsie and the fish taken were exclusively 0+ fish (Table 5, Figure 5). The modal length was 55-59 mm in Period 1 and 65-69 mm in Period 2.

Young-of-the-year goldfish were taken both above and below Poughkeepsie (Table 5, Figure 5). Fish caught in the north appeared to be larger in size with modal lengths during Period 1 at 15-19 mm and 25-29 mm compared to a modal

length of 15-19 mm in the south. In August, the modal length of fish above Poughkeepsie was 25-29 mm. No data was available on fish in the south during this period.

Another cyprinid, the spottail shiner, also showed 0+ fish which were larger in the north than in the south during Period 1 (Table 6, Figure 6). In both the north and south, the 0+ fish ranged from 10-39 mm. However, in the north, the modal length was 30-34 mm while in the south it was 20-24 mm. In Period 2, no difference in mode appears between fish from the two areas.

The common sunfish was not available in large enough numbers to compare the size distributions in the two areas (Table 6, Figure 6). However, considering the river as a whole, in Period 1 the 0+ fish ranged from 10-24 mm with a mode at 15-19 mm and in Period 2, from 10-44 mm with modes at 15-19 mm and 25-29 mm.

The Johnny darter occurred in both areas throughout the investigation and the catch consisted mostly of 0+ fish. In this age group the length varied from 10-39 mm in Period 1. As with other species cited above the fish appeared larger in the north than the south with modal lengths of 30-34 mm and 25-29 mm respectively (Table 6, Figure 6). This difference in length is not present in Period 2.

Relatively few carp, golden shiners and tidewater silversides were caught throughout the river (Table 7). The young-of-the-year carp ranged in size from 10-49 mm while the range of sizes of golden shiners was 25-89 mm. The tidewater silversides were taken only below Poughkeepsie. They were all 0+ fish and ranged in size from 25-64 mm.

Bay anchovy and white mullet were caught only at the lower stations of the southern area and were all 0+ fish (Table 7). The anchovy varied from 20-34 mm in length while the mullet ranged from 25-84 mm in length.

The final species to be considered, the American eel, ranged in size from 60-454 mm (Table 2). The size distribution by year class could not be determined as no data on age was available.

Aside from usefulness in delineating the 0+ age group for the various species, the length frequencies indicate that many of the species are larger in size during Period 1 in the area above Poughkeepsie than in the souther area. Whether this is due to earlier spawning or more favorable environmental conditions in the freshwater reaches of the river is not know.

Relative Abundance

On the basis of both the length-frequencies presented

above and the age-length frequencies computed for Hudson River fishes during 1964 (Eisenbud et. al., 1965) a quantitative comparative catch of 0+ and 1+ > fish was computed for the entire collection period for each species and for all species both for individual stations and all stations combined (Table 8, Figure 7). As has been explained previously, these quantitative comparative catches are computed from measured areas of seining at stations and converted to an arbitrary unit of catch per 100,000 square feet of shore seining area. This unit of catch will be designated by the letters p.u.a. (per unit area) in future discussion.

The relative abundance of all species of fishes taken at each station throughout the period studied ranged from 1,553-8,346 p.u.a. (Table 8). However, in seven of the nine stations the range was much smaller, 1,553-2,666 p.u.a. High levels of abundance prevailed at I W 3 and II W 2 with figures of 5,256 and 8,346 p.u.a. respectively. The high level of abundance at I W 3 was influenced by penetration of such species as the common silverside, bay anchovy and white mullet from the relatively salt water of the southern reaches of the Hudson River. At II W 2, the backwater environment appeared to be a favorable nursery habitat, particularly for the spottail

shiner, saltwater killifish, white perch and Johnny darter.

Of the eighteen species considered, the spottail shiner was the most abundant averaging 481 fish p.u.a. (Table 8, Figure 10). Most of the catch, 442 p.u.a. was 0+ fish. The remaining 39 p.u.a., were 1+ and older fish. Spottail shiners were taken at all stations except I W 3, the southernmost station. Young-of-the-year fish were most abundant at II W 2, while older fish were more prevalent upriver at II W 2, IV W 1 and IV W 4.

The second most abundant species was the freshwater killifish with a catch of 470 p.u.a. (Table 8, Figure 9). Almost half of the catch, 227 p.u.a. consisted of 1+ and older fish and the remainder, 0+ fish. Some specimens were caught at all stations, but 0+ fish were most abundant at II W 2, II W 2A, III W 2, IV W 1, and IV W 3 while 1+ and older fish were most abundant at II W 1, II W 2, II W 2A and III W 2.

Four species are in close competition as the next most abundant fish. These are the white perch, saltwater killifish, common silverside and Johnny darter. The abundance of white perch was 372 p.u.a., and consisted of 256 p.u.a. of 0+ fish and a remainder of 1+ > fish (Table 8, Figure 8). Both age groups were taken at all stations. In the lower part of the river, both age groups were most abundant at

II W 1 and II W 2, while in the upper portion of the river the 0+ fish were most prevalent at IV W 1 and the 1+ fish were most prevalent at IV W 1, IV W 2 and IV W 4. The saltwater killifish had a relative abundance of 364 p.u.a. of which more than 60 percent was 1+ > fish (Table 8, figure 9). Both the 0+ and 1+ > age groups were most common in the euryhaline area below Poughkeepsie particularly at I W 3, II W 1 and II W 2 while the 1+ > fish were also abundant at III W 2. In the freshwater area about Poughkeepsie few of this species were captured. The common silverside was calculated at 337 p.u.a. (Table 8). The catch comprised only 0+ fish and limited exclusively to the southermost two stations in the euryhaline zone, I W 3 and II W 1. The relative abundance of the Johnny darter at 336 p.u.a. was derived from a mixed catch of 0+ and 1+ > fish of which 96 percent made up the former age category (Table 8, Figure 9). Fish of this species were found at all stations but I W 3. The 0+ fish were most abundant at II W 2 and IV W 3. The majority of the 1+ > fish were captured upriver at the four freshwater stations north of Poughkeepsie.

The blueback herring was next in order of abundance with a count of 273 p.u.a. (Table 8, Figure 8). All fish belonged to the 0+ age group. While they occurred at all stations but I W 3, the center of abundance was in the three upriver stations IV W 2, IV W 3, and IV W 4.

The two other clupeids commonly found in the Hudson River, the shad and alewife, were also caught as young-of-the-year and were approximately one-fourth as abundant as the blueback herring (Table 8, Figure 8). The shad was found at all stations except I W 1 and II W 2 and was most abundant in the lower river at II W 1, II W 2A and II W 2 and in the upper river at IV W 2 and IV W 4. By contrast, the alewife which occurred at all stations but I W 1 was most abundant in the four stations north of Poughkeepsie, IV W 1 to IV W 4.

Next in order of abundance was the bay anchovy with a concentration of 160 p.u.a. (Table 8). All fish were 0+ age group and were taken only at the southernmost stations, I W 3. Similarly, the tidewater silverside and white mullet of the 0+ age group were taken in the southernmost part of the river but in relatively small numbers (Table 8). The catch of tidewater silversides was 18 p.u.a. with the bulk taken at I W 3 and a few at II W 1. The catch of white mullet was 32 p.u.a., all from I W 3.

Goldfish of the 0+ age class were found to number 107 p.u.a. (Table 8, Figure 10). They were lacking in the southernmost three stations, I W 3, II W 1 and II W 2 and the most northern station IV W 4. They were most abundant at II W 2, IV W 1 and IV W 3. Another cyprinid,

the carp, was relatively scarce in the catch. The 0+ fish had a concentration of 3 p.u.a. (Table 8, Figure 10). They were not present at III W 2 and at the four stations in which the goldfish were absent and were most abundant at II W 2A, IV W 1 and IV W 3. Still another cyprinid, the golden shiner, was rare in our catch. The average abundance of 0+ fish was 7 p.u.a. (Table 8, Figure 10). No specimens were taken at I W 3, II W 2 or IV W 2. Most of the fish were captured at II W 2A, IV W 1, IV W 3 and IV W 4.

Common sunfish were found to average 89 p.u.a. of which about 60 percent were 0+ fish and the remainder 1+ > (Table 8, Figure 9). Peak abundance for 0+ fish was at II W 2A and IV W 3 and 1+ > fish at II W 2 and II W 2A.

Coming now to the commercially and recreationally important species of fish, the striped bass, the relative abundance was computed at 41 p.u.a. for all ages captured (Table 8, Figure 8). The relative abundance of the 0+ fish alone, was 37 p.u.a. Peaks of abundance of the 0+ fish were found at II W 1 and II W 2 and of the 1+ > fish at II W 1, II W 2 and II W 2A.

The single species remaining, the American eel, had a relative abundance of 28 p.u.a. for all ages. Eels were present at all stations but were most abundant at

II W 1, II W 2 and II W 2A.

CONCLUSIONS

The information presented in this paper is basic to an understanding of the effects of changes of environmental conditions in the river on fish populations. The levels of abundance of fishes collected along the shores of the Hudson River in 1965, particularly of the 0+ age group, will serve as standards for comparison in subsequent years and is expected to be reflective of changes in the environment of the Hudson River as a whole. Studies now in progress are examining the relationships of major, man-induced environmental changes with fluctuations in abundance.

Table 1. Number of Tows and Computed Area Seined at Each Station, 1965

Period	South of Poughkeepsie														
	I W 3			II W 1			II W 2			II W 2A			III W 2		
	Total Area Seined	No. of Tows	Av. Area Seined Per Tow	Total Area Seined	No. of Tows	Av. Area Seined Per Tow	Total Area Seined	No. of Tows	Av. Area Seined Per Tow	Total Area Seined	No. of Tows	Av. Area Seined Per Tow	Total Area Seined	No. of Tows	Av. Area Seined Per Tow
June 21-22	13,750	4	3,438	5,000	2	2,500	2,675	2	1,338	6,250	2	3,125	10,000	4	2,500
July 6-7	16,750	4	4,188	5,000	2	2,500	2,500	2	1,250	10,000	2	5,000	5,000	2	2,500
July 19-20	7,500	2	3,750	5,750	2	2,875	1,375	2	688	7,500	2	3,750	5,000	2	2,500
Aug. 2-4	6,250	2	3,125	4,500	4	1,125	1,875	3	625	10,000	3	5,000	12,500	4	3,125
Aug. 16-17	6,750	2	3,375	5,500	3	1,833	4,500	2	2,250	7,500	2	3,750	9,250	3	3,083
TOTAL	51,000	14	3,600	25,750	13	1,900	12,925	11	1,200	41,250	11	3,800	41,750	15	2,800

Period	North of Poughkeepsie											
	IV W 1			IV W 2			IV W 3			IV W 4		
June 21-22	13,750	3	4,583	8,750	3	2,917	8,750	3	2,917	7,500	4	1,875
July 6-7	7,500	2	3,750	8,750	3	2,917	4,250	3	1,417	5,000	2	2,500
July 19-20	7,500	2	3,750	11,250	3	3,750	10,000	3	3,333	17,500	5	3,500
Aug. 2-4	12,500	2	6,250	15,000	3	5,000	37,500	2	3,750	13,750	3	4,583
Aug. 16-17	5,000	2	2,500	13,750	3	4,583	10,000	2	5,000	7,500	2	3,750
TOTAL	46,250	11	4,200	57,500	15	3,800	40,500	13	3,200	51,250	16	3,200

Table 2. Size Composition of White Perch, Striped Bass and Eel, 1965

Standard Length (mm.)	White Perch								Striped Bass		Eel			
	SOUTH 1/				NORTH 1/				All Stations, Whole Period		SOUTH		NORTH	
	1 2/		2 2/		1		2							
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
10-14	-	-	-	-	6	1.7	-	-	-	-	-	-	-	-
15-19	24	8.6	-	-	15	4.3	-	-	3	3.7	-	-	-	-
20-24	110	39.5	-	-	3	.9	3	5.3	19	23.2	-	-	-	-
25-29	17	6.1	2	1.8	102	29.1	1	1.8	18	21.9	-	-	-	-
30-34	34	12.2	-	-	43	12.3	2	3.6	7	8.5	-	-	-	-
35-39	3	1.1	2	1.8	55	15.7	3	5.3	4	4.9	-	-	-	-
40-44	-	-	12	10.7	12	3.4	24	42.1	6	7.3	-	-	-	-
45-49	-	-	14	12.5	1	.3	19	33.3	4	4.9	-	-	-	-
50-54	-	-	13	11.6	-	-	3	5.3	5	6.1	-	-	-	-
55-59	1	.4	1	.9	-	-	1	1.8	3	3.7	-	-	-	-
60-64	3	1.1	-	-	1	.3	-	-	3	3.7	1	1.5	-	-
65-69	12	4.3	-	-	8	2.3	-	-	-	-	6	9.2	1	3.1
70-74	17	6.1	-	-	17	4.9	-	-	-	-	10	15.4	-	-
75-79	15	5.4	-	-	53	15.1	-	-	2	2.4	6	9.2	-	-
80-84	7	2.5	11	9.8	4	1.1	-	-	-	-	7	10.8	1	3.1
85-89	2	.7	11	9.8	5	1.4	-	-	1	1.2	2	3.1	1	3.1
90-94	4	1.4	5	4.5	2	.6	1	1.8	1	1.2	1	1.5	-	-
95-99	5	1.8	10	8.9	4	1.1	-	-	2	2.4	3	4.6	2	6.3
100-104	9	3.2	3	2.7	9	2.6	-	-	1	1.2	3	4.6	-	-
105-109	7	2.5	5	4.5	4	1.1	-	-	-	-	3	4.6	2	6.3
110-114	2	.7	7	6.2	1	.3	-	-	1	1.2	1	1.5	1	3.1

Table 2 Cont'd.

Standard Length (mm.)	White Perch								Striped Bass		Eel			
	SOUTH 1/				NORTH 1/				All Stations, Whole Period		SOUTH		NORTH	
	1 2/		2 2/		1		2							
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
115-119	1	.4	7	6.2	-	-	-	-	-	-	2	3.1	3	9.4
120-124	1	.4	1	.9	1	.3	-	-	1	1.2	3	4.6	-	-
125-129	-	-	1	.9	-	-	-	-	-	-	1	1.5	-	-
130-134	-	-	2	1.8	2	.6	-	-	-	-	2	3.1	3	9.4
135-139	-	-	2	1.8	-	-	-	-	-	-	1	1.5	2	6.3
140-144	1	.4	-	-	1	.3	-	-	-	-	2	3.1	1	3.1
145-149	2	.7	2	1.8	-	-	-	-	-	-	-	-	-	-
150-154	1	.4	-	-	-	-	-	-	-	-	3	4.6	1	3.1
155-159	-	-	-	-	-	-	-	-	-	-	-	-	-	-
160-164	-	-	-	-	-	-	-	-	-	-	2	3.1	5	15.6
165-169	-	-	-	-	-	-	-	-	1	1.2	1	1.5	1	3.1
170-174	-	-	-	-	-	-	-	-	-	-	1	1.5	1	3.1
175-179	-	-	-	-	-	-	-	-	-	-	1	1.5	-	-
180-184	-	-	-	-	-	-	-	-	-	-	1	1.5	-	-
185-189	-	-	-	-	-	-	-	-	-	-	-	-	1	3.1
190-194	-	-	-	-	-	-	-	-	-	-	-	-	1	3.1
195-199	-	-	1	.9	-	-	-	-	-	-	-	-	-	-
200-204	-	-	-	-	1	.3	-	-	-	-	-	-	-	-
205-209	-	-	-	-	-	-	-	-	-	-	1	1.5	-	-
210-214	-	-	-	-	-	-	-	-	-	-	1	1.5	-	-
275-279	-	-	-	-	-	-	-	-	-	-	-	-	1	3.1
305-309	-	-	-	-	-	-	-	-	-	-	-	-	1	3.1

Table 2. Cont'd.

Standard Length (mm.)	White Perch								Striped Bass		Eel			
	SOUTH 1/				NORTH 1/				All Stations, Whole Period		SOUTH		NORTH	
	1 2/		2 2/		1		2							
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
340-344	-	-	-	-	-	-	-	-	-	-	-	-	1	3.1
380-384	-	-	-	-	-	-	-	-	-	-	-	-	1	3.1
450-454	-	-	-	-	-	-	-	-	-	-	-	-	1	3.1
TOTAL	278	99.9	112	100.0	350	100.0	57	100.3	82	99.9	65	99.6	32	99.8

1/ South and North of Poughkeepsie

2/ Period 1: Includes collections taken on one day during the interval June 21-22; one day each during the intervals July 6-7 and July 19-20. Period 2: Includes collections taken on one day each during the intervals August 2-4 and August 16-17.

Table 3. Size Composition of Shad, Alewife and Blueback Herring, 1965

Standard Length (mm.)	Shad								Alewife				Blueback Herring			
	SOUTH 1/				NORTH 2/				All Stations				All Stations			
	1 2/		2 2/		1		2		1		2		1		2	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
10-14	-	-	-	-	-	-	-	-	9	6.1	-	-	-	-	4	1.3
15-19	-	-	-	-	-	-	-	-	14	9.5	-	-	4	1.3	38	12.7
20-24	-	-	-	-	-	-	-	-	25	17.0	-	-	40	12.9	33	11.0
25-29	-	-	-	-	5	6.3	-	-	39	26.5	-	-	144	46.5	56	18.7
30-34	20	39.2	-	-	21	26.3	-	-	13	8.8	-	-	103	33.3	89	29.6
35-39	7	13.7	28	68.3	31	38.8	3	3.9	17	11.6	-	-	17	5.5	66	22.0
40-44	9	17.6	12	29.3	19	23.8	14	18.2	21	14.3	-	-	1	.3	12	4.0
45-49	12	23.5	1	2.4	4	5.0	27	35.1	4	2.7	1	5.6	-	-	2	.7
50-54	3	5.9	-	-	-	-	26	33.8	4	2.7	1	5.6	-	-	-	-
55-59	-	-	-	-	-	-	7	9.1	1	.7	4	22.2	-	-	-	-
60-64	-	-	-	-	-	-	-	-	-	-	6	33.3	-	-	-	-
65-69	-	-	-	-	-	-	-	-	-	-	5	27.8	-	-	-	-
70-74	-	-	-	-	-	-	-	-	-	-	1	5.6	-	-	-	-
TOTAL	51	99.9	41	100.0	80	100.2	77	100.1	147	99.9	18	100.1	309	99.8	300	100.0

1/ South and North of Poughkeepsie

2/ Period 1: Includes collections taken on one day during the interval June 21-22; one day each during the intervals July 6-7 and July 19-20. Period 2: Includes collections taken on one day each during the intervals August 2-4 and August 16-17.

Table 4. Size Composition of Freshwater Killifish, 1965

Standard Length (mm.)	SOUTH 1/												NORTH 1/											
	1 2/						2 2/						1						2					
	I 3/		M 3/		F 3/		I		M		F		I		M		F		I		M		F	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
10-14	26	4.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15-19	107	17.3	-	-	-	-	3	1.1	-	-	-	-	2	2.9	-	-	-	-	4	1.4	-	-	-	-
20-24	60	9.7	-	-	-	-	33	12.0	-	-	-	-	18	26.5	-	-	-	-	27	9.3	-	-	-	-
25-29	13	2.1	-	-	-	-	99	35.8	-	-	-	-	5	7.4	-	-	-	-	82	28.1	-	-	-	-
30-34	8	1.3	-	-	-	-	49	17.7	-	-	-	-	1	1.5	-	-	-	-	87	29.8	-	-	-	-
35-39	1	.2	-	-	-	-	10	3.6	-	-	2	.7	-	-	-	-	-	-	41	14.1	-	-	-	-
40-44	-	-	6	1.0	1	.2	-	-	-	-	4	1.5	-	-	-	-	-	-	18	6.2	-	-	-	-
45-49	-	-	24	3.9	13	2.1	1	.4	1	.4	4	1.5	-	-	-	-	-	-	3	1.1	-	-	-	-
50-54	-	-	33	5.4	28	4.5	-	-	3	1.1	-	-	-	-	7	10.3	3	4.4	-	-	1	.3		
55-59	-	-	71	11.5	36	5.8	-	-	8	2.9	3	1.1	-	-	7	10.3	3	4.4	-	-	3	1.0		
60-64	-	-	37	6.0	47	7.6	-	-	13	4.7	12	4.3	-	-	6	8.8	5	7.4	-	-	5	1.7	2	.7
65-69	-	-	28	4.5	23	3.7	-	-	3	1.1	11	4.0	-	-	3	4.4	4	5.9	-	-	1	.3	6	2.1
70-74	-	-	14	2.3	10	1.6	-	-	1	.4	11	4.0	-	-	1	1.5	3	4.4	-	-	-	-	5	1.7
75-79	-	-	3	.5	13	2.1	-	-	-	-	3	1.1	-	-	-	-	-	-	-	-	-	-	5	1.7
80-84	-	-	4	.7	8	1.3	-	-	-	-	1	.4	-	-	-	-	-	-	-	-	-	-	-	-
85-89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	.3
90-94	-	-	-	-	-	-	-	-	-	-	1	.4	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	215	34.8	220	35.8	179	28.9	195	70.6	29	10.6	52	19.0	26	38.3	24	35.3	18	26.5	262	90.0	10	3.3	19	6.5

1/ South and North of Poughkeepsie

2/ Period 1: Includes collections taken on one day during the interval June 21-22; one day each during the intervals July 6-7 and July 19-20. Period 2: Includes collections taken on one day each during the intervals August 2-4 and August 16-17.

3/ I, M and F; immature, mature males and mature females respectively.

Table 5. Size Composition of Saltwater Killifish, Common Silverside and Goldfish, 1965

Standard Length (mm.)	Saltwater Killifish												Common Silverside				Goldfish					
	SOUTH 1/												SOUTH				SOUTH		NORTH 1/			
	1 2/						2 2/															
	I 3/		M 3/		F 3/		I 3/		M 3/		F 3/		1		2		1		1		2	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
10-14	1	.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	14.3	2	2.3	-	-
15-19	17	2.7	-	-	-	-	2	.8	-	-	-	-	6	2.6	-	-	46	43.8	26	29.5	-	-
20-24	69	11.0	-	-	-	-	28	11.6	-	-	-	-	16	6.9	-	-	30	28.6	17	19.3	15	9.3
25-29	73	11.7	-	-	-	-	58	24.0	-	-	-	-	16	6.9	8	2.7	9	8.6	21	23.5	49	30.4
30-34	56	9.0	6	1.0	-	-	53	21.9	11	4.5	6	2.5	8	3.5	11	3.8	2	1.9	11	12.5	34	21.1
35-39	36	5.8	19	3.0	-	-	32	13.2	9	3.7	18	7.4	15	6.5	12	4.1	1	1.0	7	8.0	18	11.2
40-44	7	1.1	54	8.6	16	2.6	3	1.2	2	.8	6	2.5	14	6.1	12	4.1	-	-	1	1.1	18	11.2
45-49	-	-	53	8.5	40	6.4	-	-	-	-	2	.8	17	7.4	16	5.5	-	-	1	1.1	15	9.3
50-54	-	-	26	4.2	35	5.6	-	-	2	.8	1	.4	27	11.7	17	5.8	-	-	-	-	7	4.4
55-59	-	-	16	2.6	33	5.3	-	-	1	.4	-	-	71	30.8	14	4.8	-	-	-	-	2	1.2
60-64	-	-	9	1.4	24	3.8	-	-	1	.4	1	.4	37	16.1	54	18.5	-	-	-	-	2	1.2
65-69	-	-	3	.5	10	1.6	-	-	-	-	2	.8	3	1.3	78	26.7	-	-	-	-	1	.6
70-74	-	-	2	.3	11	1.8	-	-	-	-	2	.8	-	-	48	16.4	-	-	-	-	-	-
75-79	-	-	-	-	2	.3	-	-	-	-	-	-	-	-	18	6.2	-	-	-	-	-	-
80-84	-	-	-	-	1	.2	-	-	-	-	1	.4	-	-	2	.7	-	-	-	-	-	-
85-89	-	-	-	-	3	.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
90-94	-	-	-	-	3	.5	-	-	-	-	-	-	-	-	1	.3	-	-	-	-	-	-
95-99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
100-104	-	-	-	-	-	-	-	-	-	-	1	.4	-	-	1	.3	-	-	1	1.1	-	-
150-154	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1.0	-	-	-	-
200-204	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1.0	-	-	-	-
205-209	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1.1	-	-
TOTAL	259	41.5	188	30.1	178	28.6	176	72.7	26	10.6	40	16.4	230	99.8	292	99.9	105	100.2	88	99.5	161	99.9

1/ South and North of Poughkeepsie

2/ Period 1: Includes collections taken on one day during the interval June 21-22; one day each during the intervals July 6-7 and July 19-20. Period 2: Includes collections taken on one day each during the intervals August 2-4 and August 16-17.

3/ I, M and F; immature, mature males and mature females, respectively.

Table 6. Size Composition of Spottail Shiner, Common Silverside and Johnny Darter, 1965

tandard ength mm.)	Spottail Shiner								Common Sunfish				Johnny Darter							
	SOUTH 1/				NORTH 1/				All Stations				SOUTH				NORTH			
	1 2/		2 2/		1		2		1		2		1		2		1		2	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
10-14	8	3.7	-	-	17	9.1	-	-	9	5.7	1	.5	4	2.6	-	-	2	1.4	-	-
15-19	31	14.3	-	-	9	4.8	-	-	29	18.3	53	28.5	33	21.2	-	-	3	2.1	-	-
20-24	65	30.0	-	-	33	17.6	1	.5	19	12.0	41	22.0	31	19.9	-	-	6	4.1	4	1.6
25-29	49	22.6	8	6.7	41	21.9	10	5.4	-	-	42	22.6	64	41.0	-	-	53	36.3	10	4.0
30-34	24	11.1	29	24.4	45	24.0	31	16.7	-	-	16	8.6	16	10.3	3	30.0	54	36.9	46	18.2
35-39	5	2.3	49	41.2	9	4.8	98	52.6	-	-	13	7.0	1	.6	2	20.0	5	3.4	103	40.8
40-44	-	-	23	19.3	-	-	40	21.5	-	-	1	.5	-	-	2	20.0	-	-	75	29.7
45-49	2	.9	4	3.4	-	-	3	1.6	-	-	-	-	2	1.3	3	30.0	2	1.4	12	124.8
50-54	4	1.9	-	-	-	-	1	.5	3	1.9	-	-	5	3.2	-	-	6	4.1	-	-
55-59	10	4.6	-	-	-	-	-	-	4	2.5	1	.5	-	-	-	-	10	6.8	1	.4
60-64	8	3.7	-	-	1	.5	-	-	6	3.8	-	-	-	-	-	-	4	2.7	-	-
65-69	6	2.8	3	2.5	7	3.7	-	-	6	3.8	1	.5	-	-	-	-	1	.7	1	.4
70-74	2	.9	-	-	17	9.1	1	.5	5	3.2	-	-	-	-	-	-	-	-	-	-
75-79	1	.5	1	.8	6	3.2	1	.5	4	2.5	4	2.2	-	-	-	-	-	-	-	-
80-84	-	-	2	1.7	1	.5	-	-	2	1.3	4	2.2	-	-	-	-	-	-	-	-
85-89	1	.5	-	-	1	.5	-	-	2	1.3	2	1.1	-	-	-	-	-	-	-	-
90-94	-	-	-	-	-	-	-	-	5	3.2	2	1.1	-	-	-	-	-	-	-	-
95-99	-	-	-	-	-	-	-	-	6	3.8	1	.5	-	-	-	-	-	-	-	-
100-104	-	-	-	-	-	-	-	-	13	8.2	1	.5	-	-	-	-	-	-	-	-
105-109	-	-	-	-	-	-	-	-	14	8.9	-	-	-	-	-	-	-	-	-	-
110-114	-	-	-	-	-	-	-	-	15	9.5	-	-	-	-	-	-	-	-	-	-

Table 6. Cont'd.

Standard Length (mm.)	Spottail Shiner								Common Sunfish				Johnny Darter							
	SOUTH 1/				NORTH 1/				All Stations				SOUTH				NORTH			
	1 2/		2 2/		1		2		1		2		1		2		1		2	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
115-119	-	-	-	-	-	-	-	-	6	3.8	3	1.6	-	-	-	-	-	-	-	-
120-124	-	-	-	-	-	-	-	-	1	.6	-	-	-	-	-	-	-	-	-	-
125-129	-	-	-	-	-	-	-	-	2	1.3	-	-	-	-	-	-	-	-	-	-
130-134	-	-	-	-	-	-	-	-	4	2.5	-	-	-	-	-	-	-	-	-	-
135-139	-	-	-	-	-	-	-	-	2	1.3	-	-	-	-	-	-	-	-	-	-
140-144	-	-	-	-	-	-	-	-	1	.6	-	-	-	-	-	-	-	-	-	-
TOTAL	216	99.8	119	100.0	187	99.7	186	99.8	158	100.0	186	99.9	156	100.1	10	100.0	146	99.9	252	99.9

1/ South and North of Poughkeepsie

2/ Period 1: Includes collections taken on one day during the interval June 21-22; one day each during the intervals July 6-7 and July 19-20. Period 2: Includes collections taken on one day each during the intervals August 2-4 and August 16-17.

Table 7. Size Composition of Carp, Golden Shiner, Tidewater Silverside, Anchovy and Mullet, 1965

Standard Length (mm.)	Carp		Golden Shiner		Tidewater Silverside		Anchovy		Mullet	
	All Stations Whole Period		All Stations Whole Period		SOUTH 1/ 2 2/		SOUTH 2		SOUTH 2	
	No.	%	No.	%	No.	%	No.	%	No.	%
10-14	1	8.3	-	-	-	-	-	-	-	-
15-19	1	8.3	-	-	-	-	-	-	-	-
20-24	-	-	-	-	-	-	54	54	-	-
25-29	1	8.3	1	5.3	1	5.6	44	44	9	9.8
30-34	2	16.6	2	10.6	-	-	2	2	15	16.4
35-39	2	16.6	2	10.6	-	-	-	-	19	20.7
40-44	4	33.2	-	-	-	-	-	-	9	9.8
45-49	1	8.3	1	5.3	-	-	-	-	1	1.1
50-54	-	-	-	-	3	16.7	-	-	5	5.5
55-59	-	-	1	5.3	12	66.7	-	-	14	15.3
60-64	-	-	-	-	2	11.1	-	-	12	13.1
65-69	-	-	1	5.3	-	-	-	-	5	5.5
70-74	-	-	-	-	-	-	-	-	1	1.1
75-79	-	-	2	10.6	-	-	-	-	-	-
80-84	-	-	-	-	-	-	-	-	2	2.2
85-89	-	-	2	10.6	-	-	-	-	-	-
90-94	-	-	-	-	-	-	-	-	-	-
95-99	-	-	-	-	-	-	-	-	-	-
100-104	-	-	1	5.3	-	-	-	-	-	-
105-109	-	-	1	5.3	-	-	-	-	-	-

Table 7. Cont'd.

