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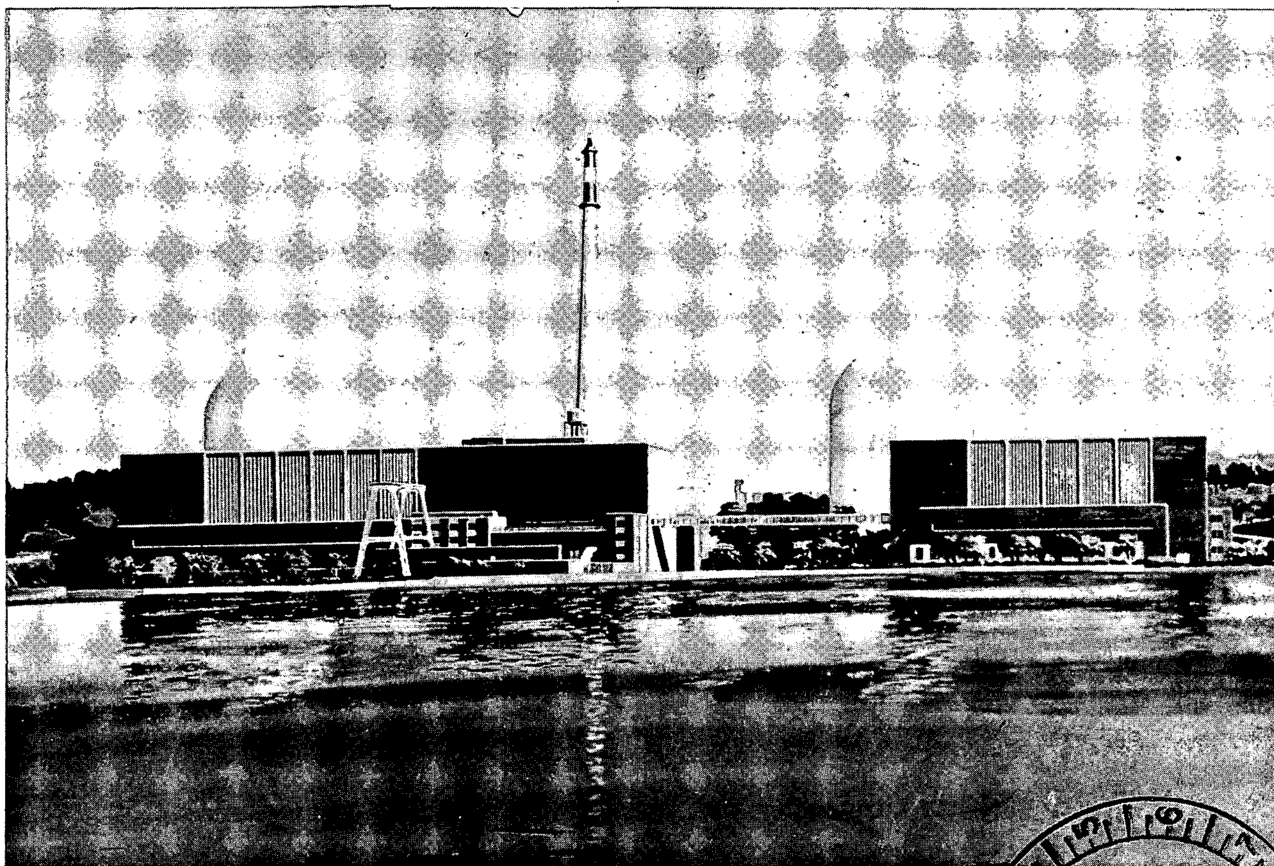
ENVIRONMENTAL REPORT

SUPPLEMENT No. 1

Received w/Ltr Dated 9-9-71



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APPENDICES - VOLUME No. 2

SEPTEMBER 1971

Con Edison

INDIAN POINT UNIT NO. 2

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DATA REPORT FOR

JUNE - DECEMBER 1969

(Revised Edition)

Ecology of Thermal Additions

Lower Hudson River Cooperative Fishery Study

Vicinity of Indian Point, Buchanan, New York

1970

for

Consolidated Edison of New York

by the

Marine Research Laboratory

New London, Conn.

of

RAYTHEON COMPANY

SUBMARINE SIGNAL DIVISION

Portsmouth, Rhode Island

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1.0 SUMMARY (JUNE—DECEMBER 1969, DATA REPORT)*

The temperature data collected during the overflight surveys and the biological sampling program indicate that essentially isothermal conditions exist throughout the study area except in the immediate vicinity of the thermal plumes issuing from the Lovett and Indian Point power plants. During the summer months, river temperatures ranged from 72 to 82 degrees F with peak temperatures occurring in August. A 10-degree F per month decline in river temperature was observed from September to December at which time the river temperature stabilized at about 32 degrees F.

The surface temperature overflight data indicate an average plume width of around 600 feet. The main concentration of heated effluent from the Indian Point plant ranged about 1/4 to 1/2 mile upstream and downstream of the plant.

The Automatic Environmental Systems water quality monitor data indicate a Delta T across the plant of 8 to 9 degrees F which increases to about 9 to 10 degrees F during apparent recirculation of 3 to 4 hours duration caused by the flooding tide.

Temperature data collected during a detailed survey of the Indian Point thermal plume on 17 and 19 September indicate that the plume did not extend more than 650 feet across-river in front of the plant. The depth to the base (thickness) of the heated effluent never exceeded 15 feet once the plume left bottom in the immediate vicinity of the outfall. The plume configuration appears to be primarily controlled by tide. Wind was also observed to have an important effect and may at times result in a submerged tongue of effluent water.

Salinity is perhaps the most variable environmental parameter in the study area. There are vertical, horizontal, tidal, daily and seasonal fluctuations. These fluctuations may have a range of 0 to 2 ppt, 0 to 4 ppt, 0 to 1.5 ppt, 0 to 3 ppt, and 5 to 7 parts per thousand, respectively. The most radical change in salinity occurred throughout the study area during November 6 through 20. At Indian Point (station 10) the salinity dropped from about 6.5 ppt on the 6th to 0.3 ppt on the 20th. This change is attributed to extensive local rainfall and major releases over the Federal Dam at Troy, New York, in early November.

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* Throughout this report, the past tense should have been used in referring to data and implications thereof.

The surface values of dissolved oxygen generally were slightly higher (0.1 - 0.4 mg/l) than bottom concentrations. Yet, in many instances the surface and bottom concentrations were equivalent. A steady increase in dissolved oxygen was observed from about 4 mg/l in September to nearly 10 mg/l in late December. The in situ dissolved oxygen readings are consistently below saturation values.

There is generally a noticeable drop in dissolved oxygen across the power plant. For example, in early November values of 5.3 ppm were recorded at the intake versus 3.7 ppm at the outfall. Since both of these readings represent less than 50 percent saturation at the corresponding temperatures, it is unlikely that heat accounts for the drop in concentration due to differential oxygen solubilities.

The pH readings across the power plant are quite stable with the intake pH ranging around 7.2 and the outfall about 7.4.

Numerically and in declining order, the most important finfish species within the study area are the bay anchovy, white perch, striped bass, tomcod, alewife, blueback herring and hogchoker. These seven species constituted 95 percent of the bottom trawl collections. The pelagic species — bay anchovy, blueback herring and alewife—comprised 97 percent of the surface trawl collections. The striped bass, white perch, alewife, spottail shiner, blueback herring and the Atlantic silverside accounted for 93 percent of the fish caught in beach seines.

The key fish species selected by the Technical Committee for special attention (laboratory studies, weight measurements, etc.) are the alewife, American shad, blueback herring, striped bass, white perch and tomcod. The bay anchovy was also cited as a key species for bioassay studies.

Very limited numbers of young-of-the-year American shad were caught in our gear during the summer-fall of 1969. Young-of-the-year alewife and blueback herring are caught throughout the study area from June through November. The peak concentrations for the alewife occurred in August and September whereas those for the blueback herring occurred in October and November. Very few of these two river herrings were caught in December. The blueback herring is considerably more abundant in the surface waters than the alewife.

The striped bass and white perch are about equal in numerical importance in the bottom trawl and beach seine collections. However, the white perch appears to have a greater preference for the shoal areas, whereas the striped bass prefers the near shore areas. These two species occur only rarely in the surface waters. They are generally composed of mixed year groups.

The tomcod ranks third numerically in the bottom trawl collections with a preference for the deeper channel stations. Its appearance in beach seine collections only during November and December is probably related to spawning activity.

The bay anchovy is numerically the most important fish. It comprised 43 percent of the bottom trawl catches and 68 percent of the surface trawls. It occurred only seldom in beach seine collections. Peak concentrations in the Indian Point area occurred in September. An abrupt decrease and general disappearance of the bay anchovy from the study area occurred during November through December.

Generally, both higher abundances and total numbers of species are found in the fish populations during August through October. The highest total number of species occurred in October for all three types of gear (surface trawls, bottom trawls, and beach seines) which collected 21, 26 and 28 species, respectively.* A marked decrease in the overall abundance and number of species, particularly in the surface and shoal populations was observed during November and December. A total of 43 species of fish were collected from June through December 1969.

The Simpson species diversity index indicates that the shore-fish communities have generally the highest diversity followed closely by the bottom-trawl communities. The collections from the surface waters have distinctly lower diversities. The higher average species diversity during October supports the previous indications provided by the total number of species data (limited numbers of observations during some months may also have an effect).

A community overlap index for comparing the proportional species compositional similarity between station pairs suggests that depth is the dominant factor controlling the distribution of the fish species within the study area. River mile plays a noticeably less important role.

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* See qualifications on page 7-5.

This community overlap technique also revealed the extent of faunal redundancy among stations and, therefore, provides a biological basis for pooling the data among similar stations in order to increase the sample size from a statistical point of view. Data on the average number caught per unit effort per gear type plus the fairly uniform degree of community overlap among the surface trawl collections indicate that the areal and vertical distribution of the key pelagic species could be adequately monitored by surface trawling at fewer stations than is presently done. The effort saved could be redirected to, for example, increased sampling frequency of other gear types.

An analysis of the fish species caught per station suggests the existence of two faunal communities within the study area. The narrowing and deepening of the river in the vicinity of Stony Point (mile 40) appears to represent the natural boundary between a community to the north characterized by higher concentrations of species that prefer deeper and fresher waters, and a community to the south (Haverstraw Bay) characterized by those species preferring shoaler and more saline waters.

Daytime samples of zooplankton at five channel stations indicate significantly higher concentrations in the bottom tows. Copepods accounted for 65 to 70 percent of the individuals collected in both surface and bottom tows. The copepods, Cyclops, and the mysid, Neomysis americana, are also abundant in the zooplankton. The seasonal nature of the zooplankton was reflected by the appearance of different invertebrate larval forms in different months.

The succession panels indicate that the encrusting fauna is not very diverse nor abundant. The barnacle Balanus improvisus occurs primarily in the more saline Haverstraw Bay. The bivalve Congeria leucophaeta and the hydroid Campanularia are also important encrusting forms. Comparison of the rather sparse fauna on the panels located at the intake and outfall areas at the power plant did not reveal any striking dissimilarities.

The polychaete Spio setosa and the isopod Cyathura polita were the two major benthic organisms collected by the bottom grab.

Since the Thorson bottles did not accumulate any significant or repeatable numbers of animals, their biological usefulness to this study appears limited.

2.0 INTRODUCTION

Raytheon Company's Marine Research Laboratory has been contracted by the Consolidated Edison Company of New York to study the ecology of the Hudson River in the vicinity of its nuclear electric power generating station at Indian Point, Buchanan, New York. The main emphasis of this study is directed towards an evaluation of possible ecological effects caused by the discharge of heated effluents into the river.

The report summarizes the results of the research efforts conducted during the months of June through December 1969. A copy of the raw data summary tabulations and statistics has been delivered to the Technical Committee. This committee, which is composed of state and federal fishery scientists, provides continuing technical evaluation of this study to the Policy Committee for the Lower Hudson River Cooperative Fishery Studies. The Policy Committee is responsible for the overall direction and guidance of the research efforts.

3.0 STUDY AREA DESCRIPTION

3.1 Geography—Bathymetry

This study encompasses 12 miles of the Hudson River from Croton Point on the south at river mile 35 to the Bear Mountain Bridge on the north at river mile 47 (Figure 3-1). The study area varies from the broad,shallow Haverstraw Bay, which is approximately 3 miles wide by 4 miles long, to the narrow, gorge-like topography in the vicinity of the Bear Mountain Bridge. The natural river channel ranges in depth from 30 feet on the south to some 130 feet on the north. The principal shoals occur on the east side of Haverstraw Bay with average depths of 8 to 10 feet. Less extensive shoals occur on the west side of Haverstraw Bay and in Peekskill Bay which average about 4 feet in depth at mean low water.

3.2 Hydrology

The approximately 22,000 cfs average annual freshwater runoff which passes through the study area is dwarfed by tidal flows which generally range between 200,000 to 300,000 cfs. About 60 percent of the freshwater runoff entering the area was contributed by the drainage basins above the Federal Dam at Troy, New York. The mean tidal range in the study area is 3 to 4 feet. Tidal currents average 0.8 knots on the flood and 1.2 knots on the ebb tide. A comparison of the tide table time difference indicates that a given tide stage occurs at the northern end of the study area about 25 to 35 minutes later than at the southern end. Seasonally, the salt-water front (defined as the location of the 50 ppm chloride concentration which is equivalent to about 0.1 ppt salinity) has been observed by others to move upstream and downstream through a reach of about 50 miles or approximately from Chelsea to Yonkers in response to changing freshwater inflow. During a tidal cycle this front may move through a distance of 3 to 15 miles depending on the particular tidal cycle, season and the location of the salt-water front in the estuary.

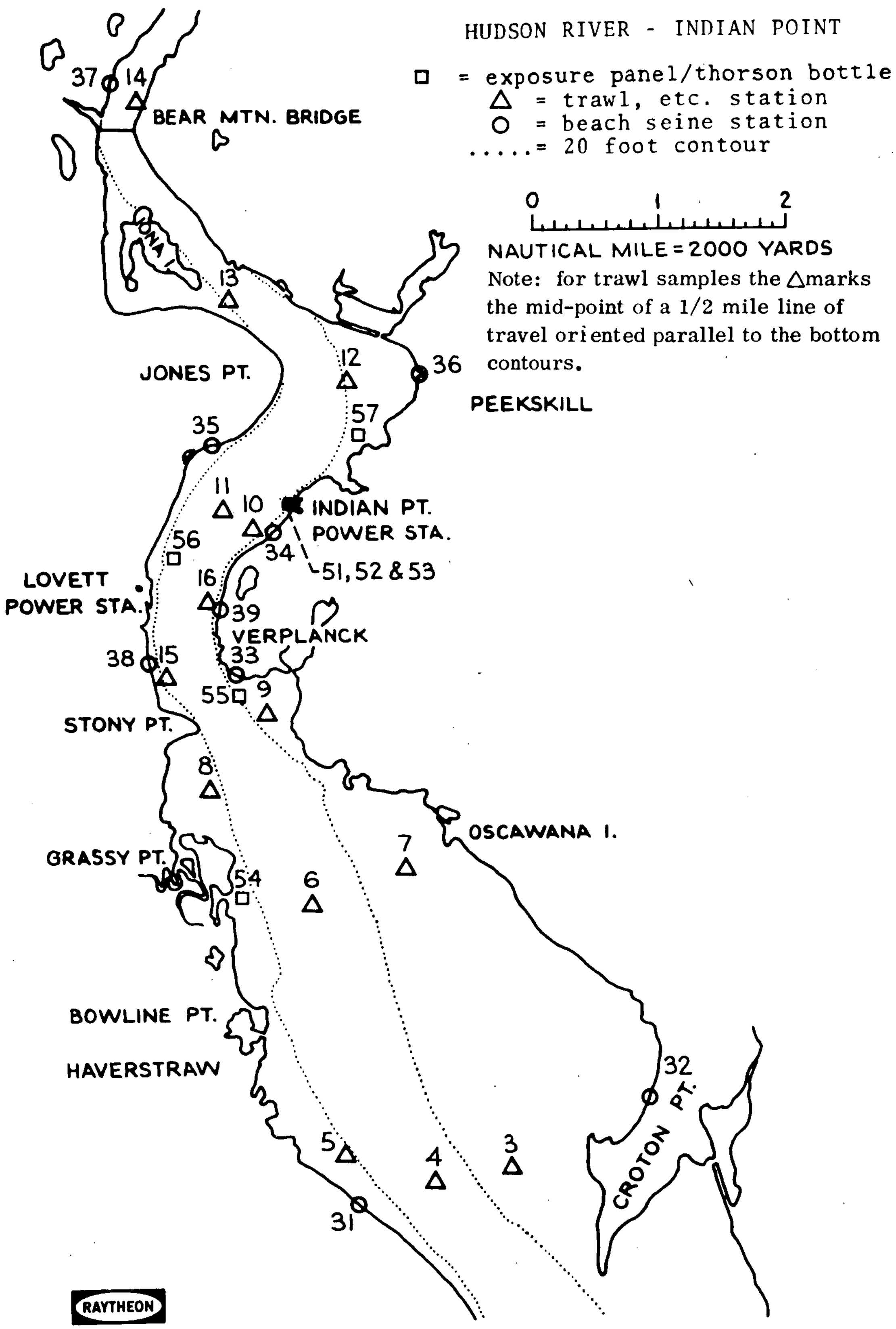


Figure 3-1. Station Locations

3.3 Power Plants

The Consolidated Edison power facilities will be composed of three pressurized water nuclear units with a total designed capacity of about 2,085 megawatts (MW). At present, only unit 1 with a capacity of 285 megawatts is operational. This unit requires 300,000 gallons per minute of cooling water which it discharges at a temperature of about 9 degrees F above ambient river temperature. This constitutes a utilization of less than 0.2 percent of the total adjacent tidal river flow.

Indian Point unit 2 with a designed output of 875 MW is scheduled to become operational in late 1970. Unit 3 with a capacity of 925 MW is scheduled for late 1971. Proposals are now being considered for two additional units with capacities of 1115 MW each to be located at the Trap Rock quarry which is 3/4 of a mile south of the present site.*

Located across the river on the west shore and about a mile south of the Indian Point facilities, is the Lovett power station owned by Orange and Rockland Utilities, Inc. This is a fossil-fueled plant with a present capacity of 314 MW.

3.4 Municipalities

The principal municipalities within the study area are Peekskill (river mile 44) with a population of 19,000, Stony Point (river mile 40) with a population of 15,000, Haverstraw (river mile 37) with a population of 23,000, and Croton-on-Hudson which is on the east shore across the bay from Haverstraw and which has a population of 7500.

* Indian Point Station

Unit 1	300,000 gpm	(existing)
Unit 2	920,000 gpm	(tentative 1971)
Unit 3	920,000 gpm	(tentative 1973)
Unit 4	875,000 gpm	(proposed)
Unit 5	875,000 gpm	(proposed)

Lovett Station

Units 1-5	316,700 gpm total	(existing)

Grand Total 4,206,700

4.0 SAMPLING STATIONS

Initially, 14 trawling and 7 beach seining stations were selected to provide the geographic and depth control necessary to evaluate the present effects of the heated effluent from unit 1 as well as the projected impacts from units 2 and 3. With the announcement of proposals for units 4 and 5 to be located at the Trap Rock quarry about 3/4 mile south of unit 1, it was decided in November by the Technical Committee to drop trawling stations 1 and 2 at river mile 29. In exchange, trawl station 16 and seine station 39 in the immediate vicinity of the Trap Rock quarry were added. Trawl station 15 and seine station 38 had been added (in October) downstream of the Lovett power station as analogs of stations 10 and 34 at Indian Point. The locations of all stations (except 1 and 2) are shown in Figure 3-1 and descriptions of bottom type and topography are summarized in Tables 4-1 and 4-2.

The number of fish collections taken at each station per month are summarized in Table 4-3. The invertebrate collections are summarized in Table 4-4.

In addition to the fourteen trawling stations (3 to 16) and the nine beach seining stations (31 to 39), six stations (51, 53 to 57) have been established for the placement of succession panels and Thorson bottles. (See Table 4-5 for descriptions.) Station 51 represents the intake forebay at the Indian Point plant, station 52 the revolving screen discharge sluiceway and station 53 the effluent canal.

Table 4-1. Trawling, Benthic Grab and Monthly Zooplankton Sampling Stations

STA	MILE*	SITE*	DPTH*	Common Name and Bottom Description
1	29	1	10	Tappan Zee Flats — This station is mostly brown silt, slightly sandy and rocky. Frequently oyster shells in considerable numbers are collected in the bottom trawl.
2	29	3	26	Tappan Zee Channel — Mostly black sticky silt with some sand. Clumps of the hydroid, Campanularia that carry a great number of amphipods are frequently collected in the bottom trawl.
5	36	1	12	Dolphin — Bottom at this station is quite hard, consisting of brown mud, sand and a great many oyster shells. This station yields the greatest volume of shells netted at any station.
3	35	3	10	Potato Rock — Bottom is mostly hard grey clay and hard sand. Oyster shells are often netted in great quantity.
4	35	2	34	Croton Point Channel — Bottom is black-grey silt and mud. Campanularia colonies full of amphipods are frequently collected.
6	38	2	30	Buoy "R 16" — Bottom here is grey silt with some clay. Colonies of hydroids (Campanularia) are frequently collected.
7	38	3	11	Oscawana Island — Bottom here is grey silt and hard sand. At the southern end,rocks are netted on occasion.
8	39	1	12	Stony Point Bay — Bottom here is grey-brown silt and slightly sandy. The bottom trawls occasionally hang up on solid objects suspected to be old mooring blocks. Oyster shells are collected on occasion but not in great numbers.
9	40	3	12	Greens Cove — Bottom here is brown-black silt that is very soft. Sunken logs are occasionally netted and net hang-ups occur, but irregularly.
15	40	1	45	Lovett—Bottom here is grey clay with some silt. The 45' contour is often difficult to follow at this station because the bottom slopes quickly to 60 and 65 feet, especially at the southern end of this station.
16	41	3	45	Trap Rock — The bottom at this station is mostly cinders. Debris of all kinds collects here, i.e., leaves, bottles, trees, rope, domestic garbage, etc. On occasion, rocks weighing up to 40 pounds have been netted. Bottom contour, however, is easy to follow.
11	42	2	50	Reserve Fleet — Bottom here is mostly black silt that is broken with a great deal of cinders. Net hang-ups occasionally occur from what may be debris dumped from the reserve fleet.
10	42	3	45	Con Ed Plant — Bottom here consists of some broken ledge, rocks at the southern end mixed with small rocks that are smooth and round from abrasion. A considerable amount of cinder exists here. Hang-ups occur with regularity at this station and everything from trees to boulders is netted here; leaves are common. The rest of the bottom is grey-brown silt broken with pebbles and rocks. Definitely not good bottom.
13	45	1	50	Round Island—Bottom here is mostly clay with black-brown silt. Occasionally, at the southern end of the station, rocks will be netted. The 55' contour at the northern end of the station is occasionally difficult to follow due to a steep slope.
12	44	3	12	Peekskill Bay — The bottom here is brown, grey sticky silt. Logs are occasionally netted. A major problem at this station is caused by the sticky mud that will not easily flush itself through the fine mesh of an innerliner in the cod end of the bottom trawl. Potamogeton is abundant in the shoaler water during summer and autumn.
14	47	3	47	Bear Mt. Bridge — Bottom here is black silt with some sand and an occurrence of organic detritus. The 45' contour is easy to follow until the southern end of the station where a very sharp slope occurs. Frequently, debris and logs are brought up from the southern end at a point just north of the bridge.

* See Appendix for explanation of terms.

Table 4-2. Beach Seine Sampling Stations

STA	MILE	SITE	Common Name and Bottom Description
31	35	1	Dolphin Beach — This beach is coarse dark sand bounded at both ends by rock. Slope of the beach is steep (1:4)
32	35	3	Croton Beach — The bottom here is part of Croton Beach and is mostly sand and silt. Cans and bottles are sometimes collected . Beach is shoal and slope is gradual (1:10).
38	40	1	Quarry Beach — Bottom all sand that is free from debris. Slope is 1:5. Some rocks are at the North end of station and on occasion cause hang-ups.
33	40	3	Verplanck Pt.—This beach is mostly small gravel with some rocks. Broken glass occurs in considerable quantities and can be traced to a source 150 feet from the station where frequent refreshments are consumed by the public. Beach is bounded to the north by a bulkhead. Slope here is 1:5. Tidal currents existing at this station often make a seine set very difficult.
39	41	3	Trap Rock Beach — Bottom is sandy with occurrence of occasional debris. North end of station is bounded by cut-off piles. Southern end of station is bounded by rocks and piles. Hang-ups occur when tidal current is strong and carries the net toward either end of the beach.
35	43	1	Reserve Fleet Beach — The beach at this station is gravel with some occurrence of rocks. The gravel beach ends shortly below the low water mark where soft sticky mud prevails. In only 2 to 3 feet of water, the aquatic weed Potamogeton is found in abundance. During high water there is no beach and willow trees and honeysuckle outcrop over the water. The slope is shallow (1:10).
34	42	3	Gas Line Beach—This beach consists of small patches of hard sand; the rest of the beach is rocky with silt. Fresh water run-off occurs through a gulley located at the south end of the beach. The slope of the beach is steep (1:4). Soft mud exists below the low water mark.
36	44	3	Lumber Co. Beach — The beach here consists of coarse black sand. This is a short beach that is bounded on the south by a bulkhead and on the north by broken piles. The slope of the beach is steep (1:4). Little vegetation is present.
37	47	1	Ft. Montgomery — This beach is generally small rocks and gravel broken with patches of coarse sand. The beach is short and does not exist at high tide. Below the low water mark, this station is dominated by mud. The beach slope is steep (1:4). Small shrubs and trees shade the water at high tide. Hang-ups frequently occur by rocks near the barge at the north end of the station.

Table 4-3. Samples Collected in 1969

	STA	MILE	SITE	DPTH	1969 June July	Aug.	Sept.	Oct.	Nov.	Dec.
BOTTOM TRAWLS	1	29	1	10	5	5	2	2		
	2	29	3	26	5	5	2	1		
	5	36	1	12	3	6	1	1	1	1
	3	35	3	10	12	7	2	1	2	1
	4	35	2	34	9	7	2	1	2	1
	6	38	2	30	4	4	2	2	1	1
	7	38	3	11	5	4	3	1	1	2
	8	39	1	12	3	4	4	5	5	2
	9	40	3	12	3	5	3	4	4	2
	15	40	1	45			1	7	4	3
	16	41	3	45			1		2	2
	11	42	2	50	3	4	4	7	3	3
	10	42	3	45	3	5	4	5	3	8
	13	45	1	50	6	6	2	1		1
	12	44	3	12	6	6	4	6	3	4
	14	47	3	47	3	4	2	1	1	1
SURFACE TRAWLS	1	29	1	10				1		
	2	29	3	26				1		
	5	36	1	12						
	3	35	3	10				2	2	1
	4	35	2	34				1	3	2
	6	38	2	30				2	2	2
	7	38	3	11		4	1	2	2	2
	8	39	1	12			2	1	4	3
	9	40	3	12			2	4	4	3
	15	40	1	45			3	1	4	4
	16	41	3	45					1	4
	11	42	2	50			2	2	4	3
	10	42	3	45		2	3	1	4	4
	13	45	1	50				2	2	1
	12	44	3	12		1	1	1	3	2
	14	47	3	47				1		
BEACH SEINES	31	35	1			4	2	2	2	
	32	35	3		2	5	2	3	2	
	38	40	1				1	6	5	6
	33	40	3		2	5	3	5	5	6
	39	41	3						3	5
	35	43	1		2	4	3	8	5	6
	34	42	3			3	3	6	6	6
	36	44	3		2	5	2	2	2	1
	37	47	1		3	4	2	2	2	1
PLANT SITE	Forebay						3	8	3	6
	Sluice						1	2	3	5
	Effluent							1		1

Table 4-4. 1969 Invertebrate Samples Collected

	STA	MILE	SITE	DEPTH	SURFACE JUNE JULY	SURFACE AUG	SURFACE SEPT	SURFACE OCT	SURFACE NOV	SURFACE DEC	BOTTOM JUNE JULY	BOTTOM AUG	BOTTOM SEPT	BOTTOM OCT	BOTTOM NOV	BOTTOM DEC
SUCCESSION PANELS	54	38	1	14				1	1	1				1	1	1
	55	40	3	10				1	1	*				1	1	*
	56	41	2	49				1	1	*				1	1	1
	51	42	3	26				1	1	1				1	1	1
	53	42	3	18			1	Δ	Δ	Δ			1	1	1	1
	57	43	3	15				Δ	Δ	Δ				1	1	1
ZOOPLANKTON TOWS	1	29	1	10		1				**	2					**
	2	29	3	26							1					
	5	36	1	12		1						1				
	3	35	3	10		1						1				
	4	35	2	34		1	1	1	1		1	1	1	1	1	
	6	38	2	30		1	1	1	1			1	1	1	1	
	7	38	3	11		1						1				
	11	42	2	50		1	1	1	1			1	1	1	1	
	10	42	3	45				1	1		1			1	1	
	14	47	3	47		1	1	1	1			1	1	1	1	
THORSON BOTTLES	54	38	1	14											1	1
	55	40	3	10										1	1	*
	56	41	2	49										1	1	1
	51	42	3	26										1		1
	53	42	3	18									1	1	1	1
	57	43	3	15										1	1	1
BENTHIC GRABS	5	36	1	12								1	1	3	1	
	3	35	3	10								1	1	3	1	
	4	35	2	34								1	1	3	1	
	6	38	2	30								1	1	3	1	1
	7	38	3	11								1	1	3	1	1
	8	39	1	12								1	1	3	1	1
	9	40	3	12								1	1	3	1	1
	15	40	1	45											3	1
	16	41	3	45											3	1
	11	42	2	50								1	1	3	1	1
	10	42	3	45								1	1	3	1	1
	13	45	1	50								1	1	3	1	1
	12	44	3	12								1	1	3	1	1
	14	47	3	47								1	1	3	1	1

* lost by ice abrasion.
** the river ice built up faster than expected and thereby prevented the normally scheduled end of the month sampling.
Δ in shallow water only one panel 4 feet off the bottom is set.

Table 4-5. Succession Panel/Thorson Bottle Stations

Sta No.	Location and Exposure	Method of Attachment	M.L.W. River Depth (ft)
7 *	1200 yards due West of Oscawana Island; southerly exposure	tied to a gill-net stake	10
13 *	The middle of the eastern face of the dock located at Round Island; north east exposure	tied to beam joist under the dock	12
51	100' from the northern corner of the Con Ed dock; westerly exposure	tied to a bar screen which is part of the fore-bay perimeter	26
53	On the outside face of the "old" effluent canal bulkhead, 1 foot from the edge of the opening; westerly exposure	tied through bulkhead	14
54	Hung under a scaffold walk 50' to the west side of the loading chute of National Gypsum Plant at Grassy Point; southerly exposure	tied to an "I" beam	20
55	At the range marker located in Green's Cove and 550 yards S.E. from the most easterly tip of Verplanck Point; south-west exposure	tied from a horizontal that joins the tripod legs of the range marker	14
56	At the westernmost ship of the southernmost tier of ships in the reserve fleet. 500 yards due south of the over-river power lines; southerly exposure	tied from the anchor chain	60
57	At the dolphins located 75 yards from the shore at Charles Point; southerly exposure	tied from a piling	7

* Temporary Stations.

5.0 TEMPERATURE STUDIES

During the summer and fall of 1969, the primary sources of temperature data were the monthly aerial overflights, the biological sampling program and the automatic monitoring of the intake and outfall temperatures. In addition, a fine-grained survey of the plume structure in the immediate vicinity of the outfall was conducted on 17 and 19 September.

5.1 Infrared Overflight/Bathythermograph Surveys

Twelve overflight surface temperature surveys using an airborne-infrared radiometer were flown from August through December. One day each month was selected such that the times of maximum flood and ebb tides occurred during daylight hours. It had been shown previously that the maximum extent of the thermal plume issuing from a power plant is reached under maximum current conditions rather than at times of high and low-slack water. These overflight surveys were conducted on 6 and 27 August, 24 September, 24 October, 21 November and 22 December.

On each overflight, which is scheduled to bracket the time of maximum current, a total of 38 miles is flown in transects which criss-cross the Hudson from the Tappan Zee to the Bear Mountain Bridges (Figure 5-1). This aerial survey, which measures actual surface termperatures and records them continuously on a strip chart, requires slightly less than one hour to complete.

Concurrently with the aerial survey, three boats and crews are collecting vertical temperature profile data at 75 predesignated locations. Electronic bathythermographs which are coupled to X-Y pen recorders are used to produce a hard copy of the vertical temperature profile. Since 50 of these profiles are located upstream of the Indian Point plant during the flood tide and a corresponding 50 profiles are located downstream during the ebb, a total of 125 different river locations are profiled during the day of the comparison overflights. The same 25 locations in the immediate vicinity of the plant are occupied on both tides (Figure 5-2).

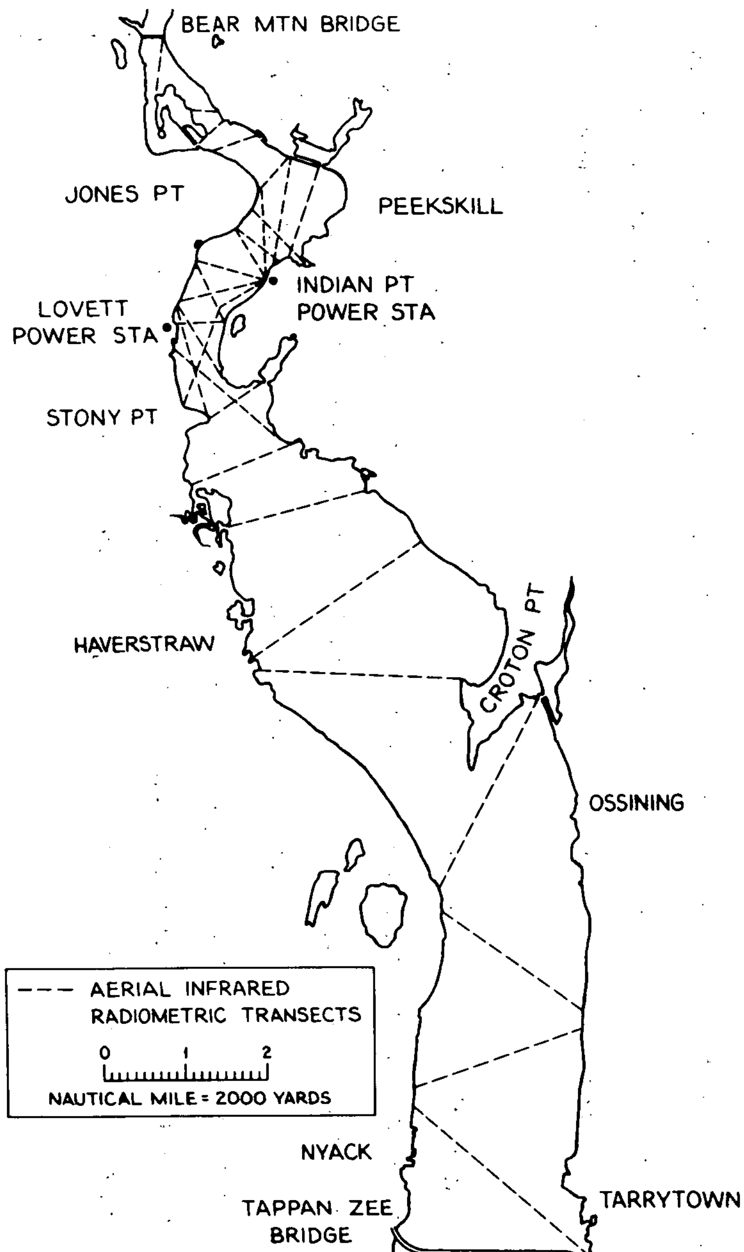


Figure 5-1. Radiometric Surface Temperature Survey Flight Lines

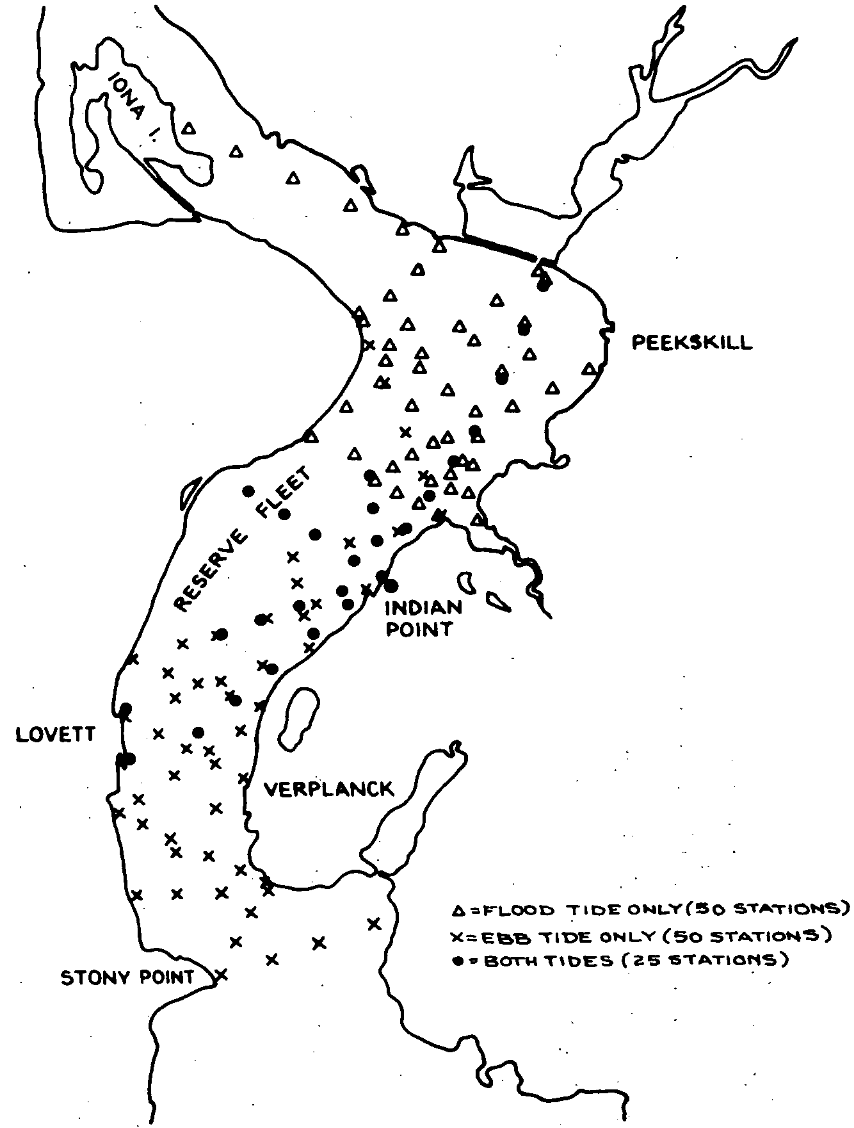


Figure 5-2. Boat-Occupied Bathythermograph Profile Station During Overflights

5.1.1 Monthly Overflights—Results

The surface temperature overflight data from August through December 1969 indicate that the Indian Point plume generally averaged about 600 feet in width. The upstream or downstream extent of the main concentration of heat ranged around 1/4 to 1/2 mile. The thermal plume from the Lovett power station generally exceeded that from Indian Point both in terms of areal extent and surface temperature. While the Lovett plume has a comparable width, its main concentration of heat was observed to have an upstream/downstream range two to three times that of Indian Point. Seasonally the thermal plumes from these two power plants are observed to undergo a general decrease of areal extent with decreasing river temperature.

The surface isotherm map of the ebb tide on 24 September illustrates the type of contour maps produced from the overflight data (Figure 5-3). The original contour map is six times larger than shown herein. Copies of the Indian Point section of each of the original surface isotherm maps have already been included in the monthly reports following each overflight.

The vertical temperature profile data from the boat surveys accompanying the overflights indicated that the river is essentially isothermal during late summer-fall (Figures 5-4 through 5-6). The only significant thermal structure was associated directly with the power plant plumes and, on occasion, certain shoal areas such as Peekskill Bay and Green's Cove. The tidal flow apparently keeps the river well mixed.

5.2 In Situ Temperature Data

The temperature data collected in conjunction with the biological sampling program likewise indicate that generally isothermal conditions exist at each sampling station. The expected exceptions are stations 10 and 15 which are located in the immediate vicinity of the Indian Point and Lovett power stations. Here the differences between surface and bottom temperature range from 0 to 2 degrees F. The average daily power output of the Indian Point plant as a measure of thermal loading to the river is summarized in Figure 5-7. A comparison of the seasonal temperature distributions among the channel stations reveals no marked or consistent temperature differences and likewise suggests rather uniform temperature conditions throughout the study area (Figures 5-8 through 5-15). Even a comparison of the surface

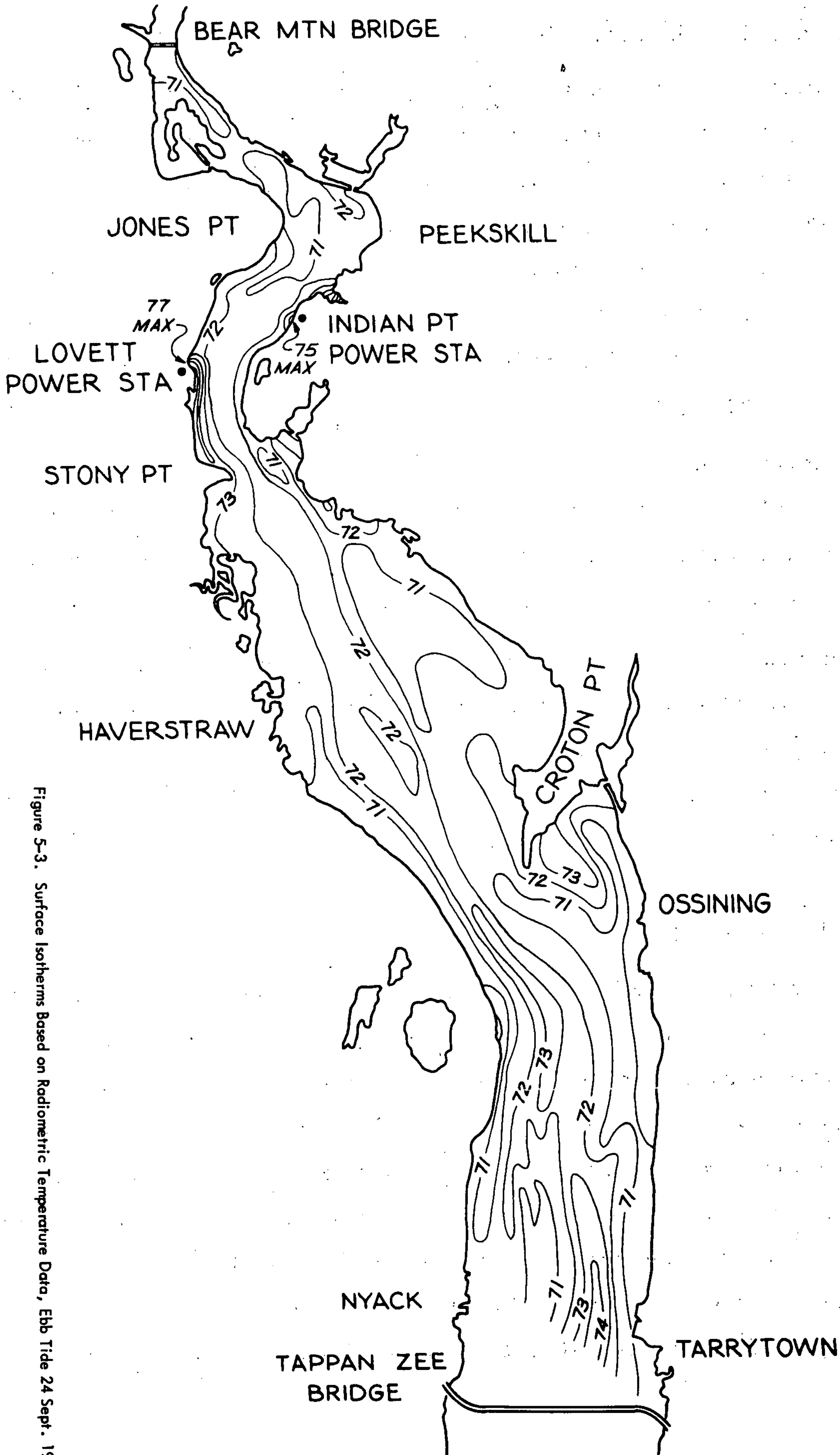


Figure 5-3. Surface Isotherms Based on Radiometric Temperature Data, Ebb Tide 24 Sept. 1969

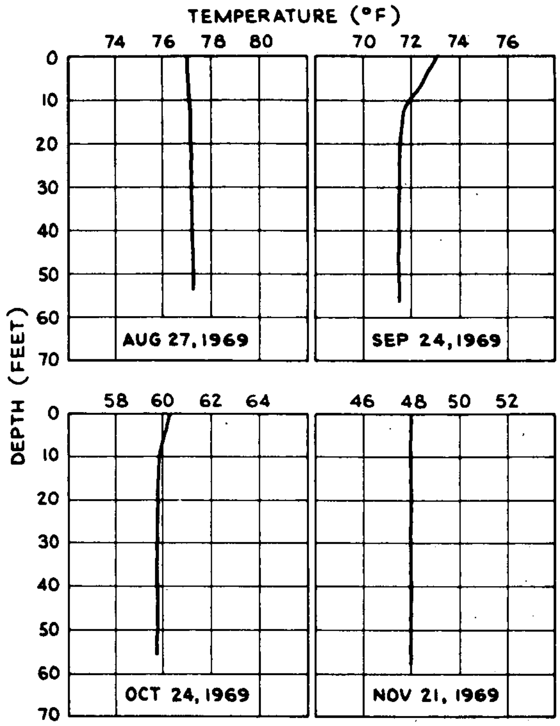


Figure 5-4. Overflight Bathythermograph Profiles Vicinity of Stony Point (Channel Between Stations 15 and 9), Ebb Tide

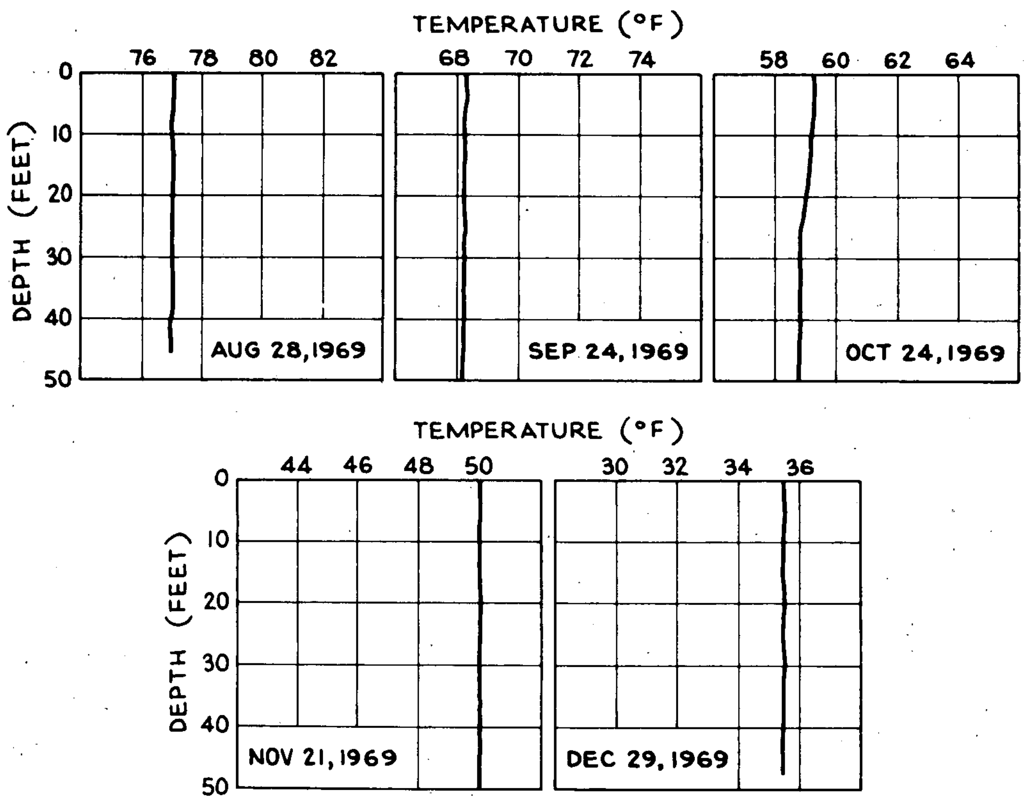


Figure 5-5. Overflight Bathythermograph Profiles Mid-Channel Off Plant Site (Vicinity of Station 11), Flood Tide

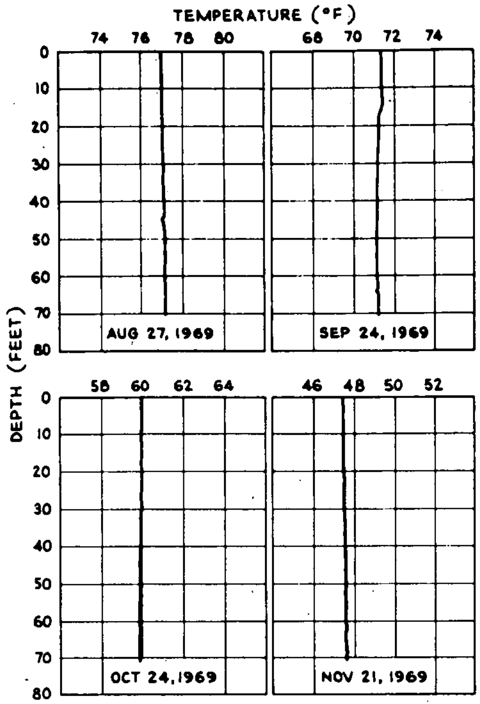


Figure 5-6. Overflight Bathythermograph Profiles South End of Iona Island (Vicinity of Station 13), Flood Tide

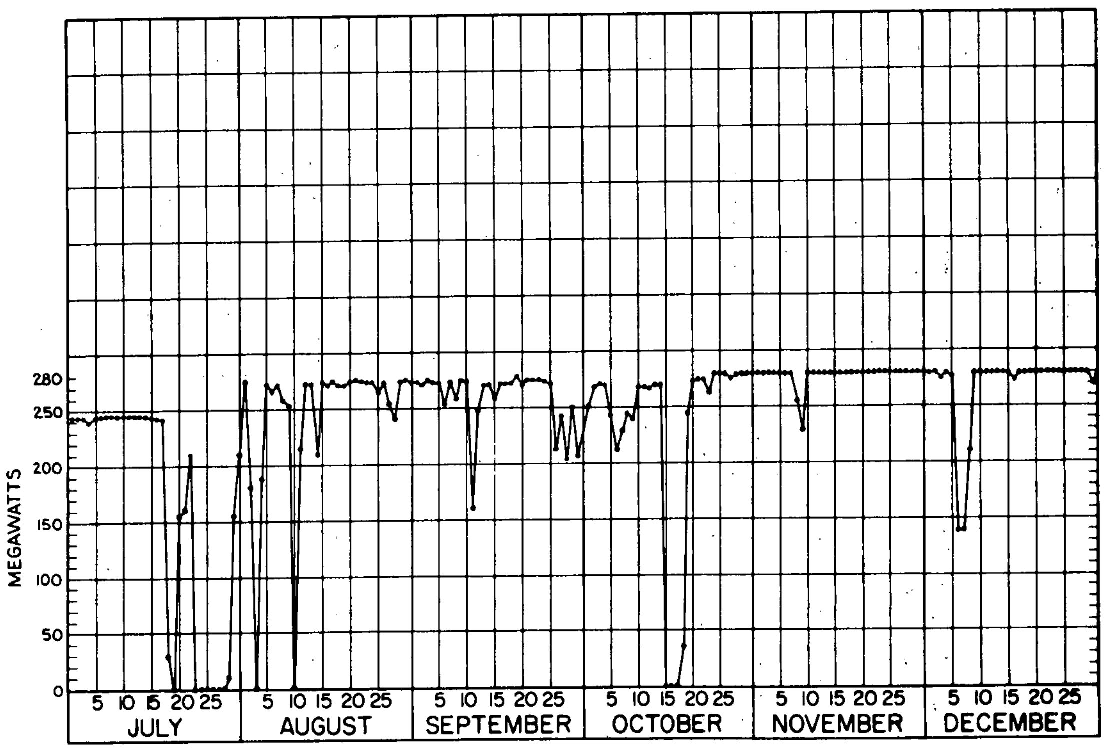


Figure 5-7. Average Daily Output, Indian Point – Unit One

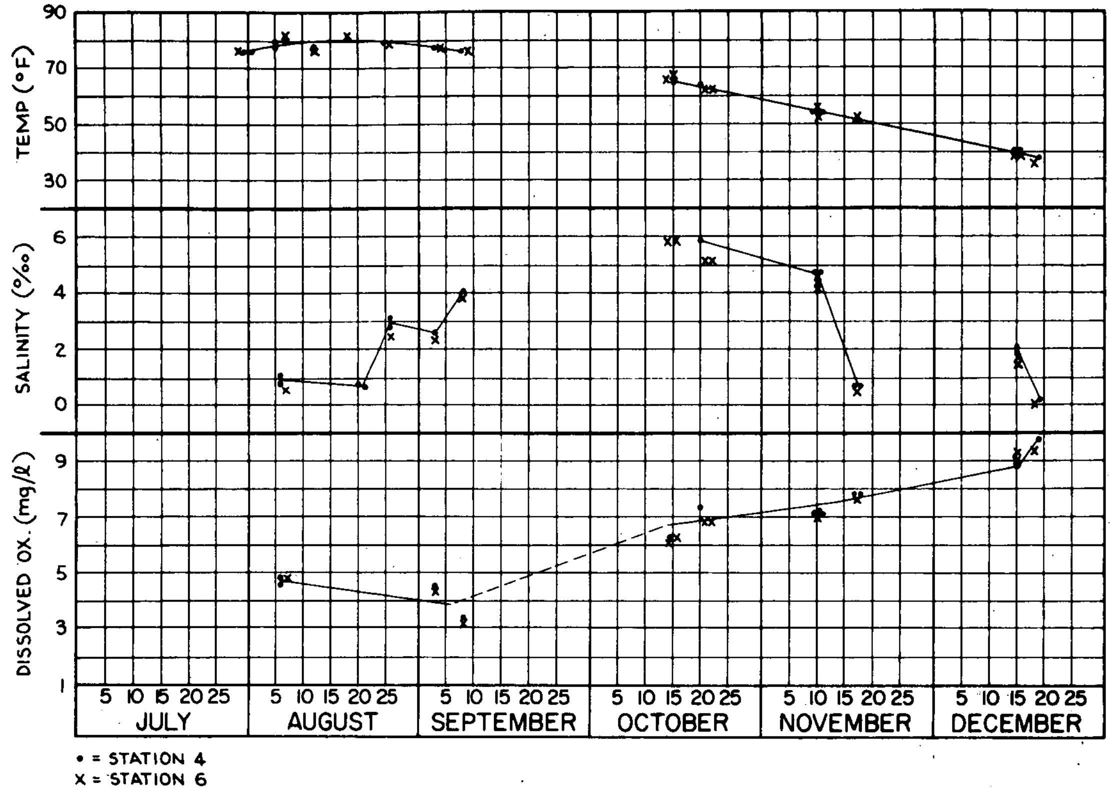


Figure 5-8. In Situ Environmental Data (1969), Collected During Biological Sampling, Surface, Stations 4 and 6

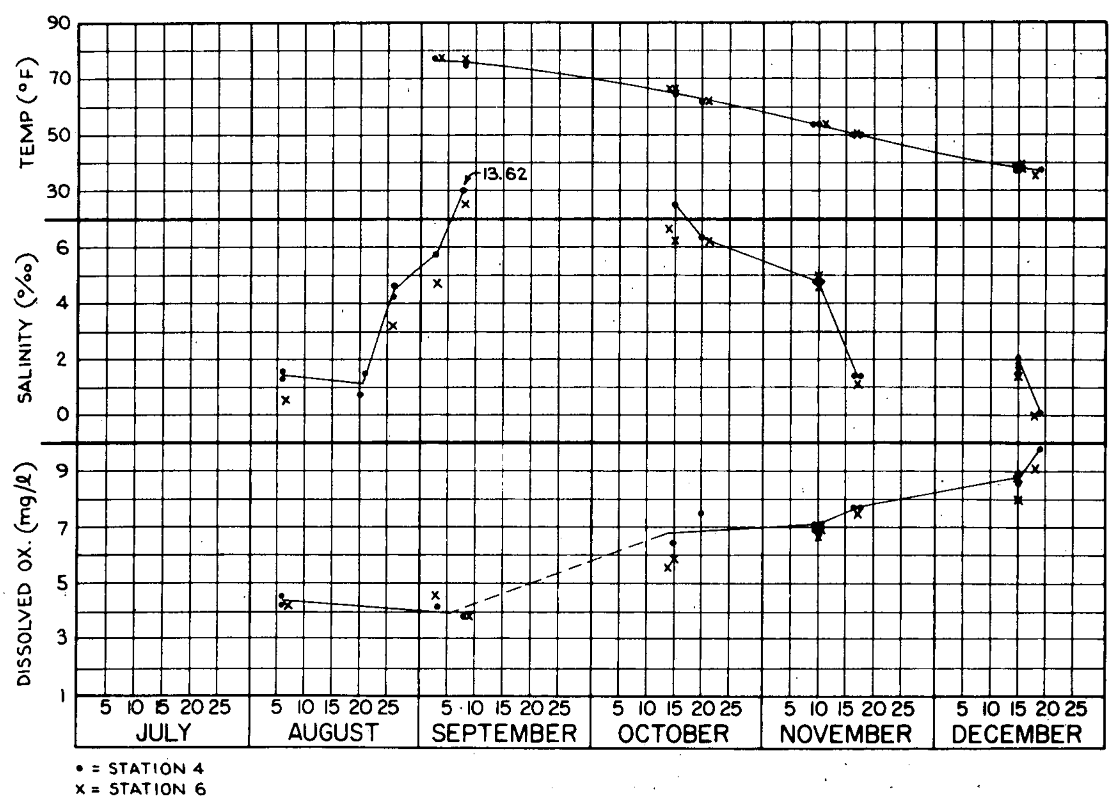


Figure 5-9. In Situ Environmental Data (1969), Collected During Biological Sampling, Bottom, Stations 4 and 6

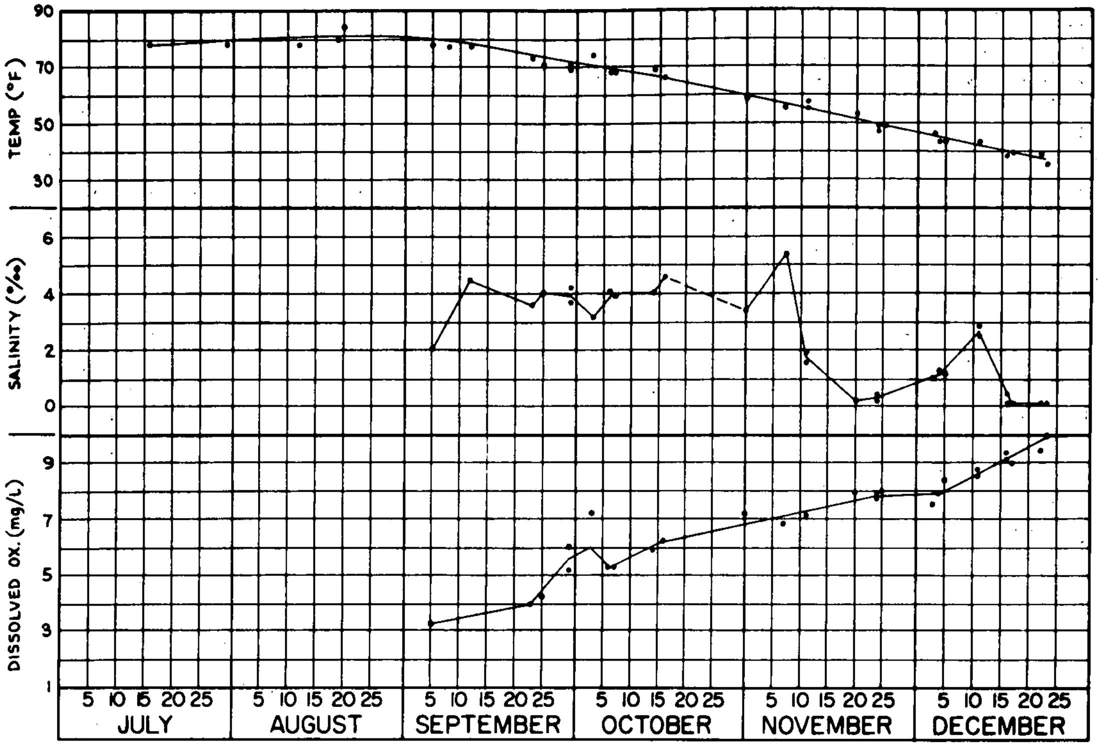


Figure 5-10. In Situ Environmental Data (1969), Collected During Biological Sampling, Surface, Station 10

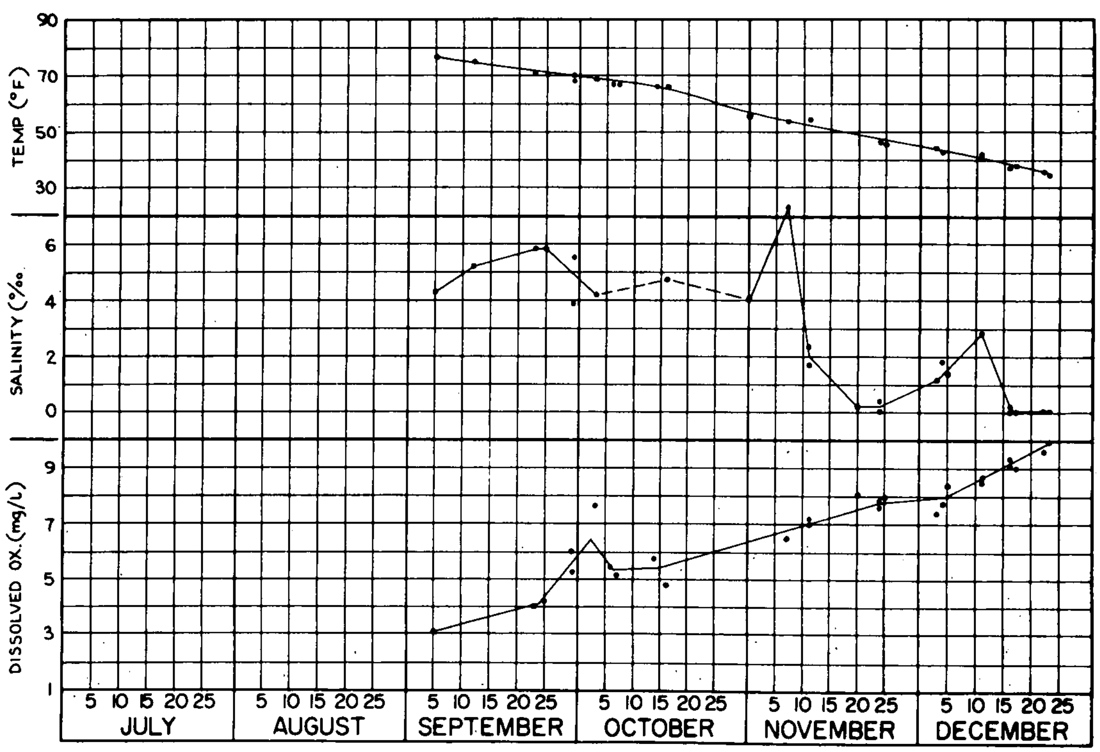


Figure 5-11. In Situ Environmental Data (1969), Collected During Biological Sampling, Bottom, Station 10

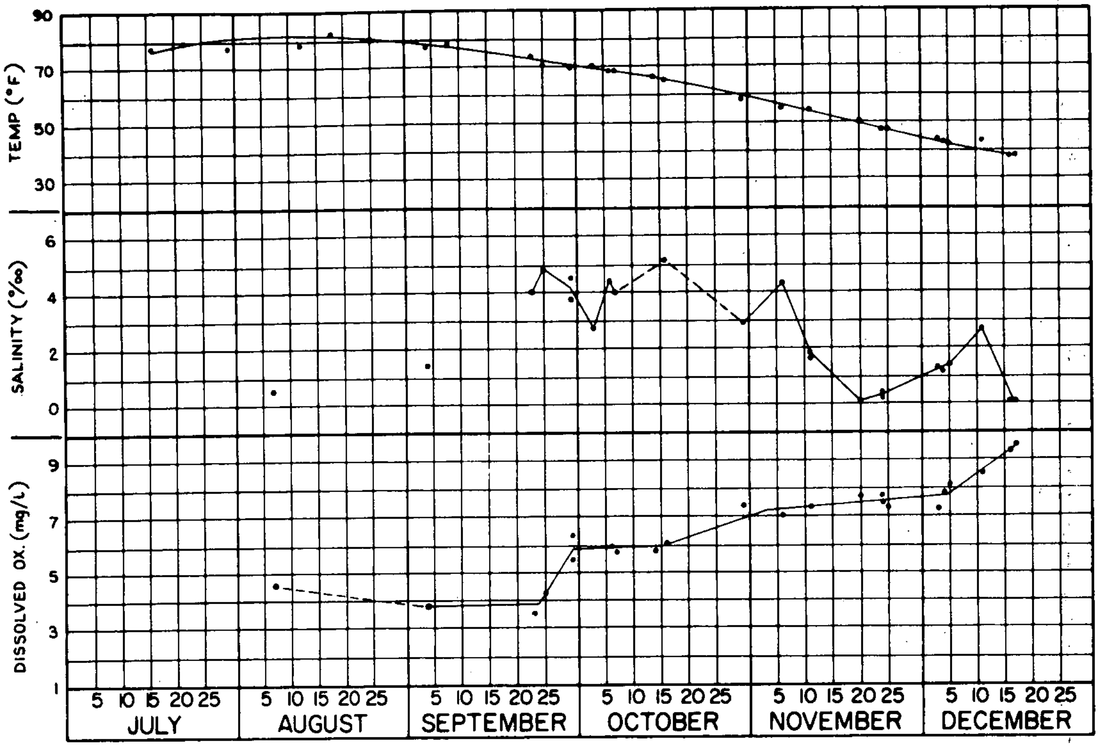


Figure 5-12. In Situ Environmental Data (1969), Collected During Biological Sampling, Surface, Station 11

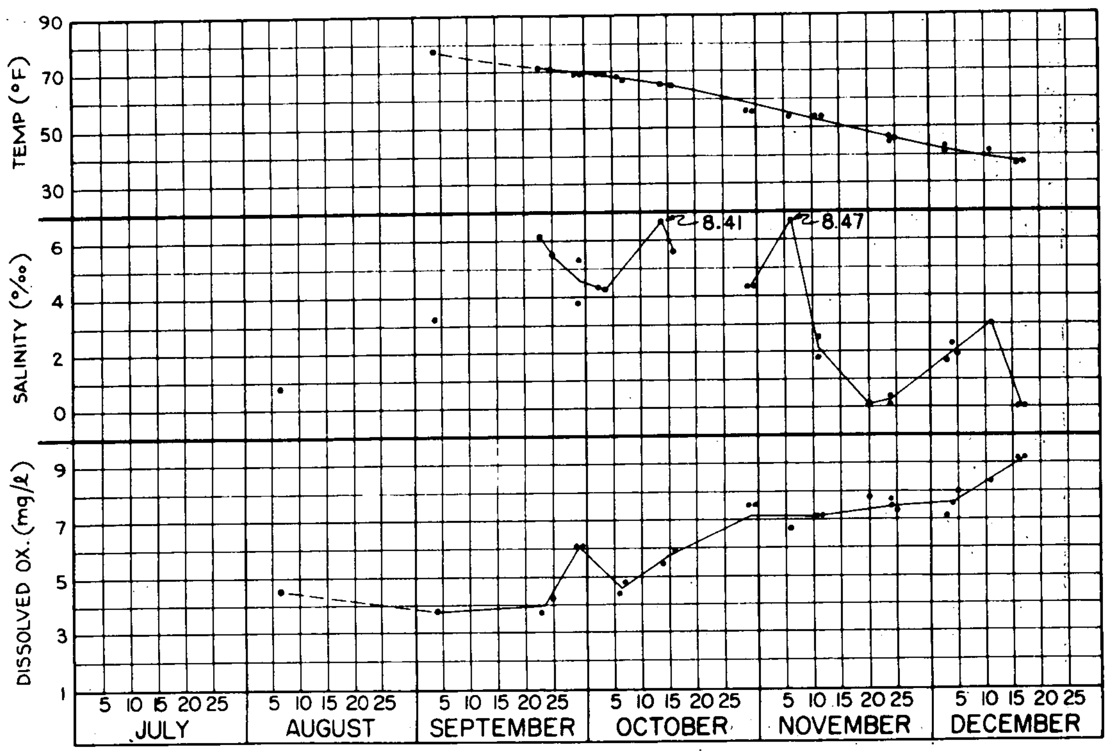


Figure 5-13. In Situ Environmental Data (1969), Collected During Biological Sampling, Bottom, Station 11

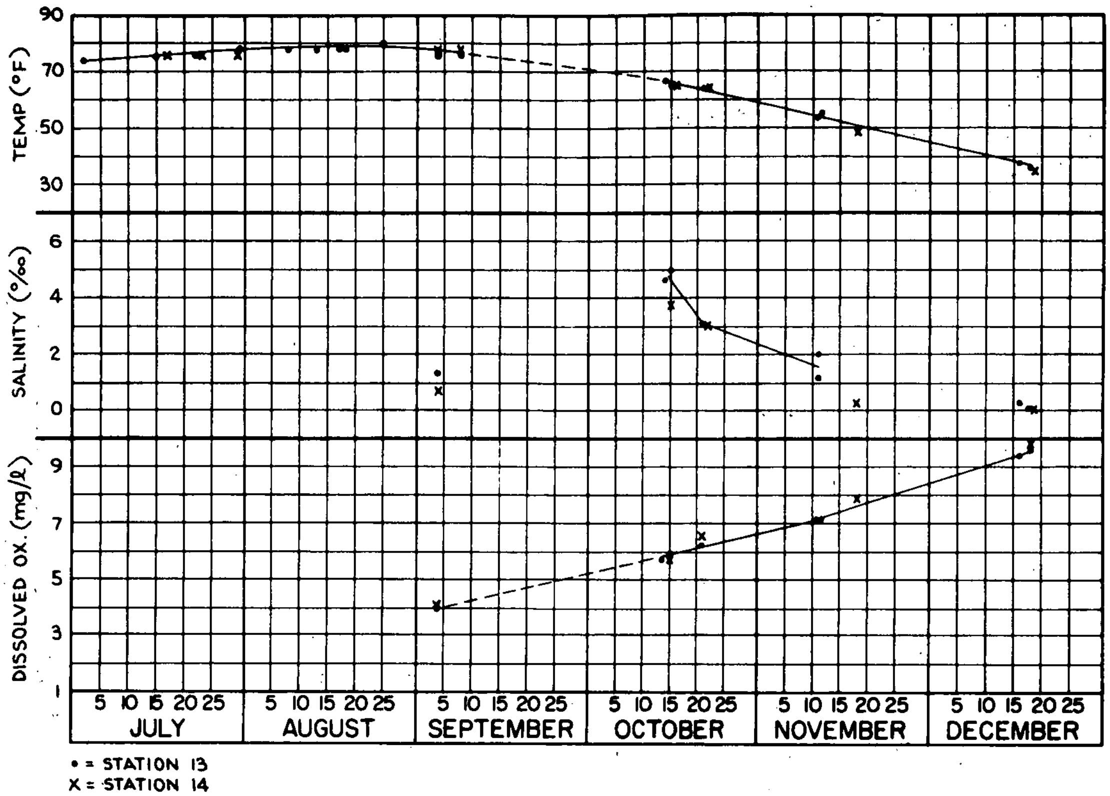


Figure 5-14. In Situ Environmental Data (1969), Collected During Biological Sampling, Surface, Stations 13 and 14

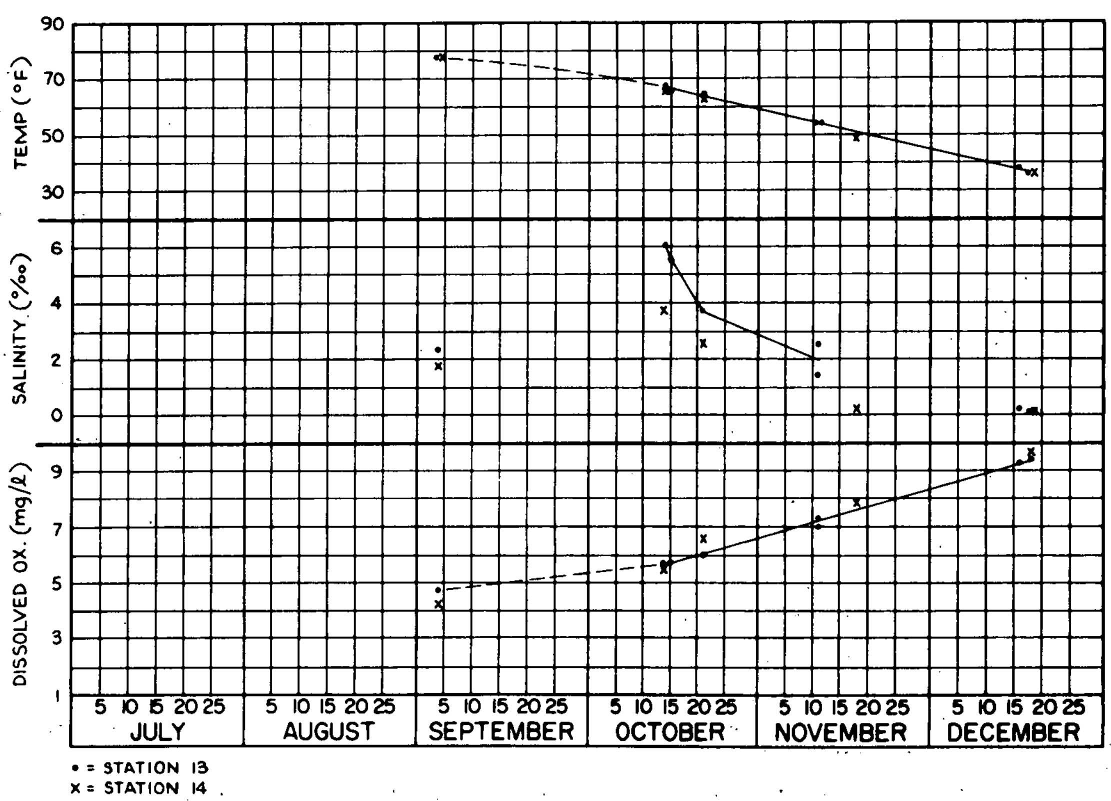


Figure 5-15. In Situ Environmental Data (1969), Collected During Biological Sampling, Bottom, Stations 13 and 14

temperature distribution from lower Haverstraw Bay with the bottom temperatures at the stations in the vicinity of the Bear Mountain Bridge revealed no discernable differences. During 1969, the July, August and early September temperatures ranged about 72 to 82 degrees F with the peak temperatures occurring in August. Thereafter, the river temperature underwent a steady decline of about 10 degrees F per month until it reached 32 degrees F in late December.

5.3 Automatic Environmental Systems (Temperature Data)

An Automatic Environmental Systems (AES) water quality monitoring system (Model SM1200) continuously monitors temperature, dissolved oxygen and pH of the water directly in front of Unit 1 intake at 13 3/4 feet below mean low water. In addition, temperature, dissolved oxygen, pH, salinity and cupric ion are monitored in water pumped directly from the effluent canal from a depth of 5 1/2 feet below mean low water. The data from these 8 probes are individually recorded every three minutes on a strip chart recorder. The system was installed on 30 September.

The temperature data from the AES records appear to indicate a natural recycling of the effluent waters through the intake forebay with the outfall configuration as it existed in the fall of 1969. At this time, the surface outfall was located some 300 feet south of the intake forebay.

Approximately one hour after low slack water, the intake temperature exhibits an abrupt increase of 2.3 to 4.0 degrees F within a period of about 15 minutes (Figure 5-16). This abrupt increase is attributed to the tidal shift of the effluent plume upstream by the incoming tide.

Recirculation of plume water through the plant is suggested by an equally abrupt increase in the temperature (1.4 to 3.1 degrees F) measured at the end of the effluent canal. The smaller increase of outfall versus intake temperatures signifies that ambient river water as well as plume water is being pumped into the plant simultaneously. This increase in the outfall temperature lags that at the intake (Figure 5-16). The main part of the recirculation continues for 3 to 4 hours with the final return to ambient conditions in 5 to 6 hours, again, being tidal controlled.

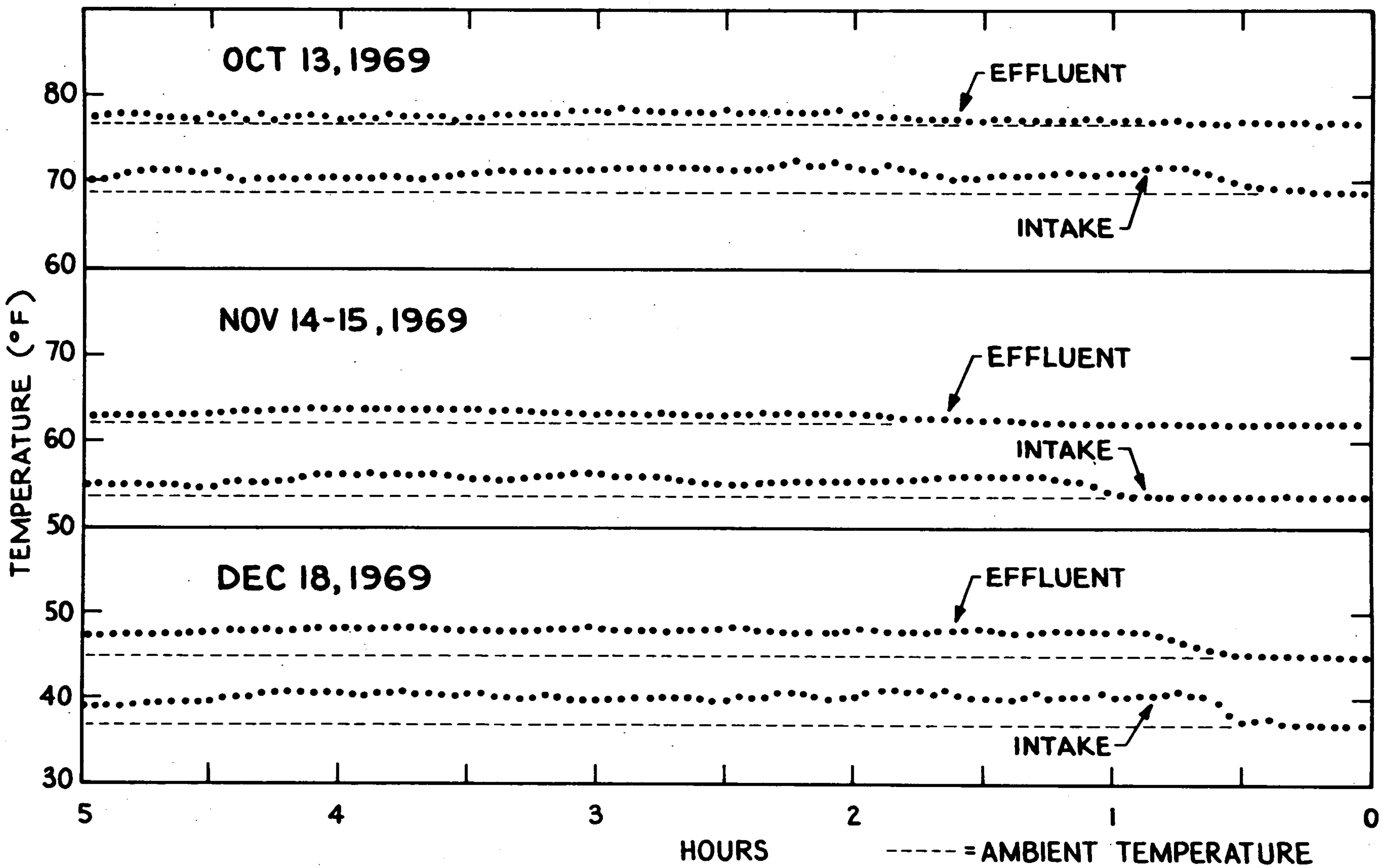


Figure 5-16. Effluent Water Tidal Recycling Tracings (Old Outfall Configuration)

The normal Delta T across the plant with unit 1 in operation averages about 8 to 9 degrees F above ambient. However, under conditions of recirculation this Delta T increases another degree F. The December data indicate somewhat higher Delta T's (11.1 to 11.5 degrees F) than previous months under conditions of tidal recirculation. This situation is probably attributable to the operation of the installed effluent recirculation system (which is used to prevent the icing of the intake screens) in addition to the tidal induced recirculation.

5.4 Intensive Thermal Plume Survey

Intensive three-dimensional mapping of the thermal plume from unit 1 was conducted on 17 and 19 September 1969. This mapping was in preparation for the intended deployment of the thermal chain monitoring systems in the vicinity of the then active outfall located 130 feet south of the southern edge of Consolidated Edison pier. This outfall was closed off in January 1970. The new outfall is now located 890 feet downstream of the pier.

The survey times were chosen to cover a full tidal cycle. Thus the across-river plume extent could be measured at slack water and the up and downstream extent at max ebb and flood currents.

A grid system of 19 polystyrene buoys exhibiting identification markings was deployed to facilitate positive position control of the collected data. A total of 32 electronic bathythermograph profiles were collected on September 17th from max flood current to high slack water; and on the 19th, 49 profiles were made straddling max ebb current. In addition, 20 plume crossings of continuous surface temperature recordings were made following the rectangular coordinates of the buoy grid (Figures 5-17 and 5-18).

The influence of the wind and tide upon the areal dispersion of the heated effluent is readily apparent from a comparison of the surface isotherm maps from September 17th and 19th (Figures 5-19 and 5-20). Under the slight northwest wind (10 mph) and max flood current condition of the recording period of September 17th, the leading edge of the plume (defined as 1 degree F above ambient isotherm) extends 650 feet across-stream and 550 feet upstream. With the high northwest wind (25 mph and gusts to 32 mph) and max ebb current conditions for

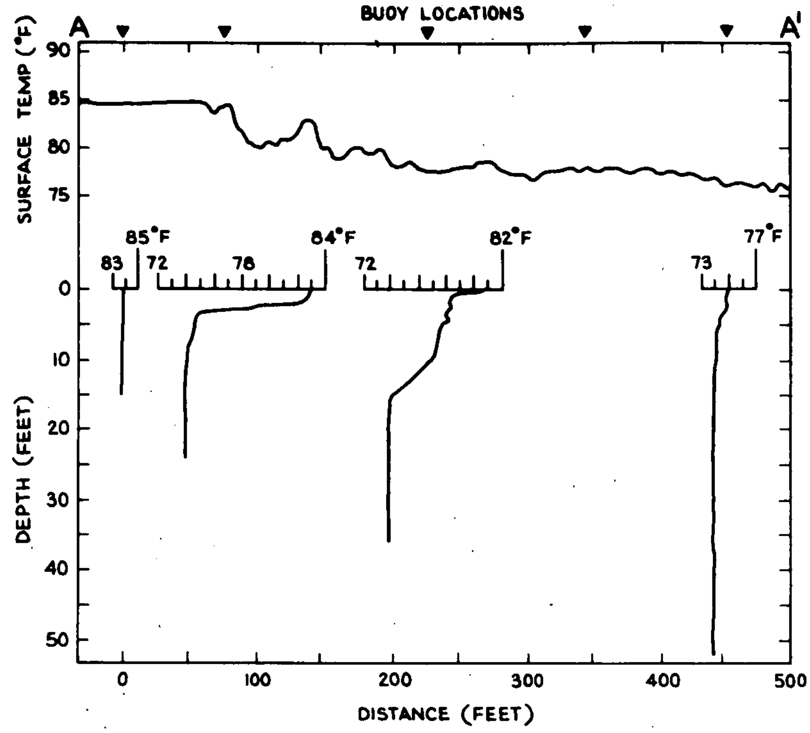
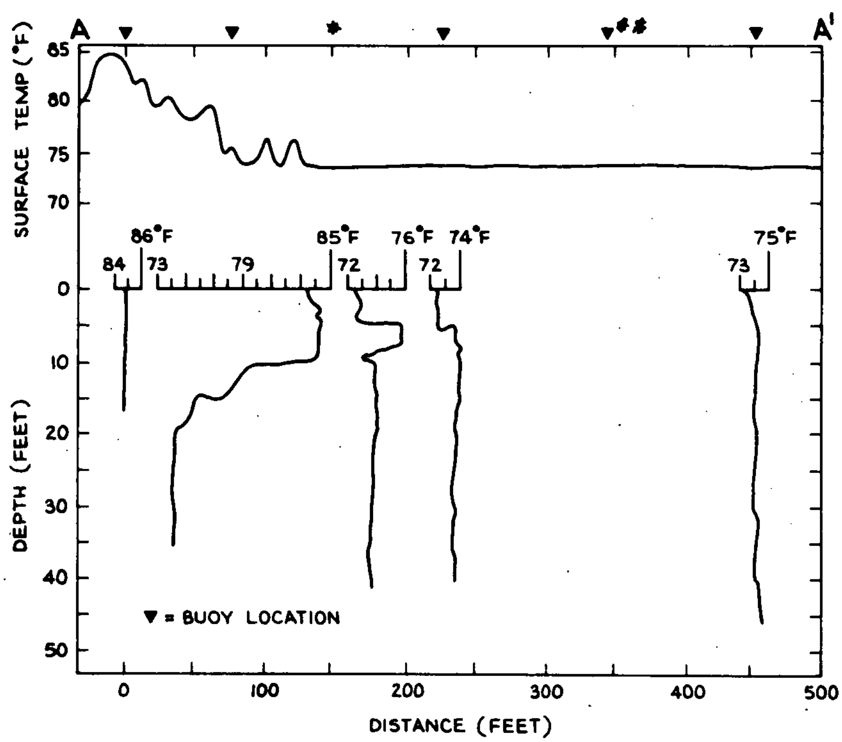


Figure 5-17. Horizontal and Vertical Bathythermograph Data, Unit 1 Plume Survey, 17 Sept. 1969 (at Section A-A', Figure 5-19)



* Profile taken at intermediate point between buoys.

** Profile not taken at this buoy as outside of plume pattern.

Figure 5-18. Horizontal and Vertical Bathythermograph Data, Unit 1 Plume Survey, 19 Sept. 1969 (at Section A-A', Figure 5-20)

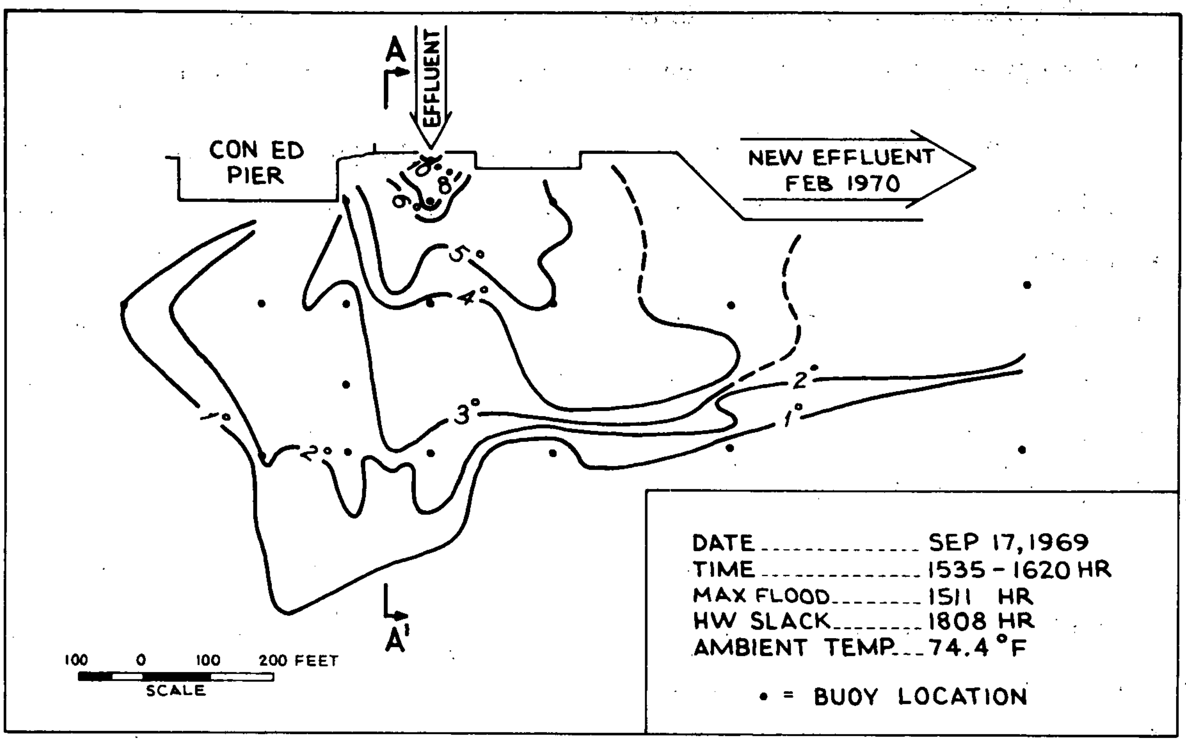


Figure 5-19. Surface Isotherms of Unit 1 Plume

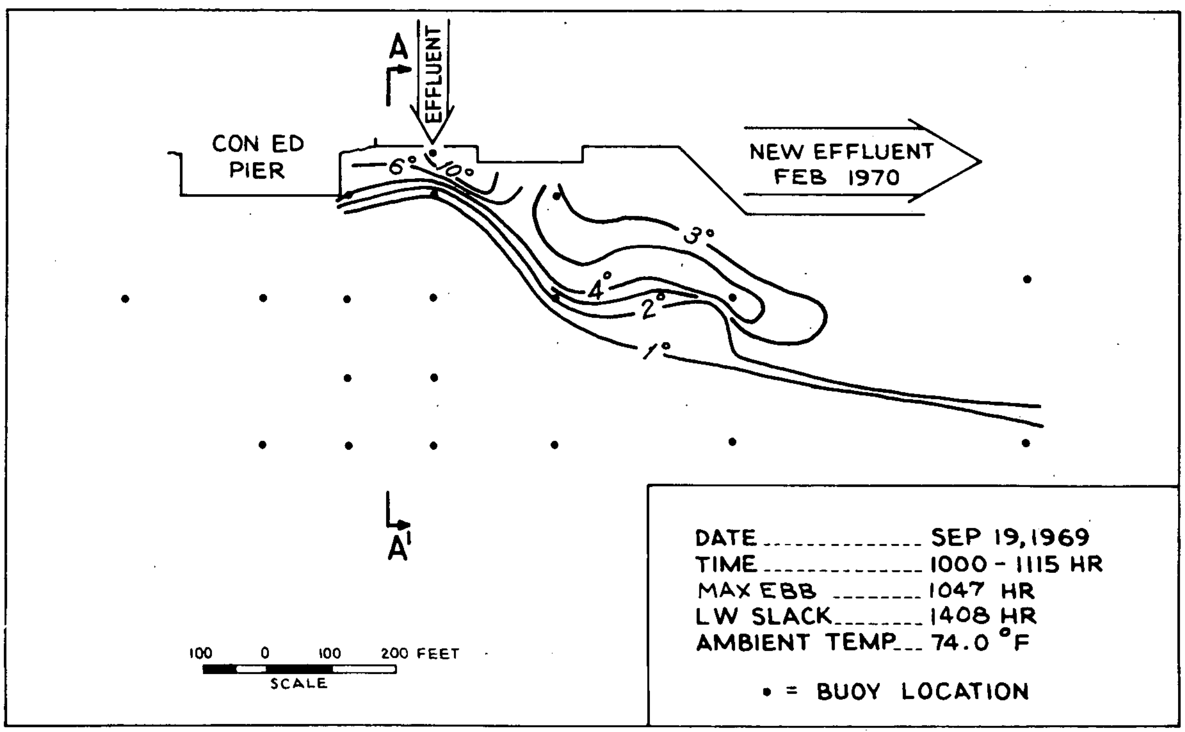


Figure 5-20. Surface Isotherms of Unit 1 Plume

the September 19th recording period, there is no extension of the plume upstream beyond the southern edge of the pier. The across-stream extension was reduced to 450 feet.

While it is probable that these differences in areal extent between the 17th and 19th are more directly related to the inherent tidal changes, the wind does appear to deform the shape of the plume's leading edges. A comparison of the cross sections indicates that the across-river surface expansion of the plume was impeded by the strong northwest wind conditions on the 19th. This resulted in a submerged tongue of effluent water which protruded in the direction of the river channel some 40 feet in length. The cool wedge above the tongue had a maximum depth of 4 feet (Figures 5-21 and 5-22).

From this two-day survey, it is observed that the leading edge of the plume did extend as much as 650 feet across-stream and the depth to the base of the heated effluent never exceeded 15 feet once the plume left bottom in the immediate vicinity of the outfall.

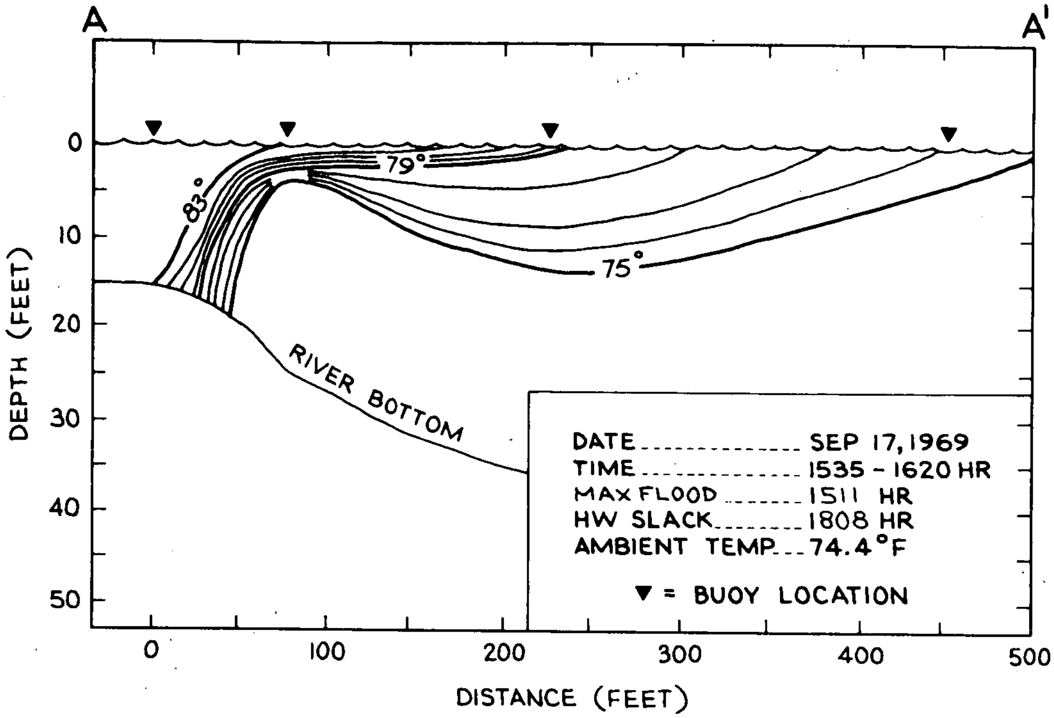


Figure 5-21. Vertical Cross-Section of Unit 1 Plume Along Transect A-A'

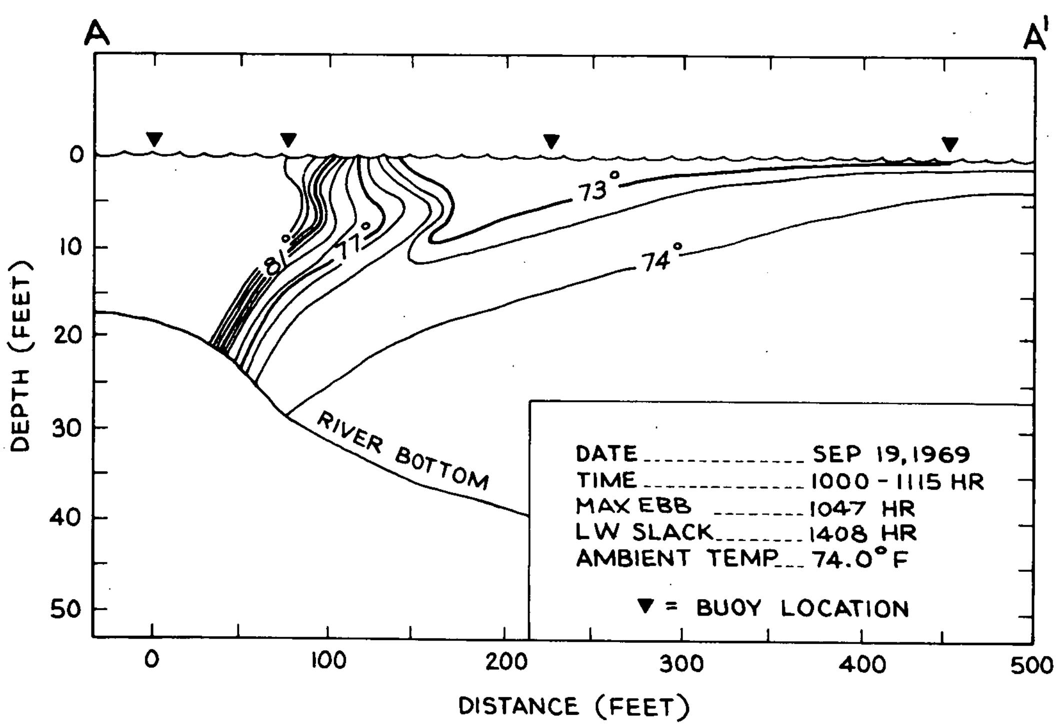


Figure 5-22. Vertical Cross-Section of Unit 1 Plume Along Transect A-A'

6.0 WATER CHEMISTRY

6.1 Salinity

Salinity is perhaps the most variable parameter within the study area. There are tidal, daily and seasonal variations. For example, in the vicinity of Indian Point the tidal fluctuations of salinity may range around 1 to 1.5 ppt, whereas the salinity may vary several parts per thousand over a few days and as much as 5 to 7 ppt from early to late fall (reference Figures 5-8 through 5-15).

6.1.1 Salinity—In Situ Data

The salinity data collected in conjunction with the biological sampling program indicate that the bottom waters are generally more saline than the surface, which is to be expected in an estuary. However, the difference is usually less than a part per thousand. Occasionally differences of 1 to 2 ppt are observed between the surface and bottom salinities at the deeper channel stations, particularly in the warmer months when the salt front tends to be located north of the study area (Figures 5-8 through 5-15). There is a south to north decline in both surface and bottom salinity of 2 to 4 ppt during the warmer months. This river mile gradient is greatly reduced under conditions of low salinity characteristic of the colder months.

On the basis of bottom salinity data, the salt-water front appears to have temporarily retreated south of Indian Point (stations 10 and 11) around November 20th but remained north of upper Haverstraw Bay (station 6) where bottom salinities of about 1 ppt were still being recorded. This retreat is attributed to extensive local rainfall (cumulative 2.4 inches) and major discharges over the Federal Dam at Troy, New York, during early November (Figures 6-1 and 6-2). This cycle of rainfall and major discharges over the Federal Dam followed by marked drop in bottom salinities occurred again in December. By the 18th of December the salt-water front appears to have retreated to the southern end of the study area as bottom salinities of 0.16 and 0.07 ppt were recorded at stations 4 (river mile 35) and 6 (river mile 38), respectively.