Standard Length (mm.)	Carp		Golden Shiner		Tidewater Silverside		Anchovy		Mullet	
	All Stations, Whole Period		All Stations Whole Period		SOUTH 1/ 2 2/		SOUTH 2		SOUTH 2	
	No.	%	No.	%	No.	%	No.	%	No.	%
110-114	-	-	1	5.3	-	-	-	-	-	-
130-134	-	-	2	10.6	-	-	-	-	-	-
145-149	-	-	1	5.3	-	-	-	-	-	-
170-174	-	-	1	5.3	-	-	-	-	-	-
TOTAL	12	99.6	19	100.7	18	100.1	100	100.0	92	100.5

1/ South of Poughkeepsie
2/ Period 2: Includes collections taken on one day each during the intervals August 2-4 and August 16-17.

Table 8. Catch[1] by Species at Sampling Stations, 1965 [2]

Station[3]	SPECIES								
	White Perch			Striped Bass			Shad	Alewife	Blueback Herring
	0+ [4]	1+>	T	0+	1+>	T	0+	0+	0+
I W 3	23	39	62	15	3	18	0	0	0
II W 1	458	281	739	76	12	88	126	41	42
II W 2	686	313	999	200	8	208	0	8	27
II W 2A	27	2	29	19	5	24	59	5	32
III W 2	32	53	85	0	0	0	168	15	45
IV W 1	942	55	997	5	3	8	11	107	4
IV W 2	71	132	203	19	3	22	178	115	1071
IV W 3	19	7	26	0	0	0	9	169	632
IV W 4	48	166	214	0	0	0	103	125	601
Average	256	116	372	37	4	41	73	65	273

Station	SPECIES								
	Spottail Shiner			Goldfish	Carp	Golden Shiner	Saltwater Killifish		
	0+	1+>	T	0+	0+	0+	0+	1+>	T
I W 3	0	0	0	0	0	0	662	257	919
II W 1	221	32	253	0	0	4	178	277	455
II W 2	3124	30	3154	0	0	0	335	814	1149
II W 2A	54	0	54	248	9	11	45	45	90
III W 2	16	59	75	10	0	2	46	544	590
IV W 1	40	143	183	648	8	24	0	0	0
IV W 2	299	24	323	2	1	0	0	0	0
IV W 3	72	0	72	59	6	9	6	10	16
IV W 4	149	63	212	0	0	15	5	52	57
Average	442	39	481	107	3	7	142	222	364

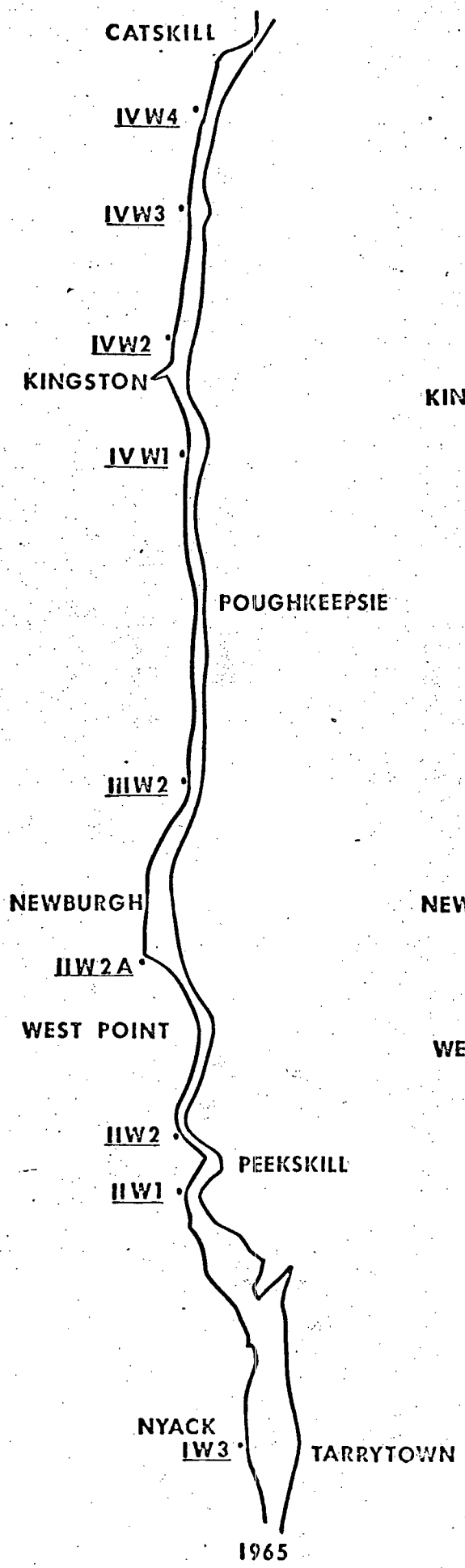
Table 8. Cont'd.

Station 3/	SPECIES								
	Freshwater Killifish			Johnny Darter			Common Sunfish		
	0+ 4/	1+>	T	0+	1+>	T	0+	1+>	T
I W 3	0	4	4	0	0	0	0	0	0
II W 1	0	158	158	15	4	19	0	4	4
II W 2	225	447	672	1785	0	1785	0	107	107
II W 2A	1155	227	1382	10	0	10	133	165	298
III W 2	129	1089	1218	86	8	94	4	10	14
IV W 1	293	76	369	54	15	69	24	25	49
IV W 2	12	0	12	13	18	31	0	4	4
IV W 3	311	16	327	895	12	907	316	9	325
IV W 4	59	25	84	44	56	100	0	1	1
Average	243	227	470	323	13	336	53	36	89

Station	SPECIES					
	Common Silverside	Tidewater Silverside	Anchovy	Mullet	Eel	All Species
	0+	0+	0+	0+	T	T
I W 3	2341	160	1442	292	18	5256
II W 1	693	4	0	0	36	2666
II W 2	0	0	0	0	30	8346
II W 2A	0	0	0	0	99	2300
III W 2	0	0	0	0	6	2335
IV W 1	0	0	0	0	5	2482
IV W 2	0	0	0	0	9	1971
IV W 3	0	0	0	0	11	2568
IV W 4	0	0	0	0	41	1553
Average	337	18	160	32	28	3281

1/ Catch per 100,000 square feet of shore area.
2/ Average of catches taken from June 21-August 17, 1965.
3/ See Figure 1 for locations.
4/ Age composition: 0+, young-of-the-year; 1+> , one year old and older; T, all ages combined.

Figure 1. Location of Sampling Station on the Hudson River, 1964 and 1965.


CATSKILL
IVW4
IVW3
IVW2
KINGSTON
IVW1
POUGHKEEPSIE
IIIW2
NEWBURGH
IIW2A
WEST POINT
IIW2
PEEKSKILL
IIW1
NYACK
IW3
TARRYTOWN
1965

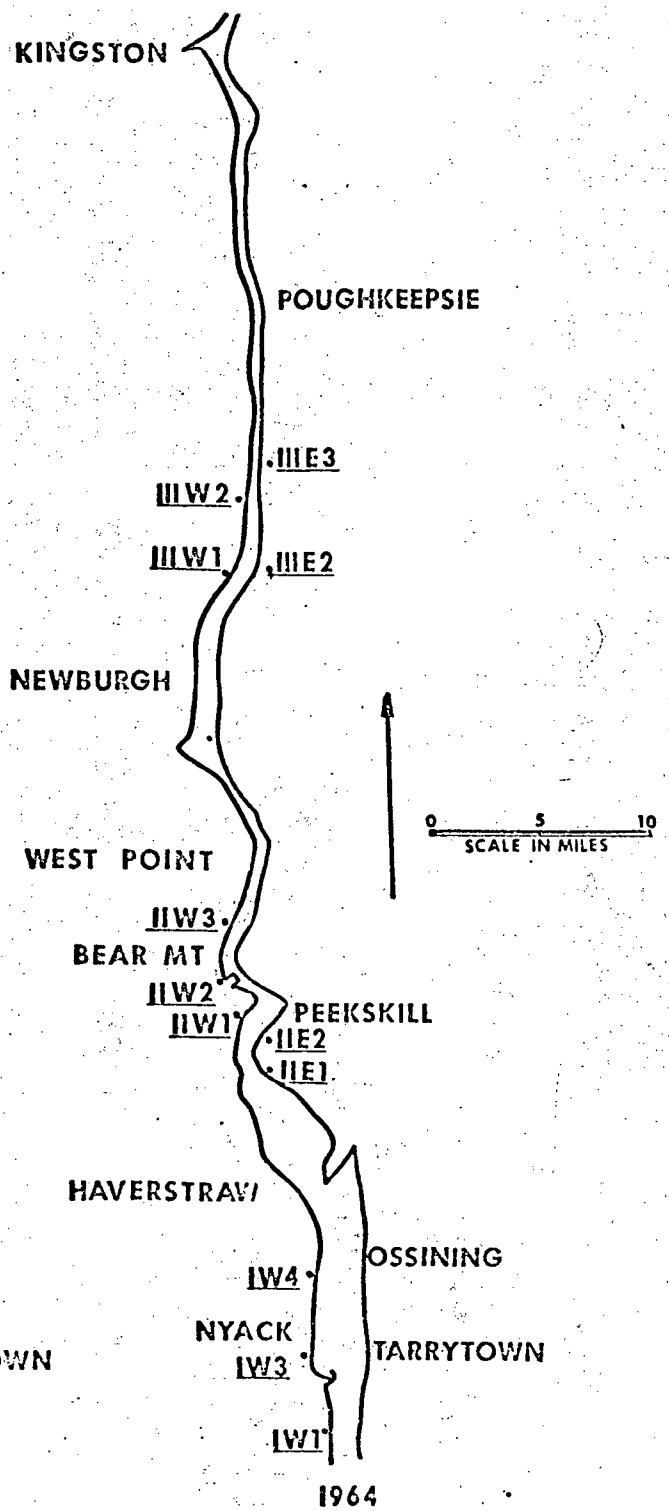

KINGSTON
POUGHKEEPSIE
IIIE3
IIIW2
IIIW1
IIIE2
NEWBURGH
0 5 10
SCALE IN MILES
WEST POINT
IIW3
BEAR MT
IIW2
IIW1
PEEKSKILL
IIE2
IIE1
HAVERSTRAW
OSSINING
IW4
NYACK
IW3
TARRYTOWN
IW1
1964

Figure 2. Length frequencies of white perch and striped bass. White perch in the 0+ year class ranged from 10-49mm in June-July and 20-59mm in August. Striped bass in the 0+ year class taken from June through August were 15-64mm in length.

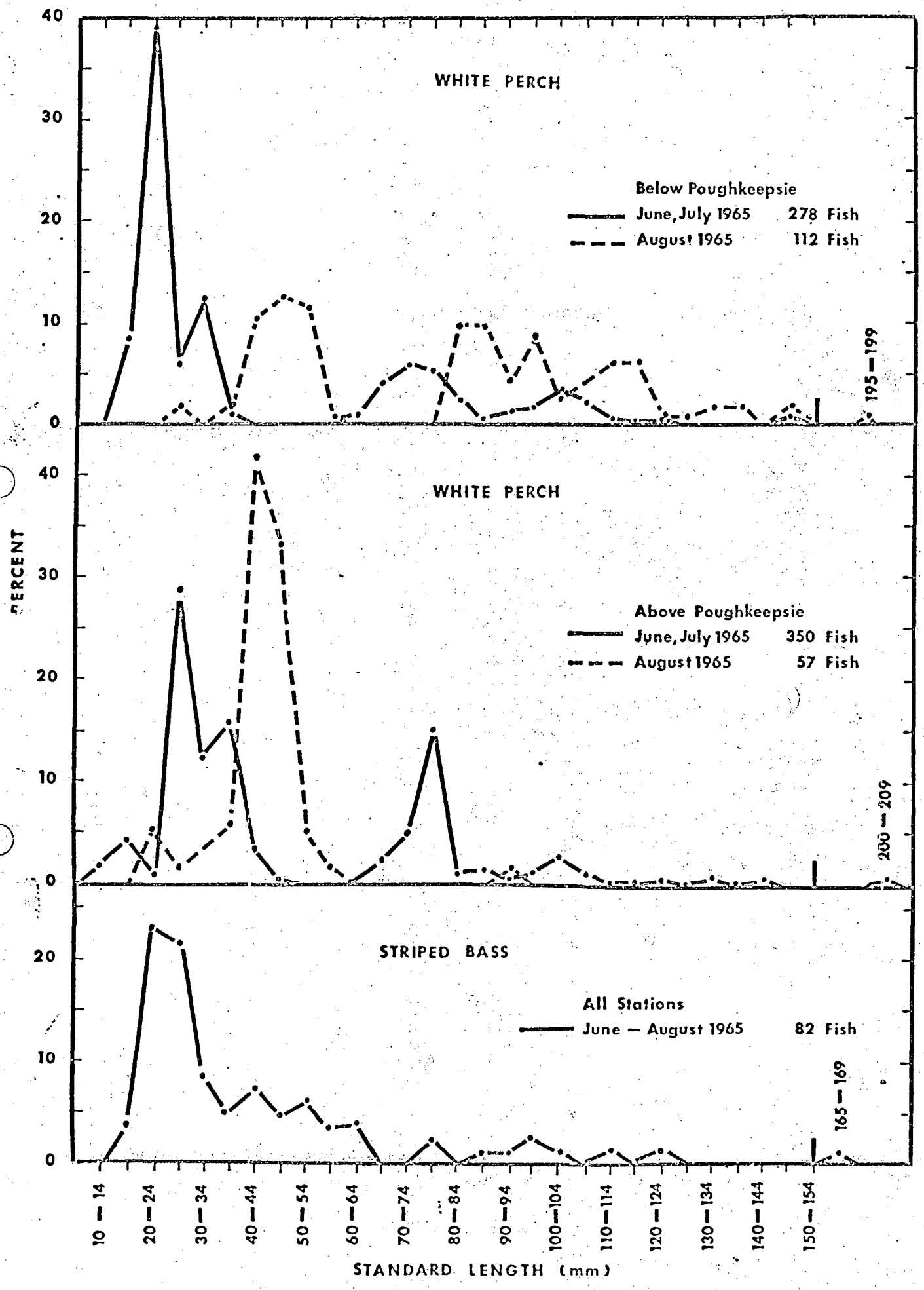

WHITE PERCH
Below Poughkeepsie
June, July 1965 278 Fish
August 1965 112 Fish
195—199
WHITE PERCH
Above Poughkeepsie
June, July 1965 350 Fish
August 1965 57 Fish
200—209
STRIPED BASS
All Stations
June — August 1965 82 Fish
165—169
PERCENT
0
10
20
30
40
10—14
20—24
30—34
40—44
50—54
60—64
70—74
80—84
90—94
100—104
110—114
120—124
130—134
140—144
150—154
STANDARD LENGTH (mm)

Figure 3. Length frequencies of the shad, alewife and blueback herring. All fish captured were 0+ (young-of-the-year).

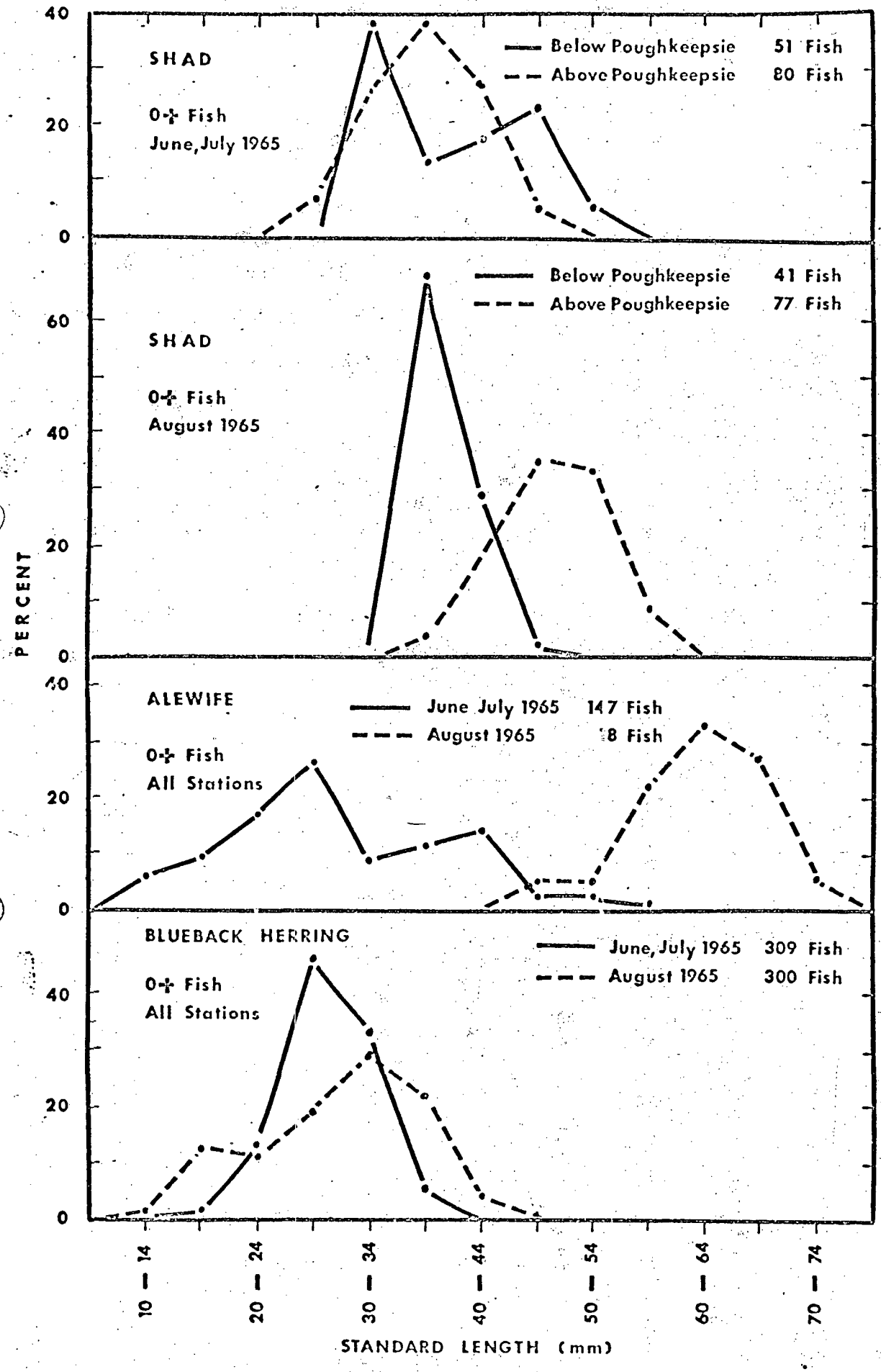

SHAD
0+ Fish
June, July 1965
Below Poughkeepsie 51 Fish
Above Poughkeepsie 80 Fish
SHAD
0+ Fish
August 1965
Below Poughkeepsie 41 Fish
Above Poughkeepsie 77 Fish
ALEWIFE
0+ Fish
All Stations
June July 1965 147 Fish
August 1965 18 Fish
BLUEBACK HERRING
0+ Fish
All Stations
June, July 1965 309 Fish
August 1965 300 Fish
PERCENT
0
20
40
60
10 — 14
20 — 24
30 — 34
40 — 44
50 — 54
60 — 64
70 — 74
STANDARD LENGTH (mm)

Figure 4. Length frequency distributions of the 0+ age group or unmature and the mature males and females of the freshwater killifish.

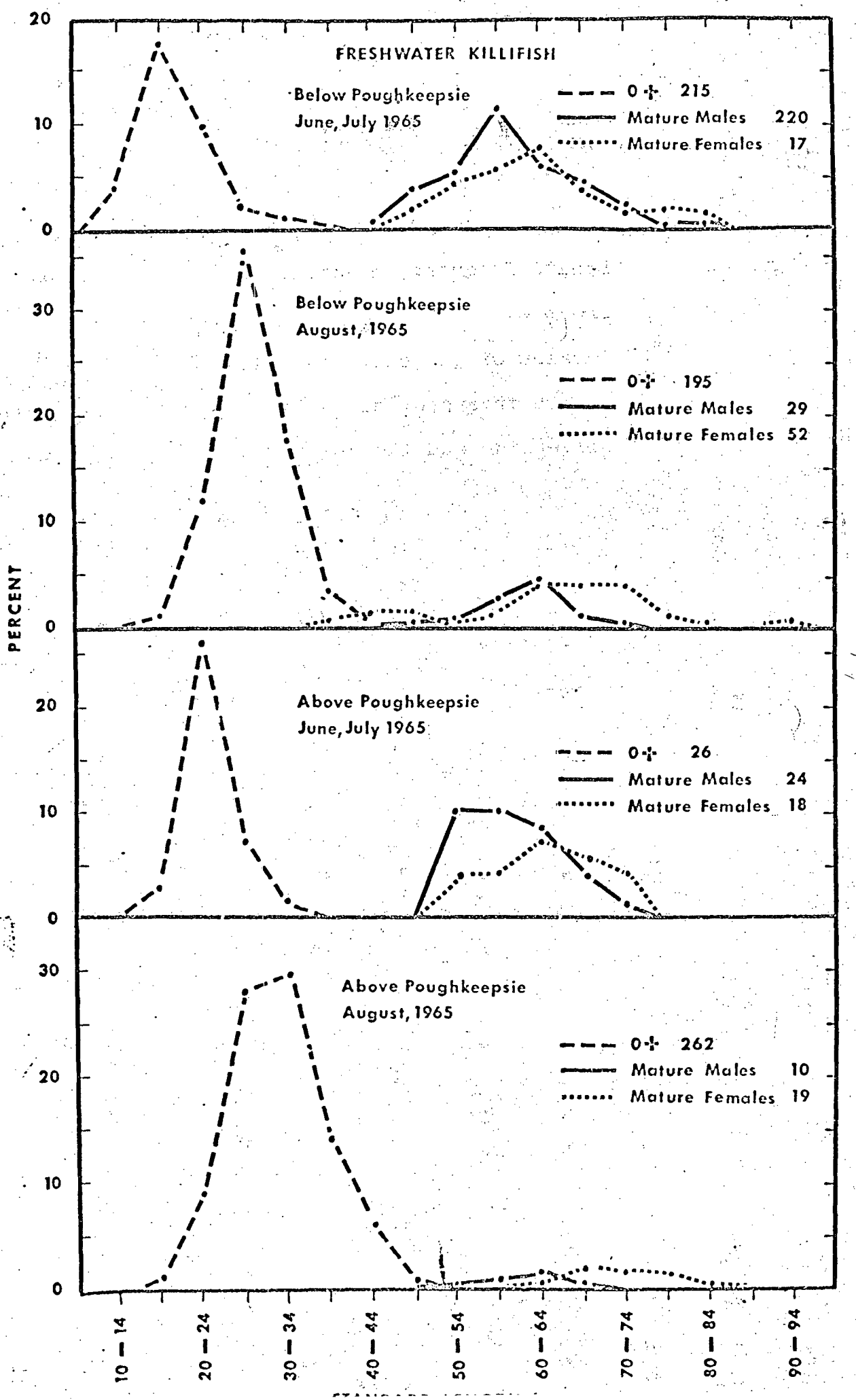

FRESHWATER KILLIFISH
Below Poughkeepsie
June, July 1965
0+ 215
Mature Males 220
Mature Females 17
Below Poughkeepsie
August, 1965
0+ 195
Mature Males 29
Mature Females 52
Above Poughkeepsie
June, July 1965
0+ 26
Mature Males 24
Mature Females 18
Above Poughkeepsie
August, 1965
0+ 262
Mature Males 10
Mature Females 19
PERCENT
0
10
20
30
10 — 14
20 — 24
30 — 34
40 — 44
50 — 54
60 — 64
70 — 74
80 — 84
90 — 94

Figure 5. Length frequency distributions of the 0+ age group or immatures and the mature males and females of the saltwater killifish. Also, length frequency distributions of the northern silverside and the goldfish.

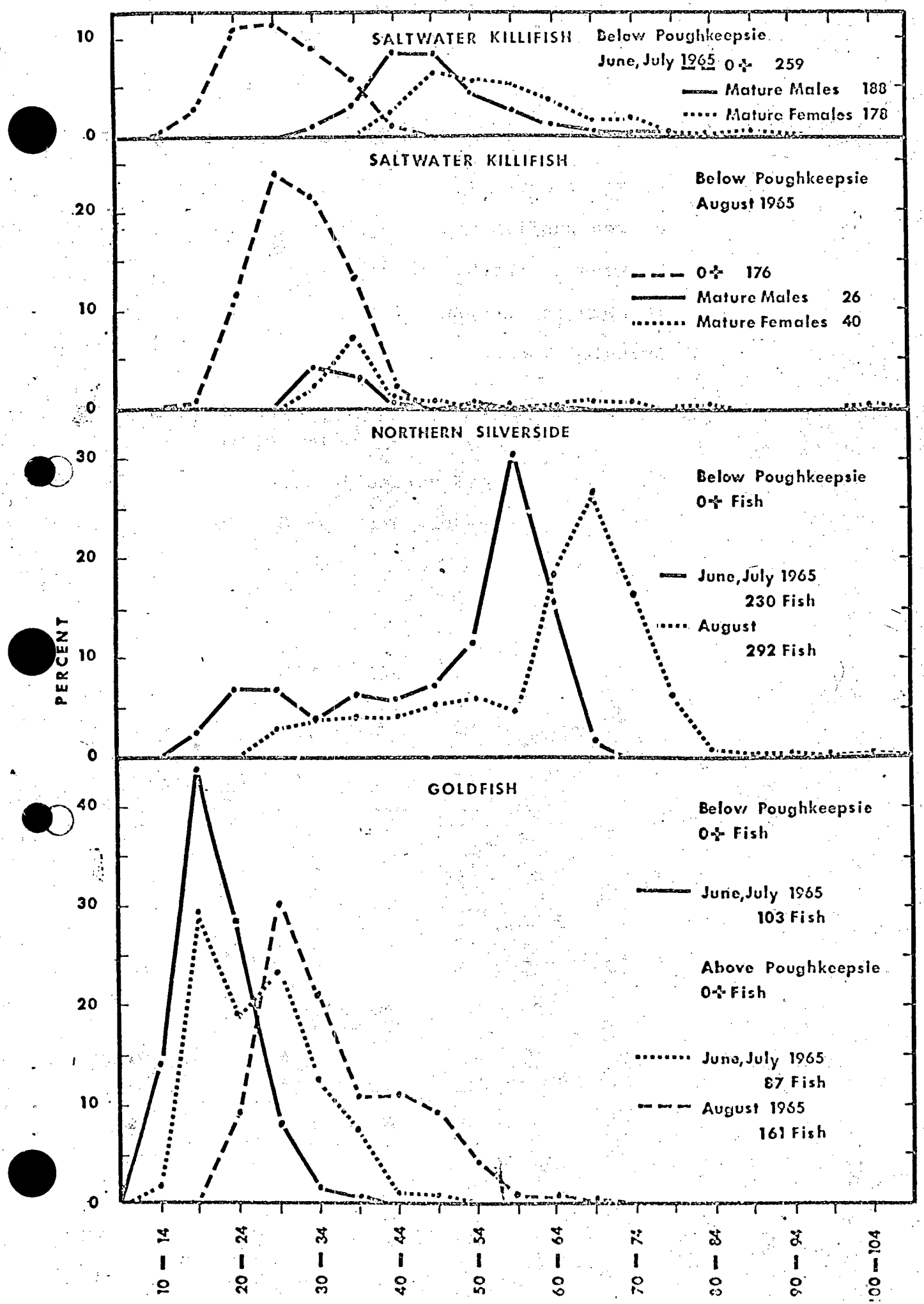

SALTWATER KILLIFISH
Below Poughkeepsie
June, July 1965
0+ 259
Mature Males 188
Mature Females 178
SALTWATER KILLIFISH
Below Poughkeepsie
August 1965
0+ 176
Mature Males 26
Mature Females 40
NORTHERN SILVERSIDE
Below Poughkeepsie
0+ Fish
June, July 1965
230 Fish
August
292 Fish
GOLDFISH
Below Poughkeepsie
0+ Fish
June, July 1965
103 Fish
Above Poughkeepsie
0+ Fish
June, July 1965
87 Fish
August 1965
161 Fish
PERCENT
10
0
20
10
0
30
20
10
0
40
30
20
10
0
10 — 14
20 — 24
30 — 34
40 — 44
50 — 54
60 — 64
70 — 74
80 — 84
90 — 94
100 — 104

Figure 6. Length frequencies of the spottail shiner, common sunfish and Johnny darter. Spottail shiners in the 0+ year class ranged from 10-39mm in June-July and from 25-49mm in August. The 0+ year class in the common sunfish was 10-24mm long in June-July and 10-44mm in August. The Johnny darter in the 0+ year class varied in length from 10-39mm in June-July and from 25-54mm in August.

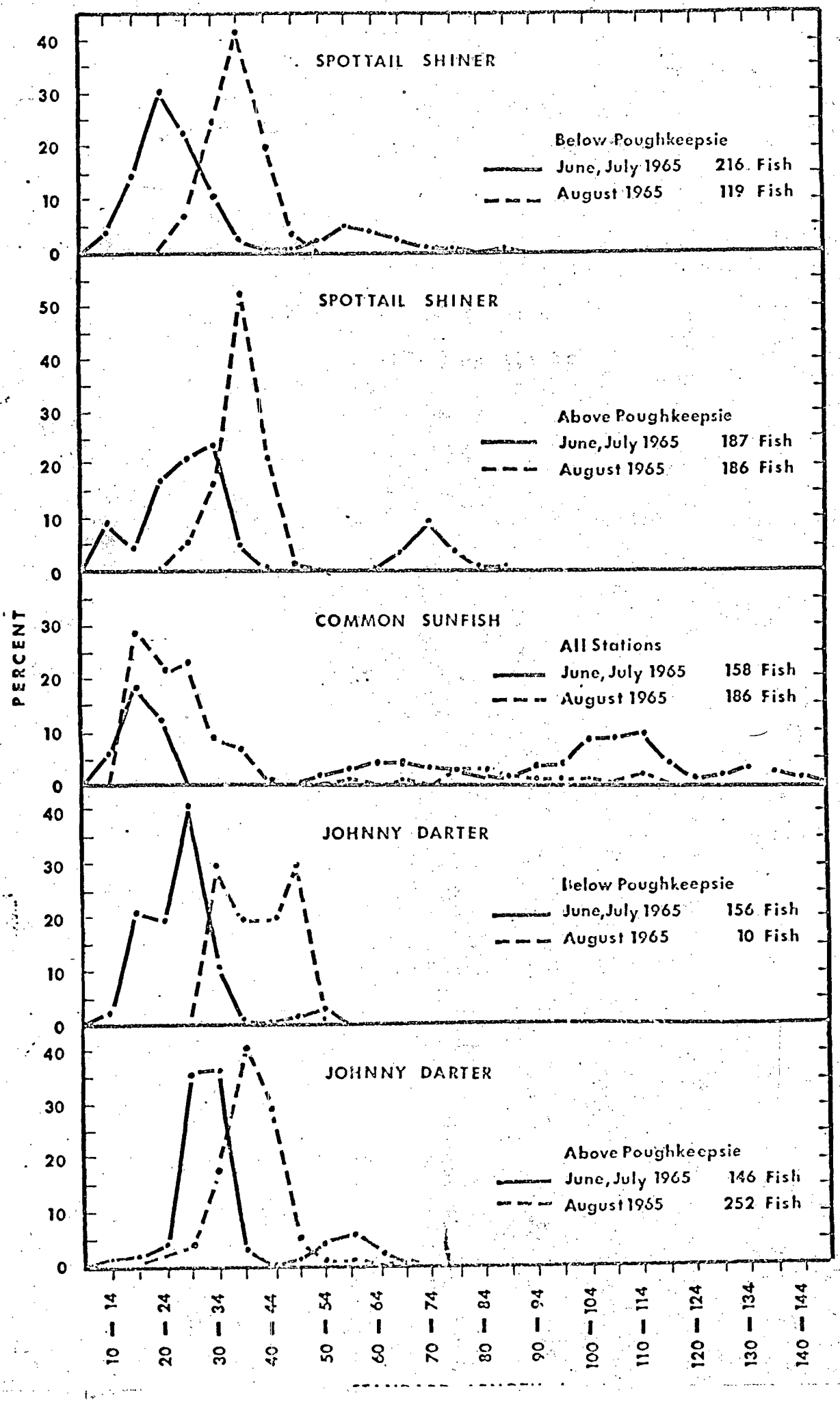

SPOTTAIL SHINER
Below Poughkeepsie
June, July 1965 216 Fish
August 1965 119 Fish
SPOTTAIL SHINER
Above Poughkeepsie
June, July 1965 187 Fish
August 1965 186 Fish
COMMON SUNFISH
All Stations
June, July 1965 158 Fish
August 1965 186 Fish
JOHNNY DARTER
Below Poughkeepsie
June, July 1965 156 Fish
August 1965 10 Fish
JOHNNY DARTER
Above Poughkeepsie
June, July 1965 146 Fish
August 1965 252 Fish
PERCENT
0
10
20
30
40
50
10 — 14
20 — 24
30 — 34
40 — 44
50 — 54
60 — 64
70 — 74
80 — 84
90 — 94
100 — 104
110 — 114
120 — 124
130 — 134
140 — 144

Figure 7. Relative abundance of the 0+ and 1+ and older age groups of the various species of fishes, 1965.

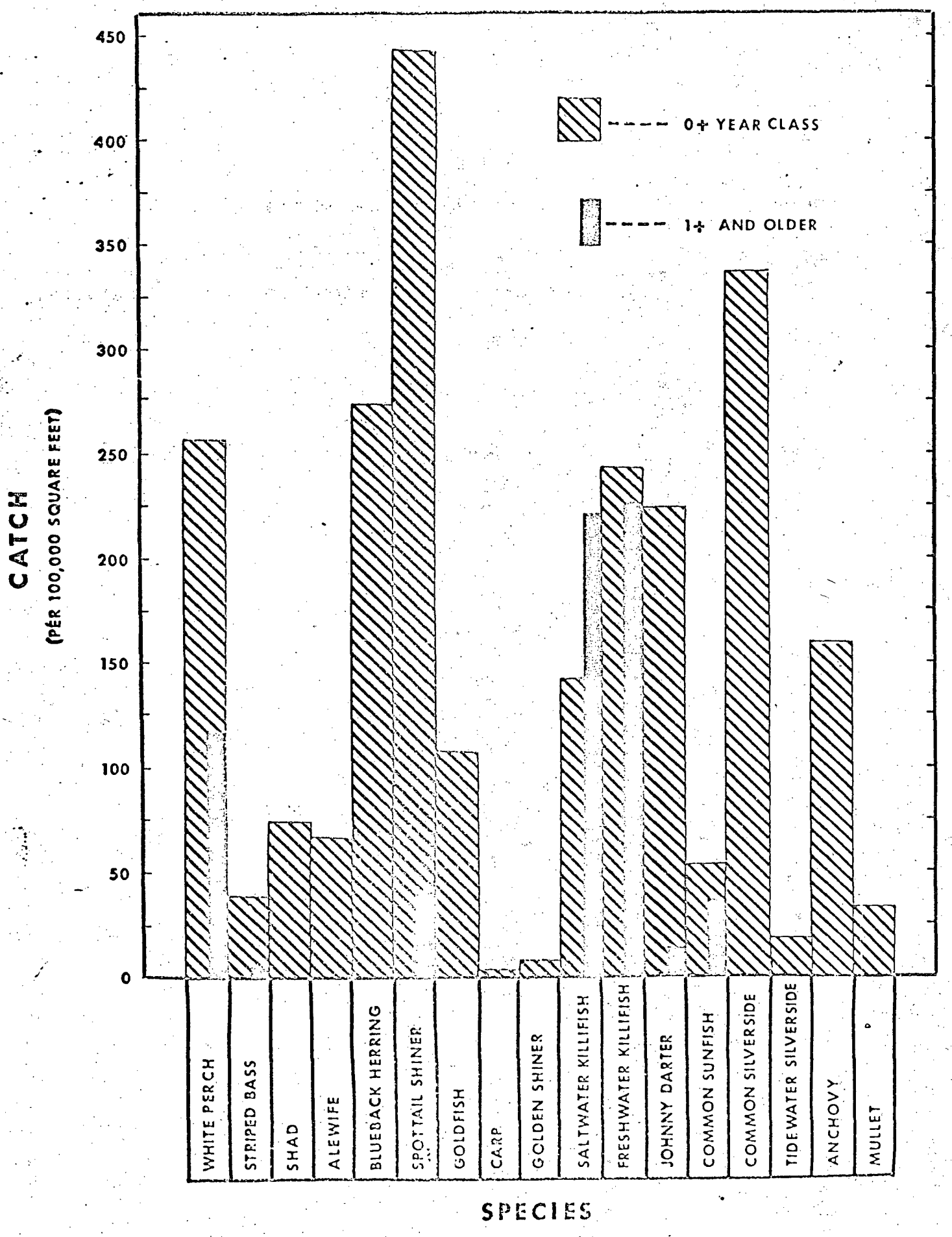

CATCH
(PER 100,000 SQUARE FEET)
450
400
350
300
250
200
150
100
50
0
0+ YEAR CLASS
1+ AND OLDER
WHITE PERCH
STRIPED BASS
SHAD
ALEWIFE
BLUEBACK HERRING
SPOTTAIL SHINER
GOLDFISH
CARP
GOLDEN SHINER
SALTWATER KILLIFISH
FRESHWATER KILLIFISH
JOHNNY DARTER
COMMON SUNFISH
COMMON SILVERSIDE
TIDEWATER SILVERSIDE
ANCHOVY
MULLET
SPECIES

Figure 8. Relative abundance of the white perch, striped bass, shad, alewife and blueback herring at the various collecting stations, 1965.

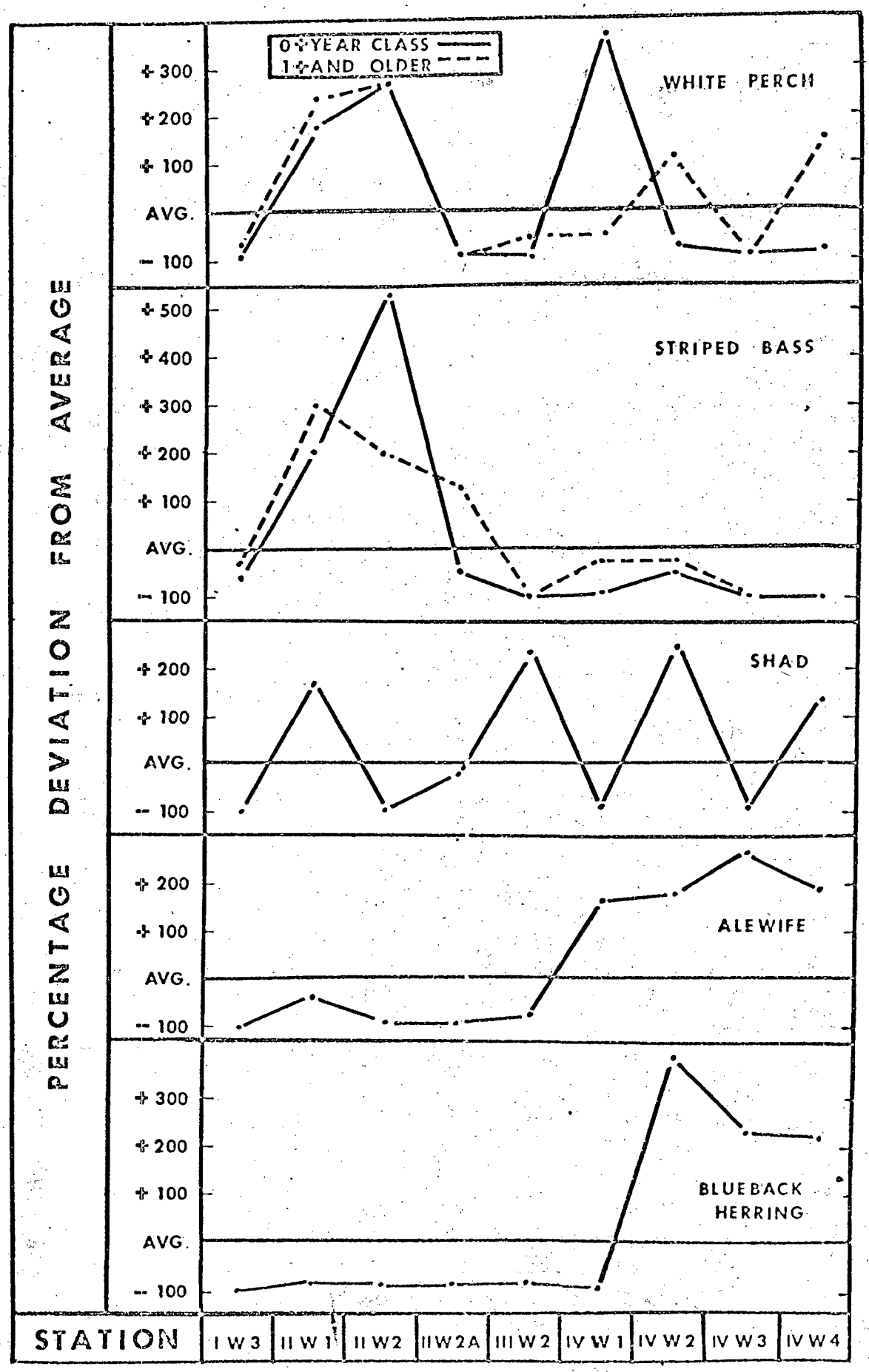

PERCENTAGE DEVIATION FROM AVERAGE
0+ YEAR CLASS
1+ AND OLDER
WHITE PERCH
+300
+200
+100
AVG.
-100
STRIPED BASS
+500
+400
+300
+200
+100
AVG.
-100
SHAD
+200
+100
AVG.
-100
ALEWIFE
+200
+100
AVG.
-100
BLUEBACK HERRING
+300
+200
+100
AVG.
-100
STATION
I W3
II W1
II W2
IIW2A
III W2
IV W1
IV W2
IV W3
IV W4

Figure 9. Relative abundance of the saltwater killifish, freshwater killifish, Johnny darter and common sunfish at the various collecting stations, 1965.

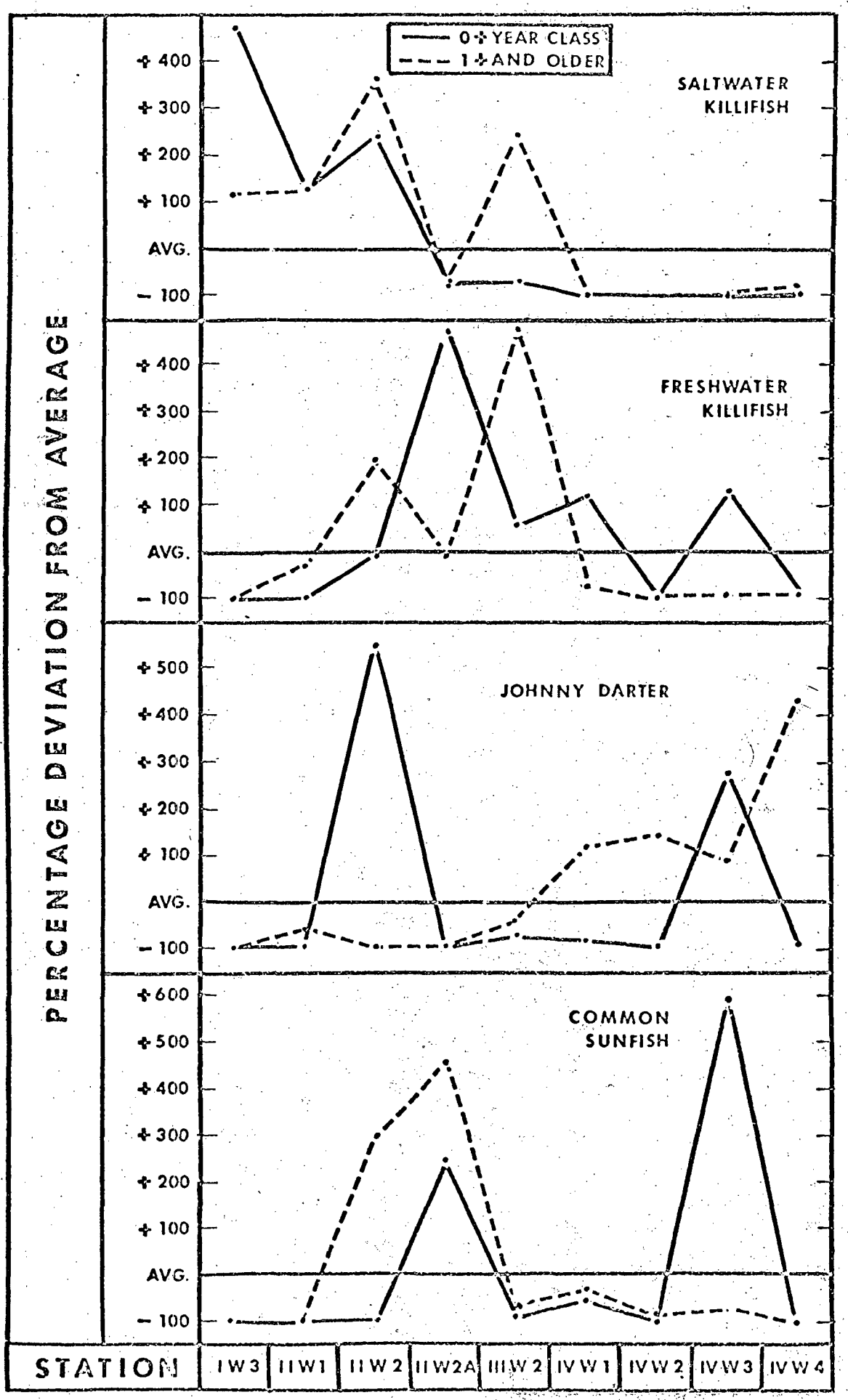
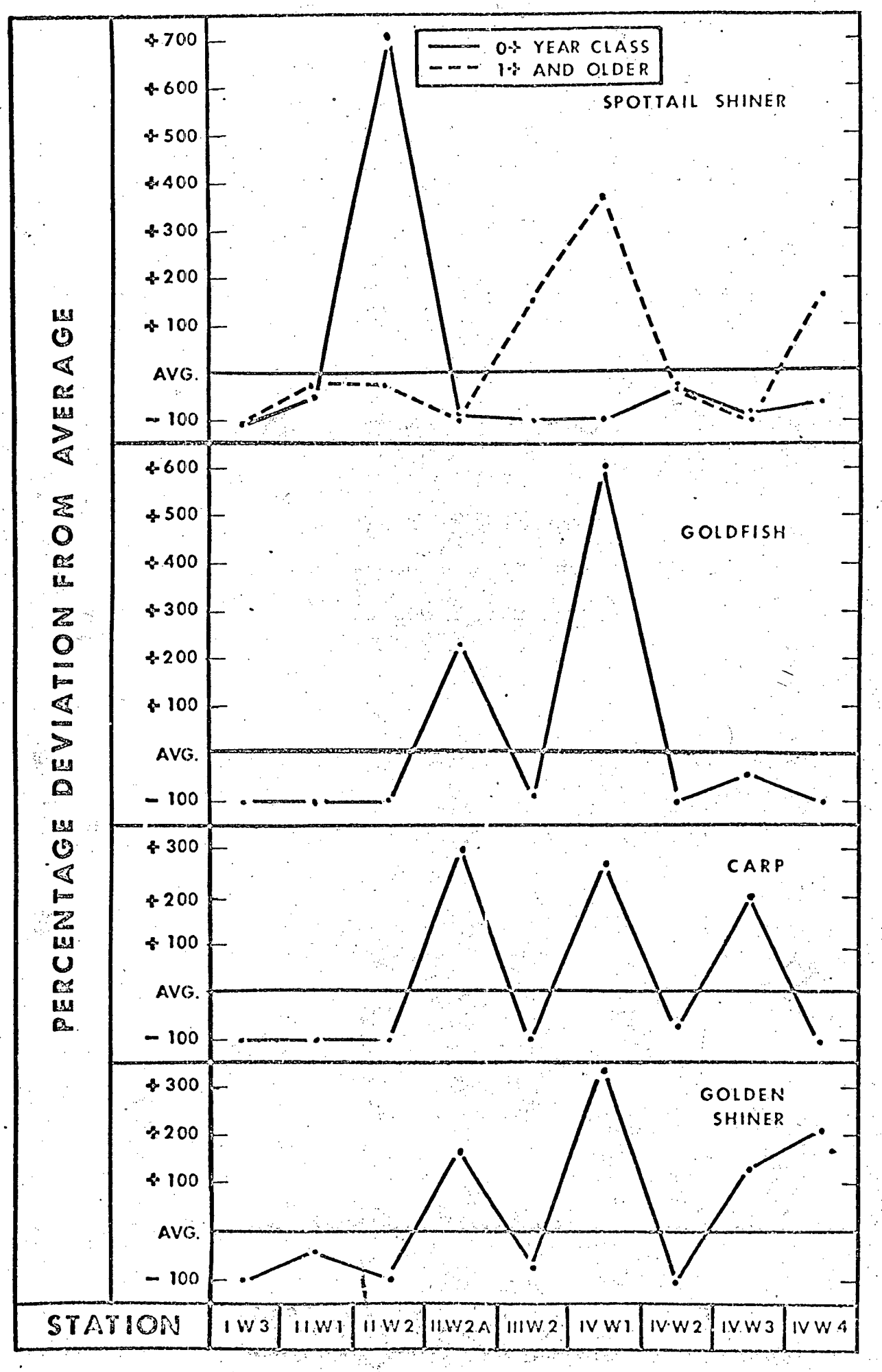

0+ YEAR CLASS
1+ AND OLDER
SALTWATER KILLIFISH
FRESHWATER KILLIFISH
JOHNNY DARTER
COMMON SUNFISH
PERCENTAGE DEVIATION FROM AVERAGE
+600
+500
+400
+300
+200
+100
AVG.
-100
STATION
IW3
IIW1
IIW2
IIW2A
IIIW2
IVW1
IVW2
IVW3
IVW4

Figure 10. Relative abundance of the spottail shiner, goldfish, carp and golden shiner at the various collecting stations, 1965.


PERCENTAGE DEVIATION FROM AVERAGE
0+ YEAR CLASS
1+ AND OLDER
SPOTTAIL SHINER
GOLDFISH
CARP
GOLDEN SHINER
+700
+600
+500
+400
+300
+200
+100
AVG.
-100
STATION
I W3
II W1
II W2
II W2A
III W2
IV W1
IV W2
IV W3
IV W4

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SEDIMENTARY AND GEOCHEMICAL STUDIES

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I. Introduction

A. Purpose and Area of Study

This study, based on field work done in the Summer of 1965, is an extension of work begun in the Summer of 1964 and reported in our initial progress report. The objective was to document changes in river hydrography and sediments in 1964-65 and to study the geochemistry of the sediments. The knowledge sought was intended to yield some understanding of the capacity of the sediments to absorb chemical pollutants.

The work was confined to a 30-mile section of the Hudson River between Poughkeepsie and Stony Point, but most samples were taken from oligohaline (0.5 to 5 o/oo S) waters in a 12-mile sector between Wappinger Creek and West Point (see Figures 1,2 and Appendix A).

B. Methods of Study

1. Field Procedures

Grab samples and cores (up to 6 feet long) of bottom sediments, and top and bottom water samples, were obtained by means of the Marberlee IV, a 28-foot inboard motor vessel maintained by the New York University Geology Department. This motor launch is equipped with hoisting equipment, recording fathometer[1], salinometer-

[1] Bludworth Model ES-30

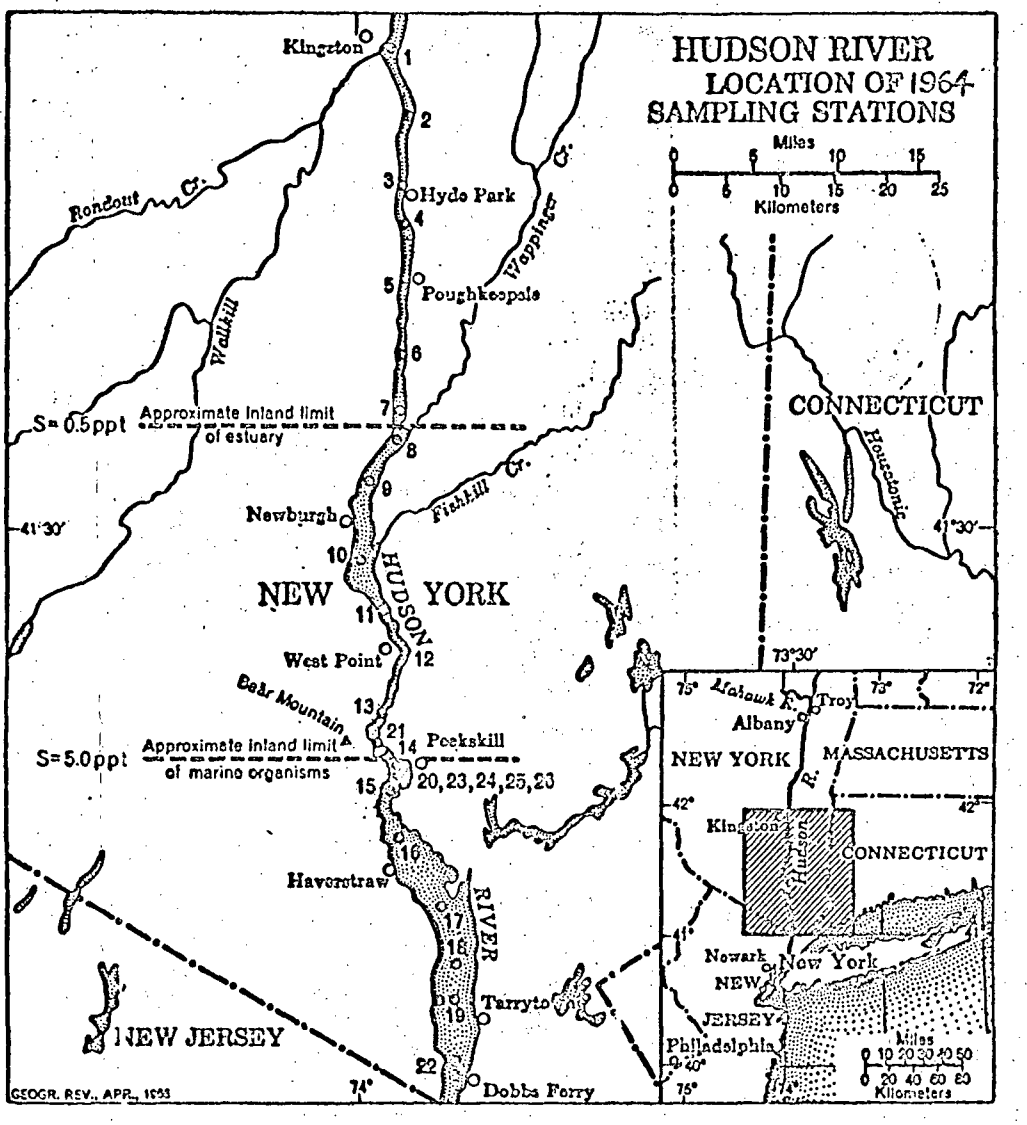

Figure 1. Geographic setting of Hudson River Estuary and location of 1964 sampling stations (after McCrone, 1966).

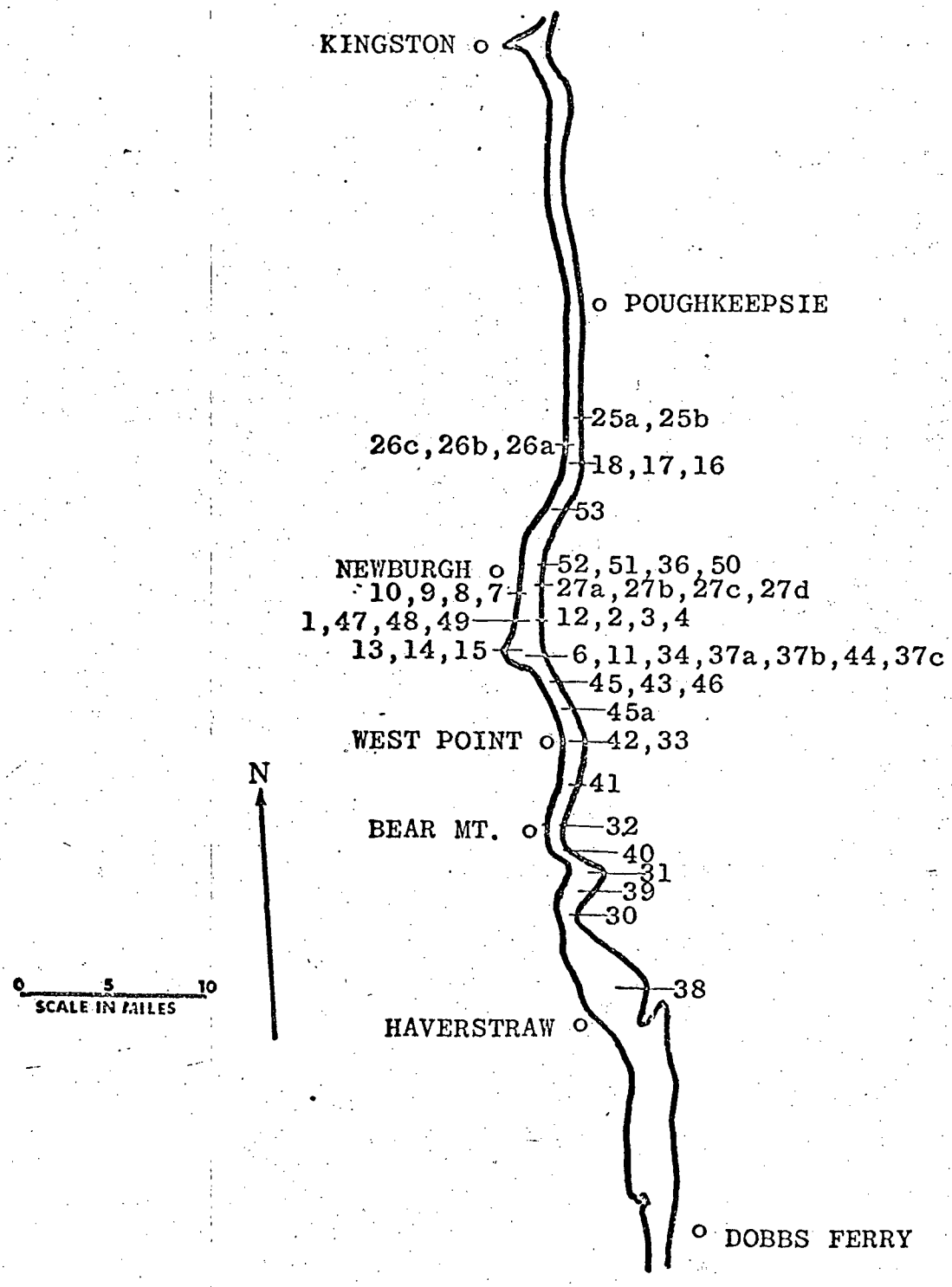

Figure 2. Approximate locations of 1965 sampling stations.

thermometer[2], pH-Eh meter[3], water sampler[4], etc. A few samples were obtained by SCUBA divers.

Numerous water and mud samples were tested in the field for pH (Table 2), and vertical salinity and temperature profiles were taken at a number of key stations (Appendix B).

2. Laboratory Procedures

Particle size analyses on air-dried and oven-dried ($<105^{o}C$) sediments were done by standard sieving and pipette techniques, after ultrasonic probe disaggregation. Textural constituents were observed and described under binocular and petrographic microscopes. Gross easily-oxidizable organic content of selected dry samples was determined by hydrogen peroxide leaching and other techniques (see Table 3). Cation exchange capacities and other geochemical parameters of the muds were determined on extracts using standard and atomic absorption spectrometry techniques documented in Tables 3 to 8 and Appendix C. Attempts were made to determine the proportions of common metallic cations that were held on organic components of the sediments. Major ionic composition of selected river water samples was determined using atomic absorption spectrometry[5] (Table 1).

[2]Industrial Instruments, Model RS

[3]Beckman Model G, with platinum, glass and calomel electrodes

[4]Foerst Sampler

[5]Perkin-Elmer, No. 303 Atomic Absorption Spectrophotometer

II. Hydrography of the Hudson River

The Summer of 1965 was one of acute drought in the Hudson River drainage basin. The resultant low river discharges were dramatically recorded at the Green Island Gauging Station near Troy, New York, where minimum daily mean flows in the order of only 1600 cfs were recorded (U.S. Public Health Service, 1965, p. 7). Previous estimates of extreme minimum weekly mean discharge rates, which might be expected only once in a decade, were in the order of 3000 cfs. Average annual discharge of fresh water opposite Manhattan Island has been estimated at nearly 22,000 cfs from the total drainage basin of some 13,400 square miles. The extraordinarily low discharge in August, 1965, allowed saltwater to intrude up the river bottom nearly to Poughkeepsie, whereas, in August 1964, the boundary at depth between fresh and brackish water fell roughly midway between Newburgh and Poughkeepsie (see Figure 3). However, because freshwater overrides these saltwater "wedges", the surface limit of saltwater intrusion was comparatively closer to Newburgh. In years of normal discharge the August boundary between fresh and saltwater (i.e. the inland estuarine limit as defined by the 0.5 parts per thousand salinity contour) is usually south of Newburgh and closer to West Point. Only during unusually high tides does saltwater reach upstream beyond the above mentioned approximate limits.