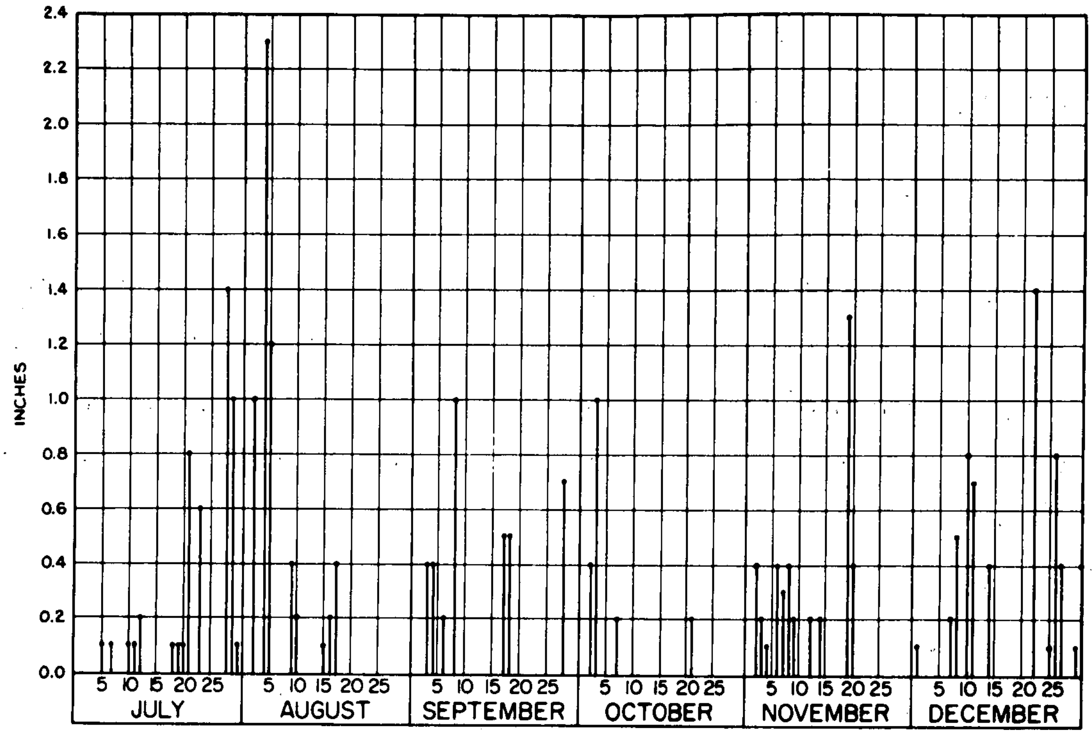


Figure 6-1. Rainfall Recorded at Peekskill Waterworks (1969)

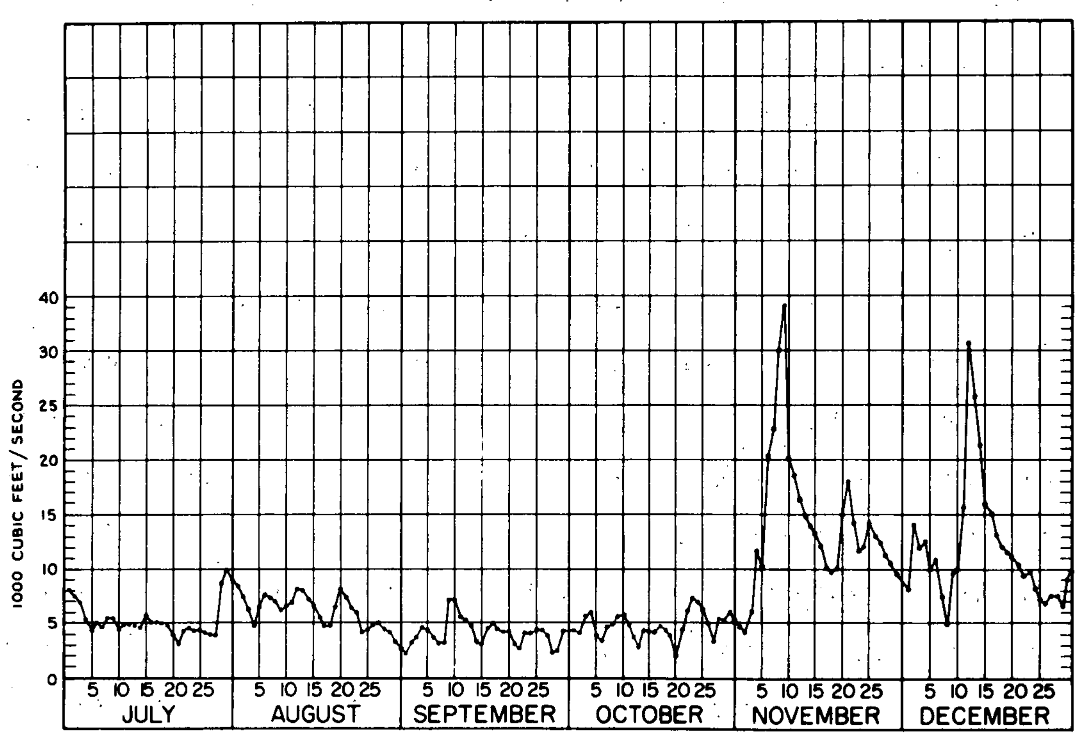


Figure 6-2. Average Discharge Over Federal Dam at Troy N.Y. (1969)

6.1.2 Salinity—Automatic Environmental Systems Data

Unlike temperature, salinity readings never really stabilize to the point where one can speak of ambient conditions. Rather, salinity varies with a low amplitude sinusoidal rhythm that mirrors that of the tide with salinity maxima occurring about 12 hours apart. The salinity minima occur about an hour after low slack. The abrupt increase in intake forebay temperature at this same time (which signals the turn of the tide) likewise marks the onset of increasing salinity (Figure 5-16).

The tidal induced salinity fluctuations are very apparent on the AES records. For example, on October 13 through 14 the salinity readings at the outfall were seen to vary from 4.84 to 3.70 to 5.16 to 4.00 to 5.00 to 3.75 to 4.80 ppt. This tidal variation of 1.0 to 1.5 ppt accounts for much of the scatter observed in the in situ data.

The AES salinity data supplements as well as confirms the seasonal trends observed in the in situ data (Figures 5-8 through 5-15). For example, the AES data indicate that it was mid-day on 8 November when the river salinity began a major decline from around 4 ppt to around 0.5 ppt early on the 15th. Values of 0.1 to 0.2 ppt persisted until the evening flood tide on 2 December brought in a major influx of saline water with peak values of 1.7 ppt. In succeeding days salinities of 2 to 3 ppt were recorded, but on the evening of 11 December, the river salinity again declined and thereafter generally averaged less than 0.5 ppt.

6.2 Dissolved Oxygen

6.2.1 Dissolved Oxygen—In Situ Data

The dissolved oxygen data collected in conjunction with the biological sampling program indicate that the surface values, in general, are slightly (0.1 to 0.4 mg/l) higher than the bottom concentrations. Yet, in many instances the surface and bottom concentrations are equivalent (Figures 5-8 through 5-15). There are no marked or consistent river mile gradients in the dissolved oxygen concentrations among the channel stations.

Seasonally, a very distinct and inverse correlation occurs between the dissolved oxygen and the temperature parameters. Opposed to the steady decline of temperature throughout the fall months is a steady increase of dissolved oxygen from about 4 mg/l in September to values approaching 10 mg/l in late December. The August dissolved oxygen minima appear to stabilize at values between 4 and 5 mg/l (ppm).

The observed dissolved oxygen values are consistently far below saturation values.

6.2.2 Dissolved Oxygen—Automatic Environmental System Data

Like temperature, the dissolved oxygen concentrations are fairly stable on a daily basis. Minor semicycle fluctuations of generally less than 0.2 parts per million (ppm) occur within a day's record but there is no consistent correlation with tidal rhythm. On occasions, slight decreases in dissolved oxygen are noted by the intake probe and seem to be associated with the onset of tidal ebb currents. This suggests a source of increased BOD upstream of the plant.

There is generally a significant drop in dissolved oxygen across the power plant. For example, in early November the intake concentrations ranged around 5.3 ppm whereas at the outfall the values ran around 3.7 ppm for a Delta D.O. of minus 1.8 ppm. Yet, in both instances, the observed values were less than 50% of the potential saturation values. Thus, the decreased saturation limits normally associated with an increase in heat do not seem to account for the drop in concentration.*

6.3 pH—Automatic Environmental System Data

The pH readings are quite stable over long periods of time with reliable readings seldom recorded below 7.0 or above 8.0. Generally, the intake pH averages about 7.2 and the outfall pH about 7.4.

* Standard Methods for the Examination of Water and Waste Water, 12th Edition, 1965. American Public Health Association.

There are on occasions curious dips in the outfall pH readings which show no obvious correlation with any internal plant operations investigated, e.g., chlorination. These characteristics, sawtooth-shaped dips of 0.5 pH units, last about 30 minutes and occur erratically about once every day or so.

7.0 FIELD BIOLOGY

7.1 Introduction

There are two main levels from which ecological changes can be evaluated. One is at the individual species level in which environmental changes can be evaluated as to their significance for a particular species. This is the concept of key species and it is generally applied to those species considered of critical importance from one or more aspects, e.g., commercial, recreational, aesthetic, biological, etc.

The second concept involves the evaluation of environmental changes from the perturbations they produce at the community level. Under this concept, environmental modifications are signalled by shifts in both the kinds and amounts of organisms living in an area. These community shifts can be recognized by monitoring such parameters as the compositional similarity among stations, the total number of species caught and species diversity.

7.2 Sampling Gear (Procedures)

A variety of methods were employed in sampling fish populations during the first six months of the project. Emphasis was placed on trawling (bottom and surface) and beach seining, with limited gill netting. Mid-water trawling (with gear inherited from the Cornwall Project) was attempted without success.

Water temperature, weather conditions, dissolved oxygen and salinity were recorded with each collection.

7.2.1 Bottom Trawls

Bottom trawls (25-foot semiballoon trawls) were constructed as follows: 26-foot headrope; 31-foot footrope; nylon net, 1-1/2 inch stretch mesh, no. 9 thread body; 1-1/4 inch stretch mesh, no. 15 thread codend, rigged with an inner liner of 1/4-inch stretch mesh, no. 42 knotless nylon netting; head and footropes of 3/8 inch diameter Poly-dac net rope with legs extended 4 feet and wire ring thimbles spliced in at each end; six 1/2 x 3-inch Ark floats spliced evenly on center bosom of headrope; one-eighth inch galvanized chain hung loop style on footrope; net treated in green copper net preservative on completion; trawl boards (doors), 36 inches in length and 17 inches in width.

Bottom trawls were routinely made at 16 stations between Tappan Zee and Bear Mountain Bridges from June through December 1969. Initially, the trawl duration was 10 minutes, but was changed to 7 minutes on August 8, 1969 because of large catches of fishes. Seven-minute tows at 4 knots cover a distance of approximately 1/2 nautical mile. Tow speeds varied between 3 and 4 knots depending on bottom types and the current. Direction of the tows were opposite the tidal current except at slack tide when tows are made upstream (because of the net downstream flow of water) or when strong winds made it difficult to tow against the current. Towing against the current provides for easier retrieval of the net if it becomes snagged on an underwater object. For each one foot of river depth, 3 to 3 1/2 feet of towing cable is used depending on current velocity and bottom type.

7.2.2 Surface Trawls

A semiballoon bottom trawl was converted to a surface trawl in the following manner: 1) invert net, 2) remove chain on footrope and replace it with floats from headrope, 3) replace headrope floats with 2-oz. lead weights, and 4) tie floats to the doors.

Surface trawls were made from August through December at the same stations set up for bottom trawling. Tows were 10 minutes in duration along a sinuous course at approximately 3 knots in a southerly or northerly direction against the direction of tidal flow or high winds. Two hundred feet of towing cable (to the gantry) are used in addition to the 40-foot bridles.

7.2.3 Beach Seines

A 75' x 8' x 1/4" square mesh seine without bag was used in June, July, August and early September, at which time a 100' x 10' x 3/8" square mesh seine with 1/4" square mesh bag arrived on site. Seine collections since September 10, 1969 have been made with the 100-foot seine. Seine collections with the 75-foot net were made by 2 men wading to depths of 4 feet.

The collections with the 100-foot seine were made by setting the net in a semicircle 30 to 50 feet from shore from an outboard motorboat, generally the small Boston Whaler. The opening of the semicircle is toward the shore and the net is hauled to the shore by hand.*

7.2.4 Benthic Grabs

The Emory type bottom grab covers an area of 250 cm^2 (5" x 8" = 40 in^2) when the jaws are fully opened and has a capacity of 2500 cm^3 (160 in^3); in appearance, this apparatus resembles half an elliptical cylinder. This grab was used to collect the monthly benthic samples from August through December. Each sample was fixed in neutral Formalin and then washed on a 0.3 x 0.5 mm mesh screen. The organisms were retained and later identified and counted with the aid of a binocular microscope.

7.2.5 Zooplankton

Monthly surface and bottom zooplankton collections in 1969 were made at channel trawling stations. A half-meter, 0.3 x 0.5 mm mesh net (not metered) was used. The plankton collections were fixed in 5 percent neutral Formalin and counted with a Sedgwick-Rafter cell, Whipple disk and binocular microscope.

7.2.6 Succession Panels and Thorson Bottles

Materials - The succession panels were made of white pine. Panels measuring 1" thick, by 4" wide by 10" long were used for the sampling period from 20 August, 1969 to 18 September, 1969. From the period of 18 September, 1969 through 7 January, 1970 the panels used were 1 x 5 x 8 inches in dimension.

The panels were secured to a 2 x 2-inch strip. The strip was made into a cross with the panels secured to the horizontal arm; the vertical arm was attached to a mooring line by means of half-inch steel staples.

Thorson bottles were modified from commercially available 1 quart polyethylene containers. Each container measured 5-1/2" h by 4" w by 4" l. A 2-1/2-inch diameter hole was cut in the top of the container to enhance retention of settling organisms.

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* Due to the change in gear from 75- to 100-foot seines, it is not possible to precisely compare the June to mid September data with those from mid-September through December.

This apparatus was used in the following manner. Each set of panels was hung by a quarter-inch nylon or polypropylene line from an existing structure at various river locations. The line was secured at the river bottom by use of cement mooring blocks. No slack was allowed in the anchoring line in order to make the panel as stationary as possible.

The first group of panels was set 21 August 1969 and collected 22 September 1969. At stations 7, 13, 51 and 53 a single panel was set 4 feet below the mean low water mark and a single panel was set 4 feet from the bottom. At the surface and bottom of each station, a Thorson bottle was attached to the vertical support, below the horizontal arm, by means of vinyl tape. Thorson bottles were collected from stations 7, 13, and 53 in September.

A completely new set of panels and Thorson bottles was set out October 1, 1969. Each set of panels had four panels mounted in the same fashion as the panels used in September. Stations numbered 51, 53, 54, 55, 56 and 57 were occupied at this time (Figure 3-1). Again the panels were mounted 4 feet below the mean low water mark and 4 feet from the bottom. If a station has 12 feet of water or less at mean low tide, only one panel was placed at 4 feet from the bottom.

Thorson bottles were employed only with the bottom panels at each station. At each station, of the four panels in each set, one was collected 11 November, one collected 1 December, one collected 6 January 1970 and one collected 31 March 1970. The Thorson bottles were replaced when 11 November samples were taken; this procedure was repeated again on 1 December. When the Thorson bottles were collected on 6 January 1970, they were not replaced.

7.3 Results on the Species Level

7.3.1 General

Monthly averages by species of individuals caught per unit effort per gear type reveal the overall spatial and seasonal distributional patterns for the species collected within the study area. These data also provide a basis for evaluating the effectiveness/selectivity of the various gear types for each species. These monthly averages represent the grand average of all the individual station averages of number caught per unit effort.

Numerically and in declining order the most important finfish species within the study area are the bay anchovy, white perch, striped bass, tomcod, alewife, blueback herring and hogchoker (Tables 7-1 through 7-3). During the summer through fall of 1969, these seven species constituted 95 percent of the fish caught in the bottom trawls, 98 percent of those in the surface trawls and 70 percent of the fish netted in beach seines. Forty-three fish species were recorded during this time interval (Table 7-4). The species codes used follow those of the Cornwall Project. (Jensen, A.C., Editor. 1970 Hudson Fisheries Investigations 1965-1968. Hudson River Policy Committee, c/o New York State Department of Environmental Conservation).

Spatially, the river herrings, alewife and blueback are the most ubiquitous species. They are caught in significant concentrations by surface trawls, bottom trawls and seines and, thus, are important constituents of both the river and shore-fish populations. Conversely, the fact that the Atlantic silverside and the spottail shiner compose 23 percent of the beach seine catch but only minor portions of the trawl catches implies that these are important shore species. Since the two river herrings and the bay anchovy comprise 97 percent of the surface trawl catch, these are obviously pelagic species. That these pelagic species also comprise 54 percent of the bottom trawls can partially be explained as a result of bottom trawling with a six-foot deep net in the shoal areas 10 to 12 feet deep. Moreover, since this type of trawl continues to fish both during the setting and retrieving phases of a tow, pelagic species are also caught in the deeper-water bottom trawls.

Seasonally, the June through December data indicate that both higher abundances and total number of species are found in the fish populations during the late summer through early fall (August to October) as shown in Tables 7-1 through 7-3. The highest total number of species occurred in October for all three types of gear (surface trawls, bottom trawls and seines) which collected 21, 26 and 28 species, respectively.* Although 30 species were collected in the August bottom trawls, 4 of these species occurred only once during the month and not at all in the preceding or succeeding months. Moreover, 3 of the 4 species were represented by only single specimens. That this peaking of number of species in all three gear types in October that cannot be attributed directly to a fluctuation in sampling effort (Tables 4-3 and 4-4) lends support to the biological validity of this trend as well as to the adequacy of the baseline sampling intensity. A marked decrease in the overall abundance and number of species, particularly in the surface and shoal water fish populations, is observed during November and December.

* Only insignificant numbers of surface trawl samples were collected before September (Table 4-3).

Table 7-1. Average Number Caught/7 Minutes, Grand Average of Station Averages (Bottom Trawls)

Species Code	Species Name	1969					
		June/ July	Aug	Sept	Oct	Nov	Dec
* 1	Alewife	43	138	72	50	11	1
2	Bay anchovy	41	783	691	26	P	P
* 3	American shad	P	P	P	P	P	
4	Bluefish	P	P	P	P		
5	Bluegill		P	P		P	P
6	Brown bullhead	P	P	P	P	1	P
7	Pumpkinseed	P	P	P	P		P
9	Carp		P	P	P	P	
10	American eel	11	10	9	17	6	P
11	Goldfish				P	P	
12	Golden shiner		P	P	P		
13	Hogchoker	5	10	38	31	157	12
14	Johnny darter	1	1	P	P	2	3
15	Banded killifish						
18	Mummichog						
19	Menhaden, Atlantic		P	2	10	P	
*22	Blueback herring	1	34	3	56	11	P
23	White sucker	P	P			1	1
24	Atlantic silverside		P		P	P	
25	American smelt	14	18	5	4	9	1
27	Shortnose sturgeon		P			P	
28	Spottail shiner	2	6	6	2	4	35
29	Atlantic sturgeon	P	P	P	1	1	P
*30	Striped bass	118	84	55	86	23	6
31	Fourspine stickleback		P				
*32	Atlantic tomcod	115	76	34	35	76	38
34	White catfish	P	P	P	P	2	P
*35	White perch	35	52	56	80	117	117
36	Yellow perch	P	P	P	P	P	1
39	Northern pipefish	1	P	P	P		
41	Atlantic needlefish						
42	Crevalle jack	P	P	1	P		
45	Weakfish	1	1	2	1	P	
70	Sturgeon, unidentified	P	P				
72	Winter flounder	P					
Miscellaneous							
21	Chain pickerel		P				
74	Lamprey, sea						P
TOTAL SPECIES		23	30	25	26	24	19

Note: unidentified not included in total species count
* = "key" species
P = presence less than 1

Table 7-2. Average Number Caught/7 Minutes, Grand Average of Station Averages (Surface Trawls)

Species Code	Species Name	1969 June/July	Aug	Sept	Oct	Nov	Dec
* 1	Alewife		32	18	9	13	P
2	Bay anchovy		146	157	151	P	
* 3	American shad		P			P	
4	Bluefish						
5	Bluegill						
6	Brown bullhead						
7	Pumpkinseed		P		1		
9	Carp			P			
10	American eel			P	P	P	P
11	Goldfish				P		
12	Golden shiner						
13	Hogchoker			2	P	P	
14	Johnny darter				P		
15	Banded killifish				1		
18	Mummichog						
19	Menhaden, Atlantic		P	1	13	P	P
*22	Blueback herring		4	15	33	65	2
23	White sucker				P		
24	Atlantic silverside				P	P	
25	American smelt		2	1	P	P	P
27	Shortnose sturgeon						
28	Spottail shiner		1		P	P	
29	Atlantic sturgeon						
*30	Striped bass		P	P	2	P	P
31	Fourspine stickleback						
*32	Atlantic tomcod			P	P		
34	White catfish				P		
*35	White perch		P	P	4	P	P
36	Yellow perch				P		
39	Northern pipefish						
41	Atlantic needlefish						
42	Crevalle jack				P		
45	Weakfish			P		P	
70	Sturgeon, unidentified						
72	Winter flounder						
Miscellaneous							
71	Northern porgy				P		
TOTAL SPECIES			10	12	21	13	7

Note: P = presence less than 1
* = key species

Table 7-3. Average Number Caught/Haul, Grand Average of Station Averages (Beach Seine)†

Species Code	Species Name	1969 June/July	Aug	Sept	Oct	Nov	Dec
* 1	Alewife	4	13	19	51	36	P
2	Bay anchovy		1	1	2		
* 3	American shad		1	2	1	P	
4	Bluefish		P	P	P		
5	Bluegill		P	P	1	P	P
6	Brown bullhead					P	
7	Pumpkinseed	1	P	2	1	1	P
9	Carp			P	P	P	P
10	American eel			P	1	P	
11	Goldfish	P		P	P	P	P
12	Golden shiner	P	P		1	2	
13	Hogchoker		P	P	P		
14	Johnny darter	P	1	1	2	3	1
15	Banded killifish		P	1	3	2	P
18	Mummichog	1	1	P	P	P	P
19	Menhaden, Atlantic		P	3	3	P	P
*22	Blueback herring	11	11	24	27	15	1
23	White sucker			P	P	P	P
24	Atlantic silverside	5	23	27	17	1	
25	American smelt						
27	Shortnose sturgeon						
28	Spottail shiner	2	5	8	38	31	12
29	Atlantic sturgeon						
*30	Striped bass	7	18	11	80	39	9
31	Fourspine stickleback				P	1	1
*32	Atlantic tomcod					1	1
34	White catfish				P		
*35	White perch	15	15	21	57	30	1
36	Yellow perch				P	P	P
39	Northern pipefish		1			P	
41	Atlantic needlefish						
42	Crevalle jack		P	1	P		
45	Weakfish						
70	Sturgeon, unidentified						
72	Winter flounder						
Miscellaneous							
17	Largemouth bass		P		P	P	
21	Chain pickerel		P	P			
33	Unidentified		P				
40	Redbreast sunfish				P		
71	Northern porgy				P		
73	Tidewater silverside					P	
TOTAL SPECIES		11	21	22	28	25	17

Note: P = presence less than 1
* = key species

† = no compensation for seine size change in mid-September.

Table 7-4. Species of Fish Collected by the Indian Point Ecological Survey Through December 1969

		Abundance
Petromyzonidae-lampreys		
Sea lamprey	Petromyzon marinus	R
Acipenseridae-sturgeons		
Shortnose sturgeon	Acipenser brevirostrum	U
Atlantic sturgeon	Acipenser oxyrhynchus	U
Clupeidae-herrings		
Blueback herring	Alosa aestivalis	C
Alewife	Alosa pseudoharengus	A
American shad	Alosa sapidissima	U
Atlantic Menhaden	Brevoortia tyrannus	C
Engraulidae-anchovies		
Bay anchovy	Anchoa mitchilli	C
Osmeridae-smelts		
Rainbow smelt	Osmerus mordax	C to U
Esocidae-pikes		
Chain pickerel	Esox niger	R
Cyprinidae-minnows and carps		
Goldfish	Carassius auratus	U
Carp	Cyprinus carpio	U
Golden shiner	Notemigonus crysoleucas	R
Common shiner	Notropis cornutus	R
Spottail shiner	Notropis hudsonius	C
Catostomidae-suckers		
White sucker	Catostomus commersoni	U
Ictaluridae-freshwater catfishes		
White catfish	Ictalurus catus	U to C
Brown bullhead	Ictalurus nebulosus	U to C
Anguillidae-freshwater eels		
American eel	Anguilla rostrata	A
Belonidae-needlefishes		
Atlantic needlefish	Strongylura marina	C*
Cyprinodontidae-killifishes		
Banded killifish	Fundulus diaphanus	U to C
Mummichog	Fundulus heteroclitus	U to C
Gadidae-codfishes and hakes		
Silver hake	Merluccius bilinearis	R
Atlantic tomcod	Microgadus tomcod	A
Gasterosteidae-sticklebacks		
Fourspine stickleback	Apeltes quadracus	U
Syngnathidae-pipefishes and seahorses		
Northern pipefish	Syngnathus fuscus	C to U
Serranidae-sea basses		
White perch	Morone americanus	A
Striped bass	Morone saxatilis	A
Centrarchidae-sunfishes		
Pumpkinseed	Lepomis gibbosus	U to C
Bluegill	Lepomis macrochirus	U
Redbreast sunfish	Lepomus auritus	R
Largemouth bass	Micropterus salmoides	R
Percidae-perches		
Johnny darter	Etheostoma nigrum	U to C
Yellow perch	Perca flavescens	U to C
Pomatomidae-bluefishes		
Bluefish	Pomatomus saltatrix	U
Carangidae-jacks, scads, and pompanos		
Crevalle jack	Caranx hippos	U
Sciaenidae-drums		
Weakfish	Cynoscion regalis	U
Sparidae-porgies		
Scup	Stenotomus chrysops	R
Mugilidae-mullets		
Striped mullet	Mugil cephalus	R
Atherinidae-silversides		
Atlantic silverside	Menidia menidia	C
Tidewater silverside	Menidia beryllina	U
Pleuronectidae-righteye flounders		
Winter flounder	Pseudopleuronectes americanus	U
Soleidae-soles		
Hogchoker	Trinectes maculatus	C

Legend

A — abundant - readily caught in trawl or seine and in great numbers
C — common - readily caught in trawl or seine
U — uncommon - caught in trawl or seine, but only occasionally and/or not in any numbers
R — rare
* — commonly observed in the effluent waters

7.3.2 Key Species

On March 5, 1970, the Technical Committee selected the alewife, American shad, blueback herring, striped bass, white perch and tomcod as key species for this study. The bay anchovy was also cited as a key species for bioassay studies. The term key species as used in this study denotes that special attention (laboratory studies, weight/measurements, etc.) will be given to those species so designated in order to evaluate more thoroughly the effects of thermal additions on their biology.

7.3.2.1 Alewife, Alosa pseudoharengus (Wilson)

The alewife is an anadromous species which enters the Hudson River in the spring (March to June) to spawn. Spawning takes place upriver from the study area at temperatures between 50 and 60 degrees F. It is a prolific spawner producing demersal, adhesive eggs. After spawning, the adult returns to the ocean where most of its life is spent. The young remain in the river throughout the first summer of their lives and migrate downstream in the late summer and autumn to the ocean. Here they mature in several years and then return to rivers to spawn.

The alewife, like other herrings, is primarily a plankton feeder and a schooling species; its general geographic range spans South Carolina and Nova Scotia. It is of minor commercial importance in the Hudson River. This species is important as a forage fish.

Numerically, the alewife ranks third among the number of fish caught in surface trawls and in beach seines, comprising 11 percent of the former and 17 percent of the latter. In the bottom trawl collections, this species ranks fourth and comprises 9 percent of the fish caught.

Young-of-the-year alewife are caught throughout the study area from June through November. In December this species was not recorded in any of the samples from Haverstraw Bay or upstream from Peekskill Bay. The December presence of limited numbers of alewife only in the general area between the Lovett and Indian Point power stations alludes to a possible correlation to the heated effluents (Tables 7-5 through 7-7). Occasional older specimens of this species were recorded in the screen washings from the Indian Point plant.

Table 7-5. Average Number Alewife Caught/7 Minutes (Bottom Trawls)

	STA	MILE	SITE	DPTH	1969 June/July	Aug	Sept	Oct	Nov	Dec
SHALLOW	1	29	1	10	3	6	11	96		
	5	36	1	12	30	45	15	144	31	0
	3	35	3	10	8	25	50	27	5	0
	7	38	3	11	11	191	182	5	28	0
	8	39	1	12	160	725	24	263	17	0
	9	40	3	12	104	482	46	18	14	0
	12	44	3	12	250	344	599	110	10	1
DEEP	2	29	3	26	1	7	0	20		
	4	35	2	34	7	22	7	1	23	0
	6	38	2	30	15	58	19	19	0	0
	15	40	1	45			39	6	1	1
	16	41	3	45			104		7	2
	11	42	2	50	1	2	15	16	5	6
	10	42	3	45	1	13	18	9	P	2
	13	45	1	50	2	3	14	12		0
	14	47	3	47	2	15	12	6	0	0
	Grand Avg No. Cght				43	138	72	50	11	1
	Pcnt Avg Cght *				11	11	7	12	3	P
	Avg Pcnt Occ *				60	88	83	94	68	17

blank = no samples, 0 = species absence, P = presence less than 1

* see Appendix A for explanation of terms.

Table 7-6. Average Number Alewife Caught/7 Minutes (Surface Trawls)

	STA	MILE	SITE	DPTH	1969 June/July	Aug	Sept	Oct	Nov	Dec
SHALLOW	1	29	1	10				10		
	5	36	1	12						
	3	35	3	10				22	P	0
	7	38	3	11		11	0	4	1	0
	8	39	1	12			15	8	6	0
	9	40	3	12			92	0	4	0
	12	44	3	12		6	0	24	9	0
DEEP	2	29	3	26				0		
	4	35	2	34				0	3	0
	6	38	2	30				11	0	0
	15	40	1	45			2	0	6	P
	16	41	3	45					52	1
	11	42	2	50			3	5	4	0
	10	42	3	45		78	16	20	45	1
	13	45	1	50				7	24	0
	14	47	3	47				13		
	Grand Avg No. Cght					32	18	9	13	P
	Pcnt Avg Cght *					17	9	4	16	7
	Avg Pcnt Occ *					67	36	65	66	09

blank = no samples, 0 = species absence, P = presence less than 1

* see Appendix A for explanation of terms.

Table 7-7. Average Number Alewife Caught/Haul (Seines and Plant Site)[†]

	STA	MILE	SITE	1969 June/July	Aug	Sept	Oct	Nov	Dec
Seines	31	35	1		10	3	32	221	
	32	35	3	3	18	78	205	2	
	38	40	1			0	9	2	P
	33	40	3	4	31	13	20	6	0
	39	41	3					69	0
	35	43	1	3	3	56	77	1	0
	34	42	3		3	0	2	22	1
	36	44	3	2	24	0	32	6	0
	37	47	1	11	4	1	35	1	0
Grand Avg No. Cght				5	13	19	51	36	P
Pcnt Avg Cght*				11	14	16	18	22	P
Avg Pcnt Occ *				60	86	38	80	59	05
Plant Site	Forebay					28	19	P	0
	Sluice					39	100	54	5
	Effluent						0		0
	Avg Pcnt Occ					100	63	67	20

blank = no samples, 0 = species absence, P = presence less than 1
*see Appendix A for explanation of terms.
†= no compensation for seine size change in mid-September.

The surface trawl data indicate that the alewife is fairly well distributed amongst Stations 7, 10, and 12 in August and throughout the study area in September and October (Table 7-6). Bottom trawls in the shoal areas contain consistently higher concentrations of alewife than those taken at the deeper channel stations. However, this may only indicate that the bottom trawl is functioning as a pseudo-surface trawl in these 10 to 12-foot depths rather than a shoal preference by this species (Tables 7-5 through 7-7).

Greater numbers of alewife caught by bottom trawls at the upstream shoal stations 7, 8, 9 and 12 than at stations 2, 3 and 5 in the vicinity of Croton Point suggested an upstream preference through September (Table 7-5). This tends to even out during October through November as total numbers decrease markedly, correlating with the expected seaward movement of this species.

The alewife is most successfully and consistently caught by bottom trawling; beach seining is less successful and surface trawling is least successful. (See Tables 7-5 through 7-7.)

7.3.2.2 Blueback Herring, Alosa aestivalis (Mitchill)

The blueback herring is closely related to the alewife. It is an anadromous species which spawns upriver from the study area at about the same time as the alewife. The spawning run of the blueback herring begins later and lasts longer than the alewife. Spawning occurs between 70 and 75 degrees F with demersal and adhesive eggs. Adults return to the sea after spawning and young-of-the-year migrate to the sea in late summer and autumn.

The blueback herring's geographic range spans between the coasts of Florida and Nova Scotia; this species is generally a plankton feeder but also feeds on small plants and animals. It is a schooling species which is probably important as a forage fish.

Numerically, young-of-the-year blueback herring ranks second in surface trawl collections, fifth in beach seine samples and sixth in bottom trawls, comprising 18, 12 and 3 percent of the fish caught, respectively. Since a third again as many blueback herring as alewife were caught in surface trawls compared to three times as many alewife as blueback herring caught in bottom trawls, there is the suggestion that the blueback herring has a stronger preference for the surface waters than does its close relative the alewife. This suggestion is also supported by the distinctly higher percent occurrence of the blueback herring in surface trawls (79 to 97 percent) versus bottom trawls (34 to 67 percent) during the months of August through November.

The peak concentrations for the alewife occur in August through September (bottom trawls) and those of the blueback herring occur in October through November (surface and bottom trawls) (Tables 7-8 through 7-10). The blueback herring declines markedly in abundance from November to December, but slightly less so than the alewife. As with the alewife, the limited numbers of blueback herring remaining in the study area during December occur in the area between upper Haverstraw Bay and Indian Point.

The blueback herring is most successfully and consistently caught by surface trawling. Moderate success is found with beach seining, but bottom trawling produces generally limited and erratic results.

7.3.2.3 American Shad, Alosa sapidissima (Wilson)

This anadromous species ascends rivers to spawn, mostly in tidal freshwater, from April to June. Eggs are demersal and nonadhesive. Adults may spawn more than once and return to sea after spawning. The young remain in the river until autumn when they migrate to the ocean. Maturity takes place in three to four years at sea. While at sea, shad are schooling fish.

The geographic range of the shad spans between Florida and the St. Lawrence River; this species is primarily a plankton feeder, but it also eats a variety of plants and animals. The shad is an important commercial food species in the Hudson River, but not as important a sport fish as in other areas. Shad runs vary in size from year to year and 1969 was a good year in the Hudson as far as the commercial fishermen are concerned. There was a large spawning run, but juvenile survival may have been reduced by excessive rain and freshwater run-off in August.

Only young-of-the-year shad were collected within the study area during June through December 1969 and then in very limited numbers (Tables 7-11 and 7-12). One hundred and five specimens were collected by beach seines during August through October. Bottom trawling produced 26

Table 7-8. Average Number Blueback Herring Caught/7 Minutes (Bottom Trawls)

	STA	MILE	SITE	DPTH	1969 June/July	Aug	Sept	Oct	Nov	Dec
SHALLOW	1	29	1	10	P	P	0	6		
	5	36	1	12	P	1	0	21	1	0
	3	35	3	10	P	0	0	0	5	0
	7	38	3	11	P	2	0	0	5	0
	8	39	1	12	P	134	1	25	9	1
	9	40	3	12	0	25	7	625	105	0
	12	44	3	12	15	306	39	58	1	0
DEEP	2	29	3	26	0	0	0	30		
	4	35	2	34	0	0	1	0	5	0
	6	38	2	30	1	P	0	6	0	0
	15	40	1	45			0	13	7	2
	16	41	3	45			0		1	1
	11	42	2	50	P	1	0	32	1	0
	10	42	3	45	0	3	4	19	1	1
	13	45	1	50	P	2	0	3		0
	14	47	3	47	P	0	1	8	5	0
	Grand Avg No. Cght				1	34	3	56	11	P
	Pcnt Avg Cght *				P	3	P	14	3	P
	Avg Pcnt Occ *				21	34	23	64	67	15

blank = no samples, 0 = species absence, P = presence less than 1

* see Appendix A for explanation of terms.

Table 7-9. Average Number Blueback Herring Caught/7 Minutes (Surface Trawls)

	STA	MILE	SITE	DPTH	1969 June/July	Aug	Sept	Oct	Nov	Dec
SHALLOW	1	29	1	10				6		
	5	36	1	12						
	3	35	3	10				27	48	0
	7	38	3	11		3	0	56	14	P
	8	39	1	12			19	2	20	7
	9	40	3	12			7	31	72	5
	12	44	3	12		6	40	1	11	P
DEEP	2	29	3	26				4		
	4	35	2	34				24	16	0
	6	38	2	30				5	32	0
	15	40	1	45			13	127	11	6
	16	41	3	45					41	P
	11	42	2	50			24	104	50	1
	10	42	3	45		4	4	5	407	1
	13	45	1	50				49	55	0
	14	47	3	47				24		
Grand Avg No. Cght						4	15	33	65	2
Pcnt Avg Cght *						2	8	15	82	72
Avg Pcnt Occ *						92	79	97	87	26

blank = no samples, 0 = species absence, P = presence less than 1

* see Appendix A for explanation of terms.

Table 7-10. Average Number Blueback Herring Caught/Haul (Seines and Plant Site)†

	STA	MILE	SITE	1969 June/July	Aug	Sept	Oct	Nov	Dec
Seines	31	35	1		0	0	0	44	
	32	35	3	0	2	3	0	0	
	38	40	1			20	60	1	0
	33	40	3	16	8	16	89	4	6
	39	41	3					1	P
	35	43	1	5	2	0	1	37	0
	34	42	3		7	70	28	42	1
	36	44	3	5	50	42	8	5	0
	37	47	1	9	5	43	35	2	0
Grand Avg No. Cght				7	11	24	27	15	1
Pcnt Avg Cght *				15	12	20	10	9	4
Avg Pcnt Occ *				60	46	61	41	51	10
Plant Site	Forebay					1	1	0	P
	Sluice					7	1	63	9
	Effluent						0		0
	Avg Pcnt Occ					67	30	50	26

blank = no samples, 0 = species absence, P = presence less than 1

*see Appendix A for explanation of terms.

† = no compensation for seine size change in mid-September

Table 7-11. Average Number American Shad Caught/7 Minutes
(Bottom Trawls)

	STA	MILE	SITE	DPTH	1969 June/July	Aug	Sept	Oct	Nov	Dec
SHALLOW	1	29	1	10	0	P	1	0		
	5	36	1	12	0	P	0	0	0	0
	3	35	3	10	P	P	1	0	0	0
	7	38	3	11	0	0	0	0	0	0
	8	39	1	12	0	0	0	P	P	0
	9	40	3	12	0	0	0	P	0	0
	12	44	3	12	0	0	0	P	0	0
DEEP	2	29	3	26	0	0	0	0		
	4	35	2	34	0	0	2	0	0	0
	6	38	2	30	0	P	0	0	0	0
	15	40	1	45			0	P	P	0
	16	41	3	45			0		0	0
	11	42	2	50	0	0	0	P	0	0
	10	42	3	45	0	P	0	P	0	0
	13	45	1	50	0	P	0	0	0	0
	14	47	3	47	0	0	0	0	0	0
	Grand Avg No. Cght				P	P	P	P	P	0
	Pcnt Avg Cght *				P	P	P	P	P	0
	Avg Pcnt Occ *				01	09	10	09	04	0

blank = no samples, 0 = species absence, P = presence less than 1

* see Appendix A for explanation of terms.

Table 7-12. Average Number American Shad Caught/Haul (Beach Seines)†

STA	MILE	SITE	1969 June/July	Aug	Sept	Oct	Nov	Dec
31	35	1		1	6	1	0	
32	35	3	0	1	1	0	0	
38	40	1			0	3	0	0
33	40	3	0	1	3	P	P	0
39	41	3					0	0
35	43	1	0	P	0	0	0	0
34	42	3		1	P	1	P	0
36	44	3	0	3	3	0	0	0
37	47	1	0	1	0	1	0	0
Grand Avg No. Cght			0	1	2	1	P	0
Pcnt Avg Cght*			0	1	1	P	P	0
Avg Pcnt Occ*			0	50	38	22	05	0

blank = no samples, 0 = species absence, P = presence less than 1

*see Appendix A for explanation of terms.

† = no compensation for seine size change in mid-September

specimens and surface trawling only 3. No specimens were collected in December and only 1 occurred in a bottom trawl during July. The shad caught in bottom trawls were larger (72 to 145 mm) than those obtained by seining (62 to 96 mm). However, these few data do not provide a sufficient basis for establishing trends at this time.

7.3.2.4 Bay Anchovy, Anchoa mitchilli (Valenciennes)

The bay anchovy is a schooling species found in coastal salt waters and brackish waters (ranging from Mexico to Maine). This species has a long spawning season from late spring to September in the New York area. Eggs are buoyant when spawned, but gradually become demersal. Young-of-the-year fish, immatures and adults are abundant from late spring to early autumn in the lower Hudson River.

Young and adults of this pelagic schooling species are an important food item for larger carnivorous fishes.

The anchovy numerically is by far the most abundant fish caught by trawls within the study area. This species comprised 43 percent of the bottom trawl and 68 percent of the surface trawl catches. It comprised less than a percent of the beach seine populations, occurring only in small numbers in 11 catches from August through October.

The highest concentrations of the anchovy were observed during the months of August through October and were confined primarily to Haverstraw Bay (Tables 7-13 and 7-14). There appears to be a general dispersal of the anchovy population from lower Haverstraw Bay in July throughout the entire Bay during August. The anchovy was caught in every surface and bottom trawl sample taken in September. There is an abrupt decrease and general disappearance of the anchovy from the study area during November and December. This species occurred at only 3 of the 14 bottom trawl stations sampled during December and the three stations (10, 11, 15) were located in the immediate vicinity of the Indian Point and Lovett power plants (Table 7-13). Yet, the implied correlation of the species with heated effluents is weakened by the complete absence of this species from all surface trawl collections in December (Table 7-14).

Table 7-13. Average Number Bay Anchovy Caught/7 Minutes (Bottom Trawls)

	STA	MILE	SITE	DPTH	1969 June/July	Aug	Sept	Oct	Nov	Dec
SHALLOW	1	29	1	10	84	3620	918	9		
	5	36	1	12	233	1248	14	0	0	0
	3	35	3	10	93	521	2820	0	0	0
	7	38	3	11	13	182	1423	0	0	0
	8	39	1	12	14	185	622	40	P	0
	9	40	3	12	24	3376	1298	6	1	0
	12	44	3	12	17	7	3161	31	0	0
DEEP	2	29	3	26	27	356	58	10		
	4	35	2	34	66	570	135	13	2	0
	6	38	2	30	3	818	283	22	0	0
	15	40	1	45			11	82	2	1
	16	41	3	45			90		0	0
	11	42	2	50	0	38	114	88	P	2
	10	42	3	45	P	32	75	84	0	P
	13	45	1	50	P	1	25	0		0
	14	47	3	47	0	3	16	6	0	0
Grand Avg No. Cght					41	783	691	26	P	P
Pcnt Avg Cght *					10	64	71	6	P	P
Avg Pcnt Occ *					51	83	100	66	12	09

blank = no samples, 0 = species absence, P = presence less than 1

* see Appendix A for explanation of terms.

Table 7-14. Average Number Bay Anchovy Caught/7 Minutes (Surface Trawls)

	STA	MILE	SITE	DPTH	1969 June/July	Aug	Sept	Oct	Nov	Dec
SHALLOW	1	29	1	10				498		
	5	36	1	12						
	3	35	3	10				122	0	0
	7	38	3	11		432	365	113	P	0
	8	39	1	12			77	0	P	0
	9	40	3	12			226	0	1	0
	12	44	3	12		0	45	0	0	0
DEEP	2	29	3	26				476		
	4	35	2	34				605	2	0
	6	38	2	30				263	1	0
	15	40	1	45			80	1	0	0
	16	41	3	45					0	0
	11	42	2	50			96	2	0	0
	10	42	3	45		8	213	14	0	0
	13	45	1	50				8	1	0
	14	47	3	47				6		
Grand Avg No. Cght						146	157	151	P	0
Pcnt Avg Cght *						78	80	70	P	0
Avg Pcnt Occ *						50	1	75	23	0

blank = no samples, 0 = species absence, P = presence less than 1

* see Appendix A for explanation of terms.

7.3.2.5 Striped Bass, Morone saxatilis (Walbaum)

The striped bass is an anadromous species, ascending rivers in the spring to spawn; its general geographic range spans from northern Florida to New Brunswick. Spawning occurs from May to June in the Hudson River in fresh to slightly brackish waters. The eggs are demersal to semibuoyant, nonadhesive and are laid when water temperatures range between 58 and 67 degrees F. After spawning, adults generally return to sea. Larvae and young-of-the-year remain in freshwaters and estuaries. Striped bass in the Hudson may remain in the estuary for two to three years before migrating to the sea. During winter, adults and young are found in the lower Hudson. Young striped bass are very abundant in the Hudson River.

This species is very important in the Hudson because of commercial, sportfishing and aesthetic values.

Striped bass comprise ten percent of the bottom trawl samples and rank third in numbers caught. It is the most important species in the shore population, comprising 22 percent of the beach seine collections. Striped bass occur only rarely in surface trawls.

This species, like white perch, shows a definite preference for the bottom waters in shoal areas (Tables 7-15 and 7-16). Only small numbers were collected in the bottom trawls at the channel stations north of Stony Point whereas large numbers are caught in Haverstraw Bay and at shoal station 12 in Peekskill Bay. Striped bass during the summer-fall of 1969 occurred in 63 to 90 percent of all bottom trawl collections. Except for July (60 percent) and December (42 percent), this species occurred in 90 to 99 percent of all beach seine samples.

Seasonally, the higher concentrations of striped bass in bottom trawls are observed during the warmer months (July through October) with a general decline occurring in November through December (Table 7-15). In the seine collections, the higher numbers are noted in the October through November samples (Table 7-16). This species becomes nearly ubiquitous in the bottom and shore populations in October when it occurs in 90 percent of the bottom trawl collections and 99 percent of the seine samples.

Table 7-15. Average Number Striped Bass Caught/7 Minutes (Bottom Trawls)

	STA	MILE	SITE	DPTH	1969					
					June/ July	Aug	Sept	Oct	Nov	Dec
SHALLOW	1	29	1	10	77	58	98	231		
	5	36	1	12	291	126	108	354	88	21
	3	35	3	10	355	61	28	14	4	5
	7	38	3	11	115	217	168	168	31	1
	8	39	1	12	485	64	39	69	61	20
	9	40	3	12	149	119	335	146	29	3
	12	44	3	12	100	144	87	19	83	21
DEEP	2	29	3	26	4	51	0	21		
	4	35	2	34	10	19	1	120	3	3
	6	38	2	30	62	312	4	122	0	1
	15	40	1	45			0	7	1	3
	16	41	3	45			1		0	4
	11	42	2	50	1	1	1	1	P	4
	10	42	3	45	0	4	8	16	1	0
	13	45	1	50	1	3	3	1		0
	14	47	3	47	0	1	3	1	2	1
	Grand Avg No. Cght				118	84	55	86	23	6
	Pcnt Avg Cght *				30	7	6	21	6	3
	Avg Pcnt Occ *				63	80	70	90	72	72

blank = no samples, 0 = species absence, P = presence less than 1

* see Appendix A for explanation of terms.

Table 7-16. Average Number Striped Bass Caught/Haul (Seines and Plant Site)†

	STA	MILE	SITE	1969 June/July	Aug	Sept	Oct	Nov	Dec
Seines	31	35	1		32	19	228	70	
	32	35	3	6	15	20	256	101	
	38	40	1			1	19	79	32
	33	40	3	13	19	13	63	35	3
	39	41	3					37	15
	35	43	1	2	1	5	4	10	1
	34	42	3		49	12	25	17	12
	36	44	3	0	7	1	29	2	0
	37	47	1	17	4	16	17	2	0
Grand Avg No. Cght				8	18	11	80	39	9
Pcnt Avg Cght *				17	20	9	28	24	33
Avg Pcnt Occ *				60	90	90	99	93	42
Plant Site	Forebay					12	16	15	42
	Sluice					41	24	25	31
	Effluent						P		0
	Avg Pcnt Occ					100	100	100	91

blank = no samples, 0 = species absence, P = presence less than 1

*see Appendix A for explanation of terms.

† = no compensation for seine size change in mid-September

7.3.2.6 Atlantic Tomcod, Microgadus tomcod (Walbaum)

The tomcod has been reported as far south as Virginia, but is not abundant south of New York, although its general geographic range is between Virginia and Canada. It is a coastal benthic species that spawns demersal and adhesive eggs in estuaries. Spawning occurs in the Hudson River from December through February; adults and young are found in the river throughout the year.

Tomcod feed on a variety of organisms including small crustaceans, especially shrimp and amphipods, worms, small mollusks, squids and small fish. There is no commercial value for this fish in the Hudson. Some sportsfishermen catch this species.

Within the study area tomcod comprised 10 percent of the bottom fish samples (18 percent if anchovy is excluded), ranging third in numbers caught with a definite preference for the deeper water channel areas. This species occurred only rarely in surface trawls (1 to 3 specimens in 4 tows) (Table 7-2) and only a few specimens in the beach seines during November and December (Table 7-3). This latter occurrence may be related to the overall decrease in river temperature and/or preliminary spawning activity.

The seasonal trends in the average number of tomcod caught in bottom trawls at a station indicate that for the channel stations the higher concentrations generally occur during July and August. These higher concentrations show an apparent down-river shift from the vicinity of Iona Island (station 13) in July to Haverstraw Bay in October. On the other hand, for the shoal stations the higher concentrations occur during November through December, e.g., stations 5, 8, 9 and 12 (Table 7-17). This late fall increase in numbers in shoal areas also appears to be accompanied by more uniform dispersion of the tomcod over the river bottom. The average percent occurrence, which is a measure of the geographic dispersion of a species within the study area, indicates that whereas tomcod occur in only 58 percent of the samples during August, they occur in every bottom trawl collection during November and December (Table 7-17). Again, this has a possible correlation with spawning activity.

Table 7-17. Average Number Tomcod Caught/7 Minutes (Bottom Trawls)

	STA	MILE	SITE	DPTH	1969 June/July	Aug	Sept	Oct	Nov	Dec
SHALLOW	1	29	1	10	67	2	1	156		
	5	36	1	12	4	16	9	2	168	69
	3	35	3	10	24	1	1	0	13	3
	7	38	3	11	98	P	1	3	50	7
	8	39	1	12	10	0	P	7	70	153
	9	40	3	12	2	20	1	6	76	11
	12	44	3	12	2	1	0	P	26	26
DEEP	2	29	3	26	141	238	275	120		
	4	35	2	34	141	251	4	126	135	13
	6	38	2	30	104	23	28	30	208	1
	15	40	1	45			106	38	54	57
	16	41	3	45			22		39	67
	11	42	2	50	234	307	17	1	83	57
	10	42	3	45	513	145	29	3	40	35
	13	45	1	50	187	50	23	6		11
	14	47	3	47	77	16	22	32	29	24
Grand Avg No. Cght					115	76	34	35	76	38
Pcnt Avg Cght *					29	6	3	9	18	18
Avg Pcnt Occ *					88	58	67	71	100	100

blank = no samples, 0 = species absence, P = presence less than 1

* see Appendix A for explanation of terms.

7.3.2.7 White Perch, Morone americana (Gmelin)

This species is found in fresh, brackish and coastal saltwater between South Carolina and Nova Scotia. Spawning of demersal and adhesive eggs occurs in fresh and brackish water from April to June, depending on geographic location, and at water temperatures between 45 and 60 degrees F. Young and adults remain in fresh or brackish waters. They are not bottom fish except in winter when they congregate in the deeper parts of bays and rivers where they remain sluggish until spring. During spring, summer and autumn, localized wandering occurs. This species feeds on invertebrates and small fish.

This is one of most abundant species in the lower Hudson River and is found throughout the year in all life stages. People fish for the white perch from shore in many localities.

Numerically, white perch ranks second only to bay anchovy in the bottom trawl collections and second only to striped bass in the seines. It comprises 13 percent of the former and 19 percent of the latter. This species occurs only rarely in surface trawl samples.

White perch, like the striped bass, prefers the bottom waters in shoal areas. However, comparisons of the average percent occurrence in bottom trawls and beach seines indicate that the white perch has a greater preference for the river shoals versus that of the striped bass for the near shore areas (Tables 7-15, 7-16, 7-18 and 7-19).

Seasonally, in the bottom trawls the white perch exhibits moderate concentrations in the warmer months (July through September) and generally higher concentrations from October through December. This trend is reversed for striped bass. Like the striped bass, the peak numbers of white perch in the seine collections are recorded during October through November. In December, the white perch shows a more rapid disappearance from the shore populations than does the striped bass.

Table 7-18. Average Number White Perch Caught/7 Minutes (Bottom Trawls)

	STA	MILE	SITE	DPTH	1969 June/July	Aug	Sept	Oct	Nov	Dec
SHALLOW	1	29	1	10	18	24	17	218		
	5	36	1	12	33	61	64	126	270	20
	3	35	3	10	32	13	20	65	15	3
	7	38	3	11	57	46	51	173	212	49
	8	39	1	12	108	78	60	24	180	602
	9	40	3	12	55	212	281	348	423	101
	12	44	3	12	91	229	331	106	237	309
DEEP	2	29	3	26	27	14	20	30		
	4	35	2	34	16	10	1	18	38	64
	6	38	2	30	37	25	4	34	40	43
	15	40	1	45			3	42	15	44
	16	41	3	45			0		17	101
	11	42	2	50	12	1	2	2	12	264
	10	42	3	45	4	2	9	1	40	28
	13	45	1	50	1	2	9	4		8
	14	47	3	47	5	10	17	16	27	7
	Grand Avg No. Cght				35	52	56	80	117	117
	Pcnt Avg Cght *				9	4	6	20	28	54
	Avg Pcnt Occ *				94	76	75	87	98	100

blank = no samples, 0 = species absence, P = presence less than 1

* see Appendix A for explanation of terms.

Table 7-19. Average Number White Perch Caught/Haul (Seines and Plant Site)†

	STA	MILE	SITE	1969 June/July	Aug	Sept	Oct	Nov	Dec
Seines	31	35	1		8	2	45	15	
	32	35	3	25	65	76	175	15	
	38	40	1			7	20	46	1
	33	40	3	5	0	4	23	24	P
	39	41	3					118	P
	35	43	1	0	1	45	55	28	1
	34	42	3		9	11	10	18	2
	36	44	3	50	17	12	83	9	0
	37	47	1	4	6	9	47	3	0
Avg No. Cght				17	15	21	57	30	1
Pcnt Avg Cght*				36	16	17	20	19	2
Avg Pcnt Occ*				53	57	84	88	87	22
Plant Site	Forebay					50	60	17	47
	Sluice					28	22	246	1829
	Effluent						0		P
	Avg Pcnt Occ					100	67**	100	100

blank = no samples, 0 = species absence, P = presence less than 1
*see Appendix A for explanation of terms.
**(100 in forebay and sluice)
† = no compensation for seine size change in mid-September

7.4 Results at the Community Level

7.4.1 Community Overlap Index

The community overlap index has appeared in the literature under many aliases, such as percent overlap and index of overlap.* This index is a measure of the proportional overlap between percent frequency histograms of the species assemblages at two stations. Here, the values of average number caught per species per unit effort at a station for a type gear and month are first percentized. This percent species composition is then compared with the percent composition from another station by matching species and summing the lower percentage between each species pair (i.e., the amount of overlap) until all pairs have been compared. Thus, this index of compositional similarity ranges from 0 which signifies that the stations being compared have no species in common to a value of 100 (i.e., 100 percent) in which there is a perfect match in terms of both species and proportions.**

A minor weakness of this index is that it is not very sensitive to the fluctuations among the rarer and, therefore, presumably less important species. However, this is balanced by the usefulness of this index as an easily understood measure of the general faunal similarity between station pairs. Moreover, because this index is based on percentized data, it facilitates the comparison of the fauna collected with the different gear types.***

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* Ruddiman, Tolderlund and Be 1970. Foraminiferal evidence of a modern warming of the North Atlantic Ocean. Deep Sea Research, Volume 17, pages 141-155.

Raney 1969. An ecological study of the Delaware River in the vicinity of Artificial Island. Ichthyological Associates, Delaware Progress Report I (June-December 1968).

** Consider the following hypothetical situation. At Station X in August, species A, B and C comprise 20, 50 and 30 percent respectively, of the average number of fish caught per unit effort by bottom trawls. At Station Y during August, species A, B and C constitute 40, 10 and 50 percent, respectively. The amount of overlap between the species is 20, 10 and 30 percent, respectively. Summing these overlaps results in a community overlap index of 60 between Stations X and Y based on the bottom trawl data for August.

*** In the future, the community overlap index could be utilized to compare differences related to other factors such as day vs night sampling and relative catch data at various tide stages.

7.4.1.1 Monthly Community Overlap

Station 10 is located in the immediate vicinity of the Indian Point power station in 45 feet of water (Figure 3-1). An examination of the monthly community overlap indices using the botton trawl data at this station as a reference (Figures 7-1 through 7-6) indicates the following hierachy of decreasing faunal similarity:

a) channel stations immediate vicinity of Indian Point - most similar
b) up-river channel stations
c) down-river channel stations
d) shoal stations
e) surface trawl collections
f) seine collections - least similar.

This hierarchy suggests that depth is the dominant factor controlling the general distribution of the fish species within the study area.

The constriction of the river in the vicinity of Stony Point and the concomitant up-stream increase in depth creates a habitat change which is reflected in the fish community characteristic of the northern half of the study area and that characteristic of Haverstraw Bay. This is to say, a community characteristic of water depths (station depths) averaging 45 to 50 feet and one characteristic of water depths less than 35 feet and averaging 10 to 12 feet.

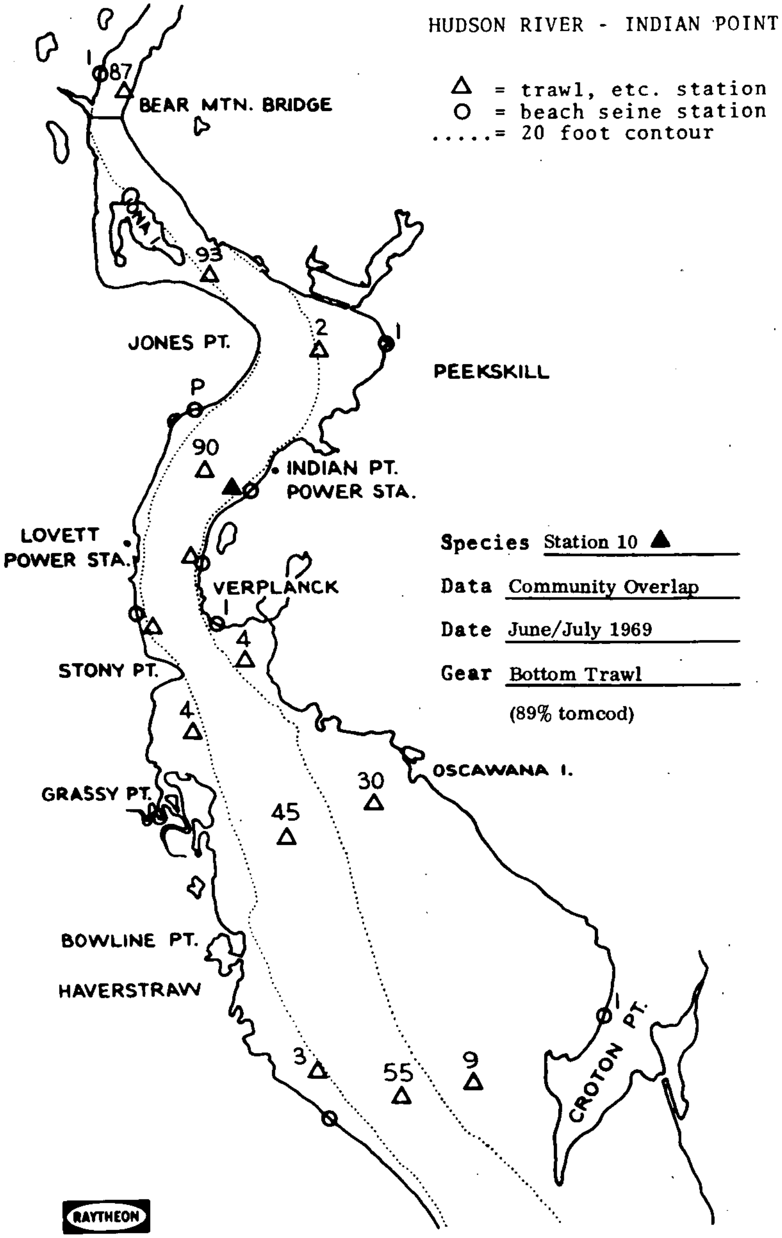

Figure 7-1. Overlap Trends Bottom Trawl Data Station 10, June & July 1969

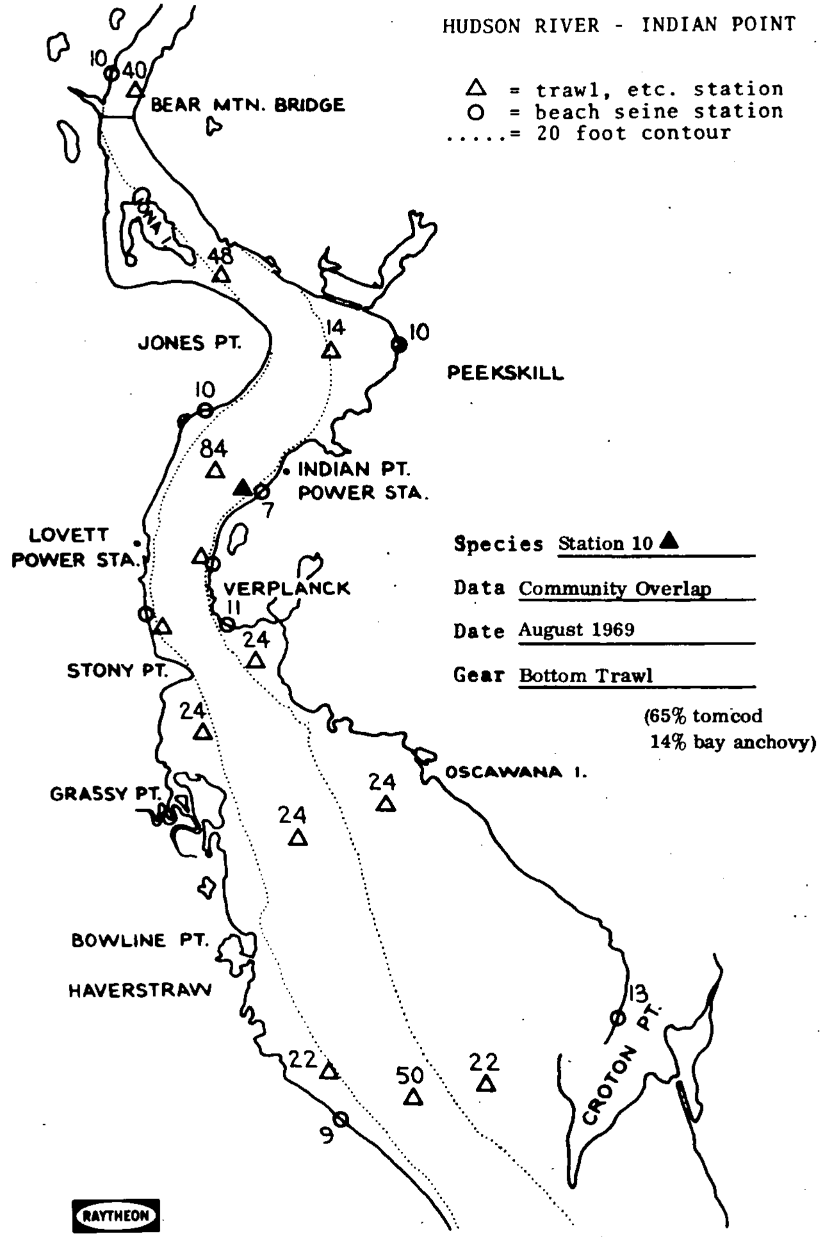

Figure 7-2. Overlap Trends Bottom Trawl Data Station 10, August

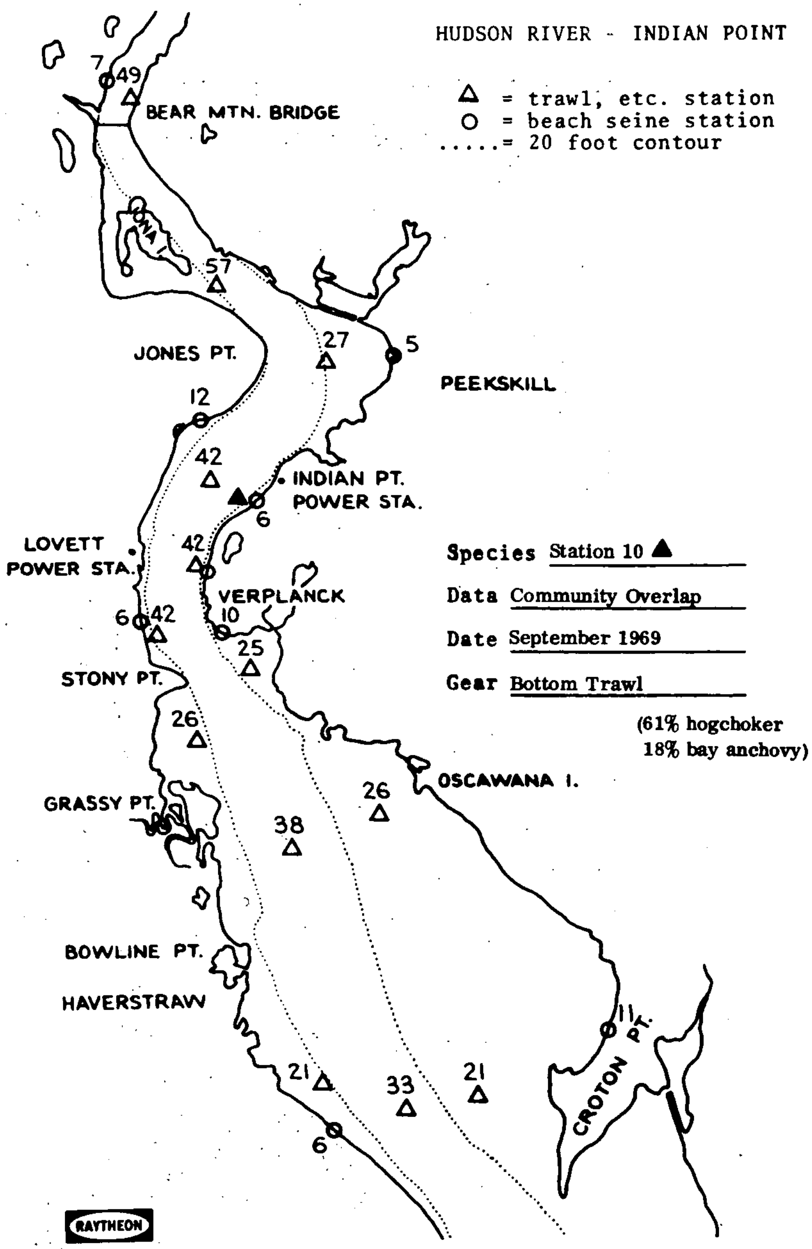

Figure 7-3. Overlap Trends Bottom Trawl
Data Station 10, September

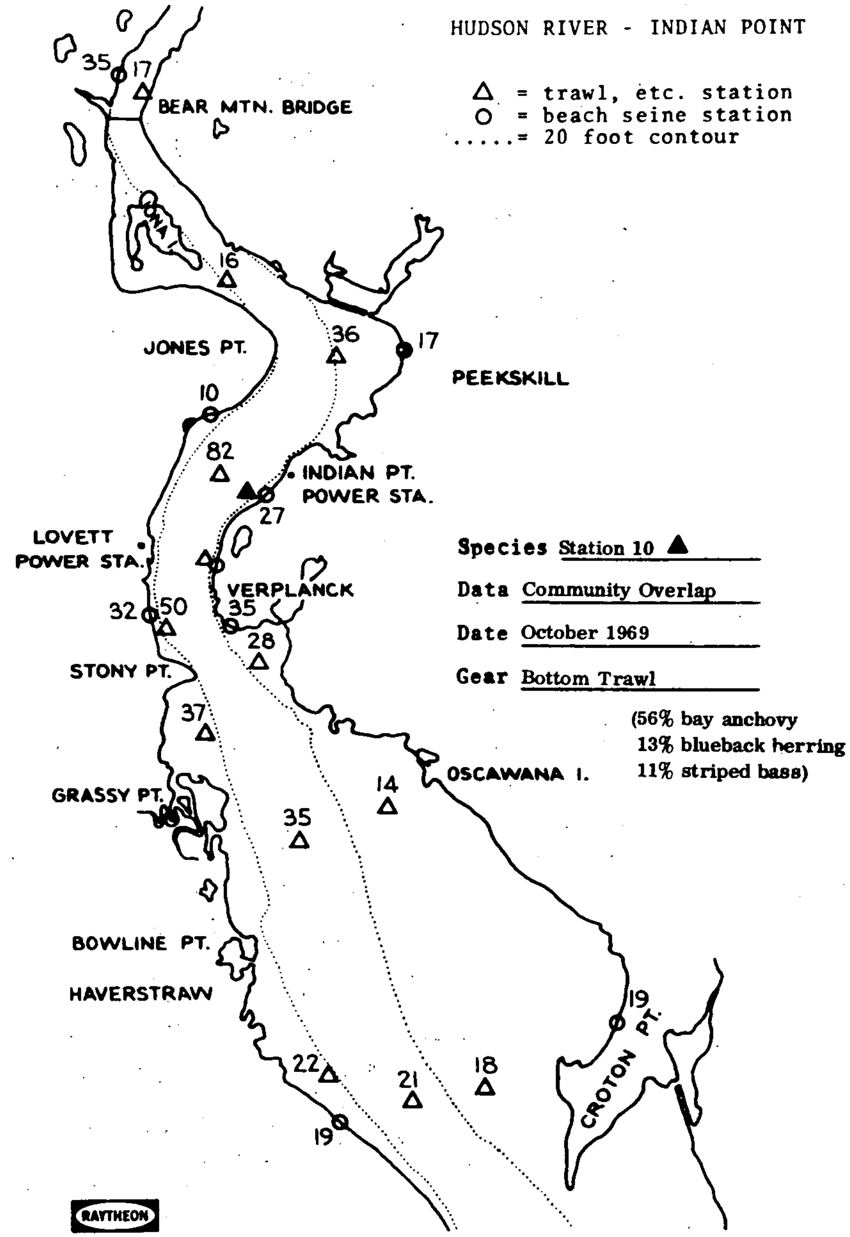

Figure 7-4. Overlap Trends Bottom Trawl
Data Station 10, October

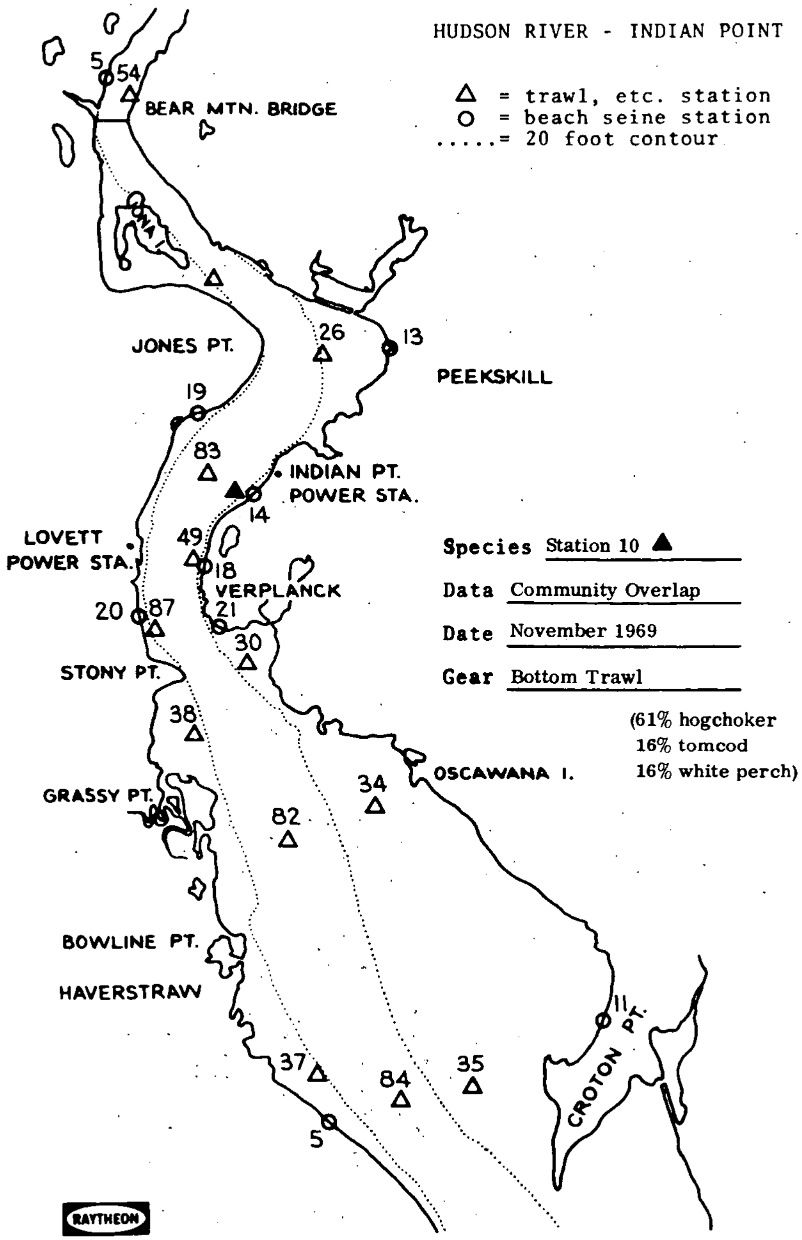

Figure 7-5. Overlap Trends Bottom Trawl Data Station 10, November

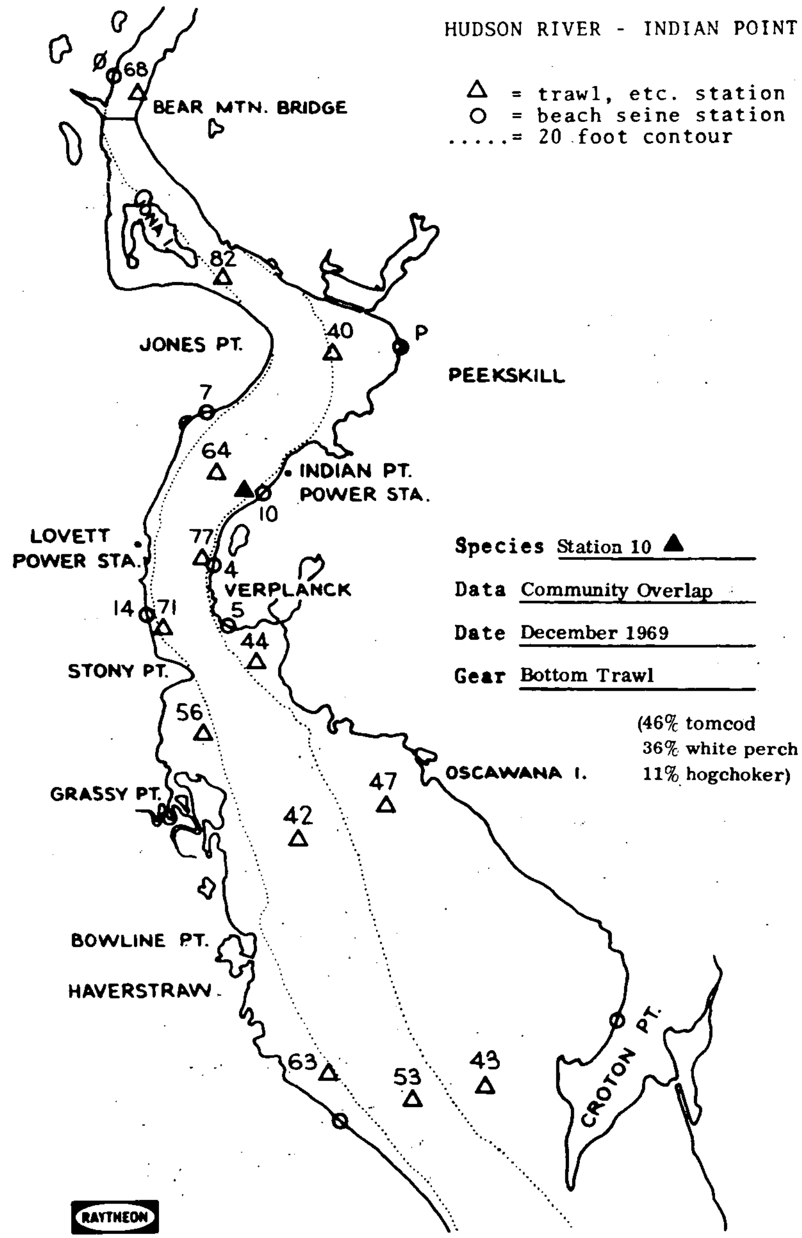

Figure 7-6. Overlap Trends Bottom Trawl Data Station 10, December

The existence of two major fish communities is supported by the fact that the amount of overlap with station 10 exhibited by the channel stations north of Stony Point is noticeably greater than that of the stations to the south (Figures 7-1 through 7-6). This is true during July, August, September and December. In October, except for stations 11 and 15 in the immediate vicinity of Indian Point, there are no important overlaps. In November, major overlaps (82 to 84 percent) occur between the Haverstraw channel stations 4, 6, and 10. This is attributable primarily to a brief influx of hogchoker at these stations.

The effect of river mile in this particular situation is shown by an analysis of the trends of overlap both above and below Indian Point (Figures 7-1 through 7-6). For example, a monthly comparison of stations 13 (mile 45) and 14 (mile 47) reveals that in 4 out of 5 cases there is a 6 to 14 percent decrease in the amount of overlap with station 10 from station 13 to 14. While it is doubtful that these small differences in themselves are significant, there is the suggestion of a trend of decreasing overlap with increasing distance from station 10.

However, similar comparisons between station 10 and stations 6 (mile 38), 4 (mile 35) and 2 (mile 29) seem to contradict this trend. Here the average overlap values are 44, 49, and 48 percent, respectively. This contradiction appears to be the result of localized conditions at station 6 which result in generally lower tomcod concentrations here than at stations 4 and 2 (Table 7-17). In those months in which station 10 is characterized by significant proportions of tomcod (July through August and in December) there are correspondingly higher values of overlap with stations 4 and 2 than with station 6.*

Thus, at station 10 the monthly community overlap values based on bottom-trawl data indicate that depth is the principal factor controlling community structure during the summer-fall of 1969. River mile has a less obvious effect on the community structure.

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* See June-December, 1969 computer print-out, "Finfish Data, Matrices of Percentized Actual Counts/Unit Effort."

7.4.1.2 Average Community Overlap

Averages of monthly community overlap values summarize the patterns of faunal similarity among stations during summer-fall 1969. Only within-gear values have been tabulated (Tables 7-20 through 7-22) although among-gear values have been calculated and selected values are shown on accompanying figures.

Monthly trends can be visualized in the average overlap map based on the bottom trawl data from station 10 (Figure 7-7). Marked differences noted earlier between the area north of Stony Point and the Haverstraw Bay area are readily apparent. The within-area (shoal versus channel) differences are also obvious.

Aside from the highest overlap with the immediately adjacent station 11 (74 percent), the next highest average overlap (63 percent) occurs with the bottom fauna at station 15 in the immediate vicinity of the Lovett power station. The implication that this similarity between stations 10 and 15 is somehow related to their proximity to a power station can only be considered speculation at this stage of investigation and could equally well be explained by the geographic proximity.

The shore populations samples by the seine have little resemblance to either the deep water bottom trawl or the surface trawl populations. In both cases the average amount of overlap never exceeds 26 percent (Figures 7-7 and 7-8). On the other hand there is a noticeable increase in the similarity between the bottom fish populations in shoal waters and the shore populations. For example, comparisons of average overlap made separately on the bottom trawl data at station 9 (mile 40) and station 12 (mile 44) show ranges of 20 to 48 percent overlap with the seine populations. Still, the distinction between the shoal and shore populations is readily apparent (Figures 7-9 and 7-10).

The average community overlap values for the surface trawl data at station 10 indicate that the two faunal communities, suggested by the bottom trawl data, do not exist in the surface waters (Figure 7-8). Rather, all surface trawl stations have an overlap with station 10 that ranges from 37 to 61 percent. In 8 out of 12 stations the overlap exceeds 50 percent. The dissimilarity between the surface and bottom populations at station 10 is further evidenced by the fact that there was only an average of 24 percent overlap between the surface and bottom populations.

Table 7-20. Average Community Overlap (%) June-December, 1969
(Bottom Trawls)

	STA.	MILE	SITE	DEPTH	Number of Comparisons	Average Community Overlap (%)															
						1	5	3	7	8	9	12	2	4	6	15	16	11	10	13	14
						SHALLOW							DEEP								
SHALLOW	1	29	1	10		X	58	72	64	46	66	39	39	64	71	23	37	33	23	24	22
	5	36	1	12		4	X	61	49	48	53	37	28	37	42	31	45	19	28	28	36
	3	35	3	10		4	6	X	57	57	60	44	27	42	47	26	47	27	25	24	28
	7	38	3	11		4	6	6	X	66	62	56	29	51	65	24	53	37	29	27	32
	8	39	1	12		4	6	6	6	X	58	62	21	42	51	29	56	37	31	27	31
	9	40	3	12		4	6	6	6	6	X	60	27	41	49	23	45	32	26	23	25
	12	44	3	12		4	6	6	6	6	6	X	18	27	38	24	41	30	24	26	26
DEEP	2	29	3	26		4	4	4	4	4	4	4	X	59	46	61	31	41	48	55	56
	4	35	2	34		4	6	6	6	6	6	6	4	X	74	49	55	59	49	45	43
	6	38	2	30		4	6	6	6	6	6	6	4	6	X	50	52	55	44	34	34
	15	40	1	45		2	4	4	4	4	4	4	2	4	4	X	50	57	53	55	54
	16	41	3	45		1	3	3	3	3	3	3	1	3	3	3	X	59	56	68	59
	11	42	2	50		4	6	6	6	6	6	6	4	6	6	4	3	X	74	54	45
	10	42	3	45		4	6	6	6	6	6	6	4	6	6	4	3	6	X	59	52
	13	45	1	50		4	5	5	5	5	5	5	4	5	5	3	2	5	5	X	75
	14	47	3	47		4	6	6	6	6	6	6	4	6	6	4	3	6	6	5	X

Table 7-20A. Community Overlap (%) June-July, 1969 (Bottom Trawls)

STA	MILE	SITE	DPTH	Community Overlap (%)															
				1	2	5	3	4	6	7	8	9	15	16	11	10	13	12	14
1	29	1	10	X	51	64	59	69	67	71	39	44	0	0	37	28	31	28	39
2	29	3	26	51	X	20	27	77	61	49	18	23	0	0	71	64	65	16	72
5	36	1	12	64	20	X	75	38	37	46	63	61	0	0	7	3	5	31	10
3	35	3	10	59	27	75	X	37	40	50	73	59	0	0	13	9	11	28	15
4	35	2	34	69	77	38	37	X	63	53	18	23	0	0	63	55	57	18	66
6	38	2	30	67	61	37	40	63	X	82	47	47	0	0	52	45	45	39	56
7	38	3	11	71	49	46	50	53	82	X	54	57	0	0	38	30	32	40	41
8	39	1	12	39	18	63	73	18	47	54	X	80	0	0	9	4	6	54	11
9	40	3	12	44	23	61	59	23	47	57	80	X	0	0	8	4	6	67	11
15	40	1	45	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0	0
16	41	3	45	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0
11	42	2	50	37	71	7	13	63	52	38	9	8	0	0	X	90	91	6	95
10	42	3	45	28	64	3	9	55	45	30	4	4	0	0	90	X	93	2	87
13	45	1	50	31	65	5	11	57	45	32	6	6	0	0	91	93	X	3	88
12	44	3	12	28	16	31	28	18	39	40	54	67	0	0	6	2	3	X	9
14	47	3	47	39	72	10	15	66	56	41	11	11	0	0	95	87	88	9	X

Table 7-20B. Community Overlap (%) August, 1969 (Bottom Trawls)

STA	MILE	SITE	DPTH	Community Overlap (%)															
				1	2	5	3	4	6	7	8	9	15	16	11	10	13	12	14
1	29	1	10	X	49	85	85	62	68	31	18	82	0	0	9	17	3	3	5
2	29	3	26	49	X	59	58	84	59	38	24	53	0	0	45	53	47	11	36
5	36	1	12	85	59	X	96	67	81	44	28	90	0	0	12	22	8	17	14
3	35	3	10	85	58	96	X	66	82	45	27	89	0	0	11	22	7	17	12
4	35	2	34	62	84	67	66	X	67	34	21	65	0	0	41	50	40	9	34
6	38	2	30	68	59	81	82	67	X	60	28	76	0	0	12	24	8	20	13
7	38	3	11	31	38	44	45	34	60	X	58	48	0	0	10	24	7	51	29
8	39	1	12	18	24	28	27	21	28	58	X	35	0	0	10	24	7	54	28
9	40	3	12	82	53	90	89	65	76	48	35	X	0	0	11	24	7	21	21
15	40	1	45	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0	0
16	41	3	45	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0
11	42	2	50	9	45	12	11	41	12	10	10	11	0	0	X	84	53	5	41
10	42	3	45	17	53	22	22	50	24	24	24	24	0	0	84	X	48	14	40
13	45	1	50	3	47	8	7	40	8	7	7	7	0	0	53	48	X	10	64
12	44	3	12	3	11	17	17	9	20	51	54	21	0	0	5	14	10	X	33
14	47	3	47	5	36	14	12	34	13	29	28	21	0	0	41	40	64	33	X

Table 7-20C. Community Overlap (%) September, 1969 (Bottom Trawls)

STA	MILE	SITE	DPTH	Community Overlap (%)															
				1	2	5	3	4	6	7	8	9	15	16	11	10	13	12	14
1	29	1	10	X	13	19	90	62	80	90	91	78	7	37	68	23	29	78	15
2	29	3	26	13	X	17	12	20	26	14	15	15	70	31	32	52	59	15	50
5	36	1	12	19	17	X	10	14	20	26	23	40	19	20	22	21	30	23	32
3	35	3	10	90	12	10	X	63	80	81	86	69	7	37	67	21	27	77	14
4	35	2	34	62	20	14	63	X	74	64	64	64	22	50	73	33	40	64	30
6	38	2	30	80	26	20	80	74	X	84	82	70	27	54	85	38	44	80	31
7	38	3	11	90	14	26	81	64	84	X	89	80	15	45	75	26	89	88	42
8	39	1	12	91	15	23	86	64	82	89	X	81	9	39	70	26	37	86	23
9	40	3	12	78	15	40	69	64	70	80	81	X	8	38	69	25	37	78	25
15	40	1	45	7	70	19	7	22	27	15	9	8	X	43	39	42	66	19	57
16	41	3	45	37	31	20	37	50	54	45	39	38	43	X	66	42	61	49	43
11	42	2	50	68	32	22	67	73	85	75	70	69	39	66	X	42	56	75	44
10	42	3	45	23	52	21	21	33	38	26	26	25	42	42	42	X	57	27	49
13	45	1	50	29	50	30	27	40	44	39	37	37	66	61	56	57	X	46	71
12	44	3	12	78	15	23	77	64	80	88	86	78	19	49	75	27	47	X	27
14	47	3	47	15	50	32	14	30	31	22	23	25	57	43	44	49	71	27	X

Table 7-20D. Community Overlap (%) October, 1969 (Bottom Trawls)

STA	MILE	SITE	DPTH	Community Overlap (%)															
				1	2	5	3	4	6	7	8	9	15	16	11	10	13	12	14
1	29	1	10	X	41	65	55	63	67	63	37	45	39	0	16	24	33	48	30
2	29	3	26	41	X	18	13	56	40	13	28	17	53	0	17	23	49	31	64
5	36	1	12	65	18	X	54	38	69	70	46	37	25	0	17	22	27	30	15
3	35	3	10	55	13	54	X	18	33	63	44	43	19	0	13	18	22	53	9
4	35	2	34	63	56	38	18	X	63	39	26	19	43	0	8	21	35	16	44
6	38	2	30	67	40	69	33	63	X	62	41	31	51	0	23	35	34	37	38
7	38	3	11	63	13	70	63	39	62	X	23	44	21	0	4	14	10	35	11
8	39	1	12	37	28	46	44	26	41	23	X	27	26	0	31	37	28	59	18
9	40	3	12	45	17	37	43	19	31	44	27	X	26	0	27	28	12	50	14
15	40	1	45	39	53	25	19	43	51	21	26	26	X	0	42	50	43	34	43
16	41	3	45	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0
11	42	2	50	16	17	17	13	8	23	4	31	27	42	0	X	82	18	39	15
10	42	3	45	24	23	22	18	21	35	14	37	28	50	0	82	X	16	36	17
13	45	1	50	33	49	27	22	35	34	10	28	12	43	0	18	16	X	27	76
12	44	3	12	48	31	50	58	16	37	35	59	50	34	0	39	36	27	X	19
14	47	3	47	30	64	15	9	44	38	11	18	14	53	0	15	17	76	19	X

Table 7-20E. Community Overlap (%) November, 1969 (Bottom Trawls)

STA	MILE	SITE	DPTH	Community Overlap (%)															
				1	2	5	3	4	6	7	8	9	15	16	11	10	13	12	14
1	29	1	10	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	29	3	26	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	36	1	12	0	0	X	75	25	25	76	87	65	30	58	23	37	0	72	65
3	35	3	10	0	0	75	X	25	24	66	69	63	31	60	22	35	0	57	70
4	35	2	34	0	0	25	25	X	94	24	30	20	89	41	90	84	0	15	42
6	38	2	30	0	0	25	24	94	X	20	28	17	91	40	90	82	0	11	43
7	38	3	11	0	0	76	66	24	20	X	81	82	24	46	20	34	0	73	54
8	39	1	12	0	0	87	69	30	28	81	X	70	33	51	25	38	0	77	61
9	40	3	12	0	0	65	63	20	17	82	70	X	22	37	17	30	0	69	52
15	40	1	45	0	0	30	31	89	91	24	33	22	X	45	88	87	0	15	50
16	41	3	45	0	0	58	60	41	40	46	51	37	45	X	37	49	0	32	73
11	42	2	50	0	0	23	22	90	90	20	25	17	88	37	X	83	0	12	40
10	42	3	45	0	0	37	35	84	82	34	38	30	87	49	83	X	0	26	54
13	45	1	50	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0	0
12	44	3	12	0	0	72	57	15	11	73	77	69	15	32	12	26	0	X	43
14	47	3	47	0	0	65	70	42	43	54	61	52	50	73	40	54	0	43	X

Table 7-20F. Community Overlap (%) December, 1969 (Bottom Trawls)

STA	MILE	SITE	DPTH	Community Overlap (%)															
				1	2	5	3	4	6	7	8	9	15	16	11	10	13	12	14
1	29	1	10	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	29	3	26	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	36	1	12	0	0	X	58	37	22	33	40	47	51	58	32	63	70	26	82
3	35	3	10	0	0	58	X	41	26	34	44	37	45	45	36	43	52	29	46
4	35	2	34	0	0	37	41	X	83	91	95	57	43	75	79	53	54	43	41
6	38	2	30	0	0	22	26	83	X	83	81	56	33	62	71	42	40	42	26
7	38	3	11	0	0	33	34	91	83	X	90	64	37	69	75	47	49	50	34
8	39	1	12	0	0	40	44	95	81	90	X	57	46	78	78	56	58	44	44
9	40	3	12	0	0	27	37	57	56	64	57	X	34	59	59	44	52	75	28
15	40	1	45	0	0	51	45	43	33	37	46	34	X	62	60	71	57	30	56
16	41	3	45	0	0	58	45	75	62	69	78	59	62	X	74	77	76	44	62
11	42	2	50	0	0	32	36	79	71	75	78	59	50	74	X	64	52	42	36
10	42	3	45	0	0	63	43	53	42	47	56	44	71	77	64	X	82	40	68
13	45	1	50	0	0	70	52	54	40	49	58	52	57	76	52	82	X	43	74
12	44	3	12	0	0	26	29	43	42	50	44	75	30	34	42	40	43	X	28
14	47	3	47	0	0	82	46	41	26	34	44	28	56	62	36	68	74	28	X

Table 7-21. Average Community Overlap (%) August-December, 1969

(Surface Trawls)

	STA	MILE	SITE	DEPTH	Number of Comparisons	Average Community Overlap (%)															
						Shallow							Deep								
						1	5	3	7	8	9	12	2	4	6	15	16	11	10	13	14
Shallow	1	29	1	10		X	0	72	58	7	5	3	97	92	96	3	0	6	38	17	18
	5	36	1	12		0	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	35	3	10		1	0	X	54	32	38	22	69	46	57	26	23	38	50	35	46
	7	38	3	11		1	0	3	X	56	61	34	55	46	50	58	33	60	61	39	45
	8	39	1	12		1	0	3	4	X	67	55	4	31	28	66	42	63	59	36	35
	9	40	3	12		1	0	3	4	4	X	41	4	26	34	81	32	84	58	49	51
	12	44	3	12		1	0	3	5	4	4	X	1	23	20	52	58	46	48	48	27
Deep	2	29	3	26		1	0	1	1	1	1	1	X	91	93	2	0	3	36	14	15
	4	35	2	34		1	0	3	3	3	3	3	1	X	54	27	28	26	37	32	21
	6	38	2	30		1	0	3	3	3	3	3	1	3	X	22	22	34	44	30	22
	15	40	1	45		1	0	3	4	4	4	4	1	3	3	X	50	80	57	57	45
	16	41	3	45		0	0	2	2	2	2	2	0	2	2	2	X	41	53	44	0
	11	42	2	50		1	0	3	4	4	4	4	1	3	3	4	2	X	60	51	52
	10	42	3	45		1	0	3	5	4	4	5	1	3	3	4	2	4	X	42	54
	13	45	1	50		1	0	3	3	3	3	3	1	3	3	3	2	3	3	X	71
	14	47	3	47		1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	X

Table 7-21A. Community Overlap (%) September, 1969 (Surface Trawls)*

STA	MILE	SITE	DPTH	Community Overlap (%)															
				1	2	5	3	4	6	7	8	9	15	16	11	10	13	12	14
1	29	1	10	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	29	3	26	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	36	1	12	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
3	35	3	10	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0
4	35	2	34	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0
6	38	2	30	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0
7	38	3	11	0	0	0	0	0	0	X	69	68	83	0	67	90	0	53	0
8	39	1	12	0	0	0	0	0	0	69	X	83	85	0	85	77	0	70	0
9	40	3	12	0	0	0	0	0	0	68	83	X	73	0	72	77	0	55	0
15	40	1	45	0	0	0	0	0	0	83	85	73	X	0	82	87	0	66	0
16	41	3	45	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0
11	42	2	50	0	0	0	0	0	0	67	85	72	82	0	X	71	0	70	0
10	42	3	45	0	0	0	0	0	0	90	77	77	87	0	71	X	0	55	0
13	45	1	50	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0	0
12	44	3	12	0	0	0	0	0	0	53	70	55	66	0	70	55	0	X	0
14	47	3	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X

* Too few collections in August for useful presentation.