The gradient of the Hudson River is remarkably low. In 150 miles southward from Troy it drops only 5 feet. Nevertheless, during ebb

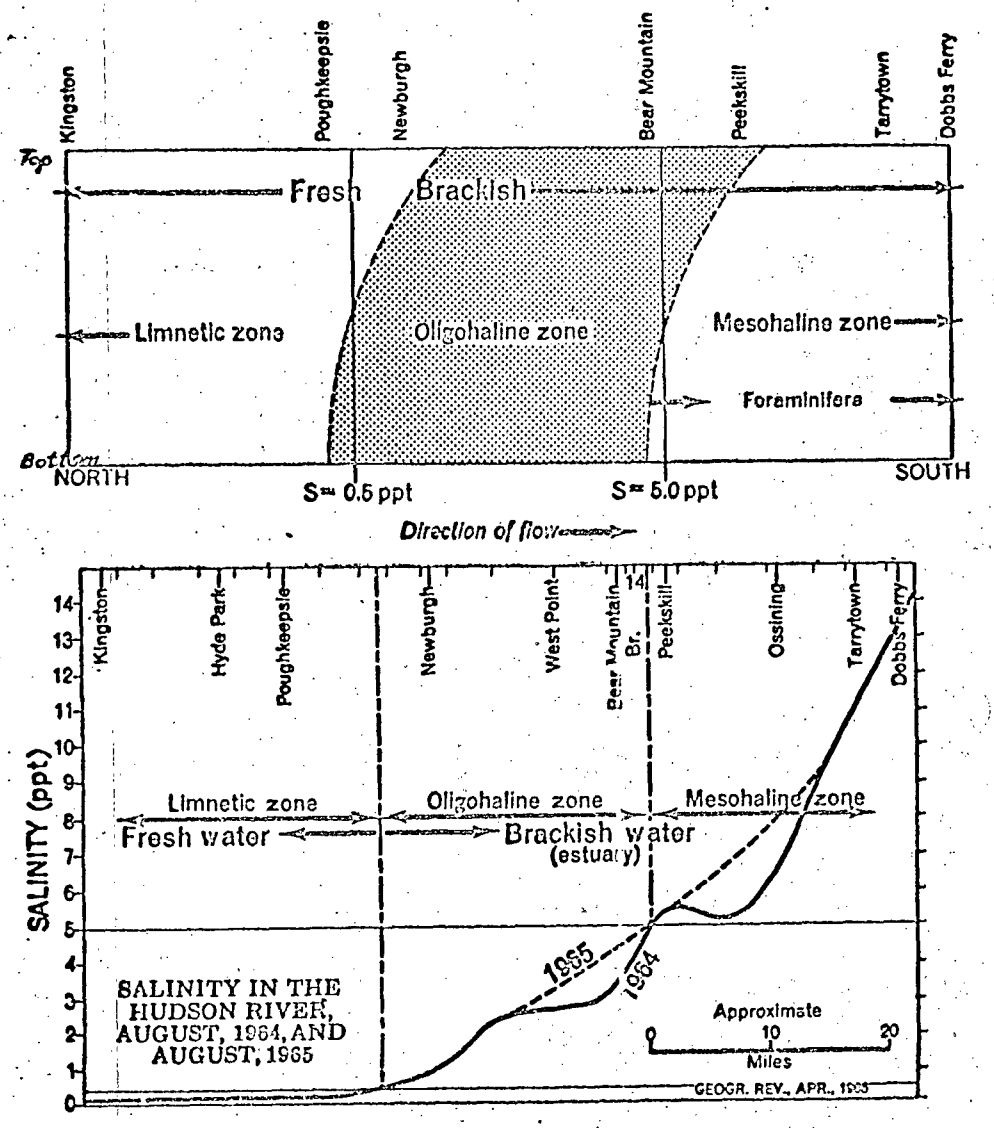

Figure 3. Generalized salinity patterns in Hudson River Estuary between Kingston and Dobbs Ferry, New York, August, 1964 and 1965 (modified from McCrone, 1966).

tides river currents range between 1.1 and 2.3 knots. During flood tide upstream currents are known to range between 0.8 and 1.7 knots. Slack waters and maximum flood currents occur 4 hours later at Albany than at Bear Mountain, nearly 100 miles to the south.

Waters in marshes adjoining the Hudson estuary are usually fresher than in the river proper, but during low discharges in dry years parts of them can become relatively more brackish due to evaporation.

In July and August of 1964 and 1965 vertical thermal mixing in the estuary was found to be remarkably thorough. All vertical temperature profiles showed temperature differences in the order of only 1°C between top and bottom waters, despite the indistinct salinity stratification wherein fresher water overrode slightly more brackish waters (see: 1965 Salinity and Temperature profiles in Appendix B). Vertical salinity and temperature gradients are least at West Point where the Hudson narrows and bends sharply, causing much turbulence and mixing.

Approximate chemical composition of Hudson River waters at various stations is given in Table 1. pH values at selected stations are recorded in Table 2. In July 1965, as discharge diminished, average water pH's were in the order of 6.5 but in June pH's were closer to neutrality. Eh readings of selected water samples showed mild oxidizing conditions, a circumstance confirmed by the dissolved oxygen readings recorded in August 1965 by the U.S. Public Health Service (see bibliography "Report").

III. Bottom Sediments

A. General Lithology

Most muds taken in the main river channel were mainly medium gray, very sticky clayey silts, usually topped by up to an inch of dark brownish-gray "soupy" muds of similar granulometric composition. Histograms from selected samples are recorded in Figure 4 (See also Appendix D). Dried muds were light gray and friable but difficult to break due to the binding effects of the abundant organic and mineral clay and silt particles. Most samples showed about 15% shrinkage on drying. Sediments taken from the middle of the river-margin shelves closely resembled those from the adjoining main channel. Similar consistency was also encountered vertically in 4-foot cores except at Station 37c where the clayey silts were drier and much more highly compacted (almost shale-like) than all other cores obtained in this study.

Humic matter plus fragments of leaves, twigs, worm and insect remains (i.e. easily oxidizable organic matter) in most bottom surface samples averaged between 5 and 6 percent (Tables 3,4,5,6,) and only slightly less downward in cores (Tables 7 and 8). It has been established (Eisenbud et al., 1965; McCrone, 1966) that the predominant clay minerals in the typical clayey silt are chlorite and well-crystallized illite, in the approximate ratio of 2 to 3. Of the clay-sized mineral fraction of these sediments these minerals comprise up to 75 percent and quartz up to another 15 percent. A great variety

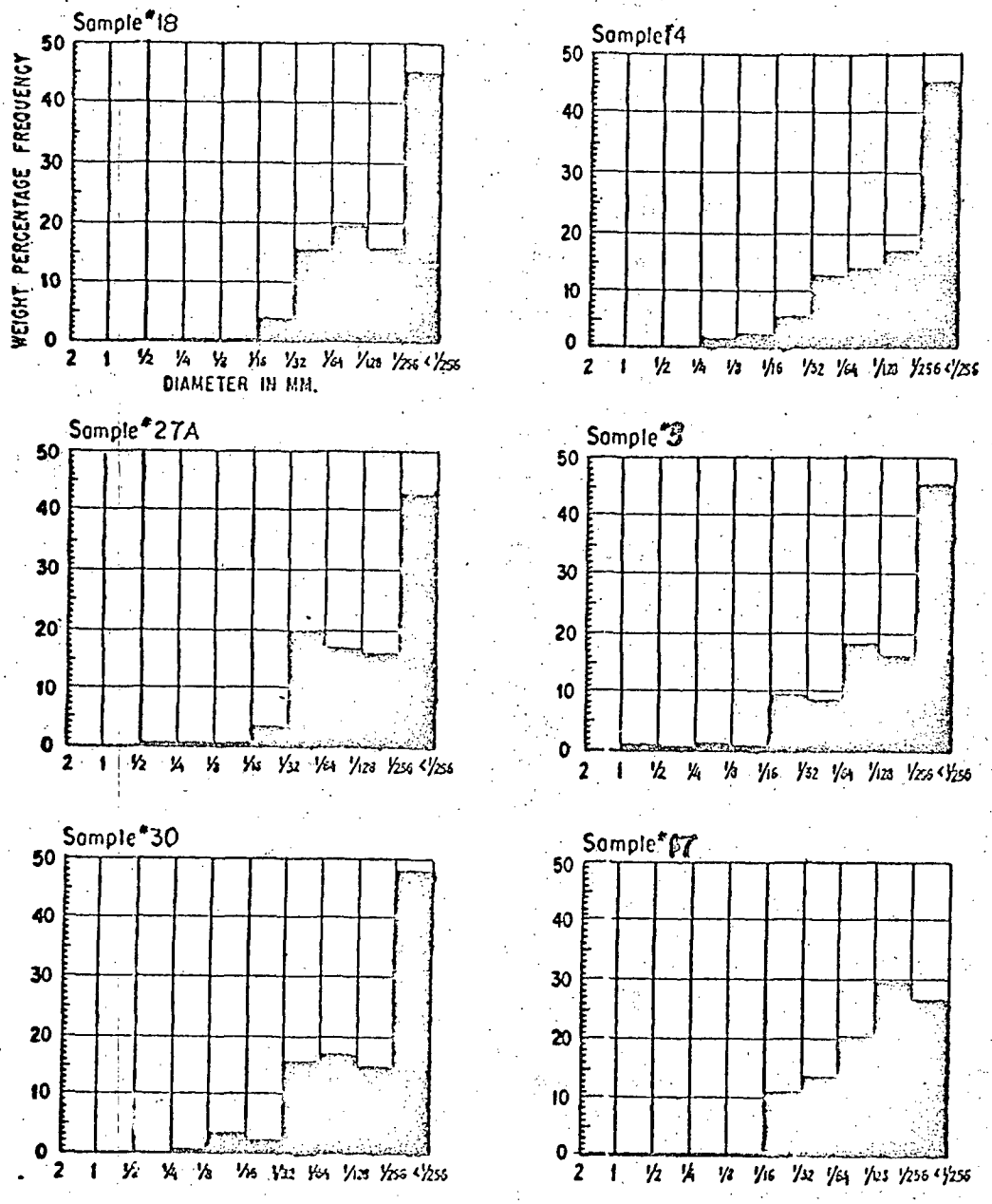

Figure 4. Histograms of typical Hudson River channel clayey silts. See Figure 1 for sample locations.

of minerals, including traces of montmorillonite and some mixed layer clays (montmorillonite-illite-chlorite) make up the remainder.

In the megascopic fractions of samples from most stations, quartz is commonly the dominant (> 65%) mineral followed by muscovite, sesquioxides and clays (< 10%), and small quantities of a great variety of other minerals including albite, amphiboles, calcite, epidote, garnet, ilmenite, magnetite, pyrolusite, pyroxenes, tourmaline and sphene.

These minerals are derived from the glacial drift that mantles the entire Hudson River drainage basin. By its very nature the glacial drift can be expected to contain rock fragments and minerals originally from all varieties of bedrock within the Hudson Basin and from areas as far away as Ontario, Quebec, and northern Vermont. Traces of red and gray shale and siltstone, and iron-stained quartz grains similar to materials in the Catskill mountains are common in the river sediments. The samples studied showed no significant downstream differences in mineralogy that could be correlated with salinity or other geological parameters. Likewise, no significant differences in natural mineral composition between top and bottom of the 4-foot cores was detected.

Newly-collected wet samples give the illusion of being largely made of clay. Consequently the discovery in the laboratory that silt commonly constitutes more than 50 percent and clay between 20 and 45 percent sizeable quantities of such manmade debris down to depths of a foot or more, thereby giving a rough idea of how much natural sediment

and garbage has accumulated in the river during the past century or less.

Tables 3 to 8 show that, along with their textural and mineralogical similarities, channel muds (very clayey silts) samples are quite similar in their nitrogen and easily-oxidizable organic matter content, and carbon-nitrogen ratios, regardless of the salinity of their surroundings. Properties of sandy shore sediments are much more variable. Cation exchange capacities seemed to be only slightly lower in fresher water muds than in the brackish muds, probably because the freshwater muds were slightly sandier. Cation exchange capacities were in the order of 30 to 40 milliequivalents per 100 grams in the common channel silt samples; and the clay-size organic matter, rather than minerals, accounted for the largest proportion of this capacity.

It is surprising that in the presence of so much salty water coming in from the sea, and with such sizeable exchange capacities, the brackish water muds are so highly unsaturated (av. approx. 76%, Table 3-6) or so low in content of bases such as Ca and Na. The dearth of exchangeable sodium in some samples is especially remarkable in view of the great amounts of that element that are brought in from the sea with every flood tide. The cation exchange sites in the clay and organic colloids of the muds are presumably occupied mainly by hydrogen, together with small quantities of other cations and trace elements.

The organic and nitrogen content, and the carbon/nitrogen ratios of the silt sediments are slightly higher than in many terrestrial soils (Lyon, Buckman and Brady, 1950, p. 171), possibly because of the low oxidizing tendencies prevalent in the muds.

Although most coarse cinders, brick, coal, etc. are confined to the uppermost few inches of sediments, traces of such manmade debris (fine sand size) are present through the cores. It is believed that aquatic worms are responsible for transporting these materials downward as they collectively overturn vast quantities of sediment in the course of their feeding activities.

B. Bulk Chemical Properties of Bottom Surface Grab Samples

In the Summer of 1965, reducing conditions prevailed in the bulk of the typical clayey silts, although mild oxidizing conditions were present at the depositional interface. pH's were commonly in the range of 6.3 to 6.8 (Table 2) although several readings as low as 6 were recorded.

Tables 4, 5 and 6 show the various chemical properties of the grab samples studied in 1965. In the common clayey channel silts the following general properties were noted (sandier, nearshore sediments were unsystematically low in all parameters recorded).

Organic matter	average	approximately	5.5%
Total Nitrogen	average	"	0.2%

Carbon-Nitrogen ratios	Average	Approximately 13
Cation exchange capacity	"	Approx. 35 me/100 gms.
% Cation exchange capacity accounted for by organic matter	"	Approximately 72%

Exchangeable Cations

H	Average	30.4 me/100 gms.
Ca	"	5.3
Mg	"	3.6
K	"	0.3
Na	"	0.8
Mn	"	1.2

It should be remarked that actual exchangeable hydrogen, and "unsaturation" values, must be somewhat lower than the recorded values because manganese and ferrous iron are present (as documented in Tables 5, 6 and 10). However, other ions such as Cu and Ni (Table 10), which are so scarce in the river water (Table 1), are believed to affect the recorded exchange values in the muds so slightly as to be more or less negligible in these studies.

Chemical properties recorded vertically downward through the four-foot cores, as documented in Tables 7 and 8, are discussed in the text section.

Several of the observed bulk chemical observations call for comment. For example, it is remarkable that so little exchangeable

sodium is present in the brackish water mud samples to which a constant supply of marine sodium was available (see Table 1). Indeed, Na was amongst the least abundant of the cations considered in this study (Tables 3-8). Hydrogen probably occupies most of the exchange sites (implicit in the "unsaturation" column of Tables 3 to 6). Such high hydrogen levels in exchange sites located largely on the organic clay fraction of the sediments prevent the adsorption of notable amounts of sodium and other cations. The exact mechanism (probably bacterial) of hydrogen ion generation in the strongly anaerobic (reducing) muds is not known, but some of it must be adsorbed on the humic clays before it is consumed by other kinds of bacteria such as the sulfate, nitrate, and nitrite reducers. Certainly the 25°C water temperatures, the pH and Eh, and the mineral and organic nutrients acquired by the bottom muds, are all favorable to hydrogen-producing bacteria (ZoBell, 1947).

Another noteworthy observation is the substantial concentration (small in terms of total cation content, however) of exchangeable manganese (Tables 5 and 6) in the sediments, as compared with its paucity in the water[6] (Table 1). Very little of the manganese in ordinary aerated soils is present in exchangeable and easily-reducible forms. However, under reducing conditions

[6]Exchangeable managnese is also quite scarce in most ordinary soils.

such as those that exist in the Hudson River muds, manganese in sediments washed in from soils of the drainage basin is apparently converted to the exchangeable form. Thus it assumes an important role in the exchangeable cation status of the muds, as documented in Tables 5 and 6. In view of these geochemical attributes of manganese, and low permeability of the muds, it is likely that the bulk of the exchangeable manganese is derived from minerals in the sediments with only trivial contributions from the river water itself.

These observations document the existence of a sedimentary reservoir of manganese which could supply the high amounts of manganese that were reported in the aquatic Chara by Eisenbud et al, (1965).

Monovalent sodium, and to a lesser extent, potassium, (with their low ionic charges), and high hydration are easily displaced from the weakly acidic (Table 2) clayey silts. This accounts for the low values of accumulated exchangeable Na and K that do exist in the muds, in the presence of comparatively large amounts of exchangeable divalent Ca and Mg (Tables 3-8).

The data in Table 9 indicate that substantial amounts ($>10\%$) of the Mg^{++}, Ca^{++}, Na^{+} and K^{+} in the sediments are positionally rendered non-exchangeable by organic coatings, especially after drying (because organic films do not re-wet as thoroughly as their original degree of wetness). The removal of such coatings by ignition

releases these "organic bound" ions. This is in marked contrast with ordinary soils, wherein most of the Ca and Mg are not organic bound. Table 9 also suggests that some of the iron in the sediments may be chelated with organic matter, because, after removal of the organic matter from the samples by ignition, less iron was obtainable from them than before ignition. That is, the free iron which was oxidized (Fe_2O_3) during ignition did not appear to be as soluble in the leachate as was the other (presumably chelated) iron. Alternatively, similar relationships might have resulted if some of the iron were merely converted to more refractory form at the high ignition temperatures.

Appreciable amounts of the iron in the muds was in the ferrous state, as might be expected in the reducing microenvironments therein. This was obvious in the laboratory when leachates from the muds developed rusty precipitates on standing exposed to air. This iron also must have contributed to the "unsaturation" mentioned earlier.

Tables 3-8 show an unsystematic but expectable direct correlation between organic content and cation exchange capacity of the sediments.

It is clear from Tables 4, 5 and 6 that easily-oxidizable organic matter commonly accounts for 65 to 80 percent of the cation exchange capacity of the clayey silts. Together with the unsaturation data this suggests that the river bottom muds are capable of

absorbing tremendous quantities of chemical pollutants, including radionuclides. As could be expected, sandy nearshore sediments have very low cation exchange capacities, and are therefore of minor significance as potential reservoirs for chemical pollutants. Conversely, the sands are good reservoirs for oil slicks[7] which drift to the shore and make their way into the open interstices, but which tend to be forced out of clayey sediments by compaction, osmotic and capillary pressures.

C. Bulk Chemical Properties of the Cores

The chemical properties, as well as texture and mineralogy, of the channel silt cores change very little with depths (Tables 7 and 8). Only the few topmost sediments (e.g. core XII) that contain substantial amounts of cinders (etc.) differ noticeably in bulk chemical properties from those below. (That is, the coarse topmost sediments yield lower values of all parameters measured than do the normal uniform clayey silts.) The aforementioned mixing by worms, and general constancy of depositional conditions, must account for much of the encountered sedimentary and geochemical uniformity.

[7] Irresponsibility on the part of boat and ship operators accounts for many oil-stained sands along the banks of the Hudson.

CONCLUSIONS

1. Most Hudson River estuarine channel muds are clayey silts that contain between 5 and 6 percent of humic and other easily-oxidizable organic matter. Quartz is most common, but a great variety of finely fragmented minerals also are present in these silts. Chlorite and illite are the dominant clay minerals.
2. The Hudson River estuarine muds contain insufficient Na^{+}, Ca^{++}, K^{+}, and Mg^{++} (and other minor ions) to drive out H^{+}, which occupies more than 2/3 of the cation exchange sites. In the presence of salty estuarine water south of Newburgh the deficiency of sodium in the muds is especially striking.
3. Cation exchange sites are located largely on the easily-oxidizable organic fraction of the muds, which accounts for about 3/4 of the total cation exchange capacity.
4. Organic and nitrogen content, and carbon/nitrogen ratios of dried muds, are slightly higher than in most subaerial soils.
5. Substantial amounts of the Ca^{++}, Mg^{++}, and Na^{+} and K^{+} in the sediments are "organic bound" in contrast with ordinary soils wherein most of the Ca and Mg are not organic bound.
6. Exchangeable manganese, scarce in the river waters, comprised a comparatively large proportion of the exchangeable cations in the muds. Remarkably, more manganese than sodium was present in the muds, despite the large amounts of sodium

supplied daily to the estuary by tidal inflow. The exchangeable manganese levels in the muds are substantially higher than in ordinary subaerial soils.

7. In general the river bottom muds appear to be capable of absorbing tremendous quantities of chemical pollutants. More research is needed to determine the ionic concentrations in river water and other geologic mechanisms required to effect fixation of pollutant ions in the muds (i.e. to effect displacement and replacement of the hydrogen and other ions that presently occupy the exchange sites).

Table 1

COMPOSITION OF WATER SAMPLES (ppm)

(July-August 1965)

Station	Conductivity (mohs) x10^{-5}	Ca	Mg	K	Na	Si	Cl	Fe	Al	Cu	Ni	Mn	Zn
17	900	17.6	17.3	8.8	200	1.5	270	0.12	0.00	0.017	0.039	0.012	0.014
18	820	17.6	14.0	7.0	145	1.0	240	0.28	0.04	0.017	0.039	0.008	0.014
23A	235	13.0	3.8	1.4	13.5	0.05	30	0.08	0.01	0.012	0.012	0.002	0.006
30	6250	38.0	200	52	1400	2.0	2250	0.13	0.00	0.078	0.044	0.40	0.310
22A	235	13.0	3.8	1.4	14.0	0.05	37.8	0.10	0.00	0.016	0.011	0.002	0.006
20B	220	13.0	4.5	1.6	15.5	0.05	45	0.14	0.02	0.013	0.015	0.003	0.007
31	235	15.4	4.8	1.0	7.3	0.05	22.5	0.01	0.05	0.012	0.015	0.001	0.004
34	475	18.0	7.0	2.0	25.0	1.5	90	0.10	0.50	0.020	0.022	0.006	0.100
20A	240	13.4	4.5	1.6	15.5	0.05	37.8	0.17	0.05	0.014	0.015	0.003	0.012
33	3500	19.8	71.2	20.0	520	1.5	1050	0.08	0.55	0.040	0.018	0.038	0.220
31A	240	15.4	4.8	1.0	7.3	0.05	22.8	0.07	0.16	0.015	0.015	0.006	0.013
26A	280	13.4	3.8	2.4	42.5	0.75	120	0.04	0.02	0.017	0.017	0.002	0.027
25A	210	13.4	3.6	2.6	18.8	0.75	60	0.03	0.30	0.25	0.016	0.001	0.016
32	3200	19.8	71.2	20	520	1.5	1500	0.07	0.35	0.086	0.024	0.044	0.260

Table 2

pH OF WATER AND MUD SAMPLES TAKEN IN SUMMER OF 1965

Station	Water pH	Mud pH
1	7.5	6.0
2	7.4	6.0
3	7.7	6.0
4	7.5	6.0
5	7.6	6.0
6	6.5	6.5
9	6.0	6.0
10	6.0	6.0
11	7.0	7.0
12	7.2	
13	6.8	
14	6.6	
15	6.8	6.8
16	8.1	
20	6.6	6.5
21	6.4	6.6
22	6.7	
23	6.4	6.5
25	6.8	
25A	6.4	
26A	6.6	
26B	6.6	6.8
26C	6.4	6.3
27A	6.4	
27B	6.4	
27C	6.4	
27D	6.4	
28A	5.4	6.4
28B	6.2	5.9
28C	6.4	6.8
30	6.5	6.7
Mean	6.7	6.3

Table 3

Station	Lithology Dried Mud	Total** Nitrogen k (%)	Organic Matter** s (%)	h	C.E.C.*** (me/100gm)	Unsat'n %	H*	Exchangeable Cations Ca	Mg	K	Na
							me/100 gm				
2B-64	tan silt	0.218	5.85		28.4	70.0	20.1	6.0	2.1	0.2	0.1
3-64	grey silt	0.202	4.57	2.0	16.5	47.0	8.7	6.4	1.1	0.2	0.0
4A-64	grey silt	0.218	5.44		37.5	82.0	30.8	5.4	1.1	0.2	0.1
5A-64	grey silt	0.198	6.05		28.4	78.8	22.4	5.5	0.4	0.2	0.1
6-64	grey, sandy silt	0.175	5.00	4.0	26.6	68.7	18.2	5.9	2.4	0.1	0.0
8-64	grey, clayey silt	0.202	4.97	2.0	34.8	81.8	28.5	6.0	0.1	0.2	0.0
10-64	grey, clayey silt	0.211	4.90	5.0	39.7	68.0	27.0	7.2	4.9	0.2	0.3
11-64	grey, clayey silt	0.221	5.20	3.0	36.5	78.8	28.8	4.3	2.3	0.3	0.7
12B-64	grey, clayey silt	0.255	6.55		39.6	78.7	31.1	3.9	3.3	0.5	0.8
14A-64	grey, clayey silt	0.239	5.70		40.2	80.5	32.4	1.9	2.0	0.7	3.1
15B-64	grey, clayey silt	0.246	7.8		35.8	64.3	23.0	3.6	7.1	0.7	1.4
16-64	grey, clayey silt	0.159	3.90	4.0	34.7	73.2	25.4	2.2	3.6	0.6	2.9
18A-64	grey, clayey silt	0.171	4.20		39.0	72.6	28.2	3.1	4.5	0.8	3.3
19-64	grey, sandy, clayey silt	0.159	3.98		33.5	77.8	26.1	6.8	0.1	0.4	0.1
20-64	grey, clayey silt	0.146	4.50		31.6	61.3	19.4	6.8	3.7	0.6	1.0
22A-64 (shore)	lt.brown sand & shell frag.	0.118	2.26		3.0	0.0	0.0	2.0	0.9	0.1	0.3
14B-64 (shore)	organic grey silt	0.202	11.50		26.5	54.9	14.5	4.9	4.9	0.4	1.6
25-64 (shore)	lt.brown sand	0.087	1.22		3.0	10.0	0.3	0.8	1.0	0.7	0.1

k = Kjeldahl method
s = modified Schollenberger method
h = hydrogen peroxide method

C.E.C. = cation exchange capacity
* = by difference (C.E.C.-sum (Ca+Mg+K+Na))
** = oven dried material
*** = wet samples

All samples are channel samples except where designated otherwise:
For details on analytical techniques consult M.L. Jackson: Soil Chemical Analysis (Prentice-Hall,

Table 4

HUDSON RIVER BOTTOM MUDS

Sample Number	Description Dried Mud	Total[2] N	Organic[2] Matter	C/N	C. E. C.[1]	C. E. C.[4] minus O. M.	Unsat'n	Exchangeable Cations H[3]	Ca	Mg	K	Na
		%	%		me/100 gms	me	%	me/100 gms				
1-65	Grey clayey silt	0.202	5.17	14.0	44.0	10.6	76.3	33.6	4.9	4.9	0.4	0.2
2-65	Grey clayey silt	0.214	5.55	14.2	30.9	9.8	69.2	21.4	5.4	4.1	0.3	0.1
3-65	Grey clayey silt	0.210	5.50	14.4	33.5	12.0	75.5	25.3	4.3	3.5	0.3	0.1
4-65	Grey clayey silt	0.242	5.80	13.1	50.9	8.4	82.1	42.8	4.6	3.2	0.2	0.1
5-65	Grey, sandy gravel, some shell & coal fragments.	0.034	1.20	19.4	3.7	2.3	82.6	1.9	0.4	0.0.	0.0	0.0
6-65	Grey, sandy gravel, some shell & coal fragments.	0.055	1.17	11.5	3.8	3.1	87.2	2.7	0.4	0.0	0.0	0.0
7-65	Grey silty clay	0.261	6.16	12.9	49.8	12.4	84.7	42.2	5.7	1.5	0.3	0.1
8-65	Grey silty clay	0.177	4.93	15.3	37.2	11.8	79.0	29.4	4.7	2.8	0.2	0.1
9-65	Grey silty clay	0.193	4.80	13.6	36.8	8.4	75.3	27.7	5.5	3.2	0.2	0.2
10-65	Grey silty clay	0.311	7.23	12.7	37.5	11.3	71.2	26.7	5.8	3.6	0.3	0.1
11-65	Grey silty clay	0.267	5.95	12.2	35.7	10.2	74.5	26.5	5.0	3.6	0.2	0.4

1 - Moist samples, calculated to oven dry basis.
2 - Oven-dried material. Walkley - Black Method.
3 - By difference (Cation Exchange Capacity - (Ca + Mg + K + Na).
4 - Of residue, from 100 grams oven dried material, after removal of organic matter using H_2O_2.

Table 5

Sample Number	Description Dried Mud	Total[2] N	Organic[2] Matter	C/N	C.E.C.[1]	C.E.C.[4] minus O.M.	Unst'n	Exchangeable Cations H[3]	Ca	Mg	K	Na	Extractable[5] Fe	Exchangeable[2] Mn
		%	%		me/100 gms	me	%	me/100 gms					me/100 gms	
12-65	Grey silt	0.171	3.70	11.8	24.7	8.9	57.4	14.2	3.9	2.4	0.4	2.4	1.0	1.3
13-65	Grey silt	0.236	7.34	17.0	34.0	10.4	40.6	13.8	9.1	5.9	0.6	3.7	0.3	1.7
14-65	Grey silt	0.250	5.70	12.5	34.0	10.9	49.1	16.7	6.4	5.0	0.6	5.3	0.6	1.0
15-65	Grey silt	0.217	5.30	13.4	25.8	10.0	42.6	12.0	6.2	4.1	0.5	3.0	0.4	1.2
16-65	Grey silt	0.251	5.82	12.7	25.8	17.5	44.1	12.4	7.5	3.5	0.3	2.1	0.3	1.6
17-65	Grey silt	0.251	6.10	13.5	31.8	11.3	64.7	20.6	6.4	2.7	0.3	2.0	0.4	1.9
18-65	Grey silt	0.274	6.14	12.3	32.5	11.1	54.4	17.7	8.8	3.9	0.4	1.7	1.0	2.8

1 - Moist samples, calculated to oven dried basis.
2 - Oven-dried material.
3 - By difference (C.E.C. - sum of (Ca + Mg + K + Na).
4 - Of residue, after removal of organic matter by use of H_2O_2.
5 - Content in NH_4AC extract (soluble plus exhchangeable).

Table 6

Sample Number	Description Dried Mud	Total N[2]	Organic Matter[2]	C/N	C.E.C.[1]	C.E.C.[4] minus O.M.	Unsat'n	H[3]	Exchangeable Cations[2] Ca	Mg	K	Na	Mn[5]
		%	%		me/100 gm	me	%	me/100 gms					
26B	Grey silt	0.214	5.15	13.2	41.0	8.0	84.8	34.8	4.9	0.9	0.2	0.2	1.5
26C	Grey silt	0.264	5.94	12.3	63.0	10.1	90.3	56.9	5.2	0.5	0.2	0.2	1.2
27A	Grey silt	0.280	5.86	11.5	61.0	10.1	90.0	54.8	5.6	0.1	0.3	0.2	1.2
27B	Grey silt	0.252	5.90	12.8	44.6	8.2	91.0	40.6	2.5	1.1	0.2	0.2	0.8
27C	Grey silt	0.187	4.50	13.2	42.2	6.4	88.1	37.2	3.9	0.8	0.1	0.2	0.6
27D	Grey silt	0.249	5.75	12.6	40.2	8.8	86.3	34.7	5.0	0.1	0.2	0.2	0.9
28A	Grey silt	0.239	5.34	11.9	41.2	8.5	87.1	35.9	4.8	0.1	0.2	0.2	0.7
28B	Some large stones. Cleaned sample-grey clayey silt.	0.205	5.22	14.0	44.4	8.5	89.9	39.8	3.9	0.3	0.2	0.2	0.8
28C	Grey silt-coal fragments.	0.274	6.44	12.9	47.1	10.0	85.9	40.4	5.7	0.6	0.2	0.2	1.4

1 - Moist samples, calculated to oven dried basis.
2 - Oven-dried material.
3 - By difference
4.- Of residue, after removal of O.M. by use of H_2O_2.
5 - Not included in determination of exchange H.

Table 7

HUDSON RIVER CORE SAMPLES - 1965

Core Number	Depth	Description	Total N	Organic Matter[2]	C/N	C. E. C.[1]	C. E. C.[4] minus O. M.	Unsat'n	Exchangeable Cations					
									H[3]	Ca	Mg	K	Na	Mn[5]
	Inches		%	%		me/100 gm	me	%		me/100 gms				
XIII[2] Sta. 41-65	0-6	Reddish Grey Silt	0.265	5.24	10.8	22.6	13.7	41.1	9.3	7.9	4.4	0.5	0.5	0.5
	6-18	Grey Silt	0.205	3.60	9.7	18.7	13.7	10.7	2.0	6.3	3.7	0.4	0.3	1.0
	18-30	Grey Silt	0.205	3.55	9.4	23.2	11.3	51.7	12.0	4.6	4.7	0.8	1.1	1.1
	30-44 1/2	Grey Silt	0.187	3.40	10.0	22.4	9.7	54.4	12.2	3.8	4.2	0.9	1.8	0.6
XVII Sta. 51-65	0-6	Grey Sandy Silt	0.078	0.94	3.0	5.4	4.2	55.5	3.0	1.3	0.7	1.2	0.2	0.2
	6-18	Grey Silt	0.137	2.78	11.1	16.7	7.1	58.6	9.8	3.7	2.6	0.3	0.3	0.5
	18-34	Grey Silt	0.146	3.20	12.0	19.3	6.6	56.4	10.9	4.7	3.1	0.3	0.3	0.8
XVIII[2] Sta. 52-65	0-6	Grey Silt	0.258	4.95	10.5	21.6	11.9	38.8	8.4	8.0	4.3	0.5	0.4	1.1
	6-18	Grey Silt	0.233	4.80	11.3	21.3	11.5	44.6	9.5	6.8	3.0	0.4	0.6	2.0
	18-30	Grey Silt	0.233	4.16	9.8	24.5	11.5	51.4	12.6	5.5	4.5	0.8	1.1	1.5
	30-40	Grey Silty Clay	0.230	4.31	10.0	23.0	11.5	38.7	8.9	6.0	5.4	0.9	1.8	1.3
VI Sta. 31-65	0-6	Reddish Grey Silt	0.183	3.13	9.4	12.6	11.9	9.5	1.2	3.9	4.8	1.0	1.7	0.8
	6-18	Grey Silt	0.196	3.17	8.8	12.1	9.7	14.9	1.8	3.3	4.7	0.9	1.4	0.5
	18-30	Grey Silt	0.199	3.20	8.3	10.5	9.7	9.5	1.0	3.2	4.0	0.9	1.4	0.5
	30-40	Grey Silt	0.205	3.12	8.2	10.7	9.7	4.6	0.5	3.2	4.0	1.1	1.9	0.3

1 - Moist samples calculated to oven-dried basis.
2 - Oven-dried basis.
3 - By difference.
4 - Of residue after removal of O. M. by use of H_2O_2.
5 - Not included in determination of exchange H+.

Table 8

HUDSON RIVER CORE SAMPLES - 1965

Core Number	Depth	Description	Total N	Organic Matter[2]	C/N	C. E. C.[1]	C. E. C.[4] Minus O. M.	Unsat'n	Exhcangeable Cations H[3]	Ca	Mg	K	Na	Mn[5]
	Inches		%	%		me/100 gm	me	%	me/100 gms					
XVI	0"-3 1/2"	Grey Silt	0.199	5.60	15.4	40.7	13.9	81.5	33.2	3.4	3.0	0.3	0.8	0.7
Sta. 50-65	3 1/2"-9"	Grey Silt	0.165	4.55	15.1	19.0	8.0	57.9	11.0	3.9	2.8	0.3	1.0	0.6
	9" - 15"	Grey Silt	0.143	3.77	14.4	14.7	7.1	49.6	7.3	3.2	3.2	0.3	0.7	0.4
XIX	0"-6"	Grey Silt	0.236	5.92	13.8	41.1	13.1	72.7	29.9	6.6	3.5	0.3	0.8	1.7
Sta. 53-65	6"-18"	Grey Silt + Coal	0.214	5.26	13.5	43.6	16.4	77.5	33.8	5.5	3.1	0.3	0.9	1.8
	18" - 30"	Grey Silt	0.160	4.05	15.1	39.1	11.0	73.1	28.6	4.0	4.9	0.5	1.1	1.7
	30" - 45"	Grey Silt	0.199	4.39	12.0	47.7	12.8	81.3	38.8	2.1	4.3	0.5	2.0	0.6
XII	0" - 6"	Grey Silt + Coal and Cinder	0.089	2.10	13.5	19.0	4.3	68.9	13.1	2.0	2.7	0.2	1.0	0.5
Sta. 46-65	6" - 18"	Grey Silt	0.226	5.10	12.3	31.4	10.8	60.0	18.8	3.9	5.4	0.4	2.9	0.9
	18" - 30"	Grey Silt	0.255	5.18	11.1	47.0	13.5	72.3	34.0	3.8	5.9	0.5	2.8	0.7
	30" - 45"	Grey Silt	0.229	5.46	13.5	51.6	10.6	71.1	36.7	3.8	5.6	0.6	3.9	0.5
XV	0" - 6"	Grey Silt	0.236	5.84	13.6	66.0	15.0	86.5	57.1	3.5	1.0	0.3	0.9	1.3
Sta. 49-65	6" - 19 1/2"	Grey Silt	0.226	5.64	14.1	33.0	10.8	82.7	27.3	3.5	1.0	0.3	0.9	1.3
XI	0" - 6"	Grey Silt	0.230	5.64	13.4	58.0	13.1	83.4	48.4	2.9	4.8	0.5	1.4	1.3
Sta. 45-65	6" - 18"	Grey Silt	0.256	5.46	12.6	57.1	15.0	82.9	47.3	3.7	4.8	0.4	0.9	2.0
	18" - 36"	Grey Silt	0.218	4.60	11.5	56.5	13.3	81.6	46.1	3.8	5.3	0.4	0.9	0.8

1 - Moist samples, calculated to oven-dried basis.
2 - Oven-dried samples.
3 - By difference.
4 - Of residue, after removal of O. M. by use of H_2O_2.
5 - Not included in determination of exchange H.

Table 9

EXCHANGEABLE** AND ORGANIC BOUND CATIONS

(me/100 gms)

Sample	Exchangeable Cations				Non-Exchangeable Cations***				Ignited	Not Ignited
	Na	K	Ca	Mg	Na	K	Ca	Mg	Fe mg/100gms	
					N pH 7.0 NH_4Ac					
1-1965	0.2	0.4	4.9	4.9	0.4	1.0	0.8	0.4	140	265
2-1965	0.1	0.3	5.4	4.1	0.3	0.9	0.9	0.3	95	110
3-1965	0.1	0.3	4.3	3.5	0.2	1.2	0.7	0.6	70	110
4-1965	0.1	0.2	4.6	3.2	0.2	1.0	0.5	1.9	130	110
					0.05 N HCl*					
1-1965	0.3	0.6	6.7	8.5	0.4	1.0	0.3	0.2		
2-1965	0.2	0.3	7.7	8.9	0.2	1.3	0.3	5.0		
3-1965	0.2	0.3	5.4	4.6	0.3	1.5	0.1	2.6		
4-1965	0.2	0.3	11.0	9.7	0.3	1.2	0.2	2.8		

* Higher values for exchangeable cations by use of 0.05 HCl is due to its lower pH, and its effect on Ca and $MgCO_3$.

** Water Soluble cations removed prior to extraction. Technique outlined in appendix.

*** "Organic bound" cations. (Ignited - Unignited = Organic Bound)

Table 10

SOLUBLE METALS*

(me/100 gms)

Sample #	Fe	Mn	Cu	Ni	Total
30	0.35	0.14	0.02	0.10	0.61
25A	0.94	0.71	0.03	0.004	1.68
25B	0.33	0.25	0.01	0.003	0.59
26A	0.04	0.12	0.01	0.06	0.23
26B	0.70	0.44	0.03	0.11	1.51
26C	1.12	0.24	0.02	0.005	1.38
27A	1.92	0.29	0.04	0.09	2.34
27B	1.11	0.30	0.03	0.02	1.46
27C	1.18	0.20	0.02	0.03	1.43
27D	1.71	0.10	0.03	0.11	1.95
28A	2.27	0.31	0.05	0.31	2.94
28B	0.51	0.36	0.07	0.06	1.00
28C	1.14	0.42	0.02	0.01	1.59

* Contained in N neutral NH_4Ac extracts used to determine C.E.C. on moist samples taken in 1965.

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RADIOLOGICAL STUDIES

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I. Radiological Techniques

Samples were analyzed by gamma spectrometry using a 4 inch NaI(Tl) well crystal. One of the primary objectives of sample preparation prior to analysis was to reduce the volume of samples to no more than 16 ml. This was necessary in order to accommodate all samples in standard snapcap plastic vials used in conjunction with the well-type scintillation detector. When samples were not of sufficient volume to fill the vial, the difference was made up with ordinary granulated sugar which was ground with the sample to form a homogeneous mixture of the required volume. The sugar proved to add no significant radioactivity to the samples.

A. Sediments

Bottom sediments were dried on a hot plate and sifted through 11 mesh screening. The material left on the screen consisted mainly of shell fragments, pebbles, driftwood and other organic material which was discarded. No further effort was made to remove organic material from the sifted portions. By weighing the sample before and after ashing, the organic material was found to account for approximately 15% of the sample weight. The sifted samples consisted of coarse to very fine sand, silt and clays. An aliquot large enough to fill the 16 ml vial was weighed and they assayed by gamma spectrometry.

B. Biological Samples

Biological material consisting of fish, invertebrates, plants and algae, were first identified. The material was then washed, weighed after blotting with paper towelling, dried on a hot plate to prevent splattering at higher temperatures, and placed in silica trays to be ashed for 24 hours at 600° C. in a muffle furnace. Temperatures above 600° C. during ashing were avoided due to the possibility of volatilization loss of certain nuclides, notably cesium and ruthenium. The ash was then weighed, ground to a uniform size, and an aliquot put into 16 ml vials to be counted.

Green and Finn (1) indicate that the volatilization of cesium in the ashing of dryed milk samples becomes important at temperatures greater than 450° C. The loss of Cs^{137} at an ashing temperature of 620° C. increases from 37% for a one day ashing to about 90% after 6 days. Since our samples have been ashed at 600° C. for 1 day a possible loss of 37% of the Cs^{137} is indicated. In light of these facts the ashing temperature will be reduced to 450° C. on all future samples.

C. Water and Suspended Solids

Water samples were first filtered under vacuum through a tared sheet of Whatman #1 filter paper. The filter paper was then dryed, weighed, and inserted into a vial for the counting of suspended solids. Two 3 liter aliquots of the filtered water were then evaporated to dryness after the addition of 20 ml.

of 12N HCl to prevent hydrolysis. The residue salts were weighed, ground to uniform particle size, and also placed in vials for counting.

D. Chemical Analysis

For samples containing relatively large amounts of manganese, stable manganese determinations were performed by the persulphate oxidation of MnO_2 with silver catalyst to the permanganate stage and subsequent titration with the reducing agent ferrous ammonium sulphate.

The Sr-90 content of a representative number of samples has been determined by measurement of its daughter product, Y-90 (2). Radiochemical procedures for the determination of Fe-55 are currently being developed for estimation of this nuclide in Hudson River samples. Thus far, preliminary determinations on several representative samples containing Fe-55 have established important pre-treatment techniques and determined the size of sample necessary to attain minimum detectectable levels (3).

Rapid electrolytic concentrating techniques have been developed to implement the determination of tritium at the low levels encountered in the environment. Tritium samples for the 1966 survey will be counted in a Nuclear Chicago Mark IV Liquid Scintillation counting system purchased this year. In addition, various scintillating cocktails are being investigated for the purpose of increasing sensitivity in both tritium and Fe-55 determinations.

E. Counting Procedures

Counting was performed using a 4 x 4 inch NaI (Tl) well detector and a Nuclear Data Model ND-130T 512 Channel Analyzer. Two hundred and fifty-five channels of information were recorded. Normal calibration was 10 keV/channel so that gamma energies up to 2.5 MeV were examined.

Readout of the information stored in the analyzer was accomplished using punched tape. The punched tape allows information to be reintroduced in the analyzer memory whenever desired and is essential for tape to card conversion for computer analysis.

Standard solutions of Ce-144, Co-60, and Cs-137 were prepared by evaporation on planchets and assayed by 2π gas flow proportional counting. These standard solutions have associated measurement errors of $\pm$ 5%. Standard solution of Ra-226, Ra-228 and Th-228 were similarly prepared and assayed. The Ra-228 solution was prepared from Monazite ore and contained approximately 10% of Ra-226 and approximately 12% of Th-228 (by activity) with an associated measurement error of $\pm$ 10%.

Solutions of Mn-54 and Zn-65 were obtained from the Nucleonic Corporation of America calibrated to $\pm$ 10%. For these nuclides N.C.A.'s calibrations were accepted as correct. A Ru-106/Rh-106 standard was prepared and assayed by 2π beta counting. The error on this source is approximately $\pm$ 10%. Standards for the spectrometric assay were prepared from these solutions. All standards were aqueous solutions with

a volume of 16 ml, a volume identical to that of the samples processed; and were counted sufficiently long to accumulate over 10,000 counts in the peak channels again under conditions identical to those used in counting samples. Background samples using sugar were run with each batch of samples processed.

F. Data Analysis

Quantitative estimation of the activities of Ce-144, Cs-137, Ru-106/Rh-106, Co-60, Zn-65, Mn-54, Ra-228, Ra-226 and K-40 was accomplished by a weighted least squares method developed by Pasternack and Liuzzi (4,5,6). This method has been programmed in Fortran for the NYU-AEC CDC 6600 computer (7).

The method of analysis requires the following: an index card indicating the number of channels of information used; a program deck which describes the operations to be performed; a background spectrum for subtraction from the samples; a background spectrum for subtraction from the reference nuclides; a reference spectrum obtained from a known concentration of a mixture of the nuclides assumed to be in the sample; and the sample deck composed of twenty-five data cards and one title card per sample.

The computer program provides for the subtraction of background from the sample and reference decks. Determination of a ratio of the activities of each component in the sample to the reference spectra is accomplished by minimizing the

sum of the squares of the weighted residuals. Then, all of the reference spectra are fitted, channel by channel, to the sample spectrum. This ratio is multiplied by the known activity of the reference sources as indicated on the title card of each individual reference nuclide. The method of analysis is such that a greater statistical weight (in terms of estimating the unknown activities) is given to channels with the largest number of accumulated counts.

The analysis provides estimates of the amount of each nuclide present, as well as estimates of the standard error of the assay. These estimates are based on counting statistics and do not include the errors associated with the calibration of the reference sources. In addition, the program computes a ratio statistic which has an expected value of unity if the fit is good. Departures from ideal conditions are indicated by the decrease in this ratio. Ideal conditions would exist if the reference spectra approximated the composition of the sample spectra and both spectra were run under identical conditions of geometry, amplifier baseline and gain. If these conditions varied significantly a ratio less than one would result. On this basis ratios below 0.70 were considered unacceptable since the results produced would be excessively biased.

An informative check on the analysis is a plot of the weighted residuals from the fitting process versus the channel number. From this plot it is possible to ascertain whether

a low ratio was caused by a gain shift or the absence of a nuclide in the reference spectra which was present in the sample. Further details regarding this procedure will be found in references (4,5,6).

II Radiological Findings

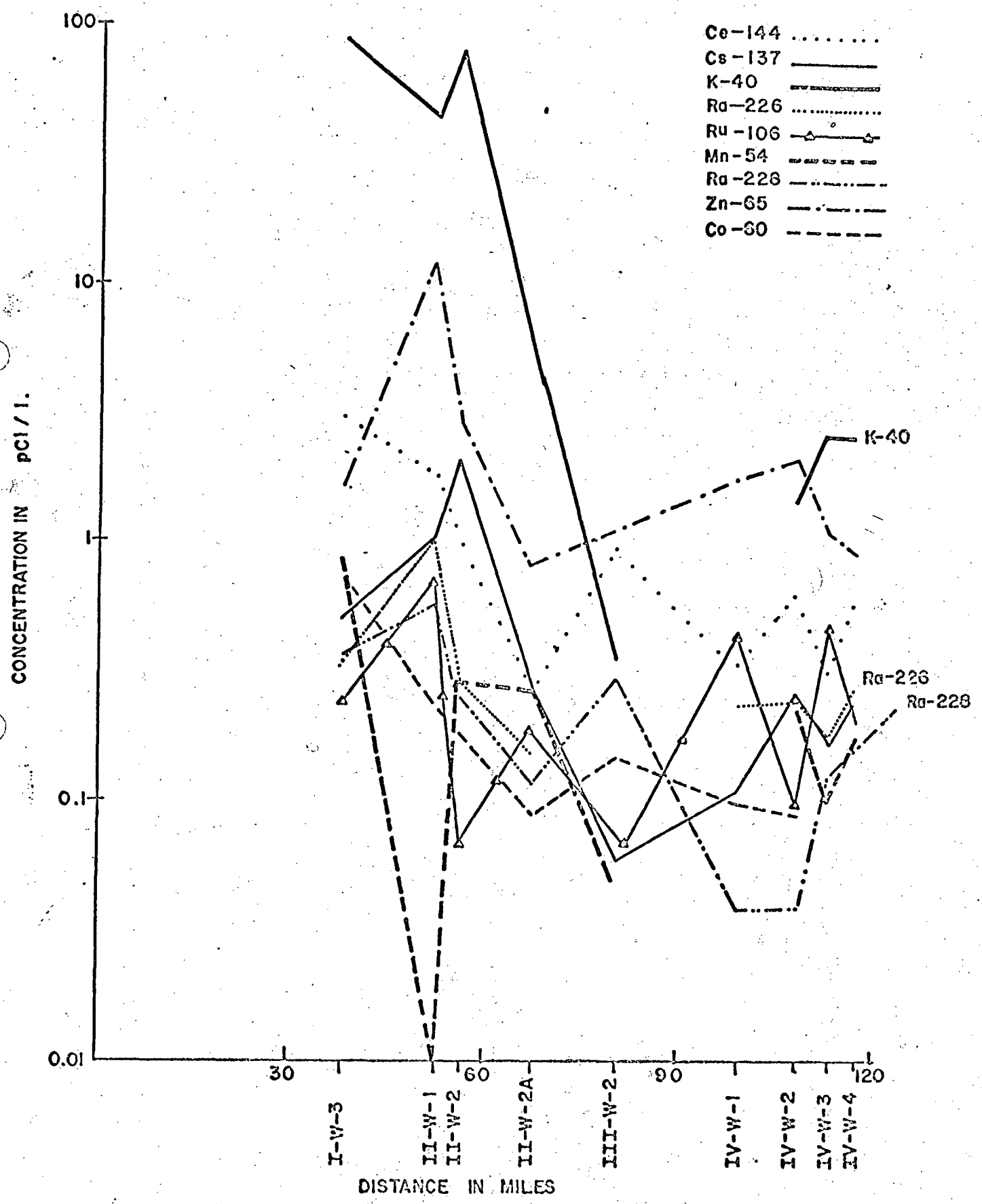
A. Water Samples

Naturally occurring K-40 was again found to constitute the principle activity in Hudson River water. The highest contribution to the water activity from a manmade nuclide appeared to be from Zn-65 which ran about one order of magnitude less then K-40. The maximum observed Zn-65 activity was about 10 pCi/l while the maximum observe K-40 activity was approximately 90 pCi/l. These values are plotted in Figure 1 which shows the site-to-site variation in the activity of 9 radionuclides. The values plotted in this figure represent the mean activity of approximately 5 water samples taken at each site. Table 1 summarizes the range and means of the observed values.

The other seven radionuclides which include Cs-137, Ce-144, Ru-106, Mn-54, Co-60, among the fission product radionuclides and Ra-226, Ra-228 among the naturally occurring radionuclides, almost all lie within the range of 0.1 to 1 pCi/l. The two exceptions are Cs-137 and Ce-144 which show peak concentrations of 2 and 3 pCi/l, respectively. Six samples of river water from Sectors I and II were chemically separated for Sr-90 analysis. Five of these samples were found to have activities within the narrow range of 1.07 to 1.31 pCi/l and only one sample was

FIG. 1

GRAPHIC REPRESENTATION OF RADIONUCLIDE DISTRIBUTION IN HUDSON RIVER / WATER



found at the higher level of 2.55 pCi/l.

By comparison, seven samples of water were prepared from the Hudson River watershed area (See Table 2). These were 3 samples along the Mohawk River; 1 sample at the Indian Point Pond; 1 sample from Indian Lake and 2 from Sterling Lake. The latter two lakes are both located in Sterling Forest, New York. All of the above samples showed very low K-40 concentrations. Four samples had non-detectable amounts while the three samples from the Sterling Forest area ranged from 3.7 to 13.0 pCi/l. Ru-106 appeared to be present in six of the seven samples at a level averaging less than 2 pCi/l. The next most abundant isotope was Ra-226 with two samples showing activity. These were both from the Mohawk River and had activity levels of 1.3 and 1.9 pCi/l. The only other activity found was in one sample from Indian Lake which had 0.4 pCi/l of Cs-137. No detectable amounts of Ce-144, Mn-54, Ra-228, Zn-65, or Co-60 were found.

B. Sediments

The bottom muds of the Hudson River, although variable in composition, do not exhibit a high variability in individual radionuclide concentration (See Table 3). The mean concentration of K-40 from site-to-site had a range of only 8.57 to 19.32 pCi/gm* and was approximately one order of magnitude greater than the activity of the next most abundant isotope Ce-144.

* All sediments are reported in pCi/gm of dry weight.

The mean concentration of Ce-144 ranged from 0.65 to 3.14 pCi/gm with most of the samples running approximately 2 pCi/gm.

Naturally occurring Ra-226 was found consistently within a range of 1 to 2 pCi/gm throughout the length of the river. Ra-228 was also found to be uniformly distributed at a level very close to 1 pCi/gm. Visual examination of Figure 2, which illustrates the radionuclide distribution in Hudson River sediments, shows all three of the naturally occurring radionuclides to be well correlated along the length of the river.

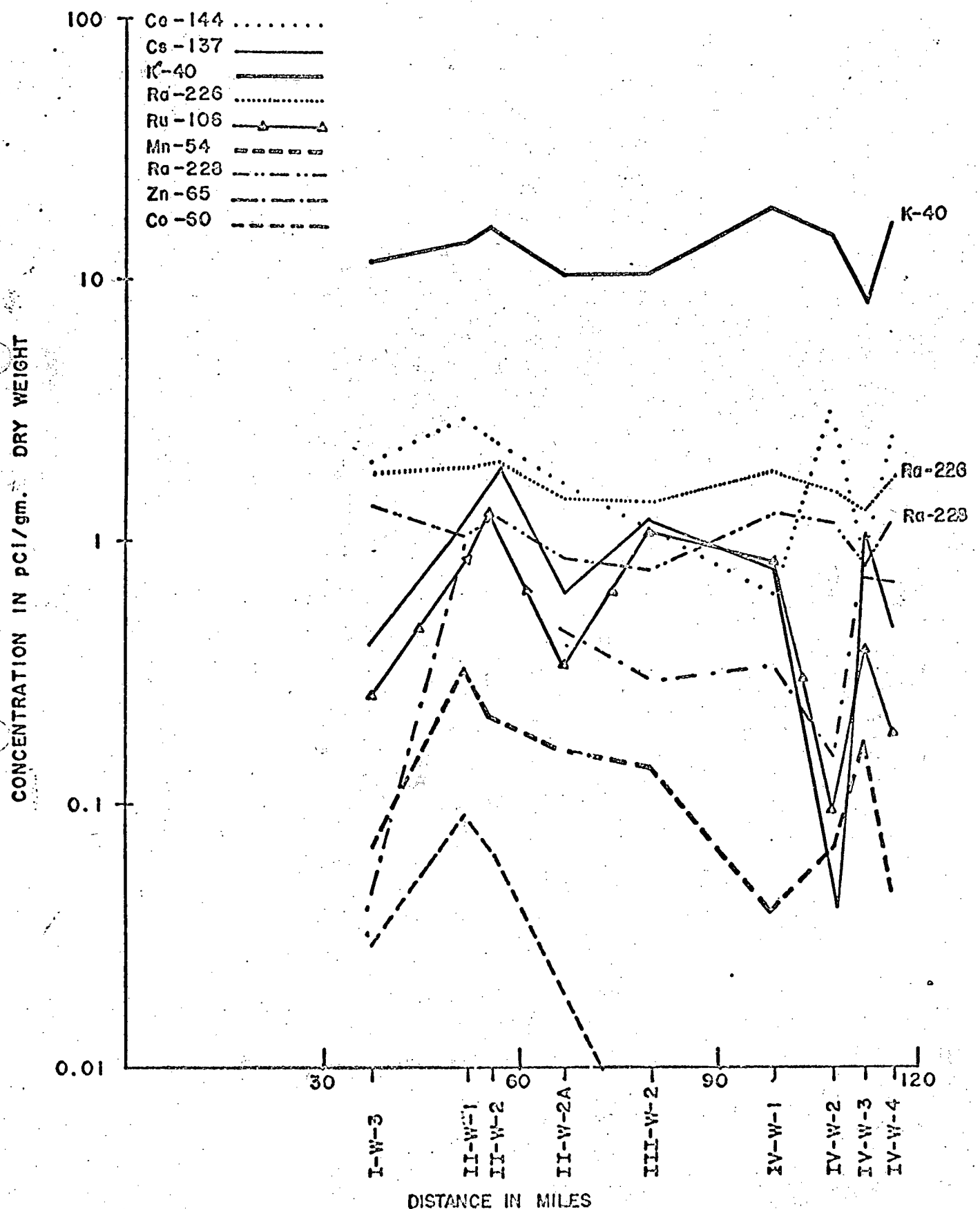
In contrast to the water samples, the apparent activity of Zn-65 in sediments was nearly two orders of magnitude less than that of K-40. The highest mean concentration of Zn-65 was approximately 1 pCi/gm at site II-W-I. The other sites ranged from non-detectable to 0.74 pCi/gm.

Cs-137 and Ru-106 show nearly the same pattern of distribution along the river. The mean concentrations of Cs-137 varied from 0.05 to 2 pCi/gm whereas those of Ru-106 were generally at a lower level ranging from 0.10 to 1.24 pCi/gm. Mn-54 and Co-60 were the least abundant of the radionuclides which were analyzed. The maximum of the means of the Mn-54 concentrations was 0.32 pCi/gm while that of Co-60 was only 0.09 pCi/gm. Of the 11 sites examined, 7 had detectable amounts of Co-60.

Seven samples from Sectors I and II were chemically

FIG. 2

GRAPHIC REPRESENTATION OF RADIONUCLIDE DISTRIBUTION IN HUDSON RIVER SEDIMENTS



separated for the determination of Sr-90 concentrations. These samples had a range of from 0.100 to 0.250 pCi/gm. The mean concentration for these seven samples was 0.175± 0.017 pCi/gm. The values for Sr-90 for these sectors were reported incorrectly last year as 0.0 pCi/gm. Examination of last year's data showed that the mean Sr-90 concentration should have been reported as less than 0.01 pCi/gm. In addition, a review of the chemical procedure used in both years casts some doubt on the validity of the 1964 figures. The 1964 Sr-90 samples were prepared by sodium carbonate fusion followed by dissolving the melt in concentrated HCL. Any excess siliceous material was then filtered out. In contrast the 1965 samples were treated with nitric, perchloric and hydrofluoric acids prior to sodium carbonate fusion resulting in a much smaller loss of siliceous material and associated Sr-90. Thus it is felt that samples prepared in 1965 reflect the Sr-90 concentration more accurately than those prepared during the pilot study.

Table 4 lists nine samples of sediments which were taken from the surrounding watershed. Six of these samples are from the Mohawk River. These samples exhibit the same relative amounts of activity for all the radionuclides with the exception of Cs-137 and Co-60 which exhibit from 5 to 10 times as much activity as the levels observed in the Hudson River sediments. Slightly higher concentrations of Cs-137

are also indicated in the single samples taken from Indian Point Pond and Sterling Lake. In addition the sample from Sterling Lake had 16.4 ± 5.5 pCi/gm of Ce-144. This is four times greater than the next highest observed concentration of this radionuclide.

C. Fish

With only several exceptions, the individual nuclide activity contained in most species of Hudson River fish was found to be less than 0.1 pCi/gm (See Table 5). For sixteen of the twenty species examined, the total fission product activity of the "average" fish of each species was found to be less than 0.5 pCi/gm. wet weight. Of the remaining four species, three were found to contain up to 0.8 pCi/gm and a single sample of Cyprinus Carpio, "Carp", was found to contain 2.4 pCi/gm.

The Blueback Herring samples had a mean total fission product activity of 0.53 pCi/gm with the major contribution coming from 0.24 pCi/gm of Zn-65. Two single samples of White Sucker and Bluefish had fission product activities of 0.8 pCi/gm each. In both cases, the major contributing isotope appeared to be Ru-106, which was present at a level of 0.6 and 0.5 pCi/gm respectively. The single sample of Carp, which had a total manmade radionuclide activity of 2.4 pCi/gm, derived 88% of its activity from 1.5 pCi/gm of Ru-106 and

0.6 pCi/gm of Zn-65. Of the twenty species examined, however, eighteen were found to contain more naturally occurring K-40 activity than the total activity due to the man-made radionuclides.

Sr-90 was found at a mean level of 0.302 pCi/gm in the 5 samples listed in Table 6. Two samples of Sterling Lake fish are shown for comparison, in Table 7. It is of interest to note that the Sterling Lake Black Bass contains three times more Sr-90 than the Hudson River Sunfish (these two species being from the same family "Centratchidae").

Fish from the surrounding watershed area had Cs-137 concentrations ranging from non-detectable to 2.9 pCi/gm (See Table 8). This is one order of magnitude greater than the Cs-137 concentrations reported for the Hudson River. (i.e., non-detectable to 0.3 pCi/gm). Kolemainen, Hasanen, and Miettinen, and their studies of Finnish lakes and rivers carried out during 1963-65, obtained similar results. Their data indicates that Cs-137 activity in fish is inversely proportional to the K-content of water (8).

D. Vegetation

Table 9 lists 66 samples of 14 species of aquatic vegetation which have been examined for radionuclide content. K-40 is generally found in Hudson River vegetation at a level of 1 to 2 pCi/gm wet weight. *Microspora sp.* a "blue-

green algae" was found to contain 12.0 pCi/gm of K-40 and the nut of Trapa natans, the water chestnut, contained 6.5 pCi/gm of K-40. These two results are, however, based on single samples.

Mn-54 was found to concentrate in several species of vegetation. In particular the algae Chara was found to contain from 6.3 to 17.6 pCi/gm in 3 samples, and 4 samples of Potomogeton Crispus had a range of 3.3 to 10.2 pCi/gm. The above samples along with several others were analyzed for stable manganese and Table 10 lists the stable manganese content along with the pCi/gm of Mn-54 per mg of stable manganese and other pertinent data.