Table 7-21B. Community Overlap (%) October, 1969 (Surface Trawls)

STA	MILE	SITE	DPTH	Community Overlap (%)															
				1	2	5	3	4	6	7	8	9	15	16	11	10	13	12	14
1	29	1	10	X	97	0	72	92	96	58	7	5	3	0	6	38	17	3	18
2	29	3	26	97	X	0	69	91	93	55	4	4	2	0	3	36	14	1	15
5	36	1	12	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
3	35	3	10	72	69	0	X	74	77	74	24	20	16	0	22	59	39	15	46
4	35	2	34	92	91	0	74	X	94	64	12	10	5	0	6	39	16	1	21
6	38	2	30	96	93	0	77	94	X	60	11	7	3	0	8	41	19	5	22
7	38	3	11	58	55	0	74	64	60	X	27	33	27	0	30	49	41	3	45
8	39	1	12	7	4	0	24	12	11	27	X	12	5	0	10	23	18	24	35
9	40	3	12	5	4	0	20	10	7	33	12	X	93	0	93	14	75	1	51
15	40	1	45	3	2	0	16	5	3	27	5	93	X	0	93	13	74	1	45
16	41	3	45	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0
11	42	2	50	6	3	0	22	6	8	30	10	93	93	0	X	19	81	6	52
10	42	3	45	38	36	0	59	39	41	49	23	15	13	0	19	X	38	23	54
13	45	1	50	17	14	0	39	16	19	41	18	75	74	0	81	38	X	12	71
12	44	3	12	3	1	0	15	1	5	3	24	1	1	0	6	23	12	X	27
14	47	3	47	18	15	0	46	21	22	45	35	51	45	0	52	54	71	27	X

Table 7-21C. Community Overlap (%) November, 1969 (Surface Trawls)

STA	MILE	SITE	DPTH	Community Overlap (%)															
				1	2	5	3	4	6	7	8	9	15	16	11	10	13	12	14
1	29	1	10	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	29	3	26	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	36	1	12	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
3	35	3	10	0	0	0	X	64	95	88	72	93	63	45	93	91	67	52	0
4	35	2	34	0	0	0	64	X	67	74	80	69	75	56	71	73	78	68	0
6	38	2	30	0	0	0	95	67	X	90	74	94	64	34	93	90	70	54	0
7	38	3	11	0	0	0	88	74	90	X	80	93	70	51	94	94	75	60	0
8	39	1	12	0	0	0	72	80	74	80	X	78	87	66	79	81	90	78	0
9	40	3	12	0	0	0	93	69	94	93	78	X	68	49	97	95	72	57	0
15	40	1	45	0	0	0	63	75	64	70	87	68	X	78	70	72	93	89	0
16	41	3	45	0	0	0	45	56	44	51	66	49	78	X	52	54	74	85	0
11	42	2	50	0	0	0	93	71	93	94	79	97	70	52	X	97	74	54	0
10	42	3	45	0	0	0	91	73	90	94	81	95	72	54	97	X	76	61	0
13	45	1	50	0	0	0	67	78	70	75	90	72	93	74	74	76	X	83	0
12	44	3	12	0	0	0	52	68	54	60	78	57	89	85	59	61	83	X	0
14	47	3	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X

Table 7-21D. Community Overlap (%) December, 1969 (Surface Trawls)

STA	MILE	SITE	DPTH	Community Overlap (%)															
				1	2	5	3	4	6	7	8	9	15	16	11	10	13	12	14
1	29	1	10	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	29	3	26	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	36	1	12	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
3	35	3	10	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0
4	35	2	34	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0
6	38	2	30	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0
7	38	3	11	0	0	0	0	0	0	X	50	50	53	15	50	59	0	50	0
8	39	1	12	0	0	0	0	0	0	50	X	94	88	18	78	53	0	50	0
9	40	3	12	0	0	0	0	0	0	50	94	X	92	15	75	47	0	50	0
15	40	1	45	0	0	0	0	0	0	53	88	92	X	21	75	55	3	53	0
16	41	3	45	0	0	0	0	0	0	15	18	15	21	X	31	51	15	31	0
11	42	2	50	0	0	0	0	0	0	50	78	75	75	31	X	53	0	50	0
10	42	3	45	0	0	0	0	0	0	59	53	47	55	51	53	X	12	59	0
13	45	1	50	0	0	0	0	0	0	0	0	0	3	15	0	12	X	50	0
12	44	3	12	0	0	0	0	0	0	50	50	50	53	31	50	59	50	X	0
14	47	3	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X

Table 7-22. Average Community Overlap (%), June—December 1969 (Beach Seines)

STA	MILE	SITE	Average Community Overlap (%)								
			31	32	38	33	39	35	34	36	37
31	35	1	X	42	44	52	45	24	41	22	25
32	35	3	4	X	43	50	39	47	37	38	38
38	40	1	3	3	X	66	69	29	51	24	33
33	40	3	4	5	4	X	57	40	55	32	45
39	41	3	1	1	2	2	X	46	63	21	31
35	43	1	4	5	4	6	2	X	43	32	46
34	42	3	4	4	4	5	2	5	X	43	55
36	44	3	4	5	4	6	2	6	5	X	46
37	47	1	4	5	4	6	2	6	5	6	X

Number of Comparisons (values below the diagonal X)

Table 7-22A. Community Overlap (%) June-July, 1969 (Beach Seines)

STA	MILES	SITE	Community Overlap (%)								
			31	32	38	33	39	35	34	36	37
31	35	1	X	0	0	0	0	0	0	0	0
32	35	3	0	X	0	38	0	17	0	45	25
38	40	1	0	0	X	0	0	0	0	0	0
33	40	3	0	38	0	X	0	55	0	22	68
39	41	3	0	0	0	0	X	0	0	0	0
35	43	1	0	17	0	55	0	X	0	14	57
34	42	3	0	0	0	0	0	0	X	0	0
36	44	3	0	45	0	22	0	14	0	X	26
37	47	1	0	25	0	68	0	57	0	26	X

Table 7-22B. Overlap (%) August, 1969 (Beach Seines)

STA	MILE	SITE	Community Overlap (%)								
			31	32	38	33	39	35	34	36	37
31	35	1	X	60	0	62	0	28	48	23	30
32	35	3	60	X	0	59	0	32	34	37	43
38	40	1	0	0	X	0	0	0	0	0	0
33	40	3	62	59	0	X	0	36	47	40	43
39	41	3	0	0	0	0	X	0	0	0	0
35	43	1	28	32	0	36	0	X	32	42	44
34	42	3	48	34	0	47	0	32	X	32	51
36	44	3	23	37	0	40	0	42	32	X	58
37	47	1	30	43	0	43	0	44	51	58	X

Table 7-22C. Community Overlap (%) September, 1969
(Beach Seines)

STA	MILE	SITE	Community Overlap(%) 31	32	38	33	39	35	34	36	37
31	35	1	X	30	69	58	0	12	28	6	23
32	35	3	20	X	15	37	0	79	24	19	25
38	40	1	69	15	X	59	0	13	45	28	30
33	40	3	58	37	59	X	0	28	57	37	49
39	41	3	0	0	0	0	X	0	0	0	0
35	43	1	12	79	13	28	0	X	16	22	22
34	42	3	28	24	45	57	0	16	X	72	76
36	44	3	6	19	28	37	0	22	72	X	73
37	47	1	23	25	30	49	0	22	76	73	X

Table 7-22D. Community Overlap (%), October 1969
(Beach Seines)

STA	MILE	SITE	Community Overlap (%) 31	32	38	33	39	35	34	36	37
31	35	1	X	65	35	51	0	32	43	37	41
32	35	3	65	X	38	54	0	64	44	47	63
38	40	1	35	38	X	74	0	30	64	37	59
33	40	3	51	54	74	X	0	31	71	38	60
39	41	3	0	0	0	0	X	0	0	0	0
35	43	1	32	64	30	31	0	X	33	54	61
34	42	3	43	44	64	71	0	33	X	54	53
36	44	3	37	47	37	38	0	54	54	X	51
37	47	1	41	63	59	60	0	61	53	51	X

Table 7-22E. Community Overlap (%) November, 1969
(Beach Seines)

STA	MILE	SITE	Community Overlap (%)								
			31	32	38	33	39	35	34	36	37
31	35	1	X	26	27	36	45	25	46	20	8
32	35	3	26	X	75	64	39	42	47	42	35
38	40	1	27	75	X	83	59	42	32	30	20
33	40	3	36	64	83	X	62	49	52	44	26
39	41	3	45	39	59	62	X	43	58	37	22
35	43	1	25	42	42	49	43	X	70	52	38
34	42	3	46	47	42	52	58	70	X	52	33
36	44	3	20	42	30	44	37	52	52	X	70
37	47	1	8	35	20	26	22	38	33	70	X

Table 7-22F. Community Overlap (%) December, 1969
(Beach Seines)

STA	MILE	SITE	Community Overlap (%)								
			31	32	38	33	39	35	34	36	37
31	35	1	X	0	0	0	0	0	0	0	0
32	35	3	0	X	0	0	0	0	0	0	0
38	40	1	0	0	X	48	79	32	52	1	23
33	40	3	0	0	48	X	52	41	50	10	24
39	41	3	0	0	79	52	X	50	68	4	40
35	43	1	0	0	32	41	50	X	62	11	51
34	42	3	0	0	52	50	68	62	X	2	64
36	44	3	0	0	1	10	4	11	2	X	0
37	47	1	0	0	23	24	40	51	64	0	X

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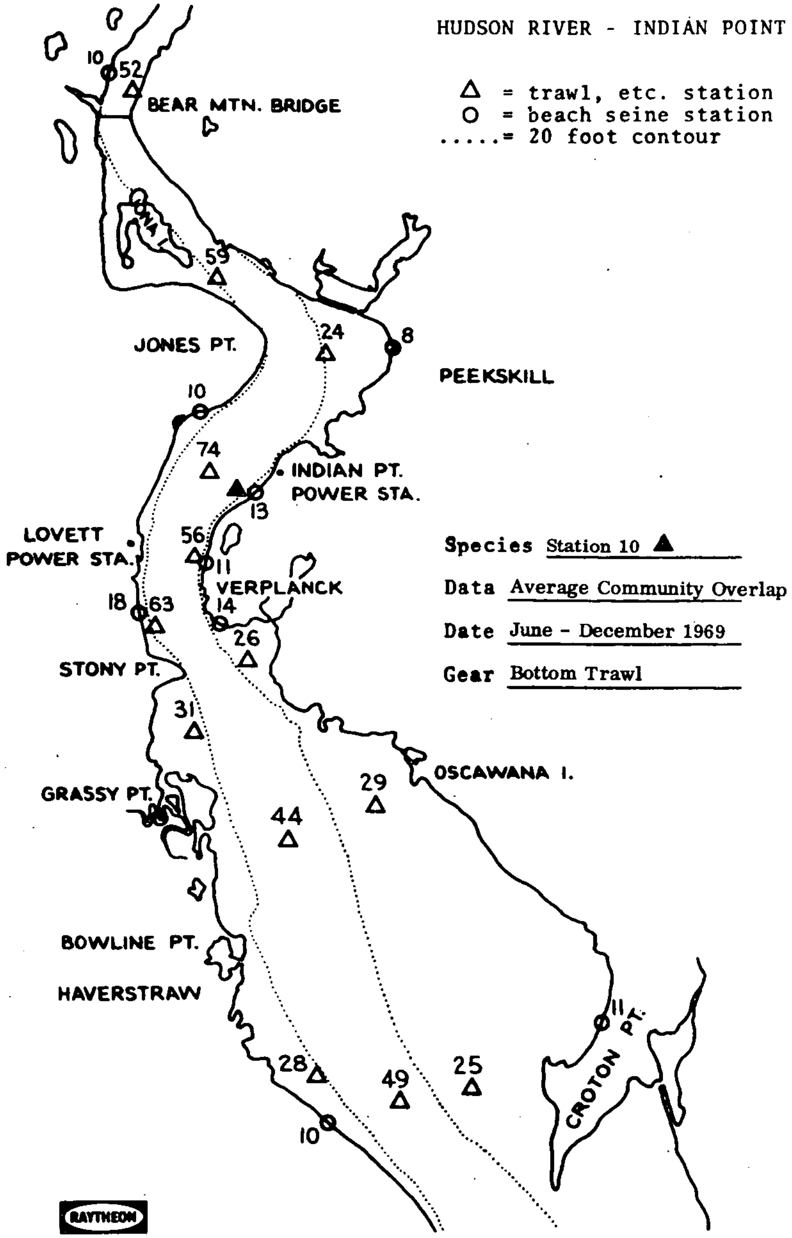


Figure 7-7. Overlap Trends on Bottom Trawl Data, Station 10

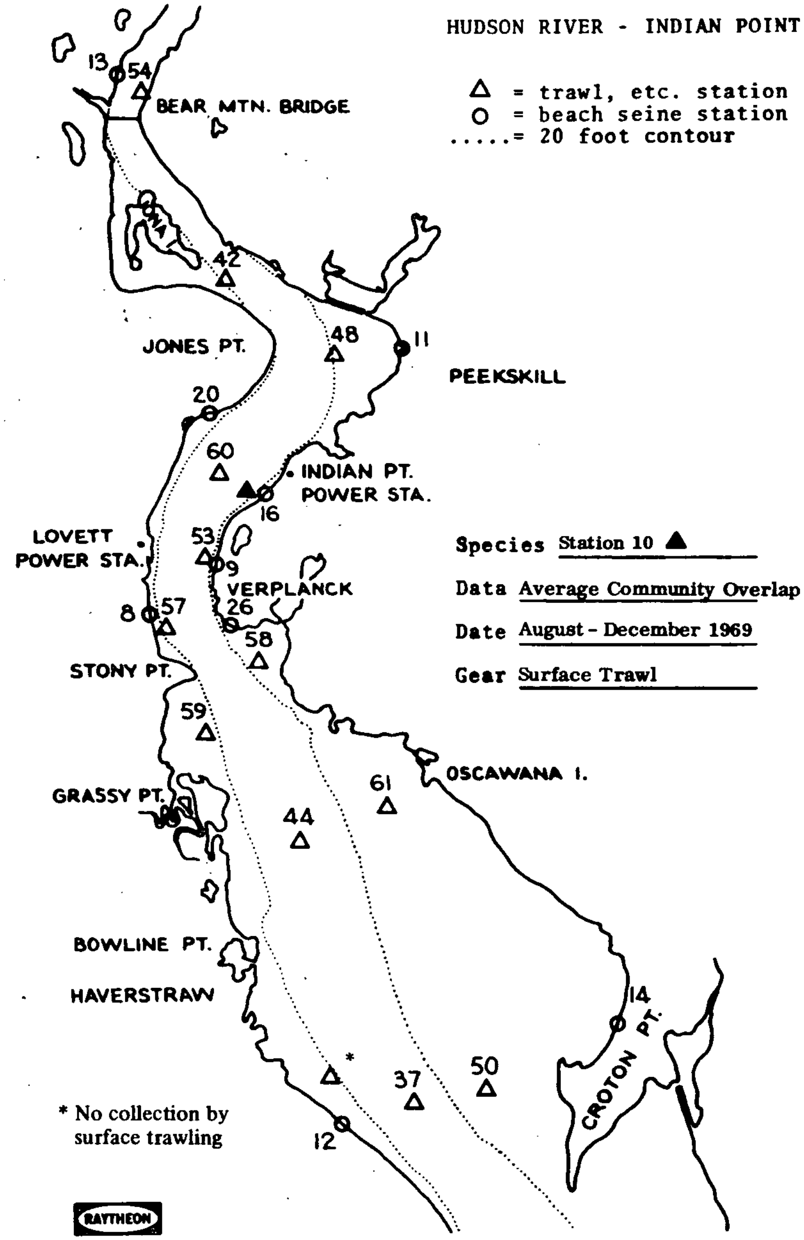


Figure 7-8. Overlap Trends on Surface Trawl Data, Station 10

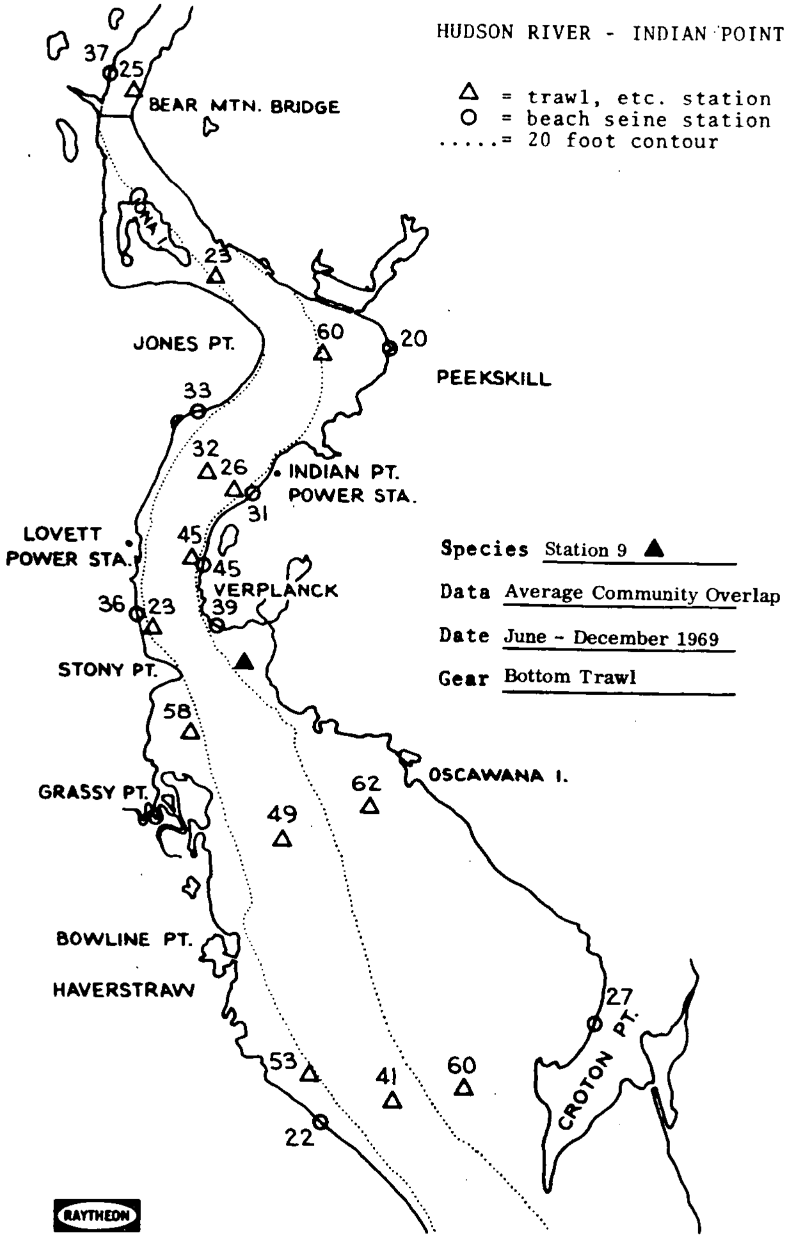


Figure 7-9. Overlap Trends on Bottom Trawl Data, Station 9

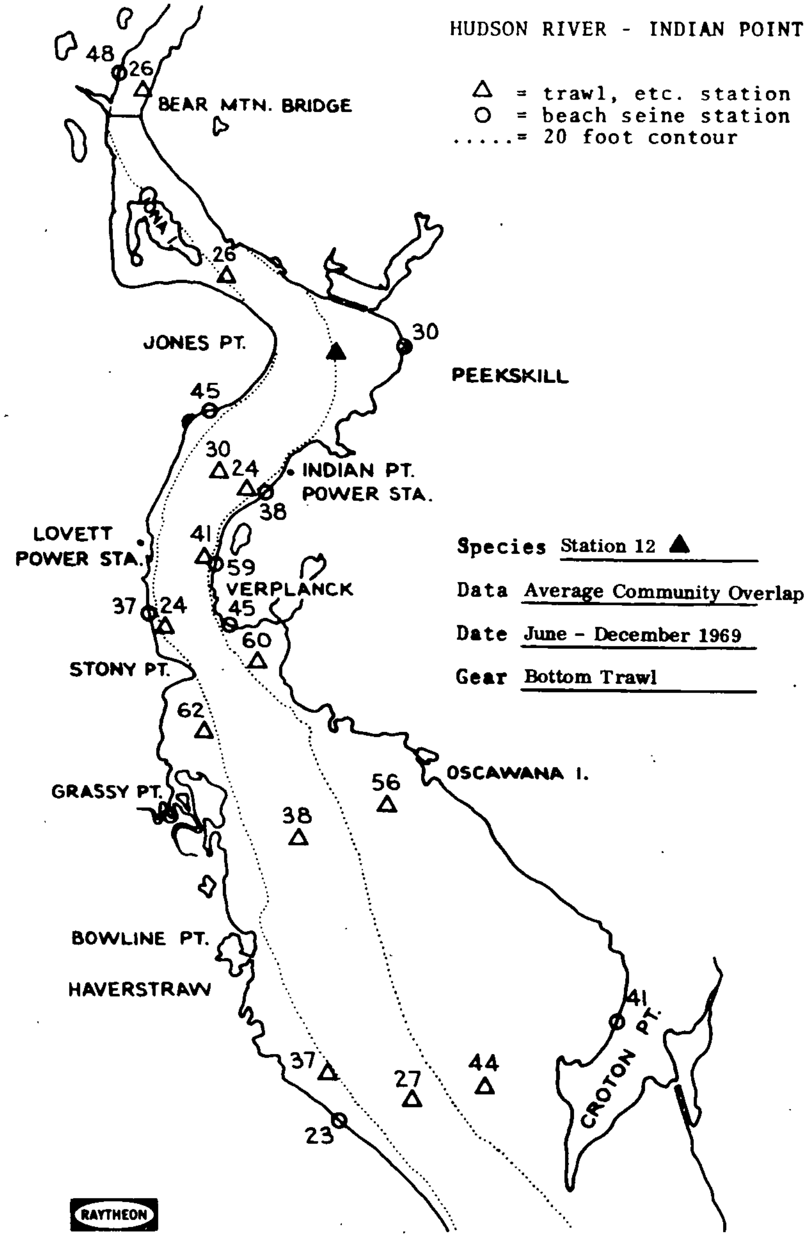


Figure 7-10. Overlap Trends on Bottom Trawl Data, Station 12

7.4.1.3 Station Redundancy

Average community overlap indices can also be used to evaluate general faunal redundancy among stations. For example, the major faunal components of both the surface and bottom populations at stations 11, 15 and 16 average greater than 50 percent overlap with the corresponding populations at station 10 (Figures 7-7 and 7-8). That these high values are indicative of similarity among the major faunal components is confirmed by an examination of the actual percent composition data for the bottom trawls from these stations (Table 7-23). Thus, it would be biologically legitimate to pool the data from these stations if it were desired to increase the sample size in the immediate vicinity of Indian Point from a statistical point of view.

Likewise, it is observed that there is a high degree of faunal redundancy among the bottom populations at shoal station 12 and stations 8 and 9 (Figure 7-10) and among shoal station 9 and stations 5, 3, 7, 8 and 12 (Figure 7-9). Seine station 34 in the immediate vicinity of the Indian Point power station could reasonably be pooled with stations 39, 38, 33 and 37 (Figure 7-11). Seine station 33 has a high degree of faunal similarity with stations 38, 39, and 34 (Figure 7-12).

7.4.1.4 Gear Redundancy

There are no major community overlaps among the gear types—surface trawl, bottom trawl and seine. However, on the basis of efficiency in collection of the key pelagic fish species, the bottom trawl is as effective as the surface trawl in collecting two of the three primary pelagic species, namely, alewife and anchovy (Tables 7-5, 7-6, 7-7, 7-13 and 7-14). Blueback herring are better caught by surface trawling. The fairly ubiquitous abundance distribution of the latter species during the months of August through November (Tables 7-8, 7-9 and 7-10), coupled with the more uniform community overlap among the surface trawl stations (compared to bottom trawl data), suggest that the areal distribution of the blueback herring as well as the vertical distribution of all the pelagic species could be adequately monitored by surface trawling at fewer stations than is presently done. The saved effort could be redirected to, for example, increased sampling frequency elsewhere, if this indication should be confirmed by subsequent data collected throughout the year.

Table 7-23. Percent Abundance Based on the Average Number Caught/Species/7 Minutes (Bottom Trawl Data)

Station		October			November				December			
		10	11	15	10	11	15	16	10	11	15	16
Species												
Code	Name											
1	Alewife	6	11	2	P	1	P	9	2	2	1	1
2	Bay anchovy	56	59	29	0	P	1	0	P	P	1	0
3	American shad	P	P	P	0	0	P	0	0	0	0	0
10	American eel	P	P	2	4	2	2	2	1	1	1	P
13	Hogchoker	1	P	21	61	76	65	14	11	19	36	2
14	Johnny darter	0	P	P	P	0	0	0	P	0	0	P
19	Menhaden, Atlantic	3	2	P	0	1	1	0	0	0	0	0
22	Blueback herring	13	21	5	P	P	3	1	2	0	1	P
25	American smelt	6	2	9	P	P	1	1	2	1	2	P
28	Spottail shiner	0	0	P	0	0	0	0	0	0	0	P
30	Striped bass	11	1	3	P	P	P	0	0	1	2	2
32	Atlantic tomcod	2	1	14	16	17	21	51	46	14	32	37
35	White perch	1	1	15	16	3	6	21	36	62	24	56
	Miscellaneous	1	2	0	3	0	0	1	0	0	0	2
Total No. Species		12	14	17	10	13	14	8	11	10	11	10
Avg Total No. Cght		151	149	280	245	490	259	77	87	417	179	179
Overlap with Station 10		100	82	50	100	83	87	49	100	64	71	77

P = presence less than 1

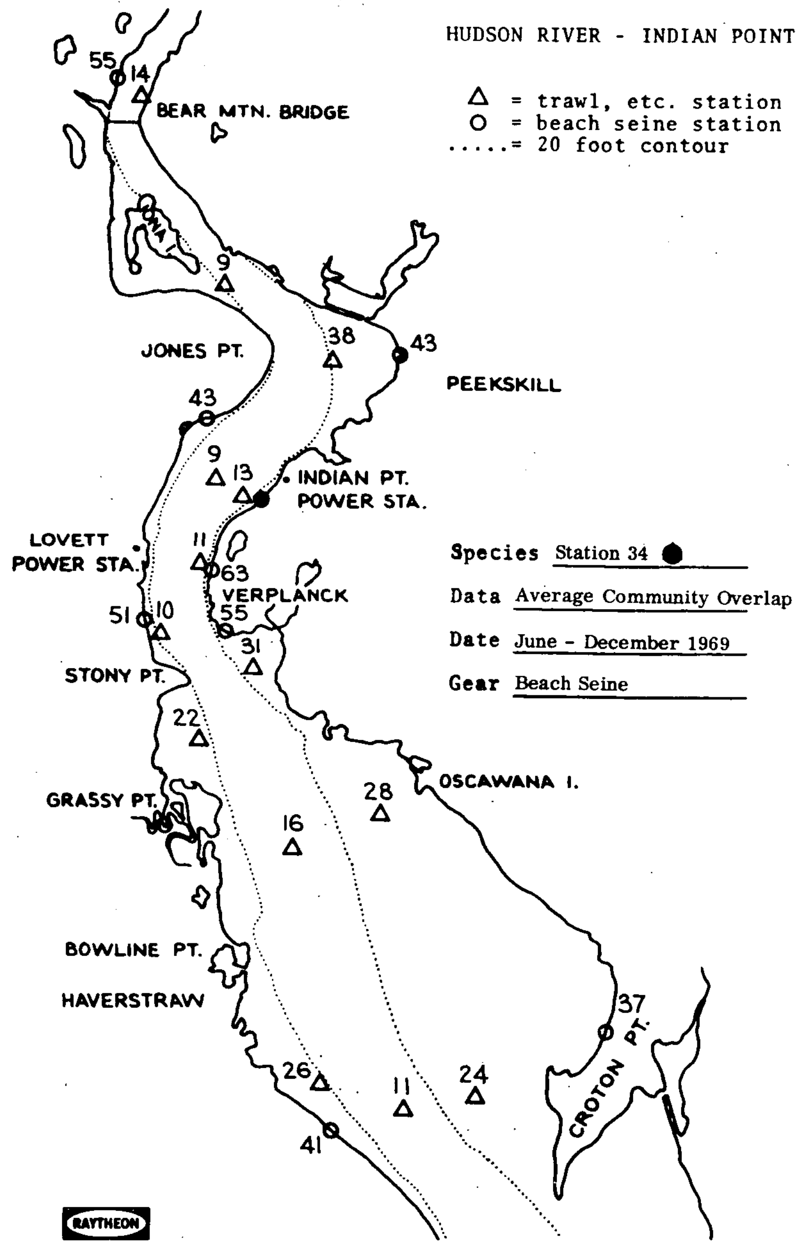


Figure 7-11. Overlap Trends on Beach Seine Data, Station 34

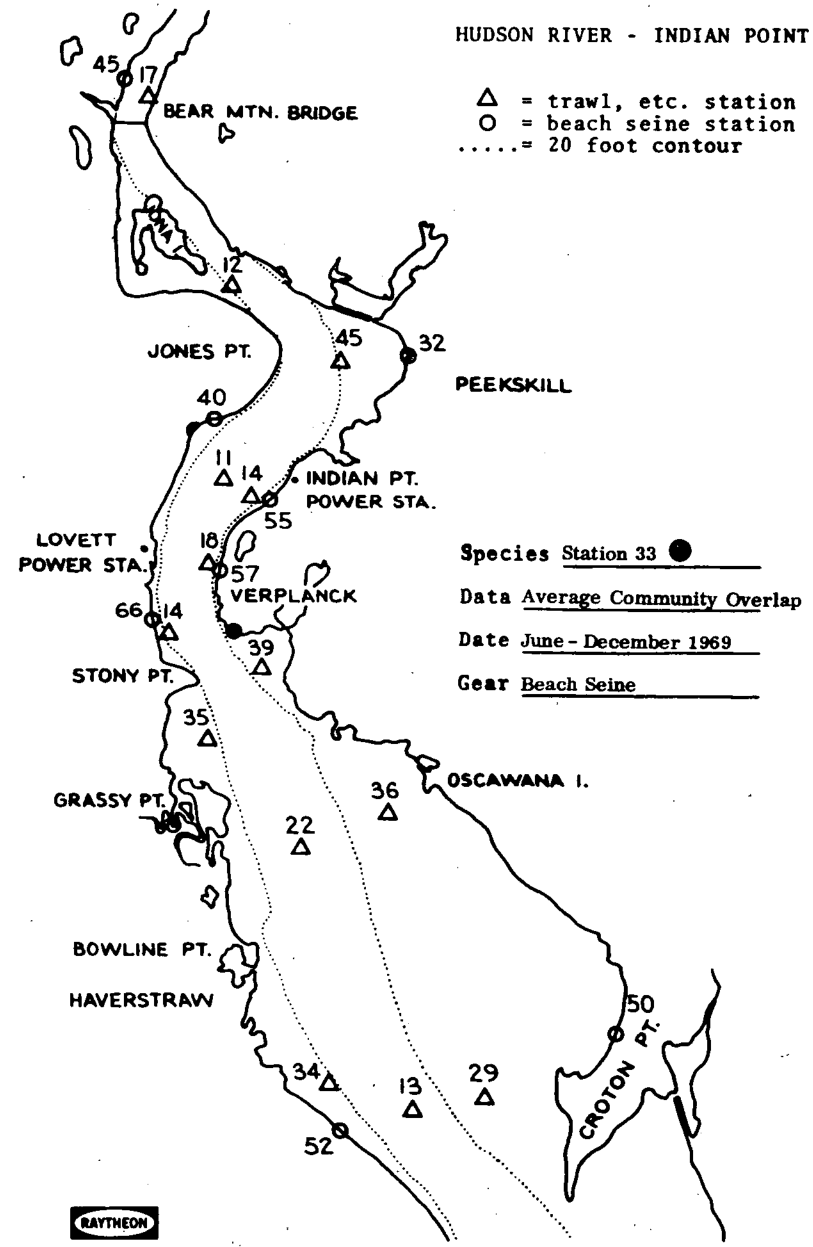


Figure 7-12. Overlap Trends on Beach Seine Data, Station 33

7.4.2 Two Faunal Communities

An analysis of the actual fish species caught per gear per station during June through December 1969, plus a consideration of the cumulative number of species caught at each station adds further support to the suggestion that there are two major faunal communities within the bottom and shore populations. As discussed under the section on community overlap, the vicinity of Stony Point appears to represent a natural demarkation between a "Haverstraw Bay" community and a community characteristic of the upper half of the study area. On the basis of presence or absence, there were 9 species caught at every bottom trawl station; 3 (possibly 5) species at every surface trawl station and 9 at every beach seine station with a total of 5 occurring at all bottom trawl and seine stations (Figures 7-13 through 7-15).

Ubiquitous Species

Bottom Trawl Species	Rank	Beach Seine Species	Rank
alewife	4	alewife	3
blueback	6	blueback	5
white perch	2	white perch	2
striped bass	3	striped bass	1
American eel	7	American eel	9
bay anchovy	1	spottail shiner	4
tom cod	3	menhaden	7
hogchoker	5	American shad	8
American smelt	8	Atlantic silverside	6

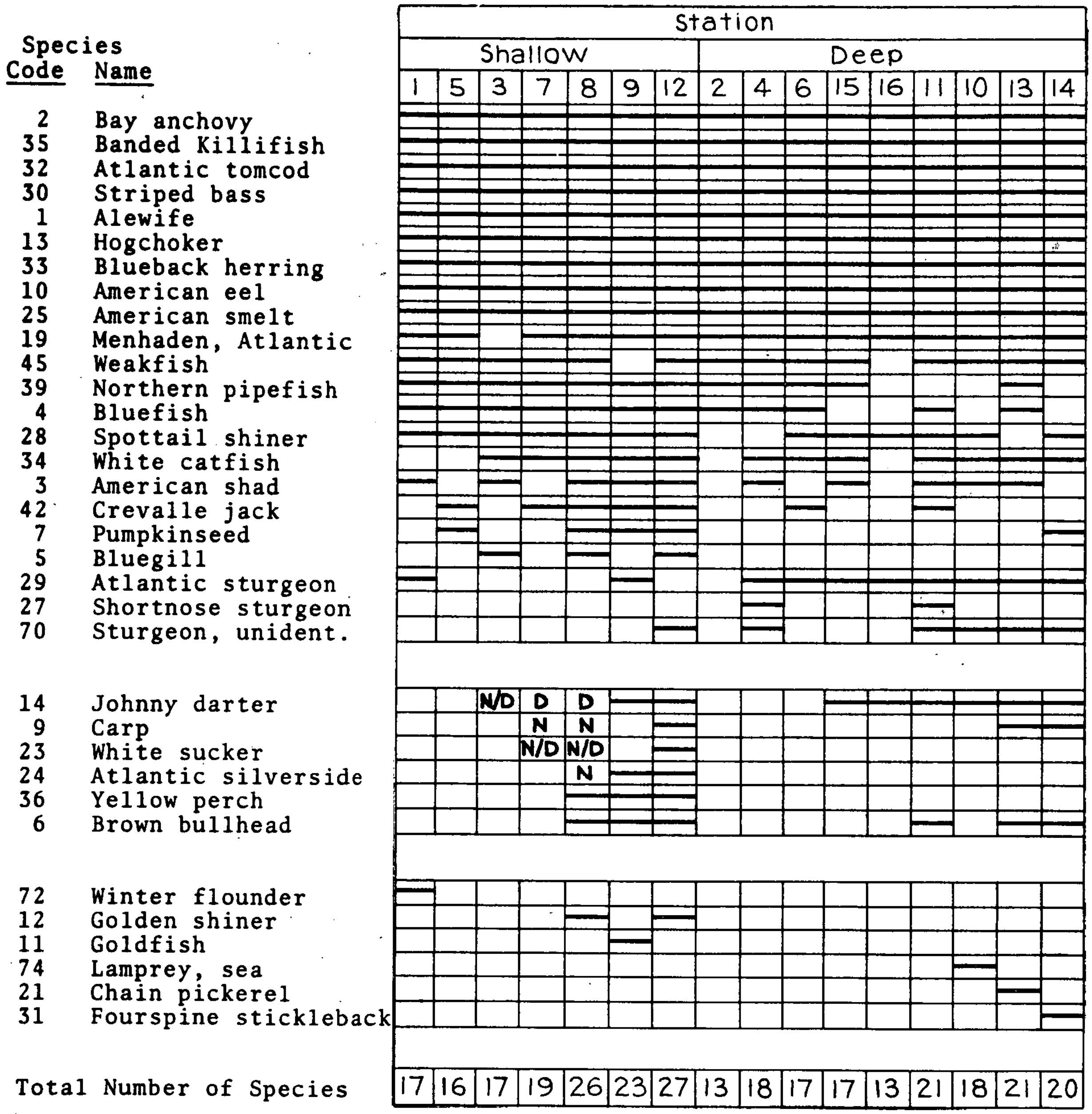
These ubiquitous species comprise the numerically most important species in the study area. The distinction between the upstream and Haverstraw Bay communities is most easily recognized by the general restriction of the fresher-water species only to the northern half of the study area. Fresher-water species caught at bottom trawl stations are carp, white sucker, yellow perch, brown bullhead and Johnny darter; those caught at beach seine stations are carp, white sucker, yellow perch, bluegill, pumpkinseed, goldfish and golden shiner.

Trawl stations 8 and 9 and seine stations 33 and 38, which are located in the vicinity of Stony Point, represent the transition zone between these two faunal areas. This is signified

SPECIES OCCURRENCE BY STATION*

June - December 1969

Bottom Trawl



*cf. Table 4-3 Number of Samples Taken

N = November only, D = December only, N/D = November & December only.

Figure 7-13. Species Occurrence by Station (Bottom Trawls)

SPECIES OCCURRENCE BY STATION*

August - December 1969

Surface Trawls

Species Code	Name	Station: Shallow 1	5	3	7	8	9	12	Deep 2	4	6	15	16	11	10	13	14
2	Bay anchovy	—	- -	—	—	—	—	—	—	—	—	—	- -	—	—	—	—
22	Blueback herring	—	- -	—	—	—	—	—	—	—	—	—	- -	—	—	—	—
19	Menhaden, Atlantic	—	- -	—	—	—	—	—	—	—	—	—	- -	—	—	—	—
1	Alewife	—		—	—	—	—	—		—	—	—	- -	—	—	—	—
30	Striped bass	—		—	—	—	—	—			—	—	- -	—	—	—	—
35	White perch			—	—	—	—	—				—	—		—	D	—
25	American smelt				—	—	—	—		—	—	—	—	—	—	—	—
10	American eel				D	—	—				—	D		—	D	N	
13	Hogchoker						—			N	—			—			—
32	Atlantic tomcod					—	—							—			—
28	Spottail shiner					N		—		N					—		
24	Atlantic silverside				N		N	—								N	
34	White catfish					—											
45	Weakfish						—							—			
9	Carp													—			
42	Crevalle jack													—			
3	American shad						N								—		
23	White sucker							—									
7	Pumpkinseed							—									
14	Johnny darter							—									
36	Yellow perch							—									
11	Goldfish							—									
15	Banded killifish							—									
71	Northern porgy							—									
	Total Number of Species	5	(3)	6	9	11	13	(16)	3	7	8	8	(7)	12	10	9	9

*cf. Table 4-3 Number of Samples Taken
N = November only, D = December only, ( ) = Uncertain value

Note: Rare species at Station 12 occurred in only one October tow - gear appeared to be functioning normally.

Figure 7-14. Species Occurrence by Station (Surface Trawls)

SPECIES OCCURRENCE BY STATION*

June - December 1969

Beach Seines

Species Code	Name	Station 31	32	33	38	39	34	35	36	37
30	Striped bass	—	—	—	—	—	—	—	—	—
35	White perch	—	—	—	—	—	—	—	—	—
1	Alewife	—	—	—	—	—	—	—	—	—
28	Spottail shiner	—	—	—	—	—	—	—	—	—
22	Blueback herring	—	—	—	—	—	—	—	—	—
10	American eel	—	—	—	—	—	—	—	—	—
3	American shad	—	—	—	—	- -	—	—	—	—
19	Menhaden, Atlantic	—	—	—	—	- -	—	—	—	—
24	Atlantic silverside	N	—	—	—	- -	—	—	—	—
14	Johnny darter		—	—	—	—	—	—	—	—
2	Bay anchovy	—	—	—	—			—		—
42	Crevalle jack	—	—	—	—			—	—	—
32	Atlantic tomcod	N	N	N/D	N/D	N/D	D	N/D		
4	Bluefish	—	—		—		—	—		
34	White catfish	—	—					—	—	
15	Banded killifish	—	—	—			—	—	—	N
13	Hogchoker		—	—			—			—
18	Mummichog		—					—	—	—
9	Carp			—	—	- -	—	—	N	
7	Pumpkinseed	N		—	—	- -	—	—	—	—
5	Bluegill			—	—	- -	—	—	—	—
12	Golden shiner			—			—		—	—
36	Yellow perch				—	—	—	—	—	
11	Goldfish				D		—	—		
23	White sucker			D	D			—	—	
73	Tidewater silverside	—								
39	Northern pipefish	—		N						
31	Fourspine stickleback				N			—		
40	Redbreast sunfish							—		
71	Northern porgy							—		
17	Largemouth bass							—	—	
21	Chain pickerel								—	—
6	Brown bullhead							N		N
	TOTAL NUMBER OF SPECIES	18	18	21	21	(15)	20	28	22	20

*cf. Table 4-3 Number of Samples Taken
N = November only, D = December only, ( ) = Uncertain value

Figure 7-15. Species Occurrence by Station (Beach Seines) both by the increased number of species occurring at these stations and by the fact that none of the fresher-water species occur south of the Stony Point area during the summer-early fall conditions of higher river salinities (Figures 5-8 through 5-15). With the onset of decreasing river salinities in late fall, several of these species appear to migrate several miles down-river (Figures 7-13 through 7-15).

The most distinctive case of seasonal migration occurs with the tomcod which were observed in the shore populations only during November and December (Figure 7-15). During November an average of from 1 to 3 tomcod were collected per beach seine haul at Stations 31, 32, 38, 33, 39 and 35. None were collected at Stations 34, 36, and 37. In December an average of from 1 to 2 tomcod were collected at Stations 33, 39, 35 and 34. Six individuals on the average were collected at Station 38, while no tomcod were caught at Stations 36 and 37. This occurrence of Atlantic tomcod in the beach seine collections only during November and December may possibly be related to spawning activity (see also Figure 7-15). The bottom trawl data indicated a general preference of this species for the deeper-water channel stations (Table 7-17). This shoaling of a fish which otherwise prefers channel depths is thought to be related to spawning activity.

7.4.3 Faunal Diversity

In addition to evaluating environmental changes by monitoring shifts in compositional similarity (via community overlap), changes in the environment can also be evaluated on the basis of faunal diversity. Decreasing faunal diversity not directly attributable to expected or natural fluctuations is generally taken as a signal of environmental deterioration. In this study faunal diversity will be monitored by counts of the number of species collected and by a species diversity index which takes into account the distribution of individuals among the species.

7.4.3.1 Number of Species

The number of species as a measure of faunal diversity can be considered from several aspects: a) the average number of species per catch, b) the total number of species per station and c) the total number of species within the study area.

One of the inherent weaknesses with the number of species as a measure of diversity is the well known increase in the number of species with increased sample size and/or sampling frequency (cf. Tables 4-3 and 4-4). This increase generally reflects the detection of the rarer species.

This effect of sample frequency on the number of species is readily apparent in the following comparisons based on bottom trawls of 7 minutes duration collected during October. At stations 11, 10 and 13 there were 7, 5, and 1 samples collected, respectively. These yielded a total of 14, 12 and 7 species for the month. This implies a direct relationship between the number of samples and total number of species. On the other hand, the average number of species caught per trawl was 6, 7 and 7 species with ranges for the month of 2 to 9, 2 to 10 and 7 species, respectively. This suggests that a single bottom trawl, on the average, underestimates by about one-half the actual number of species present within a month. Hence, a minimum of 2 samples and preferably 3 to 4 samples per month are needed at a station to ensure the sampling of most all the species present.

The seasonal fluctuations in the total number of species collected per month at a station, in general, reflect a trend towards a peaking of values during October (Tables 7-24 through 7-26). This trend was also observed in the monthly totals for the entire study area. Another seasonal trend is a distinct decrease in the total species occurring at the shoal stations with the onset of colder temperatures and lower salinities in November through December.

Finally, there are the natural segregations of fish into bottom, pelagic and shore habitats. Thus, out of the 43 species collected throughout the study area during June through December 1969, the bottom trawls and beach seines obtained a total of only 33 species each, and the surface trawls a total of only 24 species (Tables 7-1 through 7-3). Moreover, at any given station during this summer - fall period the maximum number of species caught was 27 by bottom trawl, 25 by beach seine and 13 by surface trawl.

7.4.3.2 Species Diversity

Equally important to the number of species as a measure of faunal diversity is a consideration of the distribution of individuals among the species. The species diversity index employed here gives a measure of the probability that two individuals picked at random and

Table 7-24. Total Number of Fish Species (Bottom Trawls)

	STA	MILE	SITE	DPTH	1969 June/ July	Aug	Sept	Oct	Nov	Dec
SHALLOW	1	29	1	10	14	14	11	9		
	5	36	1	12	10	15	8	9	8	4
	3	35	3	10	13	10	10	3	10	4
	7	38	3	11	12	12	11	6	9	6
	8	39	1	12	15	9	13	16	17	8
	9	40	3	12	19	21	17	20	15	13
DEEP	2	29	3	26	9	11	6	10		
	4	35	2	34	15	13	13	10	10	4
	6	38	2	30	10	12	10	11	7	4
	15	40	1	45			9	17	14	11
	16	41	3	45			8		8	10
	11	42	2	50	9	11	12	14	13	10
	10	42	3	45	9	14	11	12	10	11
	13	45	1	50	10	15	14	7		3
	14	47	3	47	8	15	13	12	10	3
	Total Species for Month				23	30	25	26	24	19

Table 7-25. Total Number of Fish Species (Surface Trawls)

	STA	MILE	SITE	DPTH	1969					
					June/ July	Aug	Sept	Oct	Nov	Dec
SHALLOW	1	29	1	10				5		
	5	36	1	12						
	3	35	3	10				6	2	0
	7	38	3	11		5	1	6	5	2
	8	39	1	12			4	8	7	4
	9	40	3	12			10	3	8	2
	12	44	3	12		5	2	13	7	2
DEEP	2	29	3	26				3		
	4	35	2	34				3	7	0
	6	38	2	30				7	5	0
	15	40	1	45			5	3	5	5
	16	41	3	45					2	4
	11	42	2	50			10	7	3	2
	10	42	3	45		6	6	6	5	6
	13	45	1	50				6	8	1
	14	47	3	47				9		
	Total Species for Month					10	12	21	13	7

Table 7-26. Total Number of Fish Species (Beach Seines)

	STA	MILE	SITE	1969 June/July	Aug	Sept	Oct	Nov	Dec
Beach Seines	31	35	1		8	6	11	9	
	32	35	3	6	14	10	11	6	
	38	40	1			6	14	12	9
	33	40	3	6	8	11	17	13	8
	39	41	3					9	6
	35	43	1	7	10	14	24	16	11
	34	42	3		8	11	13	12	9
	36	44	3	5	12	13	14	16	2
	37	47	1	8	12	9	14	11	1
Total Species for Month				11	22	22	28	25	17
Plant Site	Forebay					5	11	7	6
	Sluice*					10	15	15	19
	Effluent						1		4
	Total Species for Month					11	17	16	19

*Sluice which receives the washings from the traveling screens independently from a sample will be of the same species (Simpson, 1949). In order to make the value of the diversity index increase with increasing diversity, the Simpson index has been subtracted from unity.

$$1 - \frac{\sum_{i=1}^{x} n_i (n_i - 1)}{N(N-1)}$$

where: n equals the number of individuals in species n_1, n_2, n_3---n_x

N equals the total number of individuals in the sample.

Thus, this index varies from zero for a sample in which every individual belongs to the same species (a probability of one that two individuals chosen at random belong to the same species) to unity for a sample in which every individual represents a different species.

In terms of this index, a decrease in value does not necessarily mean a decrease in the number of species. An increase in dominance by a species will also cause a decrease in its value.

A third factor which affects the value of this diversity index (the probability of species equivalence) is the total number of individuals in a sample. A catch with few individuals tends to increase the value of this index by decreasing the probability that the two individuals will be of the same species. For example, in a catch of 40 fish with 20 individuals per species, the Simpson probability equals 0.487 giving a diversity index value of 0.513. For a catch of of 400 fish with 200 individuals per species, the Simpson value is 0.498 giving a diversity index value of 0.502.

For the purpose of discussion, a diversity index value of 0.500, which is intermediate between the extremes of zero and unity, has been chosen as a boundary value between "low" and "high" diversity. This value of 0.500 approximates a situation of two equally dominant species. If the data in Tables 7-27 through 7-29 are "contoured" as either falling above 0.500 (high diversity) or below (low diversity), then the following observations can be made. On this basis the shore fish communities are seen to have the generally highest diversity followed closely by the river bottom communities. The fish communities of the surface waters have a distinctly low average diversity (Tables 7-27 through 7-29). The generally higher average

Table 7-27. Average Fish Species Diversity (Bottom Trawls)

	STA	MILE	SITE	DPTH	1969 June/July	Aug	Sept	Oct	Nov	Dec
SHALLOW	1	29	1	10	.573	.699	.193	.727		
	5	36	1	12	.271	.315	.657	.628	.675	.566
	3	35	3	10	.555	.359	.366	.547	.782	.791
	7	38	3	11	.469	.647	.406	.540	.580	.525
	8	39	1	12	.582	.540	.556	.503	.709	.447
	9	40	3	12	.739	.775	.422	.548	.443	.533
	12	44	3	12	.681	.678	.645	.621	.607	.435
DEEP	2	29	3	26	.663	.434	.458	.831		
	4	35	2	34	.443	.411	.577	.761	.501	.353
	6	38	2	30	.556	.205	.346	.695	.467	.164
	15	40	1	45			.759	.619	.601	.649
	16	41	3	45			.708		.628	.447
	11	42	2	50	.345	.474	.414	.460	.309	.438
	10	42	3	45	.173	.427	.613	.639	.593	.541
	13	45	1	50	.175	.681	.671	.598		.600
	14	47	3	47	.355	.731	.769	.686	.765	.401

species diversity throughout the study area in the fish collections from the bottom trawls, surface trawls and beach seines in October supports the previous indications provided by data on total number of species, which also show a peak in October (Tables 7-24 through 7-26).

Table 7-28. Average Fish Species Diversity (Surface Trawls)

	STA	MILE	SITE	DPTH	1969 June/July	Aug	Sept	Oct	Nov	Dec
SHALLOW	1	29	1	10				.130		
	5	36	1	12						
	3	35	3	10				.500	.020	.000
	7	38	3	11		.175	.000	.551	.407	.000
	8	39	1	12			.439	.809	.327	.073
	9	40	3	12			.303	.227	.263	.053
	12	44	3	12		.750	.502	.733	.201	.500
DEEP	2	29	3	26				.074		
	4	35	2	34				.223	.642	.000
	6	38	2	30				.204	.422	.000
	15	40	1	45			.351	.032	.227	.265
	16	41	3	45					.497	.167
	11	42	2	50			.481	.347	.237	.000
	10	42	3	45		.185	.273	.672	.151	.383
	13	45	1	50				.431	.194	.000
	14	47	3	47				.739		

Table 7-29. Average Fish Species Diversity (Beach Seines)

STA	MILE	SITE	1969					
			June/ July	Aug	Sept	Oct	Nov	Dec
31	35	1		.630	.440	.581	.287	
32	35	3	.390	.636	.495	.740	.528	
38	40	1			.480	.514	.664	.131
33	40	3	.735	.631	.597	.592	.696	.421
39	41	3					.747	.363
35	43	1	.744	.637	.642	.717	.652	.754
34	42	3		.491	.525	.648	.616	.560
36	44	3	.425	.630	.694	.650	.757	.667
37	47	1	.515	.694	.689	.764	.639	.000

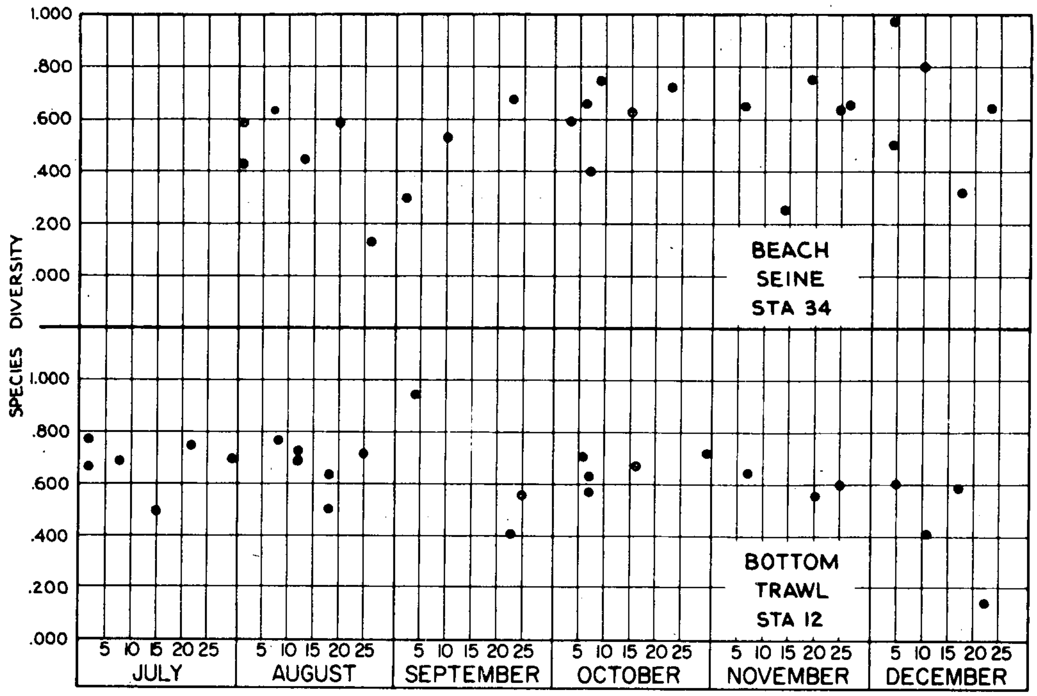


Figure 7-16. Species Diversity Per Beach Seine/Bottom Trawl Collections (1969)

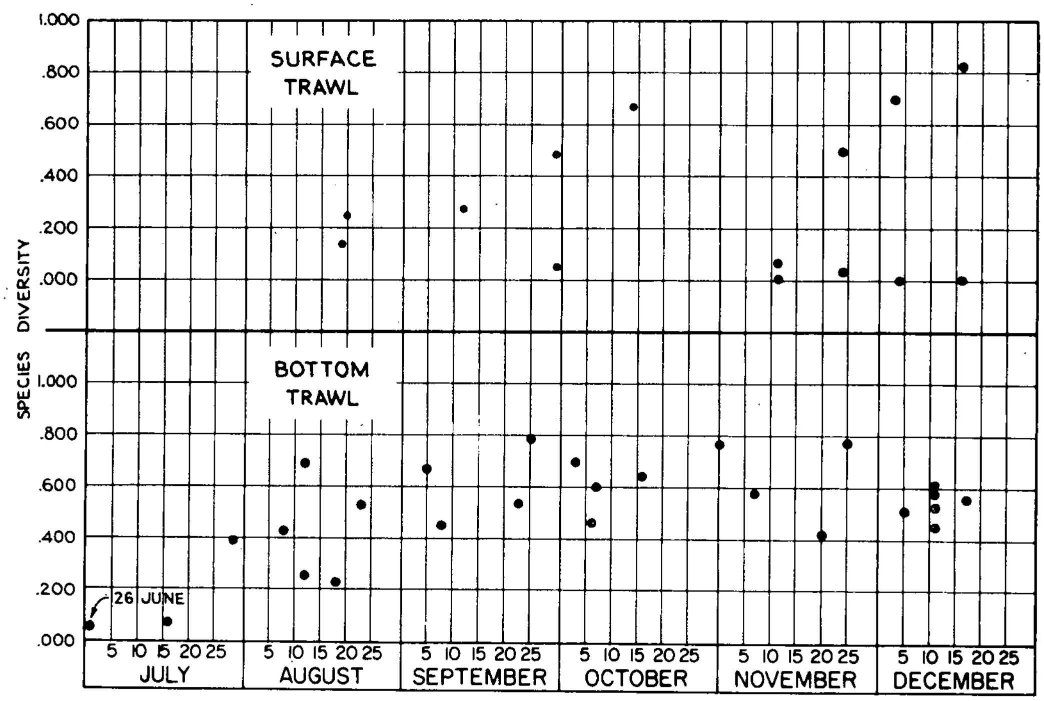


Figure 7-17. Species Diversity Per Surface/Bottom Trawls, Station 10

The wide scatter of diversity values from the surface waters is attributed to the schooling tendencies of the pelagic fish. This schooling results in wide variations of dominance among the few species caught consistently by surface trawls. The shore and bottom populations tend to have less variation in diversity from catch to catch (Figures 7-16 and 7-17).

Although the surface trawl data are not very complete for the summer months, there is the slight suggestion that higher diversities occur in the surface water during the warmer months compared to the colder months of November-December. Conversely, the bottom collections indicate a reversal of this situation with generally lower diversities in the summer months compared to the November-December data, particularly in Haverstraw Bay (Tables 7-27 through 7-29). In December noticeably higher diversities in the surface trawl collections are observed in Indian Point vicinity (stations 15, 16, 10 and 12) compared to Haverstraw Bay. A possible relationship to thermal additions is suggested by the higher values at stations 15 (Lovett) and 10 (Indian Point) compared to 16 which is located midway between the aforementioned (15 and 10), and station 11 which is on the opposite side of the channel from station 10 (Tables 7-27 and 7-28).

The probable effect of bottom habitat, and/or salinity on diversity is shown by the consistently lower values for seine station 34 compared to stations 35 and 36 (Tables 7-22 through 7-29). For example, during the warmer more saline months, white sucker, a fresher-water species, was recorded only at stations 35 and 36 and not at station 34 (Figure 7-15).

7.5 Invertebrates

The distribution and abundance of invertebrates at Indian Point is being evaluated through the use of a variety of gear types. In the fish sampling program, invertebrates were captured in beach seines, and surface and bottom trawls. In addition, monthly samples were collected with an Emory type benthic grab, zooplankton nets, and Thorson jars and settlement/succession panels. Not surprisingly, each piece of gear seems to be selective in efficiency in capturing different species. (See Tables 7-30, 7-31, 7-32 and 7-33.)

Table 7-30. Species of Invertebrates Most Commonly Collected Through December, 1969

Collecting Gear	Species	Group
Trawls	Crangon septemspinosa	Decapod
	Rhithropanopeus harrisii	Decapod
Seines	Callinectes sapidus	Decapod
	Palaemonetes intermedius	Decapod
Exposure panels	Balanus improvisus	Cirripede
	Congeria leucophaeta	Mollusc
Benthic grabs	Spio setosa	Polychaete
	Cyathura polita	Isopod
Zooplankton nets	Copepods	
	Cladocerans	
	Mysids	
	Larval stages	
Thorson jars	None	

7.5.1 Overall Numerical Importance

The overall relative numerical importance of the major species within the study area has been determined through a compilation of the monthly averages of numbers caught per unit effort for each gear type (Tables 7-34 through 7-38). The segregation of the samples by depth due to selective sampling by each gear type permits an evaluation of differences in surface and bottom abundances.

Differences with depth are clearest in the zooplankton. Most of the zooplankton were taken in bottom tows, probably because samples in the first six months were collected exclusively during daylight hours. Zooplankton show a predominately negative reaction to bright daylight conditions. At both surface and bottom the copepods comprise 65 to 70 percent of the individuals collected. At the bottom cladocerans rank second (16 percent), while at the surface polychaete larvae rank second (20 percent). Since larvae are only temporary members of the plankton, their abundance should be interpreted with caution.

Depth differences are seen in the exposure panel fauna as well. Surface panel populations appear to be dominated by the amphipod, Gammarus, while on the bottom panels Balanus are most abundant.

Table 7-31. Species of Invertebrates Collected through December, 1969 (Benthic Grabs)

Benthic Grab	Abundance
Polychaeta, segmented worms, marine	
Spio setosa (tentacle worm)	C
Prionospio spp. (gold crown worm)	U
Oligochaeta	
Chaetogaster spp.	U
Nemertea, round worms	
Unidentified	R
Turbellaria, flat worms	
Unidentified	R
Crustacea	
Balanus improvisus (barnacle)	U
Edotea montosa (isopod, sowbug)	U
Cyathura polita (isopod, stick sowbug)	U
Corophium volutator (amphipod, scud)	R
Gammarus fasciatus (amphipod, scud)	U
Hyalella azteca (amphipod, scud)	U
Rhithropanopeus harrisii (mud crab)	U
Mollusca	
Congeria leucophaeta (mussel)	
Diptera	U
Tendipes tentans (midge)	R
Chaoborus albipes (midge)	

C = common - readily caught
U = uncommon- caught only occasionally and/or not in any numbers
R = rare

Table 7-32. Species of Invertebrates Collected through December, 1969 (Zooplankton Nets)

Zooplankton	Abundance
Crustacea	
Crangon septemspinosa (snapping shrimp)	R
Pontocrates norvegicus (scud)	U
Gammarus fasciatus (scud)	U
Neomysis americana (ghost shrimp)	C
Edotea montosa (sowbug)	R
Cyathura polita (stick sowbug)	R
Barnacle cyprid	R
Crab zoea	U
Crab megalops	U
Rhithropanopeus harrisii (mud crab)	R
Callinectes sapidus (blue crab)	R
Cyclops spp. (copepod)	C
Eurytemora spp. (copepod)	C
Copepodid	U
Daphnia spp. (water flea)	U
Diaphanosoma spp. (water flea)	R
Hydrozoa	
Gonionemus murbachii (jellyfish)	C
Podocoryne carnea (jellyfish)	U
Polychaeta, segmented worms	
Nectochaete larvae	C
Nemertea, round worms	
Unidentified	R
Diptera	
Chaoborus albipes (midge)	U
Tendipes tentans (midge)	R

Table 7-33. Species of Invertebrates Collected through December, 1969 (Trawls, Seines, Panels)

Trawls and Seines	Abundance
Crustacea	
Crangon septemspinosa (snapping shrimp)	C
Palaemonetes intermedius (shrimp)	R
Livoneca ovalis (fantail sowbug)	R
Rhithropanopeus harrisii (mud crab)	U
Callinectes sapidus (blue crab)	U
Gammarus fasciatus (scud)	U
Succession Panels	**Abundance**
Crustacea	
Balanus improvisus (barnacle)	C
Gammarus fasciatus (scud)	C
Rhithropanopeus harrisii (mud crab)	U
Edotea montosa (sowbug)	R
Diptera	
Tendipes tentans (midge)	R
Hydrozoa	
Campanularia calceolifera	C
Cordylophora lacustris	U
Mollusca	
Congeria leucophaeta (mussel)	C

Table 7-34. Benthic Grabs—All Stations Average Number Organisms Caught Per Species Per Sample, 1969

Group	SPP Code	Name	1969				
			Aug	Sept	Oct	Nov	Dec
Polychaete	283	S. setosa	11	19	19	8	13
Polychaete	284	Prionospio	0	0	7	4	17
Nemertean	260	Nemertean	1	P	1	P	P
Cirripede	383	B. improvisus	1	25	63	87	0
Amphipod	363	G. fasciatus	P	4	P	0	9
Amphipod	365	H. azteca	P	0	35	5	8
Amphipod	362	C. volutator	0	0	0	0	0
Mollusc	572	C. leucophaeta	0	1	2	4	0
Mollusc	570	Spat	0	0	6	57	0
Isopod	504	E. montosa	P	0	1	0	1
Isopod	502	C. polita	3	2	7	2	6
Diptera	303	T. tentans	0	0	2	2	4
Diptera	302	C. albipes	0	0	P	P	P
Ectoproct	671	E. crustulenta	0	0	P	0	0
Total Number of Species			7	6	13	10	9

P = presence less than 1

Table 7-35. Succession Panels—All Stations Average Number Caught Per Panel, 1969

		Group	SPP Code	Name	Sept*	Oct	Nov	Dec
Surface		Cirripede	383	B. improvisus	106	29	26	5
		Mollusc	572	C. leucophaeta	11	P	1	P
		Amphipod	363	G. fasciatus	350	0	1	1
		Decapod	467	R. harrisii	0	0	0	0
		Diptera	303	T. tentans	0	0	0	0
	% Cover **	Hydroid	223	Campanularia	33	4	0	1
		Hydroid	222	Cordylophora	0	0	5	0
Bottom		Cirripede	383	B. improvisus	62	59	52	16
		Mollusc	572	C. leucophaeta	9	0	0	0
		Amphipod	363	G. fasciatus	159	0	3	0
		Decapod	467	R. harrisii	1	0	0	0
		Diptera	303	T. tentans	0	0	0	0
	% Cover	Hydroid	223	Campanularia	33	4	0	2
		Hydroid	222	Cordylophora	0	0	15	0

P = presence less than 1

* one panel only

** % of panel covered

Table 7-36. Thorson Jars—All Stations Average Number Caught, 1969

Group	SPP Code	Name	Sept	Oct	Nov	Dec
Polychaete	283	S. setosa	6	1	0	P
Polychaete	284	Prionospio	0	1	0	P
Nemertean	260	Nemertean	0	0	0	0
Cirripede	383	B. improvisus	0	0	0	0
Amphipod	363	G. fasciatus	2	7	8	7
Amphipod	365	H. azteca	0	1	0	0
Amphipod	362	C. volutator	0	0	0	P
Mollusc	572	C. leucophaeta	3	P	0	0
Mollusc	570	Spat	P	160	0	0
Isopod	504	E. montosa	P	0	P	P
Isopod	502	C. polita	0	0	0	0
Diptera	303	T. tentans	1	P	0	0
Diptera	302	C. albipes	0	0	0	0
Ectoproct	671	E. crustulenta	0	0	0	P
Total Number of Species			6	7	2	7

P = presence less than 1

Table 7-37. Zooplankton—All Monthly Sations Average Number Caught Per Tow (1969)

Group	SPP Code	Name	Surface						Bottom					
			July*	Aug	Sept	Oct	Nov	Dec**	July	Aug	Sept	Oct	Nov	Dec
Decapod	464	Crangon		0	0	0	0		0	2	P	0	0	
Decapod	467	R. harrisii		0	0	0	0		0	P	0	0	0	
Decapod	466	Callinectes		0	0	0	0		0	0	P	0	0	
Decapod	460	Crab zoea		8	0	0	0		53	4	0	0	0	
Decapod	460	Crab megalops		0	0	0	0		0	0	0	0	0	
Amphipod	363	Gammarus		2	0	0	0		0	201	19	9	87	
Amphipod	364	Pontocrates		P	0	0	0		0	29	6	0	326	
Copepod	420	Copepodid		P	0	14	106		0	50	2960	260	980	
Copepod	421	Eurytemora		13	0	0	158		1560	152	544	870	772	
Copepod	422	Cyclops		2	0	103	0		330000	538	5865	2120	22	
Mysid	521	Neomysis		2	0	0	0		2277	111	259	179	0	
Cladocera	402	Diaphanosoma		0	0	0	25		5505	363	0	0	682	
Cladocera	401	Daphnia		1	P	0	25		0	0	1280	0	845	
Diptera	302	Chaoborus-larva		1	0	0	0		0	22	0	0	0	
Diptera	302	Chaoborus-pupa		0	0	0	0		0	7	0	0	0	
Diptera	303	Tendipes		P	0	0	0		0	0	0	0	P	
Isopod	504	Edotea		0	0	0	0		0	1	4	0	22	
Isopod	502	Cyathura		0	0	0	0		0	1	0	0	0	
Hydrozoan	221	Gonionemus		0	0	0	0		8	0	47	6	0	
Hydrozoan	224	Podocoryne		0	0	0	0		0	0	8	0	0	
Polychaete	280	Nectochaete		0	0	117	0		0	0	0	1130	0	
Cirripede	380	Cypris		0	0	0	0		0	0	800	0	0	
Total Number of Species				10	1	3	4		6	14	13	7	9	

P = presence less than 1
* = bottom samples only collected in July
**= river ice built up, preventing scheduled sampling in December

Table 7-38. Trawls/Seines—All Stations Average Number Invertebrates Caught Per Tow, 1969

	Code	Name	June/ July	Aug	Sept	Oct	Nov	Dec
Bottom Trawls		DECAPODS:						
	464	Crangon septemspinosa	94	43	99	151	70	135
	465	Palaemonetes intermedius	0	P	1	1	2	P
	466	Callinectes sapidus	0	0	P	P	2	P
	467	Rhithropanopeus harrisii	P	2	1	1	2	1
Surface Trawls		DECAPODS:	*	**				
	464	Crangon septemspinosa			26	42	P	P
	465	Palaemonetes intermedius			P	0	P	1
	466	Callinectes sapidus			0	0	1	0
	467	Rhithropanopeus harrisii			0	0	P	0
Beach Seines		DECAPODS:	**	**				
	464	Crangon septemspinosa			1	1	1	P
	465	Palaemonetes intermedius			0	P	3	1
	466	Callinectes sapidus			1	1	P	0
	467	Rhithropanopeus harrisii			0	0	P	1

P = presence less than 1

* = no surface trawls in June/July

** = invertebrates not retained

This is somewhat misleading because the mobile Gammarus are associated with profuse hydroid settlement at one station (station 7). The barnacle Balanus, the bivalve Congeria, and the hydroid Campanularia are the major sessile forms, and therefore, the best indicators of recruitment. If Gammarus is eliminated and the percentages recalculated, Balanus accounts for 90 to 95 percent of the individuals settling on the panels.

The benthic grab percentage abundances show Spio setosa predominating. This agrees with qualitative evaluations. The high Balanus percentage results from a large number of individuals at stations 3 and 5 where Balanus is recovered attached to oyster shells; at other stations there seems to be no (very little) suitable hard substrate for barnacle attachment; the occurrence of this organism in benthic grabs implies considerable water movement in the area. Any tendency to silt deposition would preclude Balanus settlement or survival. The water must move swiftly enough to keep the silt suspended, and to provide food for Balanus, a filter feeder. These sessile animals are dependent upon the suspended organic matter carried in the water. Cyathura polita, on the other hand, is never numerous but is ubiquitous in the study area.

The Thorson jars appear to be dominated by mollusc spat. These results appear to be anomalous as average values are dominated by a large number of individuals at one station (station 56) one month. In this environment the usefulness of the Thorson jars in demonstrating biological diversity has yet to be demonstrated. Rather, the Thorson jars appear to be most useful as a monitor of the monthly accumulations of suspended sediment.

7.5.2 Species Distribution Patterns

7.5.2.1 Benthic Grabs

The benthic infauna of the study area is remarkably uniform. The distributions of the two major benthic inhabitants, the polychaete Spio setosa and the isopod Cyathura polita, during August, and November, 1969, are shown in Figures 7-18 and 7-19. Sediment type may be the most important influence on distribution. Both species are less abundant among the shells and pebbles of stations 5, 10 or 16 and the heavy organic debris of station 14, than

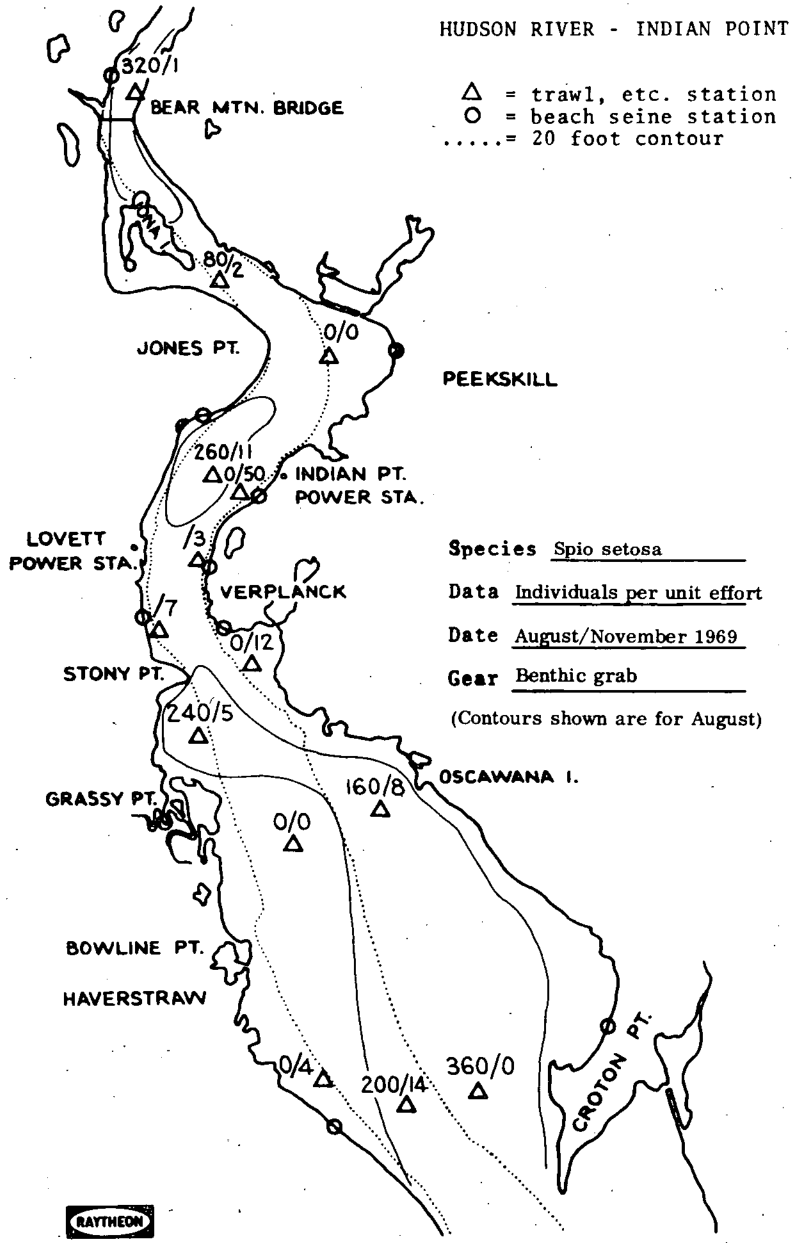


Figure 7-18. August/November Abundance of Spio Setosa

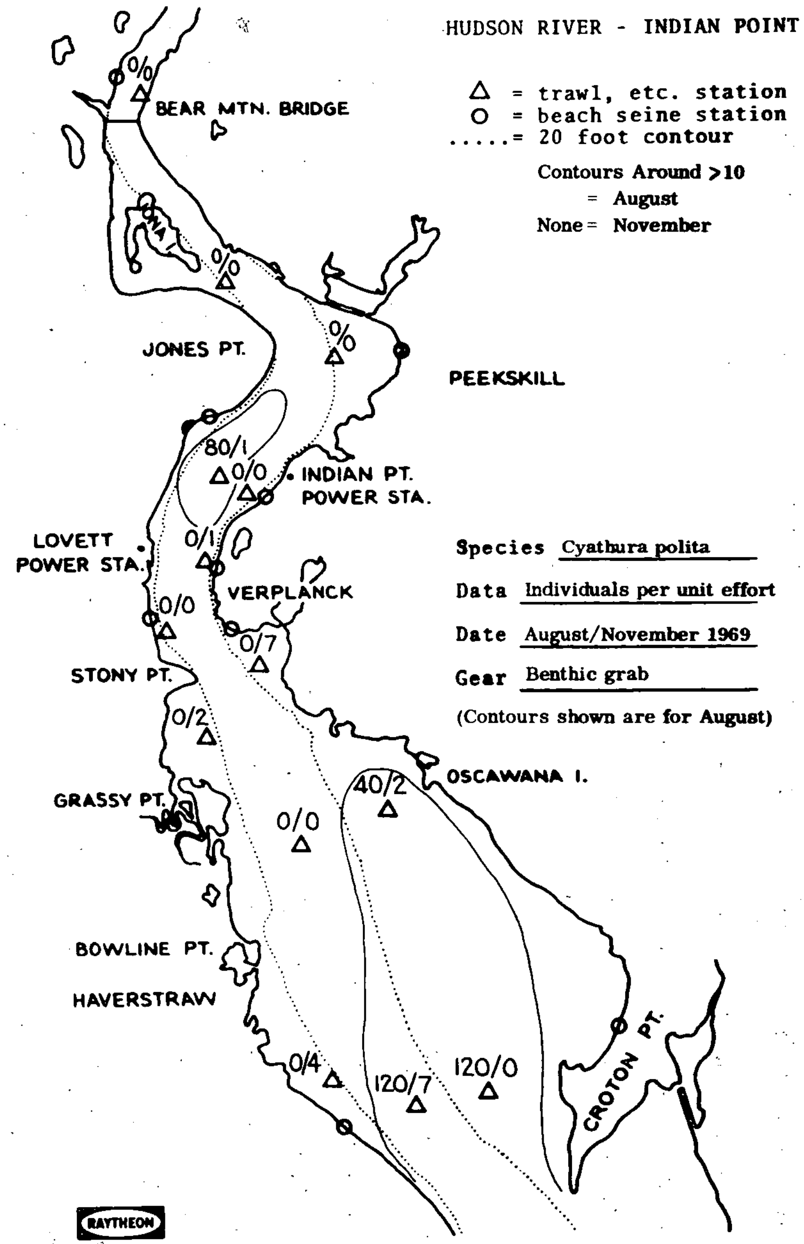


Figure 7-19. August/November Abundance of Cyathura Polita

in the more silty clay sediments of other stations. Since Spio is found throughout the study area, salinity is probably not critical. Abundance of both species is generally reduced throughout the study area in winter; neither completely disappears, however, and a population of Spio, equalling approximately one-fourth the high August densities, remains in the vicinity of Indian Point.

7.5.2.2 Succession Panels

Although the encrusting fauna is neither very diverse nor abundant, some patterns do appear in the study area. The influence of season is obvious at once (Figure 7-20); settlement of the barnacle, Balanus improvisus, declines in December by more than fifty percent compared to October values (correlated well with lower water temperatures). The correlation with salinity can be seen in the October, November and December data (Figure 7-20); as salinity decreases (river mile increases) the number of Balanus improvisus settling drops off sharply, and does so repeatedly each month. Comparing panels from intake and outfall areas at the power plant site has not revealed any striking dissimilarities in either species composition or abundance; it will be extremely interesting to maintain these data stations as added generating units come on line.

7.5.2.3 Thorson Jars

It appears that no generalities can be drawn from the Thorson jars at this time. They have not accumulated any significant or repeatable numbers of animals, with the exception of Gammarus fasciatus. While Gammarus is mobile and not a member of the benthic infauna which the Thorson jar is designed to sample, it is of significant abundance.

7.5.2.4 Zooplankton

The most diverse group of invertebrates is found in the zooplankton. Since the zooplankton includes the larval forms of most of the estuarine fauna, analysis can give an indication of spawning times and duration.

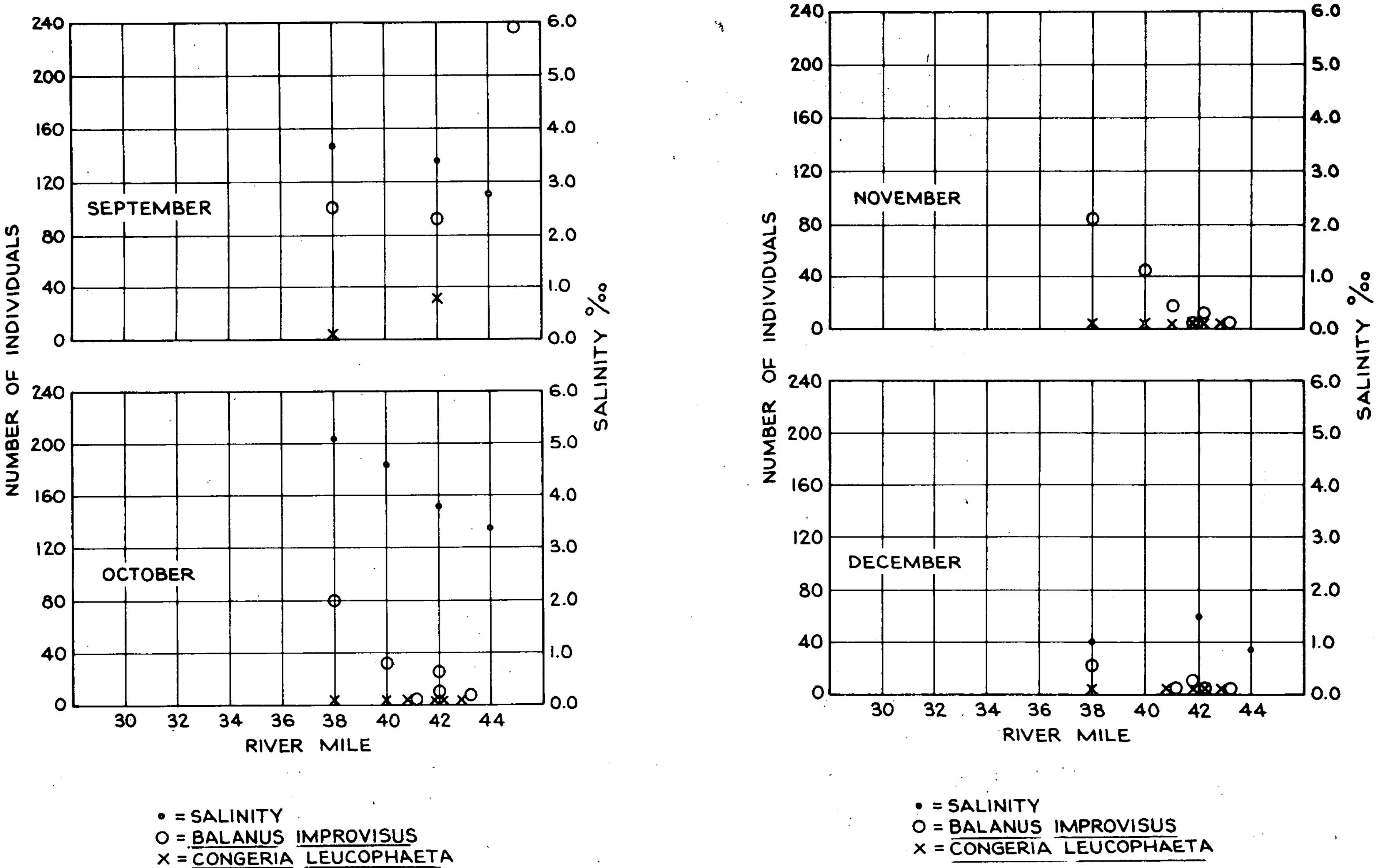


Figure 7-20. Seasonal Abundance of *Balanus* and *Congeria* in Reference to Salinity

Trophically the zooplankton convert phytoplankton into a form agreeable to carnivores and into detritus which supports benthic communities. Many carnivores, especially finfish, depend largely upon the zooplankton.

It could be expected that the zooplankton of the Hudson River study area would give the first clues regarding abnormalities of the environment. Aside from the grossest, unmistakable perturbations (fish kills), the zooplankton will be among the first fauna to reflect the effects of more subtle environmental modifications.

The seasonal nature of the zooplankton is reflected in the various larval forms which appear month to month (Figure 7-22). For example, Chaoborus larvae and pupae are relatively high in number in August, but disappear in succeeding months. Barnacle cyprids are abundant in September and polychaete larvae appear in October. Another seasonal trend is that of a decline in the total number of zooplankton species from a high of 19 in August to a low of 9 in October and 10 in November (Figure 7-21). When the data are plotted by month by river mile (Figure 7-23), the seasonal decline in species diversity is again obvious. In the

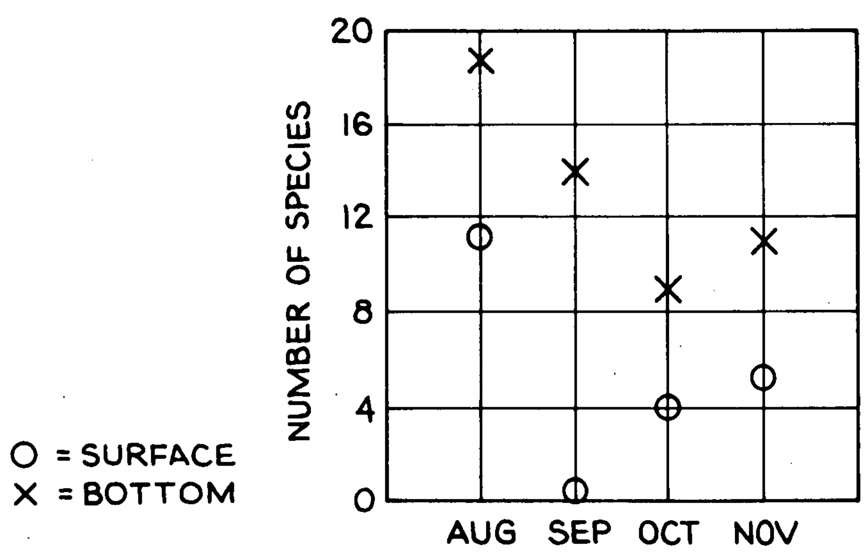


Figure 7-21. Zooplankton Seasonal Variation of Total Species

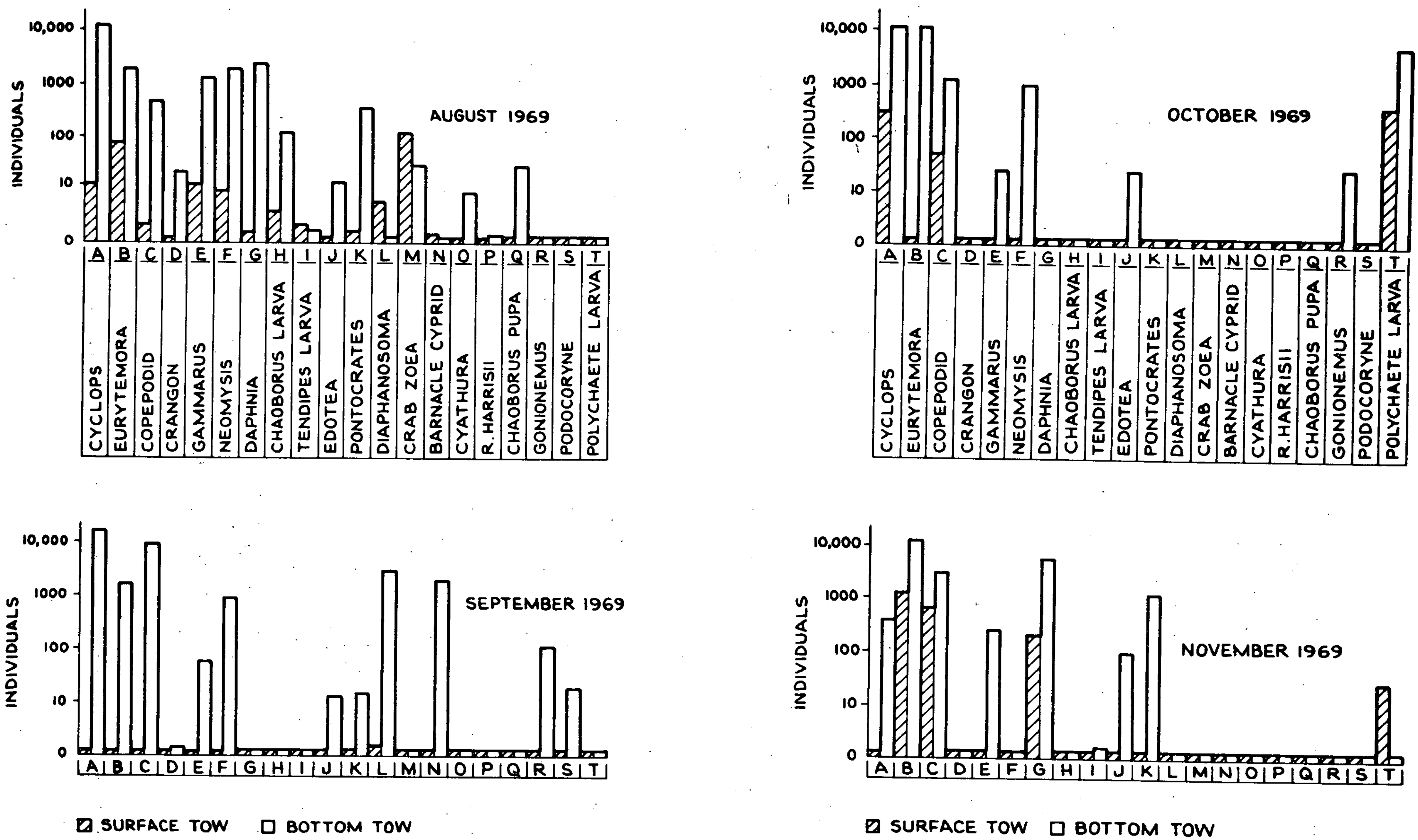


Figure 7-22. Seasonal Abundance of Zooplankton

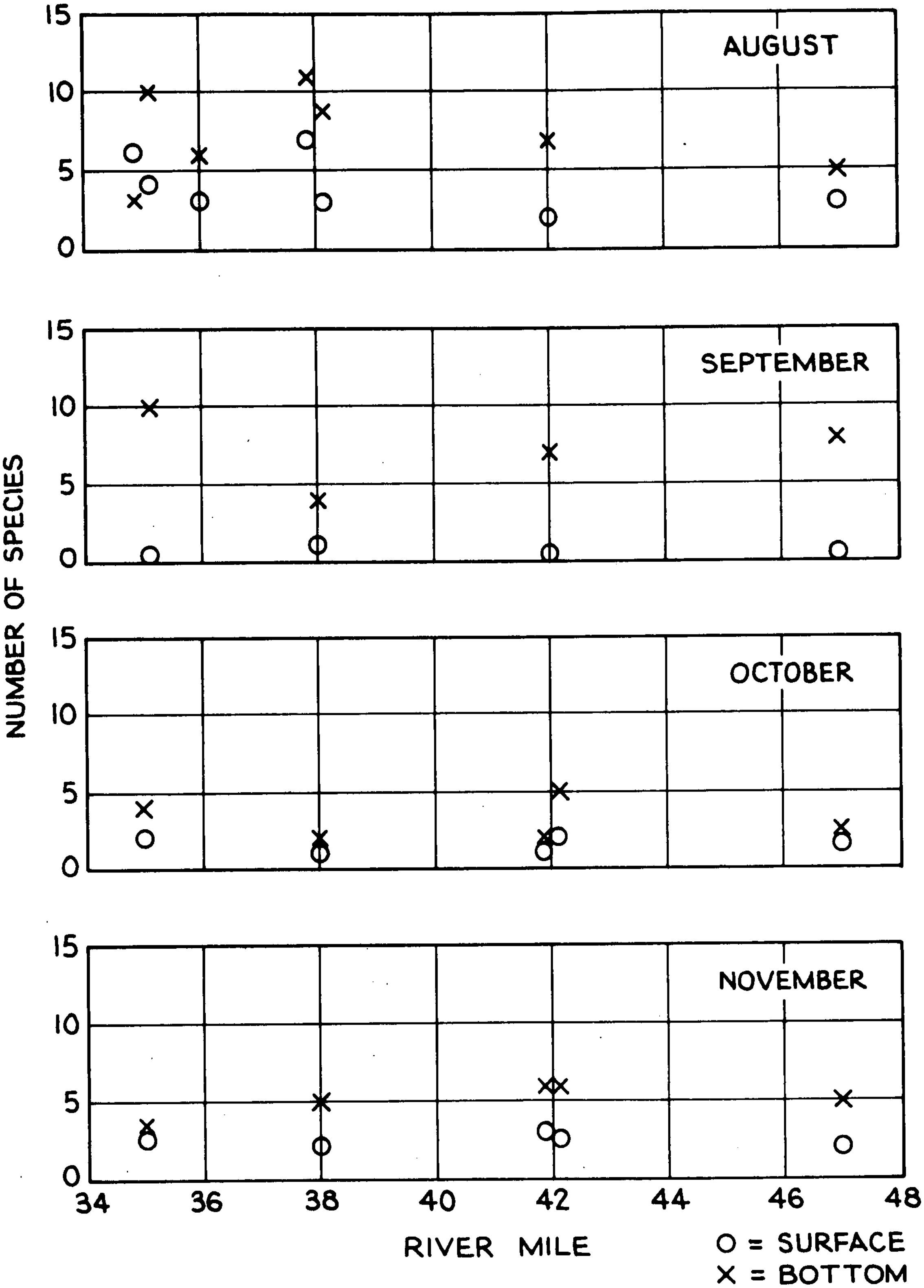


Figure 7-23. Zooplankton Seasonal Variation of Species by the River Mile

months of October and November the number of species in the vicinity of the plant site (river mile 42) is higher than at surrounding stations. This may be associated with thermal addition in the area, and should be followed as a potential indicator.

The average July through November distributions of Cyclops (Figure 7-24) and Neomysis (Figure 7-25), two of the major components of the holoplankton, show their lowest densities in the Peekskill to Haverstraw vicinity respectively. They are both important food sources for fish and are numerically significant members of the plankton as well. The distribution of the second major copepod, Eurytemora (Figure 7-26), appears to be governed by salinity. It is most abundant where salinity is highest, that is, in the lower reaches of Haverstraw Bay.

7.5.3 Invertebrates From Fish Trawls/Seines, 1969

Prior to September, 1969, invertebrates from fish trawls/seines were not retained systematically, but were kept for qualitative evaluation. Invertebrates captured in the fish sampling program are enumerated in Tables 7-30 through 7-35.

The shrimp Crangon septemspinosa is the most abundant organism and is captured primarily in the bottom trawls. Crangon has been captured through the study area (Figure 7-27) channel stations (4, 6, 10, 11, 13, 14 and 15) showing higher numerical densities than shoal stations (3, 5, 7, 8, 9 and 12). The highest concentrations of Crangon on a monthly basis shift slightly upstream in winter. That is, the August/September average for stations 10 and 11 is 58, while the November/December average is 85. Crangon is probably a major source of food for many of the fish in the study area.

The other shrimp, Palaemonetes, is not especially abundant. There is an indication that it is more commonly collected by beach seines in near shore waters than elsewhere in trawls.

Although neither Callinectes nor Rhithropanopeus (crabs) are commonly collected, Callinectes is the more abundant. It is collected most consistently in the seines. Callinectes appears to be largely limited to shallow, shoreline areas. Rhithropanopeus, on the other hand, is found throughout the study area but not in large numbers.

These invertebrates captured by the fishing gear are not captured by other methods yet may be the bulk of the fish diet in the study area. This is especially true of Crangon.

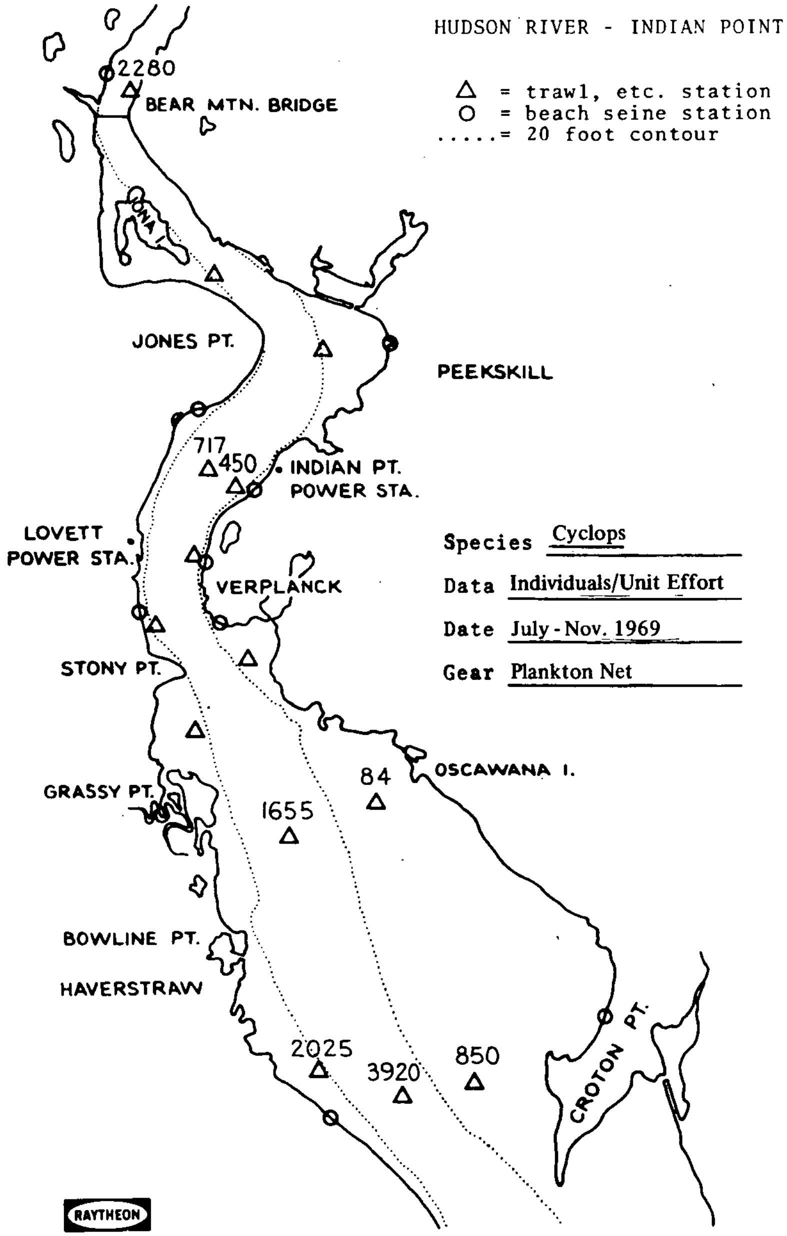


Figure 7-24. Bottom Zooplankton, Average Distribution of Cyclops

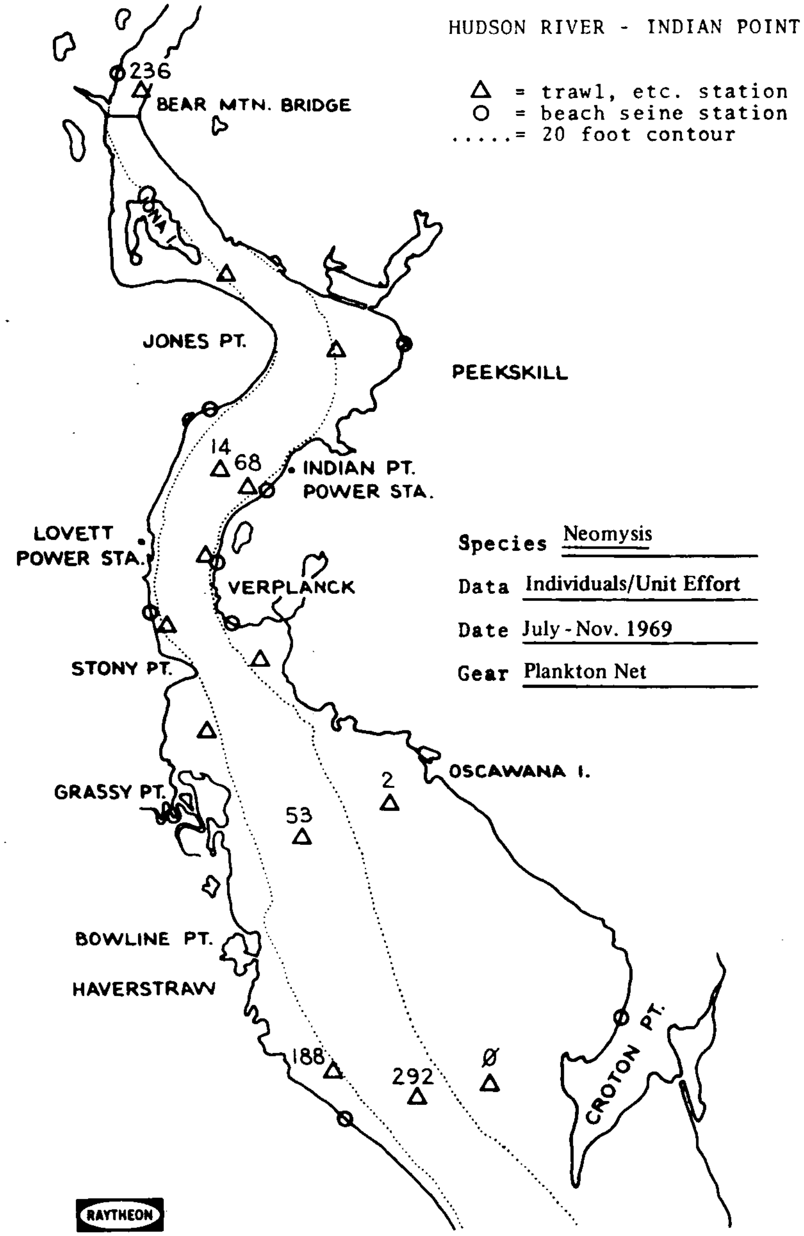


Figure 7-25. Bottom Zooplankton, Average Distribution of Neomysis

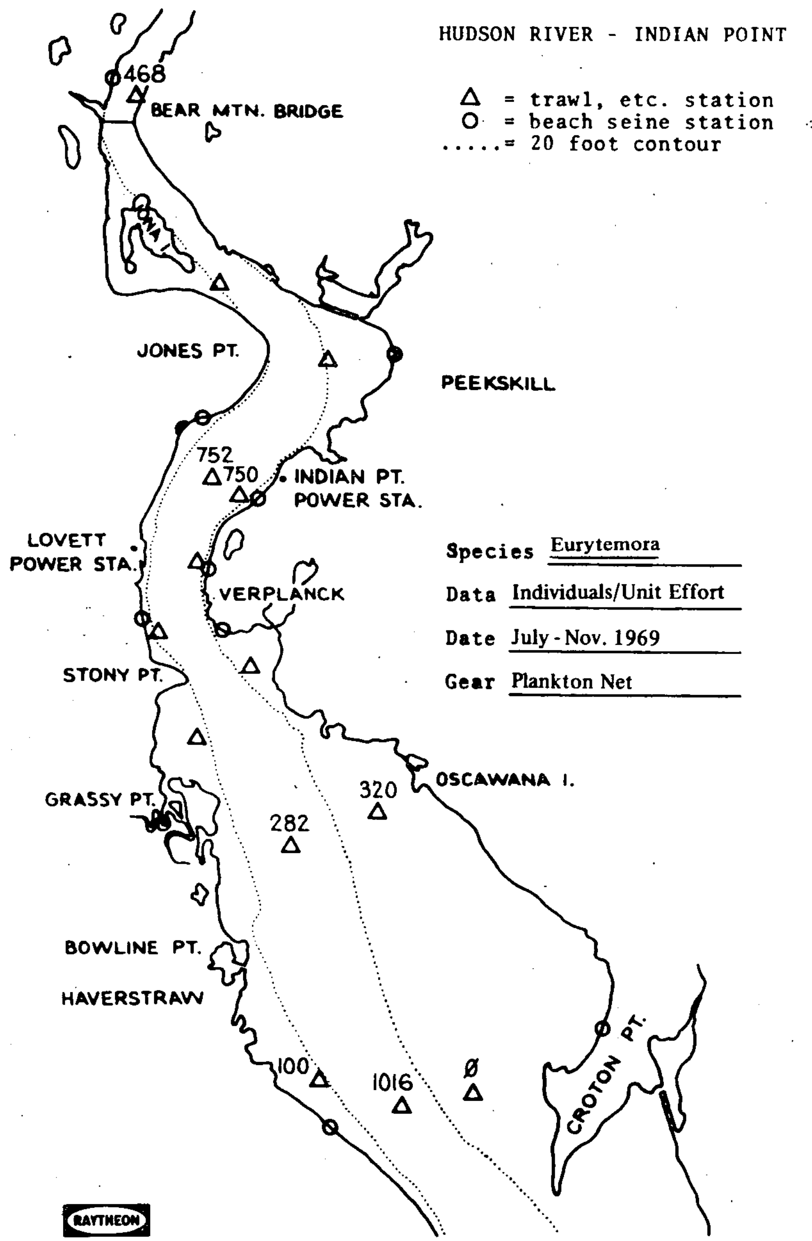


Figure 7-26. Bottom Zooplankton, Average Distribution of Eurytemora

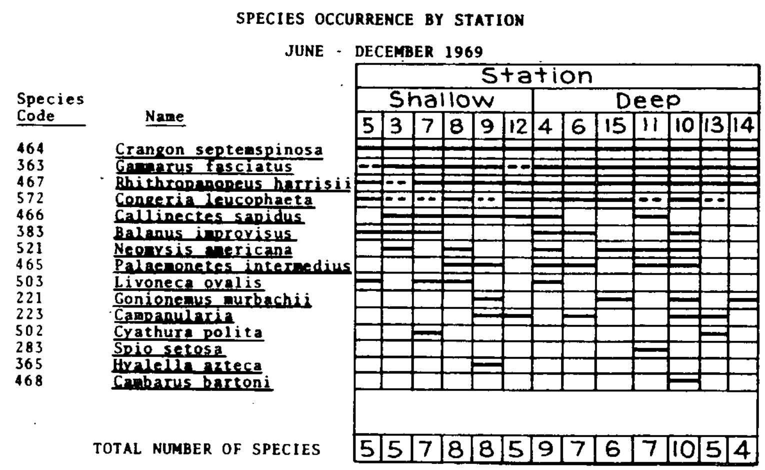


Figure 7-27. Bottom Trawl Invertebrates Distribution by Sampling Stations

APPENDIX A

GLOSSARY OF DATA ANALYSIS TERMS

A.1 Average Percent Occurrence (Avg. Pcnt Occ)—(e.g., Tables 7-5 through 7-7)

A grand average of station values of the number of samples in which a species occurred divided by the number of samples taken at a station.

$$\text{Average Percent Occurrence} = \frac{\sum_{x=1}^{N} \frac{\text{number of occurrences station x}}{\text{number of samples station x}} \times 100}{N}$$

where:

N = number of stations

A.2 Community Overlap—A measure of the proportional overlap between percent frequency histograms of the species assemblages at two stations.