It can be seen from this table that Potomogeton Crispus and Chara have a manganese content ranging from 7 to 13% of the total skeletal ash, whereas the other species analyzed are all in the order of 1 to 2 % manganese. In addition Potomogeton and Chara have 3 to 5 times the specific activity of Mn-54 as the other species of vegetation. The higher stable manganese content along with the increased specific activity might well be associated with a faster metabolic rate of exchange for manganese for the two species sited.

Following Mn-54 the next most abundant radionuclides are Ce-144, Ra-226, and Ru-106. These radionuclides are generally present at a level of less than 0.2 pCi/gm. Cs-137 was present at very low levels (less than 0.1 pCi/gm) and

Ra-228 and Zn-65 appeared in trace amounts.

Sr-90 could not be analyzed in vegetation due to an unusually large amount of siliceous material present in the ash. It was, therefore, felt that some of the activity which we attributed to the vegetation in the past might be due to sedimentary activity attached to the plant: i.e., activity not removed in the ordinary washing of the vegetation. At present, steps are being taken to improve washing techniques. Future samples should, therefore, be more indicative of the true radionuclide burden of Hudson River vegetation.

Seven samples of vegetation from the surrounding watershed area (Table 11) were analyzed. With the exception of the absence of Zn-65 and Co-60, the watershed samples exhibit no other distinguishing characteristics.

III Comparative Study of Radionuclide Concentrations for 1964 Versus 1965

A. Introduction

A basic question is whether the techniques used in 1964 and 1965 have yielded reproducible data. To answer this question several simple hypotheses can be tested. For example, the concentrations of K-40, Ra-226 and Ra-228 should remain constant from one year's survey to the next. This is self-evident for K-40 which has a half-life of 1.29×10^9 years. The concentration of Ra-226 ($T_{\frac{1}{2}}$ = 1620 years) and Ra-228 ($T_{\frac{1}{2}}$ = 6.7 years) should also remain constant since these radio-

nuclides are in secular equilibrium with the daughters of the uranium series and thorium series, respectively. Fission products, on the other hand, can be expected to show variations in concentrations which will be functions of cumulative fallout; their physical and biological half-lives, and their eventual fate in the environment. On the basis of physical half-lives alone, the Ce-144 ($T \frac{1}{2}$ = 285 days), Mn-54 ($T \frac{1}{2}$ = 314 days) and Ru-106 ($T \frac{1}{2}$ - 1 year) should have decreased to 41%, 45% and 50% respectively, from one years survey to the next. That there are other factors in the environment which affect radionuclide concentration is clearly illustrated by the data.

As will be seen in succeeding discussions, K-40 appears to be the best available measure for indicating the precision of the radiological measurements. Considering the practical limitations in environmental sampling, the concentrations of Ra-226 and Ra-228 are insufficient to yield statistically reproducible data for the sample sizes employed. K-40, on the other hand, has been shown in most instances to have equal concentrations for 1964 versus 1965 at the 95% confidence limit. Thus it is felt that K-40 will be a useful tool in evaluating the reliability of the measurements from one year to the next.

In addition to comparing the data for analytical precision, certain other advantages have been obtained through comparison. Insight into the value of the various sampling

sites has been gained by comparing variations in radionuclide concentrations from region to region. For example, the samples of vegetation from the four sites in Sector IV showed very little variation in radionuclide concentrations. Although, samples will be collected at all four sites, in the next year, pooling of samples should give a higher total activity and hence, more significant data regarding the concentrations of various nuclides in several species.

B. Statistical Considerations

The ratio statistic used in the comparative study is an indication of the goodness of fit obtained in the quantitative estimation of the activities of the various radionuclides. The estimates are made by the weighted least squares method developed by Pasternack and Liuzzi (4, 5, 6) which has been previously described.

As has been indicated, departures from ideal conditions are indicated by a decrease in this ratio. Ratios below 0.70 were considered unacceptable in that the results produced would be excessively biased.

The mean concentrations in both years samples were compared by means of the Student t-test. In performing the analysis it was assumed that the populations were normally distributed and had equal, though unknown, variances (9).

C. Comparison of Radionuclide Concentrations in Hudson River Fish 1964 Versus 1965

Table 12 compares the concentration of 8 radionuclides in Hudson River fish for 1964 versus 1965. Seventeen species of fish common to both years were utilized in compiling the data. Fifty-six samples were available for 1964. All of these had ratios greater than the selected critical ratio of 0.70. The ratio range was 0.78 to 1.15. These 56 samples represented a total of 7,716 fish weighing a total of 34.6 kgms.

For 1965, 50 samples of the same 17 species were available. These samples had a ratio range of 0.72 to 1.08 and represented a total of 7,401 fish with a total weight of 16.9 kgms.

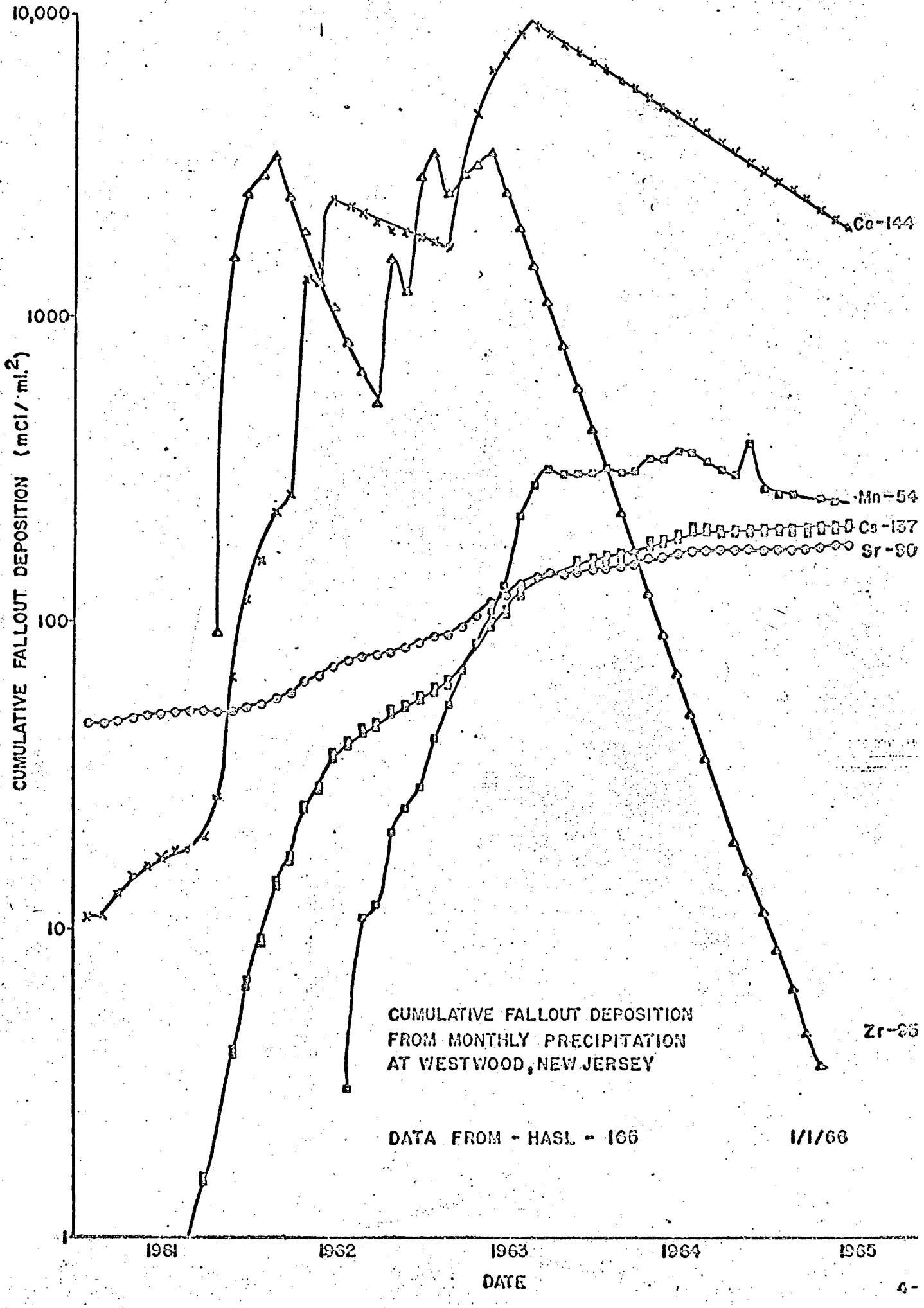
Statistical analysis of the results tabulated in Table 12, indicated the mean K-40 activities to be equal at the $\alpha = 0.05$ level of significance. It is apparent from the results, however, that this is not the case for Ra-226 or Ra-228. Statistical tests of the equality hypothesis confirmed the fact that neither the Ra-226 mean activities nor the Ra-228 mean activities were equal. Concentrations of these two radionuclides are evidently too low to demonstrate equality within the statistical limitations imposed by the available sample sizes. Therefore, the best indicator for reproducibility of radiological techniques in Hudson River fish, appears to be the mean K-40 concentration.

D. Comparison of Radionuclide Concentrations in Hudson River Sediments from Sectors I and II 1964 Versus 1965

In the preliminary survey of the Hudson River during the Summer of 1964 only the area south of West Point had been sampled for sediments. Thus to permit an unbiased comparison for 1964 and 1965 only those stations sampled in both years are included in the data (Table 13).

Contrary to the trend indicated in fish, Ru-106 and Mn-54 in Hudson River sediments appeared to decrease markedly in concentration. These two radionuclides, as previously indicated, have half-lives of one year or less. The low results in 1965 for both Ru-106 and Mn-54 seem to indicate that these nuclides are cleared more rapidly from sediments than the combined rates of introduction. For 1965 the observed concentrations were 35% and 29% of the concentration which would be predicted from physical decay alone. In addition cumulative fallout data for Mn-54 (Figure 3) indicates that the cumulative activity of Mn-54 has been relatively constant since August of 1963. These facts in addition to the findings reported by McCrone et al. (in section III of this report) indicate that the manganese derived from fallout appears to be present in exchangeable and easily-reducible forms similar to the manganese in sediments washed in from soils of the drainage basin. Additionally, this may help to explain the high concentrations of radio-manganese reported in the aquatic alga Chara in both last years and this years report.

FIG. 3


10,000
1000
100
10
1
CUMULATIVE FALLOUT DEPOSITION (mCi/ml.²)
Ce-144
Mn-54
Cs-137
Sr-90
Zr-95
CUMULATIVE FALLOUT DEPOSITION
FROM MONTHLY PRECIPITATION
AT WESTWOOD, NEW JERSEY
DATA FROM - HASL - 166
1/1/66
1961
1962
1963
1964
1965
DATE

The long lived radionuclides, represented here by Co-60, Sr-90 and Cs-137, all show a trend toward increasing concentrations. This trend is in accord with the increase in the cumulative fallout activities shown in Figure 3 for Sr-90 and Cs-137 indicating that rates at which these radionuclides are leaving the sediments are slower than the uptake rates.

A statistical test on the mean concentrations of K-40 rejects the equality hypothesis. The K-40 concentrations are, however, within 7% of each other. In view of the sample sizes, and the fact that the sample analyses were separated by one year, a 7% difference in the mean K-40 concentrations does not appear to be unreasonable. Additional confirmation of the accuracy of the results was supplied by the mean concentrations of Ra-228: 1.07 pc/gm for 1964 versus 1.04 pc/gm for 1965. These means were shown to be equal at the $\alpha = 0.05$ level of significance.

E. Comparison of Radionuclide Concentrations in Hudson River Sediments for 1965 - Sectors I & II Versus Sectors III & IV*

The previous comparison was based on the southern most sampling region which was studied in both 1964 and 1965. With the expansion of the survey to regions north of West Point it became possible to inquire into regional variations in the concentrations of radionuclides. For this comparison Sectors I and II which comprise a 39-mile stretch of river south of West Point and Sectors III and IV which constitute practically

* See Table 14

an equal length of river north of West Point were compared based on the data available from the 1965 study.

The concentrations of K-40, Ra-226, and Ra-228 can be seen to be very nearly identical in both regions. This is not the case for the six other radionuclides. Tests of the equality hypothesis gave negative results in each of the six cases. In fact, the data indicates that the activity of five radionuclides is greater in the region south of West Point, i.e., Sectors I and II show more Ce-144, Cs-137, Ru-106, Mn-54, Co-60 activity than Sectors III and IV. Zn-65 is the only radionuclide that does not follow the above pattern.

F. Comparison of Radionuclide Concentrations in Hudson River Water Samples 1964 Versus 1965*

The mean concentrations of six of the radionuclides are all within the same order of magnitude but no trend is evident. The K-40 concentrations appear to be very nearly equal in both years, but the other radionuclides have concentrations in the order of 30 times less than K-40 and do not yield clear-cut results for the sample size available due to the low levels of activity. In the most extreme cases the mean concentrations of both Ra-226 and Mn-54 differ by more than one order of magnitude.

The possibility of analyzing a more statistical significant number of samples in the coming year is presently under

* See Table 15

consideration. For the present the important single fact which can be noted from the tabulated results is that the concentrations of the man-made radionuclides are many orders of magnitude below the recommended maximum permissible concentrations for these radionuclides. These range from Mn-54 which is presently at about 1/10,000,000th of its MPC_w to Ce-144 and Ru-106 which are currently running 1/7,000th of their MPC_w's. Ra-226 and Ra-228, which are both naturally occurring, are at 1/10th and 1/60th of their MPC_w's, respectively.

G. Comparison of Radionuclide Concentrations in Hudson River Suspended Solids for 1964 Versus 1965 *

Here again, as was the case for Hudson River water, low activity combined with an insufficient number of samples preclude the investigation of variations of radionuclide concentrations in suspended solids. There are in addition several other factors which make the sampling of suspended solids a rather semi-quantitative science. The condition of the river bed at the various sampling stations varies from a silty-clay to a coarse gravel and, hence, the nature of the suspended solids is highly variable. This fact combined with variations in current and local disturbances make it appear highly improbable that the sampling of suspended solids even at the same location could yield statistically reproducible results. These samples and the tabulated results, therefore,

* See Table 16

merely serve as an indication of the order of magnitude of radionuclide concentrations in suspended solids. From this standpoint it can be seen that the amount of radionuclides present in the solids fraction of the river water are in general at about 1000 times the concentrations in the river water. (Note that the tabulated results for suspended solids are in the same order of magnitude as those for river water but the suspended solids is reported in pc/gm and the water in pc/l).

H. Comparison of Radionuclide Concentrations in the Alga Chara for 1964 Versus 1965 *

The aquatic algae chara has been of special interest among the aquatic vegetations because it has been found to greatly concentrate Mn-54 and to a lesser extent Co-60. The concentrating ability for Mn-54 is no longer a mystery since the skeletal ash of this variety of algae has been shown to be composed of approximately 10% manganese. The tabulated results for both years show comparable amounts of Mn-54. The mean activity of two samples in 1964 was 16.78 ± 0.22 pc/gm with the lower of the two samples containing 15.08 ± 0.24 pc/gm and the higher of the two samples containing 18.49 ± 0.36 pc/gm. In 1965 three samples of this vegetation were collected. These ranged from 6.30 ± 0.10 pc/gm to 17.60 ± 0.20 pc/gm with the mean concentration for 1965 being 10.97 ± 0.08 pc/gm. A rather large decrease in the amount of Ru-106 can be noted from the

* See Table 17

1964 to 1965 samples. In 1964 the two available samples yielded nearly identical results of 9.58 ± 2.74 pc/gm and 9.65 ± 1.40 pc/gm of Ru-106, whereas, the highest concentration observed in a 1965 sample was only 1.10 ± 0.20 pc/gm.

Table 1

RADIONUCLIDES IN HUDSON RIVER WATER
Concentration in pCi/l

Mile	No. Of Samples		Ce-144	Cs-137	K-40	Ra-226	Ru-106	Mn-54	Ra-228	Zn-65	Co-60	Sr-90*
36.8	5	Mean	3.02	0.50	89	0.34	0.24	0.85	0.36	1.64	0.79	1.89
		Min.	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.2±0.1
		Max.	8.4±7.5	0.7±0.6	190±30	0.7±1.5	1.2±2.7	1.6±0.9	1.1±0.6	7.2±4.6	0.9±0.7	2.6±0.1
52.0	5	Mean	1.82	1.06	45	1.02	0.75	0.01	0.58	11.34	0.24	1.21
		Min.	ND	ND	34±5	ND	ND	ND	ND	ND	ND	1.1±0.1
		Max.	3.7±3.4	1.9±0.9	66±13	4.4±2.4	3.7±3.7	0.1±0.9	1.6±1.2	27±9.2	0.6±0.5	1.3±0.1
56.0	5	Mean	1.17	2.08	78	0.25	0.07	0.29	0.26	2.92	0.85	-
		Min.	ND	0.5±0.3	15±4.4	ND	ND	ND	ND	ND	ND	
		Max.	1.8±1.2	1.0±0.3	303±51	1.2±0.8	0.3±1.4	0.6±0.4	0.5±0.4	6.1±3.2	3.2±3.0	
67.5	5	Mean	0.31	0.29	6	0.16	0.19	0.29	0.12	0.83	0.09	-
		Min.	ND	ND	ND	ND	ND	ND	ND	ND	ND	
		Max.	1.4±1.0	0.5±0.2	14±3.4	0.8±0.7	0.5±1.0	0.7±0.3	0.6±0.3	2.4±2.7	0.3±0.3	
79.5	3	Mean	0.95	0.06	0.5	-	0.06	0.05	0.30	1.13	0.15	-
		Min.	ND	ND	ND	ND	ND	ND	ND	ND	ND	
		Max.	1.7±0.8	0.2±0.2	1.0±3.2	-	0.2±1.0	0.1±0.3	0.5±0.3	2.5±2.3	0.3±0.2	
98.5	3	Mean	0.39	0.11	-	0.24	0.47	-	0.04	1.78	0.10	-
		Min.	ND	ND	ND	ND	ND	ND	ND	ND	ND	
		Max.	0.6±0.9	0.2±0.3	-	0.7±0.6	1.4±1.2	-	0.8±0.3	3.7±2.5	0.3±0.2	
107.5	4	Mean	0.64	0.27	1.5	0.25	0.10	0.23	0.04	2.10	0.09	-
		Min.	ND	ND	ND	ND	ND	ND	ND	ND	ND	
		Max.	1.8±0.9	0.5±0.2	6.0±3.1	0.6±0.6	0.2±1.0	0.5±0.3	0.1±0.3	4.9±2.4	0.3±0.3	

Table 1 Cont'd.

Mile	No. Of Samples		Ce-144	Cs-137	K-40	Ra-226	Ru-106	Mn-54	Ra-228	Zn-65	Co-60	Sr-90*
113.0	4	Mean	0.33	0.17	2.6	0.18	0.49	0.10	0.12	1.16	-	-
		Min.	ND	ND	ND	ND	ND	ND	ND	ND	ND	
		Max.	1.2±0.9	0.5±0.2	6.0±3.4	0.7±0.6	1.7±1.2	0.2±0.3	0.3±0.3	2.8±2.5	-	
117.0	4	Mean	0.57	0.24	2.6	0.25	0.22	0.17	0.22	0.92	0.10	-
		Min.	ND	ND	ND	ND	ND	ND	ND	ND	ND	
		Max.	2.0±1.0	0.3±0.2	9.0±3.3	0.6±0.6	0.9±1.1	0.3±0.2	0.5±0.3	1.4±1.9	0.4±0.2	
51.5	1		1.5±1.7	1.3±0.8	ND	1.8±1.6	5.0±2.3	ND	ND	ND	ND	1.3±0.1
54.8	1		ND	ND	12±5.8	ND	1.8±1.5	ND	ND	3.7±2.8	ND	-

*Determined by radiochemical analysis
ND = Non-Detectable

Table 2
RADIONUCLIDES IN HUDSON RIVER WATERSHED FILTRATES
Concentration in pCi/l

Sampling Site	No. Of Samples	Sample Vol. (liters)	Ce-144	Cs-137	K-40	Ra-226	Ru-106	Mn-54	Ra-228	Zn-65	Co-60
Mohawk River											
M-1	1	12.0	ND	ND	ND	1.3±0.6	1.9±1.0	ND	ND	ND	ND
M-2 (top)	1	8.5	ND	ND	ND	ND	2.4±1.8	ND	ND	ND	ND
M-2 (bottom)	1	8.0	ND	ND	ND	1.9±1.4	2.8±2.4	ND	ND	ND	ND
Indian Point, N.Y.											
Indian Pt. Pond	1	8.0	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sterling Forest, N.Y.											
Indian Lake	1	9.0	ND	0.4±0.3	3.7±3.7	ND	1.3±0.9	ND	ND	ND	ND
Sterling Lake	2	13.0-13.0	ND	ND	3.8±2.0 13.0±5.3	ND	0.8±0.5 1.8±1.3	ND	ND	ND	ND

ND = Non-Detectable

TABLE 3

RADIONUCLIDES IN HUDSON RIVER SEDIMENT
Concentration in pCi/gm of Dry Weight

Mile	No. Of Samples		Ce-144	Cs-137	K-40	Ra-226	Ru-106	Mn-54	Ra-228	Zn-65	Co-60	Sr-90*
36.8	5	Mean	2.01	0.43	11.53	1.80	0.26	0.07	1.38	0.04	0.03	0.21
		Min.	ND	ND	10.6±1.2	1.8±0.2	ND	ND	1.3±0.1	ND	ND	0.13±0.04
		Max.	7.6±4.2	0.5±0.0	13.8±1.3	2.2±0.2	1.0±0.5	0.2±0.1	1.6±0.1	0.2±1.0	0.1±0.1	0.26±0.06
52.0	4	Mean	2.90	1.28	13.95	1.97	0.88	0.32	1.06	0.96	0.09	0.16
		Min.	0.8±0.5	1.2±0.1	13.5±1.6	1.5±0.3	0.8±0.6	ND	0.8±0.2	ND	ND	0.10±0.04
		Max.	7.2±6.8	1.6±0.1	16.6±1.8	2.3±0.2	1.6±0.5	0.4±0.2	1.4±0.1	3.0±1.2	0.2±0.1	0.20±0.06
56.0	4	Mean	2.42	1.98	15.72	2.01	1.24	0.22	1.35		0.07	-
		Min.	1.2±0.5	1.2±0.1	13.2±1.8	1.0±0.4	1.0±0.6	ND	1.0±0.2	ND	ND	
		Max.	2.9±0.6	2.6±0.2	17.0±2.0	2.6±0.3	2.8±0.6	0.3±0.2	1.6±0.2		0.1±0.1	
67.5	5	Mean	1.72	0.66	10.36	1.52	0.35	0.16	0.88	0.47	0.02	
		Min.	0.5±0.3	0.2±0.0	10.1±1.2	1.0±1.2	ND	ND	0.6±0.1	ND	ND	
		Max.	4.8±6.2	1.0±0.1	11.0±1.2	1.7±0.2	0.8±0.5	0.3±0.1	0.9±0.1	1.0±0.9	0.1±0.1	
79.5	5	Mean	1.16	1.22	10.41	1.43	1.08	0.14	0.78	0.30		
		Min.	ND	0.2±0.0	4.0±1.3	1.0±0.2	0.7±0.6	ND	0.8±0.1	ND	ND	
		Max.	1.9±0.4	2.4±0.1	12.8±1.4	1.9±0.2	1.9±0.6	0.3±0.1	1.1±0.1	1.0±0.6		
98.5	4	Mean	0.65	0.81	19.32	1.82	0.87	0.04	1.28	0.33		
		Min.	ND	0.3±0.0	15.6±1.2	1.5±0.6	ND	ND	1.0±0.3	ND	ND	
		Max.	1.2±0.9	1.6±0.2	23.4±3.5	2.4±0.4	2.6±0.7	0.1±0.3	1.7±0.2	0.9±0.9		
107.5	5	Mean	3.14	0.05	15.18	1.55		0.07	1.17	0.16		
		Min.	ND	ND	14.0±1.3	1.2±0.2	ND	ND	0.9±0.1	ND	ND	
		Max.	0.5±0.3	0.1±0.1	17.0±1.4	2.0±0.2		0.2±0.1	1.4±0.1	0.4±1.5		

TABLE 3 Cont'd.

Mile	No. Of Samples		Ce-144	Cs-137	K-40	Ra-226	Ru-106	Mn-54	Ra-228	Zn-65	Co-60	Sr-90*
113.0	5	Mean	0.92	1.09	8.57	1.32	0.39	0.17	0.83	0.74		
		Min.	0.9±0.3	0.6±0.0	7.8±1.1	0.9±0.2	ND	ND	0.6±0.1	ND	ND	
		Max.	1.4±0.3	1.3±0.1	11.0±0.9	1.4±0.2	0.6±0.3	0.2±0.1	0.9±0.1	1.8±1.0		
117.0	5	Mean	2.50	0.49	15.51	1.70	0.20	0.05	1.18	0.70	0.03	
		Min.	ND	0.2±0.1	14.2±1.2	ND	ND	ND	0.9±0.1	ND	ND	
		Max.	0.7±0.4	0.9±0.1	18.2±1.6	2.0±0.2	1.0±0.4	0.1±0.1	1.2±0.1	2.2±1.2	0.1±0.1	
51.5	3	Mean	1.13	1.55	13.00	1.15	1.06		0.92		0.07	
		Min.	ND	ND	6.2±0.8	0.6±0.2	ND	ND	ND	ND	ND	0.125±0.047
		Max.	1.7±0.4	1.2±0.0	15.9±1.2	1.2±0.2	1.3±0.5		0.8±0.1		0.2±0.0	
54.8	3	Mean	1.09	0.82	12.49	0.97	0.67	0.02	0.52		0.09	
		Min.	1.0±0.3	1.0±0.0	16.0±0.9	1.0±0.2	0.5±0.3	ND	0.8±0.0	ND	ND	
		Max.	1.4±0.4	2.2±0.1	22.0±1.6	1.2±0.2	1.8±0.4	0.2±0.0	1.0±0.1		0.1±0.0	

*Sr-90 Chemical analysis of selected samples
ND = Non-Detectable

TABLE 4

RADIONUCLIDES IN SEDIMENTS OF SURROUNDING WATERSHED

pCi/gm of Dry Weight

Sampling Site	No. Of Samples	Ce-144	Cs-137	K-40	Ra-226	Ru-106	Mn-54	Ra-228	Zn-65	Co-60
Mohawk River										
M-1	1	0.7±0.4	7.0±0.2	18.8±2.0	0.9±0.4	2.2±0.5	0.5±0.1	0.8±0.2	ND	1.0±0.1
M-2	1	0.8±0.4	ND	ND	ND	ND	ND	ND	ND	ND
M-3	1	4.8±0.4	3.0±0.1	14.1±1.4	2.1±0.2	2.8±0.5	0.7±0.1	1.2±0.1	ND	ND
M-4	1	1.3±0.3	6.3±0.1	18.8±1.0	0.7±0.2	0.9±0.4	0.3±0.1	0.7±0.1	ND	0.9±0.1
M-5	1	2.8±0.4	3.0±0.0	13.5±1.0	1.7±0.2	1.8±0.5	0.2±0.1	0.7±0.1	ND	ND
M-6	1	ND	0.2±0.1	1.6±0.9	ND	ND	ND	ND	ND	ND
Indian Point, N.Y.										
Indian Pt. Pond	2	0.9±0.5 1.5±0.5	1.9±0.2 3.0±0.2	19.8±2.2 22.1±2.0	1.3±0.4 1.5±0.3	0.7±0.6 1.3±0.6	ND	1.1±0.2 1.5±0.2	ND	ND
Sterling Forest, N.Y.										
Sterling Lake	1	16.4±5.5	2.5±0.1	6.9±1.1	ND	ND	ND	0.2±0.1	ND	ND

ND = Non-Detectable

Table 5

RADIONUCLIDES IN HUDSON RIVER FISH

Concentration in pCi/gm of Wet Weight

Species	No. Of Samples (Total No. Of Fish)		Ce-144	Cs-137	K-40	Ra-226	Ru-106	Mn-54	Ra-228	Zn-65	Co-60
Morone americanus	8	Mean	0.09		0.73	0.02	0.08	0.01		0.03	
"White Perch"	(916)	Min.	ND	ND	0.2±0.5	ND	ND	ND	ND	ND	ND
		Max.	0.6±0.2		1.2±0.7	0.1±0.1	0.4±0.3	0.1±0.0		0.1±0.2	
Fundulus heteroclitis	4	Mean			0.31		0.10	0.03		0.04	
"Saltwater Killifish"	(638)	Min.	ND	ND	0.2±0.2	ND	ND	ND	ND	ND	ND
		Max.			0.6±0.1		0.4±0.3	0.1±0.1		0.2±0.7	
Fundulus diaphanus	7	Mean	0.07	0.04	0.36	0.02	0.09		0.01	0.02	
"Freshwater Killifish"	(1340)	Min.	ND	ND	ND	ND	ND	ND	ND	ND	ND
		Max.	0.4±0.4	0.1±0.1	0.9±0.2	0.1±0.2	0.5±0.5		0.1±0.0	0.1±0.2	
Roccus saxatilis	2	Mean		0.05	0.48	0.15		0.04		0.16	
"Stripped Bass"	(25)	Min.	ND	ND	0.4±0.3	0.1±0.1	ND	ND	ND	ND	ND
		Max.		0.1±0.1	0.6±0.8	0.2±0.1		0.1±0.0		0.3±0.3	
Menidia menidia notata	2	Mean			0.49			0.05			
"Spearing"	(996)	Min.	ND	ND	0.4±0.1	ND	ND	ND	ND	ND	ND
		Max.			0.5±0.1			0.1±0.0			
Notropis hudsonus	4	Mean	0.01	0.04	0.46		0.02	0.02		0.02	
"Spottail Shiner"	(711)	Min.	ND	ND	0.2±0.2	ND	ND	ND	ND	ND	ND
		Max.	0.1±0.0	0.1±0.0	0.7±0.1		0.1±0.1	0.1±0.0		0.1± 0.1	
Anchoa mitchelli "Anchovy"	NONE IN 1965										

Table 5 Cont'd.

Species	No. Of Samples (Total No. Of Fish)		Ce-144	Cs-137	K-40	Ra-226	Ru-106	Mn-54	Ra-228	Zn-65	Co-60
Bolesoma nigrium	2	Mean			0.37		0.05	0.08		0.03	
"Johnny Darter"	(672)	Min.	ND	ND	ND	ND	ND	ND	ND	ND	ND
		Max.			0.8±0.1		0.1±0.2	0.1±0.0		0.1±0.1	
Alosa sapidissima	2	Mean			0.43		0.12				
"Shad"	(249)	Min.	ND	ND	0.4±0.2	ND	0.1±0.1	ND	ND	ND	ND
		Max.			0.5±0.2		0.2±0.2				
Alosa pseudoharengus	2	Mean	0.07		0.33	0.06	0.20	0.03			
"Alewife" ...	(165)	Min.	ND	ND	ND	ND	ND	ND	ND	ND	ND
			0.2±0.1		0.7±0.4	0.1±0.2	0.4±0.3	0.1±0.0			
Alosa aestivalis	2	Mean	0.10	0.05	0.20			0.06	0.06	0.24	0.08
"Blueback Herring"	(1155)	Min.	ND	ND	ND	ND	ND	ND	ND	ND	ND
		Max.	0.2±0.5	0.1±0.0	0.4±0.1			0.1±0.1	0.1±0.1	0.5±1.2	0.2±0.1
Notomigonus chrysoleucas	2	Mean			0.99		0.07				
"Golden Shiner"	(19)	Min.	ND	ND	0.9±0.2	ND	ND	ND	ND	ND	ND
		Max.			1.0±0.1		0.1±0.0				
Lepomis gibbosus	4	Mean	0.02	0.05	0.73		0.04	0.02			
"Pumpkinseed Sunfish"	(420)	Min.	ND	ND	0.4±0.4	ND	ND	ND	ND	ND	ND
		Max.	0.1±0.1	0.1±0.0	1.0±0.1		0.1±0.1	0.1±0.0			
Lepomis auritus	1	Mean									
"Redbellied Sunfish"	(5)	Min.	ND	ND	0.7±0.1	0.1±0.0	0.1±0.0	ND	ND	ND	ND
		Max.									
Microgaddus "Tomcod"	NONE IN 1965										

Table 5 Cont'd.