A.3 "DPTH"—depth of the water in feet at a station

A.4 Mile—river mile above the Battery (lower Manhattan)

A.5 Percent Average Caught (Pcnt. Avg. Cght)—(e.g., Tables 7-5 through 7-7)

The percent of the total fish population within the study area represented by a species and based on the grand average of station averages of the number caught per unit effort for each species.

$$\text{Percent Average Caught} = \frac{\text{average number caught per unit effort of a species}}{\sum_{x=1}^{n} \text{average number caught per unit effort of species x}} \times 100$$

where:

n = number of species

A.6 Site—1 = west, 2 = center, 3 = east side of river

R942

DATA REPORT FOR

JANUARY — JUNE 1970

(Revised Edition)

Ecology of Thermal Additions

Lower Hudson River Cooperative Fishery Study

Vicinity of Indian Point, Buchanan, New York

1970

for

Consolidated Edison of New York

by the

Marine Research Laboratory

New London, Conn.

of

RAYTHEON COMPANY

SUBMARINE SIGNAL DIVISION

Portsmouth, Rhode Island

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ADDENDUM

After completion of this report, the identification of the following species was verified:

a) *Leptocheirus pinguis* is correet

b) *Pontocrates norvegicus* should be *Monoculoides* sp.

c) Sampling depth at the bottom for Stations 12 and 22 should be 8 and 41 feet respectively for Tables 9-1, 9-3 through 9-13.

1.0 SUMMARY (JANUARY—JUNE 1970, DATA REPORT)

The temperature data collected during the biological sampling program and from the temperature sensor buoys indicated that essentially isothermal conditions existed throughout the study area except in the immediate vicinity of the thermal plumes issuing from the Lovett and Indian Point generating stations. During January and February the river was essentially frozen over in the study area. From March through June, river temperatures increased from 32 to 73 degrees Fahrenheit with about a 10-degree F per month gradient.

The Indian Point Unit I operated from January to March 20 when it went off-line for refueling operations. On May 20 the plant went on-line for one day and had to shut down for mechanical repairs. The plant did not operate during the remainder of this six month period.

Temperature sensing probes recorded data in the vicinity of the plume.

Salinity was perhaps the most variable environmental parameter in the study area. There were vertical, horizontal, tidal and seasonal fluctuations.

The salinity at the plant site ranged from about 0 ppt to about 4 ppt during the six month period.

Dissolved oxygen concentrations were around 10 mg/1 during the winter months and decreased when the river water temperatures increased. By June the dissolved oxygen had declined to about 4 mg/1.

Four American shad were sonic tagged and tracked past the plant site in May. Three of them were tracked when the plant was off the line and the fourth when the plant was on-line. Shad were also gill netted in the plant vicinity. These data indicated that shad utilized the natural river channel in the vicinity of the plant site during their spawning migration. A total of eleven shad were sonic tagged.

Zooplankton sampling was emphasized during the spring. A total of 755 plankton samples were collected and analyses of spatial distribution, diurnal vertical migration and community overlap were conducted for selected species.

Bottom and surface trawling and beach seining were limited during the period. The most abundant species were the white perch and Atlantic tomcod.

Non-plankton invertebrates collected with fishing gear, succession panels, Thorson bottles and benthic grabs were less abundant than during the previous six month period. The Thorson bottles did not accumulate any significant or repeatable numbers of animals.

Laboratory studies were conducted on species choice for effluent and river water. Data were collected on species behavior when the plant was not operating and on May 20, when it was on-line. A total of 122 "Thermal Effluent Choice" experiments were conducted.

2.0 INTRODUCTION

This is the second six month data report of the continuing Indian Point Ecological Study by Raytheon Company's Marine Research Laboratory for the Consolidated Edison Company of New York. The purpose of this study is to evaluate the present and future ecological effects of heated effluents discharged into the Hudson River in the vicinity of the Consolidated Edison Company nuclear electric power generating station at Indian Point, Buchanan, New York. A Technical Committee of state and federal fishery scientists provides continuing technical evaluation of this study to the Policy Committee for the Lower Hudson River Co-operative Fishery Studies. Overall direction and guidance of the research efforts is the responsibility of the Policy Committee.

This report summarizes the results of the research efforts conducted during the months of January through June, 1970. Major emphasis during this period was placed on zooplankton, sonic tagging of shad, and laboratory behavior studies of fishes and invertebrates. A copy of the raw data summary tabulations and statistics has been delivered to the Technical Committee.

3.0 STUDY AREA DESCRIPTION

3.1 Geography/Bathymetry

This study encompasses 12 miles of the Hudson River from Croton Point on the south at river mile 35 to the Bear Mountain Bridge on the north at river mile 47 (Figure 3-1). In the northern half of the study area the river is narrow and has a natural river channel which ranges in depth from about 40 to 130 feet. Consolidated Edison's nuclear generating station is located at river mile 42 in an area which is primarily river channel with depths of 40 to 60 feet. Peekskill Bay is located north of the generating station and is a small shoal area which averages about 4 feet in depth at mean low water.

The southern part of the study area is Haverstraw Bay which is broad, shallow and approximately 3 miles wide by 4 miles long. The natural river channel is about 30 feet in depth and approximately three-fifths of a mile wide. Extensive shoal areas occur on the east side of the bay and less extensive shoals on the west side with average depths of 8 to 10 feet at mean low water.

3.2 Hydrology

Maximum tidal flows, which generally range between 200,000 and 300,000 cfs, dwarf the approximately 22,000 cfs average annual freshwater runoff which passes through the study area. About 60 percent of the freshwater runoff entering the area is contributed by the drainage basins above the Federal Dam at Troy, New York. The mean tidal range in the study area is 3 to 4 feet. Tidal currents average 0.8 knots on the flood and 1.2 knots on the ebb tide. A given tide stage occurs at the northern end of the study area about 25 to 35 minutes later than at the southern end.

Seasonally, the salt-water front has been observed by others to move upstream and downstream through a reach of about 50 miles or approximately from Chelsea to Yonkers in response to changing freshwater inflow.[1]

During a tidal cycle, this front may move through a distance of 3 to 15 miles depending on the particular tidal cycle, season and location of the salt-water front in the estuary. Salinity varied from about 0 ppt to about 4 ppt, but was generally less than 1 ppt, in the vicinity of the nuclear generating station, during the winter and spring runoff.

From January to March 1970, floe ice remained in the study area. Solid ice remained in the shoal areas until early March.

3.3 Power Plants

The Consolidated Edison nuclear generating Unit 1 was on-line during most of January, February and March, but shut down on March 20, 1970 for routine refueling operations (Figure 3-2). On May 20, with refueling completed, the plant went on-line but had to shut down the same day for mechanical repairs. The plant was shut down during the remainder of the 6-month period. Thus, during most of the spring study period the plant was not operating and natural river conditions without heated effluents persisted in the plant vicinity.

Indian Point Unit 1 has a capacity of 285 megawatts and requires 300,000 gallons per minute (gpm) of cooling water. Unit 2 is scheduled to become operational in 1971 and will require an additional 920,000 gpm of cooling water. Unit 3 is scheduled for 1973 and will use another 920,000 gpm. This will result in a total of 2,140,000 gpm of cooling water which will be discharged through a single effluent canal. Units 2 and 3 have been delayed

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[1] Hudson River Ecology, 1966. Hudson River Valley Commission, New York. 325 p.

The Hudson River Estuary. A preliminary investigation of flow and water-quality characteristics. G. L. Giese and J.W. Barr, 1967. Water Resources Comm. N.Y. Bull, 61, 39 p.

in construction and the operational dates are tentative. Units 4 and 5 have been proposed for construction about 3/4 of a mile south of Units 1 through 3 and each will require about 875,000 gpm of cooling water.

The Lovett power station (owned by Orange and Rockland Utilities, Inc.) across the river on the west shore and about a mile south of the Indian Point facilities is a fossilfueled plant consisting of 5 units with a present capacity of 461 MW which requires 316,700 gpm of cooling water. An additional power station is under construction at Bowline Point on the western shore of Haverstraw Bay, 4 miles south of Indian Point.

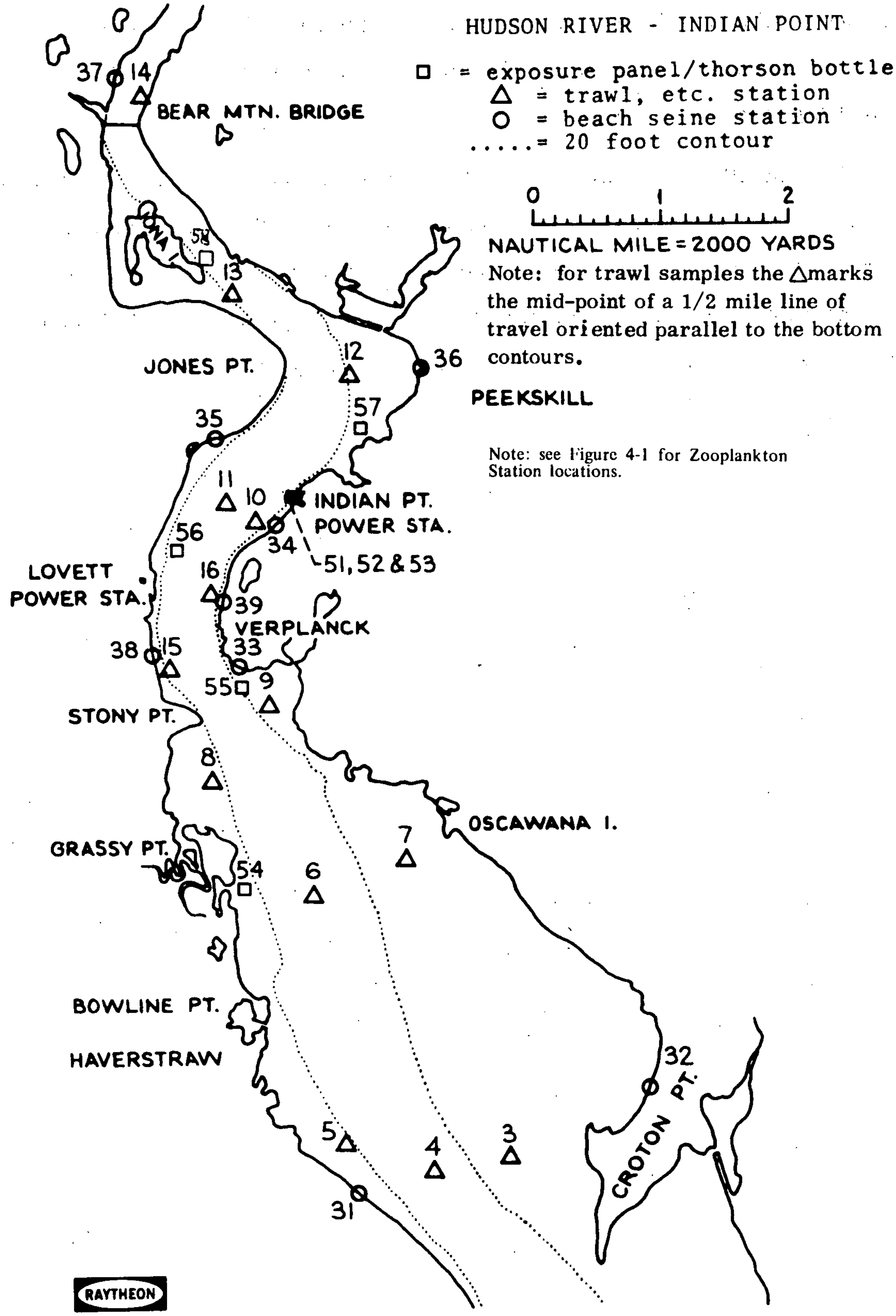

Figure 3-1. Finfish, Succession Panel and Benthic Invertebrate Station Locations

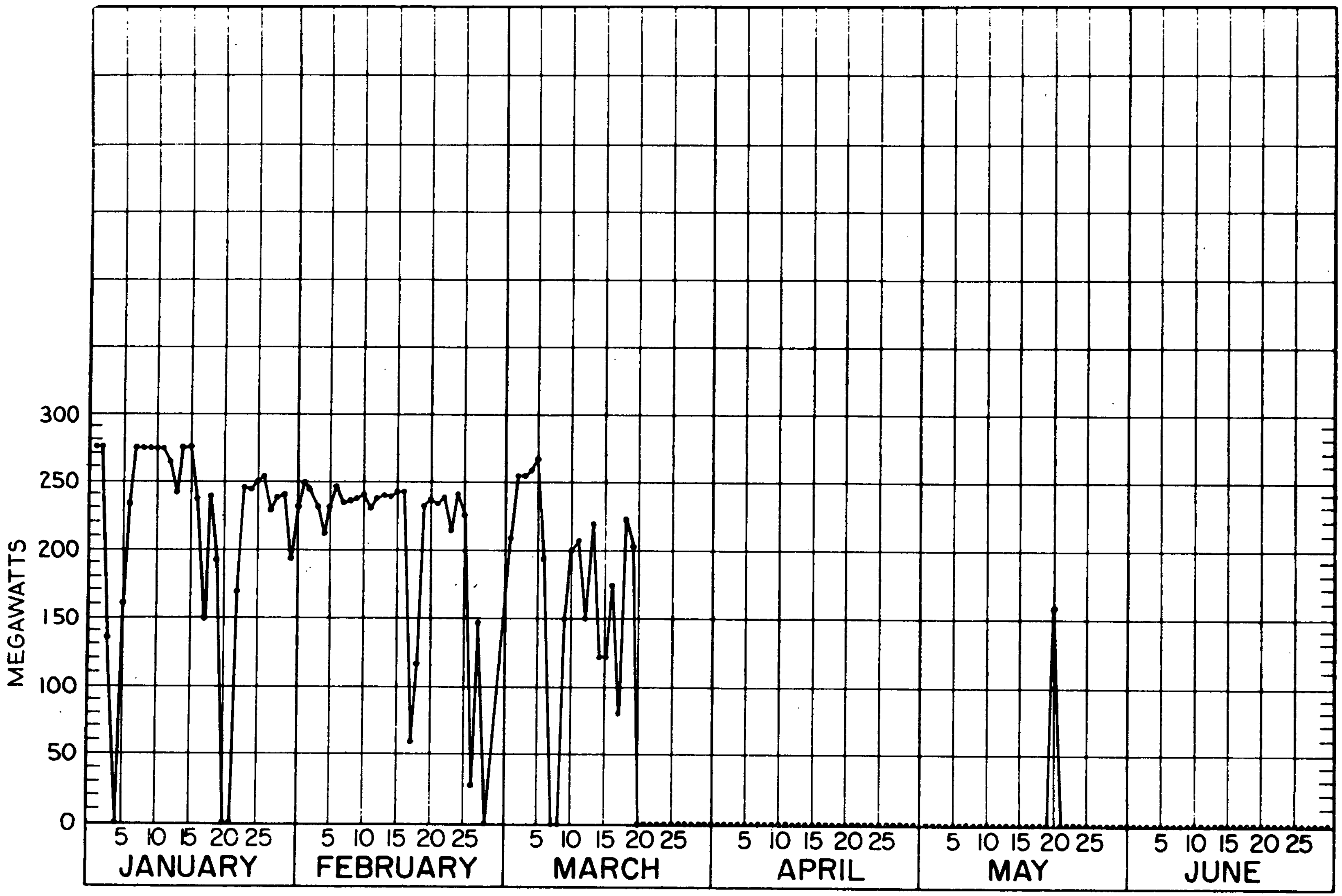

Figure 3-2. Average Daily Output 1970, Indian Point— Unit One

4.0 SAMPLING STATIONS

The 14 trawling stations (Stations 3 through 16) that were utilized during the fall and winter of 1969 have been continued through June, 1970 without change (Figure 3-1). Upon the initiation of the spring plankton program, trawl Stations 4, 6, 9, 15, 10, 11, 12, 13 and 14 doubled as plankton and trawl stations. The effluent canal, Station 53, was also utilized as a plankton station. Stations 4, 6, and 14 served as monthly plankton stations, as in 1969. Stations 20, 21, 22 and 23 were added as plankton stations.

The stations were set up in three basic transects (Figure 4-1). Each transect has a mid-river deep station, a close-to-shore deep station and one shallow water station. Stations 21, 11, 10 and 22 transect the river at the plant site. Station 22 starts in the vicinity of the forebay intake and runs north and Station 10 is located adjacent to the effluent canal and runs south. Two miles south of the plant Stations 15, 20 and 9 transect the river and Stations 13, 23 and 12 transect the river two miles north of the plant.

A summary description of the spring plankton stations arranged by transect is given in Table 4-1. Table 4-2 gives a summary description of the trawl and zooplankton, and benthic sampling stations.

The beach seine Stations 31 through 39 are the same as those utilized in 1969 with one exception. Station 39 was moved in June 1970, 100 yards to the south of its original location because it was learned that the proposed site of the effluent canal for Units 4 and 5 coincided with the original location of this station. A summary description of the seine stations is listed in Table 4-3.

The Succession Panel and Thorson Bottle stations (51, 53 to 57) are the same as those utilized in 1969, except that Station 53 was moved from its original position in the "old" effluent canal to the mouth of the new effluent canal. Station 13 has been redesignated as Station 58 to prevent confusion with trawl Station 13. Table 4-4 lists and describes the Succession Panel and Thorson Bottle stations.

The location and common names of all sampling stations are listed in Table 4-5.

Table 4-1. Spring 1970 Weekly Plankton Sampling Stations

STA	MILE*	SITE*	DPTH*	Common Name and Bottom Description
15	40	1	45	Lovett-Bottom here is grey clay with some silt. The 45' contour is often difficult to follow at this station because the bottom slopes abruptly to 60 and 65 feet, especially at the southern end of this station.
20	40	2	80	Stony Pt. Channel-The sediment is mostly black silt. The southern end has assorted stones and shell fragments mixed with small amounts of coarse sand.
9	40	3	12	Greens Cove-Bottom consists of brown-black silt that is very soft.
21	42	1	15	Inside Reserve Fleet-The bottom consists of brown-yellow silt with a few stones and many shells and fragments on the southern end.
11	42	2	50	Reserve Fleet-Bottom here is mostly black silt that is broken with a great deal of cinders.
10	42	3	45	Con Ed Plant-Bottom consists of some broken ledge, rocks at the southern end mixed with small rocks that are smooth and round from abrasion. A considerable amount of cinder exists here. The rest of the bottom is grey-brown silt broken with pebbles and rocks.
22	42	3	45	Indian Pt.-The bottom here is quite variable with fine black mud and silt with some coarse sand at the northern end. Mid-station has rocks, gravel and coarse sand. The southern end has mostly black silt with some shell fragments and coarse sand.
53	42	3	17	Effluent Canal-The bottom is mostly rocks and gravel with some black-brown silt.
13	45	1	50	Round Island-Bottom here is mostly clay with black-brown silt. The 55' contour at the northern end of the station is occasionally difficult to follow due to a steep slope.
23	44	2	80	Roa Hook Channel-Fine brown-black silt prevails throughout the station with some stone and shell fragments at the southern end.
12	44	3	12	Peekskill Bay-The bottom here is brown, grey sticky silt. Potamogeton is abundant in the shoaler water during summer and autumn.

*See Appendix A for explanation of terms.

Table 4-2. Trawling, Zooplankton and Benthic Grab Sampling Stations

STA	MILE	SITE	DPTH	Common Name and Bottom Description
5	36	1	12	Dolphin - Bottom at this station is quite hard, consisting of brown mud, sand and a great many oyster shells. This station yields the greatest volume of shells netted at any station.
3	35	3	10	Potato Rock - Bottom is mostly hard grey clay and hard sand. Oyster shells are often netted in great quantity.
4	35	2	34	Croton Point Channel - Bottom is black-grey silt and mud. Campanularia colonies full of amphipods are frequently collected.
6	38	2	30	Buoy "R 16" - Bottom here is grey silt with some clay. Colonies of hydroids (Campanularia) frequently collected.
7	38	3	11	Oscawana Island - Bottom here is grey silt and hard sand. At the southern end, rocks are netted on occasion.
8	39	1	12	Stony Point Bay - Bottom here is grey-brown silt and slightly sandy. The bottom trawls occasionally hang up on solid objects suspected to be old mooring blocks. Oyster shells are collected on occasion but not in great numbers.
9	40	3	12	Greens Cove - Bottom here is brown-black silt that is very soft. Sunken logs are occasionally netted and net hang-ups occur, but irregularly.
15	40	1	45	Lovett - Bottom here is grey clay with some silt. The 45' contour is often difficult to follow at this station because the bottom slopes quickly to 60 and 65 feet, especially at the southern end of this station.
16	41	3	45	Trap Rock - The bottom at this station is mostly cinders. Debris of all kinds collects here, i.e., leaves, bottles, trees, rope, domestic garbage, etc. On occasion, rocks weighting up to 40 pounds have been netted. Bottom contour, however, is easy to follow.
11	42	2	50	Reserve Fleet - Bottom here is mostly black silt that is broken with a great deal of cinders. Net hang-ups occasionally occur from what may be debris dumped from the reserve fleet.
10	42	3	45	Con Ed Plant - Bottom here consists of some broken ledge, rocks at the southern end mixed with small rocks that are smooth and round from abrasion. A considerable amount of cinder exists here. Hang-ups occur with regularity at this station and everything from trees to boulders is netted here; leaves are common. The rest of the bottom is grey-brown silt broken with pebbles and rocks. Definitely not good bottom.
13	45	1	50	Round Island - Bottom here is mostly clay with black-brown silt. Occasionally, at the southern end of the station, rocks will be netted. The 55' contour at the northern end of the station is occasionally difficult to follow due to a steep slope.
12	44	3	12	Peekskill Bay - The bottom here is brown, grey sticky silt. Logs are occasionally netted. A major problem at this station is caused by the sticky mud that will not easily flush itself through the fine mesh of an innerliner in the cod end of the bottom trawl. Potamogeton is abundant in the shoaler water during summer and autumn.
14	55	3	47	Bear Mt. Bridge - Bottom here is black silt with some sand and an occurence of organic detritus. The 45' contour is easy to follow until the southern end of the station where a very sharp slope occurs. Frequently, debris and logs are brought up from the southern end at a point just north of the bridge.

Table 4-3. Beach Seine Sampling Stations

STA	MILE	SITE	Common Name and Bottom Description
31	35	1	Dolphin Beach - This beach is coarse dark sand and bounded at both ends by rock. Slope of the beach is steep (1:4).
32	35	3	Croton Beach - The bottom here is part of Croton Beach and is mostly sand and silt. Cans and bottles are sometimes collected. Beach is shoal and slope is gradual (1:10).
38	40	1	Quarry Beach - Bottom is all sand that is free from debris. Slope is 1:15. Some rocks are at the North end of station and on occasion cause hang-ups.
33	40	3	Verplanck Pt. - This beach is mostly small gravel with some rocks. Broken glass occurs in considerable quantities and can be traced to a source 150 feet from the station where frequent refreshments are consumed by the public. Beach is bounded to the north by a bulkhead. Slope here is 1:5. Tidal currents existing at this station often makes a seine set very difficult.
39	41	3	Trap Rock Beach - Bottom is mostly gravel with some rocks exposed at low tide. Large rocks limit the northern end with Verplanck boat launching ramp acting as the southern boundary. The slope is 1:10. Hang-ups occur when the tide is out.
35	43	1	Reserve Fleet Beach - The beach at this station is gravel with some occurrence of rocks. The gravel beach ends shortly below the low water mark where soft sticky mud prevails. In only 2 to 3 feet of water, the aquatic weed Potamogeton is found in abundance. During high water there is no beach and willow trees and honeysuckle outcrop over the water. The slope is shallow (1:10).
34	42	3	Gas Line Beach - This beach consists of small patches of hard sand; the rest of the beach is rocky with silt. Fresh water run-off occurs through a gulley located at the south end of the beach. The slope of the beach is steep (1:4). Soft mud exists below the low water mark.
36	44	3	Lumber Co. Beach - The beach here consists of coarse black sand. This is a short beach that is bounded on the south by a bulkhead and on the north by broken piles. The slope of the beach is steep (1:4). Little vegetation is present.
37	47	1	Ft. Montgomery - This beach is generally small rocks and gravel broken with patches of coarse sand. The beach is short and does not exist at high tide. Below the low water mark, this station is dominated by mud. The beach slope is steep (1:4). Small shrubs and trees shade the water at high tide. Hand-ups frequently occur by rocks near the barge at the north end of the station.

Table 4-4. Succession Panel/Thorson Bottle Sampling Stations

STA	MILE	SITE	DPTH	Location and Exposure	Method of Attachment
54	38	1	20	Hung under a scaffold walk 50' to the west side of the loading chute of National Gypsum Plant at Grassy Pt; southerly exposure	Tied to an "I" beam
55	40	3	14	At the range marker located in Green's Cove and 550 yds S. E. from the most westerly tip of Verplanck Pt; southwest exposure	Tied from a beam that joins the tripod legs of the range marker
56	41	2	60	At the westernmost ship of the southernmost tier of ships in the reserve fleet. Five hundred yards due south of the over-river power lines; southerly exposure	Tied from the anchor chain
51	42	3	26	100' from the northern corner of the Con Ed dock; westerly exposure	Tied to a bar screen which is part of the fore-bay perimeter
53	42	3	17	On the inside face of the "new" effluent canal eastern bulkhead; westerly exposure	Tied through bulkhead
57	43	3	7	At the dolphins located 75 yards from the shore at Charles Pt; southerly exposure	Tied from a piling
58	45	1	10	The middle of the southern face of the dock located at Round Island; southerly exposure	Tied to beam joist under the dock

Table 4-5. Locations of All Sampling Stations

STA	MILE	SITE	DPTH	Position	Common Name - Locations
3	35	3	10	41° 11'07"N 73° 55'09"W	Potato Rock - 1250 yards west of Potato Rock buoy R"4". Transect is southeast.
4	35	2	34	41° 11'01"N 73° 55'58"W	Croton Point Channel - Transect is south-east from buoy R"12".
5	36	1	12	41° 11'14"N 73° 56'50"W	Dolphin - Southeast transect from dolphin in SW Haverstraw Bay.
6	38	2	30	41° 13'19"N 73° 57'10"W	Buoy R"16" - SSE transect from buoy R"16" in N Haverstraw Bay Channel.
7	38	3	11	41° 13'34"N 73° 56'27"W	Oscawana Island - NE transect in SSE from Haverstraw Bay bearing 066, 1200 yds from R"16".
8	39	1	12	41° 14'14"N 73° 58'07"W	Stony Point Bay - SSE transect 500 yds from Stony Point light "17", bearing 168.
9	40	3	12	41° 14'47"N 73° 57'43"W	Greens Cove - Bearing 048, 1000 yds from Stony Pt. light "17".
10	42	3	45	41° 16'14"N 73° 57'23"W	Con Ed Plant - 200 yds off Con Ed pier. SW transect.
11	42	2	50	41° 16'16"N 73° 57'43"W	Reserve Flt. - 800 yds off Con Ed pier. SW transect (parallel to Reserve Fleet).
12	44	3	12	41° 17'30"N 73° 56'34"W	Peekskill Bay - 1000 yds north of Peekskill Bay light "18". Transect is N-S.
13	45	1	50	41° 18'02"N 73° 58'06"W	Round Island - SE from Round Island.
14	47	3	[illegible]	41° 19'44"N 73° 58'42"W	Bear Mountain Bridge - 1000 yds NE of bridge and 100 feet off east shore. Transect is almost paralled to shore toward bridge.
15	40	1	45	41° 15'05"N 73° 58'39"W	Lovett - Between Stony Point and Rock Quarry at Tompkins Cove.
16	41	3	45	41° 15'37"N 73° 58'02"W	Trap Rock - 200 yards south from overhead power cables south towards Verplanck Point.
20	40	2	80	41° 14'48"N 73° 58'10"W	Stony Pt. Channel - midchannel 400 yds from Stony Pt. light "17" courses bearing 334° T from south end.
21	42	1	15	41° 16'30"N 73° 58'04"W	Inside Reserve Flt. - 275 yds from West bank and inside Reserve Flt. Bearing 43° T.
22	42	3	45	41° 16'22"N 73° 57'14"W	Indian Pt. - 100 yds from east bank off Indian Point, bearing 41° T.
23	44	2	80	41° 17'38"N 73° 57'16"W	Roa Hook Channel - 300-400 yds from East bank off Roa Hook, bearing 327° T.
31	35	1		41° 10'35"N 73° 56'33"W	Dolphin Beach - beach SW Haverstraw Bay bearing 280, 550 yds from light "11".
32	35	3		41° 11'23"N 73° 53'30"W	Croton Beach - beach north end of Croton Pt. public beach at Harmon.
33	40	3		41° 14'56"N 73° 57'55"W	Verplanck Pt. - beach at end of Verplanck Pt. east of bulkhead.
34	42	3		41° 16'00"N 73° 57'27"W	Gas Line Beach - beach 500 yds south of Indian Pt. Plant (Gas Co. beach).
35	43	1		41° 16'44"N 73° 58'04"W	Reserve Fleet Beach - beach on south shore of Jones Pt. just north of RR bridge.
36	44	3		41° 17'19"N 73° 55'52"W	Lumber Co. Beach - beach in NE corner of Peekskill Bay
37	47	1		41° 22'35"N 73° 59'00"W	Ft. Montgomery - beach south of Fort Montgomery Marina.
38	40	1		41° 14'56"N 73° 58'43"W	Quarry Beach - beach south of rock quarry at Tomkins Cove.
39	41	3		41° 15'21"N 73° 58'00"W	Trap Rock Beach - beach south of quarry at Verplanck.
51	42	3	26	41° 16'14"N 73° 57'14"W	Forebay-Indian Pt. Plant #1 water intake
52	42	3	26	41° 16'14"N 73° 57'14"W	Sluiceway - Indian Pt. Plant #1 screen washing sluice.
53	42	3	17	41° 16'12"N 73° 57'13"W	Effluent - Indian Pt. Plant #1 effluent channel.
54	38	1	20	41° 13'35"N 73° 57'42"W	Grassy Point - Quarry plant at Grassy Point (under dock).
55	40	3	14	41° 15'19"N 73° 57'59"W	Range Marker - Range marker at Green's Cove.
56	41	2	60	41° 15'53"N 73° 58'26"W	Anchor Chain - anchor chain western-most ship, southern tier north of Lovett Plant.
57	43	3	7	41° 17'14"N 73° 56'35"W	Peekskill Bay - Dolphin at Fleischmann's dock, Peekskill Bay.
58	45	1	10	41° 18'03"N 73° 58'09"W	Round Island

NOTE: A station as defined here may describe a geographic point or a line of travel depending on the type of sampling: for example, a bottom grab sample versus a trawl sample. (A trawl station averages about 1/2 mile in length.) The positions denote the location of the trawl transect northern points. All bearings are true degrees.

All position/location data based on the November 67 (8th) edition of the U. S. Coast and Geodetic Survey Chart No. 282.

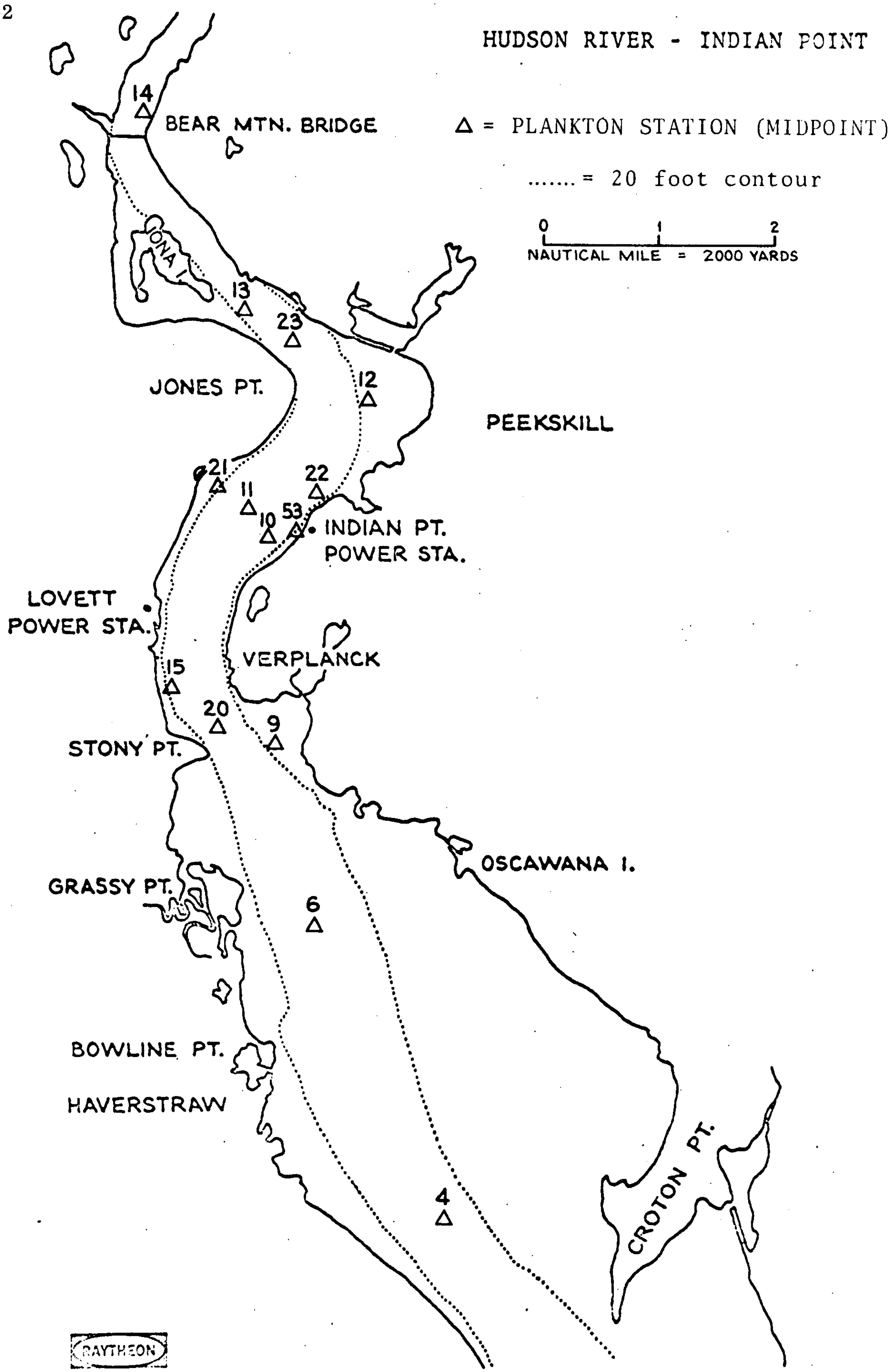

Figure 4-1. Plankton Station Locations

5.0 ELECTRONICS SYSTEMS

5.1 Introduction

The material contained in this section describes the six-month activities involving the installation, operation and maintenance of electronic systems at the power plant site. Discussions will center around the installations shown in Figure 5-1.

5.2 Automated Environmental System

5.2.1 History of Operations

The Automated Environmental System (AES) Water Quality Monitor System was installed and in operation 30 September 1969. Figure 5-2 summarizes the operational history of each of the nine sensing probes in the system since 1 January 1970. The figure shows days when valid data were recorded.

The effluent probes were inoperative at various times during the six-month period. From January 19 through 30, a shaft in the supply pump broke due to clogging and a new pump was purchased and installed. Also during this period, AES Company engineers replaced faulty parts in the effluent sample drawer. On February 1, effluent sample drawer flooded and system was off for two days. From February 5 through 11, the system was shut down to move the effluent pump 200 feet closer to plant due to effluent channel diversion. From 18 March through 17 April, 22 through 23 May and 26 May to 4 June, dissolved oxygen probe was returned to AES Company for repairs. Major problems were in calibration of the sensor due to membrane clogging plus excessive electronic drift.

Beginning 19 January, an AES maintenance schedule was established for use by the electronics technician on site. A copy of this Maintenance Record format is presented in Figure 5-3.

5.2.2 Tide Stage Height Instrument

Raytheon, using company funds, purchased an AES Water Stage Height Instrument so that the Water Quality Monitor System would record tide conditions continuously. Raytheon personnel installed the unit 27 May beneath the pier (Figure 5-1). Installation details for the truss pipe, sensor assembly and associated hardware are shown in Figure 5-4.

Three-conductor shielded cable was used to hardwire the sensor assembly to the AES. This was done to record tide-height variations in analog format on the same strip chart with the other environmental factors monitored by the AES unit. The instrument was aligned using 1970 tide table information as a reference. Mean-low tide on the recorder chart was put at 10 feet to allow tides below this to be recorded and to prevent interference with other recorder tracings.

5.2.3 AES-Digitec Interface

Cable connections were made on 27 May between the AES monitor in Biology Lab and the Digitec punch paper tape-printer system in the Electronics Van.

Interface methods, as designed by Raytheon personnel, are shown in Figure 5-5. The 0 to 5-volt analog signals from the AES output were handwired to the Digitec input coupled to scaler potentiometers to reduce signal levels acceptable to the scanner input. As a result of this installation, AES data are printed continuously on channels 18 to 26 of the printer tape and stored on punch tape to facilitate data processing at a later date. Installation was completed and system operational on 6 June.

5.3 Temperature Chains

5.3.1 History of Test Operations

The upstream buoy was put in place on January 7 approximately 900 feet upstream from the southwest corner of the dock after undergoing a leak test (submerged) in the river. The buoy was functioning, but no data were recorded because of a power - supply failure in the Digitec System. The power supply was returned to New London on 8 January. The complete system as installed was shut down pending return of the power supply.

On 14 January, the power supply was returned, connected, but again malfunctioned. It was again returned to MRL for repair, and replaced with a different power supply on 20 January.

On 21 January, the downstream buoy was installed approximately 1,000 feet downstream from the southwest corner of the dock. It was installed during hazardous ice conditions and arctic weather. The cable was cut, apparently by the ice, after installation. The buoy was removed on January 22 and a new cable was ordered.

The cross-stream buoy was installed on January 22, approximately 700 feet off the southwest corner of the dock. No problems were encountered with its installation.

The cross-stream and upstream buoys were connected to the Digitec System on 22 January and started recording temperatures every fifteen minutes, twenty-four hours a day. The effluent buoy began malfunctioning and was disconnected.

On 31 January, the upstream buoy was sighted approximately 1,000 feet downstream, but was still recording information. The buoy was sitting in shallow water and protruding above the surface. It was removed on 3 February. The cross-stream buoy continued to function.

On 20 February 1970, all the temperature chain electronics except for those installed on the cross-stream buoy were returned to New London for evaluation, redesign and reassembly.

5.3.2 Electronic Evaluation, Redesign and Reassembly

A detailed inspection of the sensor cable assemblies was conducted and repairs were made where necessary. Also, each transmitter was checked for proper operation with the set-up given in Figure 5-6. In the configuration, raising the power supply voltage from zero resulted in an increase in loop current (voltage on meter). A point was reached where the meter reading did not increase for a continued increase in supply voltage. This point was reached at about 27 volts supply voltage for a sensor temperature of 100 °F. When the meter reading stabilized, temperature (°F) was obtained by multiplying the reading by 10 and subtracting 25.0. This holds true only for a 625 ohm series resistor.

Most transmitter faults resulted in a failure to "limit" as the supply voltage was increased. In no case was the supply allowed to exceed 60 volts.

A sensor was simulated by attaching a 100-ohm resistor across terminals 1 and 2 of the transmitter and shorting terminals 3 and 4 together.

During the foregoing electrical checks, five transmitters were found to be inoperative. Transmitter 66 had a faulty amplifier card and the card from spare transmitter 60 was substituted. Transmitters 61, 62, 63 and 69 were found to have faulty transistors, Q201 on their control cards (shorted C-E). These transistors were replaced and transmitters 61, 63 and 69 placed back in operation. Transmitter 62 was found to have a faulty amplifier card and was not used in the current installation. A sample "Electronics Evaluation" record sheet is shown in Figure 5-7.

Following these checks, three electronic enclosure cans were assembled, one for each system. Each can had associated with it four transmitter and sensor units with cable lengths of 20, 20, 40 and 80 feet.

A calibration check of each transmitter and sensor unit was then performed using the set-up of Figure 5-6. The sensors alternated between ice water bath and an accurately controlled hot water bath. Readings obtained were corrected to a National Bureau of Standards certified thermometer readable to 0.05 °C (.09 °F). Additionally, where the calibration checks showed an instrument to be in error, that instrument was calibrated to within 0.1 °F of the bath temperature. The results of these checks were recorded on the "Electronics Evaluation" sheet (Figure 5-7).

Each can was then sealed, pressurized at 10 psi and submerged in the MRL-New London test tank for a 24-hour leak test. Under these conditions, a linearity check was performed for each sensor and corrected temperature readings observed at 10 °F intervals. Results were recorded graphically as illustrated in Figure 5-8.

5.3.3 Reinstallation of Temperature Chains and Electronics

Prior to 12 March, the Asst. Technical Advisor, with the Raytheon on-site electronics technician, surveyed the area near the new effluent and determined locations to plant the buoy systems. The three locations were spaced downstream, upriver and out from the mouth of the effluent on or near the 1-2 °F contour.

On March 12, plans were initiated to reinstall three temperature-chain buoy systems minus electronics and associated cables. In the morning, three orange-colored, surface-marker buoys were placed at the spots where the thermal chains were to be implanted. (Figure 5-9, Upstream, middle and downstream chain locations). Following this, a series of passes were made at each of these surface buoys (and later, at the new location of the original cross-stream chain) to map the bottom contours and determine water depths in the areas. A recording fathometer was used and the bottom characteristics (within a 50 foot radius of each buoy) were observed. Results are shown in Figures 5-10 through 5-13; actual locations for the thermal chains are also indicated on each Figure. The depth contours on these curves provided the information needed to rig the subsurface buoy 10 feet below the surface at mean low tide.

During the afternoon of 12 March three chains were prerigged and readied to be implanted on March 13th. Final cable length configurations and chain loactions are shown in Figure 5-14.

During the morning of 13 March, a series of measurements were made to each marker buoy using permanent land marks as guide points. These were made in case the surface buoys were unintentionally removed and location by other methods failed. Between 1300 and 1400 on 13 March—the upstream, middle and downstream units were implanted from a launching tug.

As mentioned, plans were made to locate the subsurface buoy (10 feet below surface) at low tide. Actual depths, as measured on a fathometer and with markings on the surface buoy rope, turned out to be 12' on the upstream buoy and 11' on the other two. After installation, marker buoys were removed and a series of sonar passes were made on each subsurface buoy to locate same acoustically. The buoys were easily detectable using this method.

On April 7 MRL personnel made final on-site preparations for installation of electronic packages to the temperature-chain buoy systems previously implanted.

Attempts were initiated on 8 April to salvage enough of the 12 conductor copper shielded cable previously used to couple to at least one system. One section long enough to reach the upstream chain was available and an electrical check showed the cable to be usable. A damaged section of the cable near the center was removed, the two ends respliced together and a connector installed on the outboard end. The shore end of the cable was run to the instrument van via a route shown in Figure 5-15.

Following this, two sections of similar type copper-shielded cable were routed from the van over the roof of the bio-lab to the pit outside the bio-lab with the intention of making all splices on new cable at this spot. This location was chosen for splicing because it is relatively dry and well protected against damage problems. Connectors were then installed on all three cables in the van and on the two remaining buoy cables.

During 9 April the cables to the three chain systems were run as shown in Figure 5-15. The repaired cable was run to the upstream chain and two new 8 conductor , #18 stranded wire, PVC coated cable fed the middle and downstream chains. Procedures used to make these runs were: cables were payed out from reels placed on the pier in front of the van and pulled by boat to each buoy. The cable trailing the boat was floated by Polystyrene blocks attached and spaced approximately every 100 feet. Once at the buoy location, the connector on the end of the cable was attached to a 10-inch thick, 4 1/2-inch long float tied to the surface marker. At this time 30 to 40 feet of cable were coiled in the boat to assure enough slack to make proper electrical connections. A second boat worked in reverse (buoy to pier) to remove floats and attached cement blocks approximately every 100 feet to sink the cable. Additionally, 12-inch long sections of lead were wrapped around the cable to prevent lateral movement of the cable on the bottom. After completing the cable laying process, the shore ends were spliced to the copper cable run the previous day.

At the same time the cable laying job was occuring, final wiring check outs were made to the shore display electronics in the instrument van. From this, a shore-cable wiring configuration list was made as shown in Figure 5-16. In essence, matching pin numbers on the connectors at each end of the cable were tied together (A to A, B to B, etc.). A continuity check verified each wire in each cable was connected properly.

Also on 9 April, a single sensor was installed in the effluent near the AES pump and was observed to function correctly. A 0.5°F temperature differential was noted between the two systems probably due to temperature loss in the AES feed pipes.

Professional divers, after some difficulties, installed the electronic cans on the upstream and middle—temperature chains on 10 April. After further difficulties other divers were retained and they installed the downstream electronics on 17 April (following delays caused by wind and tide conditions).

5.3.4 Temperature Chain Performance

From 18 April to 4 June, temperature data from the sixteen sensors were recorded continuously without difficulty on the digital printer, but some difficulties were experienced with the Digitec paper tape punch; therefore, data from digital printer were utilized until the paper tape punch was repaired.

On 4 June, during an electrical storm, ten probes became inoperative including all four on the downstream and midstream buoys and two on the upstream buoy.

On 8 June, three submerged electronic cans housing the electronics were retrieved. Continuity checks showed no electrical faults in the shore cables, also no structual damage was observed. Major faults were found in the electronic transmitters located in the cans. On 11 June, the transmitters were returned to the manufacturer for repairs.

On 23 June, the repaired transmitters were returned with a list of damaged components from which the manufacturer evaluated the damages and arrived at the following conclusion—the extensive damage to the component was due to an electrical discharge. An excessive long-term voltage of two or three times the norm could not have been thecause because there were no signs of overheating, i.e., charring or discoloration; therefore, they concluded the overvoltage was transitory in nature and of extreme magnitude such as that of a lightning strike.

During 23 June, the repaired systems were reassembled in New London and a calibration check was made with no changes observed from previous checks. At this time, steps were initiated to prevent future occurrences of this type. The shore cables from the water line to the electronic van were rerouted through an opening in the pier near the electronic van (Figure 5-15). This reduced the amount of exposed cable and used the pier as a shield against possible strikes. Additionally, voltage limiting diodes were placed across the power leads in the electronic cans to prevent transients from reaching the electronics. The downstream can was installed and operating by 30 June. The remaining two cans were placed in operation 10 July, the delay caused by delivery of new connectors for the cans.

The cross-stream buoy originally located in midriver was relocated on 23 June, midway between the upstream and midstream buoys as shown in Figure 5-9. Bottom profiles and cable lengths are given in Figures 5-13 and 5-14 for this buoy. With the relocation of this buoy, seventeen working sensors were available (sixteen surrounding and one in the effluent). Figure 5-17 illustrates days when the temperature sensors recorded valid data.

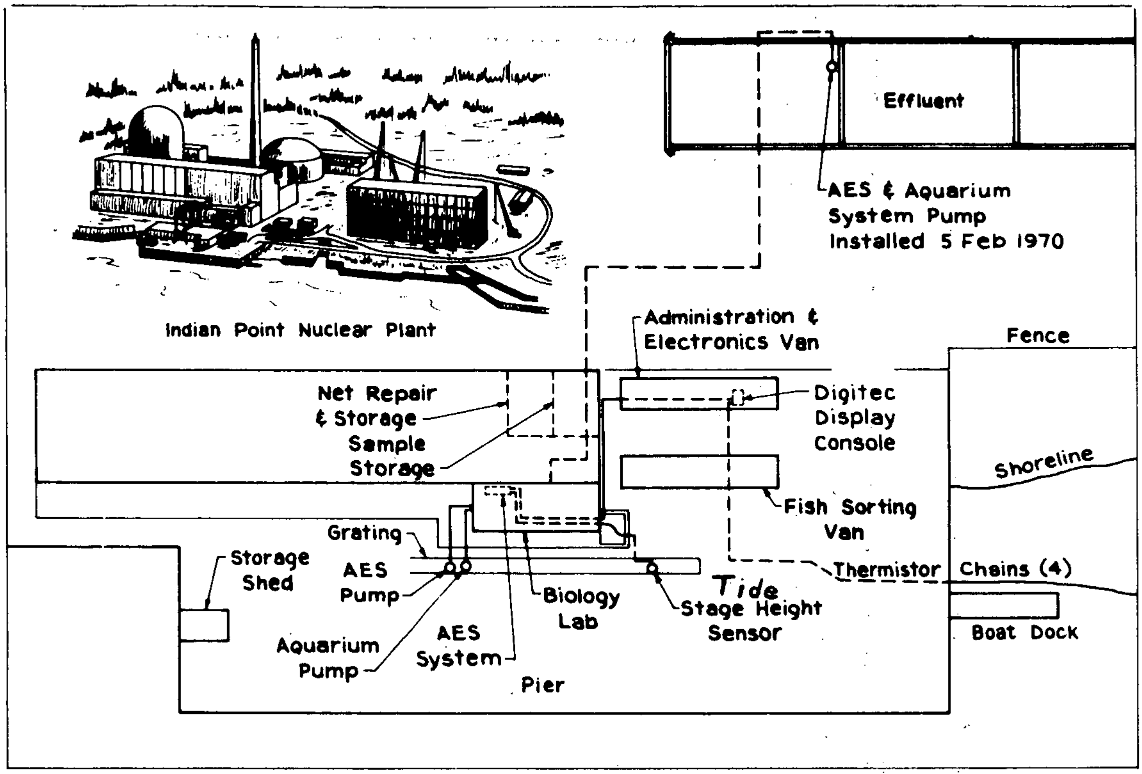

Figure 5-1. Site Locations of Electronic Installations

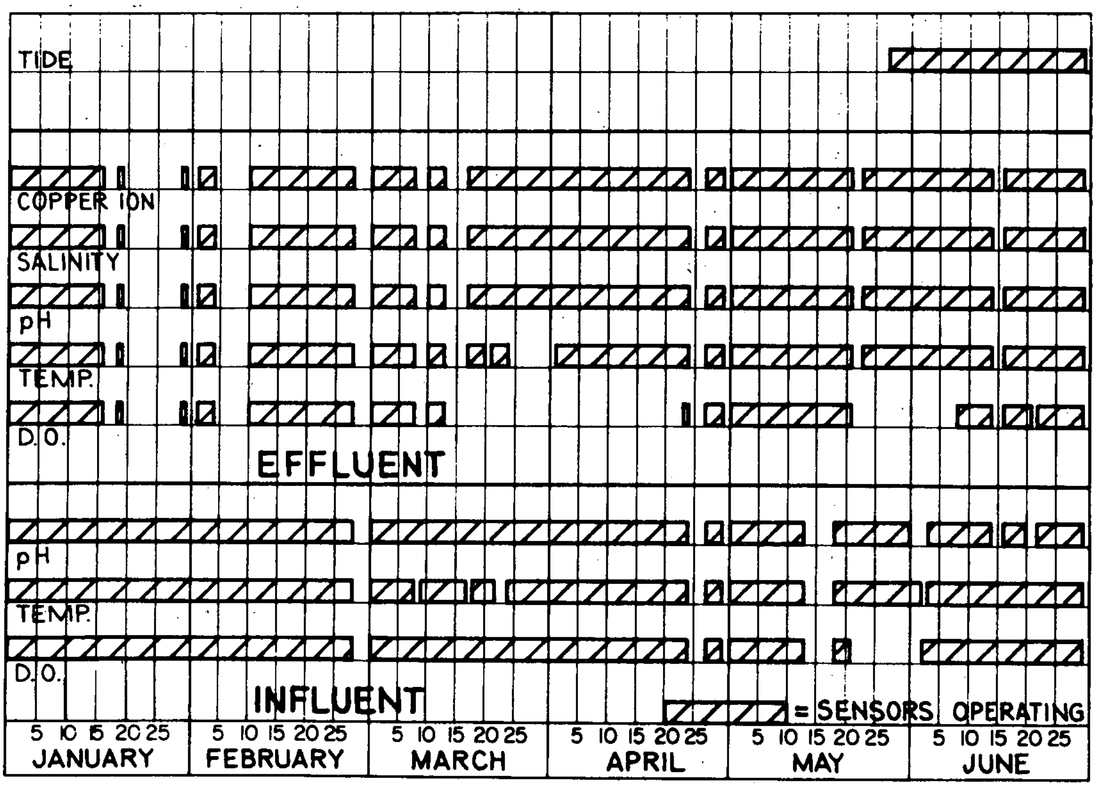

Figure 5-2. Automated Environmental System (AES) Operational History - 1970

Figure 5-3. Automated Environmental System (AES) Maintenance Record

DATE..........................

A. DAILY:

1. Annotate recording paper.
2. Check and adjust chart timing.
3. Record 0830 readings.
4. Clean sensors.
5. Visual operational check.

	M	T	W	T	F
1					
2					
3					
4					
5					
Eff.					
Inf.					

B. WEEKLY:

1. Clean sample drawers and sensor cups ....
2. Check D.O. sensor membrane ....
3. Instrument calibrations (if required)

Observed readings:

Channel	Function	Before	After Cleaning	After Calibration	Units
1	Temp. Out				^oF
2	pH In				---
3	D.O. Out				PPM
4	pH Out				---
5	Sal.				PPT
6	Temp. In				^oF
7	D.O. In				PPM
8	Cu				PPM
9	Tide				Ft.

4. Offset temperature instruments.

   Readings (before offset is performed):

   Intake: Measured .... Indicated ....

   Outfall: ....

5. Inspection of pumps and piping system (above water)

   ....

6. Remove chart paper (after PMS) ....

C. MONTHLY

1. Visually inspect pumps and clean the screens ....
2. Clean water intake and drainage system in lab ....
3. Check pH reference solution ....
4. Check D.O. electrolyte ....

D. EVERY FOUR MONTHS

1. Replace pH reference solution ....
2. Replace D.O. electrolyte ....

E. REMARKS: ....

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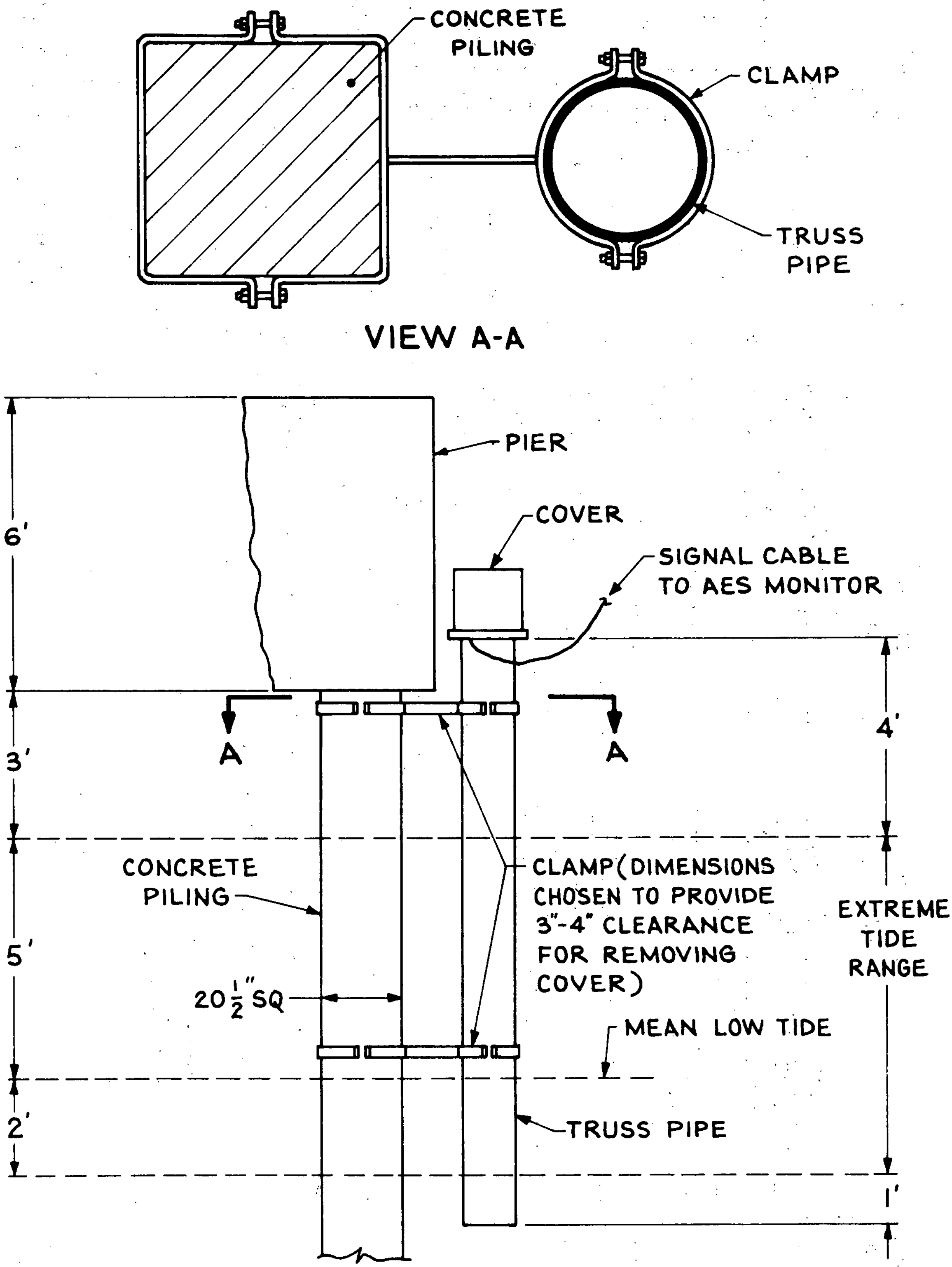
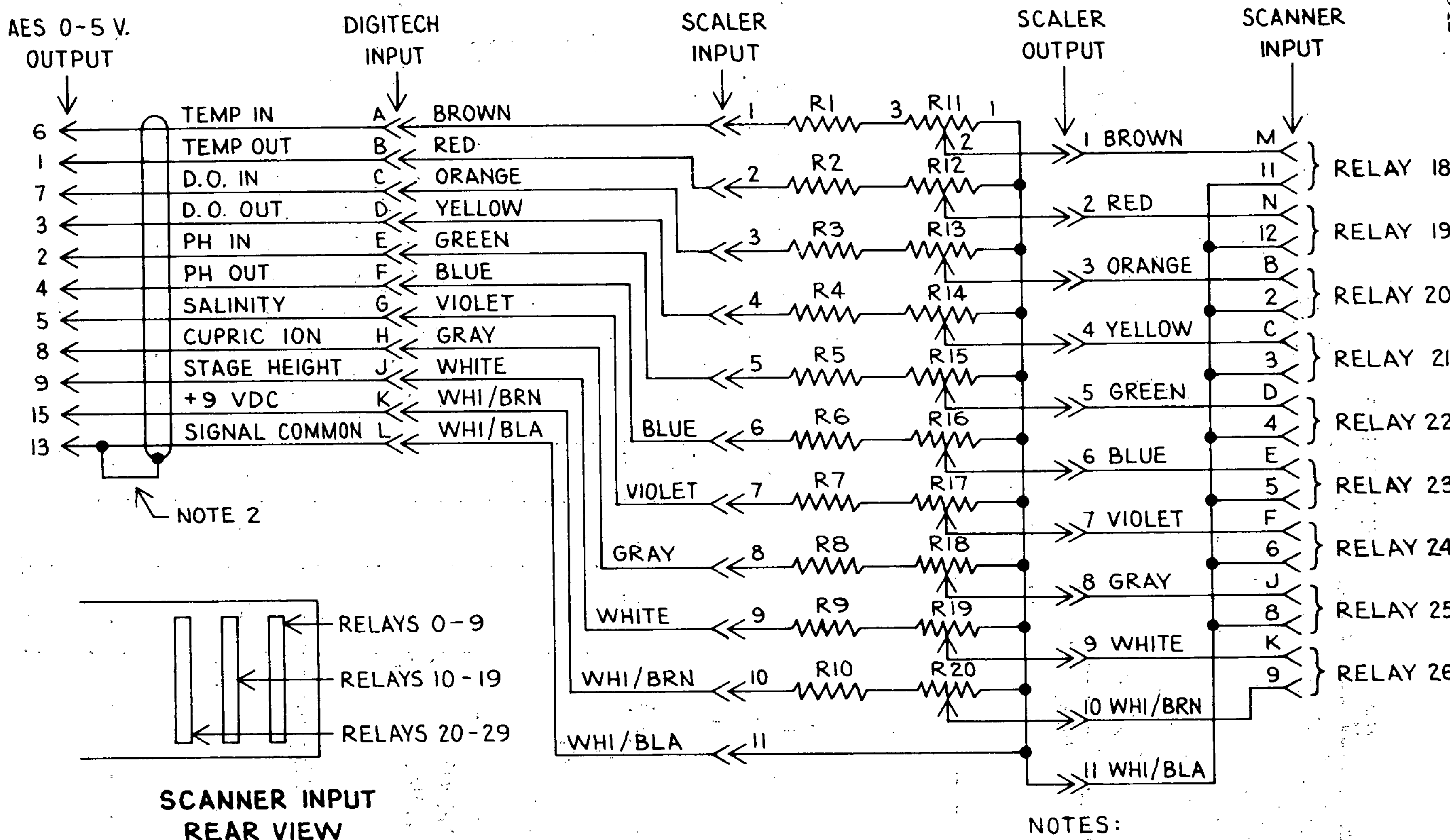


Figure 5-4. Water Stage Height Installation



NOTES:
1. R 1 THRU R9 470 K.
R 11 THRU R19 500 K.
R 10 .... 47 K.
R 20 .... 10 K.
2. CONNECT SHIELD TO SIGNAL COMMON AT AES END ONLY.

Figure 5-5. AES/Digitec Interface

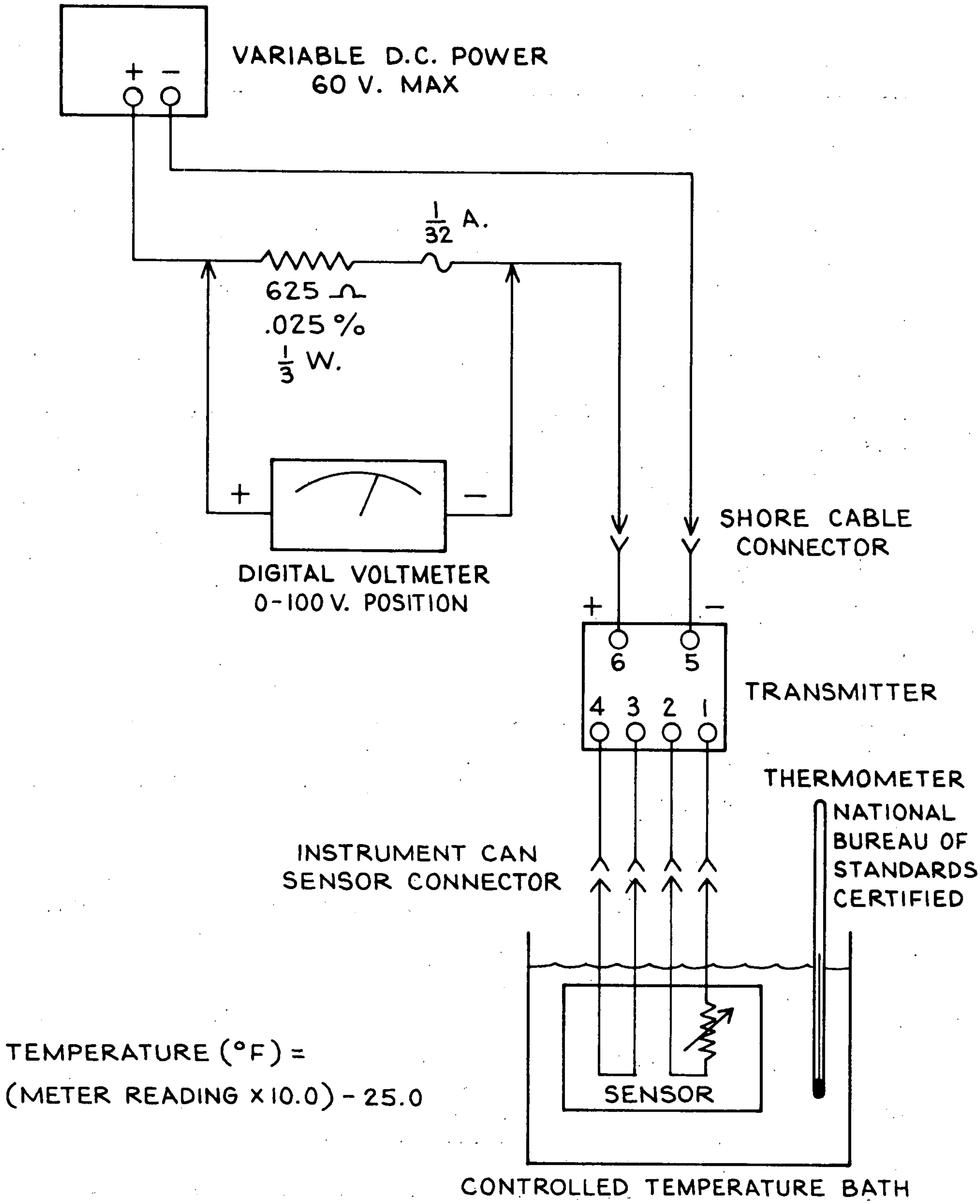
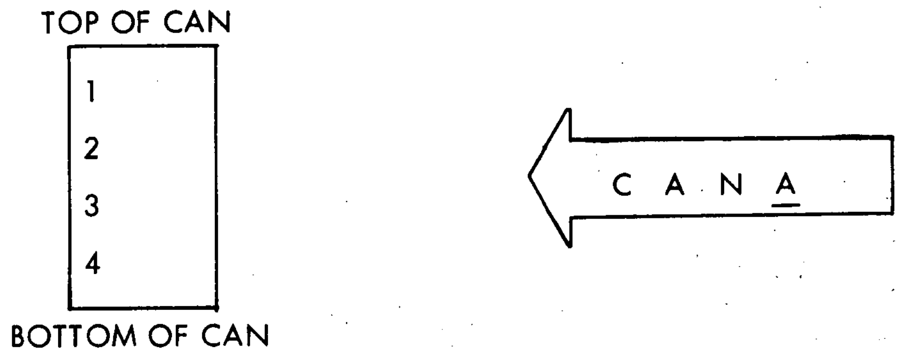


Figure 5-6. Transmitter and Sensor Test Assembly



TRANSMITTER NO.	69	1

REMARKS/HISTORY:

Electrical check disclosed transistor Q 201 on control card shorted C-E. Replaced. Electrical check O.K.

SENSOR NO.	48	LENGTH	40 Feet	2

REMARKS/HISTORY:

Sensor was unpotted spare. Potted sensor to one end of 40' of cable supplied with sensor #76. Assembled connector to other end. Cable in good condition.

CALIBRATION	VOLTS OUT	CALCULATED °F	OBSERVED °F	DATE (3)
INITIAL	5.70/12.82	32.0/103.2	32.0/103.1	3/6/70
POST				
SUBSEQUENT				

Figure 5-7. Electronics Evaluation Results (Sample Sheet)

R942

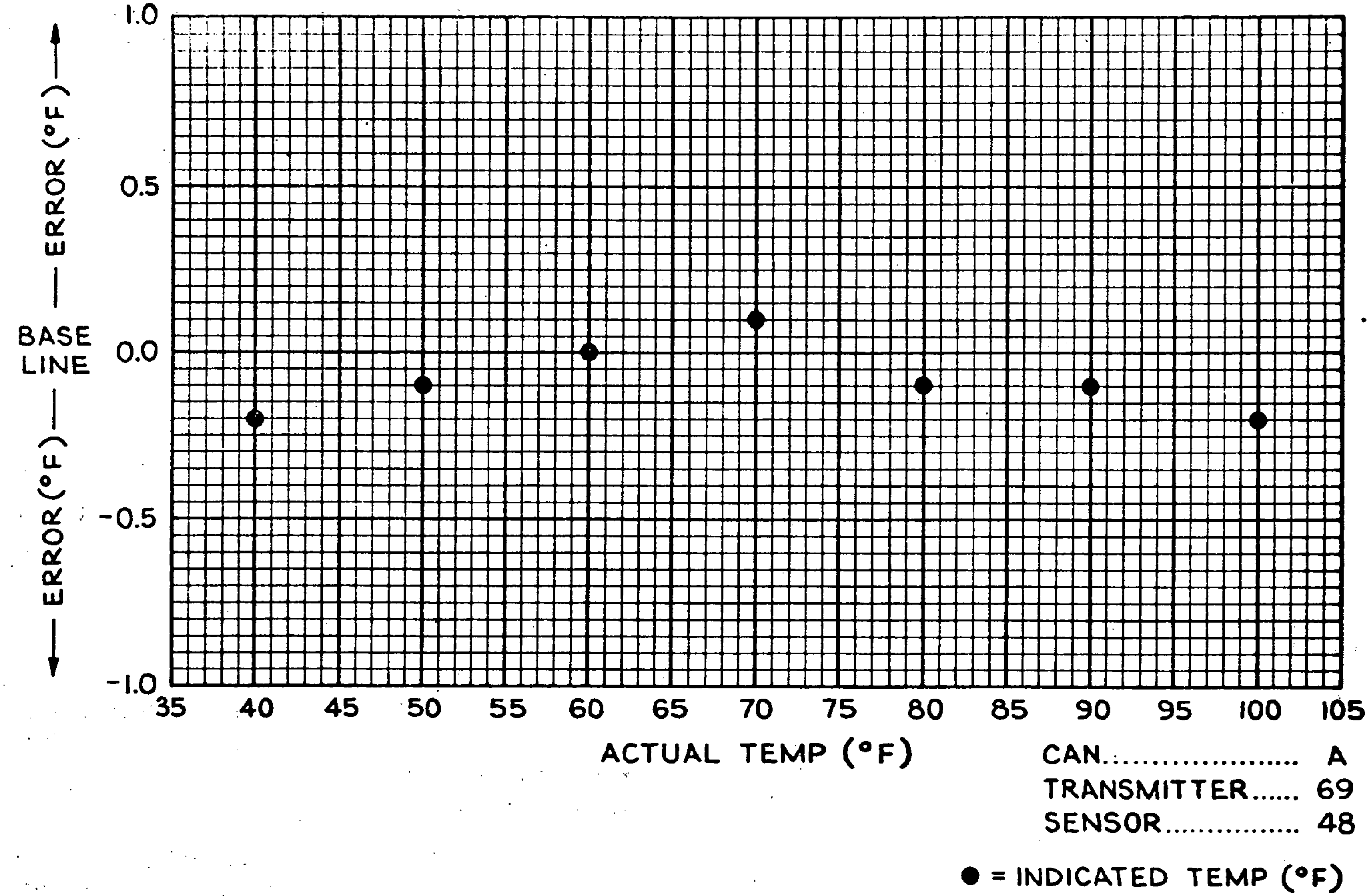


Figure 5-8. Temperature Linearity Check

R942

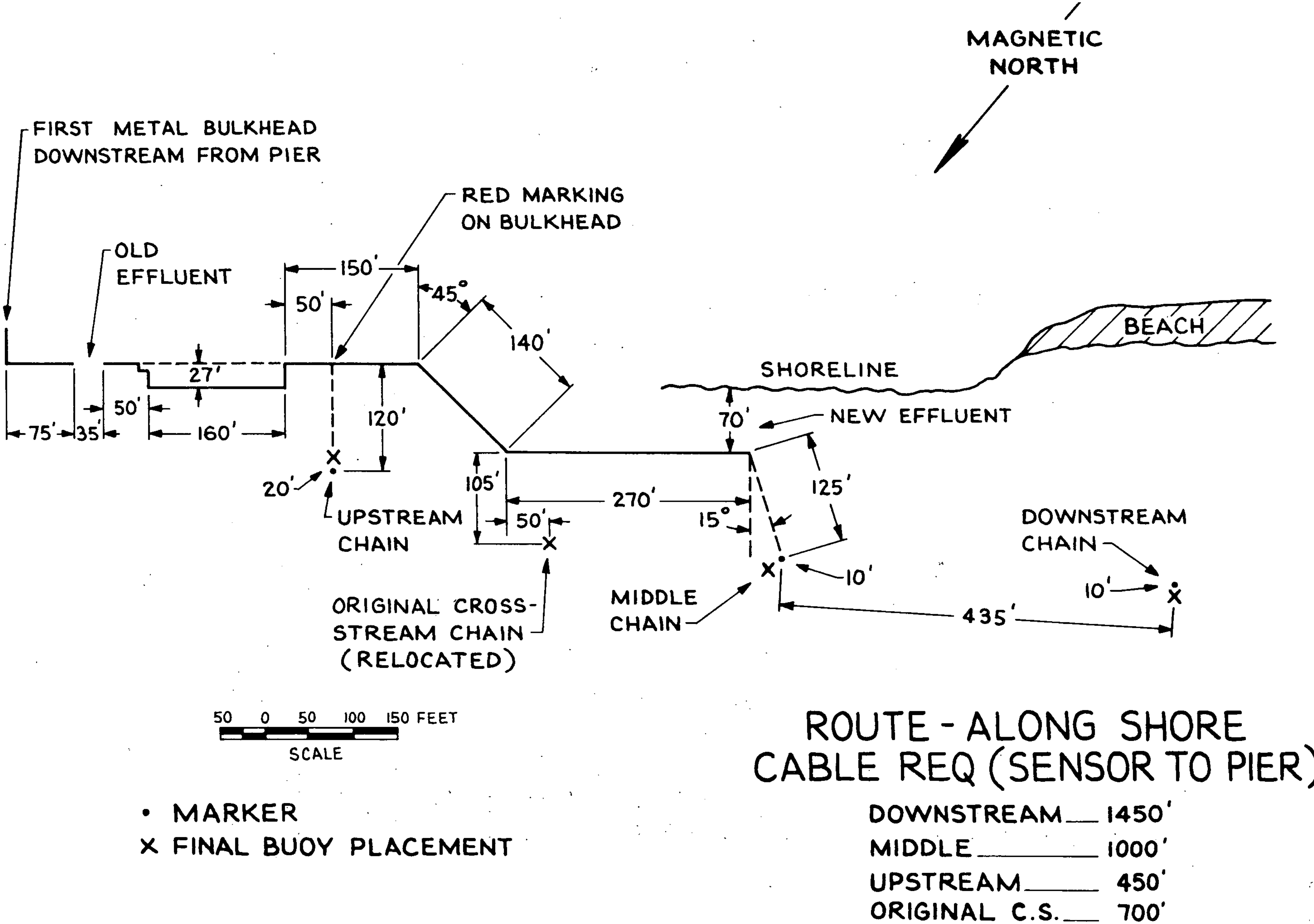


Figure 5-9. Temperature Sensor Buoy System Locations

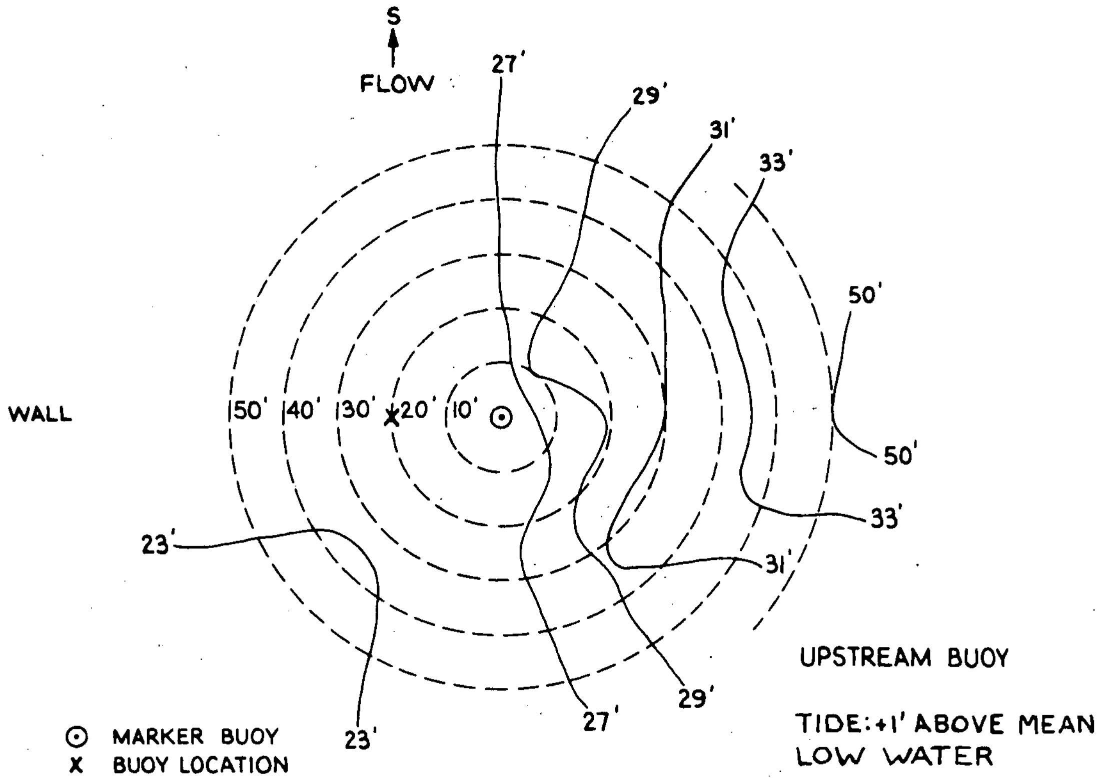


Figure 5-10. Upstream Buoy — Bottom Profile

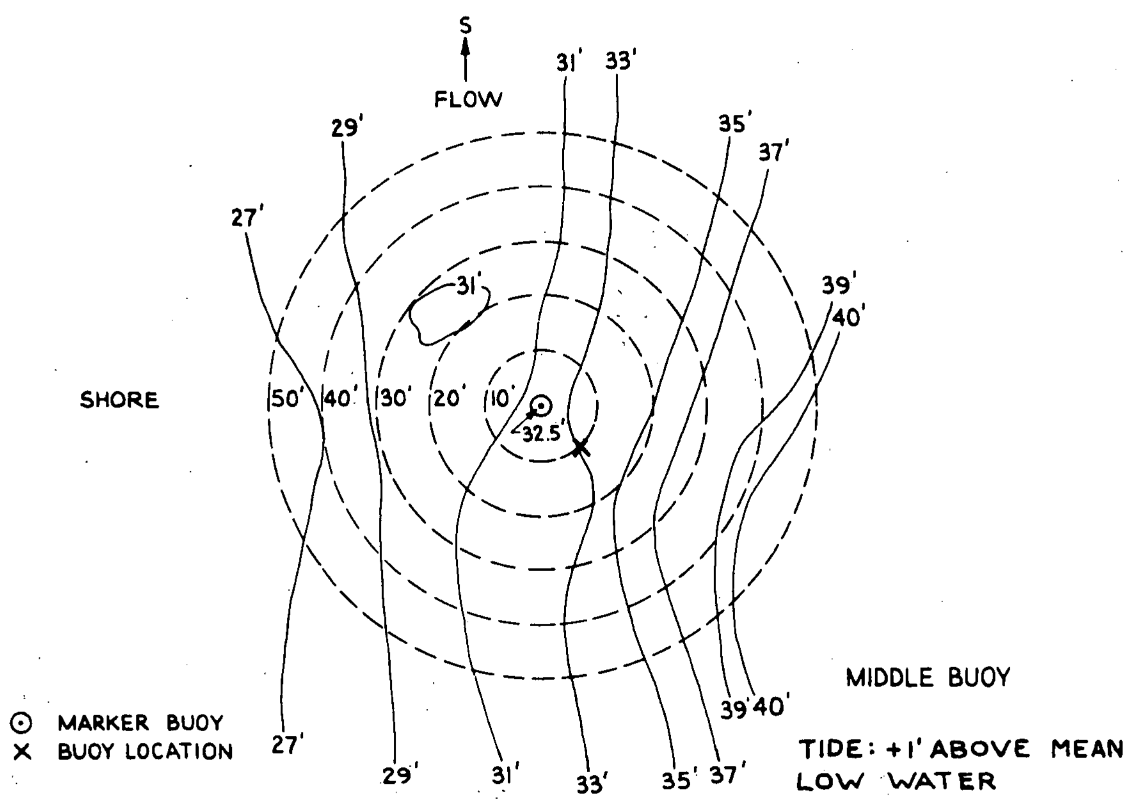


Figure 5-11. Middle Buoy — Bottom Profile

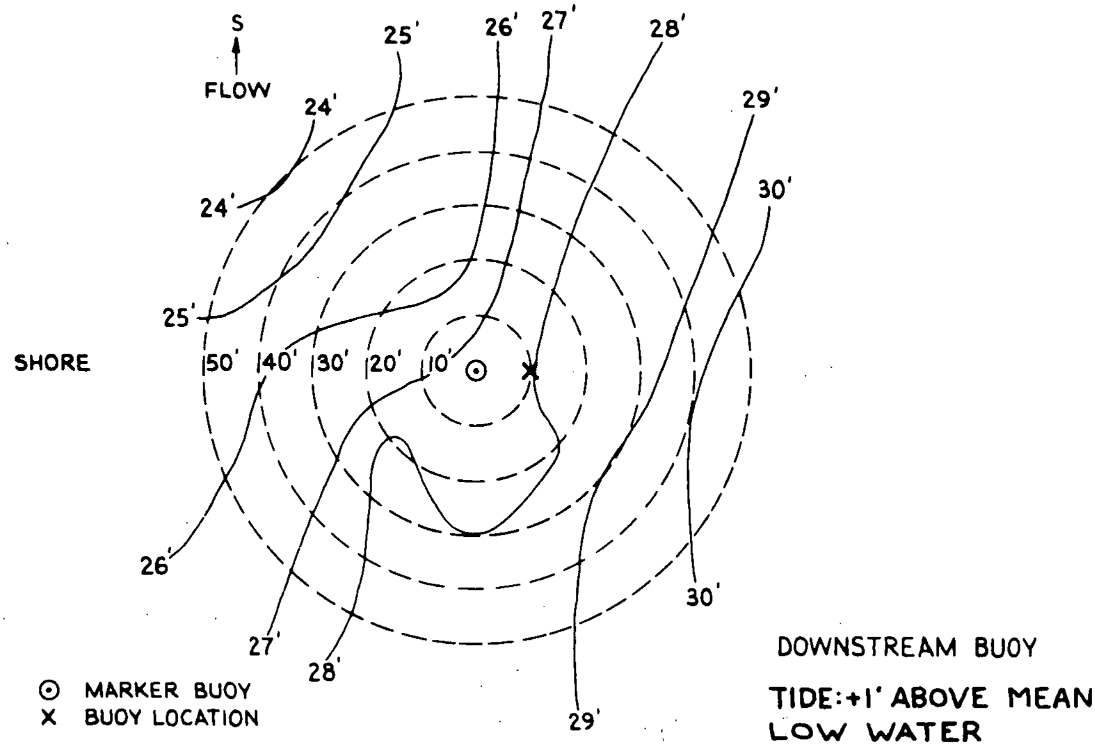


Figure 5-12. Downstream Buoy — Bottom Profile

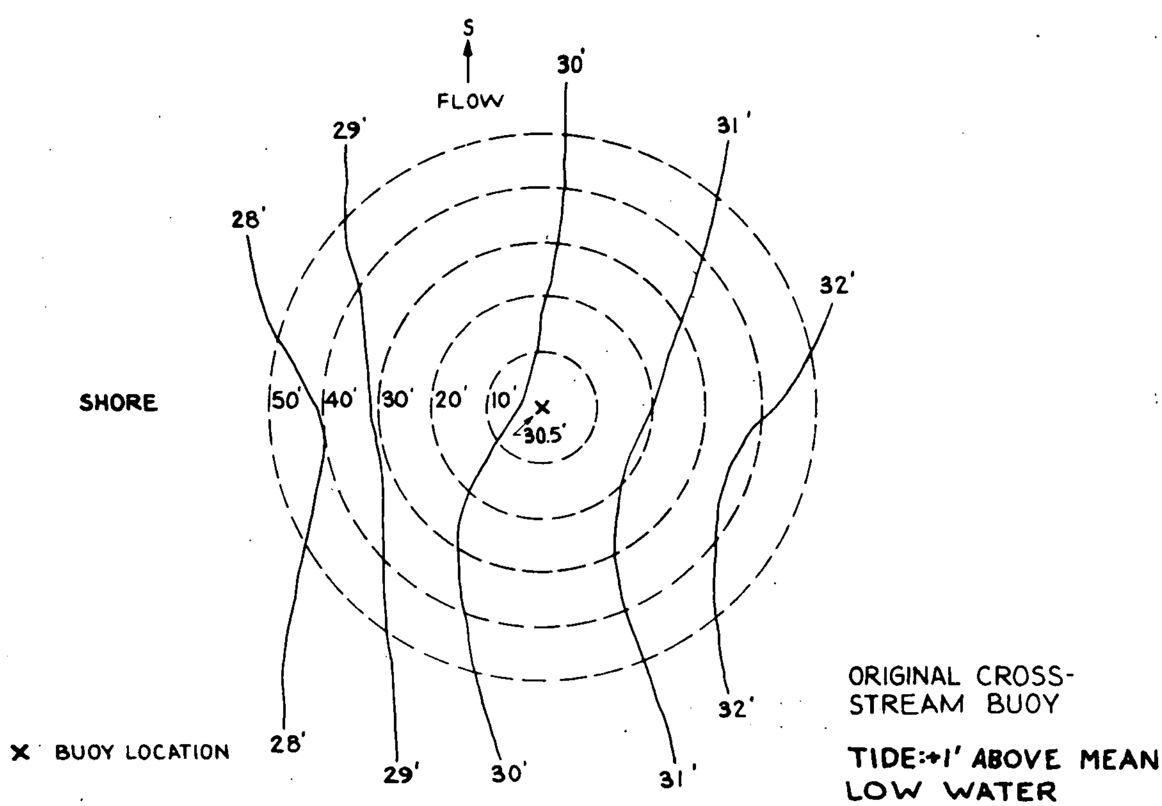


Figure 5-13. Original Cross-Stream Buoy — Bottom Profile

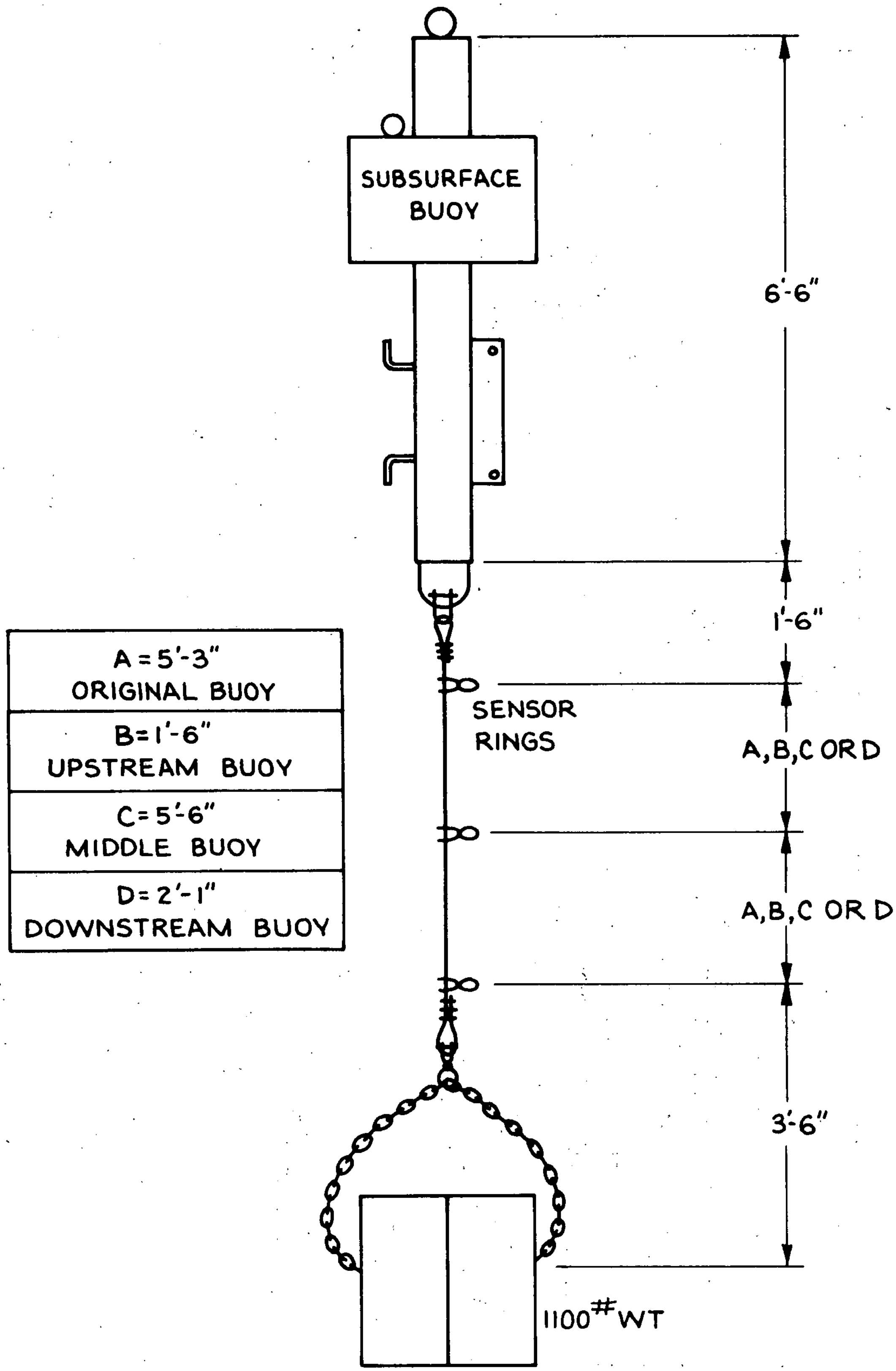


Figure 5-14. Thermal Chain Buoy Configurations

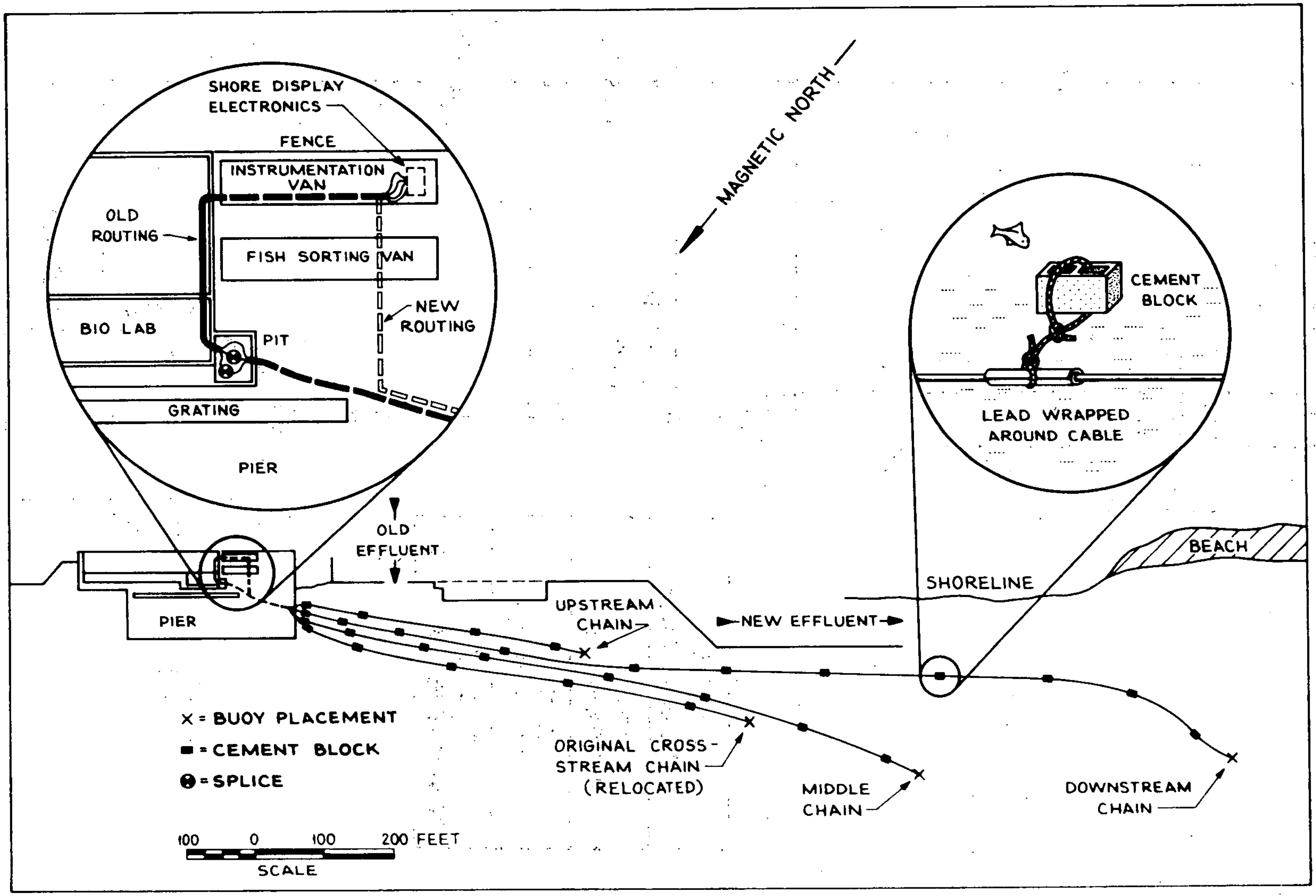


Figure 5-15. Cable Routing Diagram for Thermal Chains

SPLICED (Shore Cable Outboard Connector through Copper Shielded Cable Color)

CAN	BUOY	SENS POS	SHORE CABLE OUTBOARD CONNECTOR PIN	COLOR	XMTR	SENS	FUNC	COPPER SHIELDED CABLE COLOR	INBD MS PIN	INBD MS RECEPTACLE COLOR	UTILITY PANEL TB	UTILITY PANEL #	MX CHAIN NO.
A	MIDDLE	NT	A	BLUE	61	62	−	BROWN	A	YELLOW	2	2	6
			C	ORANGE			+	BLUE	C	BLUE		6	
		TOP	D	GREEN	64	65	−	WHITE	D	WHITE		1	5
			E	RED			+	WHITE	E	GRAY		5	
		BOTT	G	WHITE	63	64	−	BLUE	G	BLACK		4	8
			H	BLACK			+	GREEN	H	ORANGE		8	
		NB	K	GRN/BT	69	48	−	WHITE	K	WHITE/RED		3	7
				RED/BT			+	ORANGE	L	WHITE/BLACK		7	
		—	M	WHI/BT	—	—	SP.	WHITE	M	GREEN		—	—
B	DOWNSTREAM	BOTT	A	BLUE	76	77	−	BROWN	A	YELLOW	4	4	16
			B	ORANGE			+	GRAY	B	RED		8	
		NB	D	GREEN	66	67	−	WHITE	D	WHITE		3	15
			E	RED			+	WHITE	E	GRAY		7	
		TOP	G	WHITE	65	66	−	BLUE	G	BLACK		1	13
			H	BLACK			+	GREEN	H	ORANGE		5	
		NT	K	RED/BT	72	73	−	WHITE	K	WHITE/RED		2	14
			L	WHI/BT			+	ORANGE	L	WHITE/BLACK		6	
C	UPSTREAM	NT	A	BROWN	68	69	−	NO SPLICE. USED COPPER SHIELDED CABLE FROM CAN TO VAN.	A	YELLOW	1	2	2
			B	GRAY			+		B	RED		6	
		TOP	D	WHITE	70	71	−		D	WHITE		1	1
			E	WHITE			+		E	GRAY		5	
		NB	G	BLUE	75	76	−		G	BLACK		3	3
			H	GREEN			+		H	ORANGE		7	
		BOTT	K	WHITE	67	68	−		K	WHITE/RED		4	4
			L	ORANGE			+		L	WHITE/BLACK		8	
		—	C	BLUE	—	—	SP.		C	BLUE		—	—
		—	F	RED	—	—	SP.		F	BROWN		—	—
		—	J	WHITE	—	—	SP.		J	WHI/BRN		—	—
		—	M	WHITE	—	—	SP.		M	GREEN		—	—
BUOY REMAINING FROM ORIGINAL INSTALL.		TOP		WHITE(K)	78	79	−	NO SPLICE. CABLE IS THAT USED IN ORIG INSTALL. SOLID LENGTH.	E	GRAY	3	1	9
				WHITE(L)			+		D	WHITE		5	
		NT		GRAY	74	75	−		B	RED		2	10
				WHITE(H)			+		J	WHI/BRN		6	
		NB		WHITE(D)	71	72	−		K	WHITE/RED		3	11
				RED			+		F	BROWN		7	
		BOTT		GREEN	73	74	−		H	ORANGE		4	12
				BROWN			+		A	YELLOW		8	
		—		BLUE	—	—	SP.		C	BLUE		—	—
		—		WHITE	—	—	SP.		M	GREEN		—	—
		—		BLUE(Z)	—	—	SP.		G	BLACK		—	—
		—		ORANGE	—	—	SP.		L	WHITE/BLACK		—	—
EFFLUENT SENSOR		NEAR AES		SHIELD	79	63	−		—	—	5		0
				CT. COND.			+						

Figure 5-16. Electronics Wiring Diagram

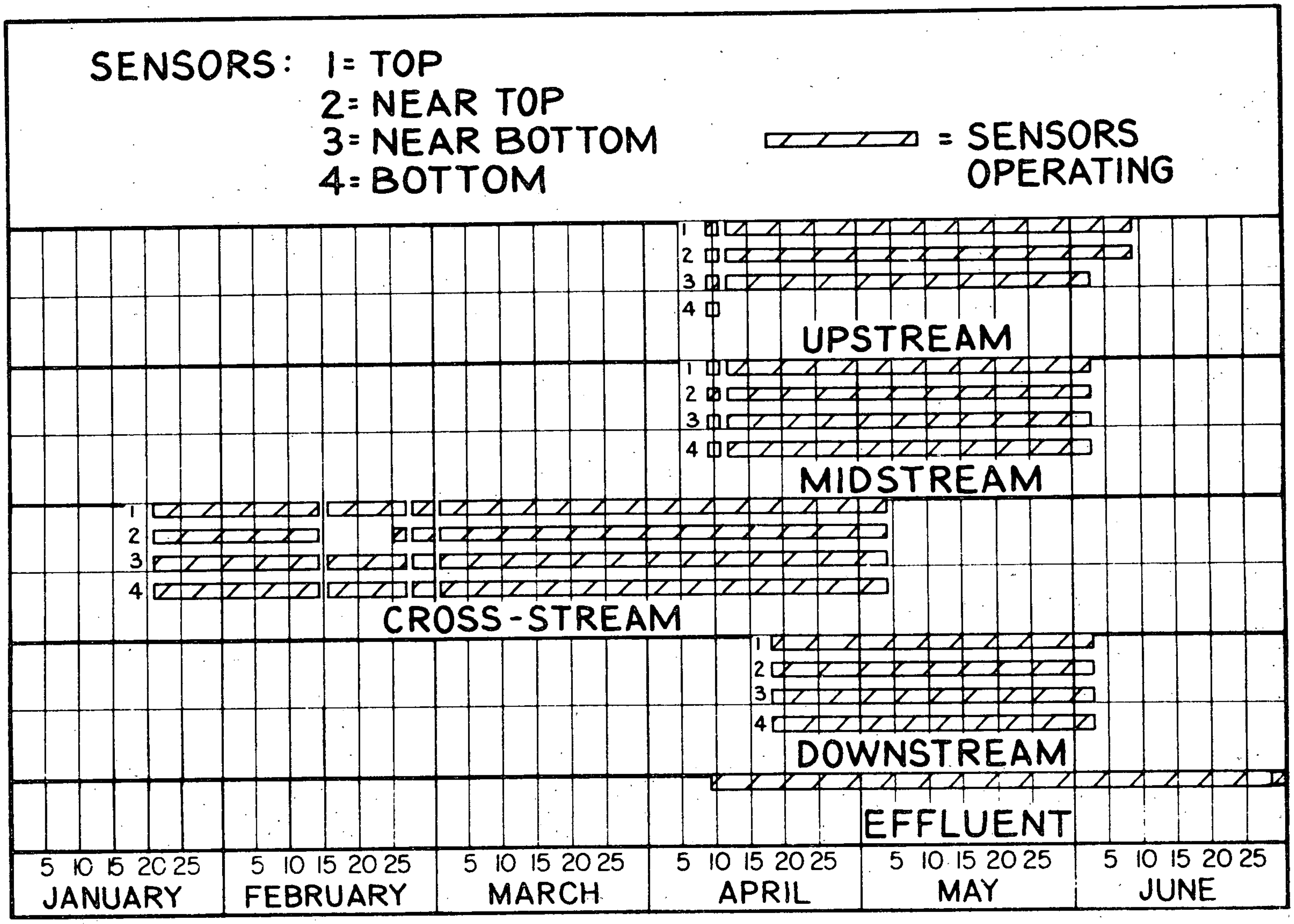


Figure 5-17. Operational History of Temperature Sensors

6.0 TEMPERATURE STUDIES

During the January through June 1970 study period, primary sources of temperature data were the biological sampling program, the A.E.S. monitor at intake and outfall, and the chains of platinum probe temperature sensors in the river at and near the effluent canal.

6.1 Temperature—Infrared Overflight/Bathythermograph Surveys

Due to river ice conditions early in this six month period, and the plant shut-down in the latter portion, no overflight/BT surveys were carried out.

6.2 Temperature—In-Situ Data from Biological Surveys

Temperature data collected (with either salinometers and/or bucket thermometers) in conjunction with the biological sampling program continue to indicate isothermal conditions at each sampling station (e.g., note almost identical curves for surface and bottom temperatures in Figures 6-1, 6-2, and 6-3), except when Indian Point or Lovett Generating Stations were operating, and wind and tide conditions caused surface plumes to travel across adjacent collecting stations causing transient variations from the isothermal condition.

The exceedingly close similarities in monthly temperatures between Stations 9, 10, 11, 12, 13, 15, 20, 21, 22 and 23 demonstrated in Figures 6-1, 6-2, and 6-3, indicate rather uniform temperature conditions throughout this study area. The seasonal increase in water temperature is clearly indicated by the monthly averages of these in-situ data. The range and number of samples for each parameter are listed in Appendix B.

6.3 Temperature—Automated Environmental System

Based on the January daily 0800 (hours) readings (Figure 6-4), an average intake temperature of 34° F and an outfall temperature of 46° F were observed. This indicated an average ΔT of about 12° for January. An increase of 3° F in both influent and discharge streams characterized the tidal shift. The plant recycled some of its cooling water (through pipes installed for this purpose) in cold winter months to prevent ice formation of the traveling screens. The AES intake sensor pump was located outside of this "recirculation" area and did not supply this heated water to the sensors. This probably explains the higher ΔT (12° F) compared to that observed during the previous summer/fall (8 to 9° F).

The 0800 influent temperatures in February averaged 34° F while the 0800 discharge temperatures were 43° F, representing a 9° F increase through the plant. The tidal pattern, mentioned above was repeated with an increase of 2.5 to 3° F in both the influent and discharge.

March 0800 temperature readings averaged 33° F for the intake and 44° F for the discharge until the plant discontinued operations on 20 March.

April temperatures increased 16° F over the course of the month with a monthly average of 44° F. The reactor was inoperative during April, and the intake and discharge temperatures were very close, 1 to 2° F difference. The discharge canal was generally warmer than the intake sample. Except for five days during this month, one or both of the plant's main circulator pumps were operating and forcing water through the effluent canal.

During May the river temperature increased by 10° F with a monthly average of 58° F, based on the 0800 readings. Discharge temperatures were almost the same (ΔT = 1 to 2° F) except for one day, 20 May 1970 when the plant was operational. A thermal gradient of 16°F through the plant was measured at that time.

June temperatures varied only 0.5 to 1.5° F between the intake and discharge as the nuclear plant was not in operation during this month. The river temperature increased about 7° F during June with a monthly average of 68° F based on the 0800 readings.

When the power plant was on-line (Figure 3-2), an increase of several degrees Fahrenheit was generally observed as the tide began to flood. This explains the "abnormal" peaks of 2 to 3 days duration in the otherwise "smooth" seasonal distribution of river temperature (Figure 6-4), i.e., these particular 0800 readings coincided with the times of active tidal recirculation of effluent water.

6.4 Temperature — Moored Sensors Data

Data collected by the "temperature chain" sensors (Figures 6-5, 6-6, 6-7, 6-8, and 6-9) tend to strongly back the suggestions provided by the "in-situ" temperature data gathered with the biological sampling (Section 6.2).

In addition to showing the seasonal increase of water temperatures, the "chain" data again indicate extremely close readings from surface to bottom within and between all the locations (except that the effluent canal temperatures were 1 to 2° F higher). Thus these also indicate the usual isothermal nature of the river from surface to bottom, and the rather uniform temperature conditions obtaining horizontally as well.

6.4.1 Statistical Analysis of Temperature Chain Sampling Rate

This study was directed toward determining the optimum sampling rate for the Indian Point automatic temperature probes. Continuous data obtained between the period of 27 May and 2 June 1970 were selected for a detailed analysis. This block of data represents 144 hours of continuous data obtained at intervals of ten minutes. There were three separate buoys and one effluent probe operating, making a total of thirteen temperature sensors located at different depths. A plot of the temperature data for the first day is shown in Figure 6-10. The 60-degree line is labeled for each sensor with the temperature scale being the same as that shown for the effluent sensor. For this plot the temperature scale is 10 degrees per inch or two small divisions per degree and the time scale is one hour per inch.

The temperature recorded each day was reduced to the mean, variance and standard deviation. The standard error of the mean and standard deviation were also computed. The above parameters were calculated by the following:

Mean ($\bar{x}$)

$$\bar{x} = \sum_{i=1}^{n} x_i/n$$

Sum of Squares (Σx^2)

$$\Sigma x^2 = \sum_{i=1}^{n} (x_i - \bar{x})^2$$

Standard Deviation σ

$$\sigma = \sqrt{\Sigma x^2 / n}$$

Unbiased best estimate of the universe standard deviation

$$\hat{\sigma} = \sqrt{\Sigma x^2 / (n - 1)} \qquad \text{where } n - 1 = \text{degrees of freedom}$$

Standard error of mean

$$\hat{\sigma}_x = \hat{\sigma} / \sqrt{n}$$

Standard error of standard deviation

$$\hat{\sigma}_\sigma = \hat{\sigma} / \sqrt{2n}$$

The results of the above are shown in Table 6-1. The daily average temperature increased continuously during this period with the daily average increasing as much as one degree on some days. The overall increase during this period was about 3.6 degrees for the effluent and about 3.9 for each of the other sensors. The daily standard deviation varied between 0.35 and 0.85 with the larger values of standard deviation on some afternoons. There is no explanation for this occurrence.

Variation in the standard error of the mean was between 0.03 and 0.07. This implies that the average which has been calculated was not more than 0.09 to 0.21 degrees away from the true average in 99.7 chances out of 100.

The same statistical properties were calculated while varying the sampling rate. This was accomplished by calculating the statistical properties first with every other sample, then with every third sample, etc., until every twelfth sample was used. Using every twelfth sample was equivalent to sampling every 2 hours. The results obtained by these calculations varied only slightly from the results originally calculated. Figure 6-11 shows the variation of the mean and standard deviation with the sampling interval. The solid line is the mean and the broken line is the standard deviation. The results shown are for sensor number 13, which was the surface sensor on buoy B (downstream buoy). This sensor was selected because it was a surface sensor and was therefore expected to be subject to more rapid temperature variation, and the temperature variation recorded on this sensor did indeed appear as wide as that from the other sensors. As seen from the figure, the difference did not exceed 0.05 degrees. This slight variation in the results implies that the statistical properties could be obtained with a much lower sampling rate.

If two samples are drawn from a given set, undoubtedly there will be a difference between the means of the sets, i.e., a difference due solely to chance variation in selection. The means which were calculated by the different sampling rates were tested to determine if there was any significant difference between them or whether the difference was merely due to chance. The standard error of the difference between two means can be calculated from the following:

$$\sigma_d = \sqrt{\sigma_1^2/n_1 + \sigma_2^2/n_2}$$

where

σ_1 = standard deviation of first set

σ_2 = standard deviation of second set

n_1 = number of samples in first set

n_2 = number of samples in second set

The standard error of the difference is plotted in Figure 6-12 (solid line) as a function of the sampling rate. The difference in the mean is plotted on the same figure. The broken line is the 50 percent line which is equal to 0.6745 times the standard error. The actual difference in mean in all cases falls below this line which indicates that the actual difference was not significant but due to chance. The 50 percent line is the probable error and was included because of its common usage.

The temperature data form a time series and can thus be analyzed by a power spectrum analysis. This analysis identifies the frequencies at which different factors cause the record to vary. Spectrum analyses was done with the Fast Fourier Transform (FFT)*. The Fast Fourier Transform algorithm is a method for computing the complex Fourier transform

$$A_k = \frac{1}{n} \sum_{j=o}^{n-1} X_j \exp (i 2 \pi j k/N)$$

for k=0, 1, 2, . . . , n-1, where X_j are the temperature values, and A_k are the complex Fourier coefficients ($A_k = a_k + ib_k$).

The FFT was used to calculate the power spectrum for the temperature data obtained on sensor 13 and the results are shown in Figure 6-13. The power spectrum was calculated for three different sampling rates and results of all three are shown in the figure. Only the first part of the power spectrum is plotted because all spectral density peaks are contained in this portion. The highest frequency which added any appreciable amount to the time series was the peak located at 0.2 cycles per hour. The Nyquist sampling rate (rate needed to reproduce original time series) was satisfied if the time series was sampled more often than once every 2.5 hours.** A sampling rate of once every 2 hours would be adequate and certainly once every hour would be more than adequate for the specific data analyzed. A comparison of the three spectrum analyses in Figure 6-13 shows they are in very good agreement at the main peaks. In these calculations of spectrum analysis, the total period of time was constant and the only thing which varied was the number of data points.

Figure 6-14, on the other hand, shows the result of varying the sampling interval from 10-to-80 minutes while holding the number of data points constant at 64. As can be seen from the figure, a longer time record was desirable in order that lower frequency variations could be revealed.

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*Cooley and Turkey, 1965. An Algorithm for the Machine Calculation of Complex Fourier Series. Math. of Comput., Vol. 19, pp. 297-301.

IEEE Transactions on Audio and Electroacoustics, Special Issue on Fast Fourier Transform and its Application to Digital Filtering and Spectral Analysis, Vol. AU-15, No. 2, June 1967.

**Nyquist, 1928. Certain Topics in Telegraph Transmission Theory, Transactions of the American Institute of Electrical Engineers, New York, Vol. 47, pp. 617-644.

Black, 1953. Modulation Theory D. Van Nostrand Co., Inc., New York, p. 50.

The tendency in automatic data collection is to collect much more data than are needed for any given situation. In fact, the water temperature at Indian Point was being sampled at a rate of once every 10 minutes when once an hour would more than provide an excellent history of the temperature variations during the period tested. This would also make it more convenient to analyze the long time series. The optimum sampling rate would therefore seem to be about once an hour for the data evaluated herein, however, Raytheon is presently sampling at twice this rate in order to ensure a record of possible future temperature variations not exemplified by the analyzed data.

Table 6-1. Statistical Parameters of Temperature Chain Data-May 27-June 2, 1970*
(Sheet 1 of 4)

SEN-SOR	MEAN **	ST. ERROR** OF MEAN	ST. DEV.**	c ST. ERROR** OF ST. DEV.	BEST EST** OF ST. DEV.
MAY 27, 1970					
0	61.941	0.037	0.447	0.026	0.448
1	61.358	0.033	0.396	0.023	0.397
2	61.043	0.034	0.407	0.024	0.409
3	61.382	0.031	0.376	0.022	0.377
5	61.323	0.031	0.371	0.022	0.373
6	61.155	0.030	0.358	0.021	0.359
7	61.220	0.030	0.354	0.021	0.356
8	61.444	0.030	0.356	0.021	0.357
13	61.422	0.031	0.376	0.022	0.377
14	61.322	0.030	0.362	0.021	0.363
15	61.457	0.032	0.378	0.022	0.379
16	61.703	0.039	0.464	0.027	0.466
MAY 28, 1970					
0	62.717	0.026	0.308	0.018	0.309
1	62.101	0.026	0.308	0.018	0.309
2	61.794	0.027	0.323	0.019	0.324
3	62.128	0.028	0.333	0.020	0.334
5	62.080	0.026	0.305	0.018	0.306
6	61.916	0.026	0.314	0.019	0.316
7	61.980	0.025	0.295	0.018	0.296
8	62.188	0.025	0.297	0.018	0.299
13	62.176	0.027	0.322	0.019	0.324
14	62.104	0.026	0.310	0.018	0.311
15	62.223	0.026	0.313	0.019	0.314
16	62.423	0.029	0.349	0.021	0.350

Table 6-1. Statistical Parameters of Temperature Chain Data-May 27-June 2, 1970*
(Sheet 2 of 4)

SENSOR	MEAN	ST. ERROR OF MEAN	ST. DEV.	ST. ERROR OF ST. DEV.	BEST EST. OF ST. DEV.
MAY 29, 1970					
0	63.381	0.036	0.429	0.025	0.431
1	62.832	0.043	0.519	0.031	0.521
2	62.524	0.047	0.561	0.033	0.563
3	62.869	0.044	0.526	0.031	0.528
5	62.820	0.044	0.527	0.031	0.529
6	62.648	0.045	0.538	0.032	0.540
7	62.716	0.044	0.526	0.031	0.528
8	62.935	0.044	0.524	0.031	0.526
13	62.934	0.047	0.566	0.033	0.568
14	62.853	0.048	0.569	0.034	0.571
15	62.997	0.046	0.555	0.033	0.557
16	63.223	0.047	0.568	0.034	0.570
MAY 30, 1970					
0	63.444	0.028	0.335	0.020	0.336
1	63.017	0.033	0.390	0.023	0.391
2	62.719	0.033	0.400	0.024	0.401
3	63.076	0.033	0.400	0.024	0.402
5	63.025	0.036	0.431	0.025	0.433
6	62.873	0.035	0.416	0.025	0.417
7	62.946	0.036	0.426	0.025	0.427
8	63.169	0.035	0.424	0.025	0.425
13	63.164	0.037	0.437	0.026	0.438
14	63.098	0.037	0.438	0.026	0.439
15	63.236	0.037	0.442	0.026	0.443
16	63.496	0.036	0.426	0.025	0.427

Table 6-1. Statistical Parameters of Temperature Chain Data-May 27-June 2, 1970*
(Sheet 3 of 4)

SENSOR	MEAN	ST. ERROR OF MEAN	ST. DEV.	ST. ERROR OF ST. DEV.	BEST EST. OF ST. DEV.
MAY 31, 1970					
0	63.444	0.060	0.715	0.043	0.718
1	63.161	0.049	0.576	0.034	0.578
2	62.846	0.052	0.612	0.037	0.615
3	63.195	0.053	0.625	0.037	0.627
5	63.149	0.054	0.634	0.038	0.636
6	62.979	0.055	0.647	0.039	0.650
7	63.050	0.052	0.614	0.037	0.616
8	63.253	0.052	0.610	0.036	0.612
13	63.257	0.051	0.601	0.036	0.603
14	63.190	0.051	0.609	0.036	0.611
15	63.334	0.052	0.613	0.037	0.615
16	63.580	0.055	0.656	0.039	0.659
JUNE 1, 1970					
0	64.614	0.052	0.632	0.037	0.634
1	64.178	0.053	0.643	0.038	0.645
2	63.816	0.053	0.637	0.037	0.639
3	64.209	0.056	0.675	0.040	0.678
5	64.194	0.058	0.701	0.041	0.704
6	64.027	0.061	0.739	0.043	0.742
7	64.096	0.062	0.754	0.044	0.756
8	64.307	0.064	0.769	0.045	0.772
13	64.289	0.059	0.711	0.042	0.714
14	64.239	0.063	0.758	0.044	0.761
15	64.378	0.065	0.781	0.046	0.783
16	64.628	0.070	0.848	0.050	0.851

Table 6-1. Statistical Parameters of Temperature Chain Data-May 27-June 2, 1970*
(Sheet 4 of 4)

JUNE 1970					
SEN-SOR	MEAN	ST. ERROR OF MEAN	ST. DEV.	ST. ERROR OF ST. DEV.	BEST EST. OF ST. DEV.
0	65.549	0.051	0.552	0.036	0.554
1	65.205	0.050	0.545	0.036	0.548
2	64.806	0.051	0.559	0.036	0.562
3	65.252	0.052	0.569	0.037	0.571
5	65.225	0.055	0.601	0.039	0.603
6	65.054	0.058	0.628	0.041	0.631
7	65.113	0.058	0.635	0.041	0.638
8	65.327	0.060	0.647	0.042	0.650
13	65.314	0.057	0.616	0.040	0.619
14	65.250	0.060	0.656	0.043	0.659
15	65.396	0.062	0.674	0.044	0.677
16	65.661	0.069	0.745	0.048	0.748

*Sensor	Position	Buoy
0		Effluent
1	Top	Upstream
2	Near Top	Upstream
3	Near Bottom	Upstream
5	Top	Middle
6	Near Top	Middle
7	Near Bottom	Middle
8	Bottom	Middle
13	Top	Downstream
14	Near Top	Downstream
15	Near Bottom	Downstream
16	Bottom	Downstream

**Calculations were carried to three decimal places to show differences.

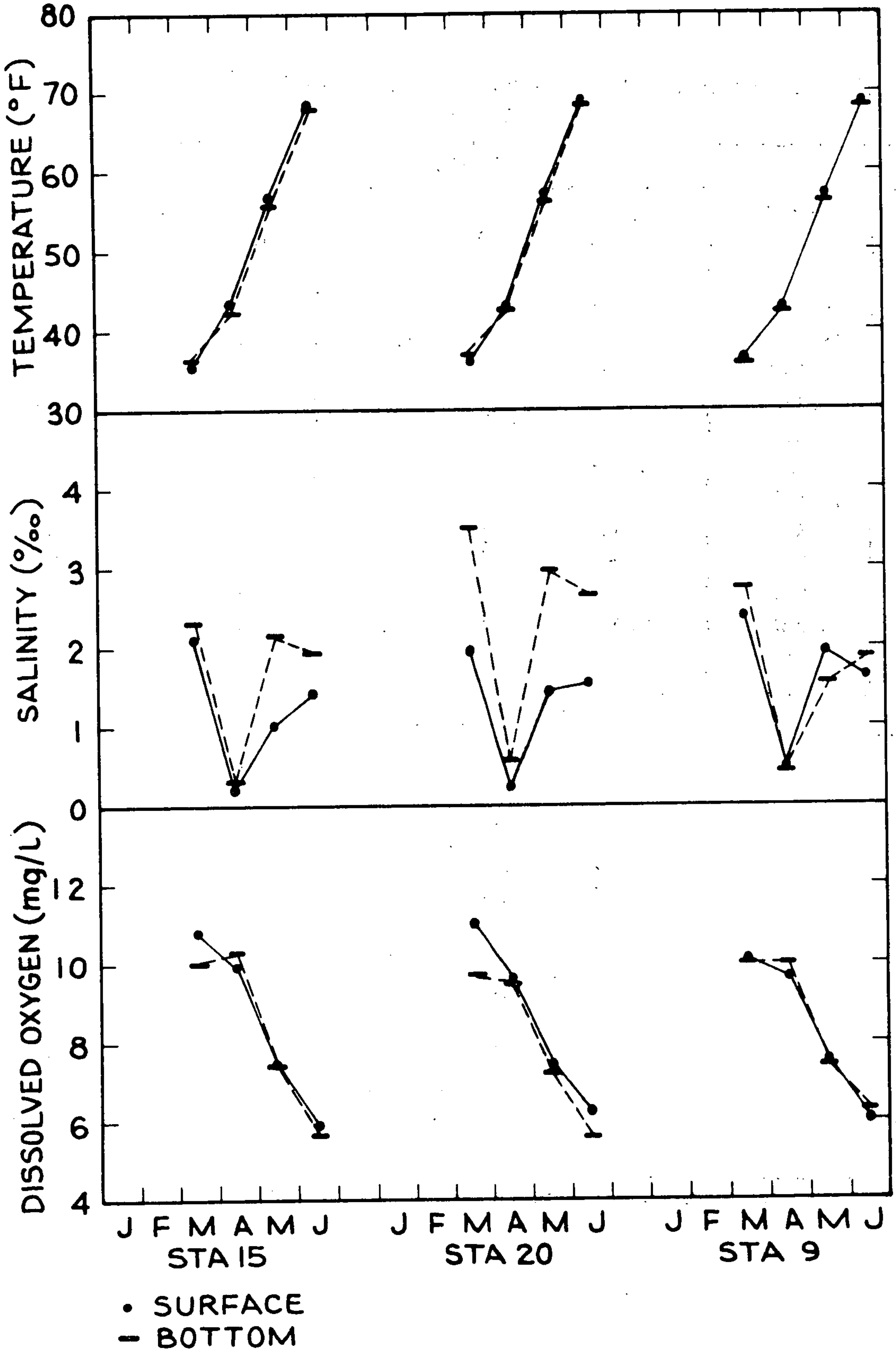

Figure 6-1. In-Situ Data—Stony Point Transect

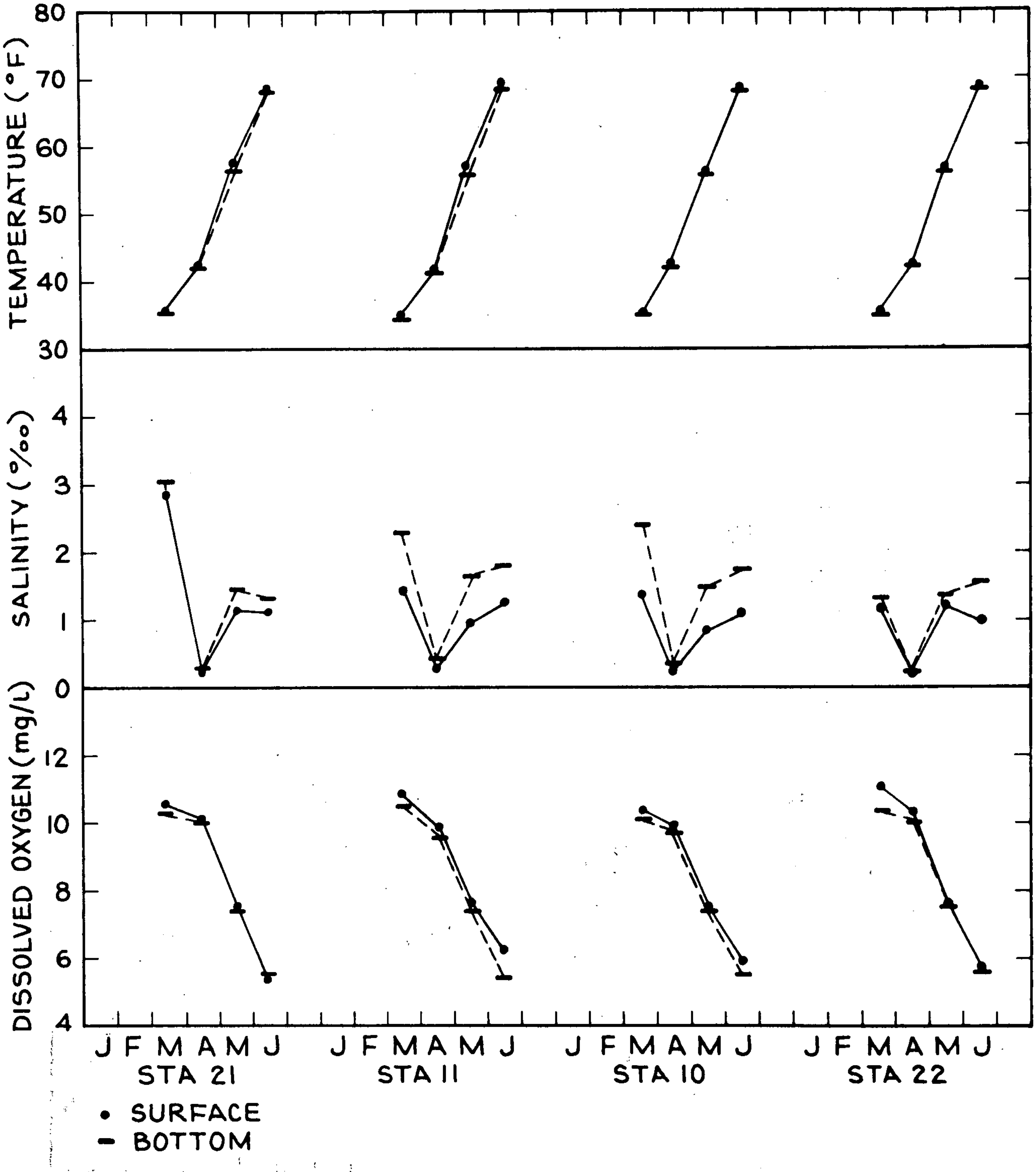

Figure 6-2. In-Situ Data—Indian Point Transect

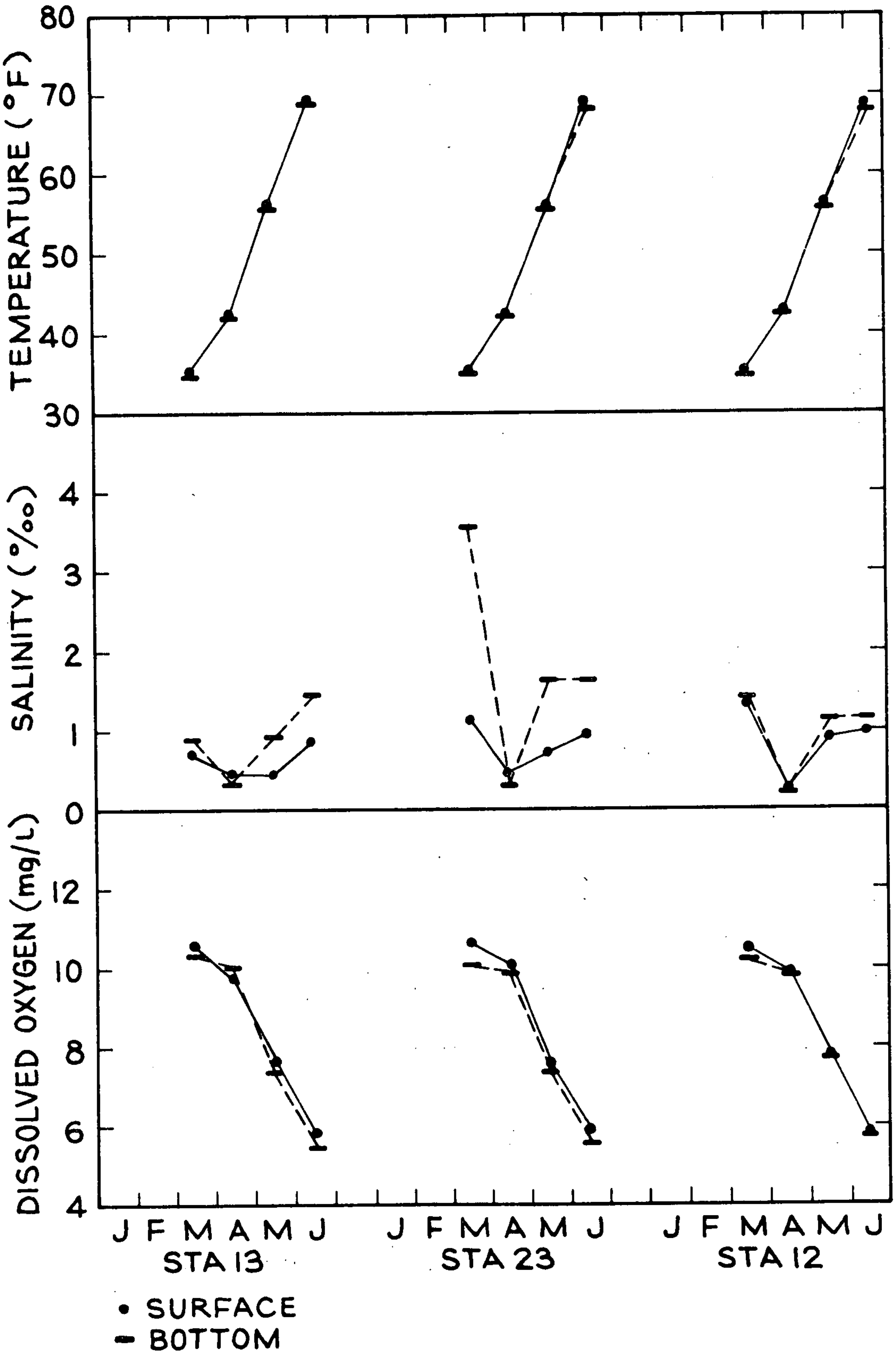

Figure 6-3. In-Situ Data—Round Island Transect

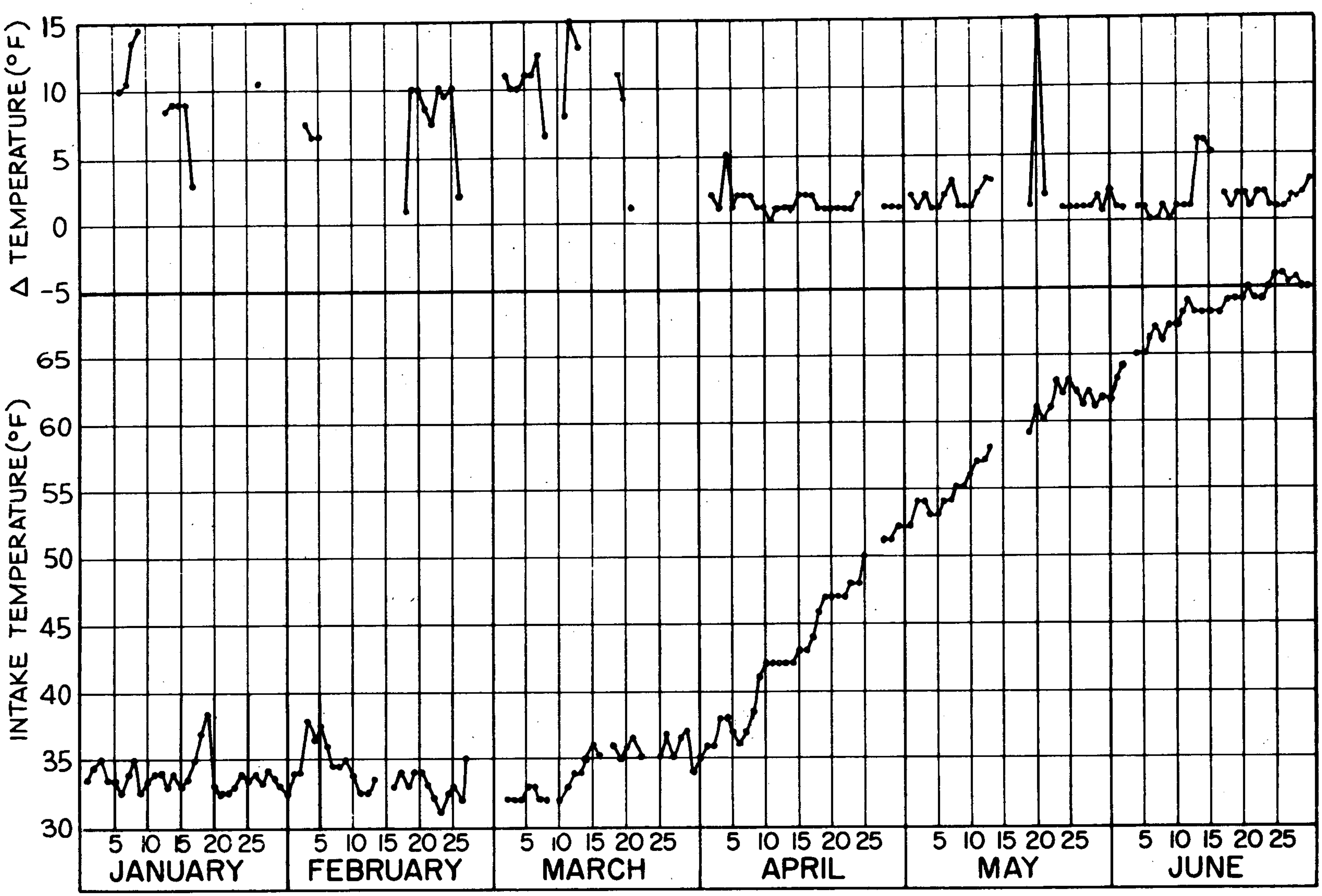

Figure 6-4. Automated Environmental System 0800—Temperature Data—1970

R942

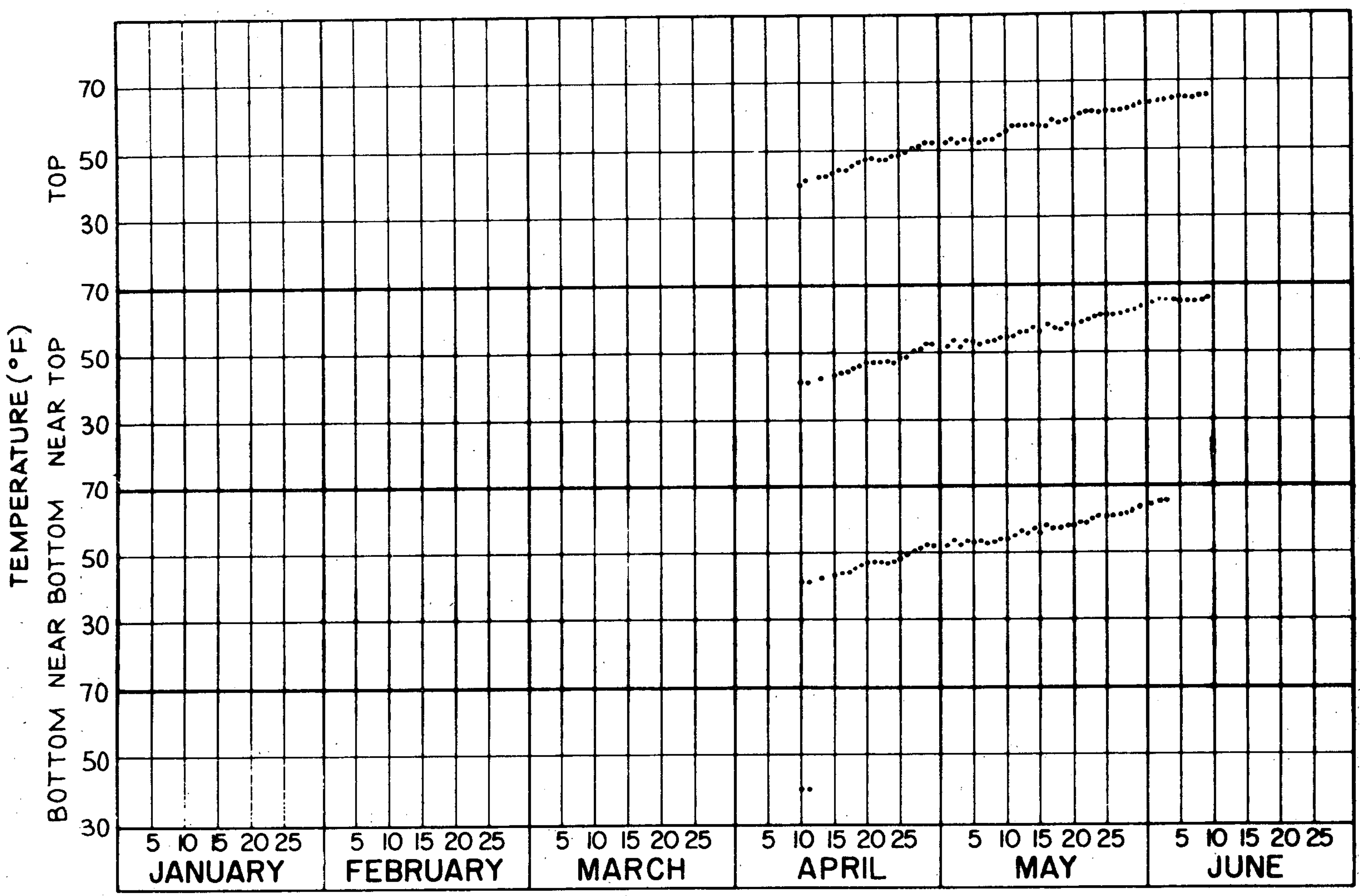

Figure 6-5. Thermal Chain 0800 Data—Upstream Buoy—1970

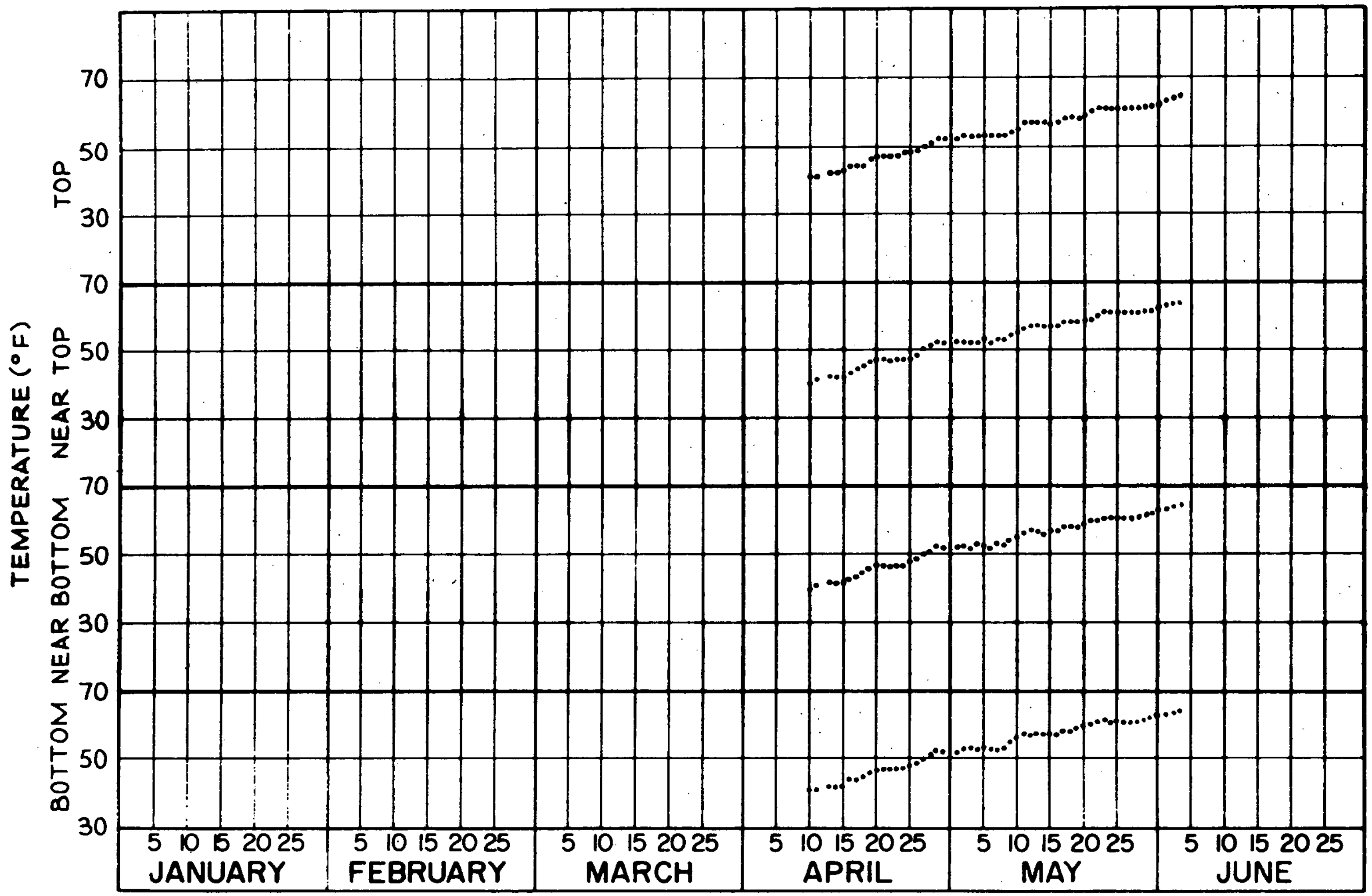

Figure 6-6. Thermal Chain 0800 Data—Middle Buoy—1970

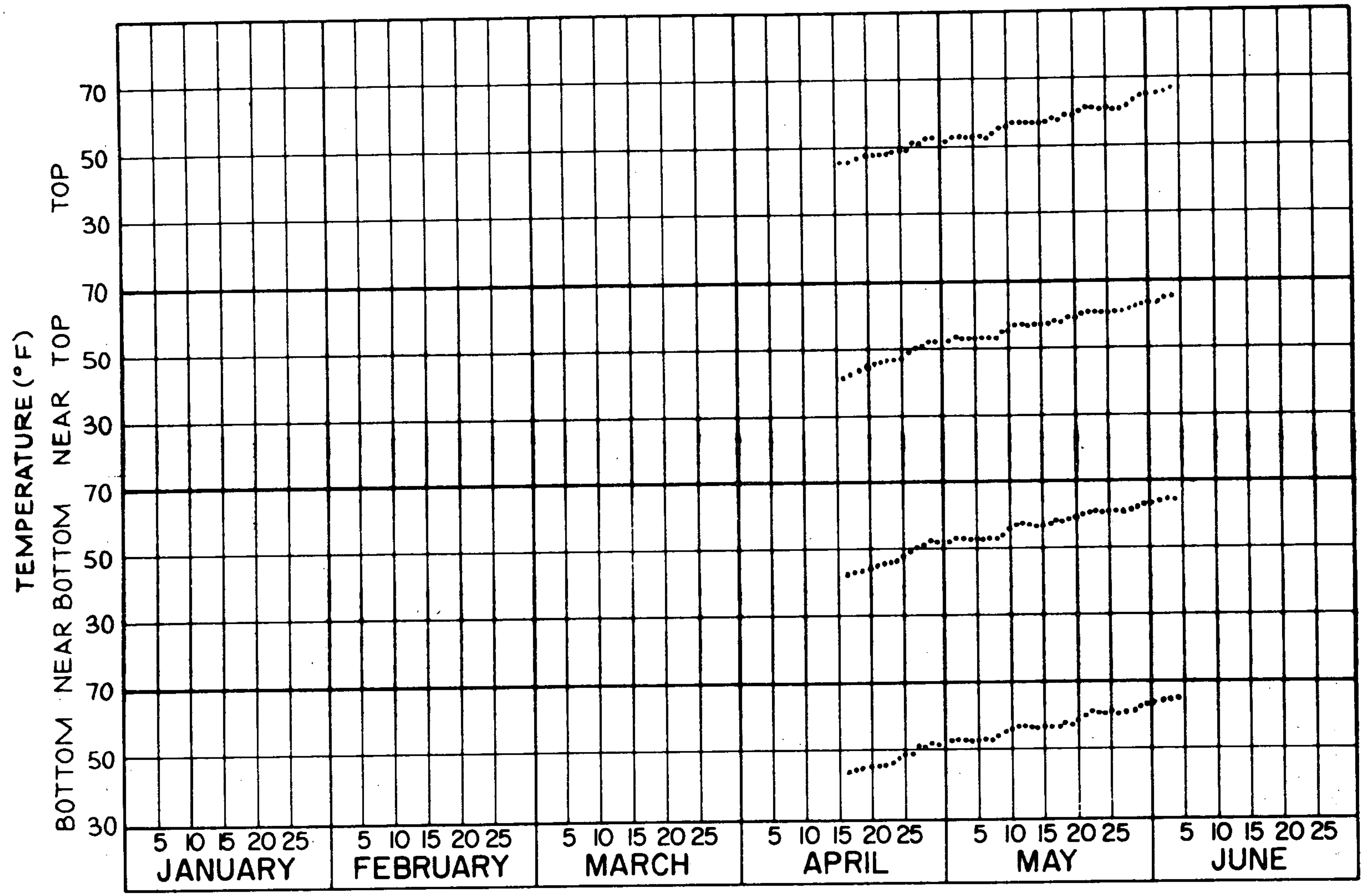

Figure 6-7. Thermal Chain 0800 Data—Downstream Buoy—1970

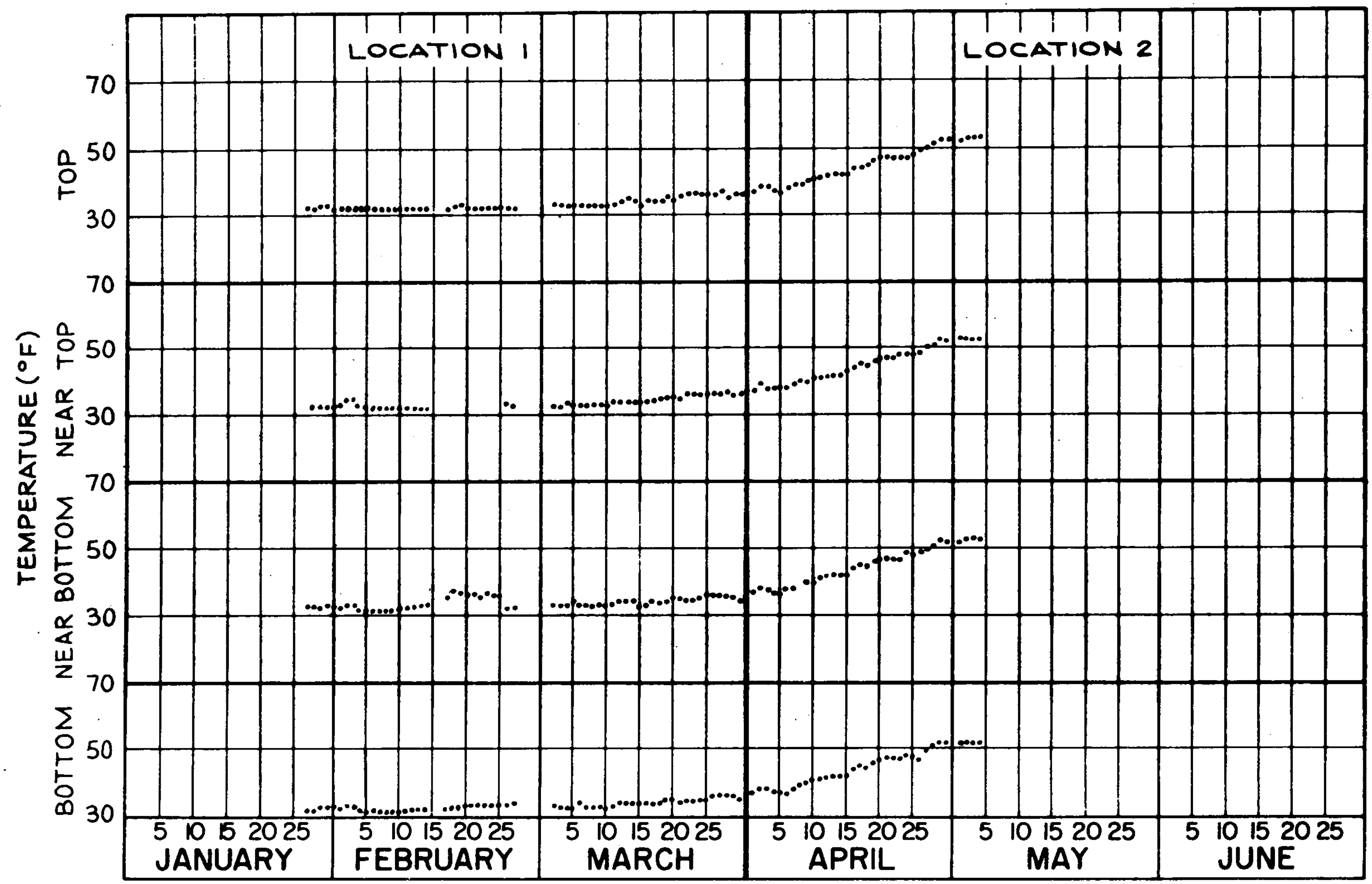

Figure 6-8. Thermal Chain 0800 Data—Cross-Stream Buoy—1970

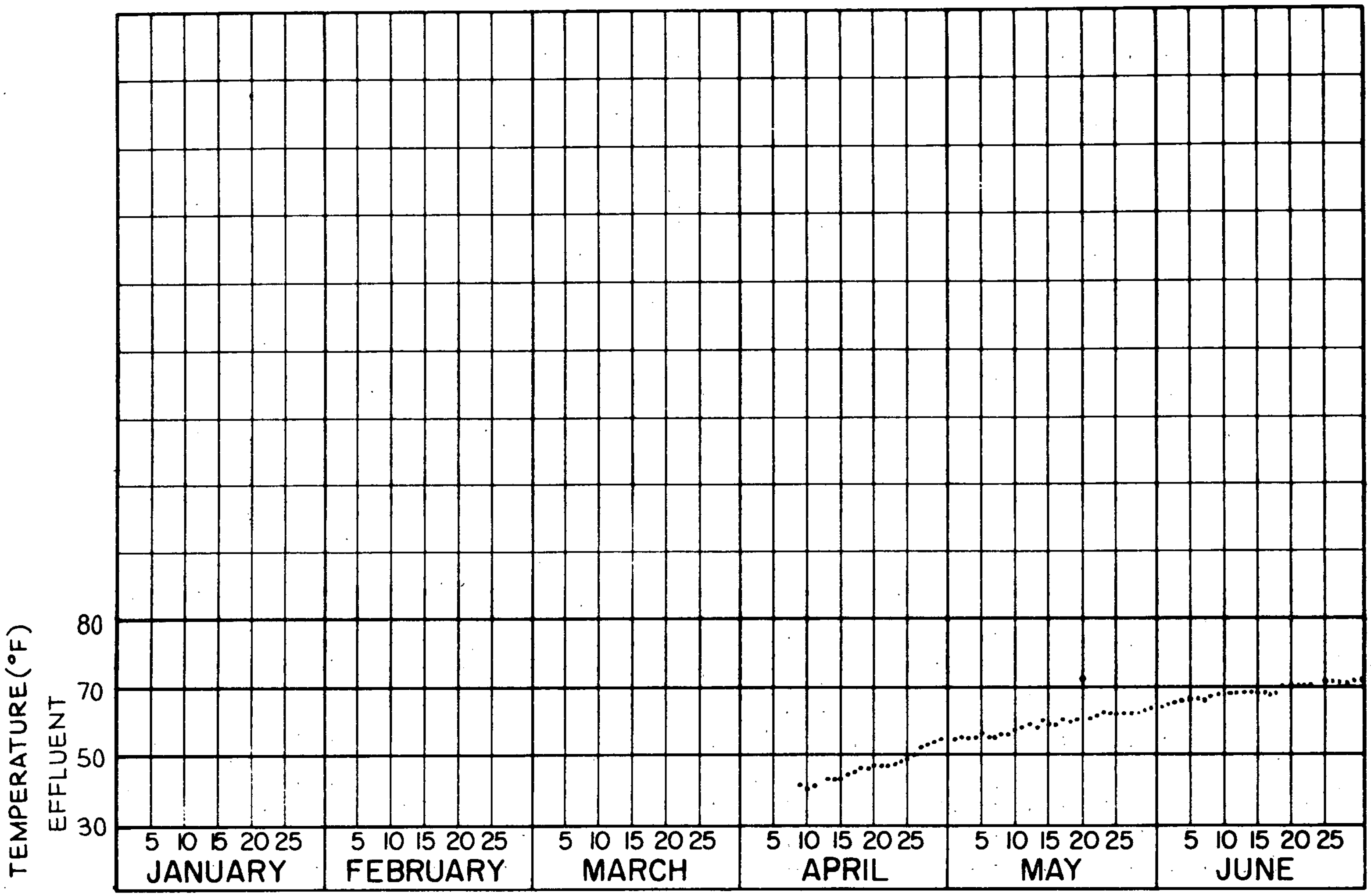

Figure 6-9. Thermal Chain 0800 Data—Effluent Canal—1970

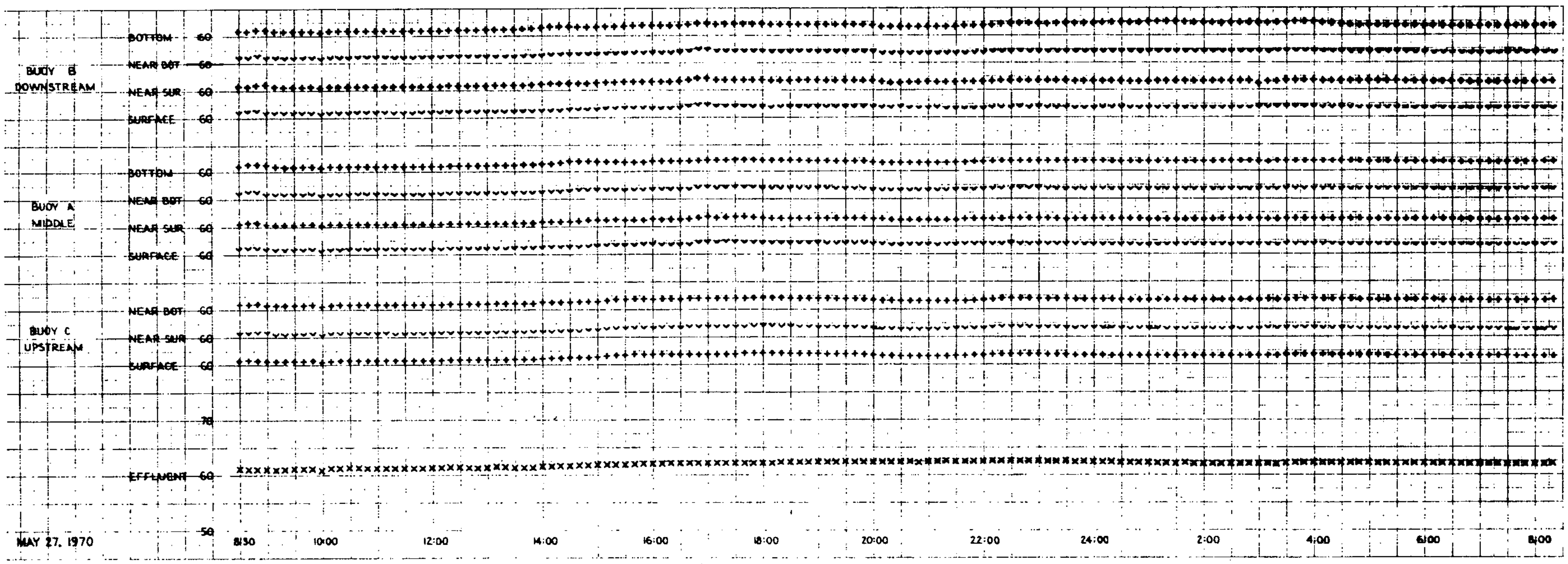

Figure 6-10. Thermal Chain Data Collected on May 27, 1970

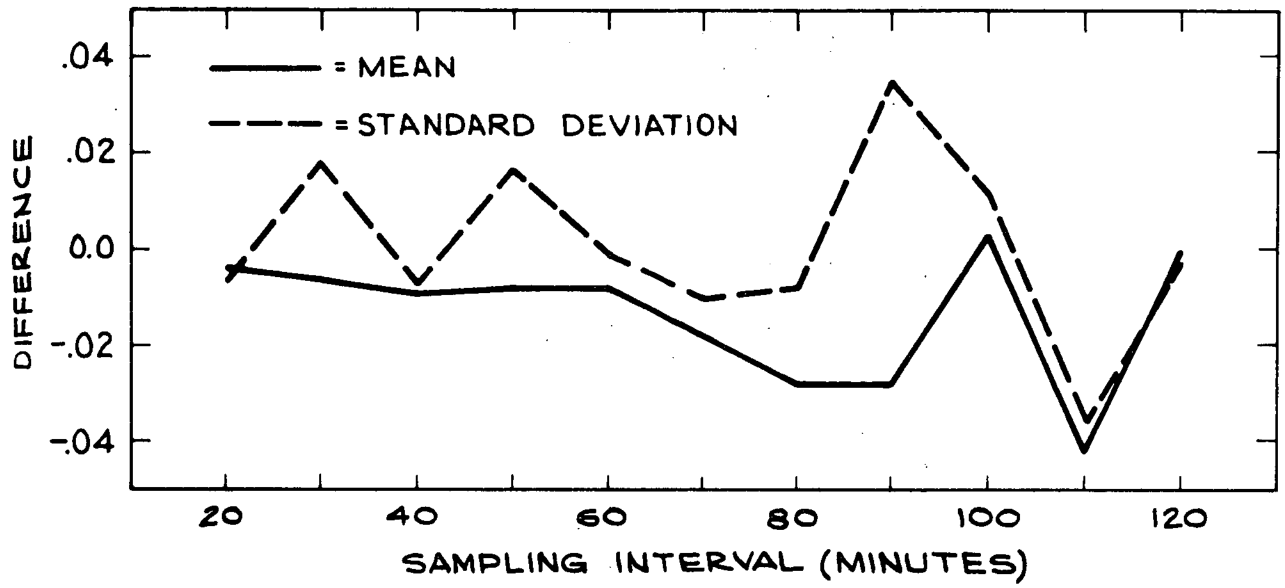

Figure 6-11. Difference between Mean and Standard Deviation for Different Sampling Intervals

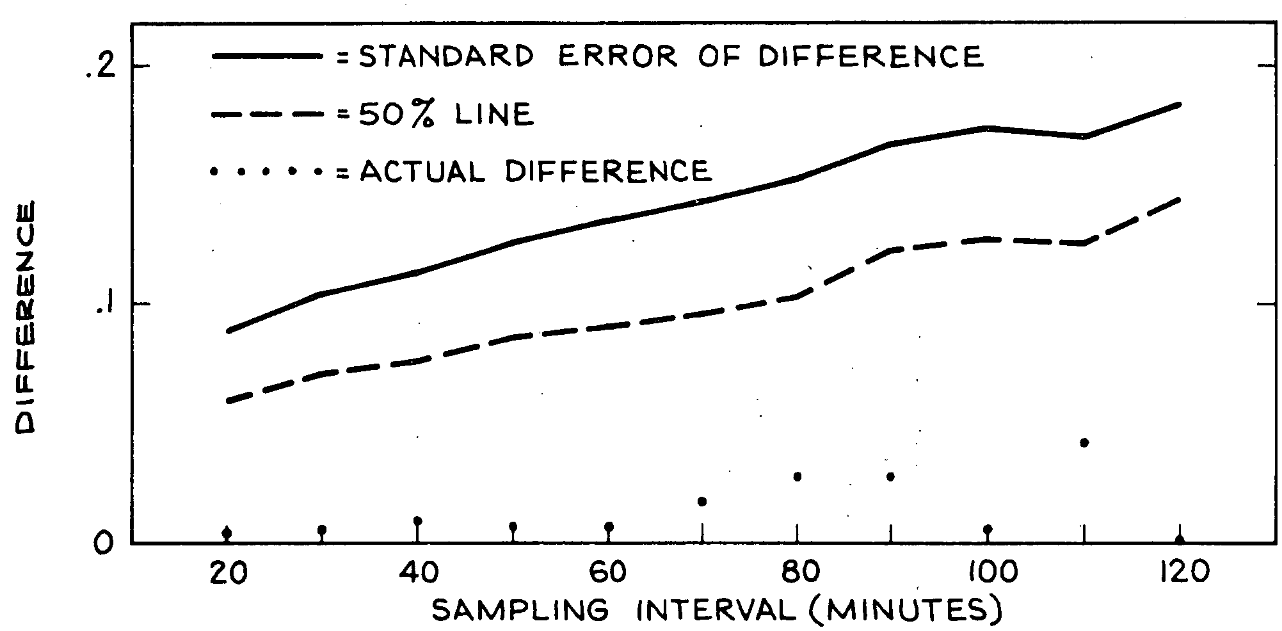

Figure 6-12. Standard Error of Difference of the Mean for Different Sampling Intervals

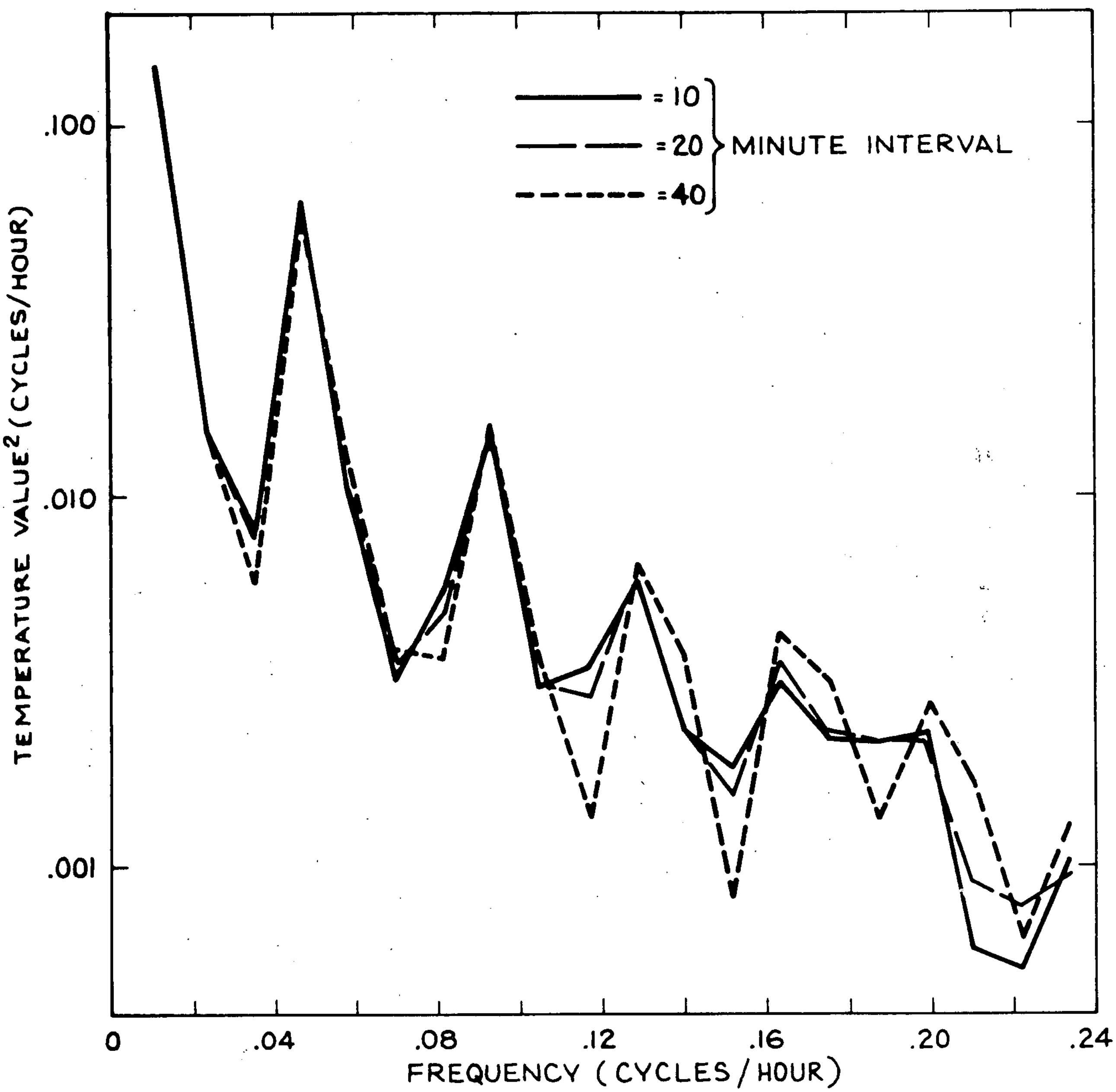

Figure 6-13. Spectral Analysis of Thermal Chain Data from Downstream Buoy Surface Sensor—27 May—2 June 1970, Varied Number of Data Points

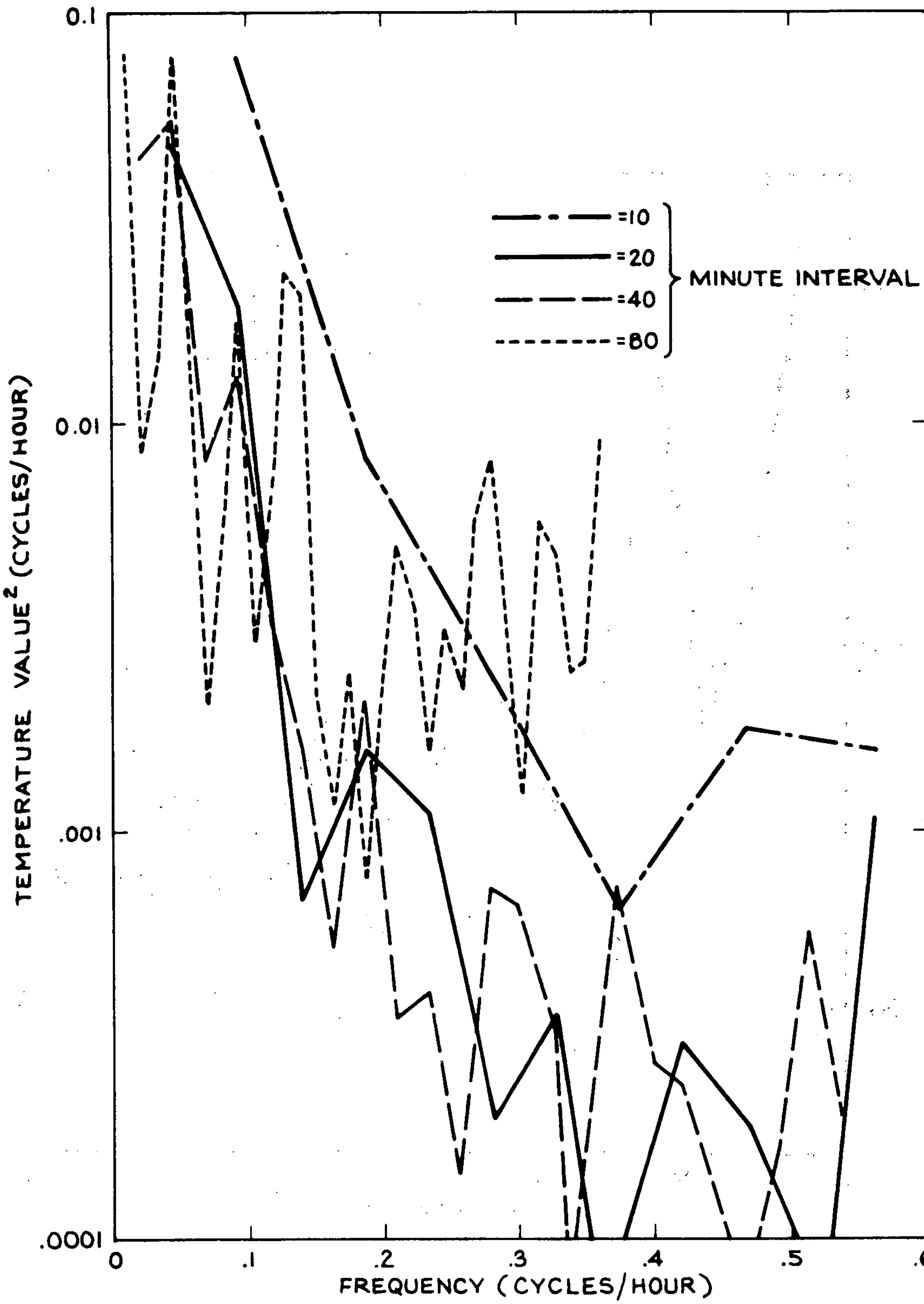

Figure 6-14. Spectral Analysis of Thermal Chain Data from Downstream Buoy Surface Sensor—27May—2 June 1970, Data Points Constant

7.0 WATER CHEMISTRY

7.1 Salinity

7.1.1 Salinity — In-Situ Data for Biological Surveys

During January, February and early March, no significant number of in-situ salinity measurements were made with the biological sampling inasmuch as the river was well covered with ice and dangerous to small boat operations.

In mid-late March the salinities were relatively low at the surface at the upstream transect. Bottom salinities at this transect were high in mid channel, and lower at shallower bottom stations at the channel edges. The mid and downstream transects both showed generally high salinities surface and bottom (Figures 6-1, 6-2 and 6-3). These data may reflect the high salinities noted the latter half of the month by the AES monitor (see Section 7.1.2).

All stations showed low salinities in April at both surface and bottom, correlating with high discharges over the Federal Dam at Troy, New York (Figure 7-1).

The month of May was characterized by rising salinities. June was very similar to May with only small variations in monthly averages.

7.1.2 Salinity — Automated Environmental Systems

Salinities ranged relatively widely in January (Figure 7-2),the early January low values reflecting late December 1969 rainfall and the mid January highs following the minimal seasonal precipitation (Figure 7-3) coupled with low average discharges over the Federal Dam at Troy (Figure 7-1). The 0800 values spread between 0.05 and 2.55 0/00. February 0800 values were consistently rather low, holding between 0.1 and 0.9 0/00. These lows correlate with fairly high early February precipitation values at the Peekskill Water Works and increasing early February discharges over the dam at Troy, New York. There is some question as to the near term effect of winter precipitation on salinities, inasmuch as the "rainfall" reported would remain frozen for some time.

Early March salinities were low but increased sharply in the latter part of mid month. There appears to be little salinity relationship with the moderate rainfall at Peekskill that month. The highest March 0800 salinity was recorded on the 23rd, when a value of 3.4 0/00 was reached. April 0800 salinities were very low with the highest value recorded at 0.5 0/00. This correlates neatly with the high seasonal Troy Dam discharges (Figure 7-1). Early May salinity values were also very low, but increased in mid month to highs of 1.5 0/00, and then dropped again at the end of this period. June salinities started very low, but increased to as high as 3.3 0/00.

7.2.1 Dissolved Oxygen — In-Situ Data from Biological Surveys

The dissolved oxygen data collected in conjunction with the biological sampling program (Figures 6-1, 6-2, and 6-3) continued to indicate that surface values usually are slightly higher or equivalent to the bottom concentrations; maximum variances occurred in March when differences averaged as high as 0.8 mg/liter.

Seasonally, the distinct inverse correlation between dissolved oxygen and temperature occurred during this study period, as in the previous 6 months. The dissolved oxygen concentrations were consistently below saturation values.

Differences between stations were too small to provide a base for conclusions on marked or consistent gradients.

7.2.2 Dissolved Oxygen — Automated Environmental System

The A.E.S. dissolved oxygen monitor utilizes a porous teflon membrane covered electrode which is clogged very easily by small particles inherent in tidal waters such as the Hudson River. Drifting dissolved oxygen readings were a recurrent problem. Membranes were replaced and the system recalibrated when dissolved oxygen values varied from concentrations determined by the Winkler Method. This calibration was carried out at least once a week and in addition, the system was recalibrated whenever the daily check showed unexpected values.

Intake dissolved oxygen consistently remained higher than discharge values during plant operations (see January, February and March in Figure 7-4). Dissolved oxygen concentrations were about 0.5 mg/l higher in the intake than the discharge points during January, February and to 20 March. The effluent dissolved oxygen data, and hence the dissolved oxygen plots, are considered to be irrelevant after 20 March due to unscheduled and intermittent operation of the pumps circulating river water through the plant and into the effluent canal during this plant shut-down period (Figure 7-4). The major feature of the A. E. S. seasonal record was the slow drop in dissolved oxygen values with the advancing summer and increasing river water temperatures. This feature thus parallels and supports the trend observed in the in-situ data.

After the tide gauge was installed, unexplained fluctuations and a drop of dissolved oxygen were seen about 1.5 hours after maximum high tide most days in June. Circulation pump operations did not correlate. This suggests an upstream source of biological oxygen demand (BOD) which moves down to the plant intake vicinity as the tide begins to ebb.

7.3 pH — Automated Environmental Systems

The pH readings nearly always remained within one unit of neutrality. Sharp variations occured when ion exchange resins were recharged. At these times the pH dropped or increased rapidly, persisted about one hour, and then the system returned to its previous pH value. Ion exchange regeneration wastes caused less than one pH unit shift in the discharge canal. The plant regenerates a water purification resin bed periodically with caustic soda and sulfuric acid. The residue of this process is discharged into the effluent canal, occasionally without full neutralization.

7.4 Chlorine

Chlorine analyses were performed by Raytheon only on effluent water at the plant site and only during laboratory experiments (see Section 11.1.3, Results—Environmental Parameters. Inclusive dates for these analyses were 20 May through 23 June; Con Ed reported no additions of chlorine (as Sodium Hypochlorite) from late March through mid May. Standard American Society of Testing Materials (ASTM) methodology was utilized. At no time was a concentration greater than 0.1 ppm indicated. Independent analyses by Con Ed chemists supported these determinations.

7.5 Copper — Automated Environmental System

A specific ion detector monitored copper, as a part of the A. E. S. installation. So far it has not registered any copper thus indicating river concentrations are below its threshold sensitivity of 0.1 mg/liter. Two water samples were analyzed by the A. E. S. Company in the last six-month report period. They found values of 0.001 and 0.006 mg/liter copper.

7.6 Statistical Analysis of Digital Sampling Rates

The dissolved oxygen and the pH data form time series and can thus be analyzed by a power spectrum analysis. This type of analysis will identify the frequencies at which different factors cause the record to vary. The Fast Fourier Transform was used to calculate the power spectrum for the data obtained between 19 June through 22 June 1970. The sampling rate at this time was once every 10 minutes.

The results of the power spectrum analysis for the dissolved oxygen at the intake are shown in Figure 7-5. The complete power spectrum was not plotted since the first portion, which is plotted, contained all major spectral density peaks. As can be seen by the figure there was no frequency beyond 0.2 cycles/hour which had a spectrum level greater than 0.001. The Nyquist sampling rate (sampling rate needed in order to reproduce the original time series) was satisfied if the time series was sampled at a rate a little greater than once every 2.5 hours. A sampling rate of once every 0.5 hour, which is the same sampling rate as for the temperature chain, would be more than adequate.

Figure 7-6 shows the results of the power spectrum analysis for the pH measurements at the intake for the same period of time. The lower frequencies had a much larger value for pH than dissolved oxygen, but the rate of decrease is much more rapid and there was no frequency greater than 0.1 cycle/hour with a spectrum level greater than 0.001. The Nyquist rate was satisfied if the pH was sampled a little greater than once every five hours.

The mean, standard deviation, standard error of the mean and standard error of the standard deviation for dissolved oxygen, pH and salinity were computed and are shown in Table 7-1. The variation in the statistical properties calculated for these three days was very low with the salinity exhibiting the greatest variations. The same statistical properties were calculated by varying the sampling rate. The properties were calculated with every sample, then with every other sample, next with every third sample, etc., until every twelth sample was used. The results obtained from sampling every hour varied only slightly from the results obtained by sampling every 10 minutes. This indicated that there was no significant difference between the statistical properties obtained by the different sampling rates and that the small difference was due to chance.

A sampling rate of once every 30 minutes would be more than adequate to completely describe these outputs of the A. E. S.

Table 7-1. Statistical Parameters of Selected Automated Environmental System Data 19-21 June 1970

DATE	SAMP. RATE (MINUTES)	MEAN	ST. ERROR OF MEAN	ST. DEV.	ST. ERROR OF S. DEV.	BEST EST. OF S. DEV.
			Dissolved Oxygen			
June 19	10	4.725	0.020	0.230	0.014	0.231
	60	4.736	0.049	0.229	0.034	0.234
June 20	10	4.916	0.019	0.233	0.014	0.234
	60	4.934	0.044	0.029	0.031	0.214
June 21	10	4.812	0.017	0.204	0.012	0.205
	60	4.800	0.047	0.223	0.033	0.228
			pH			
June 19	10	8.032	0.007	0.080	0.005	0.080
	60	8.034	0.018	0.086	0.013	0.087
June 20	10	7.888	0.006	0.053	0.004	0.053
	60	7.888	0.012	0.056	0.008	0.057
June 21	10	7.698	0.008	0.096	0.006	0.096
	60	7.692	0.020	0.097	0.014	0.099
			Salinity			
June 19	10	3.132	0.020	0.227	0.014	0.228
	60	3.134	0.049	0.231	0.035	0.236
June 20	10	2.754	0.031	0.375	0.022	0.376
	60	2.755	0.078	0.372	0.055	0.380
June 21	10	2.763	0.037	0.310	0.026	0.312
	60	2.762	0.065	0.310	0.046	0.317

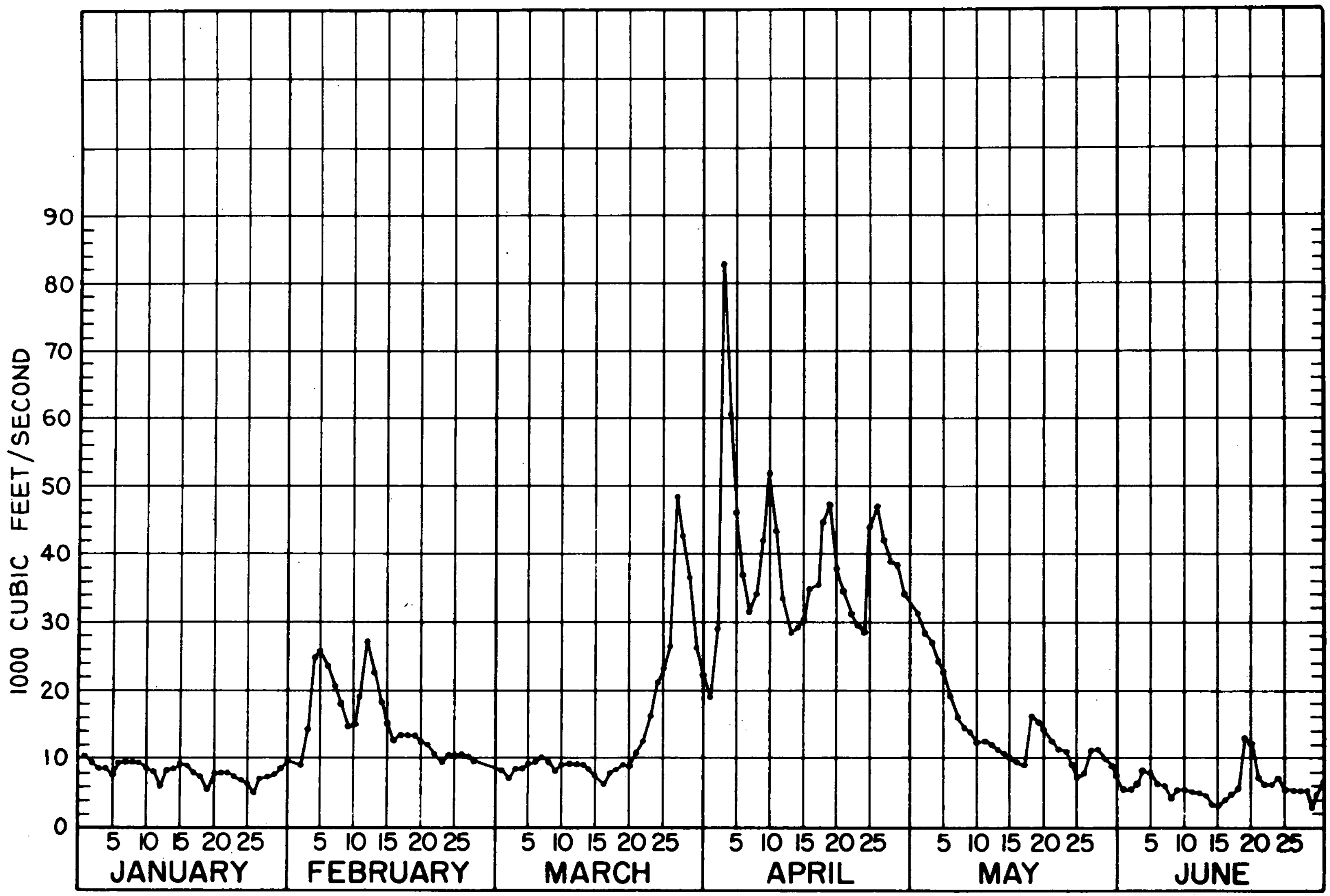

Figure 7-1. Average Discharge Over Federal Dam at Troy, New York—1970

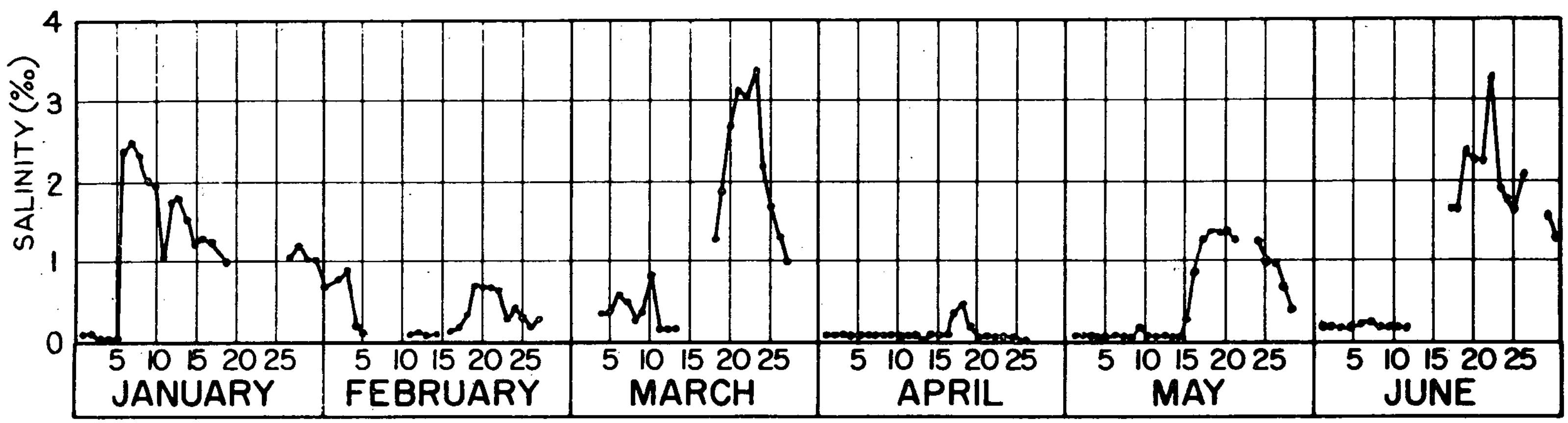

Figure 7-2. Automated Environmental System 0800 Salinity Data—1970

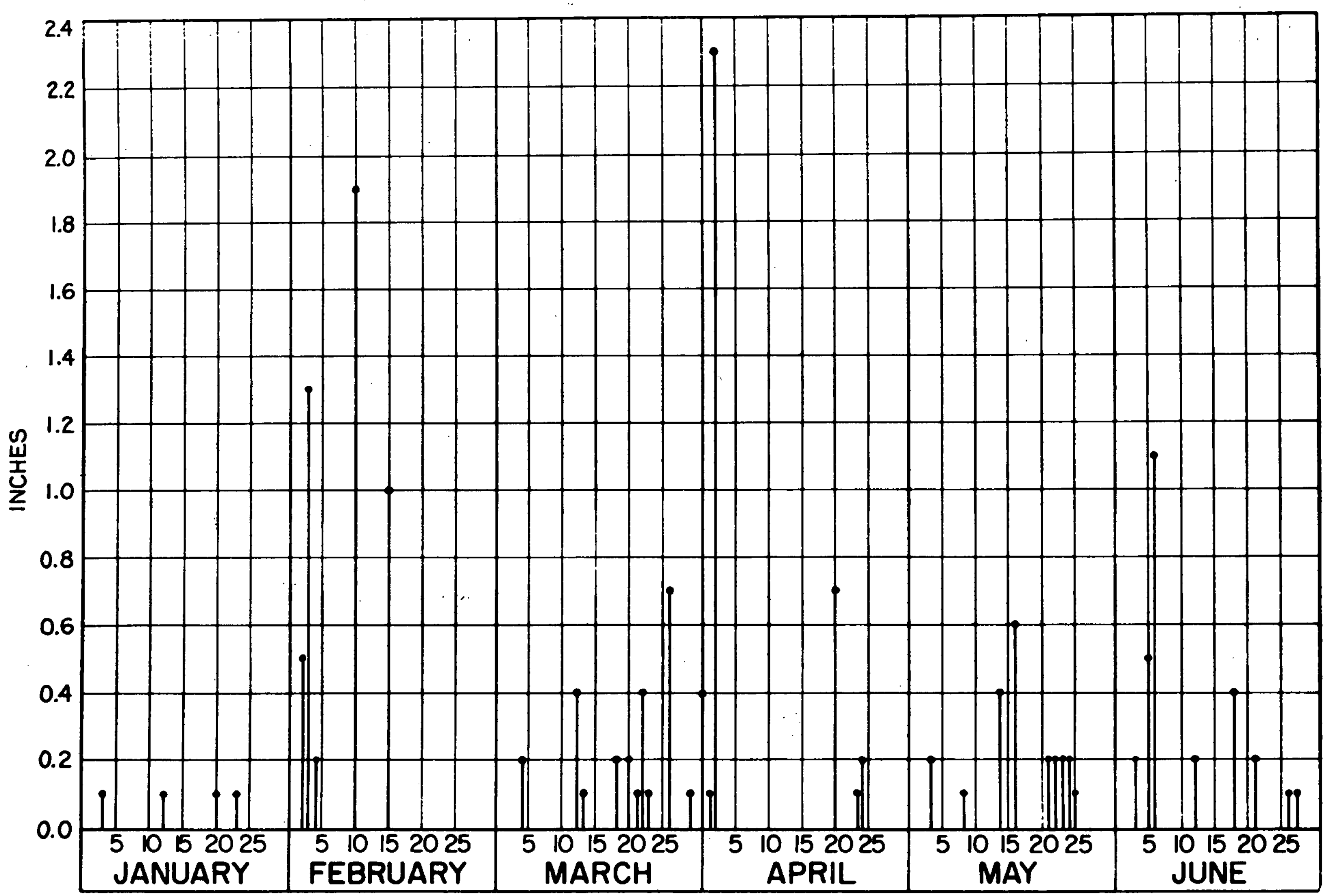

Figure 7-3. Rainfall Recorded at Peekskill Waterworks—1970

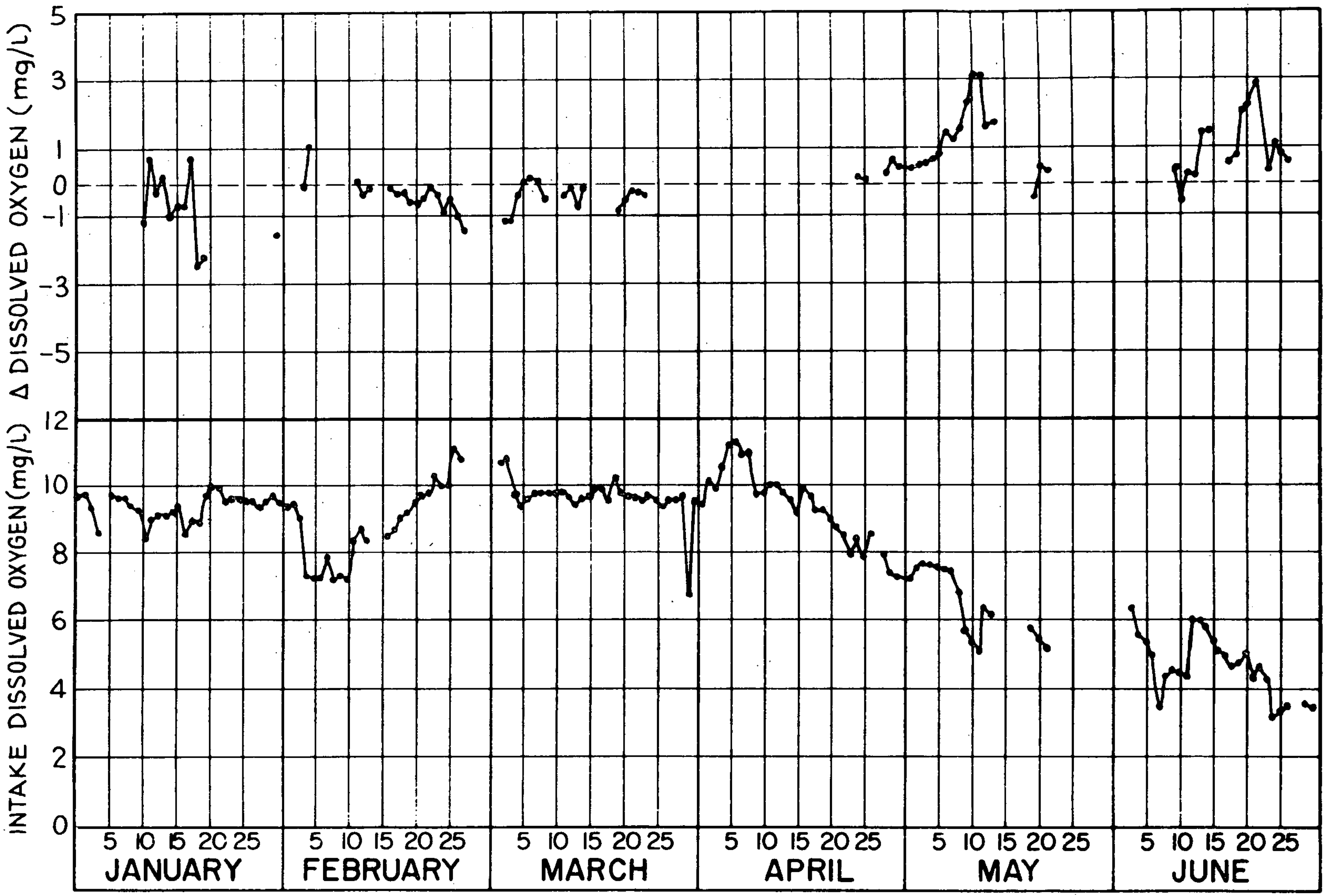

Figure 7-4. Automated Environmental System 0800 Dissolved Oxygen Data—1970

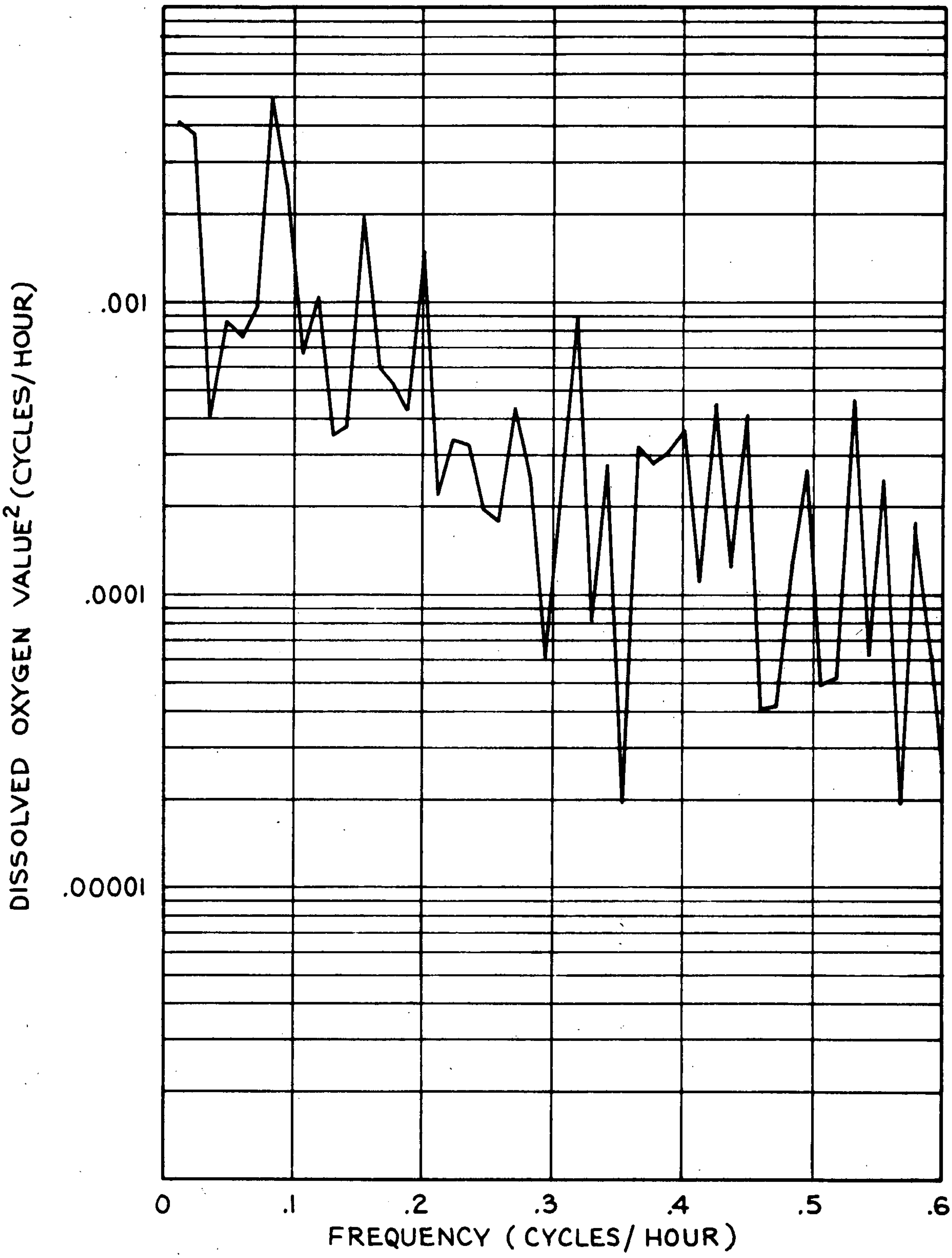

Figure 7-5. Spectral Analysis of Intake Dissolved Oxygen—June 19-22, 1970

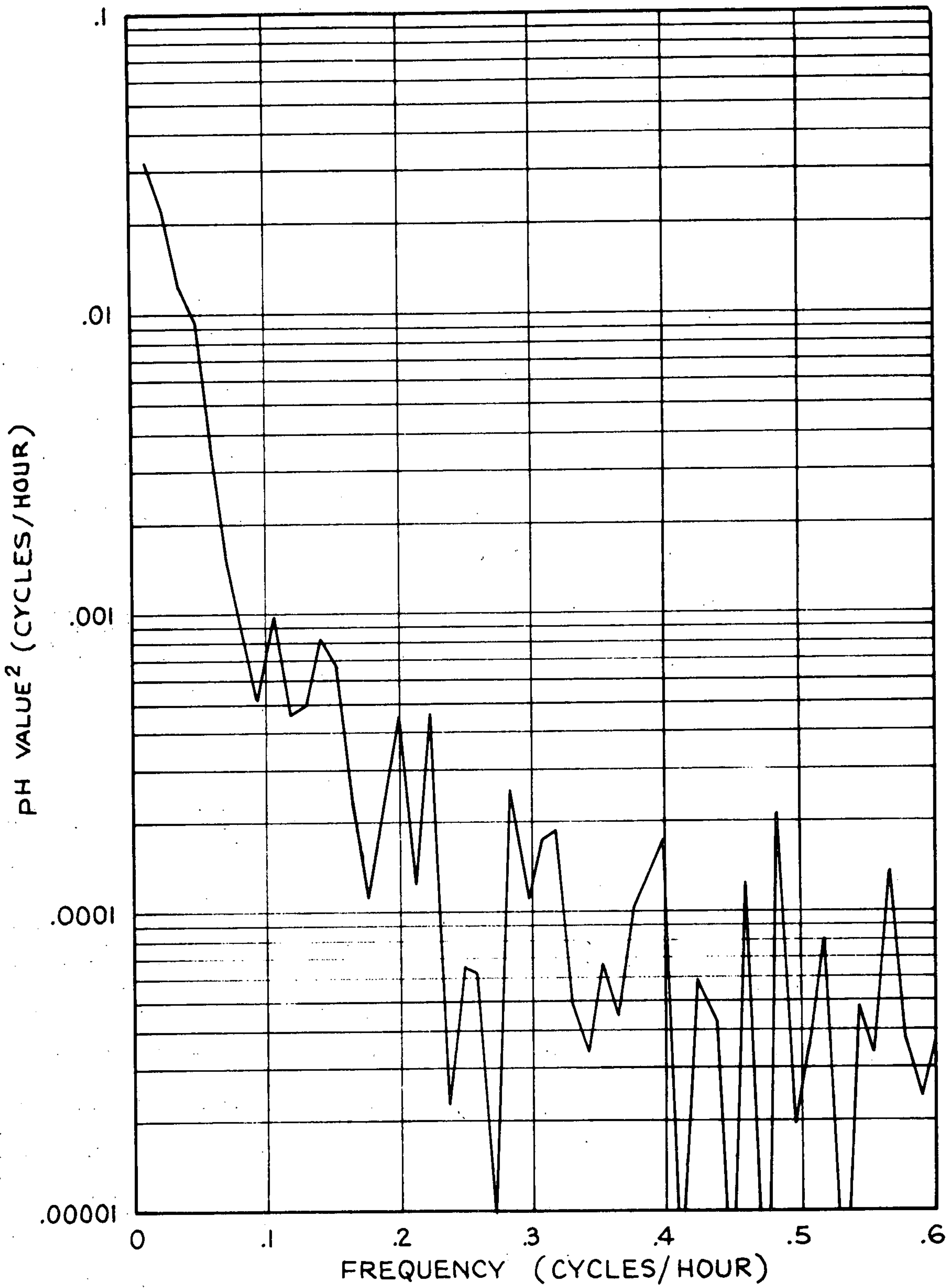

Figure 7-6. Spectral Analysis of Intake pH—June 19-22, 1970

8.0 SONIC TAGGING/SHAD STUDIES

8.1 Introduction

A shad sonic tagging program was initiated by Raytheon personnel during the spring, 1970. The primary objective was to track shad past the Consolidated Edison nuclear generating station at Indian Point when the plant was not operating during refueling operations. The spring of 1970 offered what may have been the last opportunity to study the upstream spawning migration of American shad in the vicinity of the generating station when no heated effluent was being discharged into the river. Results from 1970 were gathered under "base line" conditions and future studies in subsequent years when the plant is operating may demonstrate whether or not heated effluents cause shad to alter their migration patterns and spawning behavior.