Species	No. Of Samples (Total No. of Fish		Ce-144	Cs-137	K-40	Ra-226	Ru-106	Mn-54	Ra-228	Zn-65	Co-60
Catostomas commersoni "White Sucker"	1 (25)	Mean									
		Min.	0.2±0.2	ND	1.4±0.7	ND	0.6±0.2	ND	ND	ND	ND
		Max.									
Augilla rostrata "Eel"	2 (59)	Mean			0.24					0.12	
		Min.	ND	ND	0.1±0.1	ND	ND	ND	ND	ND	ND
		Max.			0.4±0.0					0.2±0.1	
Ectalurus natales "Catfish"	NONE IN 1965										
Carassius auratus "Goldfish"	3 (418)	Mean	0.11	0.07	0.79						
		Min.	ND	ND	0.6±0.1	ND	ND	ND	ND	ND	ND
		Max.	0.2±0.0	0.1±0.0	0.9±0.1						
Cypninus carpio "Carp"	1 (12)	Mean									
		Min.	ND	0.1±0.1	0.1±0.0	ND	1.5±0.7	0.2±0.7	ND	0.6±1.7	ND
		Max.									
Pomatomus saltatrix "Bluefish"	1 (14)	Mean									
		Min.	ND	0.3±0.1	1.2±1.2	ND	0.5±0.4	ND	0.1±0.1	ND	ND
		Max.									
Mugil Sp. "Mullet"	1 (91)	Mean									
		Min.	0.1±0.0	ND	0.7±0.1	0.1±0.0	0.1±0.1	0.1±0.0	ND	0.2±0.1	ND
		Max.									
Micropterus salmoides "Large Mouth Bass"	1 (2)	Mean									
		Min.	0.1±0.1	ND	0.4±0.2	0.1±0.0	0.1±0.1	ND	ND	0.2±0.2	ND

ND = Non-Detectable

TABLE 6

Sr-90 in Hudson River Fish

Species	pCi/gm wet weight
Lepomis	0.535 ± 0.017
Lepomis	0.497 ± 0.006
Menidia	0.033 ± 0.001
Morone	0.245 ± 0.008
Morone	0.299 ± 0.009

TABLE 7

Sr-90 in Sterling Forest Fish

Suckers	0.234 ± 0.003
Black Bass	1.604 ± 0.016

Table 8

RADIONUCLIDES IN SURROUNDING WATERSHED FISH (STERLING FOREST)

Concentration in pCi/gm of Wet Weight

Species	Total No. Of Fish		Ce-144	Cs-137	K-40	Ra-226	Ra-228	Ru-106	Mn-54	Zn-65	Co-60
Sterling Lake, N.Y.											
Micropterus salmoides* "Large Mouth Bass"	31	Mean									
		Min.	ND	2.9±0.0	1.6±0.0	ND	ND	ND	ND	ND	ND
		Max.									
Lepomis gibbosus "Pumpkinseed Sunfish"	2	Mean									
		Min.	0.5±0.5	2.0±0.0	1.2±0.2	ND	ND	0.2±0.1	ND	ND	ND
		Max.									
Esox vigrum "Chain Pickerel"	3	Mean									
		Min.	ND	1.2±0.0	1.4±0.2	ND	ND	ND	ND	ND	ND
		Max.									
Ambloplites rupestris "Rock Bass"	2	Mean									
		Min.	0.2±0.0	1.7±0.0	1.0±0.1	ND	ND	ND	ND	ND	ND
		Max.									
Notemogonis crysoleucus "Golden Shiner"	36	Mean									
		Min.	0.1±0.0	0.6±0.0	1.0±0.1	ND	ND	0.1±0.0	ND	ND	ND
		Max.									
Blue Lake, N.Y.											
Lepomis gibbosus "Pumpkinseed Sunfish"	131	Mean									
		Min.	0.2±0.0	0.2±0.0	0.8±0.0	ND	ND	ND	ND	ND	ND
		Max.									
Notemogonis crysoleucus "Golden Shiner"	126	Mean									
		Min.	0.2±0.0	0.2±0.0	1.0±0.2	0.1±0.0	ND	0.2±0.0	ND	ND	ND
		Max.									

Table 8 Cont'd.

Species	Total No. Of Fish		Ce-144	Cs-137	K-40	Ra-226	Ra-228	Ru-106	Mn-54	Zn-65	Co-60
Semotilus atromaculatus "Creek Chub"	38	Mean									
		Min.	ND	0.3±0.0	ND	ND	ND	0.3±0.2	ND	ND	ND
		Max.									
Catostomus commersonii "Sucker"	6	Mean									
		Min.	ND	0.6±0.2	4.9±3.3	ND	0.3±0.3	1.3±1.2	ND	ND	ND
		Max.									
Stream Into Blue Lake, N.Y.											
Semotilus atromaculatus "Creek Chub"	8	Mean									
		Min.	ND	ND	1.8±1.0	ND	ND	0.4±0.4	ND	ND	ND
		Max.									
Indian Lake Reservoir, N.Y.											
Catastomus commersonii "Sucker"	25	Mean									
		Min.	0.1±0.0	0.3±0.0	1.4±0.0	ND	ND	ND	ND	ND	ND
		Max.									
Notemogonis crysoleucus "Golden Shiner"	16	Mean									
		Min.	0.9±0.4	0.6±0.0	1.4±1.2	0.2±0.2	ND	ND	ND	ND	ND
		Max.									
Sterling Forest Gardens, N.Y.											
Carassius auratus * "Gold Fish"	14	Mean			0.85						
		Min.	ND	ND	0.3±0.0	ND	ND	ND	ND	ND	ND
		Max.			1.4±0.1						
Little Sterling Pond, N.Y.											
Ictalurus nebulosur "Brown Bullhead"	7	Mean									
		Min.	ND	0.5±0.0	0.6±0.2	ND	ND	ND	ND	ND	ND
		Max.									

Table 8 Cont'd.

Species	Total No. Of Fish		Ce-144	Cs-137	K-40	Ra-226	Ra-228	Ru-106	Mn-54	Zn-65	Co-60
Notemogonis crysoleucus	39	Mean									
"Golden Shiner"		Min.	0.1±0.1	0.3±0.0	0.8±0.2	ND	ND	ND	ND	ND	ND
		Max.									
Indian Pt. Pond, Buchanan, N. Y.											
Lepomis gibbosus	22	Mean									
"Pumpkinseed Sunfish"		Min.	ND	ND	0.4±0.5	ND	ND	ND	0.4±0.0	ND	ND

*Two Samples
ND = Non-Detectable

Table 9

RADIONUCLIDES IN HUDSON RIVER VEGETATION

Concentration in pCi/gm of Wet Weight

Species	No. Of Samples		Ce-144	Cs-137	K-40	Ra-226	Ru-106	Mn-54	Ra-228	Zn-65	Co-60
Chara Sp.	3	Mean	0.33	0.10	0.93	0.77	0.63	10.97	0.23		0.43
		Min.	0.2±0.1	ND	0.4±0.2	0.3±0.0	0.3±0.1	6.3±0.1	0.1±0.0	ND	0.2±0.0
		Max.	0.5±0.2	0.2±0.1	1.4±0.5	1.4±0.1	1.1±0.2	17.6±0.2	0.4±0.1		0.7±0.1
Nitella Sp.	1		2.2±0.5	0.1±0.0	1.1±0.1	0.9±0.0	0.4±0.1	1.6±0.0	0.2±0.0	0.2±0.1	ND
Potomogeton crispus	4	Mean	0.19	0.02	1.13	0.37	0.40	6.16	0.14	0.03	0.28
		Min.	ND	ND	0.8±0.1	0.2±0.0	0.3±0.1	3.3±0.0	0.1±0.0	ND	0.1±0.0
		Max.	0.2±0.0	0.1±0.0	1.6±0.4	0.6±0.1	0.6±0.3	10.2±0.2	0.2±0.0	0.1±0.1	0.5±0.0
Potomogeton perfoliatus	10	Mean	0.18	0.08	1.29	0.12	0.22	0.82	0.04	0.02	0.04
		Min.	0.1±0.0	ND	0.7±0.7	ND	0.1±0.0	ND	ND	ND	ND
		Max.	0.4±0.0	0.2±0.0	2.3±0.1	0.2±0.0	0.4±0.0	2.1±0.0	0.1±0.0	0.2±0.0	0.1±0.0
Myriophyllum Sp.	5	Mean	0.23	0.12	1.08	0.29	0.26	0.50	0.03	0.03	
		Min.	0.1±0.0	ND	1.0±0.1	0.2±0.0	0.1±0.0	0.3±0.0	ND	ND	ND
		Max.	0.3±0.0	0.2±0.0	1.3±0.1	0.4±0.0	0.4±0.0	0.6±0.0	0.1±0.0	0.2±0.0	
Vallisneria americanus	11	Mean	0.12	0.07	1.07	0.19	0.19	0.47	0.04	0.03	
		Min.	ND	ND	0.2±0.1	0.1±0.0	0.1±0.0	0.2±0.0	ND	ND	ND
		Max.	0.3±0.0	0.2±0.0	2.3±0.2	0.4±0.0	0.3±0.0	1.5±0.0	0.1±0.0	0.1±0.0	
Eleocharis Sp. "Spike Rush"	10	Mean	0.08	0.09	2.16	0.04	0.04	0.04		0.04	
		Min.	ND	ND	1.2±0.0	ND	ND	ND	ND	ND	ND
		Max.	0.2±0.0	0.2±0.0	3.5±0.2	0.1±0.0	0.1±0.0	0.1±0.0		0.2±0.0	
Filamentous algae *	8	Mean	0.32	0.17	0.94	0.23	0.21	0.47	0.08	0.03	
		Min.	0.2±0.0	ND	0.3±0.1	0.1±0.0	0.1±0.0	0.1±0.0	ND	ND	ND
		Max.	0.4±0.0	0.3±0.0	2.1±0.1	0.4±0.0	0.3±0.0	1.1±0.0	0.2±0.0	0.1±0.0	

Table 9 Cont'd.

Species	No. Of Samples		Ce-144	Cs-137	K-40	Ra-226	Ru-106	Mn-54	Ra-228	Zn-65	Co-60
Najas flexilis	6	Mean	0.16	0.06	0.96	0.18	0.22	1.14	0.04	0.03	0.05
		Min.	ND	ND	0.7±0.2	0.1±0.0	0.1±0.0	0.1±0.0	ND	ND	ND
		Max.									
Spartina	2	Mean			2.22						
		Min.	ND	ND	1.3±0.0	ND	ND	ND	ND	ND	ND
		Max.			3.1±0.1						
Spartina Sp. (roots)	1		0.4±0.12	0.20±0.08	4.80±0.47	0.52±0.08	0.34±0.15	0.22±0.04	0.60±0.04	0.20±0.33	0.01±0.03
Spartina Sp. (tops)	1		0.05	0.04	2.49±0.1	0.04	0.04	0.03	0.02	0.04	0.00
Pontederia cordata "Pickerel Weed"	2	Mean			2.23					0.04	
		Min.	ND	ND	1.0±0.1	ND	ND	ND	ND	ND	ND
		Max.			3.4±0.1					0.1±0.1	
Pontederia cordata (roots)	2	Mean			1.29	0.05					
		Min.	ND	ND	0.6±0.0	0.1±0.0	ND	ND	ND	ND	ND
		Max.			2.0±0.0	ND					
Pontederia cordata (tops)	2	Mean			1.98	0.05					
		Min.	ND	ND	1.9±0.1	ND	ND	ND	ND	ND	ND
		Max.			2.1±0.1	0.1±0.0					
Trapa natans "Water Chestnuts"	3	Mean	0.08	0.06	1.37	0.05	0.05	0.08			
		Min.	ND	ND	1.2±0.1	ND	ND	1.0±0.0	ND	ND	ND
		Max.	0.1±0.0	0.1±0.0	1.7±0.1	0.1±0.0	0.1±0.0	0.1±0.0			
Trappa natans (tops) "Water Chestnuts"	2	Mean	0.05		1.38		0.04	0.08			
		Min.	ND	ND	1.2±0.0	ND	ND	0.1±0.0	ND	ND	ND
		Max.	0.1±0.0		1.5±0.1	0.1±0.0	0.1±0.0				

Table 9 Cont'd.

Species	No. Of Samples	Ce-144	Cs-137	K-40	Ra-226	Ru-106	Mn-54	Ra-228	Zn-65	Co-60
Trappa natans (nuts) "Water Chestnuts"	1	ND	ND	6.5±0.4	ND	ND	ND	ND	ND	ND
Microspora Sp. "Blue-green Algae"	1	4.6±1.4	2.1±0.4	12.0±5.4	2.9±0.9	1.4±1.7	4.7±0.5	0.2±0.5	ND	ND

*Filamentous Algae - consisting of Spirogyra Sp., Hydodictyon, Reticulatum, Vaucheria geminata, plus

TABLE 10

pCi of Mn-54 per mg. of Stable Manganese

Species	pCi Mn-54 per gm W.W.	Wet Weight gms	Total Ash gms	Stable Manganese mg/g of Ash	pCi of Mn-54 per mgm of Stable Manganese
Potomogeton Crispus*	10.20	580.0	19.8	67.0	4.46
Chara sp.	17.60	230.0	11.8	134.8	2.54
"	9.00	678.8	18.5	94.5	3.49
"	6.30	794.8	14.2	101.1	3.49
Spirogyra sp.	1.10	555.5	28.5	18.7	1.15
"	0.20	724.9	19.3	8.8	0.85
"	0.26	380.0	10.1	8.8	1.11
Filamentous Algae	1.00	350.5	12.6	27.5	1.01
"	0.37	558.5	10.5	19.8	0.99
"	0.13	272.4	14.9	3.3	0.72
"	0.30	912.7	41.7	9.8	0.67
Nitella	1.63	761.7	20.0	79.1	0.78

* Higher aquatic (not an algae)

Table 11

RADIONUCLIDES IN SURROUNDING WATERSHED VEGETATION
Concentration in pCi/gm of Wet Weight

Species	No. Of Samples	Ce-144	Cs-137	K-40	Ra-226	Ru-106	Mn-54	Ra-228	Zn-65	Co-60
Mohawk R. (Lock No. 7)										
Trappa natans	1	ND	0.2±0.0	0.7±0.0	ND	0.2±0.0	0.3±0.0	ND	ND	ND
Trappa natans (below Lock No. 7)	1	ND	ND	0.5±0.0	ND	ND	ND	ND	ND	ND
Indian Pt. Pond, Buchanan, NY										
Utricularia Sp.	1	0.4±0.0	0.2±0.0	1.6±0.2	0.1±0.0	0.5±0.0	0.3±0.0	ND	ND	ND
Elodea Sp.	1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Utricularia, Elodea, plus	1	0.4±0.0	0.1±0.0	0.4±0.0	ND	0.3±0.0	0.2±0.0	ND	ND	ND
Indian Reservoir, Sterling Forest										
Utricularia Sp. "Bladderwort"	1	0.5±0.0	0.2±0.0	0.9±0.2	0.3±0.0	0.4±0.0	0.7±0.0	ND	ND	ND
Little Cedar Mountain, Sterling Forest										
Parmelia flavicans "Licken"	1	37.1±1.1	67.5±0.6	3.6±1.8	0.8±0.5	9.5±0.8	1.0±0.2	0.2±0.2		

TABLE 12

Comparison of Radionuclide Concentrations in Hudson River Fish*.

Radionuclide		Concentration in 1964 (pc/gm of Wet Weight)	Concentration in 1965 (pc/gm of Wet Weight)
Ce-144	Mean	0.052±.004	0.056±0.015
	Range	N.D. – 0.16	N.D. – 0.59
	Ratio**	48/56 (86%)	29/50 (58%)
Cs-137	Mean	0.034±.002	0.041±0.004
	Range	N.D. – 0.009	N.D. – 0.13
	Ratio**	54/56 (96%)	48/50 (96%)
K-40	Mean	0.551±.014	0.536±0.038
	Range	N.D. – 1.78	N.D. – 1.41
	Ratio**	51/56 (91%)	45/50 (90%)
Ra-226	Mean	0.005±.002	0.026±0.007
	Range	N.D. – 0.04	N.D. – 0.19
	Ratio**	27/56 (48%)	31/50 (62%)
Ru-106	Mean	0.082±.013	0.094±0.023
	Range	N.D. – 0.42	N.D. – 1.50
	Ratio**	44/56 (78%)	36/50 (72%)
Mn-54	Mean	0.018±.001	0.028±0.006
	Range	N.D. – 0.05	N.D. – 0.18
	Ratio**	53/56 (95%)	38/50 (76%)
Ra-228	Mean	0.025±.004	0.011±0.004
	Range	N.D. – 0.12	N.D. – 0.12
	Ratio**	53/56 (95%)	25/50 (50%)
Co-60	Mean	0.001±.001	0.009±.004
	Range	N.D. – 0.04	N.D. – 0.16
	Ratio**	14/56 (25%)	24/50 (48%)

* Included are 17 species common to both years. See Table 1.
** Ratio = Number of samples containing significant activity/ total number of samples.

TABLE 13

Comparison of Radionuclide Concentration in Hudson River Sediments from Sectors I and II*

1964 vs. 1965

Radionuclide		Concentration in 1964 (pc/gm of Dry Weight)	Concentration in 1965 (pc/gm of Dry Weight)
Ce-144	Mean	2.77±0.14	1.15±0.09
	Range	0.61 - 9.00	N.D. - 2.93
	Ratio**	11/11 (100%)	18/19 (95%)
Cs-137	Mean	0.94±0.03	1.12±0.02
	Range	0.17 - 2.80	0.09 - 2.63
	Ratio**	11/11 (100%)	19/19 (100%)
K-40	Mean	12.45±0.36	13.38±0.32
	Range	5.48 - 16.43	6.24 - 21.99
	Ratio**	11/11 (100%)	19/19 (100%)
Ra-226	Mean	0.60±0.04	1.62±0.06
	Range	0.20 - 0.90	0.64 - 2.63
	Ratio**	11/11 (100%)	19/19 (100%)
Ru-106	Mean	4.54±0.39	0.81±0.10
	Range	1.43 - 11.20	N.D. - 2.79
	Ratio**	11/11 (100%)	16/19 (84%)
Mn-54	Mean	0.95±0.03	0.15±0.03
	Range	N.D. - 5.90	N.D. - 0.42
	Ratio**	8/11 (73%)	15/19 (79%)
Ra-228	Mean	1.07±0.08	1.04±0.03
	Range	0.09 - 2.10	0.04 -1.64
	Ratio**	11/11 (100%)	19/19 (100%)
Co-60	Mean	N.D.	0.07±0.02
	Range		N.D. - 0.25
	Ratio**	0/11 (0%)	12/19 (63%)

* Sectors I and II are, respectively, the southernmost and intermediate sections of the river. Together they represent the region south of West Point.

** Ratio = Number of samples containing significant activity/total number of samples.

TABLE 14

Comparison of Radionuclide Concentration in Hudson River Sediments for 1965

Sectors I & II vs. Sectors III & IV*

Radionuclide		Concentration in Sectors I & II (pc/gm of Dry Weight)	Concentration in Sectors III & IV (pc/gm of Dry Weight)
Ce-144	Mean	1.15±0.09	0.81±0.10
	Range	N.D. - 2.93	N.D. - 1.99
	Ratio**	18/19 (95%)	19/20 (95%)
Cs-137	Mean	1.12±0.02	0.74±0.03
	Range	0.09 - 2.63	0.01 - 2.31
	Ratio**	19/19 (100%)	20/20 (100%)
K-40	Mean	13.38±0.32	14.20±0.35
	Range	6.24 - 21.99	7.85 - 23.43
	Ratio**	19/19 (100%)	20/20 (100%)
Ra-226	Mean	1.62±0.06	1.61±0.14
	Range	0.64 - 2.63	0.91 - 2.40
	Ratio**	19/19 (100%)	20/20 (100%)
Ru-106	Mean	0.81±0.10	0.62±0.10
	Range	N.D. - 2.79	N.D. - 2.66
	Ratio**	16/19 (84%)	13/20 (65%)
Mn-54	Mean	0.15±0.03	0.09±0.03
	Range	N.D. - 0.42	N.D. - 0.20
	Ratio**	15/19 (79%)	15/20 (75%)
Ra-228	Mean	1.04±0.03	1.09±0.03
	Range	0.04 - 1.64	0.69 - 1.7
	Ratio**	19/19 (100%)	20/20 (100%)
Co-60	Mean	0.07±0.02	0.02±0.01
	Range	N.D. - 0.25	N.D. - 0.10
	Ratio**	12/19 (63%)	7/20 (35%)
Co-60	Mean	0.07±0.02	0.02±0.01
	Range	N.D. - 0.25	N.D. - 0.10
	Ratio**	12/19 (63%)	7/20 (35%)

TABLE 14 (con t)

Radionuclide		Concentration in Sectors I & II (pc/gm of Dry Weight)	Concentration in Sectors III & IV (pc/gm of Dry Weight)
	Mean	0.26±0.15	0.40±0.20
Zn-65	Range	N.D. - 3.03	N.D. - 2.23
	Ratio**	8/19 (42%)	10/20 (50%)

* Sectors I & II represent the region south of West Point and Sectors III & IV the region north of West Point.

** Ratio = Number of samples containing significant activity/ Total number of samples.

TABLE 15

Comparison of Radionuclide Concentrations in Hudson River Water

1964 Versus 1965

Radionuclide		Concentration in 1964 (pCi/l.)	Concentration in 1965 (pCi/l.)
Ce-144	Mean	0.61±0.39	1.54±0.77
	Range	ND - 4.56	ND - 3.73
	Ratio*	3/9 (33%)	5/7 (71%)
Cs-137	Mean	1.24±0.21	0.94±0.29
	Range	ND - 3.70	0.01 - 1.90
	Ratio*	8/9 (90%)	7/7 (100%)
K-40	Mean	29.54±2.14	34.20±3.82
	Range	ND - 45.74	1.34 - 65.56
	Ratio*	8/9 (90%)	7/7 (100%)
Ra-226	Mean	0.03±0.15	1.07±0.48
	Range	ND - 0.25	ND - 4.39
	Ratio*	2/9 (22%)	4/7 (57%)
Ru-106	Mean	2.77±1.45	1.55±0.67
	Range	ND - 13.60	ND - 5.08
	Ratio*	4/9 (44%)	3/7 (43%)
Mn-54	Mean	0.41±0.14	0.01±0.13
	Range	ND - 1.43	ND - 0.06
	Ratio*	5/9 (56%)	1/7 (14%)
Ra-228	Mean	1.40±0.44	0.46±0.27
	Range	ND - 4.47	ND - 1.68
	Ratio*	8/9 (90%)	4/7 (57%)
Co-60	Mean	0.11±0.09	0.17±0.18
	Range	ND - 0.70	ND - 0.60
	Ratio*	2/9 (22%)	3/7 (43%)

* Ratio = Number of samples containing significant activity/ Total number of samples.

TABLE 16

Comparison of Radionuclide Concentrations in Hudson River Suspended Solids 1964 Versus 1965

Radionuclide		Concentration in 1964 (pCi/dry gm)	Concentration in 1965 (pCi/dry gm)
Ce-144	Mean	ND	0.47±0.24
	Range	ND	ND - 1.84
	Ratio*	0/5 (0%)	3/7 (43%)
Cs-137	Mean	0.13±0.09	0.03±0.05
	Range	ND - 0.60	ND - 0.20
	Ratio*	3/5 (60%)	2/7 (29%)
K-40	Mean	0.62±0.52	0.49±0.74
	Range	ND - 2.27	ND - 1.73
	Ratio*	3/5 (60%)	2/7 (29%)
Ra-226	Mean	0.06±0.14	0.20±0.24
	Range	ND - 0.19	ND - 0.49
	Ratio*	4/5 (80%)	4/7 (57%)
Ru-106	Mean	1.04±0.28	1.82±0.61
	Range	ND - 5.20	0.41 - 3.85
	Ratio*	1/5 (20%)	7/7 (100%)
Mn-54	Mean	0.18±0.05	0.10±0.07
	Range	ND - 0.41	ND - 0.55
	Ratio*	4/5 (80%)	2/7 (29%)
Ra-228	Mean	0.12±0.08	0.16±0.07
	Range	ND - 0.37	ND - 0.75
	Ratio*	4/5 (80%)	5/7 (71%)
Co-60	Mean	0.12±0.08	0.16±0.07
	Range	ND - 0.60	ND - 0.63
	Ratio*	1/5 (20%)	4/7 (57%)

* Ratio = Number of samples containing significant activity/ Total number of samples.

TABLE 17

Comparison of Radionuclide Concentrations in the Alga Chara 1964 Versus 1965

Radionuclide		Concentration in 1964 (pCi/wet gm)	Concentration in 1965 (pCi/wet gm)
Ce-144	Mean	3.12±0.50	0.33±0.08
	Range	2.74 - 3.50	0.20 - 0.50
	Ratio*	2/2 (100%)	3/3 (100%)
Cs-137	Mean	0.14±0.13	0.10±0.10
	Range	0.06 - 0.23	ND - 0.20
	Ratio*	2/2 (100%)	2/3 (66%)
K-40	Mean	1.22±0.43	0.95±0.19
	Range	ND - 2.44	0.40 - 1.40
	Ratio*	1/2 (50%)	3/3 (100%)
Ra-226	Mean	0.43±0.18	0.77±0.05
	Range	ND - 0.85	0.30 - 1.40
	Ratio*	1/2 (50%)	3/3 (100%)
Ru-106	Mean	9.62±1.54	0.63±0.08
	Range	9.58 - 9.65	0.30 - 1.10
	Ratio*	2/2 (100%)	3/3 (100%)
Mn-54	Mean	16.78±0.22	10.97±0.08
	Range	15.08 - 18.49	6.30 - 17.60
	Ratio*	2/2 (100%)	3/3 (100%)
Ra-228	Mean	1.50±0.32	0.23±0.03
	Range	1.10 - 1.90	0.10 - 0.40
	Ratio*	2/2 (100%)	3/3 (100%)
Co-60	Mean	1.52±0.14	0.40±0.03
	Range	1.43 - 1.62	0.20 - 0.70
	Ratio*	2/2 (100%)	3/3 (100%)

* Ratio = Number of samples containing significant activity/ Total number of samples.

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APPENDIX A

1965 CORES

Core	Station
I	9
II	2
III	44
IV	45
V	30
V_1	30
VI	31
VII_1	36
VII_2	36
VIII	37A
IX	37B
X	37C
*XI	45
*XII	46
*XIII	47
XIV	48
*XV	49
*XVI	50
*XVII	51
*XVIII_1	52
XVIII_2	52
*XIX	53

*Analyzed Geochemically

1965 STATION LOCATIONS

Station	Location
1	41°28'20"N - 74°00'35"W
2	41°28'26"N - 73°59'03"W
3	41°28'25"N - 73°59'20"W
4	41°28'25"N - 73°59'12"W
5	41°29'04"N - 73°59'00"W
6	41°27'15"N - 74°00'55"W
7	41°29'37"N - 73°59'12"W
8	41°29'37"N - 73°59'38"W
9	41°29'38"N - 73°59'59"W
10	41°29'29"N - 74°00'24"W
11	41°27'26"N - 74°00'08"W
12	41°28'25"N - 74°00'34"W
13	41°26'32"N - 73°59'38"W
14	41°26'39"N - 73°59'20"W
15	41°26'48"N - 73°59'02"W
16	41°33'22"N - 73°58'08"W
17	41°33'28"N - 73°58'36"W
18	41°33'32"N - 73°58'59"W
19	Not Established
20A	42°15'25"N - 73°48'34"W
20B	42°14'57"N - 73°48'49"W
21A	42°13'15"N - 73°51'03"W
21B	42°12'56"N - 73°51'14"W
22A	42°05'50"N - 73°55'50"W
22B	42°05'06"N - 73°55'58"W
23A	41°59'52"N - 73°56'34"W
23B	41°59'40"N - 73°56'15"W

1965 STATION LOCATIONS cont'd.

Station	Location
24	Not Established
25A	41°35'04"N - 73°57'34"W
25B	41°35'04"N - 73°57'05"W
26A	41°34'51"N - 73°57'34"W
26B	41°34'04"N - 73°57'48"W
26C	41°34'11"N - 73°58'04"W
27A	41°31'03"N - 74°00'23"W
27B	41°31'01"N - 74°00'04"W
27C	41°30'58"N - 73°59'39"W
27D	41°30'56"N - 73°59'20"W
28A	41°31'53"N - 73°59'08"W
28B	41°32'00"N - 73°59'30"W
28C	41°32'15"N - 73°59'57"W
30	41°14'21"N - 73°57'43"W
31	41°17'05"N - 73°56'51"W
32	41°18'12"N - 73°59'04"W
33	41°23'25"N - 73°56'58"W
34	41°27'19"N - 73°59'37"W
35	41°35'10"N - 73°57'23"W
36	41°31'07"N - 74°00'17"W
37A	41°27'00"N - 74°00'17"W
37B	41°27'01"N - 73°59'55"W
37C	41°27'12"N - 73°59'17"W
38	41°13'18"N - 73°57'06"W
39	41°15'58"N - 73°58'05"W
40	41°18'02"N - 73°58'02"W

1965 STATION LOCATIONS cont'd.

Station	Location
41	41°20'50"N - 73°57'45"W
42	41°23'18"N - 73°57'07"W
43	41°25'30"N - 73°58'14"W
44	41°27'04"N - 73°59'37"W
45	41°25'28"N - 73°58'33"W
45A	41°24'29"N - 73°57'45"W
46	41°25'39"N - 73°58'18"W
47	41°28'23"N - 74°00'30"W
48	41°28'22"N - 74°00'10"W
49	41°28'20"N - 73°59'26"W
50	41°31'06"N - 73°59'20"W
51	41°31'04"N - 73°59'59"W
52	41°31'06"N - 74°00'20"W
53	41°33'10"N - 73°58'47"W

APPENDIX B

STATION 1

Date: 6/3/65

Location: 41°28'20"N-74°00'35"W

Wind: NE

Water Temperature: 19°C.

Water Surface: Choppy

Turbidity: Top: Green

Depth: 35 feet

Bottom Sediments:

Color: Black-gray

Texture: Fine

Viscosity: Moderate

Structures: 1 large pebble

Ph: Top Water: 7.5

Mud: 6

STATION 2

Date: 6/3/65

Location: N41°28'26"-73°59'03"

Wind: NNE

Temperature Water: 19°C.

Water Surface: Choppy

Depth: 34 feet

Bottom Sediments:

Color: Black-brown

Texture: Fine

Viscosity: Moderate

Odor: None

Ph: Water: 7.4

Mud: 6

Core: C-II

Taken: Date: 7/29/65
Time: 12:00 P.M.

Depth to bottom 31 feet
Dropped from 6 feet above bottom

STATION 3

Date: 6/3/65

Location: 74°28'25"N-73°59'20"W

Wind: NE

Water Temperature: 19°C.

Depth: 6 feet

Bottom Topography: Flat

Bottom Sediments:

- Color: Brown-black
- Texture: Fine clay
- Viscosity: Moderate to high
- Odor: None

Ph: Top Water: 7.7

Mud: 6

STATION 4

Date: 6/3/65

Location: 41°28'25"N-73°59'12"W

Wind: NE

Water Temperature: 19°C.

Water Surface: Calm

Turbidity: Moderate green

Depth: .5 feet

Bottom Topography: Flat

Bottom Sediments:

- Color: Gray-black
- Texture: Fine
- Viscosity: Moderate
- Odor: None

Ph: Water: 7.5

Mud: 6

STATION 5

Date: 6/3/65

Location: 41°29'04"N-73°59'00"W

Water Surface: Calm

Turbidity: Top: Moderate - dark

Depth: 4 feet

Bottom Topography: Flat with pebbles

Bottom Sediments:

Color: Light gray

Texture: Gravel to silt

Viscosity: Low

Odor: None

Ph: Water: 7.6

Mud: 6

STATION 6

Date: 6/3/65

Location: 41°27'15"N-74°00'55"W

Water Surface: Calm

Turbidity: Top: Moderate - green

Depth: 3 feet

Bottom Topography: Flat

Bottom Sediments:

Color: Light

Texture: Sandy

Viscosity: Low

Odor: Some

Structures: Leaves, twigs

Ph: Water: 5.5

Mud: 5.5

STATION 7

Location: 41°29'37"N-73°59'12"W

Date: 6/24/65

Time: 10:40 A.M.

Depth: 3 feet

Water: Temperature: 22°C

Turbidity: Moderate

Surface: Calm

Ph: 6

Bottom Sediments: Color: Gray-black

Texture: Fine-clay

Viscosity: Moderate

Odor: None

Structures: None

eH: -30mv. (uncorrected)

Ph: 6

STATION 8

Location: 41°29'37"N-73°59'38"W

Date: 6/24/65

Time: 10:58 A.M.

Depth: 33 feet

Water: Temperature: 22°C

Surface: Small waves

Turbidity: Moderate

Bottom Sediments: Color: Brown-gray

Texture: Silty

Viscosity: Low

Odor: None

Structures: None

eH: -30mv. (uncorrected)

STATION 9

Location: 41°29'38"N-73°59'59"W

Date: 6/24/65

Time: 11:20 A.M.

Water: Temperature: 23.5°C

Surface: Moderate

Turbidity: Moderate

Ph: 6

Depth: 35 feet

Bottom Sediments: Color: Brown-gray

Texture: Silty-organic, pebbles

Viscosity: Moderate-high

Odor: None

Structures: Pebbles, grit

eH: -100mv. (uncorrected)

Ph: 6

Core: C-I

Taken: Date: 7/29/65
Time: 1200

Depth to bottom 45 feet
Core dropped 6 feet above bottom
Override of 6 to 8 inches

STATION 10

Location: 41°29'29"N-74°00'24"W

Date: 6/24/65

Time: 11:47 A.M.

Depth: 10 feet

Water: Temperature: 23.5°C

Ph: 6

Surface: Calm

Turbidity: Moderate

Bottom Sediments: Color: Brown

Texture: Silty

Viscosity: Low

Odor: H_2S

Structures: None

Ph: 6

eH: -140mv. (uncorrected)

STATION 11

Location: 41°27'26"N-74°00'08"W

Date: 6/24/65

Time: 12:25 P.M.

Depth: 35 feet

Water: Color: Light beige

Temperature: 23.5°C

Turbidity: Moderate

pH: 7

Bottom Sediments: Color: Brown-gray

Texture: Fine

Viscosity: Moderate-low

Odor: H_2S

Structures: None

Eh: -135mv. (uncorrected)

pH: 7

STATION 12

Location: 41°28'25"N-74°00'34"W

Date: 7/2/65

Time: 10:57 A.M.

Depth: 30 feet

Water: Temperature: 25°C

Turbidity: Moderate

pH: 7.2

Bottom Sediments: Color: Brown-gray

Texture: Silt - clay

Viscosity: Moderate-high

Odor: None

Structures: None

Temperature: 23.5°C

Eh: -165mv. (uncorrected)

STATION 13

Location: 41°26'32"N-73°59'38"W

Date: 7/2/65

Time: 11:48 A.M.

Depth: 25 feet

Water: Temperature: 25°C

Turbidity: Moderate

pH: 6.8

Bottom Sediments: Color: Brown

Texture: Clay

Odor: None

Structures: Leaves

Eh: -163 (uncorrected)

STATION 14

Location: 41°26'38"N-73°59'20"W

Date: 7/2/65

Time: 12:09 P.M.

Depth: 75 feet

Water: Temperature: 24.6°C

Turbidity: Moderate

pH: 6.6

Bottom Sediments: Color: Black to brown

Texture: Silt - clay

Viscosity: Low

Odor: None

Structures: None

Eh: -124mv. (*uncorrected)

STATION 15

Location: 41°26'48"N-73°59'02"W

Date: 7/2/65

Time: 12:37 P.M.

Depth: 8 feet

Water: Temperature: 24.5°C

Turbidity: Moderate

pH: 6.6

Bottom Sediments: Color: Brown

Texture: Silty - clay

Viscosity: Low

Odor: None

Structures: None

Eh: -168 (uncorrected)

STATION 16

Location: 41°33'22"N-73°58'08"W

Date: 7/13/65

Time: 4:50 P.M.

Depth: 4 feet

Water: Temperature: 26°C

Turbidity: Moderate

pH: 8.1 ?

Bottom Sediments: Color: Brown

Texture: Coarse silt

Viscosity: Moderate

Eh: -250mv. ? (uncorrected)

STATION 17

Location: 41°33'28"N-73°58'36"W

Date: 7/13/65

Time: 5:20 P.M.

Depth: 55 feet

Water: Surface: Choppy

Turbidity: Moderate

Bottom Sediments: Color: Brown-gray

Texture: Silt - clay

Viscosity: Moderate

Odor: None

Structures: None

Eh: -155mv. ? (uncorrected)

STATION 18

Location: 41°33'32"N-73°58'59"W

Date: 7/13/65

Time: 6:10 P.M.

Depth: 37 feet

Water: Surface: Choppy

Turbidity: Moderate

Bottom Sediments: Color: Brown

Texture: Silty - clay

Viscosity: Moderate

Odor: H_2S

Eh: -250mv. (uncorrected)

STATION 20A

Location: 42°15'25"N-73°48'34"W

Date: 7/18/65

Time: 8:15 A.M.

Depth: 17 feet

Water: Turbidity: Moderate

pH: 6.4

Water sample Z taken

Bottom Sediments: Color: Brown

Texture: Sandy

Viscosity: Moderate

Odor: Oily

Structures: Wood, clinkers

Temperature: 23°C

eH: -90mv. (uncorrected)

STATION 20B

Location: 42°14'57"N-73°48'49"W

Date: 7/18/65

Time: 8:35 A.M.

Depth: 45 feet

Water: pH: 6.6

Surface Turbidity: Moderate

Water sample Y taken

Bottom Sediments: Color: Brown

Texture: Sand

Viscosity: Very low

Odor: None

Structures: Plant material

Eh: -80mv. (uncorrected)

pH: 6.5

AREA APPEARS TO HAVE BEEN RECENTLY DREDGED*****

STATION 21A

Location: 42°13'15"N-73°51'03"W

Date: 7/18/65

Time: 9:00 A.M.

Depth: 8 feet

Water: pH: 6.4

Turbidity: Moderate

Bottom Sediments: Color: Brown

Texture: Medium sand

Viscosity: Low

Odor: None

Structures: Oily surface

Temperature: 23°C

Eh: -40mv. (uncorrected)

pH: 6.6

SEDIMENT MAY BE ALTERED BY DREDGING ¼ MILE UPSTREAM

STATION 21B

Location: 42°12'56"N - 73°51'14"W

Date: 7/18/65

Time: 9:25 A.M.

Depth: 58 feet

Water: pH: 6.4

Bottom Sediments: Eh: +160mv. (uncorrected)

SEDIMENT APPEARS TO BE AFFECTED BY DREDGING IN AREA OF CHANNEL

STATION 22A

Location: 42°05'50"N - 73°55'50"W

Date: 7/18/65

Time: 10:20 A.M.

Water: pH: 6.7

Turbidity moderate

Surface sample X taken

Bottom Sediments: No mud, cobbles only

STATION 22B

Location: 42°05'06"N - 73°55'58"W

Date: 7/18/66

Time: 10:30 A.M.

Water: pH: 6.4 (surf.)

Bottom Sediments: Color: Brown

Texture: Silty sand

Viscosity: Moderate-High

Odor: fishy

Eh: 53mv.

pH: 6.8

Biota: Clams, Weeds, Grasses

STATION 23A

Location: 41°59'52"N - 73°56'34"N

Date: 7/18/66

Time: 11:15 A.M.

Depth: 29 feet

Water: pH: 6.8

Bottom Sediments: Color: Brown

Texture: Fine-medium sand

Viscosity: Low

Odor: None

Structures: 1 clam

Temperature: 23°C.

pH: 220mv.

STATION 23B

Location: 41°59'40"N - 73°56'15"W

Date: 7/18/65

Time: 11:35 A.M.

Depth: 23 feet

Water: pH: 6.4

Bottom Sediments: Color: Brown

Texture: Sandy-silt

Viscosity: Moderate

Odor: Oily

Structures: Twigs, clams

Temperature 23°C

pH: 6.5

Eh: -100mv. (Uncorrected)

STATION 25A

Location: 41°35'04"N - 73°57'34"W

Date: 7/23/65

Time: 3:05 P.M.

Depth: 45 feet

Water: pH: 6.6

Mud: 6.8

Bottom Sediments: Color: Brown

Viscosity: Moderate-low

Texture: Clay

Structures: None

Odor: Oily

Oil residue

Eh: -108mv. (uncorrected)

Water sample V taken.

STATION 25B

Location: 41°35'04"N - 73°57'05"W

Date: 7/23/65

Time: 3:30 P.M.

Water: pH: 6.4

Mud: 6.4

Bottom Sediments: Color: Brown

Structures: Pebbles and clinkers present

Oil Slick

Viscosity: Low

Eh: -241mv. (uncorrected)

Depth: 12 feet

STATION 26A

Location: 41°34'51"N - 73°57'34"W

Date: 7/23/65

Time: 3:45 P.M.

Water: pH: 6.4

Mud: 6.6

Bottom Sediments: Color: Brown

Viscosity: Moderate

Texture: Pebbles to clay

Eh: -95mv. (uncorrected)

Depth: 5 feet

Water sample U taken.

STATION 26B

Location: 41°34'04"N - 73°57'48"W

Date: 7/23/65

Time: 4:00 P.M.

Depth: 58 feet

Water: pH: 6.6

Mud: 6.8

Bottom Sediments: Color: Brown

Viscosity: Moderate

Texture: Sandy-clay

Odor: Slight H_2S

Eh: -95mv. (uncorrected)

STATION 26C

Location: 41°34'11"N - 73°58'04"W

Date: 7/23/65

Time: 4:20 P.M.

Water: pH: 6.4

Mud: 6.3

Bottom Sediment: Color: Brown

Texture: Silty-clay

Viscosity: Moderate

Eh: -67mv. (uncorrected)

Depth: 40 feet

STATION 27A

Location: 41°03'03"N - 74°00'23"W

Date: 7/23/65

Time: 5:00 P.M.

Depth: 35 feet

Water: pH: 6.4

Bottom Sediment: Color: Brown

Temperature: 23.5°C.

Viscosity: Moderate-low

Texture: Clay

Eh: -174mv. (uncorrected)

STATION 27B

Location: 41°31'01"N - 74°00'04"W

Date: 7/23/65

Time: 5:15 P.M.

Depth: 40 feet

Water: pH: 6.4

Mud: 6.4

Bottom Sediments: Color: Brown

Texture: Silty-clay

Viscosity: Low-moderate

Eh: -30mv. (uncorrected)

STATION 27C

Location: 41°30'58"N - 73°59'39"W

Date: 7/23/65

Time: 5:30 P.M.

Depth: 28 feet

Water: pH: 6.4

Bottom Sediments: Color: Brown

Texture: Sandy-clay

Viscosity: Moderate-low

Structures: Worms, small clinkers

Eh: -250 mv. (uncorrected)

STATION 27D

Location: 41°30'56"N - 73°59'20"W

Date: 7/23/65

Time: 5:45 P.M.

Depth: 5 feet

Water: pH: 6.6

Mud: 6.4

Bottom Sediments: Color: Brown

Texture: Silty-clay

Viscosity: Moderate-low

Eh: -146mv. (uncorrected)

STATION 28A

Location: 41°31'53"N - 73°59'08"W

Date: 7/23/65

Time: 6:00 P.M.

Water: pH: 5.4

Mud: 5.9

Bottom Sediments: Color: Gray-brown

Texture: Silty-clay

Viscosity: Low-moderate

Structures: Grass

Eh: -105mv. (Uncorrected)

Depth: 5 feet

STATION 28B

Location: 41°32'00"N - 73°59'30"W

Date: 7/23/65

Time: 6:00 P.M.

Depth: 37 feet

Water: pH: 6.2

Bottom Sediments: Color: Brown

Viscosity: Moderate-low

Texture: Sandy-clay

Structure: Clinkers, 3" cobble

Eh: -145mv. (uncorrected)

STATION 28C

Location: 41°32'15"N - 73°59'57"W

Date: 7/23/65

Time: 6:35 P.M.

Depth: 60 feet

Water: pH: 6.4

Mud: 6.8

Bottom Sediments: Eh: -135mv. (uncorrected)

STATION 30

Location: 41°14'21"N - 73°57'43"W

Date: 8/5/65

Time: 1:30 P.M.

Surface Water: pH: 6.5

Water sample W' taken

Bottom Sediments: Color: Brown

Texture: Clay

Viscosity: Low

Odor: Rubber

Structures: Clinker

pH: 6.7

Eh: -65mv. (uncorrected)

Depth: 66 feet

Cores: $C\text{-}V_1$ dropped from 60 feet, 10 inch override

C-V dropped from 62 feet

STATION 31

Location: 41°17'05"N - 73°56'51"W

Date: August 5, 1965

Time: 2:30 P.M.

Surface Water: pH: 6.3

Depth: 75 feet

Bottom Sediments
- Color: Brown
- Texture: Clay
- Viscosity: Low
- Odor: None
- Structures: None
- pH: 6.5
- Eh: +30 (uncorrected)

Water sample X' taken

Core: C-VI

STATION 32

Location: 41°18'12"N - 73°59'04"W

Date: 8/5/65

Time: 3:30 P.M.

Water sample Q taken at mid-channel beneath the Bear Mountain Bridge

STATION 33

Location: 41°23'25"N - 73°56'58"W

Date: 8/5/65

Time: 3:53 P.M.

Water sample Z' taken in front of West Point; surface sample

STATION 34

Location: 41°27'19"N - 73°59'37"W

Date: 8/5/65

Time: 4:17 P.M.

Water sample Y' taken 100 yards west of Pollepel Island

STATION 35

Location: 41°35'10"N - 73°57'23"W

Date: 8/10/65

Time: 12:00 P.M.

Salinity Profile:

Depth (ft.)	Conductivity (milliohms)	Salinity (o/oo	Temperature (°C
1	0.54	0.33	25.9
7	0.54	0.33	
13	0.54	0.33	
16	0.66	0.40	24.98
19	0.67	0.41	
22	0.40	0.40	25.0

Depth to bottom: 25 feet

STATION 36

Location: 41°31'07"N - 74°00'09"W

Date: 8/10/65

Time: 2:00 P.M.

Salinity Profile:

Depth (ft.)	Conductivity (milliohms)	Salinity (o/oo)	Temperature (°C)
1	1.78	1.05	25.4
7	1.90	1.15	
13	1.96	1.21	24.9
19	2.0	1.25	24.8
25	2.0	1.25	
	2.06	1.25	
37	2.08	1.3	24.9

Depth to bottom: 40 feet

Cores: $C\text{-}VIII_1$ dropped from 4 feet above bottom, possible 12 inch overrride

$C\text{-}VII_2$ dropped from 2 feet above bottom

STATION 37

Location: 41°27'02"N - 73°59'55"W

Date: 8/10/65

Salinity Profile: Taken at Station 37B

Depth (ft.)	Conductivity (milliohms)	Salinity (o/oo)	Temperature (°C)
1	2.9	1.73	25.7
4	3.0	1.75	25.6
10	3.22	1.9	
16	3.57	2.10	24.7
22	3.7	2.22	
28	3.88	2.32	24.5
34	4.14	2.46	
40	4.2	2.54	24.6

Cores: C-VIII Location: 37A 41°27'00"N - 74°00'17"W

Dropped from 24 feet

Depth: 27 feet

C-IX Location: 37B 41°27'01"N - 73°59'55"W

Dropped from 41 feet

Depth: 45 feet

C-X Location: 37C 41°27'12"N - 73°59'17"W

Dropped from 4 feet above bottom; near waterchestnuts

Depth: 4 feet

STATION 38

Location: 41°13'18"N - 73°57'06"W

Date: 8/12/65

Time: 1:30 P.M.

Salinity Profile:

Depth (ft.)	Conductivity (milliohms)	Salinity (o/oo)	Temperature (°C)
1	8.85	4.79	26.47
4	8.95	4.75	25.08
7	8.99	4.95	
10	9.29	5.19	25.00
13	9.62	5.47	
16	10.50	5.98	25.10
19	10.50	5.98	
22	10.54	6.07	25.07
25	10.56	6.07	
28	10.54	6.08	24.97
31	10.59	5.98	
34	10.60	5.67	25.13

Depth to bottom: 37 feet

Near Station 16 of 1964 survey.

STATION 39

Location: 41°15'58"N - 73°58'05"W

Date: 8/12/65

Time: 2:00 P.M.

Salinity Profile:

Depth (ft.)	Conductivity (milliohms)	Salinity (o/oo)	Temperature (°C)
1	7.94	4.51	26.09
4	7.87	4.51	
7	8.00	4.61	
13	8.08	4.61	24.96
19	8.32	4.76	
25	8.70	5.02	25.03
31	9.13	5.31	25.03
37	9.51	5.45	24.99
40	9.51	5.45	
43	9.55	5.51	25.01
46	9.56	5.51	
49	9.68	5.53	24.99

Depth to bottom: 52 feet

Cable angled about 45° to water surface as result of upstream current.

Near Station 15 of 1964 survey.

STATION 40

Location: 41°18'02"N - 73°58'02"W

Date: 8/12/65

Time: 2:30 P.M.

Salinity Profile:

Depth (ft.)	Conductivity (milliohms)	Salinity (o/oo)	Temperature (°C)
1	7.22	4.08	25.32
4	7.22	4.08	25.21
7	7.20	4.01	25.21
16	7.20	4.01	25.20
25	7.22	4.02	25.20
34	7.19	4.05	25.29
43	7.17	4.03	25.20
49	7.17	4.03	
55	7.17	4.03	
61	7.27	4.09	25.13
67	7.35	4.23	
73	7.36	4.16	25.01
79	7.38	4.16	
88	7.39	4.23	25.02

Depth to bottom: 88 feet

Near Station 14 of 1964 survey

STATION 41

Location: 41°20'50"N - 73°57'45"W

Date: 8/12/65

Time: 3:00 P.M.

Salinity Profile:

Depth (ft.)	Conductivity (milliohms)	Salinity (θ/oo	Temperature (°C)
1	5.63	3.21	25.54
7	5.67	3.21	24.75
16	5.75	3.29	24.75
25	5.77	3.29	24.76
34	5.82	3.32	24.76
43	5.90	3.37	24.76
52	6.01	3.45	24.76
61	6.11	3.45	24.72
70	6.58	3.75	24.72
79	6.73	3.82	24.74
88	6.75	3.81	24.78
97	6.82	3.88	24.76

(end of cable)

Near Station 13 of 1964 survey.

STATION 42

Location: 41°23'18"N - 73°57'07"W

Date: 8/12/65

Time: 3:30 P.M.

Salinity Profile:

Depth (ft)	Conductivity (milliohms)	Salinity (o/oo)	Temperature (°C)
1	4.84	2.86	25.04
7	4.94	2.83	24.91
16	5.14	2.99	24.69
25	5.40	3.15	24.69
34	5.55	3.24	24.71
43	5.68	3.29	24.71
52	5.70	3.29	24.71
58	5.70	3.28	24.71
64	5.70	3.28	24.83

Depth to bottom: 67 feet

Near station 12 of 1964 survey

STATION 43

Location: 41°25'30"N - 73°58'14"W

Date: 8/12/65

Time: 4:00 P.M.

Salinity Profile:

Depth (ft.)	Conductivity (milliohms)	Salinity (o/oo)	Temperature (°C)
1	3.69	2.16	25.47
7	4.10	2.45	
13	4.19	2.43	24.89
19	4.24	2.51	
25	4.36	2.57	24.90
31	4.37	2.57	
37	4.40	2.59	24.94
43	4.40	2.59	
52	4.44	2.69	24.80
58	4.74	2.78	24.80

Depth to bottom 58 feet

Near station II of 1964 survey

STATION 44

Location: 41°27'04"N - 73°59'37"W

Date: 7/29/65

Time: 1:oo P.M.

Core: C-III

Depth: 42 feet

Dropped from 35 feet

Override of 6 to 8 inches

STATION 45

Location: 41°25'28"N - 73°58'33"W

Date: 7/29/65

Time: 1:30 P.M.

Core: C-IV
Depth 47 feet
Dropped from 40 feet
Possibly up to 18 inch override

STATION 45a

Location: 41°24'29"N - 73°57'45"N

Date: 8/24/65

Time: 10:15 A.M.

Core: XI
Depth 74 feet
Dropped from 72 feet
Approximately 3 feet of sediment recovered.

STATION 46

Location: 41°25'39"N - 73°58'18"W

Date: 8/24/65

Time: 11:00 A.M.

Core: XII
Depth 74 feet
Dropped from 70 feet
Override

XII
Depth 66 feet
Dropped from 63 feet
Almost 4' recovery

STATION 47

Location: 41°28'23"N - 74°00'30"W

Date: 8/24/65

Time: 11:30 A.M.

Core: XIII
Depth 40 feet
Dropped from 36 feet
Override slight

XIII_2
Depth 40 feet
Dropped from 38 feet
Approximate 4 feet recovery

STATION 48

Location: 41°28'22"N - 74°00'10"W

Date: 8/24/65

Time: 12:00 P.M.

Core: XIV
Depth 40 feet
Dropped from 37 feet
Override 2 to 3 inch

STATION 49

Location: 41°28'20"N - 73°59'26"W

Date: 8/24/65

Time: 12:15 P.M.

Core: XV
Depth 6 feet
Dropped from 6 feet
2 feet of core

STATION 50

Location: 41°31'06"N - 73°59'20"W

Date: 8/24/65

Time: 1:30 P.M.

Core: XVI
Depth 8 feet
Dropped from 8 feet
18 inch of core

STATION 51

Location: 41°31'04"N - 73°59'57"W

Date: 8/24/65

Time: 2:00 P.M.

Core: XVII
Depth 34 feet
Dropped from 29 feet
4-1/2 feet of core

STATION 52

Location: 41°31'06"N - 74°00'20"W

Date: 8/24/65

Time: 2:25 P.M.

Core: XVIII_1
Depth 34 feet
Dropped from 31 feet
Override 4 inch

XVIII_2
Depth 34 feet
Dropped from 32 feet

STATION 53

Location: 41°33'10"N - 73°58'47"W

Date: 8/24/65

Time: 3:00 P.M.

Core: XIX
Depth 47 feet
Dropped from 45 feet
4 feet of core

APPENDIX C

A. Cation Exchange Capacity

Bottom Muds Containing Free Salts and Shells

Procedure

Transfer mud sample to large dish and mix thoroughly. Weigh into duplicate 250 ml. beaker, 15 grams of wet sample. Simultaneously, weigh out two samples into a tared beaker for moisture determination. Place these samples into an oven at 105°C.

To moist samples add 50 ml. of N (pH 7.0) NH_4AC, allow to stand overnight and transfer solids to a funnel with fitted filter paper (12.5 cm. Whatman #40). Leach with small portions of NH_4AC until pH of filtrate is the same as that of the displacing agent (NH_4AC). Wash with 150-200 ml. of neutral 75% ethyl alcohol. Displace adsorbed NH_4 with 500 ml. of N NaCl and save filtrate. Distill NH_4 from aliquot (250 ml.) by adding 25 ml. of 40% NaOH solution, a pinch of Zn dust and trap NH_3 in 50 ml. of 40% Boric Acid. Titrate with standard acid after adding 2 drops of mixed indicator.

Calculations

CC's of acid x N = me in aliquot

me in aliquot x 2 = total me for dry weight of sample, calculate to me per 100 gms. dry sample.

Save solids from moisture determination for N, organic matter and exchangeable bases estimations.

Combine, grind gently in a motar, screen using a sieve with opening 0.5 mm. and store.

B. Exchangeable* Bases in Bottom Muds

Procedure

Weigh out duplicate 5 gm. portions of dried mud, place on a 11cm. Whatman filter paper fitted into a glass funnel and set into a 250 volumetric flask. Wash with distilled water until free of Cl^- or until mud begins to disperse. Discard washings, clean flask and displace exchangeable bases with N NH_4AC (pH 7.0). Collect 2-250 ml. of leachate per sample and designate as 1 and 2. Determine Ca, Mg, etc., in each leachate using atomic absorption techniques. Then:

K in first leachate = Exchangeable K

Na in first leachate = Exchangeable Na

Ca in first leachate - Ca in second leachate = Exchangeable Ca

Mg in first leachate - Mg in second leachate = Exchangeable Mg

Calculate to me per 100 gms. of oven dried material.

*i.e. displaceable by NH_4AC.

C. Organically Bound Cations in Bottom Muds

Procedure

Weigh out 4-5.0 gms. portions of oven-dried mud and place in a glass funnel fitted with a 12.5 cm. Whatman #40 paper.

Remove water soluble cations by leaching 5.0 gms. of oven-dried mud with 250 ml. of distilled water.

Take 2 of the samples, place in an evaporating dish and ignite contents for 8-12 hrs. at a temperature of 350°-400°C. Cool, transfer to glass funnel fitted with filter paper. Designate these samples as 1 and 2. The unignited samples are designated as 3 and 4.

Leach all samples with 250 ml. of N pH 7.0 NH_4AC and collect filtrates and designate as leachate A. Repeat leaching and designate second as B.

Then:

1. Determine Na, K, Ca and Mg in leachate A. The Na and K values represent exchangeable ions.
2. Determine Ca and Mg in leachate B and subtract values found from values found in leachate A to determine exchangeable Ca and Mg.

APPENDIX D

HUDSON RIVER BOTTOM MUDS

Particle Size Analysis (mm)
Summary of % by weight

Station (1965)	>2 mm	1-2 mm	1/2-1	1/4-1/2	1/8-1/4	1/16-1/8	1/32-1/16	1/64-1/32	1/128-1/64	1/256-1/128	>1/256 mm
	SAND						SILT				CLAY
1		7.2	2.5	2.8	4.1		15.3	4.0	17.1	10.8	36.2
2		.9	.6	1.8	1.2		42.3	12.6	10.6	14.6	15.3
3		1.1	.6	1.1	0.5		8.7	7.9	17.9	16.4	45.5
5		48.4	17.9	11.9	5.9				.3	1.8	12.4
6		19.2	22.4	30.4	9.7					.3	18.0
7		.3	.2	.3	1.2				19.0	15.5	55.2
8		6.3	2.7	3.6	5.2		11.0	15.9	15.2	9.0	30.8
9		17.9	2.7	2.7	2.5		8.2	6.5	18.7	6.3	34.4
10		.1	.1	.1	.3		23.5	9.8	16.6	8.3	41.0
11		Tr.	Tr.	.1	.3		8.8	14.5	17.2	13.6	45.5
12		.6	.5	1.6	10.5		8.8	13.9	14.2	10.4	39.3
13		1.2	.6	1.0	1.5		15.2	11.8	16.8	10.8	41.0
14		.1	.1	1.1	2.2		5.5	12.5	13.7	17.2	45.5
15		.2	.2	.4	1.0		2.5	18.2	23.4	3.3	50.7
16		.8	1.1	2.0	.2		14.0	13.9	17.5	15.0	35.4
17		1.2	.1	.1	.2		10.5	13.2	20.2	29.5	25.9
18		.1	Tr.	.1	.1		3.4	15.8	18.9	16.2	45.3
20A		6.2	50.5	20.0	5.8		.2	.5	1.3	.7	14.5
23A		.1	.4	12.0	47.7		22.8	.8	2.1		
23B		1.4	14.1	64.6	8.4						10.2

(cont'd)

Station (1965)	>2 mm	1-2 mm	1/2-1	1/4-1/2	1/8-1/4	1/16-1/8	1/32-1/16	1/64-1/32	1/128-1/64	1/256-1/128	>1/256 mm
	SAND						SILT				CLAY
25A		Tr.	Tr.		.1	.5			23.3	25.0	44.5
26B		.6	.5		.9	6.7			18.6	14.6	47.3
26C		.3	.4		.8	1.0	.8	19.5	20.6	15.6	40.9
27A		Tr.	.4		.4	.5	3.4	19.8	16.8	15.9	42.6
27B		.5	.2		.3	2.7	8.7	14.7	16.3	.7	55.7
27C		.4	.6		4.4	7.6	.6	14.3	11.0	13.2	47.7
28A		.3	.1		.4	2.9	2.3	14.5	18.1	14.5	46.8
28C		0	Tr.		.1	1.0	.3	18.7	18.0	20.9	40.9
30		.1	Tr.		.5	2.8	2.0	15.2	16.8	14.6	47.9
31		1.6	.7		.3	1.8			14.7	13.2	48.5
46 Top 1		.1	Tr.		.1	.8					52.1
Middle 2		0	0		Tr.	.5			19.5	15.5	51.4
Bottom 3		Tr.	Tr.		.2	1.3			16.3	14.5	51.8
48		.4	.1		.3	5.1	4.9	22.5			47.9
52 7		.3	.3		.3	.8			22.8	8.9	58.0
52 8		.3	.2		.3	.6			22.4	13.4	59.6

ACKNOWLEDGEMENT

We wish to express our thanks to Mr. and Mrs. C.B. Glunt of Saugerties, New York for the use of their property as a sampling site; and also the New York State Thruway Authority of Nyack, New York for permitting us to use facilities on the Tappan Zee Bridge.