In addition to sonic tagging, gill netting was conducted by Raytheon biologists to gather additional data on migration and behavior of shad, especially in the vicinity of the generating station. Commercial fishermen were also contacted for information on the spawning migration.

The tagging study area was delineated on the south by Croton Point and on the north by the Jones Point — Peekskill Bay area. Shad were tagged south of the plant site and tracked as long as they stayed within the study area. Once a fish passed the plant site and reached the northern study area boundary, it was decided that it had passed the "plume area" and was on its way upstream to the spawning grounds. Gill netting was conducted south of the plant to northern Haverstraw Bay to capture shad for tagging and in the plant vicinity for information on where shad travel in relation to the generating station (see Sections 8.4 and 8.5). Croton Point was chosen as the southern boundary because it was anticipated that shad tagged in upper Haverstraw Bay would wander about and go downstream after tagging before continuing their upstream migration.[1] In the event that a tagged fish traveled south of Croton Point, it was

[1] Personal communication with Robert Jones, Connecticut Fish and Game Division. Sonic tagging of shad in the Connecticut River.

decided that time was best employed in tagging another fish within the study area and hoping it would go upstream quickly after tagging.

8.2 Sonic Tagging Equipment and Techniques

On March 27, 1970, a set of Smith-Root equipment, which included a sonic hydrophone Model SR-70-H, a sonic receiver Model TA-60, headphones and Model SR-69 tags arrived at Indian Point. The tags were 2 1/4 inches long and 9/16 inches diameter with pulse rates ranging from 85 to 360 per minute and signal detection about 1/2 mile. The different pulse rates made it possible to separate fish should a previously tagged specimen return to the study area.

A gill net was drifted until one or several adult shad were caught. Tagging was accomplished by inserting the tag into the stomach of the fish, pushing it down through the mouth and esophagus with pencil or wood dowel. A fish was tagged while in the net and then usually cut out of the net. This was done with the fish underwater, unless it was so tangled in the net that it had to be removed from the water in order to release it. A fish was gently stripped to determine the sex, if possible. One lively fish would be tagged and released as quickly as possible with minimal handling.

The fish was then tracked using the hydrophone, receiver and boat. Sightings on prominent land marks were recorded, along with depth, to accurately locate the fish and plot its course. It was possible to track a fish and remain close to it when background noises from river boat traffic, pile drivers and other construction machinery were minimal. The forward motion of the boat and sometimes the engine was stopped in order to locate the tagged fish. The clarity and loudness of the tag pulses increased as one came closer to the fish. When the tagged shad was directly below the boat, the tag pulses were loud and clear and heard in every direction when the hydrophone was rotated. This enabled a very accurate location which was plotted on chart.

Fish were usually tagged in the early morning or evening and tracked continuously (on a 24-hour basis) until the fish left the study area or were lost. Only one fish was tracked at a time. Sonic tagging was conducted Tuesday through Friday each week from mid-April through May.

8.3 Results of Sonic Tagging

A total of 11 shad were sonic tagged and tracked between April 22 and May 20 (Table 8-1). Seven of these fish went south out of the study area, were lost or died. Four shad were tracked successfully past the Consolidated Edison generating station (Figures 8-1, 8-2, 8-3, and 8-4).

On April 22, the first shad was sonic tagged and tracked for approximately three hours in the vicinity of the tagging area in Haverstraw Bay before it was lost. During the tagging of another shad on April 22, the hydrophone stopped receiving, thus we were unable to continue the study. The manufacturer was notified and air mailed another hydrophone which arrived on April 28. At this time, it was discovered that the receiver was malfunctioning and it was not completely repaired until May 6.

During this two-week period, gill netting and balloon tagging were conducted. Fourteen shad were tracked by attaching rubber balloons to them with monofilament fishing line inserted behind the dorsal fin. These balloon-tagged fish remained in the general area where they were tagged in Haverstraw Bay and several went downstream. It appeared that shad were spending time in Haverstraw Bay before going upstream. Balloon tagging, handling and the drag of the line and balloon appeared to affect their behavior because they would wander, first in small circles, as if trying to orient themselves.

Gill netting, handling and sonic tagging apparently also affected the behavior and orientation of the fish. Shad that were sonic tagged generally remained in the tagging vicinity and wandered about until they presumably were able to orient themselves while other tagged fish went downstream after tagging. Some fish wandered about aimlessly for only a few minutes. See Appendix C for tracks of tagged fish which did not pass the plant site.

Three of the four fish were tracked past the plant when it was not operating, and followed the middle of the river (Figures 8-1, 8-2, and 8-3). The fourth fish was tracked past the plant site on May 20 when the plant was operating (Figure 8-4). This shad was tagged on the east side of the river about 600 yards south of the plant site. It first went downstream for a short distance after tagging and then headed upstream, crossing to the west side of the channel at a point slightly north of its release site. Unit 1 was operating at 225 megawatts at 1130 hours. The tide was high at Peekskill at approximately 1100 hours. Chlorination was not

Table 8-1. Synopsis of Sonic Tagging of American Shad

Tagging Date	Tag No.	Fish Sex*	Time of Tagging	Tagging Location	Fish Behavior	Date & Time Tracking Terminated	
April 22	6	M	0905	Haverstraw Bay	Remained in tagging area-signal lost	April 22	1210 hrs
April 30	15	-	1515	Off Stony Pt.	Fish lost after tagging, receiver malfunction	April 30	1530 hrs
May 6	12	F	0915	Verplanck Pt.	Remained & wandered w/in tagging area. Lost in rough weather & interference of signal	May 6	1355 hrs
**May 7	8	F	1020	Verplanck — overhead power lines	Past plant - mid river	May 7	1215 hrs Iona Is.
**May 7	13	F	1503	Off Verplanck, mid river	Past plant - mid channel	May 7	1640 hrs
May 12	11	-	1920	Off Verplanck Pt. — Sinclair Oil	Fish remained in tagging area. Tag malfunctioned	May 12	2230 hrs
May 13	14	F	1345	Overhead power lines mid river	Fish went south, returned to tagging area, died	May 13	1800 hrs
May 13	10	M	2025	Station 16 Verplanck	Fish traveled south out of study area	May 14	1600 hrs
**May 14	9	-	2035	Overhead power lines	Past plant - mid channel, believed died	May 14	2158 hrs
May 19	7	-	1250	Off Georgia Pacific plant	West south	May 19	1512 hrs
**May 20	5	-	1025	Off Georgia Pacific plant	Past plant - west side of channel and then went south out of study area	May 21	0324 hrs

* M = Male, F = Female, - = Not Sexed
**Fish tracked past the plant site

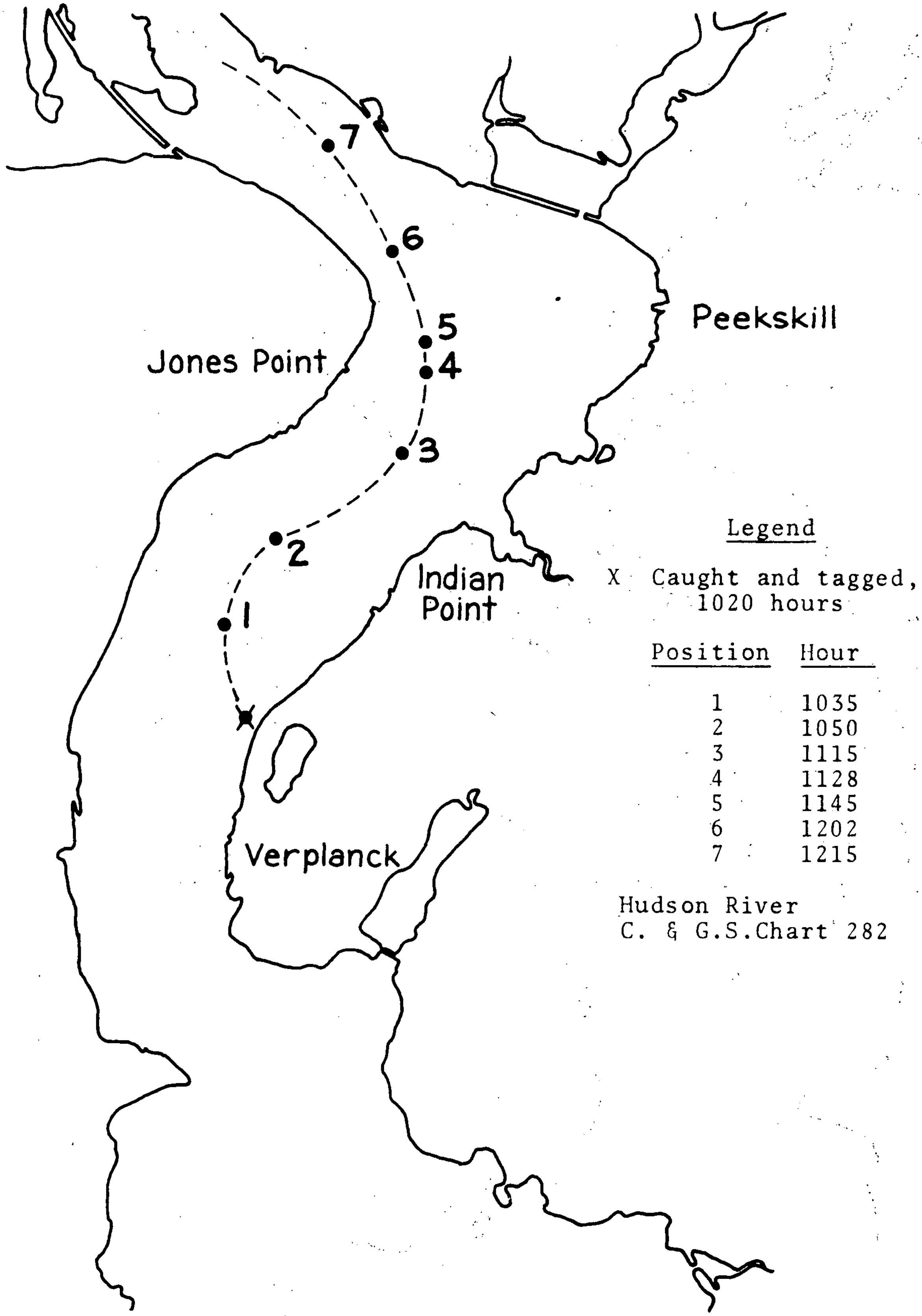

Figure 8-1. First Shad Tracked Past the Plant Site, May 7, 1970

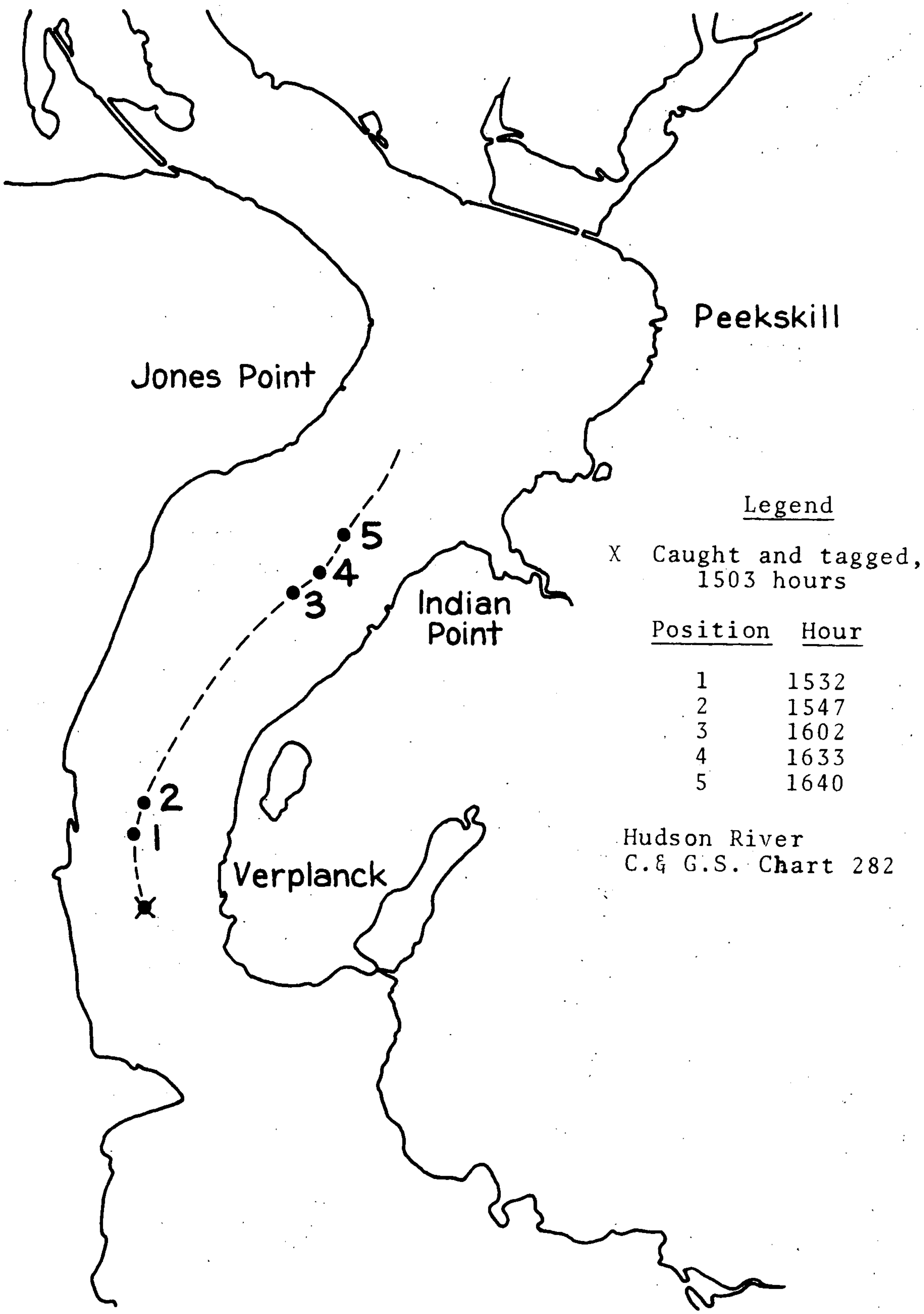

Figure 8-2. Second Shad Tracked Past the Plant Site, May 7, 1970

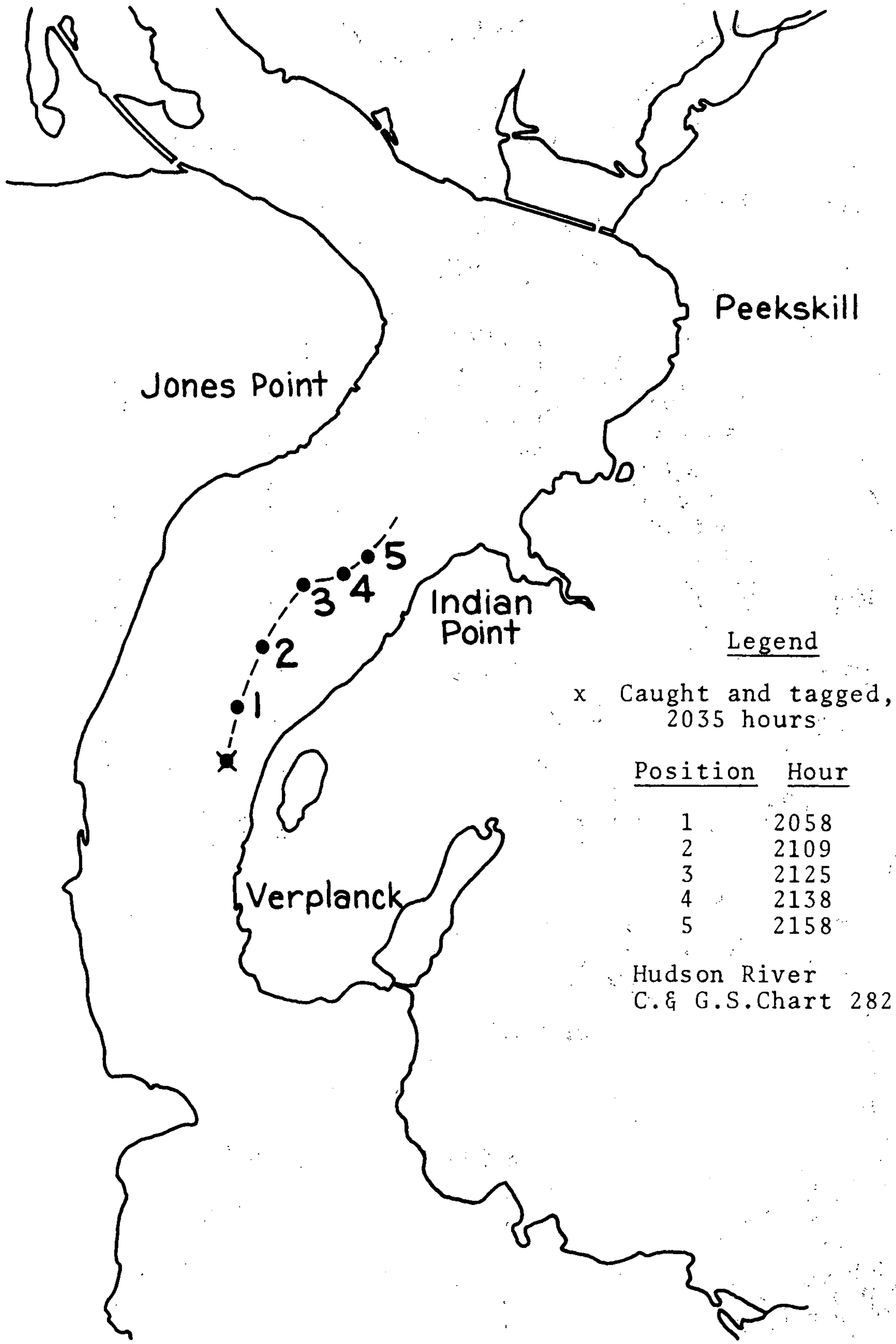

Figure 8-3. Third Shad Tracked Past the Plant Site, May 14, 1970

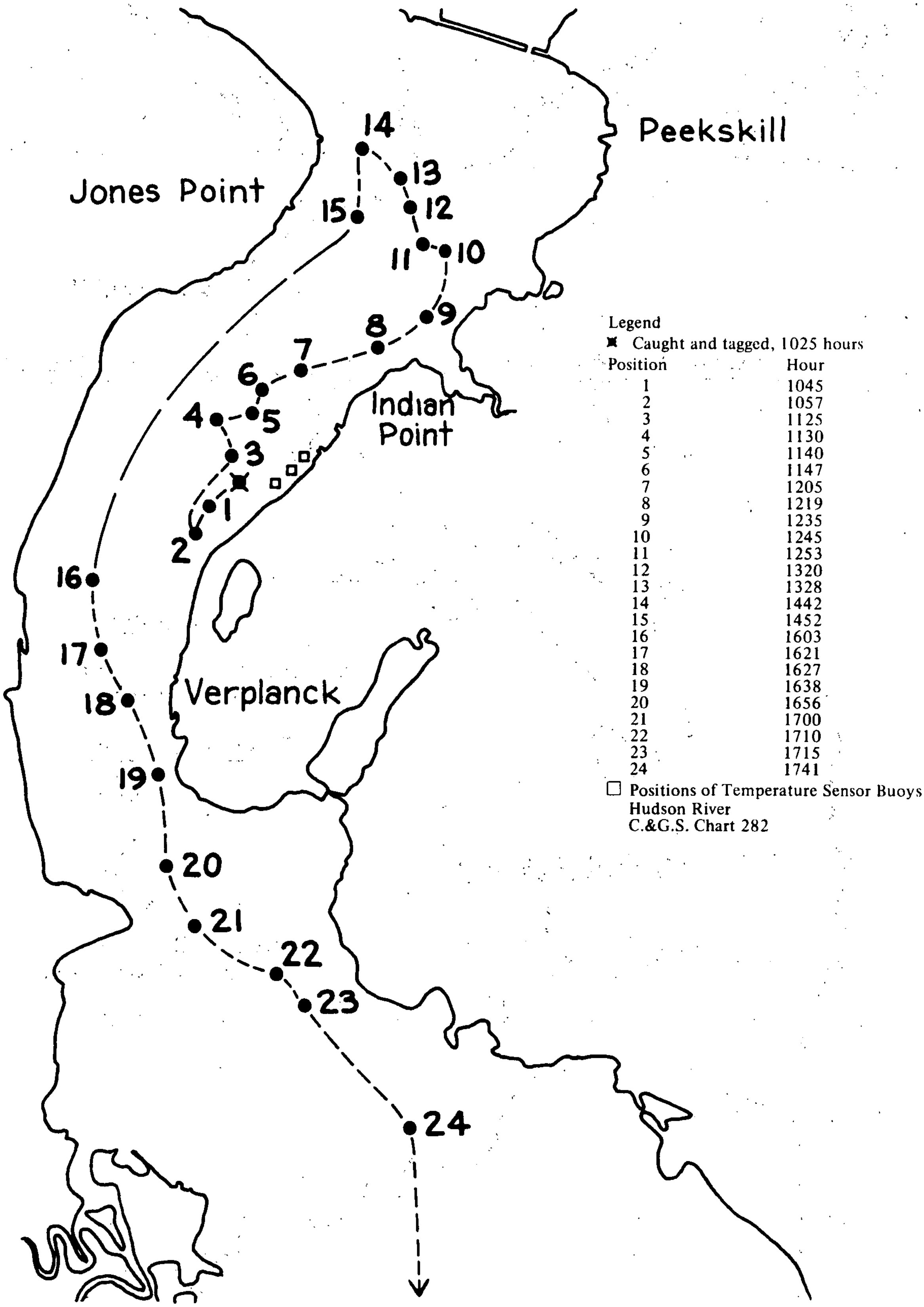

Figure 8-4. Fourth Shad Tracked Past the Plant Site, May 20, 1970

done by the plant during May and the Automated Environmental System did not record copper ions in the effluent canal. Ambient river temperature was approximately 59° F and the plume area was small with a maximum of 60.2° recorded at the surface of the midstream temperature sensing buoy (Table 8-2). No conclusions can be drawn as to why this shad appeared to wander near the plume area. Only one fish was tracked when the plant was operating.

Table 8-2. River Temperatures at Buoy Sensors at 1130 Hours (May 20, 1970)

Buoy	Sensor Position	Temperature ° F
Upstream	Top	59.04
	Near Top	58.63
	Near Bottom	58.77
Mid-stream	Top	60.17
	Near Top	58.94
	Near Bottom	58.97
	Bottom	58.82
Downstream	Top	58.82
	Near Top	58.56
	Near Bottom	58.35
	Bottom	57.95
Effluent		79.88

8.4 Gill-Netting Techniques

A 600' x 12' x 2 3/4" square mesh monofilament gill net was fabricated into 200 and 400 foot sections after its initial use on April 16 and 17. The 200 foot net was used as a surface drift net while the 400 foot net was drifted between 2 feet and 10 feet below the water's surface, depending upon the water depth.

Drift sets were made usually during the two hours around slack water. The net drifted shorter distances, was easier to handle and remained perpendicular to the current.

The primary purpose of gill netting was to obtain fish for sonic tagging. Gill netting for sonic tagging south of the plant site was considered successful if one viable shad was caught for tagging.

Additional information on the shad run was collected by gill netting in northern Haverstraw Bay, Station 16 and in the vicinity of the generating plant at Stations 10, 11, 22 and 21.

8.5 Gill-Netting Results

The first shad caught by a commercial fisherman was on April 12 (Poughkeepsie Journal). Commercial fishermen began catching a few shad in Haverstraw Bay during the week of April 12. Raytheon biologists gill netted in the vicinity of the Consolidated Edison plant site and in Haverstraw Bay on April 16 and 17, without success. Commercial fishermen in Haverstraw Bay during the week of April 20 were making profitable catches while fishermen farther upstream were not catching as many fish.

On April 22, Raytheon personnel caught 30 shad in 3 hours, 16 minutes using the 400 foot gill net. The catch per unit effort for upstream migrating shad reached its peak on May 6 and then began to decline (Tables 8-3, 8-4, and Figure 8-5).

A survey was made of the commercial gill nets between Tappan Zee Bridge and Bear Mountain Bridge on April 30. There was approximately 16,500 linear feet of gill nets in this area of the river. Commercial catches at the end of the month were averaging an estimated 100 pounds of fish per 100 feet of net per 24 hours.

From April 16 through June 4, Raytheon biologists caught 199 adult shad in 51 gill net sets averaging 45 minutes each. Ripe fish totaled 138 as opposed to 61 spent fish. The ripe fish catch was almost equal to the spent fish catch in relation to fishing effort for productive fishing days (Tables 8-3, 8-4 and Figure 8-5). Several striped bass and Atlantic sturgeon were caught incidently.

Gill net catches of shad at Stations 10 and 11 (during days when the plant was off-line) indicate that shad utilized the river area between the Reserve Fleet and the Consolidated Edison generating station without regard to the plant when there was no heated effluent (Table 8-5).

Table 8-3. Numbers of Shad Caught in Gill Nets, 1970

Date	Total Caught	Total Females	Total Males	Total Spent	Not Sexed
April 22	30	10	18	0	2
23	7	3	1	0	3
28	7	6	1	0	0
29	13	11	2	0	0
30	22	7	13	0	2
May 1	31	13	18	0	0
6	13	9	4	0	0
7	3	3	0	0	0
12	2	1	0	0	1
13	3	2	1	0	0
14	3	2	0	1	1
15	0	0	0	0	0
19	8	6	1	6	1
20	2	1	0	1	1
21	11	9	2	11	0
22	19	13	6	17	0
27	6	0	6	6	0
28	15	12	3	15	0
June 4	4	3	1	4	0
Total	199	111	77	61	11

Table 8-4. Gill Net Catch Statistics for Shad, 1970

Date	Total Fishing Time, Min.	Total* Ripe	Total* Spent	Total* Fish
April 22	196	2.30	0	2.30
23	50	2.10	0	2.10
28	60	1.75	0	1.75
29	80	2.44	0	2.44
30	75	4.40	0	4.40
May 1	100	4.67	0	4.67
6	35	5.57	0	5.57
7	60	0.75	0	0.75
12	330	0.11	0	0.11
13	105	0.86	0	0.86
14	45	1.33	0.77	2.00
15	115	0	0	0
19	185	0.36	0.97	1.33
20	20	1.50	1.5	3.00
21	180	0	1.83	1.83
22	60	1.0	8.50	9.50
27	130	0	1.38	1.38
28	225	0	2.00	2.00
June 4	130	0	0.92	0.92

*Shad Caught per 100 feet of net per hour

Table 8-5. Catch Statistics for Shad Caught at Stations 10 and 11, 1970

Station 10						
Date	Hour	Total Caught	Set Time, Min.	Net Length Ft.	Number of Males	Number of Females
May 1	0742	9	30	400	6	3
27	1452	1	20	200	1	0
28	1130	4	60	200	2	2
28	1500	1	30	200	0	1
28	1605	1	15	200	0	1
June 4	1015	1	25	200	0	1

Station 11						
Date	Hour	Total Caught	Set Time, Min.	Net Length Ft.	Number of Males	Number of Females
May 1	0902	13	30	400	8	5
27	1415	2	20	200	2	0
28	1004	4	60	200	0	4
28	1325	5	60	200	1	4
June 4	1505	0	60	200	0	0

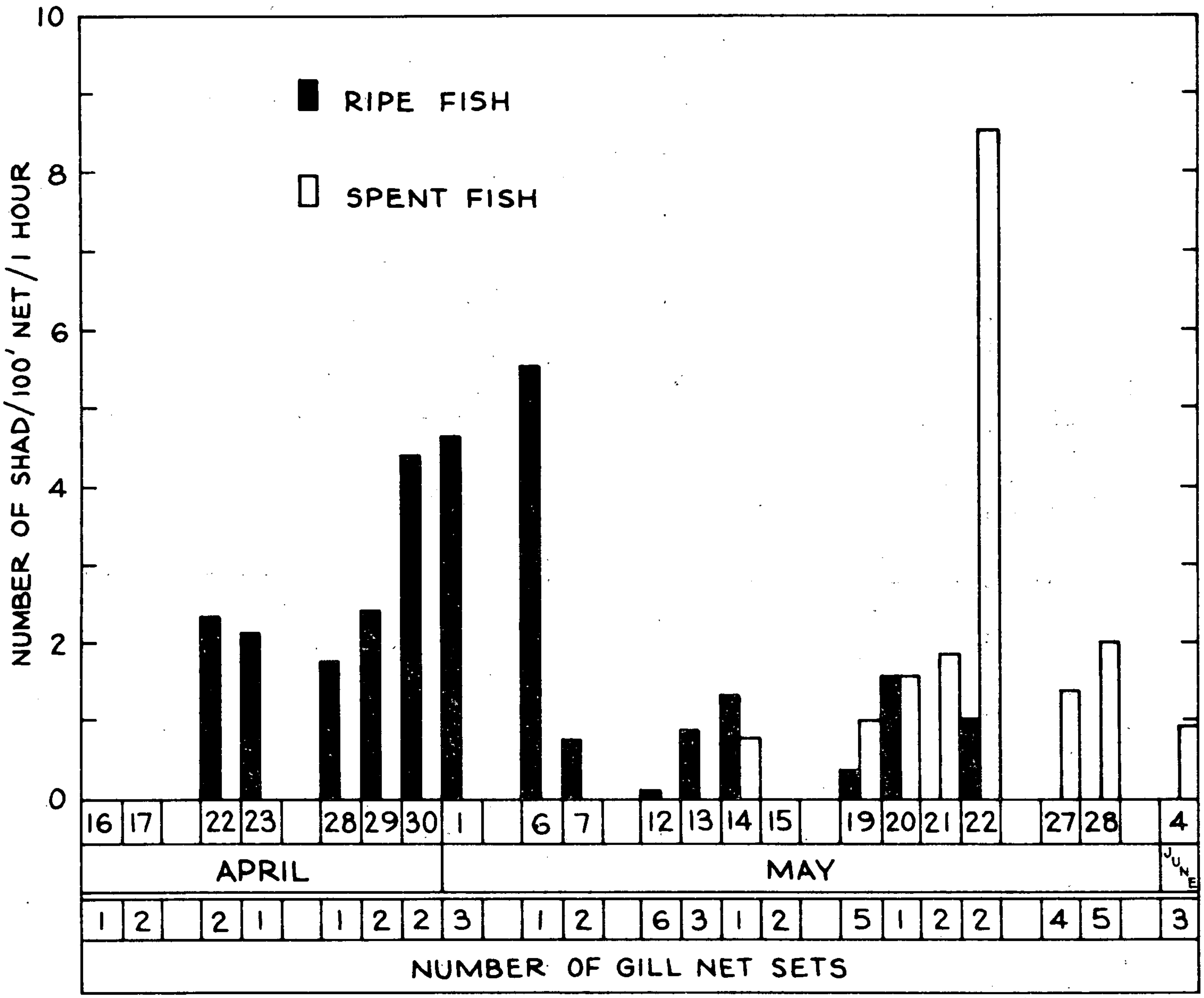

Figure 8-5. American Shad Catch Per Unit Effort

On May 1, 9 ripe shad were caught at Station 10,and 13 ripe shad were netted at Station 11 for the same unit of fishing effort. During the end of May and early June, downstream migrating shad (ones which had spawned) were caught at the rate of 3.6 fish per hour per 200 feet of net at Station 10 and 3.3 fish per hour per 200 feet of net at Station 11. This data should be interpreted with caution because: 1) of the small sample size and 2) even though the unit of effort for each station is equivalent, the hour at which the catches were made was different.

A total of 199 shad were caught during the spring. One hundred and eleven were females and 77 were males. Sex was determined in the field by stripping the fish or dissection and inspection of the gonads in the laboratory. Eleven fish were not sexed because they were tagged and handling was kept at a minimum or they were sighted in the net, but lost when hauling in the net.

The peak of the spawning migration was late April and early May according to commercial fishermen and our gill-net catches (Figure 8-5). Data for Figure 8-5 are listed in Table 8-4. For the graph (Figure 8-5), any fish for which sex was not determined was considered ripe because they were caught in the early part of the season or when tagged during the latter part of the season they were caught on the south side of the gill net, heading upstream.

After the first week of May, the shad run decreased rapidly (Tables 8-3 and 8-4). Commercial shad fishermen stopped fishing about mid-month and said it was a short season this year. On May 14, we caught our first spent shad and by the third week of May almost all the shad caught were spent. The shad studies were phased out during the first week of June.

9.0 FIELD BIOLOGY - ZOOPLANKTON STUDIES

9.1 Introduction

During recent years, increased emphasis has been placed on the collection and analysis of planktonic organisms as an integral part of estuarine ecology studies. The knowledge gained from such studies can serve a multitude of purposes such as predicting future year class strength of important fish species, determining productivity of a particular water mass, or examining the natural fluctuations in populations. Plankton provides food for many of our commercially and recreationally important fish species, and many planktonic organisms have become indicators of change and gradual degradation of our water supplies. The possible effects of industrial use on aesthetically or domestically important water resources might be signalled by an examination of the plankton community.

The scientific value of plankton collections is enhanced when repeated studies have been carried out over extended periods. Initial collections, such as those provided by Raytheon's present study at Indian Point, establish important reference material to which comparisons can be made during follow-up studies.

Equally important, but not realized at the time the plankton program was implemented, has been the suspension of on-line operations of Unit #1 until September of 1970. The plankton samples obtained during this period become more significant since they represent what may be the last plankton data collected without the influence of heated effluent from Indian Point.

9.2 Sampling Gear

The several zooplankton samples collected in January and February, when river ice conditions permitted small boat operations, were made with 0.5 x 0.8 mm mesh nets used in 1969. These nets were not equipped with flow meters or net closing devices.

Commencing 1 March 1970, new plankton nets were placed into service (Figure 9-1). These were constructed from 0.5 mm (#0 mesh) netting and rigged with a closing device which prevented contamination from depths different from those sampled. Mechanical flow meters were used to monitor the volume of water filtered during each tow.

Net design and the accessory equipment, with some modifications, were based on criteria outlined by UNESCO Working Party No. 2*. The pertinent specifications are as follows:

a) Shape – cylindrical-conical. Length of nonporous cylindrical section: 11"; side length of conical net section: 7'1", tapering to cod end canvas band 4" wide, with diameter of 3".

b) Mouth Opening – 1'6" diameter (approximately 1/2 meter), maintained by reinforced polyurethane cylinder.

c) Mouth Area – 1.7 square feet (255 square inches).

d) Net Material – monofilament NITEX nylon, basket weave, with mesh aperture width of 0.5 mm (#0 mesh).

e) Canvas Attachment to Cylinder – 4.5" width. Secured to cylinder with hose clamps.

f) Canvas Band for Throttling Line – 7" width, located 2'1" below cylindrical section. Band contains 8 brass rings located at equal points around net.

g) Cod End – polyvinylchloride collecting bucket with bayonet lock-ring attachment. Volume: 16 ounces, with single window (2" x 1 3/4") of 0.5 mm monel mesh.

h) Bridle (3 each) – 1' 6" long each, all secured commonly to a single eye.

i) Flow Meter – mechanical with digital counter-secured into center of mouth opening, equidistant between anterior and posterior openings of reinforced cylinder.

j) Net Depressor – 38 lb. bronze bat-wing design for holding net at desired depth during towing. Positioned five feet below the closing-release mechanism of the bottom net.

k) Closing Release Mechanism – (see Figure 9-1) Spring loaded brass device to which the throttling line and bridles are separately attached. A solid brass messenger releases the bridle, thus closing the net by transferring the towing point of the net to the throttling line.

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* Zooplankton Sampling - Monographs on Oceanographic Methodology. UNESCO 1968.

9.3 Field Procedures

Ten weekly plankton stations were located along three transects across the Hudson River, in addition to one station positioned within the effluent canal (Figure 4-1). Surface and bottom plankton samples were collected at each station having a water depth less than 30 feet. At stations where water depths equalled or exceeded 30 feet, a mid-depth sample was also collected. In either case the samples were obtained simultaneously. Each mid-depth and bottom net was equipped with a closing release mechanism. The surface net was towed 40 feet astern on a separate towing line, while the mid-depth and bottom nets were positioned along a 1/8-inch towing wire, which was weighted with a 38 pound depressor. A gasoline powered winch was used to haul the towing wire. Towing speed was adjusted so that the surface net remained just under the water's surface, approximately 2.8 knots. All nets were equipped with previously calibrated flow meters. Flow meter readings were recorded immediately before and after each tow.

The amount of towing wire paid out for mid-depth and bottom tows was predetermined for each station. This was accomplished by averaging the depth along each station and adding 50 percent to this figure. Thus, 75 feet of towing wire were paid out (to the water surface) at a station reflecting an average depth of 50 feet. The mid-depth net closing release mechanism was secured mid-way along the length of towing wire.

In order to maintain a basic continuity with the plankton studies of the "Cornwall Project", tows were of 10 minute duration and against the prevailing current. During slack tide periods, the tow direction was always upstream since net river flow is seaward.

Upon completion of the ten-minute towing period the mid-depth and bottom nets were tripped and closed at the sampling depth by messengers affixed to the towing wire. All three nets were hauled in simultaneously. Tows were repeated if flow meters jammed, nets did not close, or nets became contaminated with bottom sediment.

Each plankton collection was transferred to a 16 ounce glass jar and preserved immediately with 5 percent formalin buffered with borax (sodium tetraborate). The sample was labeled to reflect the date, time, station number and depth. Nets were rinsed thoroughly prior to reuse to prevent contamination from previous stations.

Water temperature, dissolved oxygen and salinity data were gathered for surface, mid and bottom depths in conjunction with the collection of each sample. Weather conditions were also recorded. Samples were collected without regard to the tide stage.

The plankton sampling program was designed so that each station would be occupied each week during daylight hours, and every other week during periods of darkness. The eleven stations yielded 28 samples from each daylight sampling period and 56 samples during alternate weeks of day/night samples. In addition, monthly samples were collected at channel stations 4, 6 and 14 to maintain continuity with the year-round sampling program.

As time permitted, extra samples were obtained primarily along the Indian Point transect, and less frequently at other stations. These additional plankton collections reflect the philosophy that the 1970 spring sampling season may provide the last opportunity to collect ecological data without the influence of heated effluent from the Indian Point complex. The value of these additional collections will ultimately be realized since they provide a greater frequency of sampling at selected stations. This will allow more accurate correlations to be made with physical and chemical variables of the river.

Field plankton operations commenced in mid-March when river ice conditions permitted small boat operations. The sampling program was initiated with a planned phase-out period projected for mid-June. However, this phase-out was not executed since significant concentrations of key organisms were collected throughout June.

9.4 Laboratory Procedures

The laboratory procedure for analyzing plankton collections involved a two-step process. The first consisted of sorting each sample into the following categories:

a) Fish eggs

b) Fish larvae

c) Mysids and shrimp

d) Amphipods

e) Miscellaneous macro-invertebrates.

Unusually productive samples were sorted after first randomly subsampling the collection with a "Folsom" plankton splitter. However, prior to splitting any sample it was scanned to determine the concentration of key organisms. If a particular group was rare, those specimens were separated prior to splitting the remaining sample.

Sorted specimens were placed by category into separate four-dram vials. Labels containing pertinent data associated with each sample were placed into the respective vials. The vials were then stored by serial number in racks built specifically for this purpose. Each category was stored separately. The residue remaining after completion of this initial sorting process was returned to the sample jar with the original label. All residue, including the micro-invertebrates, plant material and detritus, has been retained and stored by date.

The second step in the laboratory analysis involved identifying and counting the organisms previously sorted into categories a through d. Each species was first separated into its various life stages. Fish larvae were placed into four categories as outlined by Mansueti and Hardy (1968).* These were yolk sac, larval, prejuvenile, and juvenile stages, respectively. Breeding condition was noted for invertebrates. Binocular stereozoom dissecting microscopes were used during this phase of the operation. All data gathered were recorded directly or, where necessary, as numerical codes on a computerized laboratory data sheet specifically designed for this purpose (Figure 9-2).

Species other than those selected for future study were included in the analysis at this time when identification was readily accomplished and/or their presence required separation from key organisms. Thus all mysids, amphipods and fish species were included in this six month plankton analysis.

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* Mansueti and Hardy, 1968. An Atlas of Fish Eggs and Larvae of the Chesapeake Bay Region. Volume I.

No attempt was made to analyze the contents of the macro-invertebrate miscellaneous vials at this time.

9.5 Results

A total of 755 plankton samples were collected between 1 January and 30 June (Table 9-1). This total includes 8 samples collected at monthly stations during January and February. Data obtained during these winter months are questionable since floe ice and extreme weather conditions prevented efficient use of sampling equipment and caused hazardous working conditions for the field crews. Full-time weekly day and night sampling activities commenced mid-March, when floe ice left the river.

Standard field procedures, outlined in Section 9.3 were followed at all plankton stations except the effluent canal (Station 53). Intermittent operation of the main cooling water circulators considerably changed the flow pattern in the canal after Unit 1 discontinued on-line operations on 20 March.

Oblique tows were made in the effluent canal subsequent to 20 March by towing the plankton net through a sinusoidal pattern by varying the boat engine speed. This integrated depth towing technique was used to simulate the catch when normally turbulent and well mixed waters are flowing through the canal during on-line operations (see Appendix D for results).

Of the selected group of organisms collected and studied (Table 9-2) the most consistent in date of occurrence as well as numerical importance were the amphipods, Gammarus fasciatus and Pontocrates norvegicus (Tables 9-3 and 9-4). Atlantic tomcod larvae, opossum shrimp (Neomysis americanus) and the amphipod, Leptocheirus pinguis, essentially comprise the bulk of remaining organisms collected (Tables 9-5, 9-6, and 9-7). Larval striped bass[1], white perch[1], bay anchovies and clupeids[2] (blueback herring and

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[1] Identification corroborated by Mr. Walt Muraski, N.J. Dept of Conservation. Narcote Creek Experimental Station, Absecon, New Jersey.

[2] Identification of this family corroborated by Mrs. Alice Mansueti, Chesapeake Biological Laboratory, Solomons, Maryland.

alewife) were common only during June but their numerical importance never reached that noted for the invertebrates (Table 9-2).

Larvae of the American smelt reached a numerical peak in May in bottom and mid-depth collections (Table 9-8). This species was rarely collected in plankton samples prior to or after May indicating spawning to have occurred later than usual. This was supported by New York State Conservation Department personnel who indicated the Cold Spring Harbor spawning-run did not take place in March as expected.

Carp and goldfish were rare and collected only in June. The American eel was collected sporadically in the elver stage throughout the study area except Station 12 (Table 9-9). The presence of this species throughout the spring corresponds to the migration noted, and well documented*, which takes place in many east coast rivers following the winter months.

Sand shrimp, Crangon septemspinosa, were rare and collected only in March and again in June (Table 9-2). They were equally rare in trawl and seine collections for the entire spring season. It is interesting to note that this species was abundant in collections taken during the summer and autumn of 1969.

9.5.1 Spatial Distribution - Invertebrates

The plankton sampling program included limited monitoring of the plankton community both north and south of the primary study area during the peak productivity period of May and June. South of the study area, this was accomplished by sampling in Haverstraw Bay at mid-channel Stations 4 and 6 (river mile 35 and 38, respectively). Tows were taken north of the study area near the Bear Mountain Bridge at channel Station 14 (river mile 47). By collecting specimens north and south of the primary study area, observation of trends in the north-south distribution of species may be enhanced, and possibly confirmed. The samples at these three stations on 4 and 25 May and 22 June serve just such a purpose.

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* Bigelow and Schroeder, 1953, Fishes of the Gulf of Maine. Bul. No. 74, U.S.F. and W.S., Washington.

Gammarus fasciatus, Pontocrates norvegicus and Leptocheirus pinguis were equally distributed along the north-south axis of the river at the three main transects sampled. These findings were substantiated by collections from stations 4, 6, and 14 during May; however, L. pinguis appeared to be concentrated within the limits of the primary study area during June (Tables 9-3, 9-4, and 9-22).

The presence of the opossum shrimp, Neomysis americanus, appeared to be correlated with the salinity gradient which existed along the north-south river axis from March through June. During March this species was most generally abundant at the southern stations which offered higher salinities (Figures 6-1 through 6-3, Table 9-6). During April, however, when salinities reached their lowest values during the spring period, N. americanus was rarely collected. With increasing salinities during May, Neomysis was again generally collected at the southern stations. Increasing numbers at all stations occurred during June. Further evidence indicating the relationship of Neomysis to higher salinities was the apparent lack of this species at Station 14, the northern-most sampling area. Also, considerably greater numbers were collected from bottom tows, hence more saline waters. This is particularly true at Stations 20 and 23 during March (Table 9-6, Figures 6-1 and 6-3). Both stations are quite deep in comparison with the surrounding plankton stations (Table 4-1) which may explain the retention of high salinity waters during March correlating with the greater numbers of Neomysis collected at these areas (Figure 6-1 and 6-3).

9.5.2 Spatial Distribution Finfish Larvae

Planktonic stages of the major fish species collected during the spring period also showed distribution trends along the north-south axis of the river (Figures 9-3, 9-4, and 9-5). More clupeids were collected upstream along the northern and Indian Point transects than along the Stony Point transect (Figure 9-3, and Table 9-10). This trend may reflect the downstream migration of these species following initial growth of larvae in fresh water (Bigelow and Schroeder, op. cit.).

The distribution of striped bass larvae paralleled that for clupeids, however, not as strongly (Table 9-11 and Figure 9-4). The major spawning area for the striped bass occurs north of the study area, being concentrated approximately between river mile 50 and 80*, where salinities are considerably lower or absent. The relatively few eggs, yolk sac, and larval specimens collected within the study area substantiate the findings of the "Cornwall Project" which lists the Peekskill area as a minor spawning site for this species. Eggs were primarily collected on the northern transect and at Station 14, in greatest concentrations from bottom collections. Fewer numbers were collected from mid-depth samples, with the least number of eggs having been found in surface samples. Eggs were not collected at Stations 4 and 6 south of the study area.

White perch, primarily in the yolk sac and larval stages, were also collected more frequently at the northern stations (Table 9-12). The infrequent occurrence of this species may be related to their habit of remaining on or quite close to the bottom, hence out of reach of even the "bottom" plankton nets, which do not come in actual contact with bottom sediments.

Yolk sac, larval, and prejuvenile specimens of Atlantic tomcod were collected in slightly greater numbers along the southern transect of the study area (Figure 9-5, and Table 9-5). The spawning activity of this species occurs primarily in salt or brackish water from late November through February. The spawning phenomenon explains the presence of major numbers of this species mostly in the yolk sac stage during March. In April the southerly concentration of this life stage was more pronounced. The distribution of prejuvenile stages of this species appeared to be equal throughout the mid-channel stations of the study area.

The bay anchovy, a pelagic species which enters estuaries during the late spring, was represented in the plankton only in June. Numbers of larvae collected during June generally indicated equal concentrations to occur across the study area (Table 9-13), as well as at

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* Hudson River Fisheries Investigation, 1965-1968. Report of the Policy Committee.

Stations 4, 6 and 14. However, it should be noted that eggs and yolk sac larvae of the anchovy were collected only in bottom tows at mid-channel Station 20.

Differences in distribution between shallow and deep stations were indicated for only a few species, and then only during specific life stages. This is expected since very early stages of most species are unable to compete against river currents for position. For example, yolk sac larvae of the Atlantic tomcod are more concentrated in the deeper, mid-channel stations (Figure 9-5). However, the post-yolk sac stage of this species was collected in greatest numbers at Station 9 where depths rarely exceed 12 feet. This phenomenon appeared to be true for the striped bass as well since the yolk sac stage specimens were collected primarily at deep stations (Figure 9-4).

The striped bass showed a trend not noted for other species. This pertains to the unequal distribution in an east-west direction along the three transects (Figure 9-4). The greatest concentration of striped bass larvae of all stages occurred either in the mid-channel or along the west side of the river. Few specimens were collected at the east station of each transect.

Depth differences in numbers were noted among surface mid-depth and bottom samples for many species collected (Tables 9-3 through 9-13). Generally, greater concentrations of organisms occurred in bottom samples and fewer numbers in the surface and mid-depth collections. This was noted especially for the invertebrate species. Clupeids on the contrary, were primarily collected in surface samples at all stations occupied indicating the pelagic habits of these species. This was true to a lesser extent for anchovies and American eels, while the American smelt appeared to be distributed equally throughout the water column.

9.5.3 Diurnal Vertical Migration

This variation in depth distribution may be correlated with a negative reaction to bright daylight. To determine just how important this factor was, a detailed analysis based on day-night sampling was undertaken for the major species collected at Station 22. Since this station is directly adjacent to the cooling water intakes of Unit 1, the day-night vertical migration could change the susceptability of these organisms to entrainment by the cooling system of Unit 1. Organisms which are concentrated at or near the bottom would be more susceptible to entrainment than species higher in the water column since the cooling water is withdrawn near the bottom. Thus, if particular organisms move into surface waters during periods of darkness, they are less likely to be caught up in the circulator system.

Considering the high turbidity of the water in the Hudson River, it was assumed that the plankton nets were equally efficient in capturing organisms during both day and night sampling. The numbers of organisms collected for the respective day/night sampling periods show interesting patterns of vertical distribution. The data are based on collections obtained every 14-15 days (Tables 9-14 through 9-21).

All species were more abundant at the surface during periods of darkness. White perch and clupeids were more concentrated at mid-depth only during daylight hours, while at the bottom and surface greater numbers were collected at night (Tables 9-14 and 9-15). In terms of total numbers collected, clupeids were less abundant in bottom samples.

The bay anchovy was collected mostly at night (Table 9-16). Day collections of this species were primarily made at the surface.

Gammarus fasciatus and Pontocrates norvegicus, both collected in great numbers at this station, are essentially caught during periods of darkness (Tables 9-17 and 9-18).

Tomcod, striped bass, and the mysid, Neomysis americanus, are the only species which showed a distinct preference of bottom waters during daylight (Tables 9-19, 9-20, and 9-21). The striped bass was never collected during daylight at the surface. The catch of N. americanus showed a similar pattern of distribution. Atlantic tomcod is the third species which showed this pattern of behavior, though to a lesser extent. During the day some tomcod larvae were collected at the surface but they primarily occurred in bottom samples. The catch considerably increased at the surface during periods of darkness.

9.5.4 Community Overlap

Community overlap comparisons were made among all the surface, mid-depth and bottom zooplankton collections. The comparisons were based on the average monthly percent compositions of the identified planktonic organisms at each station (Table 9-2).

The monthly similarities among the stations using the surface and the bottom percent compositions at Station 10 as references are shown inFigures 9-6 through 9-13.

Computer plots of the average number caught per 1000 cubic meters in the bottom, mid-depth and surface collections of the more abundant zooplanktonic species are shown in Figures 9-14 through 9-25. Each line in a figure represents the data for a station. From bottom to top of each figure the stations are ordered as follows: 4, 6, 15, 20, 9, 21, 11, 10, 22, 13, 23, 12, 14, 51 and 53 (see Figure 4-1).

Note that each station's graph begins and ends at zero. This is an artifact of the graphing technique and should be be interpreted as an indication of the abundance trends beyond the actual data available. See Appendix D-2 for tables of community overlap.

Table 9-1. Zooplankton Samples Collected, January - June 1970

STA	MILE	SITE	SAMPLE DEPTH S	SAMPLE DEPTH M	SAMPLE DEPTH B	SURFACE Jan.	SURFACE Feb.	SURFACE Mar.	SURFACE Apr.	SURFACE May	SURFACE June	MID-DEPTH Jan.	MID-DEPTH Feb.	MID-DEPTH Mar.	MID-DEPTH Apr.	MID-DEPTH May	MID-DEPTH June	BOTTOM Jan.	BOTTOM Feb.	BOTTOM Mar.	BOTTOM Apr.	BOTTOM May	BOTTOM June	TOTAL
15	40	1	0	22	41			3	7	8	8			3	6	8(2)	8			3	7	8(2)	8	77
20	40	2	0	37	71			2	6	8	8			2	6	6	8(1)			2	6	7	8	69
9	40	3	0	-	8			3	7	6	8(1)			-	-	-	-			3	7	6	8	48
21	42	1	0	-	11			4	8	9	8			-	-	-	-			4(1)	8	8	8	57
11	42	2	0	25	46	1	1	6	8	8	8			5	8	8	8	1	1	5	8	8	9	93
10	42	3	0	22	41		1	4	9	9	10			4	8	8(1)	8		1	4	9	9(2)	11	95
22	42	3	0	25	46			4	8	9	10			4	8	9	8			4	8	8	10	90
13	45	1	0	25	46			3	7	6	8			3	7(1)	7	8			3(1)	7	6	8	73
23	44	2	0	37	71			2	7	7	9			2	7	7	9			2	7	6	9	74
12	44	3	0	-	12			3	8	6(1)	8			-	-	-	-			3	8	6	8	50
4*	35	2	0	17	30					2	1					2	1					2	1	9
6*	38	2	0	25	26		1			2	1					2	1		1			2	1	11
14*	47	3	0	23	51					2	1					2	1					2	1	9
			TOTALS:			1	3	34	75	82	88	0	0	23	50	59	60	1	3	33	75	78	90	755

EFFLUENT CANAL (oblique tows): March-3, April-8, May-8, June-8

Figures in parentheses indicate sample valid for environmental data only.

* Monthly stations

Table 9-2. Relative Abundance of Major Identified Planktonic Organisms, Jan—June 1970

JANUARY - JUNE 1970

NAME	JAN.	FEB.	MAR.	APR.	MAY	JUNE
Bay anchovy	-	-	-	-	-	C
Carp	-	-	-	-	-	R
American eel	-	-	R	U	U	R
Goldfish	-	-	-	-	-	R
American smelt	-	-	R	R	U	R
Striped bass	-	-	-	-	U	C
Atlantic tomcod	-	-	A	A	U	R
White perch	-	-	-	-	U	C
Clupeid*	-	-	-	-	U	C
Gammarus fasciatus	R	R	C	A	A	A
Pontocrates norvegicus**	-	-	C	A	A	A
Leptocheirus pinguis**	-	-	R	A	C	U
Crangon septemspinosa	-	-	R	-	-	R
Neomysis americana	-	-	U	R	C	A

* Blueback herring and Alewife combined
** Positive identification pending

A = Abundant (readily caught and in great numbers)
C = Common (readily caught)
U = Uncommon (caught but only occasionally and/or in small numbers)
R = Rare

\- = Not collected

Table 9-3. Average Number per 1000 Cubic Meters - Gammarus fasciatus
Plankton Net No. 0 Mesh (0.5 mm)

STA	MILE	SITE	SAMPLE DEPTH S	M	B	SURFACE MAR	APR	MAY	JUNE	MID-DEPTH MAR	APR	MAY	JUNE	BOTTOM MAR	APR	MAY	JUNE
15	40	1	0	22	41	94	94	137	802	525	1478	246	86	663	1372	925	1023
20	40	2	0	37	71	0	81	76	943	588	890	237	458	0	1801	4437	2780
9	40	3	0	-	8	613	85	178	551	-	-	-	-	189	792	152	3309
21	42	1	0	-	11	38	138	81	487	-	-	-	-	667	433	410	1577
11	42	2	0	25	46	29	114	69	1143	321	556	523	976	378	1207	781	3993
10	42	3	0	22	41	23	178	91	802	218	350	266	1463	241	589	1196	2875
22	42	3	0	25	46	96	220	143	1363	94	175	223	1539	340	783	696	25206
13	45	1	0	25	46	26	82	119	2668	151	395	571	3602	108	1832	1121	2156
23	44	2	0	37	71	0	116	92	827	17	864	216	2897	863	722	1314	5337
12	44	3	0	-	12	114	137	65	1109	-	-	-	-	79	460	268	6061

Table 9-4. Average Number per 1000 Cubic Meters— Pontocrates norvegicus
Plankton Net No. 0 Mesh (0.5mm)

STA	MILE	SITE	SAMPLE DEPTH			SURFACE				MID-DEPTH				BOTTOM			
			S	M	B	MAR	APR	MAY	JUNE	MAR	APR	MAY	JUNE	MAR	APR	MAY	JUNE
15	40	1	0	22	41	159	342	920	221	580	1058	1003	64	716	1679	1892	796
20	40	2	0	37	71	0	139	168	100	319	1217	394	340	0	2737	2655	3541
9	40	3	0	--	8	494	115	85	569	---	----	----	---	251	1206	137	872
21	42	1	0	--	11	141	173	562	354	---	----	----	---	572	2192	430	503
11	42	2	0	25	46	166	95	212	461	264	459	143	218	324	2027	652	1683
10	42	3	0	22	41	5	1203	163	250	364	291	461	277	326	1124	2035	2211
22	42	3	0	25	46	166	244	362	344	716	687	389	371	998	1365	904	6311
13	45	1	0	25	46	60	53	648	836	241	620	823	649	575	2304	862	1937
23	44	2	0	37	71	0	51	179	105	0	595	245	1607	1581	588	905	4525
12	44	3	0	--	12	224	402	73	126	---	---	---	----	35	1047	209	645

Table 9-5. Average Number per 1000 Cubic Meters — Atlantic Tomcod
Plankton Net No. 0 Mesh (0.5mm)

STA	MILE	SITE	SAMPLE DEPTH S	M	B	SURFACE MAR	APR	MAY	JUNE	MID-DEPTH MAR	APR	MAY	JUNE	BOTTOM MAR	APR	MAY	JUNE
15	40	1	0	22	41	158	11	0	0	509	37	0	0	1602	205	2	0
20	40	2	0	37	71	132	14	0	0	683	57	0	0	1584	137	12	1
9	40	3	0		8	561	69	0	0	-	-	-	-	1373	483	0	0
21	42	1	0		11	173	74	0	0	-	-	-	-	366	145	0	0
11	42	2	0	25	46	60	47	0	0	241	171	0	0	879	92	13	0
10	42	3	0	22	41	125	53	0	0	264	49	0	1	224	148	11	0
22	42	3	0	25	46	228	75	0	0	712	25	0	0	561	510	0	0
13	45	1	0	25	46	256	49	0	0	828	131	0	0	465	276	0	0
23	44	2	0	37	71	45	29	0	0	432	50	1	0	524	64	16	2
12	44	3	0		12	273	41	0	0	-	-	-	-	164	69	0	0

Table 9-6. Average Number per 1000 Cubic Meters—Neomysis americanus
Plankton Net No. 0 Mesh (0.5mm)

STA	MILE	SITE	SAMPLE DEPTH			SURFACE				MID-DEPTH				BOTTOM			
			S	M	B	MAR	APR	MAY	JUNE	MAR	APR	MAY	JUNE	MAR	APR	MAY	JUNE
15	40	1	0	22	41	0	0	25	233	20	0	30	91	117	0	270	2293
20	40	2	0	37	71	0	0	1	84	0	3	84	378	608	6	140	2147
9	40	3	0	--	8	40	0	0	214	--	-	--	---	84	17	P*	90
21	42	1	0	--	11	0	0	1	648	--	-	--	---	17	1	0	286
11	42	2	0	25	46	0	0	3	295	22	0	26	140	110	5	41	7210
10	42	3	0	22	41	0	0	0	350	34	0	61	304	128	0	103	2312
22	42	3	0	25	46	0	0	2	117	8	0	5	199	192	0	13	4479
13	45	1	0	25	46	0	0	0	2864	14	0	0	1793	10	0	4	4112
23	44	2	0	37	71	0	0	0	232	0	0	7	806	199	1	102	4432
12	44	3	0	--	12	0	1	0	358	--	-	-	----	0	0	2	208

* P DENOTES <1 PER 1000 METERS^3

Table 9-7. Average Number per 1000 Cubic Meters—<u>Leptocheirus pinguis</u>
Plankton Net No. 0 Mesh (0.5 mm)

STA	MILE	SITE	SAMPLE DEPTH			SURFACE				MID-DEPTH				BOTTOM			
			S	M	B	MAR	APR	MAY	JUNE	MAR	APR	MAY	JUNE	MAR	APR	MAY	JUNE
15	40	1	0	22	41	0	59	46	8	8	310	68	10	0	42	70	11
20	40	2	0	37	71	0	100	17	27	0	125	46	1	0	419	18	21
9	40	3	0	--	8	4	445	20	1	-	---	--	--	82	1519	20	32
21	42	1	0	--	11	0	113	15	2	-	---	--	--	0	210	28	5
11	42	2	0	25	46	0	67	47	5	0	40	26	4	0	19	75	18
10	42	3	0	22	41	0	5426	53	8	0	511	30	8	0	921	106	27
22	42	3	0	25	46	0	117	83	4	0	116	65	13	0	114	164	16
13	45	1	0	25	46	0	2	26	3	0	19	89	11	0	49	6	30
23	44	2	0	37	71	0	96	12	25	0	108	20	1	0	18	16	26
12	44	3	0	--	12	0	25	26	0	-	---	--	--	0	191	39	0

Table 9-8. Average Number per 1000 Cubic Meters—American Smelt
Plankton Net No. 0 Mesh (0.5mm)

STA	MILE	SITE	SAMPLE DEPTH			SURFACE				MID-DEPTH				BOTTOM			
			S	M	B	MAR	APR	MAY	JUNE	MAR	APR	MAY	JUNE	MAR	APR	MAY	JUNE
15	40	1	0	22	41	0	0	1	0	0	0	1	0	0	2	4	2
20	40	2	0	37	71	0	0	1	0	0	0	2	2	0	1	4	1
9	40	3	0	--	8	0	0	0	0	-	-	-	-	0	0	P*	4
21	42	1	0	--	11	0	0	2	1	-	-	-	-	0	0	0	1
11	42	2	0	25	46	0	0	0	1	0	0	6	0	0	0	2	2
10	42	3	0	22	41	0	1	0	1	0	0	4	1	2	0	0	1
22	42	3	0	25	46	0	0	1	2	0	0	0	0	0	0	2	0
13	45	1	0	25	46	0	0	0	1	0	0	2	1	0	0	1	4
23	44	2	0	37	71	0	0	5	0	0	0	1	0	0	0	1	0
12	44	3	0	--	12	0	0	0	1	-	-	-	-	0	0	9	3

* P denotes <1 per 1000 meters^3

Table 9-9. Average Number per 1000 Cubic Meters-American Eel Plankton Net No. 0 Mesh (0.5mm).

STA	MILE	SITE	SAMPLE DEPTH S	M	B	SURFACE MAR	APR	MAY	JUNE	MID-DEPTH MAR	APR	MAY	JUNE	BOTTOM MAR	APR	MAY	JUNE
15	40	1	0	22	41	0	4	2	0	0	0	1	0	0	0	4	1
20	40	2	0	37	71	0	1	3	0	0	0	0	0	12	3	0	1
9	40	3	0	-	8	2	1	8	0	-	-	-	-	0	0	3	0
21	42	1	0	-	11	1	14	12	0	-	-	-	-	0	3	6	1
11	42	2	0	25	46	0	1	15	1	0	2	4	0	0	0	2	1
10	42	3	0	22	41	0	0	1	0	2	0	0	0	0	1	13	0
22	42	3	0	25	46	0	1	7	0	0	0	3	0	2	0	0	0
13	45	1	0	25	46	0	1	1	0	0	0	2	0	0	0	1	0
23	44	2	0	37	71	0	4	7	0	0	2	3	0	0	0	3	0
12	44	3	0	-	12	0	0	0	0	-	-	-	-	0	0	0	0

Table 9-10. Average Number per 1000 Cubic Meters—Clupeids*
Plankton Net No. 0 Mesh (0.5mm)

STA	MILE	SITE	SAMPLE DEPTH			SURFACE				MID-DEPTH				BOTTOM			
			S	M	B	MAR	APR	MAY	JUNE	MAR	APR	MAY	JUNE	MAR	APR	MAY	JUNE
15	40	1	0	22	41	0	0	34	22	0	0	12	6	0	0	3	7
20	40	2	0	37	71	0	0	15	17	0	0	5	3	0	0	1	3
9	40	3	0	-	8	0	0	46	47	-	-	--	-	0	0	19	8
21	42	1	0	-	11	0	0	36	25	-	-	--	-	0	0	1	3
11	42	2	0	25	46	0	0	26	161	0	0	5	5	0	0	12	4
10	42	3	0	22	41	0	0	55	59	0	0	33	10	0	0	20	6
22	42	3	0	25	46	0	0	47	96	0	0	18	13	0	0	25	6
13	45	1	0	25	46	0	0	30	181	0	0	16	27	0	0	1	12
23	44	2	0	37	71	0	0	18	127	0	0	10	3	0	0	9	6
12	44	3	0	-	12	0	0	49	35	-	-	--	--	0	0	59	29

* Blueback herring and Alewife combined.

Table 9-11. Average Number per 1000 Cubic Meters — Striped Bass
Plankton Net No. 0 Mesh (0.5mm)

STA	MILE	SITE	SAMPLE DEPTH S	M	B	SURFACE MAR	APR	MAY	JUNE	MID-DEPTH MAR	APR	MAY	JUNE	BOTTOM MAR	APR	MAY	JUNE
15	40	1	0	22	41	0	0	2	351	0	0	3	107	0	0	8	176
20	40	2	0	37	71	0	0	0	111	0	0	6	295	0	0	10	95
9	40	3	0	-	8	0	0	0	24	-	-	-	---	0	0	0	10
21	42	1	0	-	11	0	0	2	90	-	-	-	---	0	0	0	161
11	42	2	0	25	46	0	0	0	59	0	0	47	73	0	0	7	426
10	42	3	0	22	41	0	0	0	91	0	0	16	55	0	0	15	36
22	42	3	0	25	46	0	0	2	76	0	0	11	46	0	0	8	58
13	45	1	0	25	46	0	0	5	265	0	0	8	45	0	0	36	377
23	44	2	0	37	71	0	0	1	182	0	0	111	70	0	0	39	855
12	44	3	0	-	12	0	0	0	34	-	-	---	--	0	0	9	8

Table 9-12. Average Number per 1000 Cubic Meters—White Perch Plankton Net No. 0 Mesh (0.5mm)

STA	MILE	SITE	SAMPLE DEPTH			SURFACE				MID-DEPTH				BOTTOM			
			S	M	B	MAR	APR	MAY	JUNE	MAR	APR	MAY	JUNE	MAR	APR	MAY	JUNE
15	40	1	0	22	41	0	0	4	24	0	0	1	17	0	0	6	17
20	40	2	0	37	71	0	0	0	9	0	0	0	31	0	0	0	14
9	40	3	0	--	8	0	0	2	12	-	-	-	--	0	0	1	7
21	42	1	0	--	11	0	0	7	23	-	-	-	--	0	0	0	15
11	42	2	0	25	46	0	0	4	29	0	0	7	26	0	0	5	77
10	42	3	0	22	41	0	0	5	24	0	0	2	21	0	0	1	12
22	42	3	0	25	46	0	0	2	23	0	0	2	4	0	0	5	12
13	45	1	0	25	46	0	0	0	21	0	0	6	53	0	0	4	76
23	44	2	0	37	71	0	0	3	18	0	0	8	21	0	0	1	76
12	44	3	0	--	12	0	0	5	9	-	-	-	--	0	0	1	21

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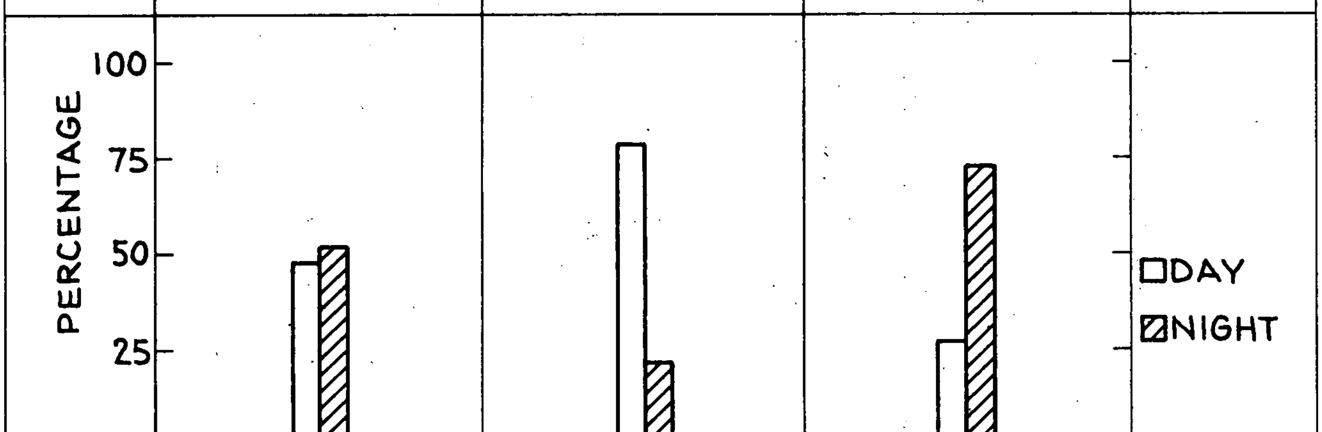
Table 9-13. Average Number per 1000 Cubic Meters — Bay Anchovy
Plankton Net No. 0 Mesh (0.5mm)

STA	MILE	SITE	SAMPLE DEPTH S	M	B	SURFACE MAR	APR	MAY	JUNE	MID-DEPTH MAR	APR	MAY	JUNE	BOTTOM MAR	APR	MAY	JUNE
15	40	1	0	22	41	0	0	0	140	0	0	0	44	0	0	0	136
20	40	2	0	37	71	0	0	0	121	0	0	0	45	0	0	0	278
9	40	3	0	-	8	-	-	-	353	-	-	-	-	0	0	0	74
21	42	1	0	-	11	0	0	0	42	-	-	-	-	0	0	0	17
11	42	2	0	25	46	0	0	0	93	0	0	0	0	0	0	0	94
10	42	3	0	22	41	0	0	0	77	0	0	0	67	0	0	0	42
22	42	3	0	25	46	0	0	0	119	0	0	0	1	0	0	0	102
13	45	1	0	25	46	0	0	0	211	0	0	0	33	0	0	0	76
23	44	2	0	37	71	0	0	0	36	0	0	0	1	0	0	0	48
12	44	3	0	-	12	0	0	0	38	-	-	-	-	0	0	0	22

Table 9-14. Diurnal Comparisons of Average No./1000 m^3 at Station 22 — White Perch

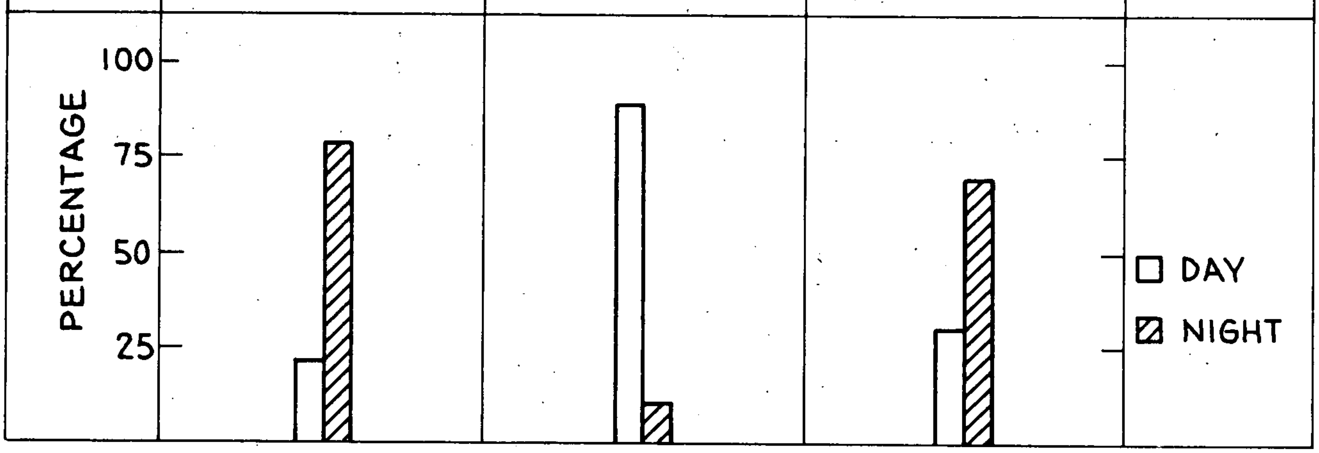
White perch				
Week	Bottom	Mid-depth	Surface	Day/Night
5 May	0	0	0	D
	0	0	8	N
12 May	0	0	0	D
	0	0	0	N
19 May	0	8	0	D
	0	8	0	N
2 June	24	9	13	D
	0	0	18	N
16 June	16	11	14	D
	17	0	46	N
30 June	0	0	0	D
	27	0	0	N



Note: This species not collected in plankton samples prior to 5 May at this station.

Table 9-15. Diurnal Comparisons of Average No./1000 m^3 at Station 22 — Clupeids

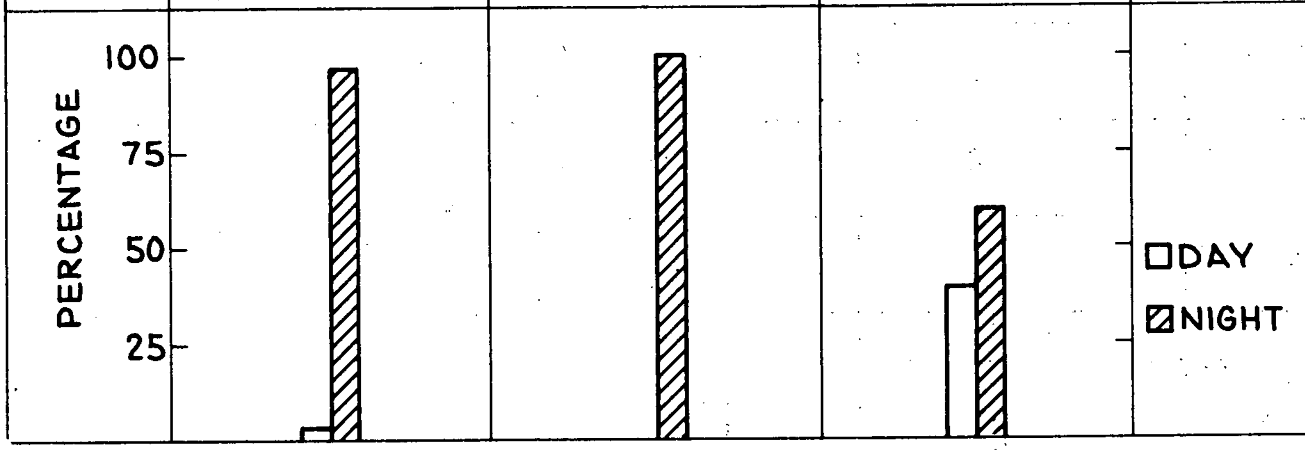
Clupeids (Blueback herring and Alewife combined)				
Week	Bottom	Mid-depth	Surface	Day/Night
5 May	0 55	0 0	7 76	D N
12 May	8 72	15 0	60 206	D N
19 May	21 0	130 16	6 20	D N
2 June	8 8	9 0	84 54	D N
16 June	0 0	45 7	56 80	D N
30 June	0 0	0 0	0 41	D N



Note: This species not collected in plankton samples prior to 5 May at this station.

Table 9-16. Diurnal Comparisons of Average No./1000 m^3 at Station 22 — Bay Anchovy

Bay anchovy				
Week	Bottom	Mid-depth	Surface	Day/Night
16 June	16 473	0 0	76 23	D N
30 June	0 53	0 8	0 95	D N



Note: This species not collected in plankton samples previous to 16 June.

Table 9-17. Diurnal Comparisons of Average No./1000 m^3 at Station 22 — Gammarus

Gammarus fasciatus (Amphipod)				
Week	Bottom	Mid-depth	Surface	Day/Night
25 March	343 868	0 361	0 384	D N
7 April	394 265	102 454	32 944	D N
21 April	1243 2386	0 724	0 784	D N
5 May	854 1669	11 536	0 527	D N
12 May	0 1541	142 264	0 154	D N
19 May	0 250	0 484	32 47	D N
2 June	8571 13445	44 4667	0 4810	D N
16 June	39 7867	730 4605	0 2431	D N
30 June	1590 4956	0 1933	46 1459	D N

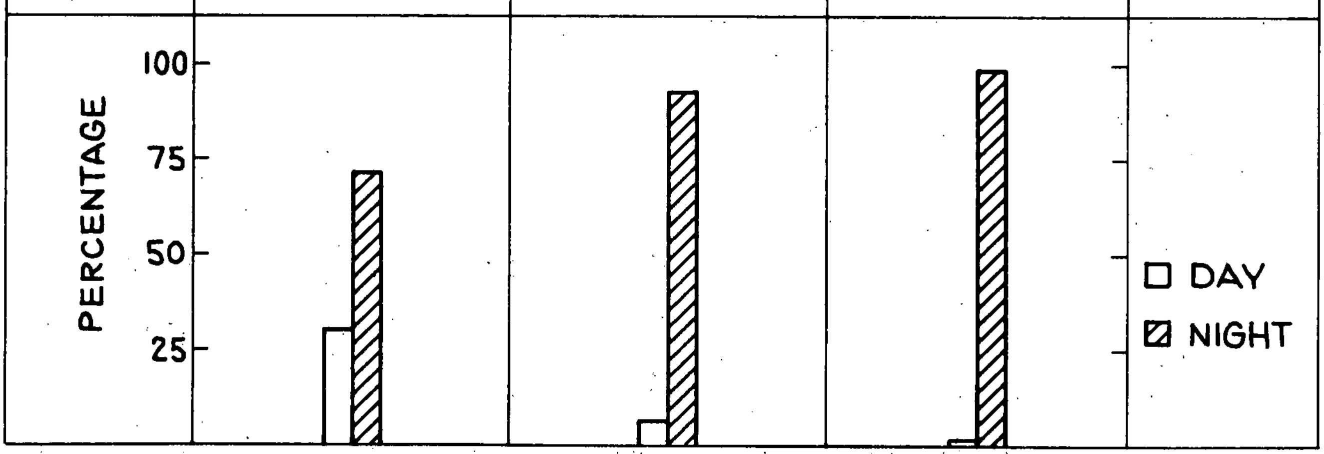


Table 9-18. Diurnal Comparisons of Average No./1000 m^3 at Station 22 — Pontocrates

Pontocrates norvegicus (Amphipod)				
Week	Bottom	Mid-depth	Surface	Day/Night
25 March	457 1333	0 2807	0 665	D N
7 April	189 477	59 647	0 222	D N
21 April	1074 6456	0 4495	0 1731	D N
5 May	2780 1543	213 871	0 1073	D N
12 May	0 1730	7 1318	0 772	D N
19 May	0 397	0 219	32 309	D N
2 June	508 264	9 349	0 524	D N
16 June	54 4600	45 1405	0 846	D N
30 June	386 5027	0 933	28 338	D N

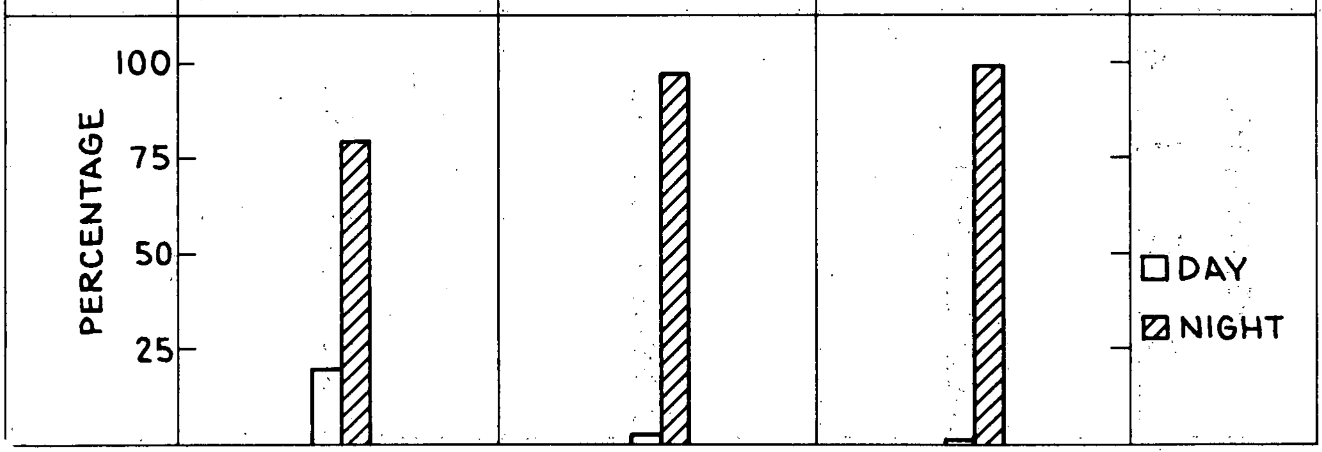
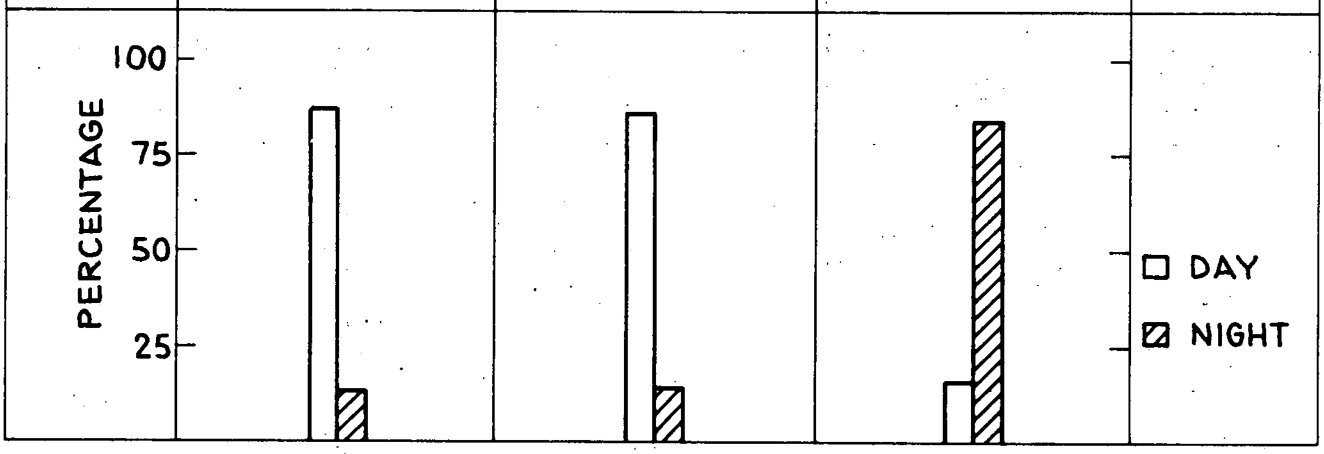


Table 9-19. Diurnal Comparisons of Average No./1000 m^3 at Station 22 — Atlantic Tomcod

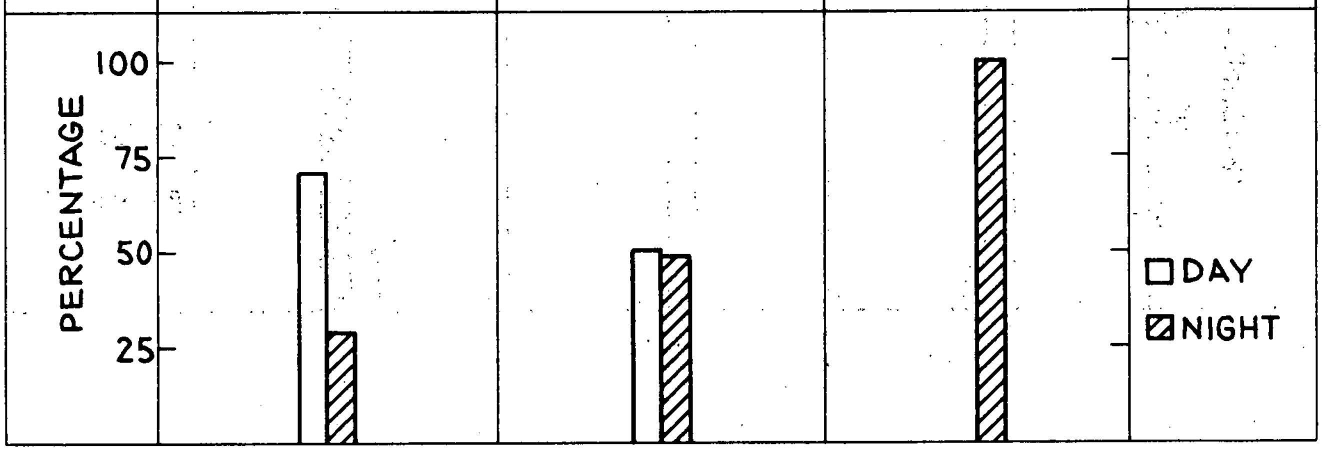
Atlantic tomcod				
Week	Bottom	Mid-depth	Surface	Day/Night
25 March	1505 225	2533 294	129 500	D N
7 April	63 23	8 17	14 49	D N
21 April	3044 403	41 95	46 479	D N



Note: Tomcod larvae not collected at Station 22 after April. Young of the year Tomcod most abundant species in bottom trawls during May and June (See Table 10-14).

Table 9-20. Diurnal Comparisons of Average No./1000 m^3 at Station 22 — Striped Bass

Striped bass				
Week	Bottom	Mid-depth	Surface	Day/Night
12 May	0 0	0 8	0 0	D N
19 May	0 0	0 0	0 0	D N
2 June	111 25	0 16	0 452	D N
16 June	31 25	34 7	0 104	D N
30 June	24 18	15 17	0 14	D N



Note: This species not collected in plankton samples prior to 12 May at this station.

Table 9-21. Diurnal Comparisons of Average No./1000 m^3 at Station 22 — Neomysis

Neomysis americanus (Opossum shrimp)				
Week	Bottom	Mid-depth	Surface	Day/Night
25 March	705 0	22 8	0 0	D N
7 April	0 0	0 0	0 0	D N
21 April	0 0	0 0	0 0	D N
5 May	0 0	0 0	0 0	D N
12 May	0 0	0 0	0 0	D N
19 May	0 22	0 47	6 0	D N
2 June	0 0	0 0	0 6	D N
16 June	132 266	0 157	0 266	D N
30 June	4867 2337	582 433	0 378	D N

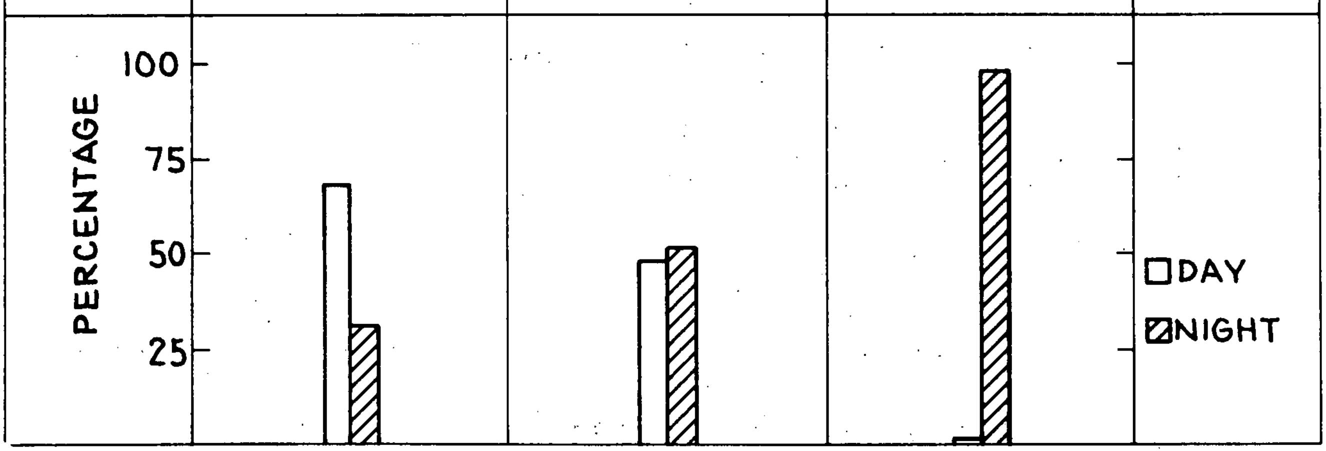


Table 9-22. Selected Planktonic Species Collected Outside the Primary Study Area

	MAY			JUNE		
STATION	4	6	14	4	6	14
MILE	35	38	47			
SITE	2	2	3			
DEPTH	34	30	55			
Striped Bass						
S	0	3	6	0	0	0
M	0	0	17	0	96	4
B	35	23	372	89	18	7
Tomcod						
S	0	0	0	0	0	0
M	0	0	0	0	0	0
B	0	8	60	0	0	0
Clupeid						
S	21	12	8	0	13	653
M	4	0	178	8	8	1
B	0	0	0	0	0	0
G. fasciatus						
S	0	6	23	0	0	11
M	0	12	108	0	8	P
B	4116	4733	3828	384	4429	908
P. norvegicus						
S	0	0	45	0	0	0
M	0	4	18	0	0	1
B	1535	2530	515	1348	6643	13
L. pinguis						
S	0	0	7	0	0	0
M	0	0	0	0	0	P
B	95	53	60	0	0	26
N. americanus						
S	0	0	0	0	0	0
M	0	0	0	0	0	0
B	325	248	0	1571	9500	33

P = denotes average of less than 1 per 1000 meters ^{3}

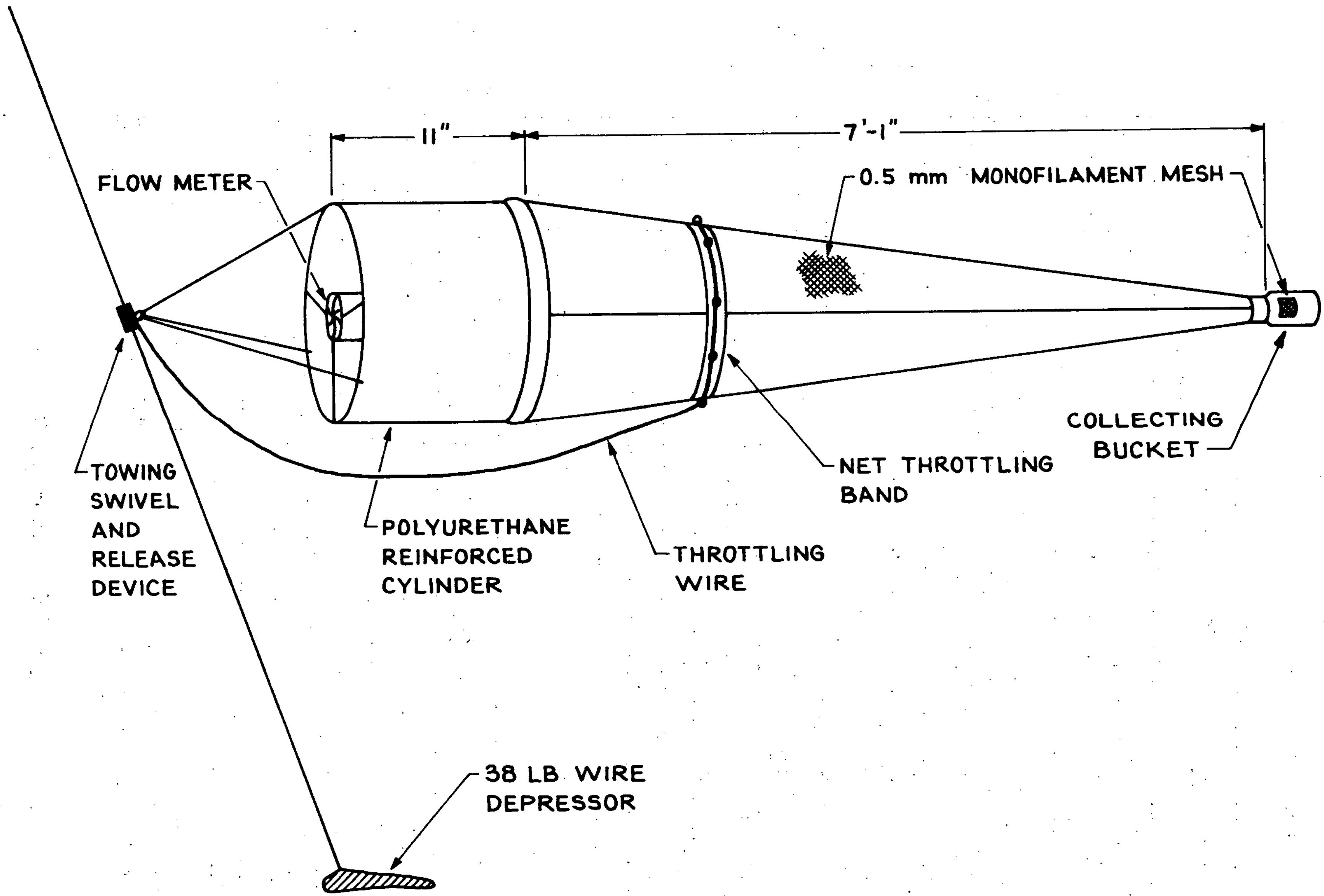


Figure 9-1. Plankton Net

INVERTEBRATE ANALYSIS SHEET A SERIAL NO.__________

Locality __________ Device __________ Depth ____ ft. Page ____ of ____

Coll. by __________ Date __________ Time __________

Sample Fraction [/] Specimens Saved [ ]

SPECIES NAME						
Species Code						
Subsample Fraction	/	/	/	/	/	/
Counting Method						
Subsample Count						
Subsample Wt.(g)						
Size Classes						
Breeding						
Life Stage						

SPECIES NAME						
Species Code						
Subsample Fraction	/	/	/	/	/	/
Counting Method						
Subsample Count						
Subsample Wt.(g)						
Size Classes						
Breeding						
Life Stage						

SPECIES NAME						
Species Code						
Subsample Fraction	/	/	/	/	/	/
Counting Method						
Subsample Count						
Subsample Wt.(g)						
Size Classes						
Breeding						
Life Stage						

Remarks: Analyzed by __________

Date __________

MAY '70 RAYTHEON

Figure 9-2. Laboratory Data Sheet

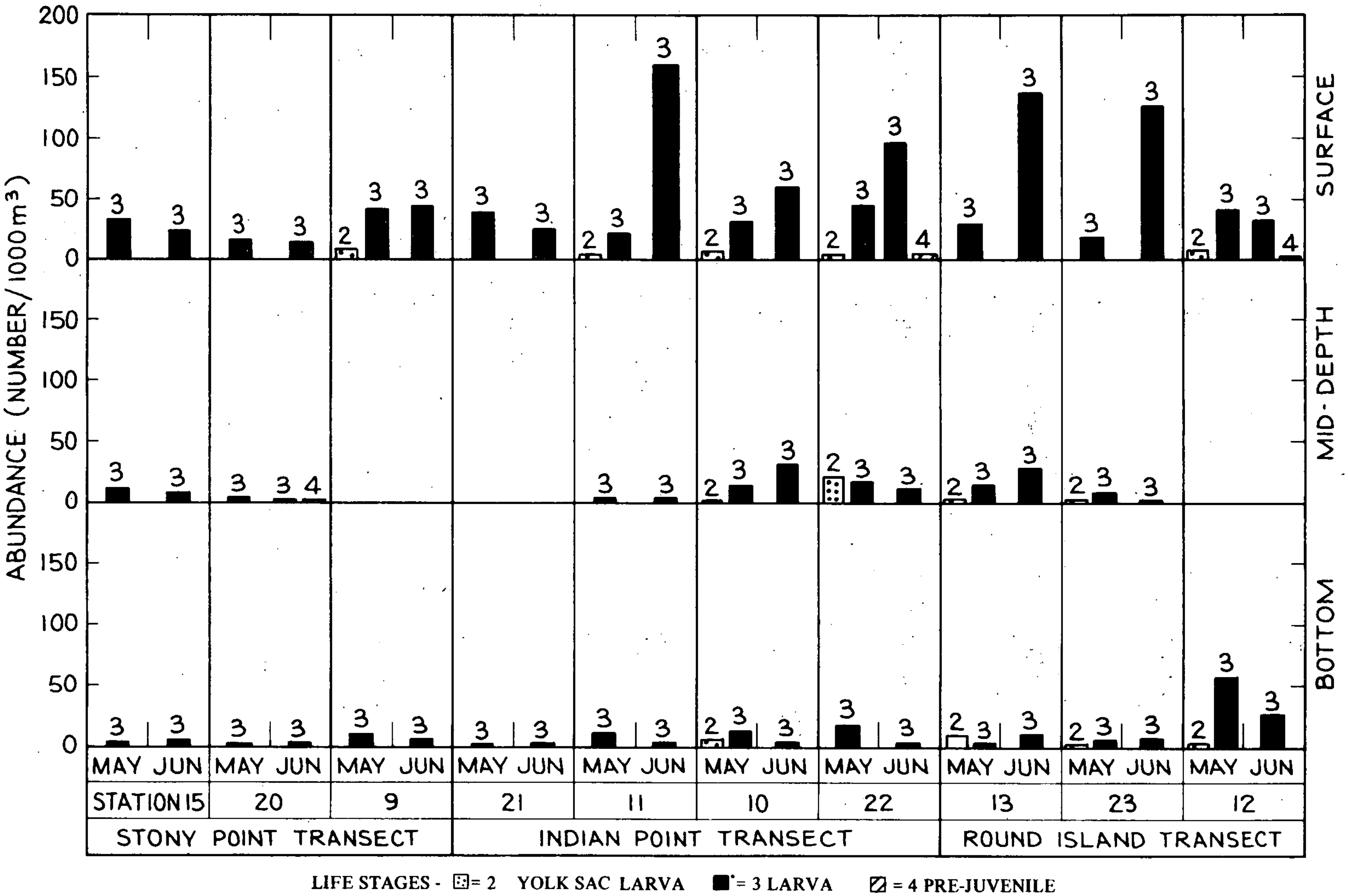


Figure 9-3. Spatial Distribution of the Planktonic Stages of the Clupeids

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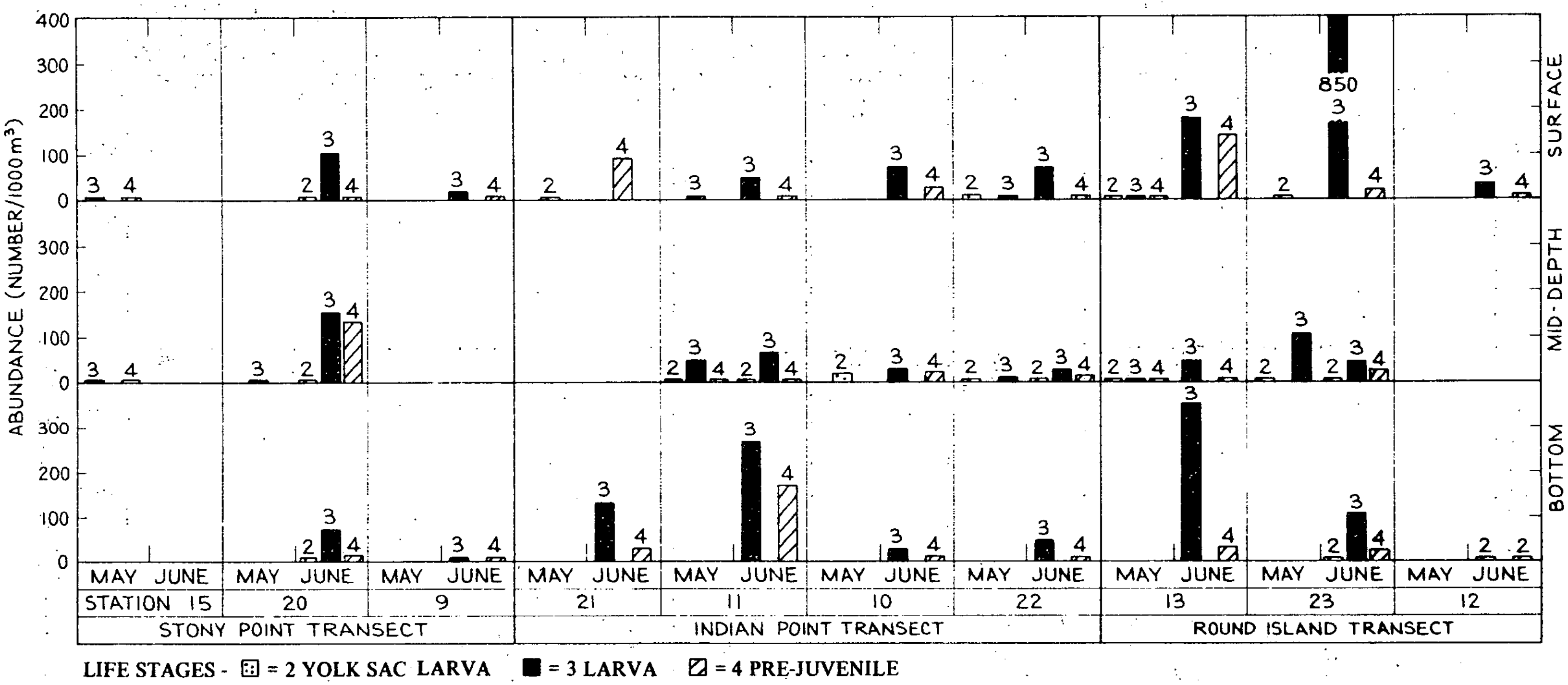

Figure 9-4. Spatial Distribution of the Planktonic Stages of Striped Bass

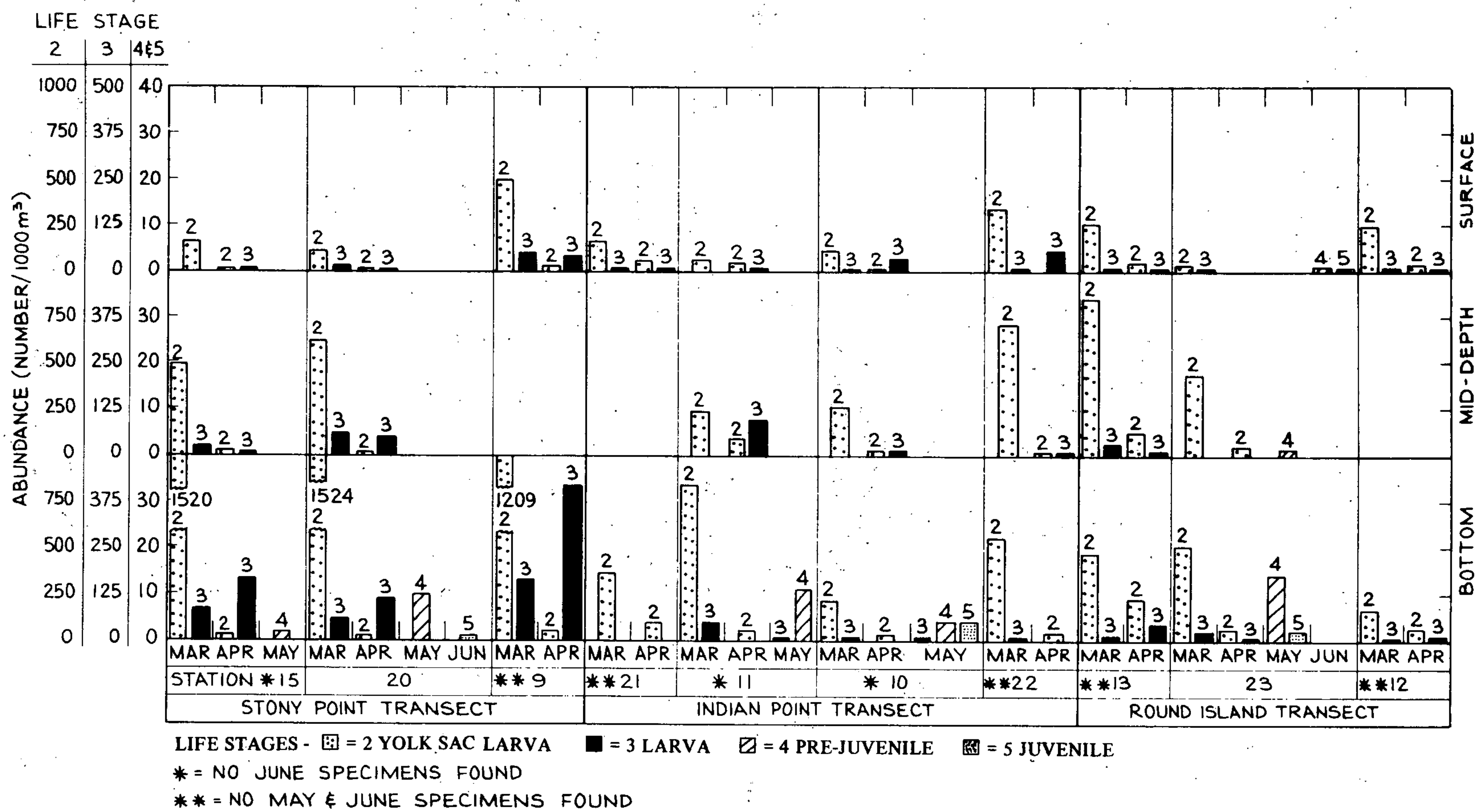

Figure 9-5. Spatial Distribution of the Planktonic Stages of the Atlantic Tomcod

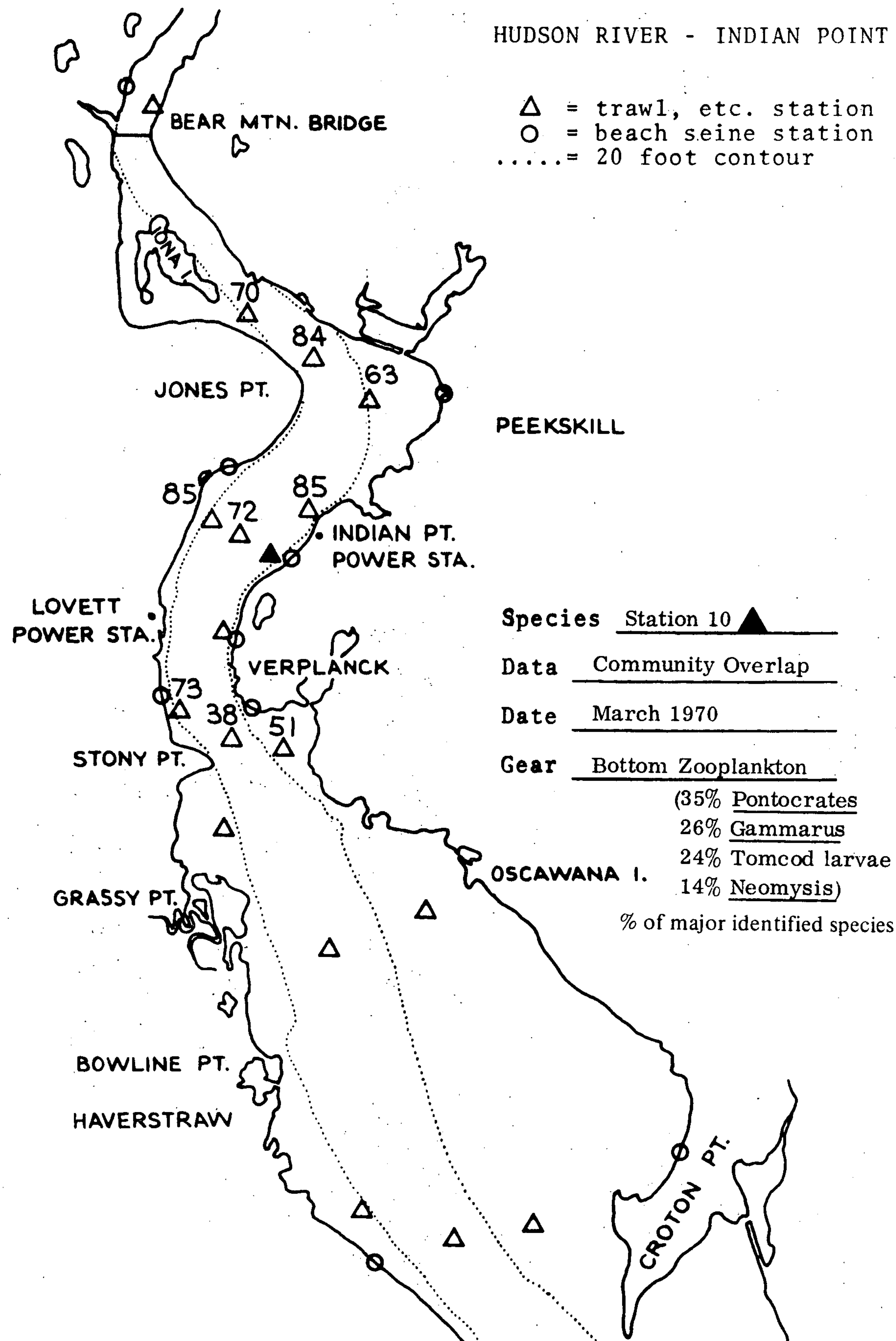

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Figure 9-6. Community Overlap Bottom Zooplankton Station 10, March

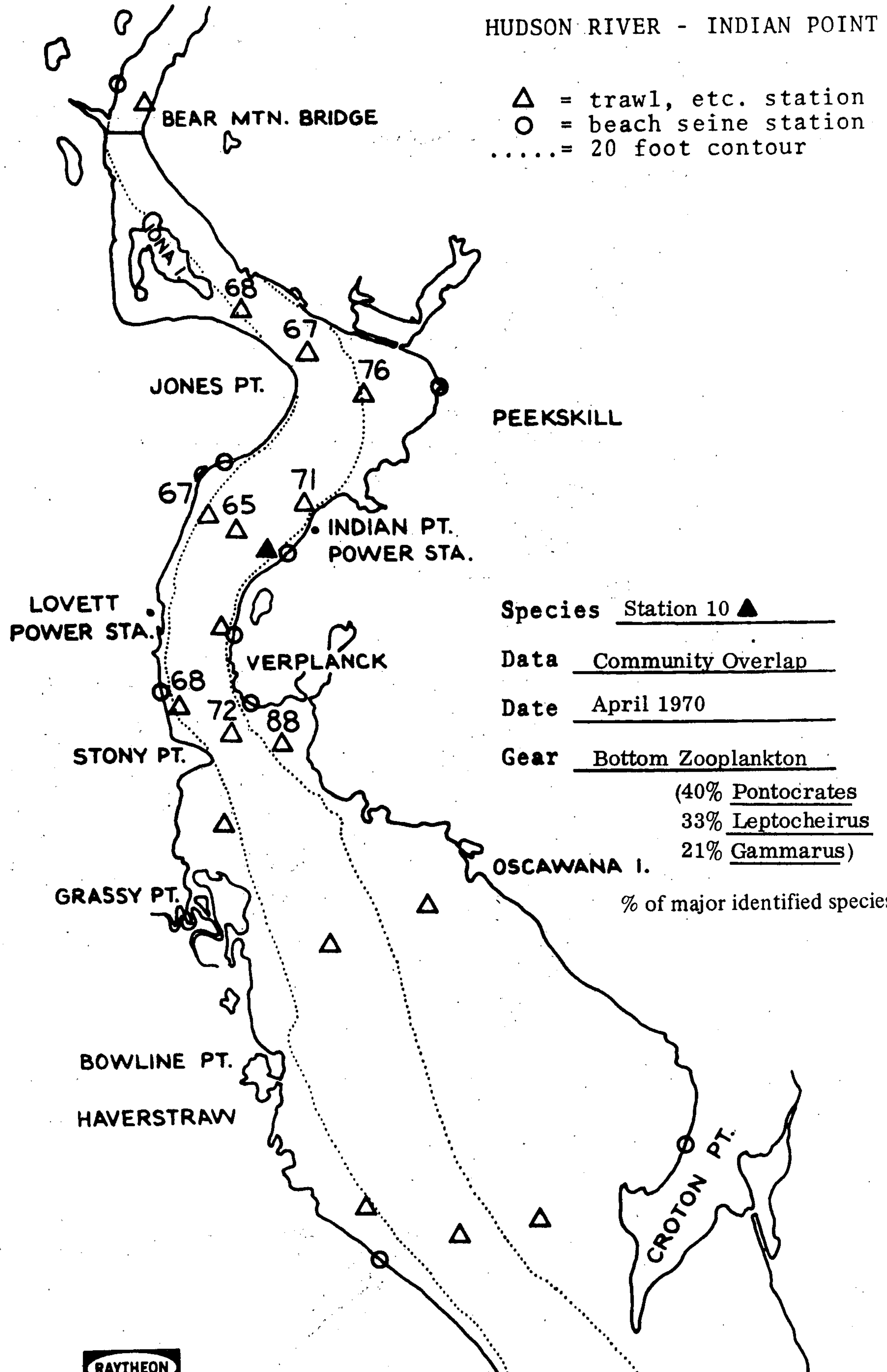

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Figure 9-7. Community Overlap Bottom Zooplankton Station 10, April

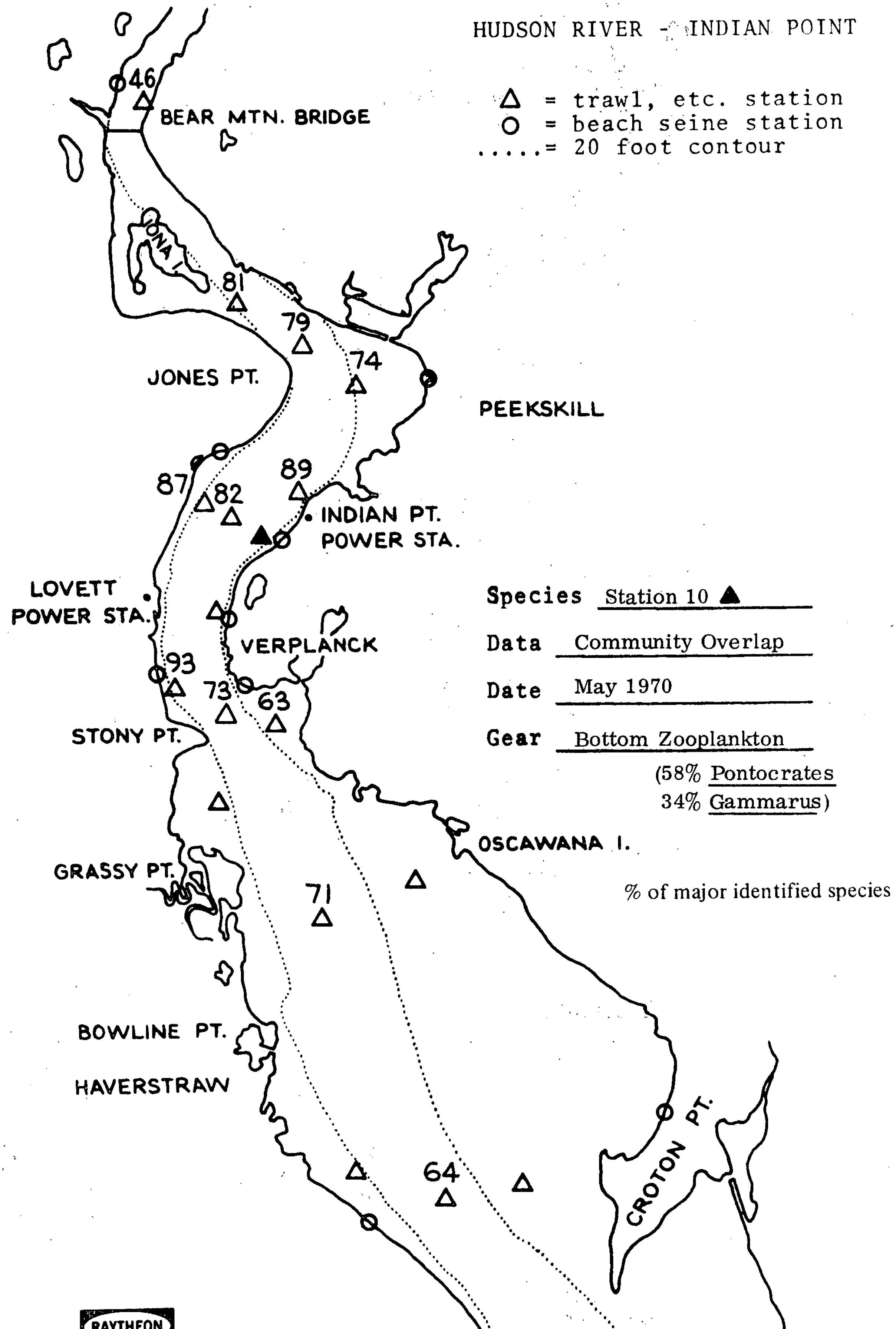

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Figure 9-8. Community Overlap Bottom Zooplankton Station 10, May

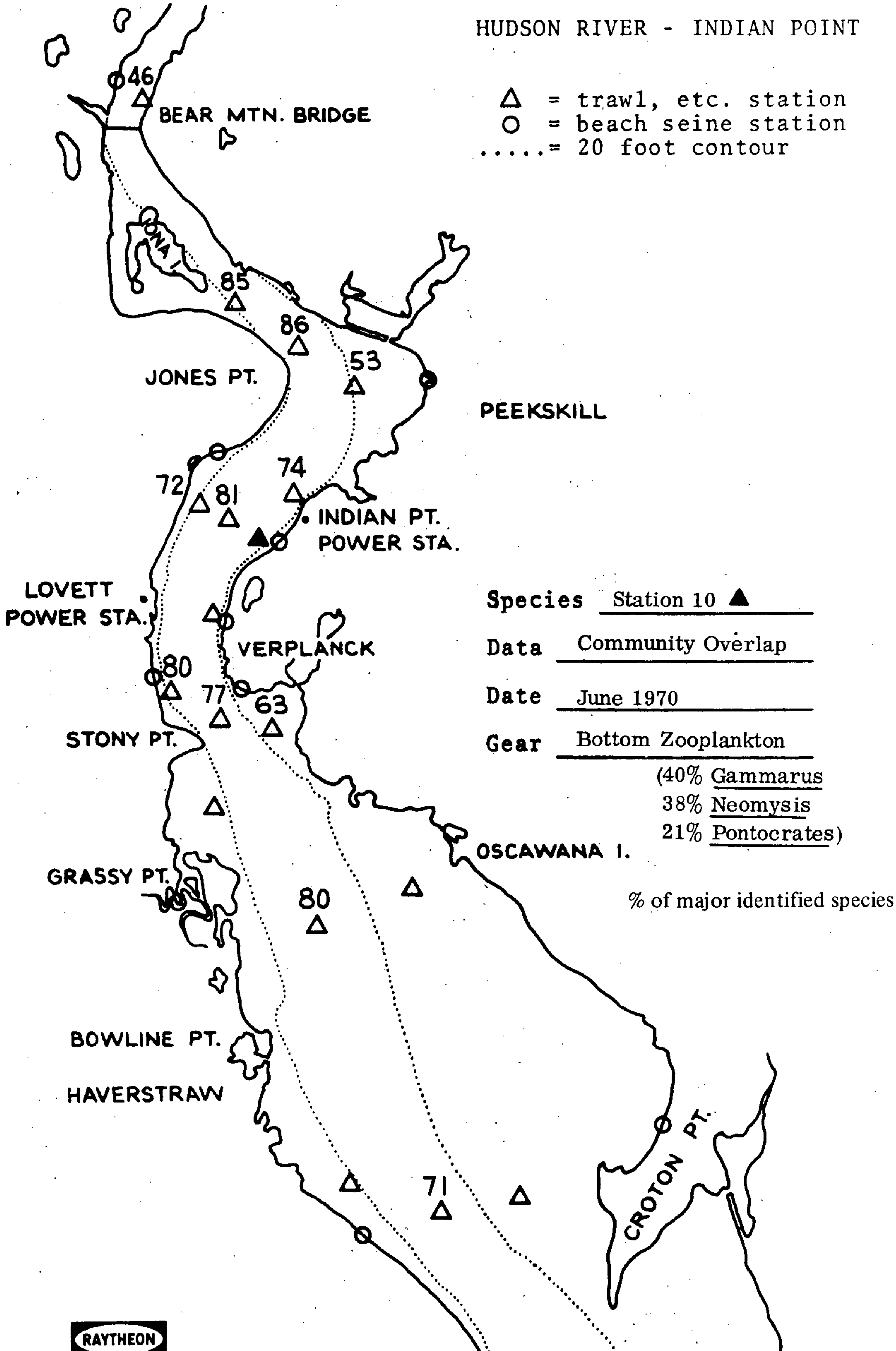


Figure 9-9. Community Overlap Bottom Zooplankton Station 10, June

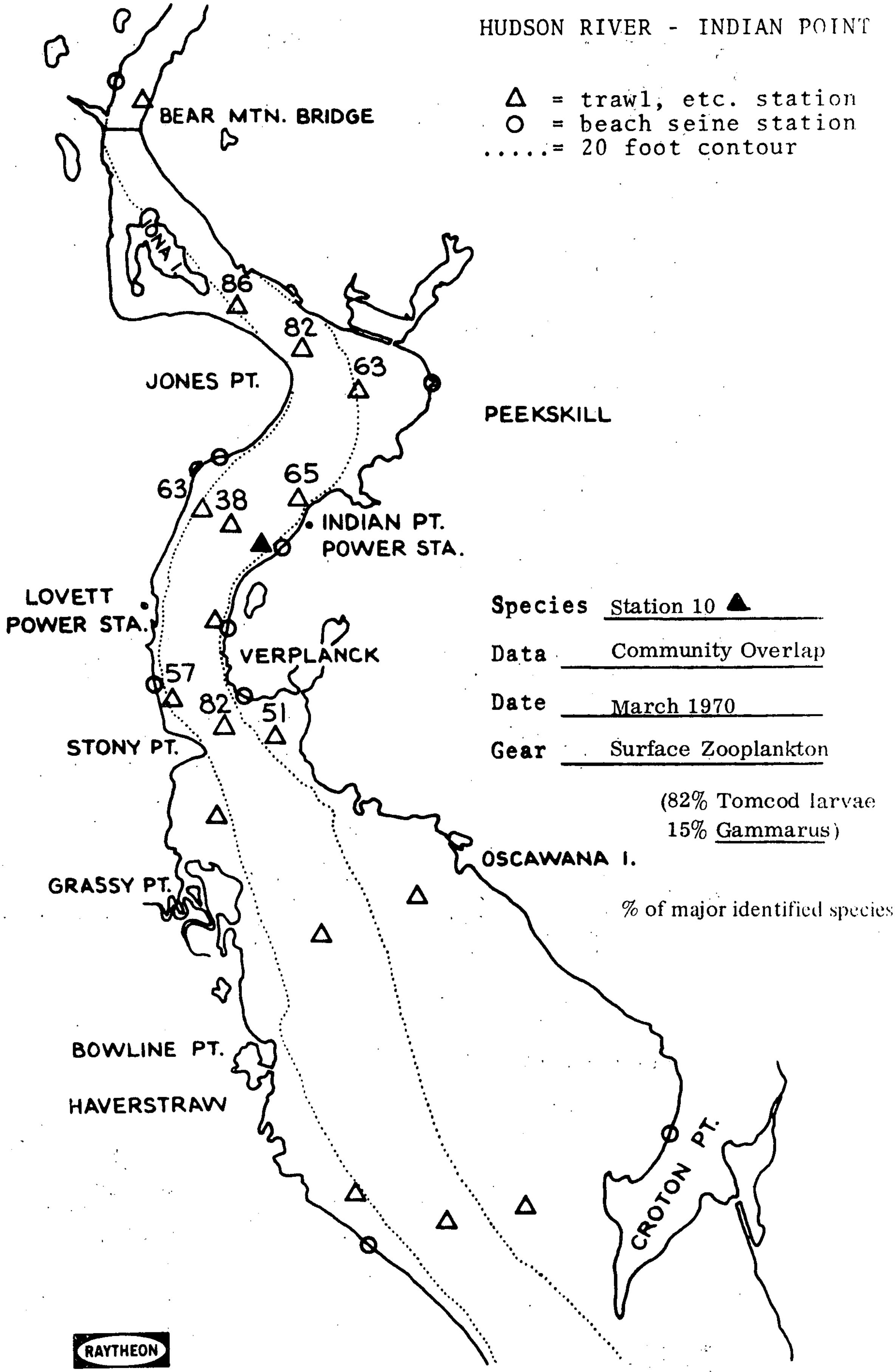


Figure 9-10. Community Overlap Surface Zooplankton Station 10, March

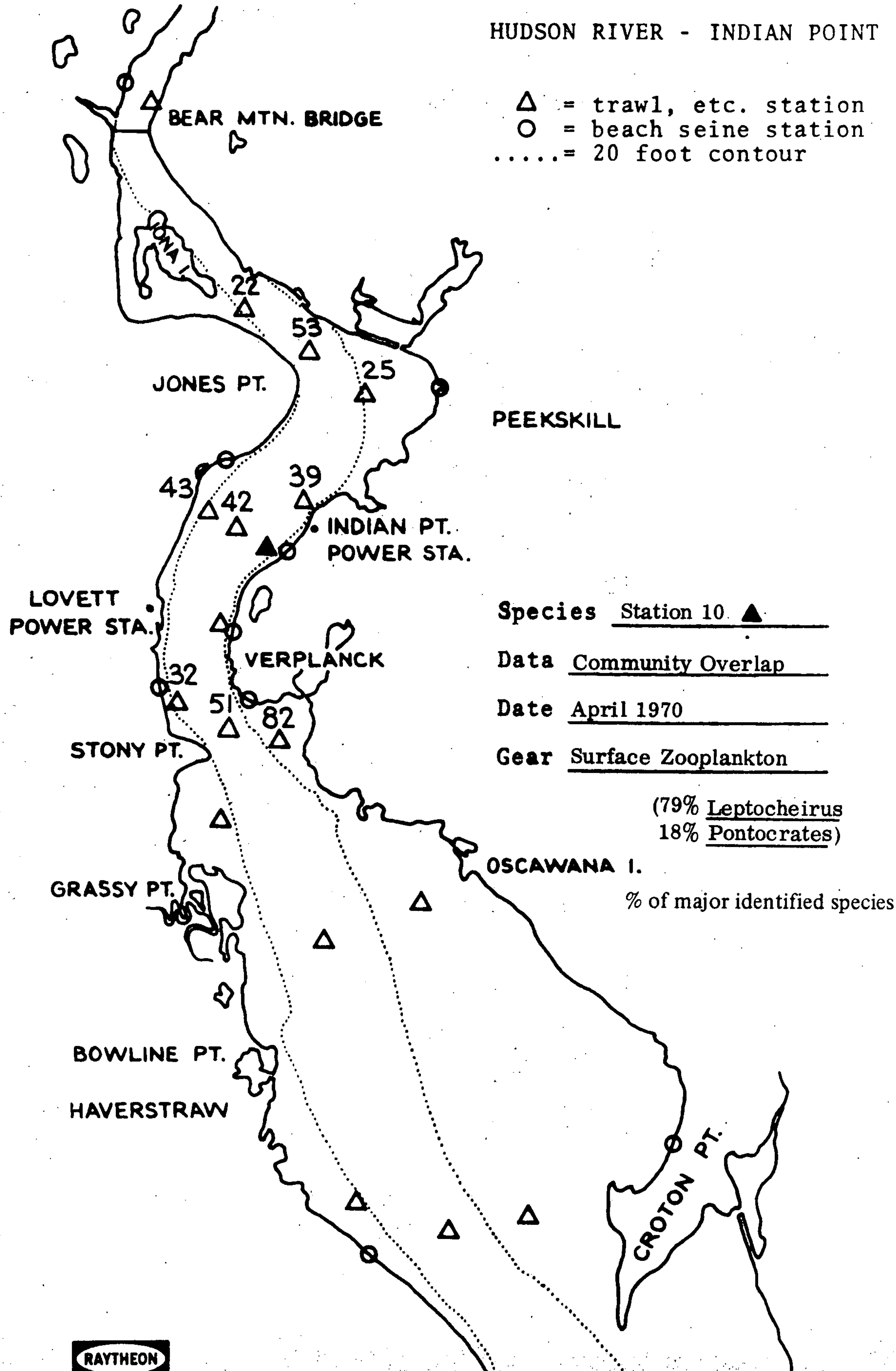


Figure 9-11. Community Overlap Surface Zooplankton Station 10, April

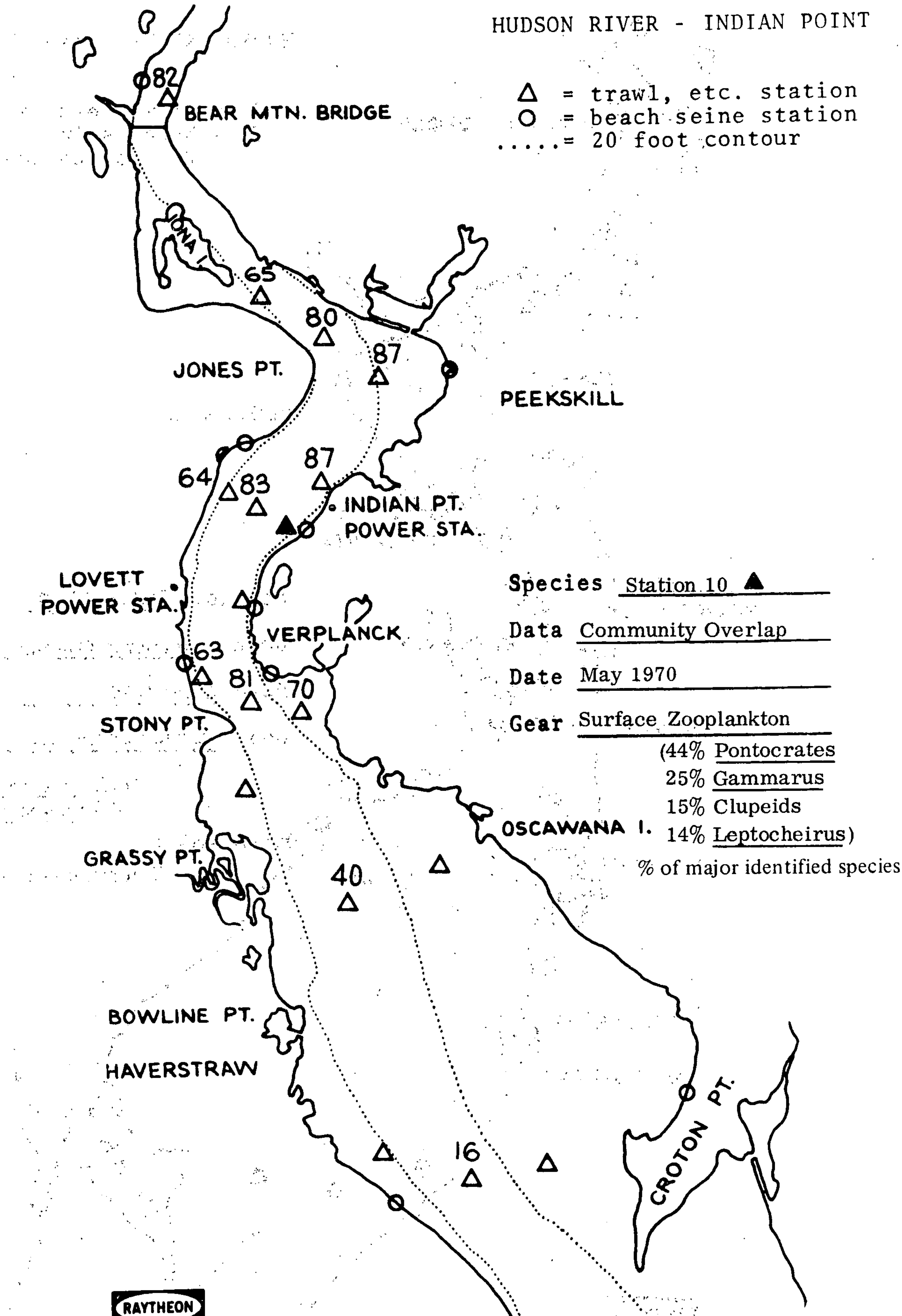


Figure 9-12. Community Overlap Surface Zooplankton Station 10, May

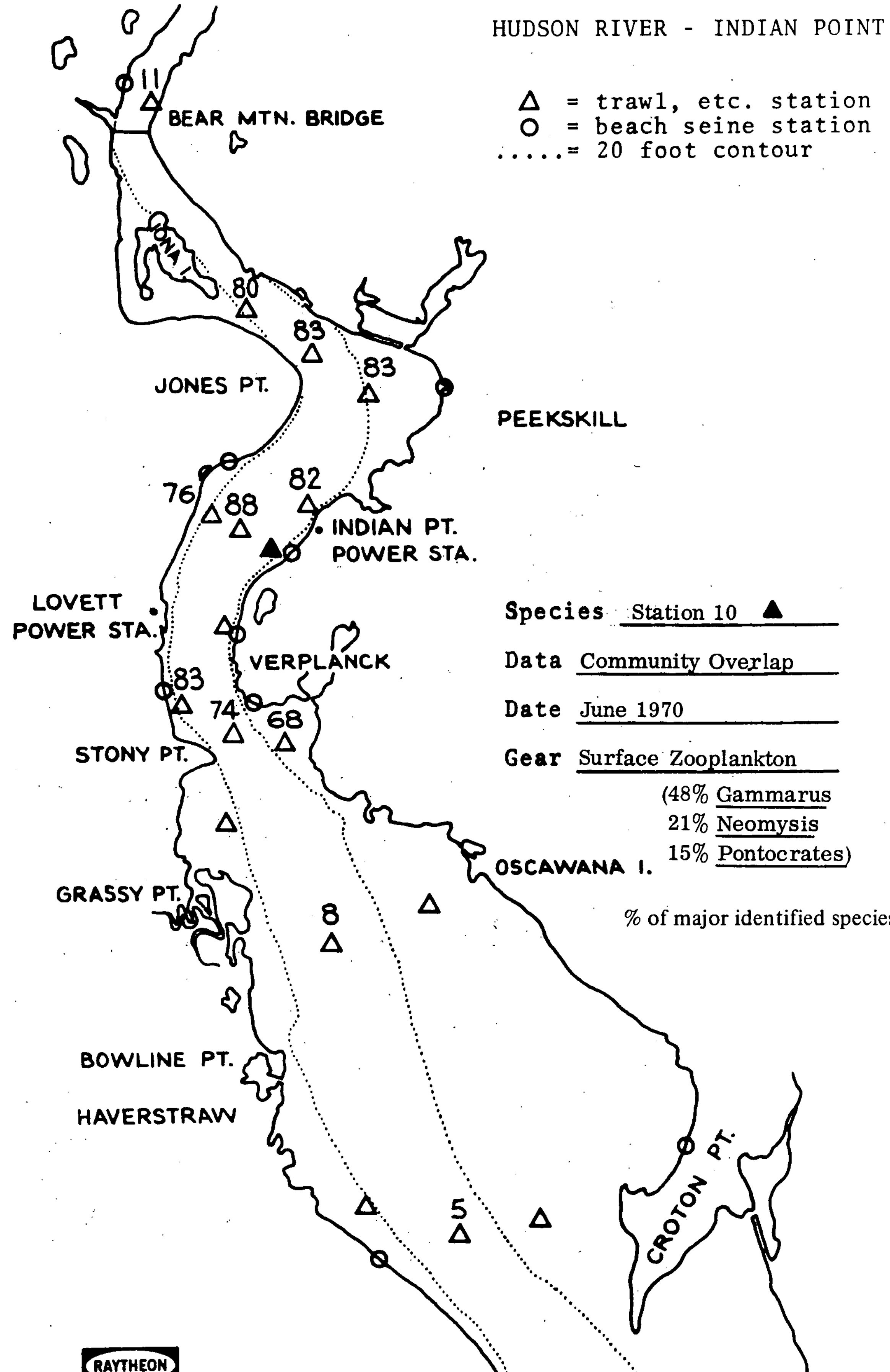


Figure 9-13. Community Overlap Surface Zooplankton Station 10, June

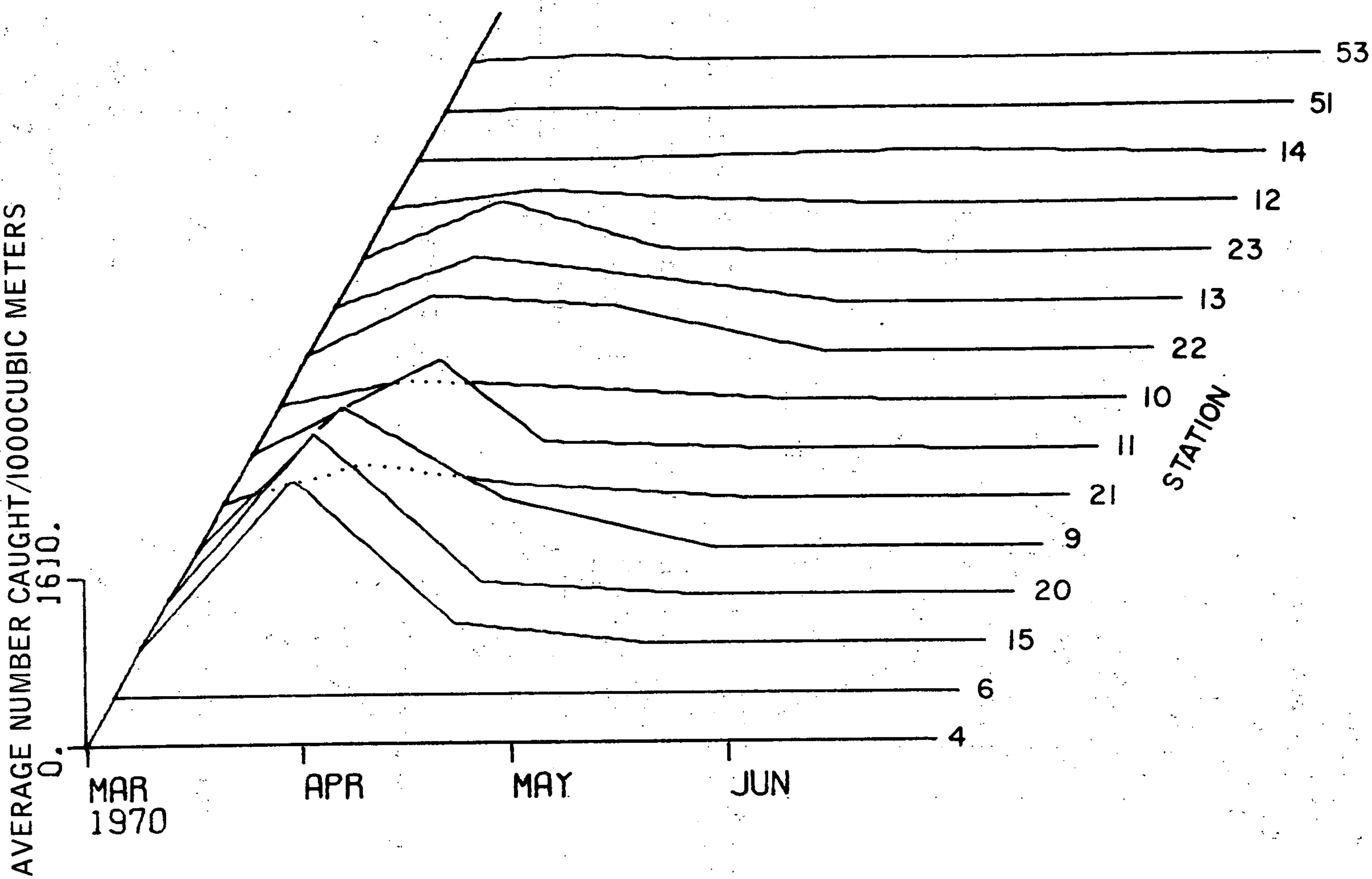


Figure 9-14. Atlantic Tomcod (Bottom Zooplankton)

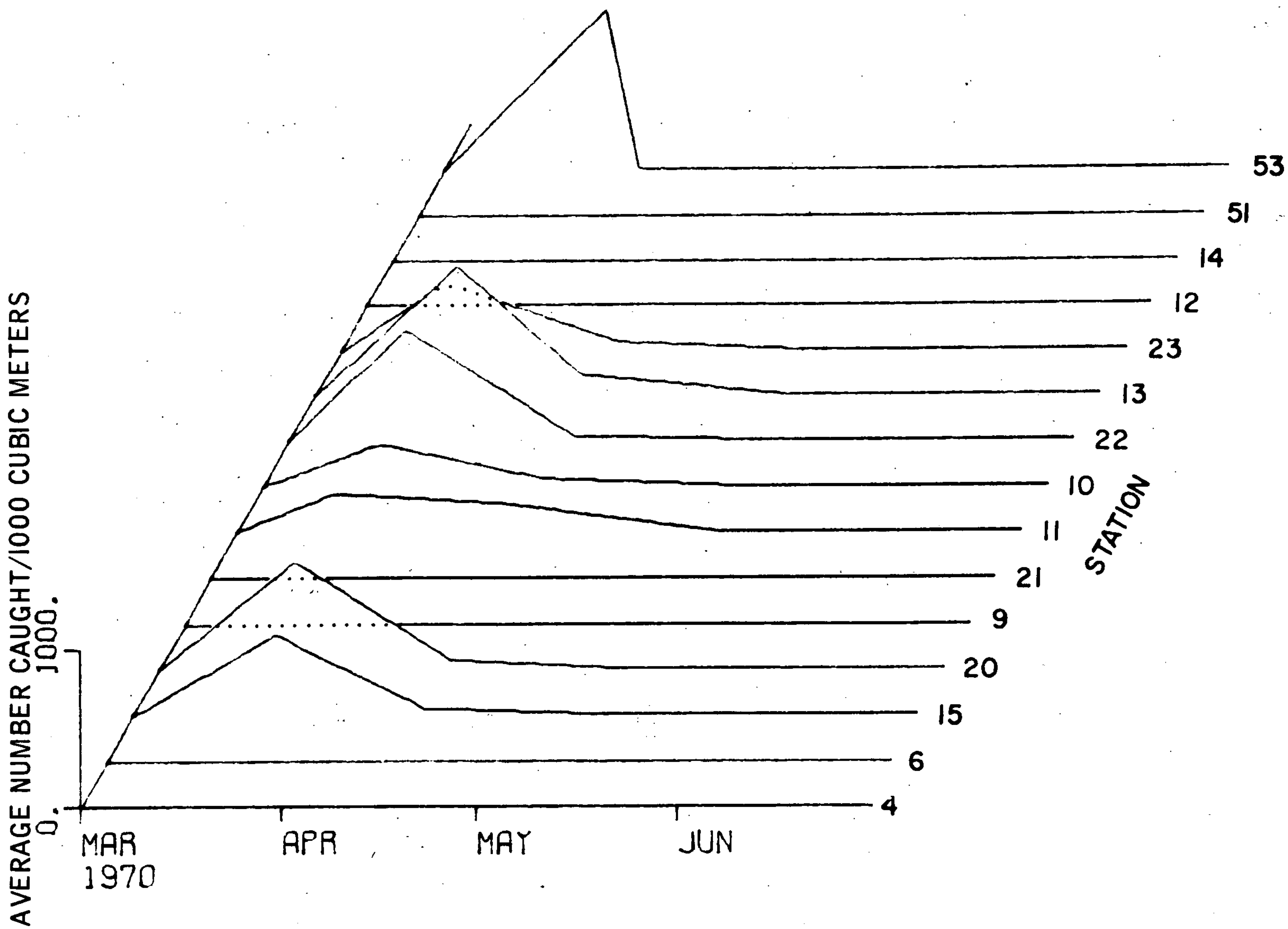


Figure 9-15. Atlantic Tomcod (Mid-Depth Zooplankton)

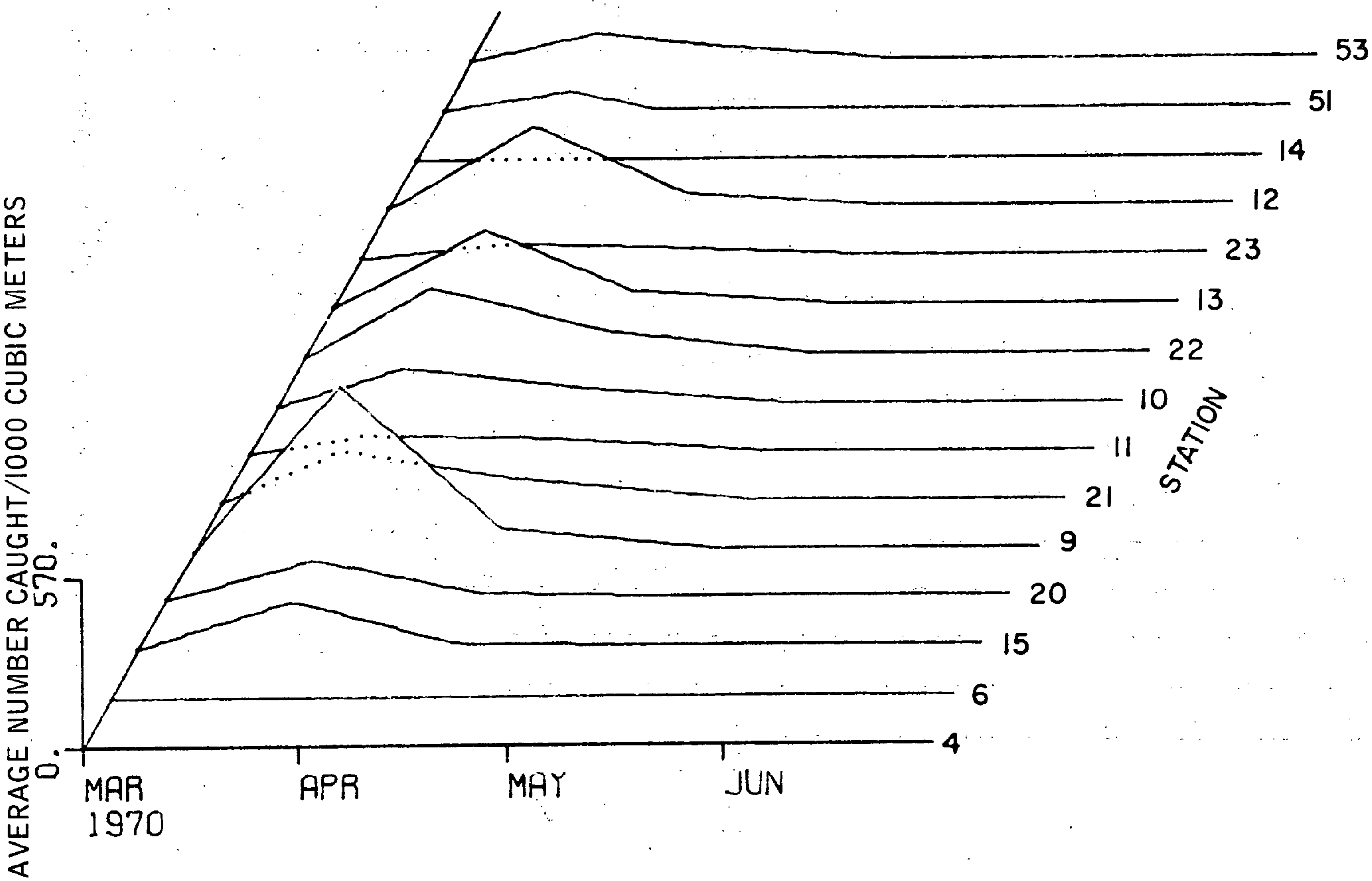


Figure 9-16. Atlantic Tomcod (Surface Zooplankton)

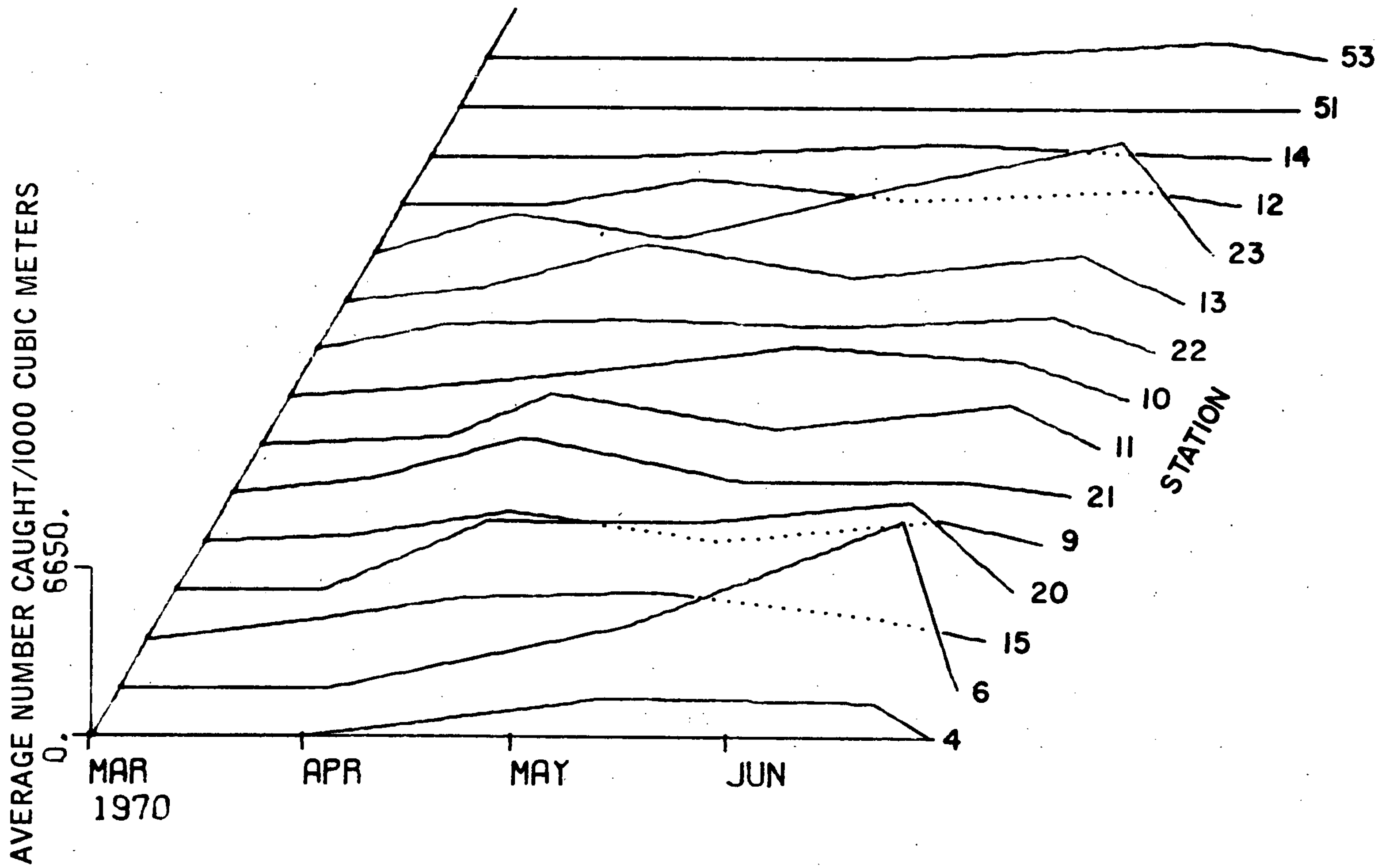


Figure 9-17. Pontocrates norvegicus (Bottom Zooplankton)

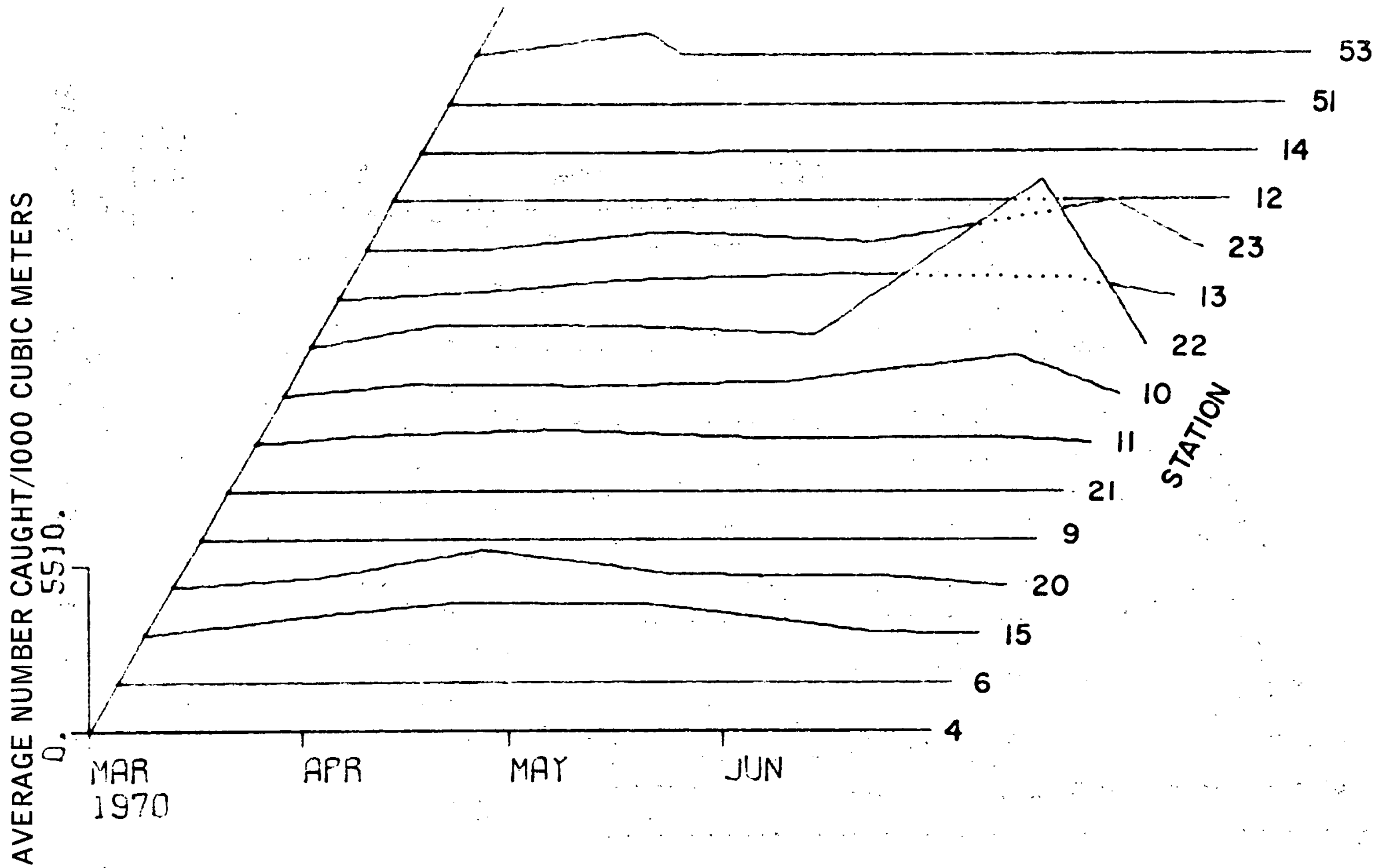


Figure 9-18. Pontocrates norvegicus (Mid-Depth Zooplankton)

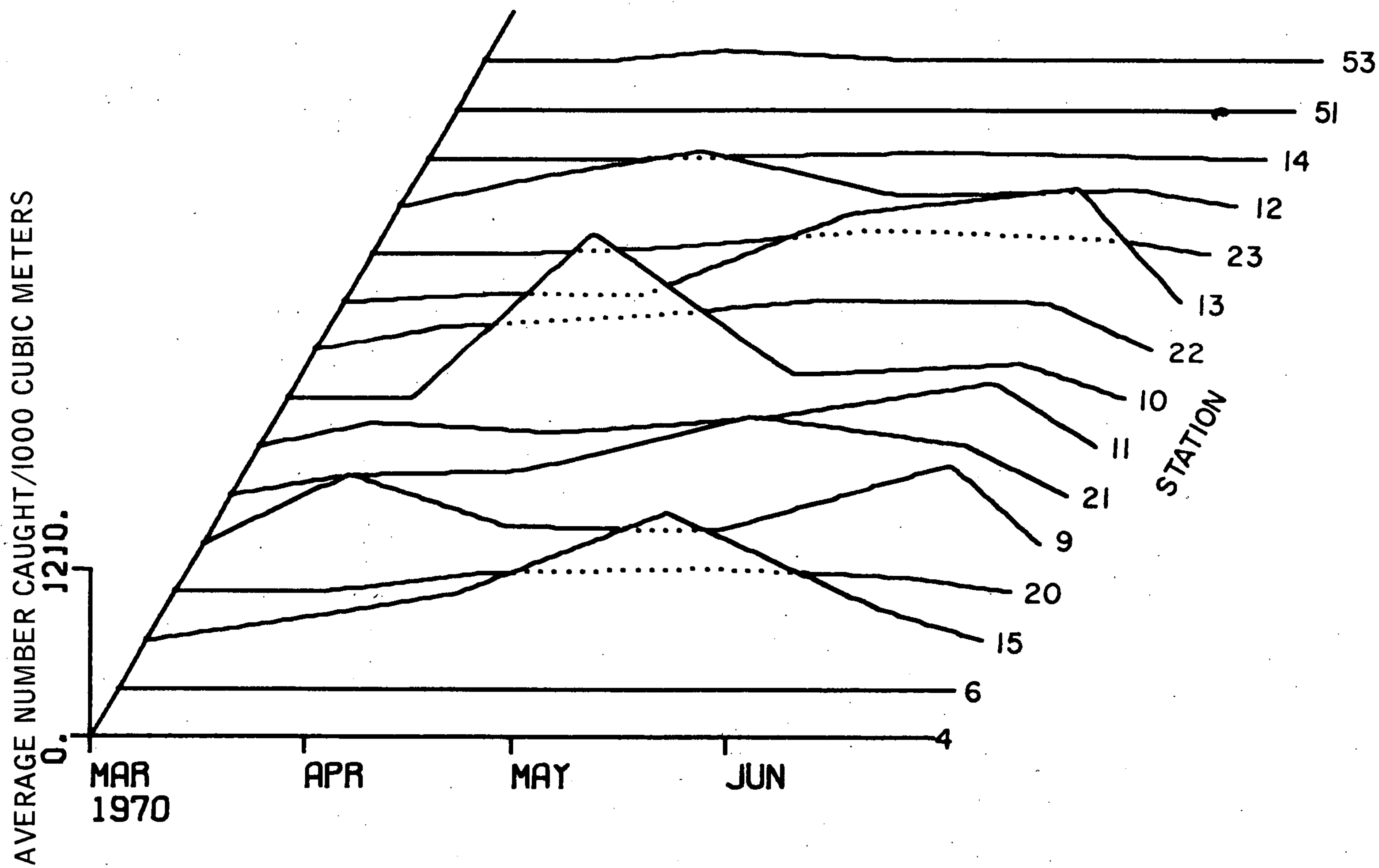


Figure 9-19. Pontocrates norvegicus (Surface Zooplankton)

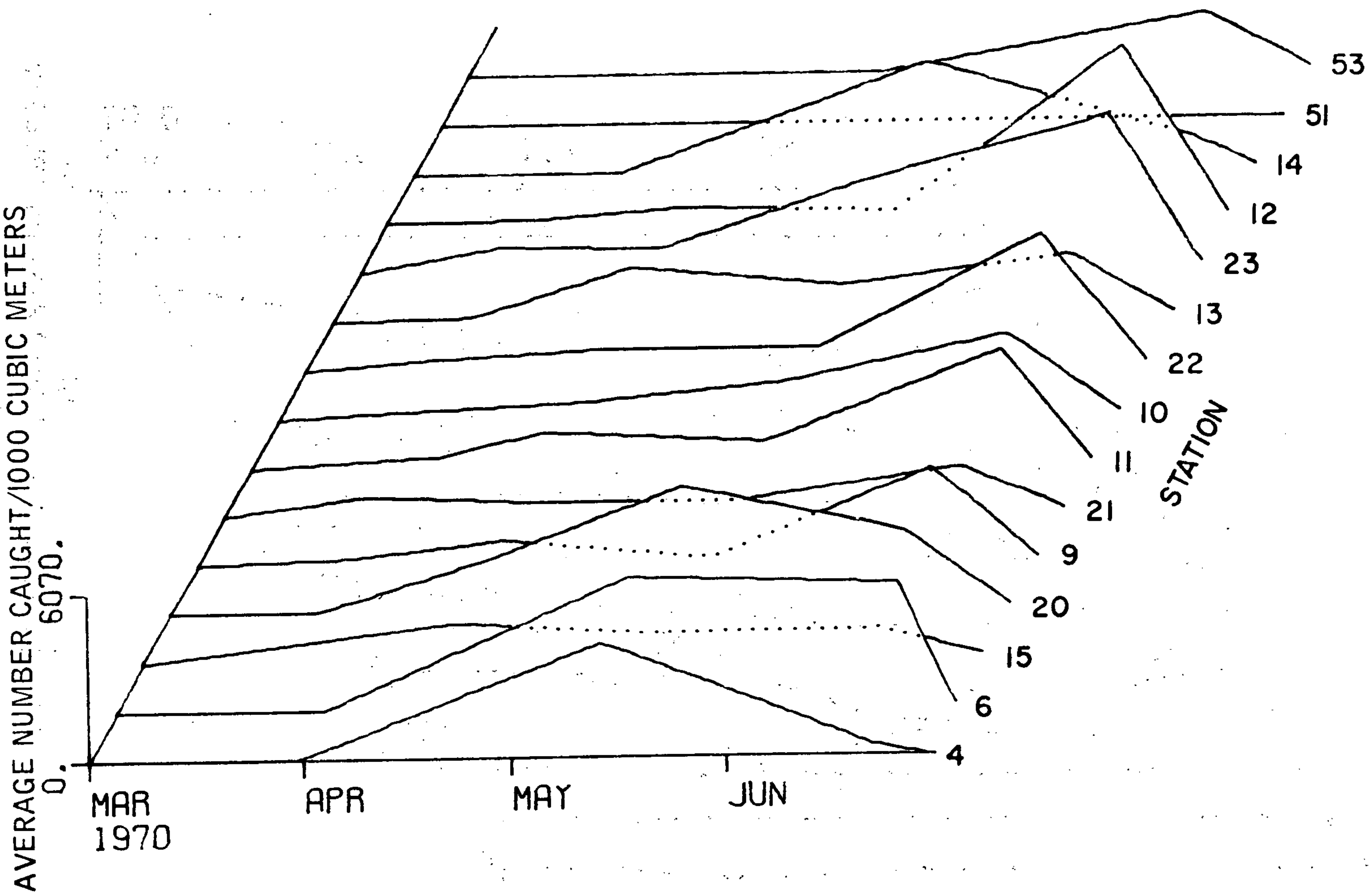


Figure 9-20. Gammarus fasciatus (Bottom Zooplankton)

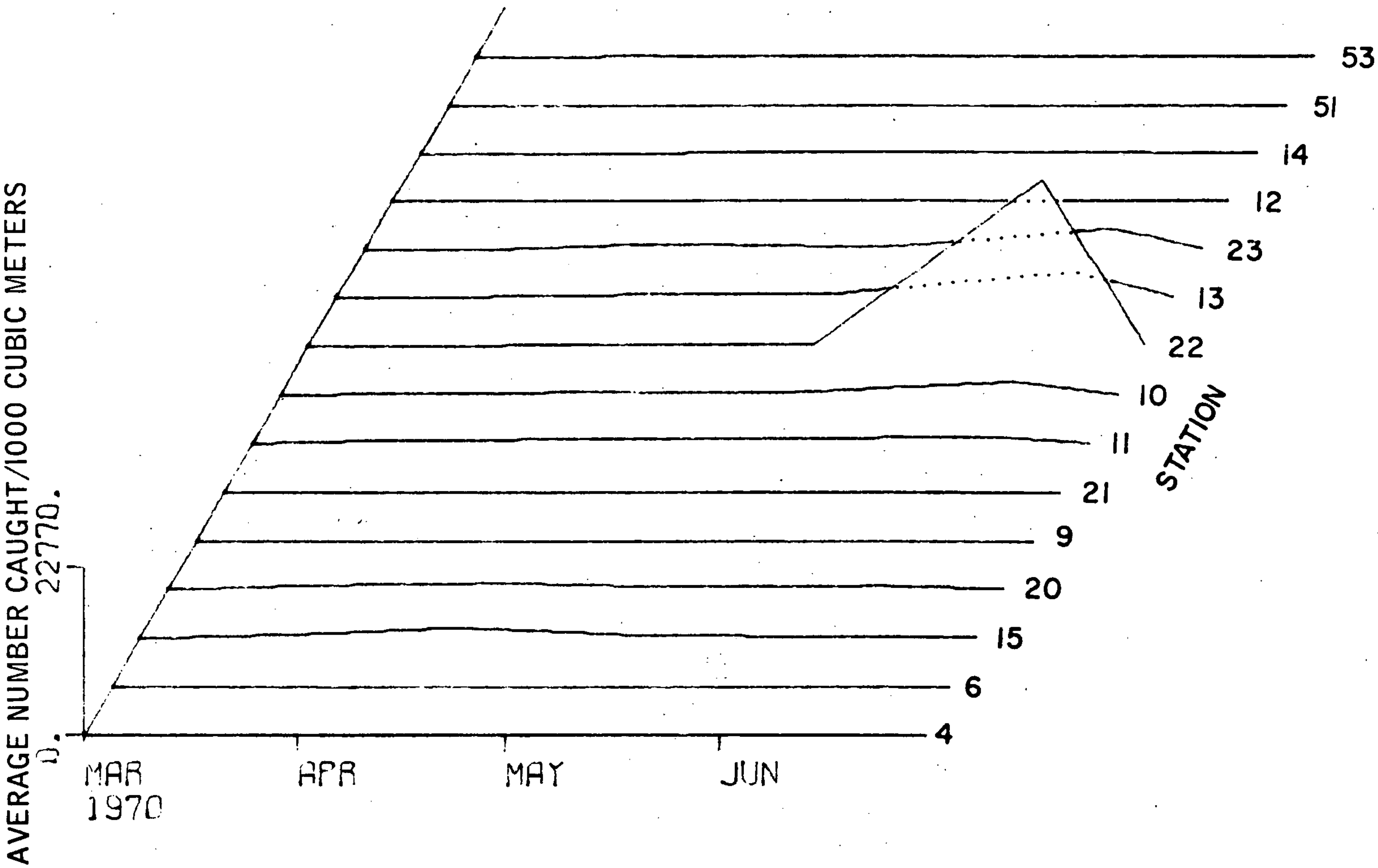


Figure 9-21. Gammarus fasciatus (Mid-Depth Zooplankton)

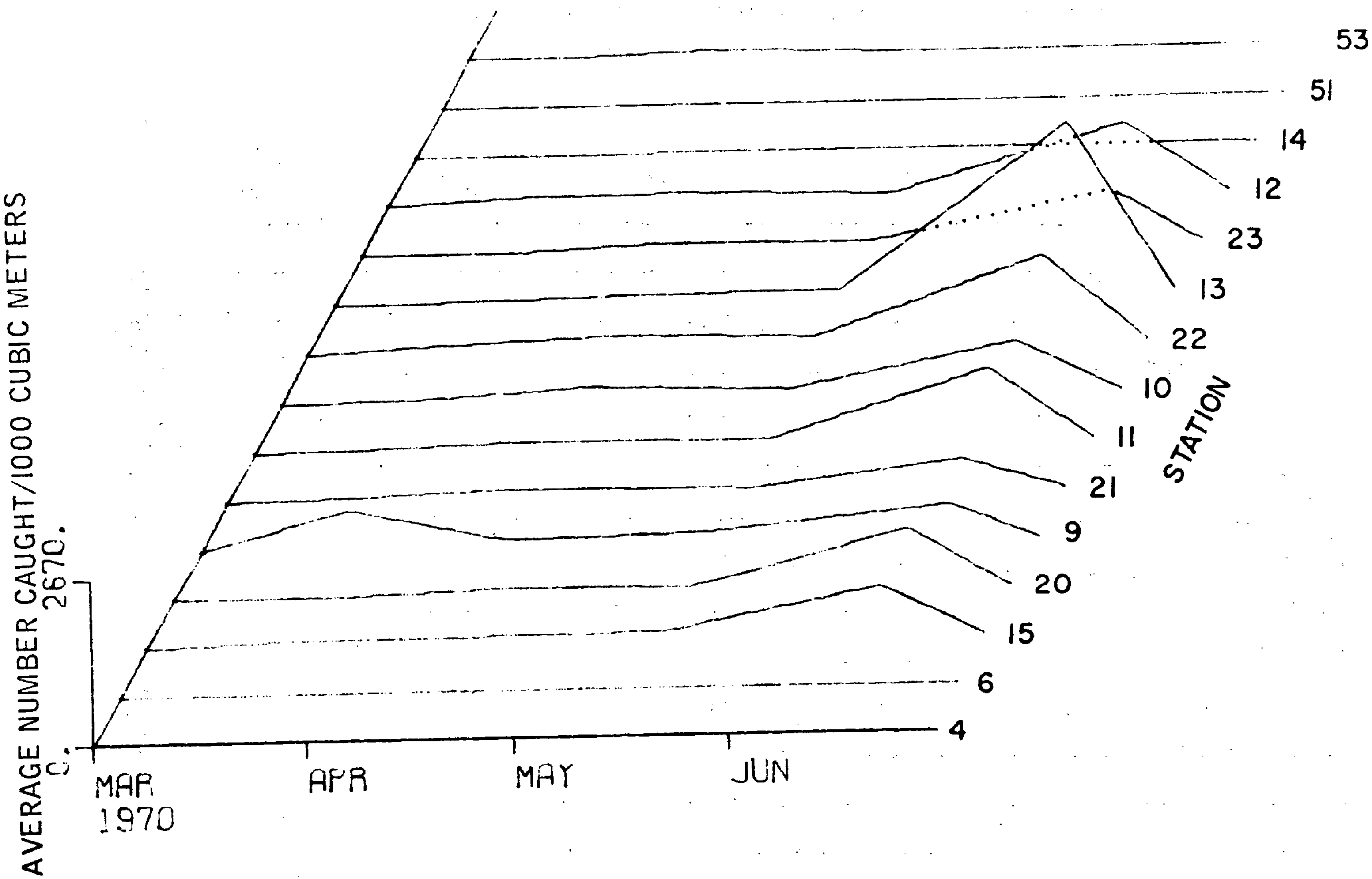


Figure 9-22. Gammarus fasciatus (Surface Zooplankton)

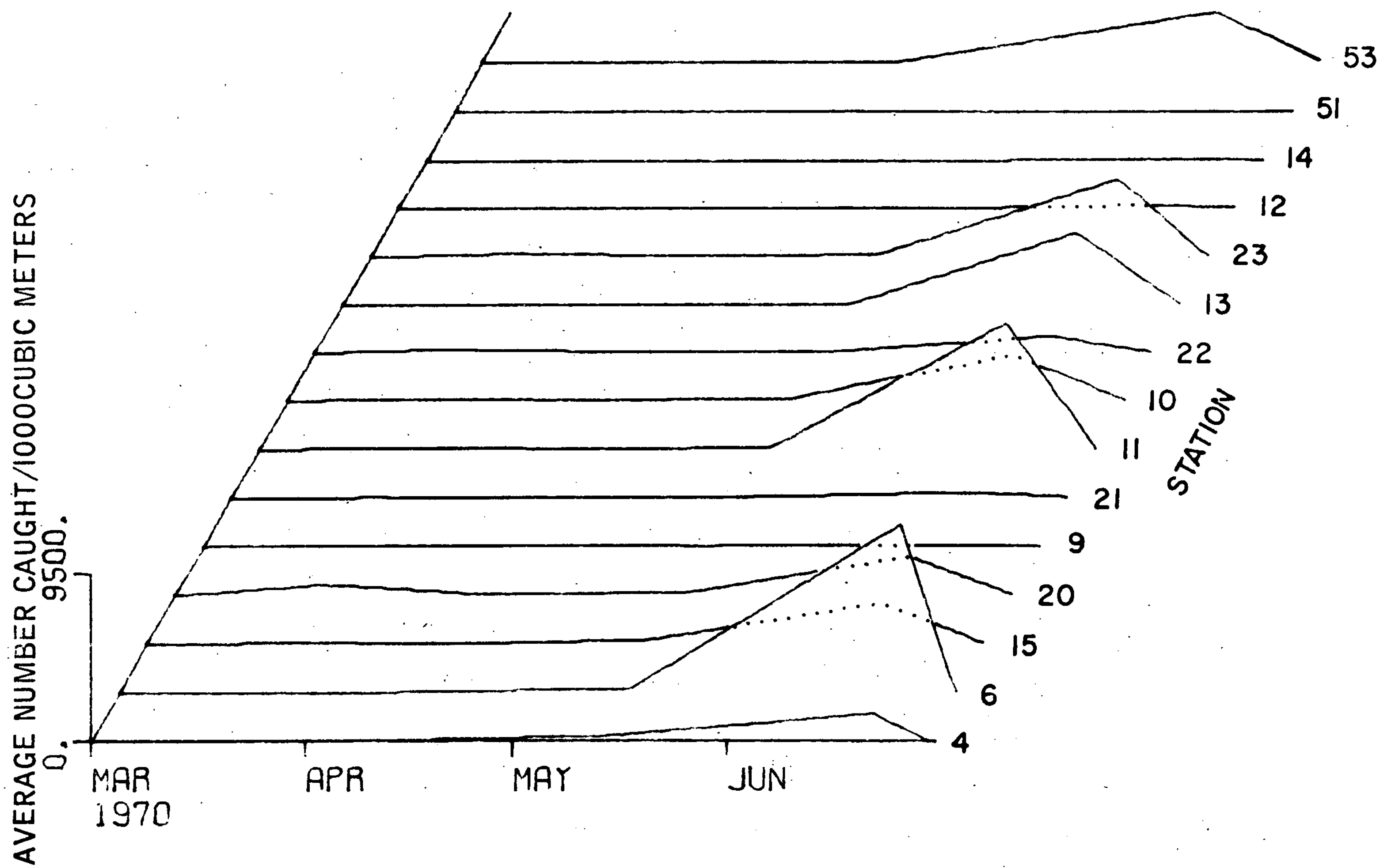


Figure 9-23. Neomysis americana (Bottom Zooplankton)

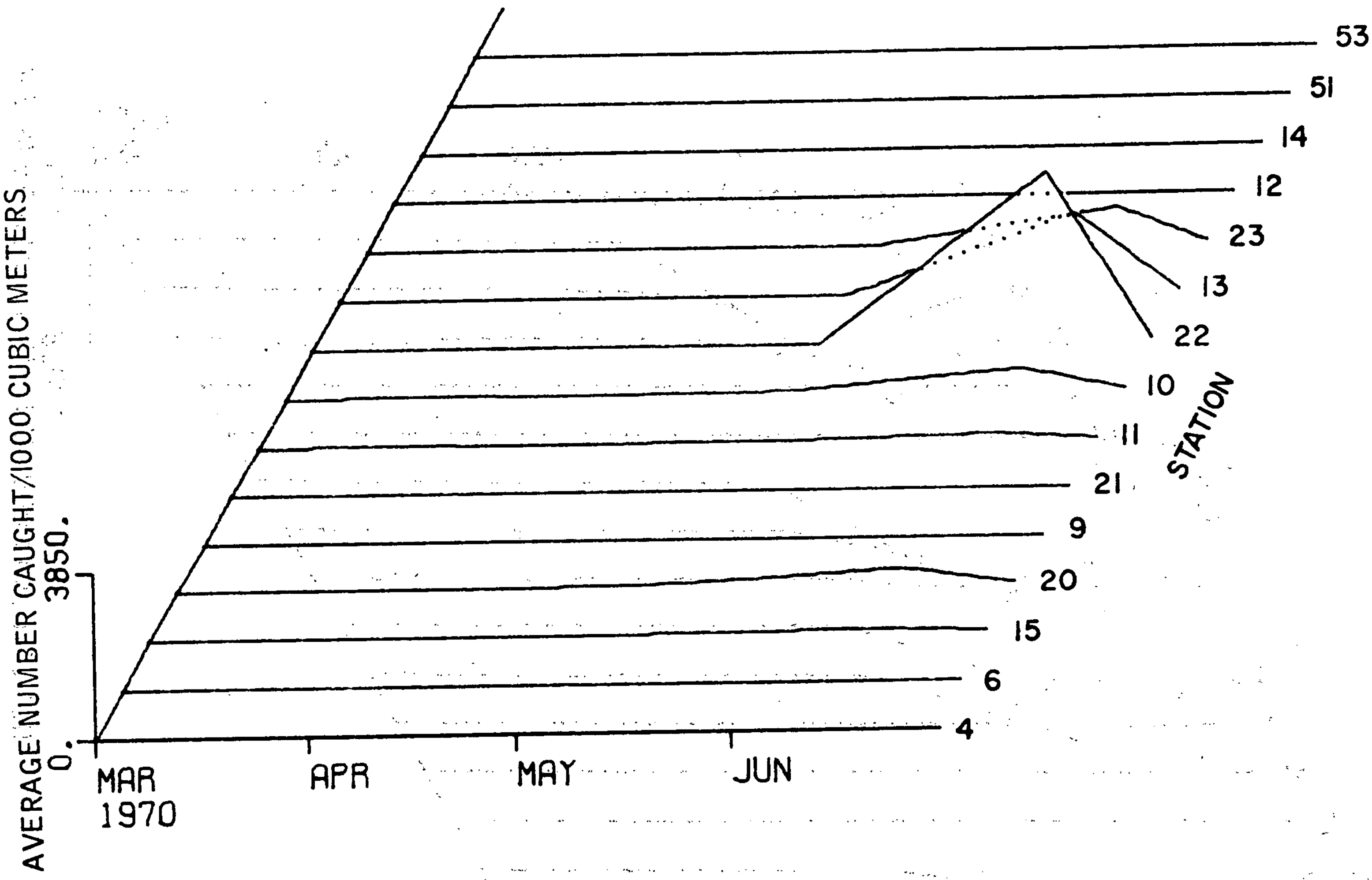


Figure 9-24. Neomysis americana (Mid-Depth Zooplankton)

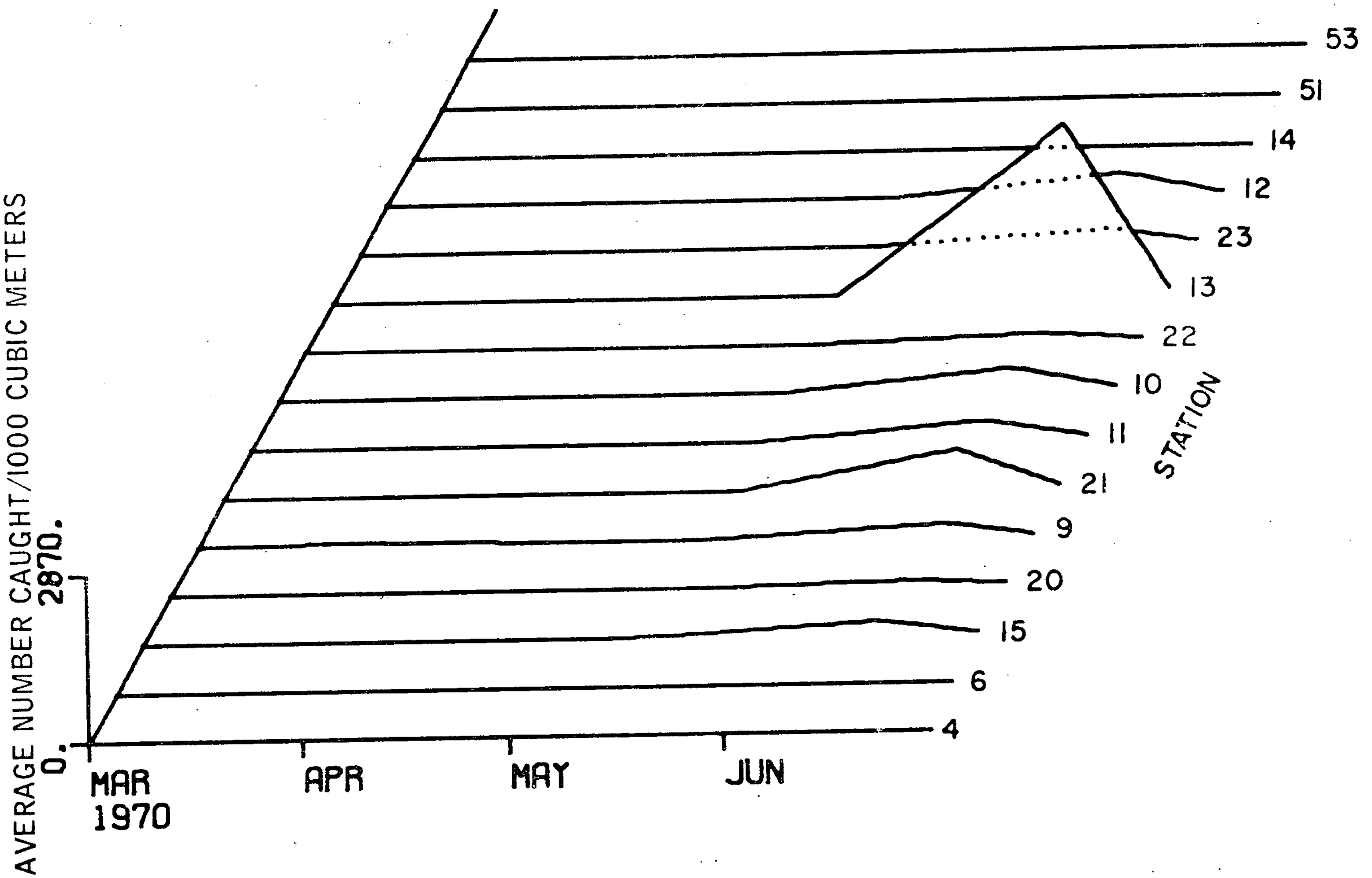


Figure 9-25. Neomysis americana (Surface Zooplankton)

10.0 FIELD BIOLOGY—FINFISH/INVERTEBRATE STUDIES

10.1 Introduction

Bottom trawling, surface trawling and beach seining were secondary to the plankton and sonic tagging programs during the spring. This limited sampling, however, did provide information on post-larval fish species growth and distribution, as well as data on older fishes and other invertebrate species during this six-month period. These data collected on fishes provided year-round continuity to the more intensive summer-fall finfish sampling program.

A fish trap was constructed and placed in the effluent canal in February in order to gain insight and data on fishes inhabiting or temporarily entering the canal.

Benthic grab, Succession Panel and Thorson Bottle sampling was conducted monthly except during January and February when ice conditions on the river allowed only limited sampling of the infauna and encrusting invertebrates.

All sampling was conducted without regard to the stage of the tide. Environmental data such as weather conditions and tide, as well as the surface, mid and bottom depth water temperatures, dissolved oxygen, and salinity were routinely recorded on the standard field data sheet with each biological collection.

10.2 Sampling Gear and Procedures

10.2.1 Bottom Trawls

Bottom trawl fish collections were made primarily at major stations (plant vicinity) each month from March through June, 1970. Occasional samples were collected in January and February when river ice conditions permitted. Twenty-five foot semi-balloon trawls were employed during 7-minute tows. The gear and methods for towing were identical to those in 1969.

10.2.2 Surface Trawls

Surface trawl collections were made from April through June at major trawl and plankton stations during a day and night each month. An inverted, modified 25-foot semi-balloon trawl was towed for 10 minutes for each sample as in 1969.

10.2.3 Beach Seines

Routine beach seine collections were regularly made from March through June with a 100' x 10' x 3/8" square mesh seine with 1/4" square mesh bag. Night time collections were made each month, and day time collections almost every week at major stations.

10.2.4 Benthic Grabs

As in 1969, monthly benthic samples were collected with an Emory type bottom grab at all trawl and plankton stations except during January and February when river ice prevented sampling at each station. Samples were also collected in the forebay area of the plant and in the effluent canal.

10.2.5 Succession Panels and Thorson Bottles

Succession panels and Thorson bottles installed in September, 1969 were recovered in January and March, 1970. Panels at several stations were lost during the winter from ice abrasion.

The succession panel and Thorson bottle arrays for 1970 were designed for a 9-month collecting period, March through December (Figure 10-1). Nine panels, each one a pine board measuring 4" x 10" x 1", were screwed to a 2' x 2' x 42" wood strip. One inch separated the individual panels. The panel array was bolted to a vertical wood strip 2" x 2" x 32" (Figure 10-1).

The Thorson bottles were constructed of one-quart freezer containers measuring 5 1/2" x 4" x 4" with a 2 1/2" diameter hole cut in the top. A Thorson bottle was secured to the base of each set of bottom succession panels. Thorson bottles were not used in conjunction with surface panels.

Stations utilized in 1969 were employed for the 1970 collections. At stations with 14 feet of depth or more, two sets of panels were used. One set of panels was positioned four feet from the surface at mean low water and one four feet from the bottom with a Thorson bottle attached. At stations less than 14 feet, only one set of panels with a Thorson bottle was used and positioned four feet above the bottom. At Station 57 the panel array was placed 4 feet below the surface because the mean low water depth is only 7 feet. Thus, this panel set was compatible with other surface panel set locations. The sets of panels were secured to quarter-inch line with staples, and anchored using cement blocks. The line was tautly secured to a fixed object at the surface to keep the panels as stationary and vertical as possible.

Each time the stations were sampled, #1 panels and the Thorson bottles were removed and replaced to give data for one month of exposure. At the same time, another panel was removed to obtain information concerning the accumulation and ecological succession of organisms during the entire sampling period (Table 10-1).

The panels and bottles were first installed at Stations 51, 54, 55 and 57 on 31 March and the next day Stations 56 and 58 were installed. The final set was placed at Station 53 (effluent canal) on 8 April, after Consolidated Edison completed their discharges of boiler compounds into the effluent canal. On the 29th and 30th of April at all stations, panel #1 was removed and replaced with a new panel and the Thorson bottles were removed and replaced. On the 26th of May, all the #1 panels and the panels with two months' exposure were removed and replaced. All stations were again sampled on 24 June by removing and replacing #1 panels and the Thorson bottles, and removing a three month succession panel.

Figure 3-1 and Tables 4-4 and 4-5 give the locations, positions and descriptions of the succession panel/Thorson bottle stations.

10.2.6 Fish Trap

A fish trap was designed and built by Raytheon biologists to sample fish in the effluent canal (Figure 10-2). The original design was initiated because of the difficulty of using conventional sampling gear in narrow confines of the cement walled canal, especially with the presence of a swift current.

The frame of the trap was constructed of 1 inch steel angle iron. The overall dimensions are 6 feet long by 4 feet wide by 4 feet high. A funnel entrance, tapering to a 6 by 6 inch opening and extending 3 feet 6 inches inward, constitutes one end of the trap. A similar secondary funnel extends beyond the entrance funnel to increase the trap's retaining efficiency. The sides were covered with 1/4 inch square mesh galvanized wire hardware cloth. Two wings measuring 4 feet by 6 feet long were mounted on adjustable hinges. These wings increase the effective catching area by guiding fish into the trap.

The trap was set for the first time on 20 February 1970 in the uppermost portion of the canal adjacent to the bridge and against the east wall facing downstream. Durations of the set ranged from a few days to several weeks. Catches were small during the colder water months of February, March and April. As the river water warmed up, catches became larger with more species appearing each month, thus the set time was decreased to about one week.

10.3 Fish Results

10.3.1 Trawls and Seines

Samples during the six-month period were generally collected at stations in the plant site vicinity (Table 10-2).

During the fall of 1969, the number of species declined when the river water cooled (Data Report I). The number of species generally increased during spring 1970, particularly at the shoal stations, as the river water temperatures increased (Table 10-3). The faunal diversity can be a measure of environmental changes and may be monitored by the number of species collected. This has the inherent weakness that there is an increase in species with increase in sample size and/or sampling frequency.

Sixteen surface trawls in April collected only two species in limited numbers in six tows. Summer resident species (bay anchovy and bluefish) began moving into the study area in May and June. By June, 43 surface trawls collected at least two species in each tow and a total of 11 species (Tables 10-2 and 10-3). The number of species collected in the surface trawls in June increased because a) young-of-the-year shad, white perch, striped bass, bay anchovy, and bluefish (summer residents) moved into the area, and b) an increase in the number of shallow water collections yields shallow water species (spottail shiner and young-of-the-year white perch).

Bottom trawl catches during the six-month period did not show an increase of species as well as surface trawl and seine collections. This can be explained by the sampling frequencies (Table 10-2). A general increase of species is evident, but many of the species remain in the study area throughout the year.

Beach seine collections could not be made in January and February because of river ice conditions. Seining during the daytime collected on the average one fish per haul during March. Night sampling after mid-month produced large catches with spottail shiner the most abundant species and Johnny darter the second most abundant species. The number of species collected in beach seines increased in April (Table 10-3). Low salinities in April (because of spring runoff) increased the number of fresh water species available for collection (brown trout, golden shiner, largemouth bass, black crappie). Summer resident species moved into the shoal areas in May and June. By the end of June, 25 species had been collected in beach seines (Table 10-3).

For all fishing gear, a total of 35 species in 18 families were collected from January through June 1970 (Table 10-4).

10.3.2 Results on the Species Level

Monthly averages by individual species caught per unit effort per gear type per station revealed the overall spatial and seasonal distributional patterns for the species collected within the study area. These data also provided a basis for evaluating the effectiveness/ selectivity of the various gear types for each species. Grand averages of all the individual station averages of number caught per unit effort have also been calculated (Tables 10-5 through 10-21). Since each station is considered as a unit location within the sampling grid, these grand averages have not been weighted on the basis of the number of samples collected.

The most abundant species in the study area from January through June, 1970 were tomcod and white perch (Tables 10-5 through 10-21). Striped bass were collected throughout the period, but only in small numbers. The bay anchovy which was the most important species numerically in the fall of 1969, was not caught in the study area until May. These were yearlings and adults. The most numerous species collected in beach seines from March through May was the spottail shiner. In June, white perch replaced the spottail shiner as the most abundant species. Golden shiner, banded killifish, and Johnny darter were commonly caught in beach seines.

Post-larval stages of blueback herring, alewife, shad, tomcod, white perch, and striped bass were avoiding capture by plankton nets in May and June, but were collected by surface and bottom trawls. Surface and bottom trawling thus enabled the collection of larval and post-larval specimens of the "key" and other species.

Computer plots of the average number caught per unit effort by month by station for selected species and gear types are shown in Figures 10-3 through 10-12. Table 10-2 should be consulted for a determination of the number of samples averaged together to produce each data point. It should be noted that each station's trace begins and ends at zero; is an artifact of the graphing technique and should not be interpreted as an indication of the abundance trends beyond the actual data available. The "deep" stations are segregated at the upper half of each figure in order of increasing river mile. The "shallow" stations, likewise, are segregated to the lower half. From bottom to top of each graph representing bottom and surface trawl catches, the station ordering is: shallow – 5, 3, 7, 8, 9, 21 and 12; deep – 4, 6, 15, 20, 16, 11, 10, 22, 13, 23 and 14 (see Table 4-5). Graphs representing seine catches are numbered from bottom to top: 31, 32, 38, 33, 39, 35, 34, 36, 37.

10.3.2.1 Blueback Herring, *Alosa aestivalis* (Mitchill)

Yearling and older individuals were not collected in the study area until May (Tables 10-5 through 10-7). This may be related to their spawning migration.

10.3.2.2 Alewife, Alosa pseudoharengus (Wilson)

The alewife was collected in the study area from April through June (Tables 10-8 through 10-10). Adults were migrating upstream to spawn. Yearlings also entered the study area. Specimens were caught in beach seines, bottom trawls, and surface trawls, and incidently in gill nets set for shad. Yearlings dominated the surface trawl catches. Young-of-the-year were collected in plankton tows (see Section 9.0). The bottom trawl data indicate that the yearling and adult migrating fish may prefer the shoal areas, especially Peekskill Bay (Table 10-9). This species also tends to be widely distributed in the study area.

10.3.2.3 American shad, Alosa sapidissima (Wilson)

This anadromous species spawns in the upper reaches of the Hudson River during the spring (see Section 8.0). The only young-of-the-year specimen collected during the spring was in a surface trawl sample at Station 9 in June. Two yearling shad were collected in May beach seines at Stations 34 and 36.

10.3.2.4 Bay anchovy, Anchoa mitchilli (Valenciennes)

In the summer and autumn of 1969, the bay anchovy was the most abundant species within the study area. This year yearling and adult bay anchovy first appeared in May and were caught in limited numbers at scattered stations (Table 10-11 through 10-13).

10.3.2.5 Atlantic tomcod, Microgadus tomcod (Walbaum)

Tomcod and white perch were the most numerous species collected by fishing gear during this six-month period (Tables 10-14 and 10-15). The tomcod was most abundant at channel stations throughout the year. Low salinities in April (see Section 7.0) may have caused the fish to move downstream and account for the smaller catches.

Spawning took place during the winter months and all larval stages were collected with plankton nets from March through June (see Section 7.0). Bottom trawls began collecting young of the year in May and large catches were made in June. Young-of-the-year were also collected in shoal areas in May and June (Tables 10-14 and 10-15). Yearlings were common in the study area, but fish older than yearlings were not numerous during the spring.

Overall, the tomcod was the most numerous species caught in May and June. In May tomcod dominated the bottom trawl catches in deep water while white perch dominated the shallow water catches (Tables 10-14 through 10-18).

10.3.2.6 White perch, Morone americana (Gmelin)

The white perch is one of the most abundant species in the lower Hudson River and is found throughout the year and in all life stages. White perch was the most numerous species collected from January through March in deep water and in April in shallow water bottom trawls (Tables 10-5 through 10-21).

A shift occurred in April and May with the largest catches of white perch in shallow water (Tables 10-17 and 10-18). This may be associated with spawning activity. The largest catches were made in shoal waters in June and it was the most numerous species caught in beach seines during June.

Young-of-the-year white perch were collected in June surface and bottom trawls (Tables 10-16 and 10-17).

10.3.2.7 Striped bass, Morone saxatilis (Walbaum)

The striped bass was collected from January through June 1970 in all types of fishing gear employed (Tables 10-19 through 10-21). From January through March, striped bass were collected primarily at deep water bottom trawl stations (Table 10-20). In May and June this species was concentrated in shoal areas (Tables 10-20 and 10-21). Yearlings and two year old fish were caught from January through June, and young-of-the-year fish became numerous in surface and bottom trawl catches in June.

10.4 Fish Trap Results

From February through April, catches were small, numbering less than one dozen fish per haul. Catches during these months yielded Atlantic tomcod, Johnny darter, white catfish, spottail shiner and yellow perch, in order of decreasing abundance. In February, tomcod was the only species caught. White catfish was caught for the first time in April.

June catches averaged about 22 fish per set with a total of nine species collected. The most numerous species was the white perch and the second most numerous was the American eel.

Eleven species of fish were collected in the trap from February through June (Table 10-22). The most numerous species were the white perch and the American eel.

10.5 Invertebrate (Non-plankton) Results

The distribution and abundance of invertebrates at Indian Point is being evaluated through the use of a variety of gear. In the fish sampling program, invertebrates were collected during the six-month period in beach seines, surface and bottom trawls. In addition, samples were collected with an Emory-type benthic grab, Thorson bottles, and settlement/succession panels (Tables 10-1 and 10-23). Zooplankton collections of invertebrates have been dealt with in Section 9.0 of this report.

The species collected from January through June, 1970 are listed by gear type in Tables 10-24 through 10-28.

10.5.1 Overall Numerical Importance

The overall relative numerical importance of the major species within the study area was determined through a compilation of the monthly averages of numbers caught per unit effort for each gear type (Tables 10-29 through 10-32). The segregation of the samples by depth due to selective sampling by each gear type permits an evaluation of differences in surface and bottom abundances.

The organisms encrusting the succession panels were primarily barnacles, Balanus improvisus, which were more numerous on surface panels than on bottom panels (Table 10-29). As yet, no generalities can be drawn from the long term panels. Balanus improvisus had just settled heavily on the June panels, providing a baseline for successional studies.

Benthic grab abundances showed that the polychaete worm Spio setosa, predominated (Table 10-30).

The amphipod, Gammarus fasciatus, was the most abundant animal collected by the Thorson bottles (Table 10-31). This is misleading because G. fasciatus is very mobile and therefore not indicative of mud infauna. Spio setosa and the midge, Tendipes tentans, which also were caught in the benthic grabs, are more typical of the habitat. They were not as abundant as G. fasciatus, but did occur every month. The amount of sediment collected each month was far more interesting (Table 10-33). For example, the volume of mud collected at the effluent was approximately one-third that collected at the intake. The sediment volume collected did not appear to be correlated with the sampling depth (Table 10-33). Thus, the Thorson bottles appear to be a better monitor of sediment deposition than benthic infauna. However, caution must be used in comparing the sediment volume data among stations as the local currents resulting from natural and artificial obstructions may affect the rate of accumulation.

The invertebrates collected by the fish sampling program were neither numerous nor evenly distributed among stations (Table 10-32). Sampling of fish populations was reduced because of the emphasis on the zooplankton and sonic tagging programs. For these reasons, no conclusions can be drawn concerning these invertebrates.

10.5.2 Species Distribution Patterns

Although the encrusting fauna on the succession panels was neither very diverse nor abundant, some patterns appeared in the study area. The 1970 panels were installed in March and they did not have barnacle, Balanus improvisus settlement until June (Figure 10-13). The total counts per panel varied from zero in May to almost thirty thousand in June. Growth and competition effects will be examined throughout the summer. The numbers of barnacles settling declined as salinity declined (river mile increased) and spat settlement was especially low on the bottom panels in the vicinity of the Consolidated Edison generating station (Figure 10-13). The absence of Congeria leucophaeta from the panels this spring (Table 10-29) may indicate that settlement occurs later in the year; they occurred on the fall panels in 1969.

With a few exceptions, the polychaete worm, Spio setosa and the isopod Cyathura polita were found throughout the study area as the most common members of the benthic fauna (Figure 10-14). Cyathura polita was not as numerous as S. setosa but it was ubiquitous. Seasonally, both animals showed an expected increase in numbers in the spring. Again, sediment type appeared to be the most important influence on distribution. Both species were less abundant among the shells and pebbles of Stations 5 or 16 and the heavy organic debris of Station 14, than in the more silty clay sediments of other stations. Since these animals were found throughout the study area, salinity is probably not critical.

It appears that no generalities can be drawn from the Thorson bottles and invertebrates collected by the fish sampling program.

Table 10-1. Schedule and Procedure for 1970 Succession Panels

MARCH 31	Panels installed at Stations 51, 54, 55 & 57.
APRIL 1	Panels installed at Stations 56 and 58.
8	Panels installed at Station 53.
29,30	A. Remove and replace #1 panel (1 month exposure).
	B. Remove and replace Thorson bottle.
MAY 26	A. Remove and replace #1 panel (1 month exposure).
	B. Remove #9 panel (2 month exposure).
	C. Remove and replace Thorson bottle.
JUNE 24	A. Remove and replace #1 panel (1 month exposure).
	B. Remove #2 panel (3 month exposure).
	C. Remove and replace Thorson bottle.
JULY	A. Remove and replace #1 panel (1 month exposure).
	B. Remove #8 panel (4 month exposure).
	C. Remove and replace Thorson bottle.
AUGUST	A. Remove and replace #1 panel (1 month exposure).
	B. Remove #3 panel (5 month exposure).
	C. Remove and replace Thorson bottle.
SEPTEMBER	A. Remove and replace #1 panel (1 month exposure).
	B. Remove #7 panel (6 month exposure)
	C. Remove and replace Thorson bottle
OCTOBER	A. Remove and replace #1 (1 month exposure).
	B. Remove #4 panel (7 month exposure)
	C. Remove and replace Thorson bottle

Table 10-2. Trawl, Seine and Effluent Samples Collected, January - June 1970*

	STA	MILE	SITE	DPTH	Jan.	Feb.	Mar.	Apr.	May	June
BOTTOM TRAWLS	5	36	1	12						1
	3	35	3	10						1
	7	38	3	11				3(1)	3	4
	8	39	1	12			3	1(1)		5(3)
	9	40	3	12			3(1)	4	1	5
	12	44	3	12	1		2	3(1)	1	7
	4	35	2	34						1
	6	38	2	30				4(2)	3	4
	15	40	1	45			3	1		4
	16	41	3	45			2			3
	11	42	2	50	1	2	3	3(1)	3	8
	10	42	3	45	2	1	3(2)	3	3	6
	13	45	1	50				1	1	5(1)
	14	47	3	55						3(2)
	TOTAL				4	3	19(3)	23(6)	15	57(6)
SURFACE TRAWLS	5	36	1	12						
	3	35	3	10						2
	7	38	3	11				2	1	4
	8	39	1	12						
	9	40	3	12				3	1	3
	21	42	1	15						3
	12	44	3	12				1		3
	4	35	2	34						2
	6	38	2	30					1	4
	15	40	1	45				2	1	4
	20	40	2	80						
	16	41	3	45				2	1	3
	11	42	2	50				3	1	5(1)
	10	42	3	45				3	1	5
	22	42	3	45						3
	13	45	1	50						2
	23	44	2	80						
	14	47	3	55						
	TOTAL							16	7	43(1)
BEACH SEINES	31	35	1				2			1
	32	35	3				1			2
	38	40	1				7	4	4	5
	33	40	3				8(1)	1	3	4
	39	41	3				8	4	4	6(1)
	35	43	1				7	4	4	5
	34	42	3				8	4	4	5
	36	44	3					3	4	5
	37	47	1							2
	TOTAL						41(1)	20	23	35(1)
Fish Trap	Effluent Canal					3	2	1	1	5

*Samples in parentheses are valid for environmental data only and are included in the total numbers of samples.

Table 10-3. Total Numbers of Fish Species Caught by Trawls and Seines, January - June 1970

	STA	MILE	SITE	DPTH	JAN 1970	FEB 1970	MAR 1970	APR 1970	MAY 1970	JUNE 1970
BOTTOM TRAWLS	5	36	1	12						8
	3	35	3	10						7
	7	38	3	11				7	9	9
	8	39	1	12			5			8
	9	40	3	12			5	13	7	14
	12	44	3	12	8		3	8	10	16
	4	35	2	34						7
	6	38	2	30				6	9	11
	15	40	1	45			7	3		7
	16	41	3	45			8			8
	11	42	2	50	6	4	3	5	9	11
	10	42	3	45	7	4	2	8	9	10
	13	45	1	50				2	5	10
	14	47	3	55						3
	TOTAL SPECIES				12	5	11	17	14	20
SURFACE TRAWLS	5	36	1	12						
	3	35	3	10						5
	7	38	3	11				2	3	5
	8	39	1	12						
	9	40	3	12				2	2	7
	21	42	1	15						4
	12	44	3	12				1		3
	4	35	2	34						2
	6	38	2	30					1	4
	15	40	1	45				0	1	3
	20	40	2	80						
	16	41	3	45				1	2	3
	11	42	2	50				0	1	3
	10	42	3	45					1	5
	22	42	3	45						5
	13	45	1	50						4
	23	44	2	80						
	14	47	3	55						
	TOTAL SPECIES							2	4	11
BEACH SEINES	31	35	1				0			2
	32	35	3				1			1
	38	40	1				7	5	11	14
	33	40	3				7	1	7	13
	39	41	3				6	8	12	12
	35	43	1				6	11	16	17
	34	42	3				8	9	15	12
	36	44	3					11	15	13
	37	47	1							8
	TOTAL SPECIES						14	19	22	25

0 = Species absent, but station was sampled

Blank = station was not sampled

Table 10-4. Fish Species Collected by the Indian Point Ecological Survey, January - June 1970 +

Acipenseridae-sturgeons	
Shortnose sturgeon	Acipenser brevirostrum
Atlantic sturgeon	Acipenser oxyrhynchus
Clupeidae-herrings	
Blueback herring	Alosa aestivalis *
Alewife	Alosa pseudoharengus *
American shad	Alosa sapidissima
Engraulidae-anchovies	
Bay anchovy	Anchoa mitchilli *
Salmonidae-trouts, whitefishes, and graylings	
Brown trout	Salmo trutta
Osmeridae-smelts	
Rainbow smelt	Osmerus eperlanus * (=mordax)
Cyprinidae-minnows and carps	
Goldfish	Carassius auratus *
Carp	Cyprinus carpio *
Golden shiner	Notemigonus crysoleucas
Spottail shiner	Notropis hudsonius
Emerald shiner	Notropis atherinoides **
Catostomidae-suckers	
White sucker	Catostomus commersoni
Ictaluridae-freshwater catfishes	
White catfish	Ictalurus catus
Brown bullhead	Ictalurus nebulosus
Anguillidae-freshwater eels	
American eel	Anguilla rostrata *
Cyprinodontidae-killifishes	
Banded killifish	Fundulus diaphanus
Mummichog	Fundulus heteroclitus
Gadidae-codfishes and hakes	
Atlantic tomcod	Microgadus tomcod *
Squirrel hake	Urophycis chuss
Gasterosteidae-sticklebacks	
Threespine stickleback	Gasterosteus aculeatus
Fourspine stickleback	Apeltes quadracus
Serranidae-sea basses	
White perch	Morone americana *
Striped bass	Morone saxatilis *
Centrarchidae-sunfishes	
Redbreast sunfish	Lepomis auritus
Pumpkinseed	Lepomis gibbosus
Bluegill	Lepomis macrochirus
Largemouth bass	Micropterus salmoides
Black crappie	Pomoxis nigromaculatus
Percidae-perches	
Johnny darter	Etheostoma olmstedii (=nigrum)
Yellow perch	Perca flavescens
Pomatomidae-bluefishes	
Bluefish	Pomatomus saltatrix
Atherinidae-silversides	
Atlantic silverside	Menidia menidia
Soleidae-soles	
Hogchoker	Trinectes maculatus

\+ Names of fishes according to "A List of Common and Scientific Names of Fishes from the United States and Canada", 1960, Special Pub. No. 2, 2nd Edit., American Fisheries Society, except for recent revisions.

* Also collected in plankton samples

** Tentative identification

Table 10-5. Average Number Blueback Herring Caught/7 Minutes (Surface Trawls)

	STA	MILE	SITE	DPTH	Jan.	Feb.	Mar.	Apr.	May	June
					1970					
SHALLOW	5	36	1	12						
	3	35	3	10						1
	7	38	3	11				0	0	0
	8	39	1	12						
	9	40	3	12				0	0	P
	21	42	1	15						0
	12	44	3	12				0		0
DEEP	4	35	2	34						0
	6	38	2	30					0	P
	15	40	1	45				0	0	0
	16	41	3	45				0	0	0
	11	42	2	50				0	0	0
	10	42	3	45				0	0	3
	22	42	3	45						0
	13	45	1	50						0
	14	47	3	55						
Grand Avg. No. Cght.								0	0	P
Pcnt Avg. Cght*								0	0	1.6
Avg. Pcnt Occ.*								0	0	12

blank = no samples, 0 = species absent
P = present, but average less than 1
* See Appendix A for explanation of terms

Table 10-6. Average Number Blueback Herring Caught/7 Minutes (Bottom Trawls)

	STA	MILE	SITE	DPTH	Jan.	Feb.	Mar.	Apr.	May	June
					1970					
SHALLOW	5	36	1	12						3
	3	35	3	10						34
	7	38	3	11				0	0	5
	8	39	1	12			0			0
	9	40	3	12			0	0	0	7
	12	44	3	12	0		0	0	0	P
DEEP	4	35	2	34						0
	6	38	2	30				0	0	P
	15	40	1	45			0	0		0
	16	41	3	45			0			0
	11	42	2	50	0	0	0	0	0	0
	10	42	3	45	0	0	0	0	0	0
	13	45	1	50				0	0	0
	14	47	3	55						0
Grand Avg. No. Cght.					0	0	0	0	0	4
Pcnt Avg. Cght*					0	0	0	0	0	100
Avg. Pcnt Occ.*					0	0	0	0	0	22

blank = no samples, 0 = species absent
P = present, but average less than 1
* See Appendix A for explanation of terms

Table 10-7. Average Number Blueback Herring Caught/Haul (Seines)

STA	MILE	SITE	Jan.	Feb.	Mar.	Apr.	May	June
					1970			
31	35	1			0			0
32	35	3			0			0
38	40	1			0	0	0	1
33	40	3			0	0	0	0
39	41	3			0	0	0	1
35	43	1			0	0	4	P
34	42	3			0	0	1	1
36	44	3				0	0	P
37	47	1						0
Grand Avg. No. Cght.					0	0	1	P
Pcnt. Avg. Cght.*					0	0	1.6	0.5
Avg. Pcnt. Occ.*					0	0	9	14

blank = no sample, 0 = species absent
P = present, but average less than 1
* see Appendix A for explanation of terms

Table 10-8. Average Number Alewife Caught/7 Minutes (Surface Trawls)

	STA	MILE	SITE	DPTH	Jan.	Feb.	Mar.	Apr.	May	June
								1970		
SHALLOW	5	36	1	12						
SHALLOW	3	35	3	10						1
SHALLOW	7	38	3	11				P	1	P
SHALLOW	8	39	1	12						
SHALLOW	9	40	3	12				P	4	2
SHALLOW	21	42	1	15						P
SHALLOW	12	44	3	12				0		P
DEEP	4	35	2	34						P
DEEP	6	38	2	30					1	0
DEEP	15	40	1	45				0	0	3
DEEP	16	41	3	45				0	2	2
DEEP	11	42	2	50				0	2	1
DEEP	10	42	3	45				0	8	1
DEEP	22	42	3	45						3
DEEP	13	45	1	50						4
DEEP	14	47	3	55						
Grand Avg. No. Cght.								P	3	1
Pcnt Avg. Cght*								19	82	7
Avg. Pcnt Occ.*								12	86	48

blank = no samples, 0 = species absent
P = present, but average less than 1
* See Appendix A for explanation of terms

Table 10-9. Average Number Alewife Caught/7 Minutes (Bottom Trawls)

	STA	MILE	SITE	DPTH	1970 Jan.	Feb.	Mar.	Apr.	May	June
SHALLOW	5	36	1	12						4
	3	35	3	10						4
	7	38	3	11				1	5	9
	8	39	1	12			0			0
	9	40	3	12			0	P	1	10
	12	44	3	12	0		0	0	35	1
DEEP	4	35	2	34						0
	6	38	2	30				0	P	P
	15	40	1	45			0	0		0
	16	41	3	45			0			0
	11	42	2	50	0	0	0	0	1	P
	10	42	3	45	0	0	0	1	0	1
	13	45	1	50				0	0	P
	14	47	3	55						0
Grand Avg. No. Cght.					0	0	0	P	6	2
Pcnt Ave. Cght*					0	0	0	0.3	3	0.6
Avg. Pcnt Occ.*					0	0	0	18	53	36

blank = no samples, 0 = species absent
P = present, but average less than 1
* See Appendix A for explanation of terms

Table 10-10. Average Number Alewife Caught/Haul (Seines)

STA	MILE	SITE	Jan.	Feb.	Mar.	Apr.	May	June
31	35	1			0			0
32	35	3			0			4
38	40	1			0	1	3	1
33	40	3			0	0	2	P
39	41	3			0	1	1	1
35	43	1			0	0	1	1
34	42	3			0	0	3	4
36	44	3				0	21	20
37	47	1						0
Grand Avg. No. Cght.					0	P	5	3
Pcnt. Avg. Cght.*					0	0.7	9.5	5.4
Avg. Pcnt. Occ.*					0	9	52	33

blank = no sample, 0 = species absent
P = present, but average less than 1
* see Appendix A for explanation of terms

Table 10-11. Average Number Bay Anchovy Caught/7 Minutes (Surface Trawls)

	STA	MILE	SITE	DPTH	Jan.	Feb.	Mar.	Apr.	May	June
					1970					
SHALLOW	5	36	1	12						
	3	35	3	10						7
	7	38	3	11				0	0	2
	8	39	1	12						
	9	40	3	12				0	0	P
	21	42	1	15						0
	12	44	3	12				0		0
DEEP	4	35	2	34						8
	6	38	2	30					0	P
	15	40	1	45				0	0	0
	16	41	3	45				0	0	0
	11	42	2	50				0	0	0
	10	42	3	45				0	0	1
	22	42	3	45						P
	13	45	1	50						0
	14	47	3	55						
Grand Avg. No. Cght.								0	0	1
Pcnt Avg. Cght*								0	0	7
Avg. Pcnt Occ.*								0	0	28

blank = no samples, 0 = species absent
P = present, but average less than 1
* See Appendix A for explanation of terms

Table 10-12. Average Number Bay Anchovy Caught/7 Minutes (Bottom Trawls)

	STA	MILE	SITE	DPTH	Jan.	Feb.	Mar.	Apr.	May	June
					1970					
SHALLOW	5	36	1	12						0
	3	35	3	10						0
	7	38	3	11				0	5	12
	8	39	1	12			0			0
	9	40	3	12			0	0	0	10
	12	44	3	12	0		0	0	0	P
DEEP	4	35	2	34						0
	6	38	2	30				0	7	1
	15	40	1	45			0	0		0
	16	41	3	45			0			1
	11	42	2	50	0	0	0	0	0	1
	10	42	3	45	0	0	0	0	1	2
	13	45	1	50				0	0	0
	14	47	3	55						0
Grand Avg.No.Cght.					0	0	0	0	2	2
Pcnt. Avg. Cght*					0	0	0	0	1	0.6
Avg. Pcnt Occ.*					0	0	0	0	15	14

blank - no samples, 0 = species absent
P = present, but average less than 1
* See Appendix A for explanation of terms

Table 10-13. Average Number Bay Anchovy Caught/Haul (Seines)

STA	MILE	SITE	Jan. (1970)	Feb.	Mar.	Apr.	May	June
31	35	1			0			0
32	35	3			0			0
38	40	1			0	0	1	2
33	40	3			0	0	0	2
39	41	3			0	0	P	1
35	43	1			0	0	3	0
34	42	3			0	0	1	1
36	44	3				0	0	0
37	47	1						1
Grand Avg.No.Cght					0	0	1	1
Pcnt Avg. Cght*					0	0	2	1
Avg.Pcnt Occ.*					0	0	17	18

blank = no sample, 0 = species absent
P = present, but average less than 1
* See Appendix A for explanation of terms

Table 10-14. Average Number Tomcod Caught/7 Minutes (Bottom Trawls)

	STA	MILE	SITE	DEPTH	Jan.	Feb.	Mar.	Apr.	May	June
SHALLOW	5	36	1	12						116
	3	35	3	10						27
	7	38	3	11				1	14	11
	8	39	1	12			0			99
	9	40	3	12			0	1	168	61
	12	44	3	12	4		0	0	7	28
DEEP	4	35	2	34						1156
	6	38	2	30				1	68	607
	15	40	1	45			5	0		328
	16	41	3	45			5			501
	11	42	2	50	258	3	0	1	180	241
	10	42	3	45	4	7	0	1	13	211
	13	45	1	50				0	285	291
	14	47	3	55						40
Grand Avg.No.Cght.					89	5	1	1	105	265
Pcnt Avg.Cght*					23	17	2	1	54	75
Avg. Pcnt Occ.*					100	75	17	30	86	98

blank = no samples, 0 = species absent
P = present, but average less than 1
* See Appendix A for explanation of terms

Table 10-15. Average Number Tomcod Caught/Haul (Seines)

STA	MILE	SITE	Jan.	Feb.	1970 Mar.	Apr.	May	June
31	35	1			0			0
32	35	3			0			0
38	40	1			P	0	0	P
33	40	3			0	0	1	4
39	41	3			0	0	0	2
35	43	1			0	0	P	P
34	42	3			P	0	0	P
36	44	3				0	P	0
37	47	1						0
Grand Avg. No. Cght.					P	0	P	1
Pcnt. Avg. Cght.*					0.5	0	0.4	1.2
Avg. Pcnt. Occ.*					6	0	14	27

blank = no samples, 0 = species absent
P = present, but average less than 1
* see Appendix A for explanation of terms

Table 10-16. Average Number White Perch Caught/7 Minutes (Surface Trawls)

	STA	MILE	SITE	DPTH	Jan.	Feb.	Mar.	1970 Apr.	May	June
SHALLOW	5	36	1	12						
	3	35	3	10						0
	7	38	3	11				0	0	1
	8	39	1	12						
	9	40	3	12				0	0	4
	21	42	1	15						0
	12	44	3	12				0		0
DEEP	4	35	2	34						0
	6	38	2	30					0	P
	15	40	1	45				0	0	0
	16	41	3	45				0	0	0
	11	42	2	50				0	0	0
	10	42	3	45				0	0	0
	22	42	3	45						P
	13	45	1	50						0
	14	47	3	55						
Grand Avg. No. Cght.								0	0	P
Pcnt Avg. Cght*								0	0	1.8
Avg. Pcnt Occ.*								0	0	14

blank = no samples, 0 = species absent
P = present, but average less than 1
* See Appendix A for explanation of terms

Table 10-17. Average Number White Perch Caught/7 Minutes (Bottom Trawls)

	STA	MILE	SITE	DPTH	1970 Jan.	Feb.	Mar.	Apr.	May	June
SHALLOW	5	36	1	12						52
	3	35	3	10						72
	7	38	3	11				167	102	87
	8	39	1	12			80			37
	9	40	3	12			1	75	55	39
	12	44	3	12	9		0	25	113	38
DEEP	4	35	2	34						5
	6	38	2	30				4	7	11
	15	40	1	45			55	3		17
	16	41	3	45			267			2
	11	42	2	50	177	25	143	4	49	4
	10	42	3	45	544	14	22	4	10	4
	13	45	1	50				4	15	23
	14	47	3	55						34
	Grand Avg.No.Cght.				243	20	81	36	50	30
	Pcnt Avg.Cght*				63	68	87	58	26	9
	Avg. Pcnt Occ.*				100	100	70	94	100	92

blank = no samples, 0 = species absent
P = present, but average less than 1
* See Appendix A for explanation of terms

Table 10-18. Average Number White Perch Caught/Haul (Seines)

STA	MILE	SITE	1970 Jan.	Feb.	Mar.	Apr.	May	June
31	35	1			0			17
32	35	3			0			162
38	40	1			0	0	3	12
33	40	3			P	0	1	5
39	41	3			P	P	5	5
35	43	1			0	0	12	18
34	42	3			1	0	1	13
36	44	3				P	7	45
37	47	1						6
Grand Avg. No. Cght.					P	P	5	31
Pcnt. Avg. Cght.*					0.8	0.3	9	50
Avg. Pcnt. Occ.*					8	10	44	93

blank = no samples, 0 = species absent
P = present, but average less than 1
* See Apprendix A for explanation of terms

Table 10-19. Average Number Striped Bass Caught/7 Minutes (Surface Trawls)

	STA	MILE	SITE	DEPTH	1970 Jan.	Feb.	Mar.	Apr.	May	June
SHALLOW	5	36	1	12						
	3	35	3	10						0
	7	38	3	11				0	0	P
	8	39	1	12						
	9	40	3	12				0	0	7
	21	42	1	15						7
	12	44	3	12				0		5
DEEP	4	35	2	34						0
	6	38	2	30					0	0
	15	40	1	45				0	0	2
	16	41	3	45				0	0	3
	11	42	2	50				0	0	0
	10	42	3	45				0	0	7
	22	42	3	45						7
	13	45	1	50						93
	14	47	3	55						
	Grand Avg. No. Cght.							0	0	10
	Pcnt Avg. Cght*							0	0	51
	Avg. Pcnt Occ.*							0	0	33

blank = no samples, 0 = species absent
P = present, but average less than 1
* See Appendix A for explanation of terms

Table 10-20. Average Number Striped Bass Caught/7 Minutes (Bottom Trawls)

	STA	MILE	SITE	DEPTH	1970 Jan.	Feb.	Mar.	Apr.	May	June
SHALLOW	5	36	1	12						12
	3	35	3	10						41
	7	38	3	11				1	18	9
	8	39	1	12			6			19
	9	40	3	12			0	1	0	2
	12	44	3	12	39		0	0	10	3
DEEP	4	35	2	34						0
	6	38	2	30				1	P	9
	15	40	1	45			1	0		0
	16	41	3	45			16			0
	11	42	2	50	22	1	3	0	2	2
	10	42	3	45	61	4	2	0	P	P
	13	45	1	50				0	1	1
	14	47	3	55						0
	Grand Avg.No.Cght.				41	2	4	P	4	7
	Pcnt Avg. Cght*				11	7	4	0.4	2	2
	Avg. Pcnt Occ*				100	75	58	19	58	48

blank = no samples, 0 = species absent
P = present, but average less than 1

* See Appendix A for explanation of terms

Table 10-21. Average Number of Striped Bass Caught/Haul (Seines)

STA	MILE	SITE	1970 Jan.	Feb.	Mar.	Apr.	May	June
31	35	1			0			4
32	35	3			0			4
38	40	1			P	0	6	4
33	40	3			P	0	1	1
39	41	3			P	P	2	1
35	43	1			0	0	0	0
34	42	3			P	0	2	12
36	44	3				0	2	2
37	47	1						0
Grand Avg. No. Cght.					P	P	2	3
Pcnt. Avg. Cght.*					1.1	0.1	3.7	4.8
Avg. Pcnt. Occ.*					10	5	39	58

blank = no samples, 0 = species absent
P = present, but average less than 1
* see Appendix A for explanation of terms

Table 10-22. Fish Species Collected in the Fish Trap in the Effluent Canal, February—June, 1970

Common name	Family	Scientific name
	Cyprinidae	
Spottail shiner		Notropis hudsonius
	Ictaluridae	
White catfish		Ictalurus catus
	Anguillidae	
American eel		Anguilla rostrata
	Gadidae	
Atlantic tomcod		Microgadus tomcod
	Serranidae	
White perch		Morone americana
Striped bass		Morone saxatilis
	Centrarchidae	
Pumpkinseed		Lepomis gibbosus
Bluegill		Lepomis macrochirus
Black crappie		Pomoxis nigromaculatus
	Percidae	
Johnny darter		Etheostoma olmstedii
Yellow perch		Perca flavescens

Table 10-23 Total Number of Invertebrate (Non-Plankton) Samples Collected January - June, 1970*

MONTH	GEAR		
	Benthic Grabs	Thorson Jars	Succession Panels
JAN	2	0	7
FEB	9	0	0
MARCH	8	0	4
APRIL	16	7	11
MAY	22	7	22
JUNE	20	7	22

* See Table 10-2 for numbers of trawls and seines.

Table 10-24. Species Most Representative of Each Gear Type

Collecting Gear	Species	Group	Abundance *
Trawls	_Gammarus fasciatus_	Amphipoda	C
	Neomysis americana	Mysidacea	U
Seines	None		
Succession Panels	_Balanus improvisus_	Cirripedia	C
	Tendipes tentans	Diptera	C
Benthic Grab	_Spio setosa_	Polychaeta	C
	Cyathura polita	Isopoda	U
Thorson jars	_Spio setosa_	Polychaeta	C
	Tendipes tentans	Diptera	C

* We do not feel any invertebrates are collected by these gear types in sufficient numbers to be designated abundant.

A = Abundant - readily caught in great numbers
C = Common - readily caught
U = Uncommon - caught only occasionally and/or not in any numbers

Table 10-25. Invertebrates Collected by Succession Panels, January - June 1970

SPECIES	ABUNDANCE
Crustacea	
Balanus improvisus (barnacle)	C
Diptera	
Tendipes tentans (midge)	C
Hydrozoa	
Campanularia calceolifera (hydroid)	U

A = Abundant - readily caught, in great numbers

C = Common - readily caught

U = Uncommon - caught only occasionally and/or not in any numbers

R = Rare

Table 10-26. Species of Invertebrates Collected by Benthic Grabs, January - June 1970

Species	Abundance
Polychaeta	
Spio setosa (tentacle worm)	C
Prionospio sp. (gold crown worm)	U
Nemertea	
Amphiporous sp.	R
Unidentified sp.	R
Crustacea	
Balanus improvisus (barnacle)	R
Edotea montosa (isopod, sowbug)	U
Cyathura polita (isopod, stick sowbug)	U
Corophium volutator (amphipod, scud)	R
Gammarus fasciatus (amphipod, scud)	U
Leptocheirus pinguis	U
Rhithropanopeus harrisii (mud crab)	R
Mollusca	
Congeria leucophaeta (mussel)	U
Diptera	
Tendipes tentans (midge)	U
Chaoborus albipes (midge)	R

A = Abundant - readily caught, in great numbers

C = Common - readily caught

U = Uncommon - caught only occasionally and/or not in any numbers

R = Rare

Table 10-27. Species of Invertebrates Collected by Thorson Bottles January - June 1970

SPECIES	ABUNDANCE
Polychaeta	
Spio setosa (tentacle worm)	C
Prionospio sp. (gold crown worm)	U
Amphipoda	
Gammarus fasciatus (amphipod)	C
Leptocheirus pinguis (amphipod)	R
Corophium volutator (amphipod)	R
Isopoda	
Edotea montosa (isopod)	R
Cyathura polita (stick sowbug)	R
Decapoda	
Rhithropanopeus harrisii (mud crab)	R
Diptera	
Tendipes tentans (midge)	C

A = Abundant - readily caught, in great numbers

C = Common - readily caught

U = Uncommon - caught only occasionally and/or not in any numbers

R = Rare

Table 10-28. Species of Invertebrates Collected by Trawls and Seines, January - June 1970

SPECIES	ABUNDANCE
Crustacea	
Balanus improvisus (barnacle)	R
Crangon septemspinosa (sand shrimp)	R
Neomysis americana (opossum shrimp)	U
Cyathura polita (sowbug)	R
Livoneca ovalis (fantail sowbug)	R
Edotea montosa (sowbug)	R
Rhithropanopeus harrisii (mud crab)	U
Callinectes sapidus (blue crab)	U
Gammarus fasciatus (scud)	C
Mollusca	
Congeria leucophaeta (mussel)	U
Polychaeta	
Spio setosa (tenacle worm)	R

A = Abundant - readily caught, in great numbers

C = Common - readily caught

U = Uncommon - caught only occasionally and/or not in any numbers

R = Rare

Table 10-29. Succession Panels. Average Number Caught per Panel. All Stations Sampled. January—June, 1970

	GROUP	SPP CODE	SPECIES	JAN *	FEB **	MAR *	APR Short	MAY Short	MAY Long	JUNE Short	JUNE Long
SURFACE	Cirripedia	383	Balanus improvisus	10		8	0	0	0	23600	21200
SURFACE	Diptera	303	Tendipes tentans	0		0	0	9	4	23	45
SURFACE, % Cover	Hydrozoa	223	Campanularia calceolifera	P		0	0	0	0	0	0
BOTTOM	Cirripedia	383	Balanis improvisus	11		0	0	0	1	7337	12250
BOTTOM	Diptera	303	Tendipes tentans	0		0	0	5	9	14	21
BOTTOM, % Cover	Hydrozoa	223	Campanularia calceolifera	1		0	0	0	0	0	0
	Number of panels examined			7		4	11	11	11	11	11

* Panels collected in January and March, 1970, had been submerged since September, 1969. Data should be interpreted with caution.

** No samples

% cover = percent of panel covered

P = Present but average less than 1

Short = Panels submerged one month

Long = Panels submerged for increasing periods. May, 1970, panels are two month exposure and June, 1970 panels are three month exposure.

Table 10-30. Benthic Grabs. Average Number Caught per Sample—All Stations Sampled, January—June, 1970.

GROUP	SPP CODE	SPECIES	JAN	FEB	MAR	APR	MAY	JUNE
Polychaeta	283	Spio setosa	14	5	15	82	47	37
Polychaeta	284	Prionospio sp.	0	11	1	4	5	1
Cirripedia	383	Balanus improvisus	40*	0	4	0	P	0
Amphipoda	363	Gammarus fasciatus	55*	P	2	P	4	2
Amphipoda	365	Leptocheirus pinguis	0	15	2	7	2	2
Amphipoda	362	Corophium volutator	0	P	0	0	0	0
Mollusca	572	Congeria leucophaeta	20*	P	9	1	P	0
Decapoda	467	Rhithropanopeus harrisii	0	0	0	0	P	0
Isopoda	504	Edotea montosa	5	0	P	P	P	P
Isopoda	502	Cyathura polita	20*	1	2	7	6	5
Diptera	303	Tendipes tentans larva	1	1	3	2	5	P
Diptera	303	Tendipes tentans pupa	0	0	0	0	P	0
Diptera	302	Chaoborus albipes	0	0	1	1	P	0
Nemertea	260	Nemertea, unidentified	0	0	0	P	1	1
Nemertea	262	Amphiporous	0	0	0	0	P	0
Total Number of Species			7	8	10	10	14	8

P = Present but average less than 1

* = Unusually high averages may be due to small number of stations. Sampled (2) in January. Not truly representative.

Table 10-31. Thorson Bottles – Average Number Caught – All Stations Sampled, April - June 1970

GROUP	SPP CODE	SPECIES	APR	MAY	JUNE
Polychaeta	283	Spio setosa	2	1	1
Polychaeta	284	Prionospio sp.	P	P	0
Amphipoda	363	Gammarus fasciatus	15	6	21
Amphipoda	365	Leptocheirus pinguis	P	0	1
Amphipoda	362	Corophium volutator	0	P	0
Decapoda	467	Rhithropanopeus harrisii	0	P	0
Isopoda	504	Edotea montosa	0	0	P
Isopoda	502	Cyathura polita	P	0	0
Diptera	303	Tendipes tentans larva	2	2	9
Diptera	303	Tendipes tentans pupa	0	0	1

* No samples collected during January - March.

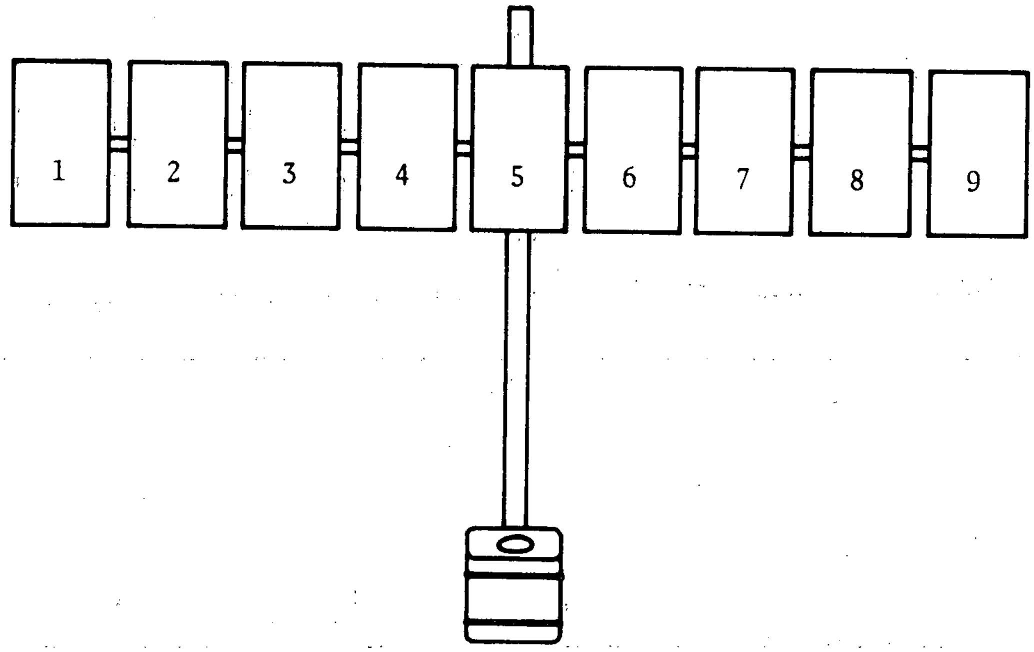
P= Present but average less than 1.

Table 10-32. Species—Average Catch per Tow for Trawls and Seines January, 1970

	SPP CODE	SPECIES	JAN	FEB	MAR	APR	MAY	JUN
BOTTOM TRAWLS		Decapoda						
	464	*Crangon septemspinosa*	0	0	0	0	P	0
	466	*Callinectes sapidus*	0	0	0	0	0	P
	467	*Rhithropanopeus harrisii*	0	0	0	1	P	P
		Cirripedia						
	383	*Balanus improvisus*	572	0	0	5	2	0
		Isopoda						
	502	*Cyathura polita*	0	0	0	P	0	1
	504	*Edotea montosa*	0	0	0	0	P	P
		Amphipoda						
	363	*Gammarus fasciatus*	0	0	0	1	10	13
		Polychaeta						
	283	*Spio setosa*	0	0	0	0	P	1
		Mysidacea						
	521	*Neomysis americana*	0	0	0	0	7	P
		Mollusca						
	572	*Congeria leucophaeta*	252	0	0	1	2	P
P= Present but average less than 1								
SURFACE TRAWLS		Isopoda						
	502	*Cyathura polita*				0	0	P
	504	*Edotea montosa*				0	0	P
	500	Unidentified isopod						P
		Amphipoda						
	363	*Gammarus fasciatus*				0	0	2
		Mysidacea						
	521	*Neomysis americana*				0	0	8
BEACH SEINES		Decapoda						
	466	*Callinectes sapidus*			0	0	2	1
		Cirripedia						
	383	*Balanus improvisus*			0	0	0	0
		Amphipoda						
	363	*Gammarus fasciatus*			0	0	0	P
		Mysidacea						
	521	*Neomysis americana*			0	0	0	P
		Mollusca						
	572	*Congeria leucophaeta*			0	0	0	0

Table 10-33. Thorson Bottle Sediment Volumes in Milliliters, April - June 1970

STA	MILE	SITE	DPTH	APRIL	MAY	JUNE
54	38	1	20	208	265	354
55	40	3	14	28	25	5
56	41	2	60	172	81	15
51	42	3	26	268	330	355
53	42	3	14	66	98	120
57	43	3	7	170	132	83
58	45	1	10	252	356	410



Sta. No.

51 Forebay 26'
1 Set of panels at 4'
1 Set of panels at 22'
1 Thorson bottle at 22'

53 Effluent 14'
1 Set of panels at 10'
1 Thorson bottle at 10'

54 Grassy Point 20'
1 Set of panels at 4'
1 Set of panels at 16'
1 Thorson bottle at 16'

55 Range Marker 14'
1 Set of panels at 4'
1 Set of panels at 10'
1 Thorson bottle at 10'

Sta. No.

56 Anchor Chain 60'
1 Set of panels at 4'
1 Set of panels at 56'
1 Thorson bottle at 56'

57 Peekskill 7'
1 Set of panels at 4'
1 Thorson bottle at 4'

58 Round Island 10'
1 Set of panels at 6'
1 Thorson bottle at 6'

Figure 10-1. Exposure Panels and Thorson Bottles (1970)

R342

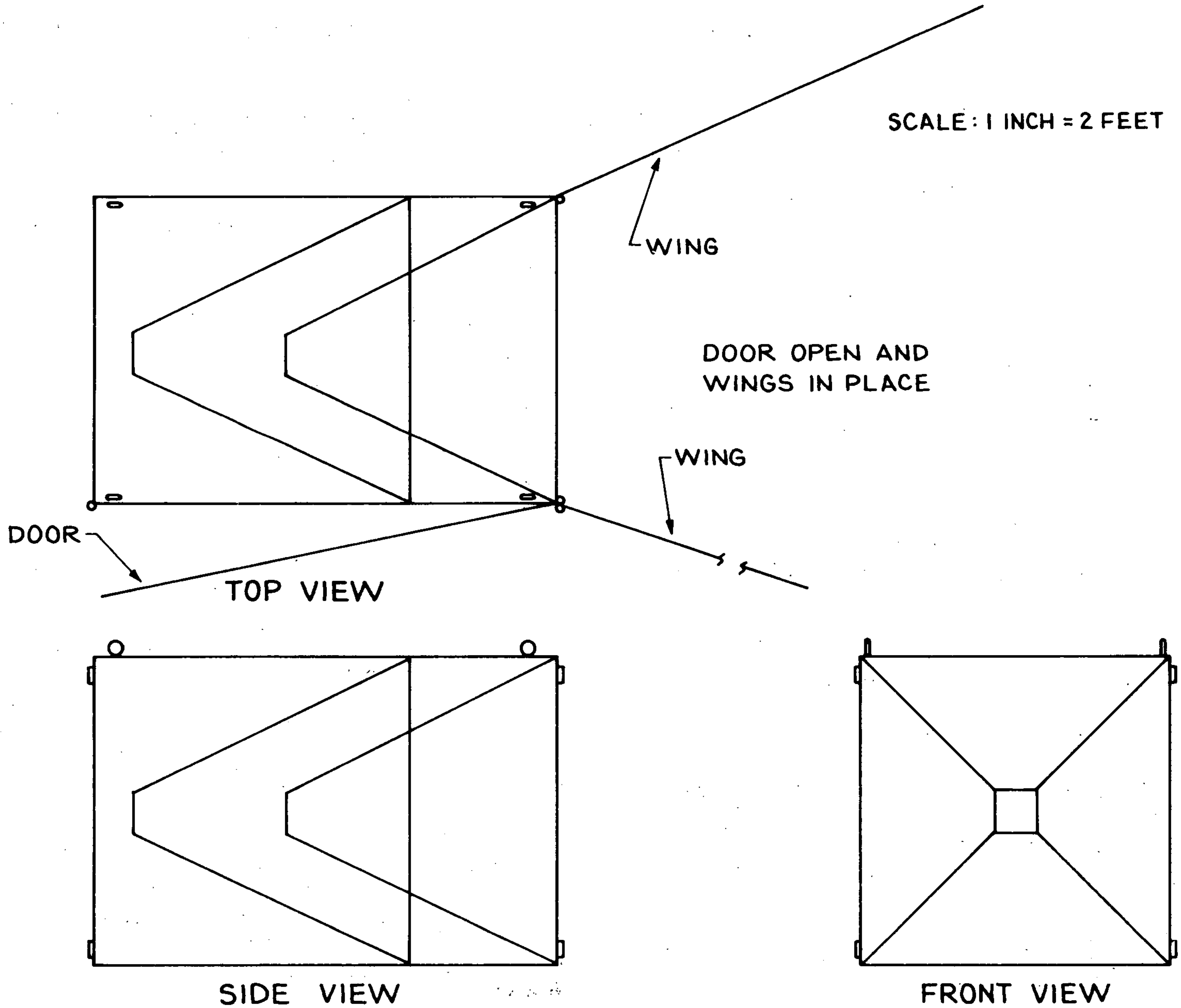


Figure 10-2. Indian Point Fish Trap

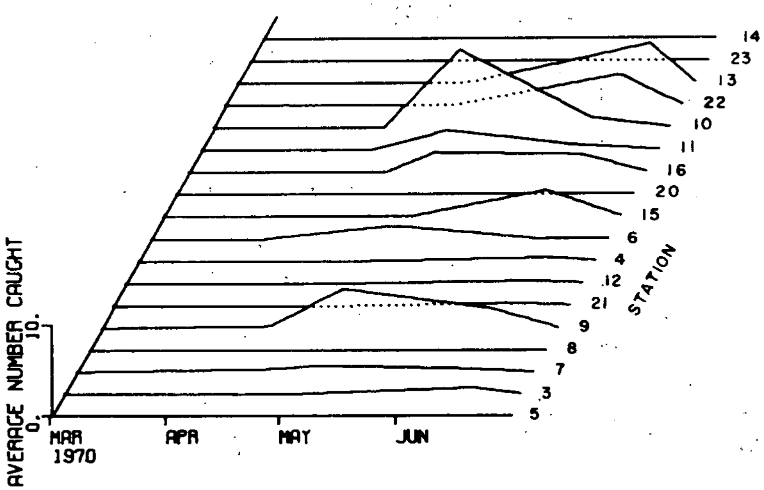


Figure 10-3. Alewife (Surface Trawls)

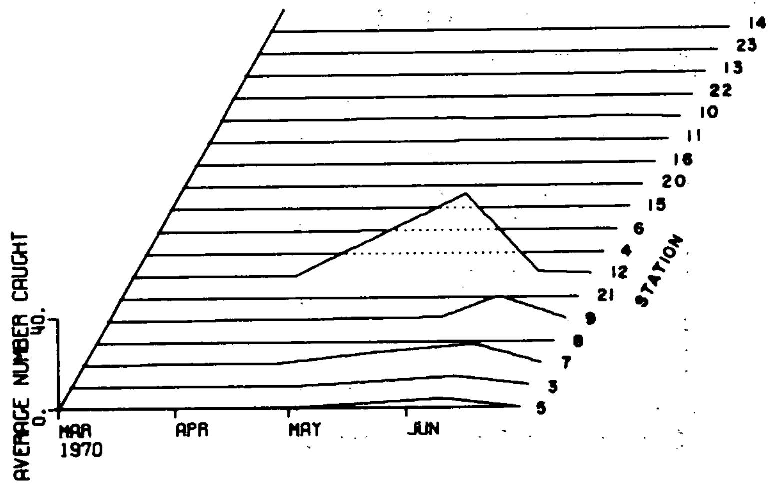


Figure 10-4. Alewife (Bottom Trawls)

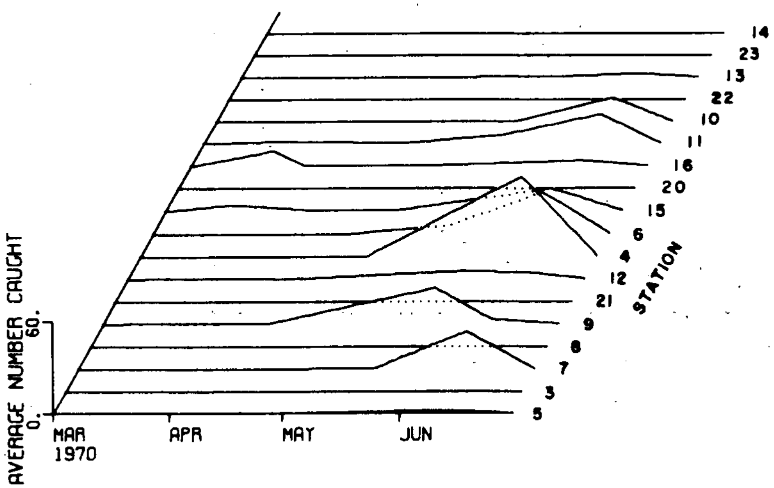


Figure 10-5. American Smelt (Bottom Trawls)

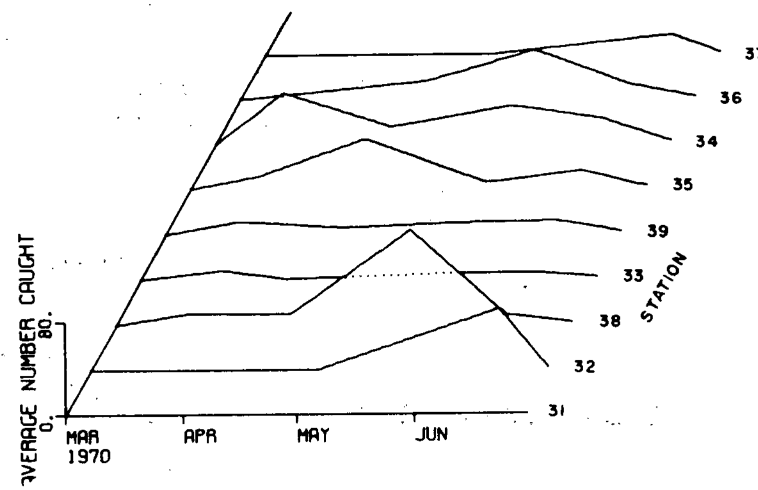


Figure 10-6. Spottail Shiner (Beach Seines)

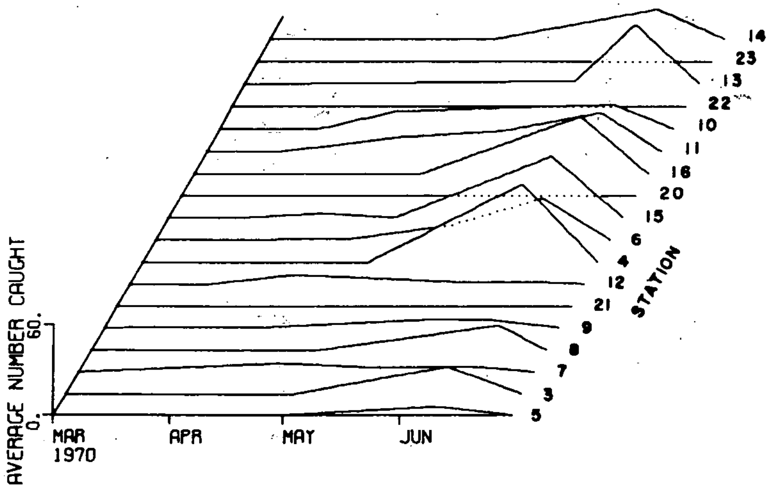


Figure 10-7. American Eel (Bottom Trawls)

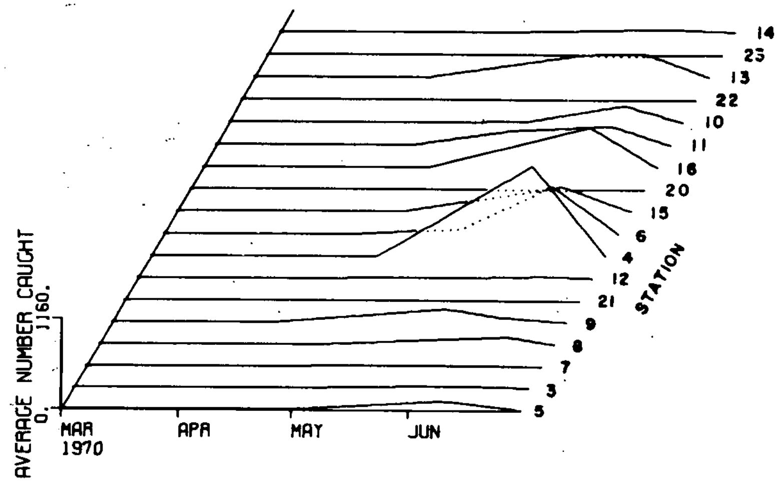


Figure 10-8. Atlantic Tomcod (Bottom Trawls)

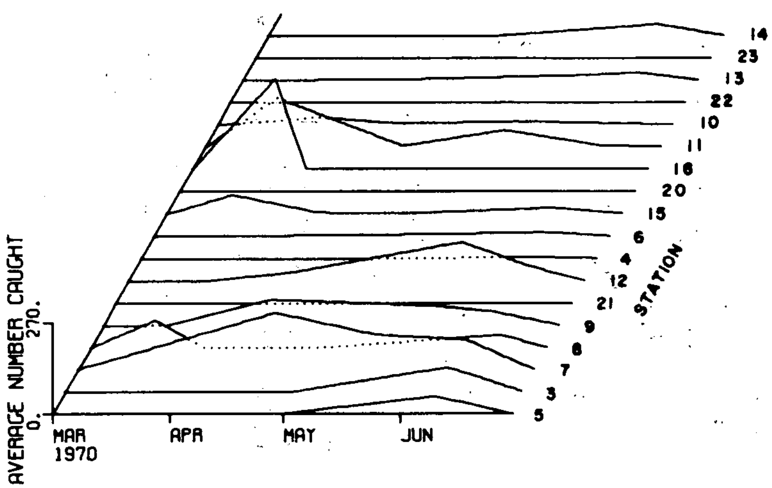


Figure 10-9. White Perch (Bottom Trawls)

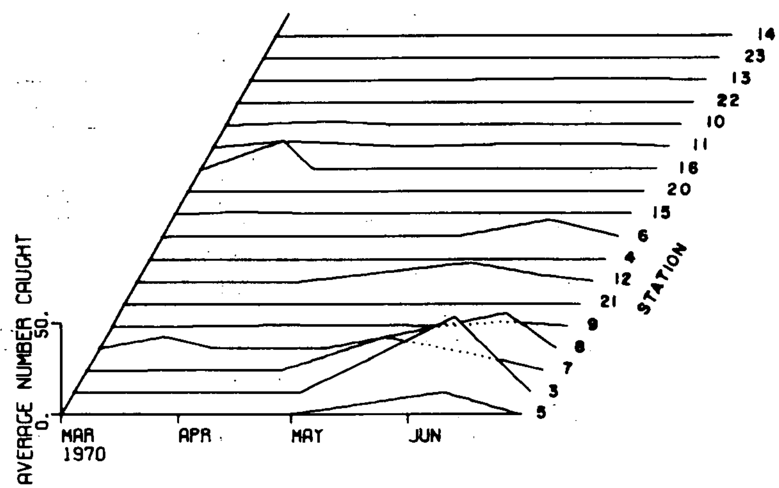


Figure 10-10. Striped Bass (Bottom Trawls)

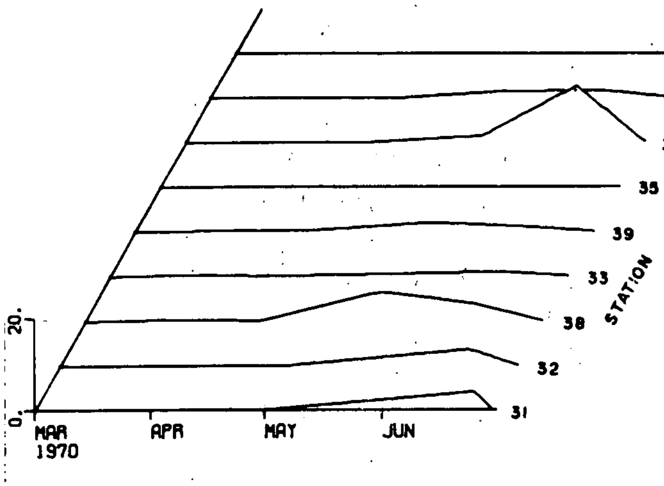


Figure 10-11. Striped Bass (Beach Seines)

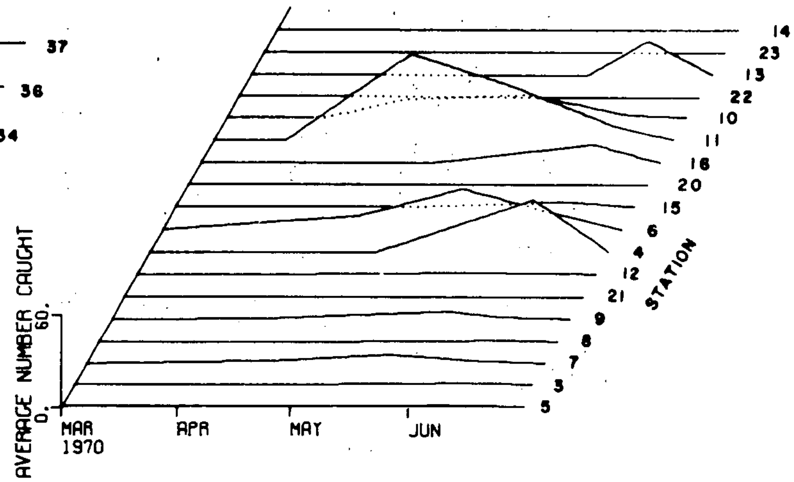


Figure 10-12. Hogchoker (Bottom Trawls)

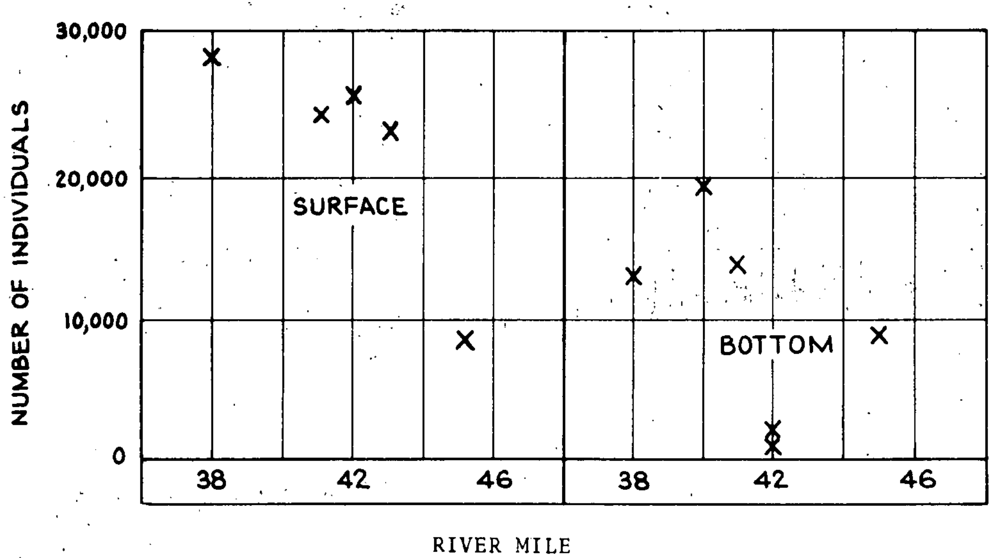


Figure 10-13. Succession Panels - Total Counts of Balanus improvisus, June 1970

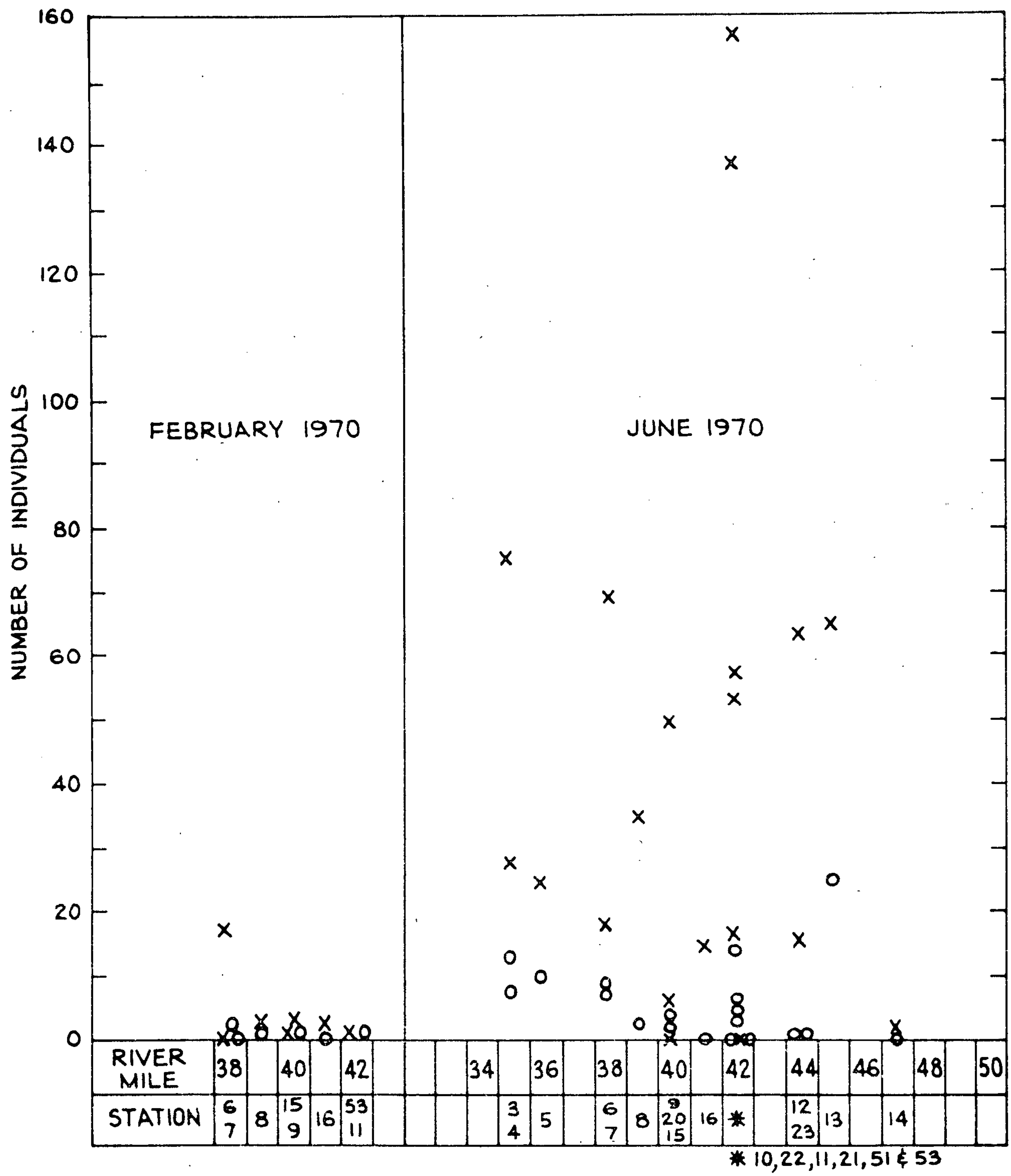


Figure 10-14. Spio setosa (x) and Cyathura polita (o) Collected in Benthic Grabs

11.0 LABORATORY STUDIES

A considerable store of knowledge exists on the effect of heated effluent on the aquatic environment, as evidenced by extensive bibliographies prepared on the subject by Raney and Menzell (1969) and Mihursky and Kennedy (1967).* Few studies, however, deal with behavior of organisms within the actual environment receiving the discharge. Data are specifically lacking on resident and migrating species of the Hudson River. The growing importance placed by the general public on the impact of heated effluents on the environment as well as the concentrated efforts of industry to determine and minimize these effects, lends an increased emphasis to studies of this nature.

The three units at Indian Point will discharge some 2,000,000 gallons per minute of cooling water into the Hudson with an expected ΔT of approximately 17°F; surface water temperature increases of 1—2°F may be detectable as much as ten miles below the point of discharge (Sorge, 1969 and Quirk, Lawler and Matusky, 1968).**

In consideration of the potential environmental changes associated with the on-line operation of five nuclear units, two experiments were designed which would demonstrate to a degree the effects of heated water on the behavior and viability of selected organisms (Table 11-1).

*Raney and Menzell, 1969. Heated Effluents and Effects on Aquatic Life with Emphasis on Fishes. Ichthyological Associates, Bull. 2. 469 p.

Kennedy and Mihursky, 1967. Bibliography on the Effects of Temperature in the Aquatic Environment. U. of Maryland, Natural Resources Institute. 89p. + addendum.

**Sorge, 1969. The Status of Thermal Discharges East of the Mississippi River Chesapeake Science 10 (3-4): 131-138.

Quirk, Lawler and Matusky, 1968. Effect of Indian Point Cooling Water Discharge on Hudson River Temperature Distribution. A report to Consolidated Edison Company of New York, Inc. 35p. + appendix.

One experiment, entitled "Thermal Effluent Choice," deals with the behavior of organisms which come in contact with the heated plume. Basically, this experiment was designed to indicate whether an avoidance or attraction reaction takes place, and if this behavior pattern changes when the highest annual plume temperatures are reached during the months of July and August.

The second experiment entitled "Thermal Shock" was designed to determine the effects on viability and behavior of organisms whose size makes them readily susceptible to passage through the intake and condenser system of Unit 1.

All experiments conducted used continuously flowing river and effluent waters piped separately through the non-toxic, plastic pump and piping systems in the dockside research laboratory at Indian Point (Figure 11-1). The use of actual environmental conditions adds authenticity to the results and interpretation becomes more applicable to the "real" environment.

11.1 Thermal Effluent Choice Experiments

11.1.1 Apparatus

Experiments were conducted using two types of choice systems, both constructed by Raytheon personnel at Indian Point. These two systems are similar, the basic difference being one of size.

The larger apparatus, illustrated in Figure 11-2, consists of three twenty-five gallon fiberglass aquaria connected to each other by 6-inch inside diameter PVC tubing. River water is introduced to one end tank and effluent water into the opposite end tank. Water flow is from the end tanks toward the center tank into which the experimental organisms are introduced. The center tank is provided with draining holes, enabling a positive pressure head to be maintained in both end tanks. This apparatus is used primarily for large fishes which require greater volumes of water.

The second choice system (Figure 11-3) consists of three one-gallon translucent polyethylene containers joined to each other by 1 7/16-inch inside diameter clear plastic tubing. The hydrodynamics of this system are essentially similar to those described for the larger apparatus. This system is utilized for invertebrates and small fishes which would not require large amounts of water.

Experiments were conducted with both systems simultaneously enabling different species to be utilized under similar water conditions.

Movable partitions were located in each of the receiving tanks of the large choice apparatus to contain experimental organisms within the center tank before each trial commenced. A similar containment of organisms in the smaller choice apparatus was accomplished with a curled sheet of polyethylene which could be slid into place, effectively blocking movement into and out of the center tank.

Flow patterns were tested by introducing nontoxic rose bengal dye at different times into each of the three tanks of both systems. The dye was observed to flow only from the end tanks toward the center tank. Water from either receiving end tank does not flow into an opposite receiving tank. Further observation showed a plume effect to occur in the center tank until a homogeneous mixture resulted. Thus, the end-receiving tanks are totally segregated from each other with water entering and mixing only in the center tank as shown diagrammatically in Figure 11-4.

Since an average maximum Δ T of only 9°F has been observed during the period Raytheon monitored water parameters for Consolidated Edison, the possibility that sufficient thermal gradients would not exist in the center tank of the choice apparatus was examined. To accomplish this a Leeds and Northrop strip chart recorder was wired to twenty submersible temperature sensing probes; each probe was accurate to within $\pm$ 0.25°F. Actual heated effluent was not available during the experimental period. Thus, artificially heated water was used to test thermal patterns. Since a constant temperature could not be maintained artificially for the quantities of water required for normal use time of the choice apparatus, actual thermal gradients were not plotted though they were observed to exist for short terms, to a lesser or greater extent, depending on depth and amount of heated water available. A cross-section at five depths was monitored within the center tank which contains a water depth of 11 1/2 inches.

Both choice systems were located on fiberglass coated wooden draining tables. Each was leveled to insure an equal water flow and drainage across the system. Water for each choice apparatus, as well as for all observation and holding tanks, was supplied by plastic coated submersible pumps, located in the forebay and effluent canal of Unit 1. The maximum pumping capacity for each pump at the installed static head, is forty gallons per minute regulated through overflow valves. Piping systems, on/off valves, and tubing to each tank were either of PVC or polyethylene construction.

11.1.2 Procedures

Key species of invertebrates and fishes, listed in Table 11-1, were planned for use during choice experiments. Methods of collection varied with season and availability of organisms. Alternate species were used when present in sufficient numbers or when key species were not available.

Experimental procedures were essentially similar for all experiments completed. Reasons for changes in location of the choice system, frequency of water quality determinations, and time period of each trial, are explained in the section covering results.

Specimens collected in the field were transferred to holding tanks in the laboratory, each supplied with a mixture of river and effluent water. This practice was instituted so that specimens used during experiments would not be subjected to an instantaneous change of water quality which would occur if acclimation took place in either river or effluent water, alone.

Prior to initiating each trial of an experiment, the partitions in the choice apparatus were in a lowered position. Ten healthy specimens of a single species were then transferred from holding tanks to the center tank of the choice apparatus. Occasionally, multiple species trials were completed to determine whether the presence of a second or third species caused a change in choice behavior. Also accomplished were trials in which twenty or thirty specimens were tested to determine behavior differences with greater concentrations of a single species.

The flow rate was adjusted so that equivalent volumes of river and effluent water entered the system. Either three or four gallons per minute (gpm) were used for the large apparatus and one gpm in the small apparatus. The velocity of water through the connecting tubes of the large choice apparatus was calculated to be 0.034 feet per second (fps) at three gpm and 0.045 fps at four gpm. In the small choice apparatus, a velocity of 0.197 fps was estimated for a flow rate of one gpm.

Temperature, salinity, dissolved oxygen, pH, and chlorinity determinations for each tank were made either electronically or by titration at commencement and completion of each trial. After 20 May, these parameters were measured only once during each trial unless the AES monitor showed a significant change to occur during the course of an experiment. Data were entered on a laboratory trial data sheet illustrated in Figure 11-5.

Between fifteen and twenty minutes elapsed from the time fish were placed into the center tank and the start of a choice trial before partitions were raised and the test specimens allowed a free choice during the trial—without interference from the investigator. Upon completion of the trial period, partitions were replaced. Water turbidity necessitated siphoning most of the water from each tank before results could be observed.

As a control for each trial, a second trial was undertaken with the same specimens replaced to the center tank. However, the water flow was switched so that the tank which received river water during trial #1 would receive effluent water during trial #2 and vice versa. This procedure would show whether a tank or water preference was demonstrated. On occasion, trials were conducted with both end tanks receiving only river water to note a difference in choice behavior, if any.

11.1.3 Results-Environmental Parameters

Heated effluent was available only on May 20 when on-line operations resumed for less than 24 hours. All trials completed previous and subsequent to this date were conducted without heated effluent. Data resulting from these latter experiments serve as baseline information of behavior in the "choice" apparatus in relation to an unheated plant discharge. Chemical additives which may be dumped into the effluent canal during off-line operations could create an attraction or avoidance reaction, and if such is the case, the results take on an increased importance.

A total of 122 "Thermal Effluent Choice" experiments were conducted between 6 April and 23 June. The species used and summarized results are tabulated in Table 11-2. Tables listing pertinent data associated with each trial have been compiled separately for a single or multiple species series of trials (Tables 11-3—11-10). Bar graphs summarizing individual trial results, plant status and experimental lighting conditions are shown in Figures 11-6 through 11-11.

With a substantial increase in water clarity during May, laboratory investigations determined that some species may be more light sensitive than others. Since slightly unequal lighting conditions were found to prevail over the large choice apparatus, the situation was corrected by equalizing the lighting as well as by painting each tank opaque and providing each tank with an opaque tank cover. All trials conducted subsequent to 1 June reflect these changes unless otherwise stated.

Four trials were conducted on the day Unit 1 resumed on-line operations (May 20). The effluent temperature for this date steadily increased to a maximum of 84.6°F, i.e., a Δ T of 23°F which is approximately 14.0°F above the normal Δ T of 9°F. The results of the trials completed in conjunction with such high effluent temperatures are significant. However, they should not be interpreted as relating to behavior during normal effluent temperatures.

The original experimental design included the procedure of testing each species monthly during the spring, summer and autumn. This would take into account the natural seasonal rise and fall of river temperature. The choice of experimental specimens depended on their availability, ease of capture, and whether they could be transported to, and maintained in, the laboratory in good condition in sufficient numbers. Gaps existing in data for particular species reflect these factors during the period experiments were conducted.

The temperature, pH, and dissolved oxygen data taken during each date experiments were undertaken, are shown in Figures 11-12 and 11-13. Since the effluent canal area can become somewhat stagnant in the absence of cooling water flow, the status of the cooling water circulators partially explains the varying differences between the river and effluent water characteristics for specific dates; these data are also shown with each figure.

When the plant was off-line, the greatest differential between river and effluent water occurred when both cooling water circulators were off the line, as evidenced for the period 26 April through 17 May. Differentials were lowest when both circulators were in operation (6-16 April; 18-20 May; 9-14 June). When only one circulator was on line, the differential was almost equal to that established when both were operating (17-26 April; 21 May-8 June). In addition to the normal cooling water volume of 300,000 gpm an additional 20,500 gpm is pumped as an auxilary flow. This additional volume passes through the plant regardless of whether none, one or both main circulators are on-line.

Measurement of residual and total chlorine in the effluent coincided with the time sodium hypochlorite compounds were introduced to the cooling water system of Unit 1. On no occasion was a concentration greater than 0.1 ppm indicated during the period experiments were undertaken. These findings were supported by Consolidated Edison chemists who made independent determinations whenever the chlorination process was initiated.

A salinity differential did not exist between the river and effluent canal. The salt content of water in the vicinity of the Indian Point site was relatively low, and rarely reached concentrations of 0.5 percent. With the exception of 20 May when Unit 1 was on the line, only a slight temperature difference prevailed between the river and effluent water (Figure 11-12). This differential fluctuated from a low mass of less than 0.1°F to a rare high of approximately 2.5°F. It is significant to note that at no time did the river water temperature exceed the temperature of the effluent water by more than 0.1°F while experiments were conducted. Thus during experiments the effluent water always offered a warmer environment (except on 22 May 1970, when the temperatures were equal) which could cause activity depending upon the thermal sensitivity and specific preferences of a particular species. This choice was available through the spring water temperature increase from approximately 40.0°F on 6 April to 73.0°F on 23 June.

The dissolved oxygen and pH showed considerable fluctuations compared to the relatively stable temperatures (Figures 11-12 and 11-13). Higher values were found in the effluent water during some days while in the river water during others. Fluctuations in dissolved oxygen concentrations depended on weather conditions, air temperature, tide, and if the cooling water circulators were operating. However, fluctuations in pH occurred primarily in the effluent canal and may have been related to the plant's regeneration of the water purfication resin bed which is periodically recharged with caustic soda and sulfuric acid. The residue of this process is discharged into the effluent canal, occasionally without full neutralization. This was particularly true for 19 May, although stabilization for pH was indicated during the latter part of May and most of June.

11.1.4 Results — Species Preference Data

An examination of the combined results for all species (Table 11-2) indicated that only the Atlantic tomcod showed a definite choice of river water (slightly cooler) opposed to effluent water. This was true for 13 of the 17 trials conducted with this species (Figure 11-6 and Table 11-3). In those trials in which the effluent water was chosen, the numbers of tomcod involved were small. This behavior pattern is in agreement with Bigelow and Schroeder (1953)* who state in reference to tomcod, "South of Cape Cod, most of them move out from the shore into slightly deeper (hence cooler) water in spring, coming in again in autumn, to winter in estuaries."

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*Fishes of the Gulf of Maine. Bul. No. 74. U.S.F. and W.S., Washington. 1953.

Of the remaining 6 species for which sufficient data are available (striped bass, spottail shiner, white perch, banded killifish, threespine stickleback and Johnny darter) no consistent pattern of behavior was apparent (Tables 11-4 through 11-9). A general increase in activity was noted for white perch and banded killifish with increasing seasonal temperatures (Figures 11-7 and 11-8, Tables 11-4 and 11-5). This interpretation is based upon the greater number of specimens which moved from the center tank during the latter periods when experiments were conducted. The increased movement and preferred choice of effluent water by banded killifish on 20 May (Figure 11-8) is significant since Unit 1 was on-line. Relatively little movement of this species was indicated prior to this date.

Striped bass, spottail shiner and threespine stickleback did not indicate a change in activity in conjunction with rising river temperatures. With the exception of few trials these species were moderately active throughout the entire experimental period (Figures 11-9, 11-10 and 11-11, Tables 11-6, 11-7 and 11-8).

During the latter part of May, three experiments were conducted on the spottail shiner using only river water through the choice system. The results indicated that lighting over the tanks may influence the movement of this species. Of the 30 specimens used during the 3 trials, 9 chose tank "C" (the darker tank) while only 1 chose tank "A" (the better lighted tank). Since no other known variable was introduced at this time, the results appear significant (Table 11-7). For this reason the lighting was equalized for all subsequent trials with all species.

Trials conducted with two and three species simultaneously did not show a significant difference in behavior from trials in which a single species was tested. Apparently, the presence of more than one species did not change the behavior pattern noticed when a species was tested alone (Table 11-10).

Trials were completed on two additional species, not listed above. Two trials each were completed for the hogchoker and the amphipod, Gammarus fasciatus. Of the 20 specimens used during the hogchoker trials, only 2 moved from the center tank, both preferring the effluent water. Additional data are needed before conclusions can be drawn.

The two trials undertaken with amphipods created unforeseen problems. Of 28 specimens utilized during the trials, 13 escaped through the overflow of the center tank. In addition, the date of each trial coincided with mating activity of Gammarus; this resulted in immediate pairing as soon as the specimens were placed in the choice apparatus. The specimens which did not escape did not move from the center tank.

Considering all species and all trials completed, one general conclusion is evident. With the exception of tomcod and banded killifish, the overwhelming majority of specimens used during the experimental period failed to indicate a preference for one water source over another (Table 11-2). Since the choice apparatus was shown to be a valid method for determining the preference of selected organisms, the reason that specimens did not "choose" is significant. This behavior is possibly related to the status of Unit 1. Considering that Unit 1 was off-line during all but four trials, no substantial difference existed between the effluent and river water throughout the experimental period. At no time did extreme temperatures or pH values occur. Dissolved oxygen concentrations were always sufficient to sustain normal activity for the species tested. Since most species tolerate a range in physical parameters in an environment, the choices offered during experiments appear insufficient to initiate a response.

11.2 Thermal Shock Experiment

This experiment was designed to simulate temperature effects of passage through the condenser system, effluent canal, and the plume of nuclear Unit 1.

The thermal shock apparatus illustrated in Figure 11-14 was constructed by Raytheon personnel at the Indian Point site. The apparatus consists of a double cradle, each section having a volume when submerged of about ten gallons, and one gallon when not in an experimental tank. The configuration will make it possible to conduct two experiments simultaneously utilizing the same or different species with a single device.

Construction materials consisted of plexiglass stripping, plastic screening, wood stripping, and metal fasteners coated with fiberglass resin to minimize adverse effects, if any, on the experimental organisms. Accessory equipment includes twenty-five gallon fiberglass aquaria and one gallon glass holding jars for observation.

Key species of juvenile fishes and small invertebrates, as defined by the Technical and Policy Committees, will be tested (Table 11-1). However, additional species will also be utilized if available in sufficient numbers, and in absence of key species in the study area at the time of testing. Multiples of ten specimens of each species will be used to facilitate interpretation and summation of results.

The condensers of unit one contain 31, 508, #18 gauge copper tubes, each 30 feet long with an approximately 3/4 inch inside diameter. Mean velocity of the intake water approximates one foot per second (fps) which increases to 6 fps during passage through the condenser. Cooling water is than transferred to theeffluent canal with a mean velocity of one fps until discharged into the river. Thus, a maximum ΔT is attained in approximately 5 seconds. The water temperature of the thermal plume steadily decreases with increased mixing and distance from the effluent canal site.

Basic experimental procedures consist of placing organisms, acclimated to ambient river temperatures, into the cradle device contained in a twenty-five gallon test tank (Figure 11-15). A continuous flow of river water will be maintained in the tank. The cradle is then transferred to a second twenty-five gallon test tank provided with a continuous flow of effluent water. Approximately two gallons of river water will be transferred in the bottom of the cradle so that the specimens will not have to be removed from the water or subjected to an instantaneous heat rise. The cradle will be kept in the effluent test tank for a period of time paralleling that required for the passage of a particle of water through the condenser and effluent canal (about fifteen minutes). After this phase of the experiment, river water will be mixed continuously with effluent water entering the tank so as to simulate formation of the plume and subsequent mixing in the river. This phase will last approximately fifteen minutes before effluent water flow is discontinued simulating assimilation of the effluent discharge by the river. Organisms will be observed to determine mortality, if any, and transferred to the one-gallon glass holding jars for observation for a two-day period.

Dissolved oxygen, pH, salinity, temperature and chlorine parameters will be measured at intervals throughout each experiment and observation period.

Experiments were scheduled to commence on 1 April and continue on a monthly basis until the end of October. In this way, experimental conditions would parallel the seasonal rise of the river temperature to its maximum in July and August and the gradual decrease again in the autumn.

Unit 1 suspended operations on March 20. Full on-line operations are not scheduled to commence again until mid-September, 1970. Since heated effluent was not available during the period, the experiment was not carried out. All equipment is operational and ready to be utilized once on-line operations are resumed.

Table 11-1. List of Key Species of Fishes and Invertebrates Selected for Laboratory Experiments

Common Name	Scientific Name
FISHES	
Striped bass	*Morone saxatilis*
White perch	*Morone americana*
Tomcod	*Microgadus tomcod*
Herrings*	*Alosa aestivalis*
	Alosa pseudoharengus
Bay anchovy (if available)	*Anchoa mitchilli*
American shad	*Alosa sapidissima*
INVERTEBRATES	
Amphipod	*Gammarus fasciatus*
Shrimp	*Crangon septemspinosus*

*Blueback herring and alewives combined due to difficulty of separation while alive at this young life stage.

Table 11-2. Thermal Effluent Choice Experiments, Summary Results

SPECIES	NO. TRIALS	TOT. NO. OF SPECIMENS	NO. TRIALS CROSSING OCCURRED	NO. TRIALS SINGLE CROSS R	NO. TRIALS SINGLE CROSS E	NO. SPECIMENS SINGLE CROSS R	NO. SPECIMENS SINGLE CROSS E	TRIALS DOUBLE CROSSING NUMBER	TRIALS DOUBLE CROSSING PREF.	TRIALS DOUBLE CROSSING RATIO	SPECIMEN TOTAL R	PREF. NUMBERS M	PREF. NUMBERS E
White perch	25	266	22	8	4	26	17	10	E	31:27	53	165	48
Striped bass	10	96	7	1	1	1	1	5	R:E	12:12	13	70	13
Tomcod	17	170	17	3	0	18	0	14	R	54:33	72	65	33
Johnny darter	8	68	7	3	2	12	12	2	R	6: 4	18	34	16
Stickleback*	9	85	9	0	1	0	3	18	R	34:23	34	25	26
Banded killifish	8	80	8	1	3	3	7	4	E	6: 5	8	59	13
Spottail shiner	27	315	17	9	5	32	27	3	E	5: 3	35	248	32
DOUBLE SPECIES TRIALS													
White perch	2	40	2	0	1	0	4	1	E	2: 1	1	13	6
Spottail shiner			2	2	0	5	0				5	15	0
Johnny darter	1	20	1	1	0	8	0				8	2	0
Banded killifish			1	0	1	0	1				0	9	1
TRIPLED SPECIES TRIALS													
Johnny darter			2					2	R	5: 2	5	13	2
Spottail shiner	2	60	1	1	0	2	0				2	18	0
Banded killifish			0								0	20	0
Trials as Separate Controls: effluent water not used											Tank A	Tank B	Tank C
Spottail shiner	3	30	3	2	0	4	0	1	A	5: 1	9	10	1

Legend:

R = RIVER, M = MIXED, E = EFFLUENT
* small choice apparatus

Table 11-3. Thermal Effluent Choice Experiments, Atlantic Tomcod

TRIAL	1970 DATE	DISSOLVED OXYGEN (ppm)			TEMPERATURE (°C)			pH			SAL. (o/oo)	RESULTS			TANK	LIGHTS	CIRC
		R	M	E	R	M	E	R	M	E		R	M	E			
1	7 Apr	10.2	10.5	10.6	4.1	4.3	4.4	7.2	7.3	7.4	0.1	5	4	1	C	on	on
2	8 Apr	9.9	9.4	10.1	4.4	4.6	4.7	7.4	7.4	7.4	0.1	3	5	2	A	on	on
3	8 Apr	11.4	10.7	10.7	4.1	4.9	5.0	7.2	7.3	7.4	0.1	2	5	3	C	on	on
4	9 Apr	10.1	10.1	9.9	5.1	5.3	5.6	7.1	7.1	7.1	0.1	6	4	0	A	on	on
5	10 Apr	9.5	9.9	9.4	5.4	5.5	5.6	7.4	7.3	7.2	0.1	4	3	3	C	on	on
6	13 Apr	10.0	10.9	10.1	6.2	6.5	6.5	7.2	7.3	7.2	0.1	4	4	2	C	on	on
7	13 Apr	9.6	10.1	10.1	5.9	6.2	6.4	7.3	7.3	7.4	0.1	2	4	4	A	on	on
8	14 Apr	10.5	10.0	10.0	6.4	6.7	6.8	7.3	7.2	7.3	0.1	7	2	1	C	on	on
9	14 Apr	10.2	10.1	10.2	6.0	6.2	6.5	7.5	7.5	7.3	0.1	5	3	2	A	on	on
10	14 Apr	10.6	10.6	10.5	6.0	6.3	6.4	7.3	7.3	7.5	0.1	6	2	2	A	on	on
11	15 Apr	9.7	9.2	9.5	6.5	6.8	6.9	7.4	7.2	7.3	0.1	5	3	2	C	on	on
12	15 Apr	10.0	9.9	9.7	6.5	6.8	7.1	7.3	7.4	7.3	0.1	5	2	3	A	on	on
13	15 Apr	9.9	10.0	10.2	6.3	6.7	6.8	7.3	7.5	7.6	0.1	7	3	0	C	on	on
14	18 June	4.6	4.8	5.0	21.8	21.8	21.8	6.8	6.8	6.8	2.2	2	4	4	A	off	off
15	18 June	4.6	5.0	5.2	21.4	21.5	21.5	6.8	6.7	6.5	2.5	2	5	3	C	off	on
16	18 June	4.9	5.0	5.1	21.0	21.2	21.3	6.9	6.8	6.8	2.2	2	7	1	A	on	on
17	18 June	4.9	5.0	5.2	21.1	21.2	21.3	6.8	6.8	6.8	2.3	5	5	0	C	on	on

R = River, M = Mixed, E = Effluent; "Tank" designates effluent tank (Figure 11-2); "Circ" designates status of cooling water circulators

Table 11-4. Thermal Effluent Choice Experiments, White Perch

TRIAL	1970 DATE	DISSOLVED OXYGEN (ppm) R	M	E	TEMPERATURE (°C) R	M	E	pH R	M	E	SAL. (o/oo)	RESULTS R	M	E	TANK	LIGHTS	CIRC
1	24 Apr	8.6	8.7	8.6	9.0	9.8	10.1	7.1	7.1	7.0	0.1	2	7	1	A	on	on
2	29 Apr	---	---	---	11.1	11.7	12.2	6.9	7.0	6.9	0.1	0	10	0	C	on	off
3	29 Apr	---	---	---	11.6	12.2	12.4	6.9	6.9	6.9	0.1	0	10	0	A	on	off
4	30 Apr	8.3	7.5	7.3	11.4	12.0	12.7	7.0	7.0	7.0	0.1	1	9	0	C	on	off
5	30 Apr	7.7	7.9	7.9	11.4	11.9	12.1	7.0	7.1	7.0	0.1	3	7	0	A	on	off
6[a]	15 May	7.0	7.5	7.8	14.7	15.2	15.8	7.2	7.2	7.1	0.3	1	17	0	A	on	off
7[a]	15 May	7.3	7.3	7.0	14.1	15.0	15.4	7.1	7.1	7.0	0.3	0	18	0	C	on	off
8	18 May	6.7	7.3	8.8	15.0	15.4	16.3	7.3	8.0	8.9	1.4	1	8	1	A	on	on
9	18 May	6.4	7.0	7.0	15.2	15.4	15.6	7.2	7.2	7.2	1.3	3	7	0	C	on	on
10	18 May	6.2	7.4	6.5	15.3	15.5	15.7	7.1	7.2	7.2	1.1	0	8	2	C	on	on
11	18 May	6.6	6.7	6.7	14.9	15.1	15.3	7.1	7.2	7.2	1.4	2	8	0	A	on	on
12	19 May	6.6	6.8	6.9	15.0	15.1	15.3	7.2	7.2	7.2	1.7	0	6	4	C	off	on
13	19 May	6.6	6.8	6.8	14.9	15.1	15.3	7.2	7.6	8.2	1.8	5	5	0	A	off	on
14	27 May	5.2	5.2	5.2	16.8	17.2	17.8	6.8	6.9	6.9	0.2	0	5	5	C	off	on
15	27 May	---	---	---	17.1	17.3	17.5	6.9	7.0	6.9	0.5	1	4	5	A	off	on
16	9 June	4.8	4.9	4.6	20.0	20.2	20.3	6.9	6.9	6.8	0.2	4	5	1	C	on	on
17	9 June	5.5	5.7	5.6	20.1	20.2	20.3	7.0	6.9	7.9	0.2	0	4	6	A	on	on
18	9 June	5.8	5.9	5.7	20.3	20.4	20.6	7.0	7.0	6.9	0.1	6	4	0	A	off	on
19	10 June	5.6	5.9	6.1	20.5	20.5	20.5	6.9	6.9	6.9	0.1	2	5	3	C	on	on
20	15 June	5.5	5.6	5.8	21.1	21.2	21.3	7.0	6.9	7.0	1.4	4	3	3	C	off	on
21	15 June	5.6	5.8	5.5	21.1	21.1	21.2	7.0	7.0	6.9	1.5	5	1	4	A	off	on
22	17 June	4.8	5.0	5.2	21.1	21.2	21.3	6.9	6.9	6.9	2.0	4	2	4	C	off	on
23	17 June	5.2	4.9	4.5	21.1	21.0	21.0	6.9	6.9	6.9	2.3	1	4	5	A	on	on
24	17 June	4.2	4.5	4.7	21.2	21.3	21.4	6.9	6.8	6.8	1.9	3	3	4	C	on	on
25	17 June	5.0	5.2	5.4	20.9	21.0	21.0	6.8	6.9	6.9	2.1	5	5	0	A	off	on

a = 18 specimen trial

R = River, M = Mixed, E = Effluent; "Tank" designates effluent tank (Figure 11-2); "Circ" designates status of cooling water circulators

Table 11-5. Thermal Effluent Choice Experiments, Banded Killifish

TRIAL	1970 DATE	DISSOLVED OXYGEN (ppm) R	M	E	TEMPERATURE (°C) R	M	E	pH R	M	E	SAL. (o/oo)	RESULTS R	M	E	TANK	LIGHTS	CIRC
1	17 Apr	9.6	9.4	9.2	7.8	8.2	8.4	7.3	7.2	7.3	0.4	0	9	1	C	on	on
2	20 Apr	10.1	10.1	10.2	8.2	8.4	8.6	7.4	---	7.5	0.4	0	9	1	A	on	on
3	11 May	7.8	8.2	8.5	13.4	13.8	14.4	7.1	7.1	7.2	0.1	3	7	0	C	on	off
4	11 May	6.8	---	8.2	13.4	13.9	14.4	7.2	7.1	7.0	0.1	1	8	1	A	on	off
5	14 May	5.8	6.5	7.5	14.6	15.1	15.6	7.0	7.1	7.1	0.1	1	8	1	C	on	off
6	14 May	6.2	6.9	8.0	14.3	14.8	15.4	7.1	7.2	7.1	0.1	1	8	1	A	on	off
7*	20 May	5.8	5.9	5.8	16.2	21.4	26.4	6.8	6.8	6.8	1.7	0	5	5	A	on	on
8*	20 May	6.1	6.0	5.7	16.2	19.7	22.1	6.8	6.8	6.8	1.4	2	5	3	C	on	on

*Plant "on the line"

R = River, M = Mixed, E = Effluent; "Tank" designates effluent tank (Figure 11-2); "Circ" designates status of cooling water circulators

Table 11-6. Thermal Effluent Choice Experiments, Striped Bass

TRIAL	1970 DATE	DISSOLVED OXYGEN (ppm) R	M	E	TEMPERATURE (°C) R	M	E	pH R	M	E	SAL. (o/oo)	RESULTS R	M	E	TANK	LIGHTS	CIRC
1[a]	28 May	4.3	5.4	6.7	17.2	17.3	17.5	6.9	6.9	6.9	0.7	0	7	0	A	off	on
2[a]	28 May	5.4	5.0	4.8	17.2	17.3	17.4	6.9	6.9	6.9	0.4	1	5	1	C	off	on
3[b]	11 June	5.6	5.5	5.7	20.7	20.8	20.9	7.0	7.0	6.9	0.2	3	5	3	A	off	on
4	11 June	4.6	4.4	4.4	20.7	20.9	21.0	7.0	6.9	6.8	.10	0	9	1	A	on	on
5	11 June	3.2	3.2	3.2	21.0	21.1	21.2	6.8	6.7	6.7	0.2	0	10	0	C	on	on
6[b]	11 June	5.7	5.7	5.9	21.0	21.1	21.1	7.0	7.0	6.9	0.2	0	11	0	C	off	on
7	12 June	5.2	5.5	5.7	21.1	21.2	21.3	6.9	6.8	6.9	0.1	1	9	0	C	off	on
8	12 June	5.5	5.4	5.3	20.9	21.0	21.1	6.9	6.9	6.9	0.1	4	3	3	A	off	on
9	23 June	4.7	5.8	6.7	21.5	21.7	22.0	7.0	6.8	6.6	1.6	1	7	2	C	on	off
10	23 June	4.5	5.1	6.4	22.3	22.3	22.4	6.9	6.9	6.8	1.4	3	4	3	A	on	off

a = 7 specimen trial

b = 11 specimen trial

R = River, M = Mixed, E = Effluents; "Tank" designates effluent tank (Figure 11-2); "Circ" designates status of cooling water circulators

Table 11-7. Thermal Effluent Choice Experiments, Spottail Shiner

TRIAL	1970 DATE	DISSOLVED OXYGEN (ppm) R	DISSOLVED OXYGEN (ppm) M	DISSOLVED OXYGEN (ppm) E	TEMPERATURE (°C) R	TEMPERATURE (°C) M	TEMPERATURE (°C) E	pH R	pH M	pH E	SAL. (o/oo)	RESULTS R	RESULTS M	RESULTS E	TANKS	LIGHTS	CIRC
1	6 Apr	11.3	11.1	11.2	4.3	4.4	5.2	7.4	7.3	7.4	0.1	0	10	0	C	on	on
2	9 Apr	10.6	10.6	10.7	4.9	5.1	5.4	7.4	7.3	7.3	0.1	0	10	0	C	on	on
3	9 Apr	10.4	10.1	9.9	5.0	5.3	5.6	7.2	7.2	7.3	0.1	1	9	0	A	on	on
4	16 Apr	9.4	8.9	9.3	7.3	7.4	7.5	7.3	---	7.5	0.2	0	5	5	C	on	on
5	16 Apr	9.2	9.1	9.2	7.5	7.8	8.1	7.5	---	7.4	0.2	0	1	9	A	on	on
6	16 Apr	9.8	9.3	9.6	7.5	7.7	8.1	7.3	7.2	7.2	0.2	0	8	2	A	on	on
7	16 Apr	8.9	9.7	9.1	7.4	7.7	8.0	7.1	7.1	7.2	0.2	4	6	0	C	on	on
8	4 May	8.7	8.8	8.9	12.1	12.7	13.3	7.2	7.1	7.2	0.0	6	4	0	A	on	off
9	4 May	---	---	---	12.1	12.8	13.4	7.1	7.2	7.2	0.0	0	7	3	C	on	off
10[a]	5 May	8.6	---	7.6	12.3	12.8	13.3	7.2	7.3	7.2	0.1	0	20	0	A	on	off
11[a]	5 May	7.5	---	8.7	12.7	13.1	13.4	7.3	7.2	7.1	0.1	0	20	0	C	on	off
12[a]	5 May	8.6	---	7.5	12.1	12.2	12.3	7.2	7.3	7.3	0.1	1	19	0	A	on	off
13	6 May	8.5	8.8	8.6	12.1	12.3	13.2	7.3	7.4	7.3	0.0	0	2	8	C	on	off
14	6 May	8.7	8.8	8.5	12.3	12.8	13.3	7.3	7.3	7.3	0.0	1	9	0	A	on	off
15[a]	6 May	8.9	8.8	9.0	12.6	13.1	13.7	7.2	7.2	7.1	0.1	4	16	0	C	on	off
16[a]	6 May	9.0	8.8	8.2	12.8	13.1	13.7	7.3	7.3	7.3	0.1	2	18	0	A	on	off
17[b]	6 May	8.9	8.8	9.0	12.5	13.0	13.6	7.2	7.2	7.1	0.1	0	5	0	C	on	off
18	13 May	6.1	7.2	8.4	14.3	14.8	15.2	7.0	7.1	7.1	0.1	1	6	3	C	on	off
19	13 May	6.1	7.1	7.8	14.2	14.7	15.3	7.2	7.2	7.1	0.1	0	10	0	A	on	off
20	19 May	6.8	6.8	6.4	15.2	15.2	15.3	7.1	7.1	7.3	2.1	0	10	0	C	on	on
21	21 May	6.1	6.9	6.6	16.1	16.3	16.5	6.9	6.9	6.9	0.1	6	4	0	A	on	on
22	21 May	6.3	6.9	6.9	15.8	16.2	16.7	6.9	6.9	6.9	0.1	1	8	1	C	on	on
23	21 May	6.3	6.2	6.5	16.4	16.4	16.4	7.0	7.0	6.9	0.1	7	3	0	A	on	on
24	21 May	6.4	6.6	6.8	15.7	15.9	16.0	6.9	7.0	7.0	0.1	1	8	1	C	on	on
												A	B	C			
25[c]	22 May	6.3	6.2	6.3	16.3	16.3	16.4	6.9	6.9	6.9	1.8	0	8	2	-	on	on
26[c]	22 May	6.5	6.4	6.4	16.1	16.1	16.1	6.9	6.9	6.9	1.7	1	4	5	-	on	on
27[c]	22 May	6.4	6.3	6.4	16.1	16.0	16.0	6.9	6.9	7.0	1.9	0	8	2	-	on	on

a = 20 specimen trial
b = small choice apparatus(5 specimens)
c = only river water used(control)
Tanks designated A,B,C, indicate position relative to lighting: A = lighter tank, B = center tank, C = darker tank
R = River, M = Mixed, E = Effluent; "Tank" designates effluent tank (Figure 11-2); "Circ" designates status of cooling water circulators

Table 11-8. Thermal Effluent Choice Experiments, Threespine Stickleback

TRIAL	1970 DATE	DISSOLVED OXYGEN (ppm) R	M	E	TEMPERATURE (°C) R	M	E	pH R	M	E	SAL. (o/oo)	RESULTS R	M	E	TANK	LIGHTS	CIRC
1	30 Apr	7.9	6.5	7.1	11.5	12.1	12.8	7.1	7.0	7.0	0.1	3	1	6	A	on	off
2	30 Apr	7.8	8.0	7.8	11.6	12.2	12.8	6.9	7.0	7.0	0.1	4	1	5	C	on	off
3	5 May	7.6	---	8.6	13.3	12.8	12.3	7.2	7.3	7.2	0.1	7	2	1	C	on	off
4	5 May	8.7	---	7.5	13.4	13.1	12.7	7.1	7.2	7.3	0.1	3	4	3	A	on	off
5	7 May	9.1	8.8	8.5	11.9	12.2	12.9	7.1	7.1	7.2	0.1	6	3	1	C	on	off
6	7 May	9.3	8.4	8.8	12.2	12.9	13.3	7.1	7.1	7.4	0.1	3	3	4	A	on	off
7	12 May	8.1	6.8	6.6	14.0	14.6	14.8	7.0	7.1	7.0	0.1	6	3	1	C	on	off
8	13 May	6.1	7.2	8.4	14.3	15.1	15.2	7.0	7.1	7.1	0.1	0	7	3	A	on	off
9[a]	19 May	6.8	6.8	6.4	15.2	15.2	15.3	7.1	7.1	7.3	2.1	2	1	2	C	on	on

NOTE: All trials completed in small choice apparatus

a = 5 specimen trial

R = River, M = Mixed, E = Effluent; "Tank" designates effluent tank (Figure 11-2); "Circ" designates status of cooling water circulators

Table 11-9. Thermal Effluent Choice Experiments, Johnny Darter

TRIAL	1970 DATE	DISSOLVED OXYGEN (ppm) R	M	E	TEMPERATURE (°C) R	M	E	pH R	M	E	SAL. (o/oo)	RESULTS R	M	E	LIGHTS	CIRC
1[a]	23 Apr	8.5	9.0	7.5	9.2	9.3	9.5	7.1	7.0	6.9	0.1	0	4	5	on	on
2[a]	23 Apr	9.4	10.1	8.1	9.4	9.5	9.7	7.1	7.1	7.1	0.1	0	2	7	on	on
3*	6 May	8.5	8.3	8.7	12.3	12.8	13.3	7.3	7.3	7.3	0.0	4	1	0	on	off
4*	6 May	9.0	8.8	8.2	12.5	13.1	13.7	7.3	7.3	7.3	0.1	0	5	0	on	off
5	7 May	9.4	8.4	8.8	12.3	12.6	13.1	7.1	7.1	7.4	0.1	3	6	1	on	off
6	7 May	9.1	8.8	8.5	12.1	12.7	13.1	7.2	7.2	7.3	0.1	3	4	3	on	off
7	12 May	7.4	7.8	8.0	13.9	14.5	14.8	7.1	7.0	6.8	0.1	4	6	0	on	off
8	12 May	8.1	6.8	6.6	13.8	14.4	14.9	7.0	7.1	7.0	0.1	4	6	0	on	off

*small choice apparatus used (5 specimens)

a = 9 specimen trial

R = River, M = Mixed, E = Effluent; "Tank" designates effluent tank (Figure 11-2); "Circ" designates status of cooling water circulators

Table 11-10. Thermal Effluent Choice Experiments

SPECIES	1970 DATE	DISSOLVED OXYGEN (ppm) R	M	E	TEMPERATURE (°C) R	M	E	pH R	M	E	SAL. (o/oo)	RESULTS R	M	E	TANK	LIGHTS	CIRC
DOUBLE SPECIES TRIALS																	
Johnny Darter	1 May	8.3	7.5	8.1	11.9	12.4	13.1	7.0	6.9	6.6	0.1	8	2	0	A	on	off
Banded Killifish												0	9	1	A		
White Perch	20 May*	6.3	6.3	5.9	15.7	20.3	25.6	6.9	6.9	6.8	1.5	1	7	2	A	on	on
Spottail Shiner												4	6	0	A		
White Perch	20 May*	6.27	6.1	6.0	16.4	22.1	26.3	6.8	6.8	6.4	1.8	0	6	4	C	on	on
Spottail Shiner												1	9	0	C		
TRIPLE SPECIES TRIALS																	
Banded Killifish												0	10	0	C		
Spottail Shiner	14 May	7.3	7.7	7.4	14.2	15.0	15.7	7.2	7.1	6.8	0.1	2	8	0	C	on	off
Johnny Darter												2	7	1	C		
Banded Killifish												0	10	0	A		
Spottail Shiner	14 May	7.7	7.1	7.8	14.2	14.4	15.2	7.2	7.0	7.0	0.1	0	10	0	A	on	off
Johnny Darter												3	6	1	A		

*Plant "on the line"

R = River, M = Mixed, E = Effluent; "Tank" designates effluent tank (Figure 11-2); "Circ" designates status of cooling water circulators

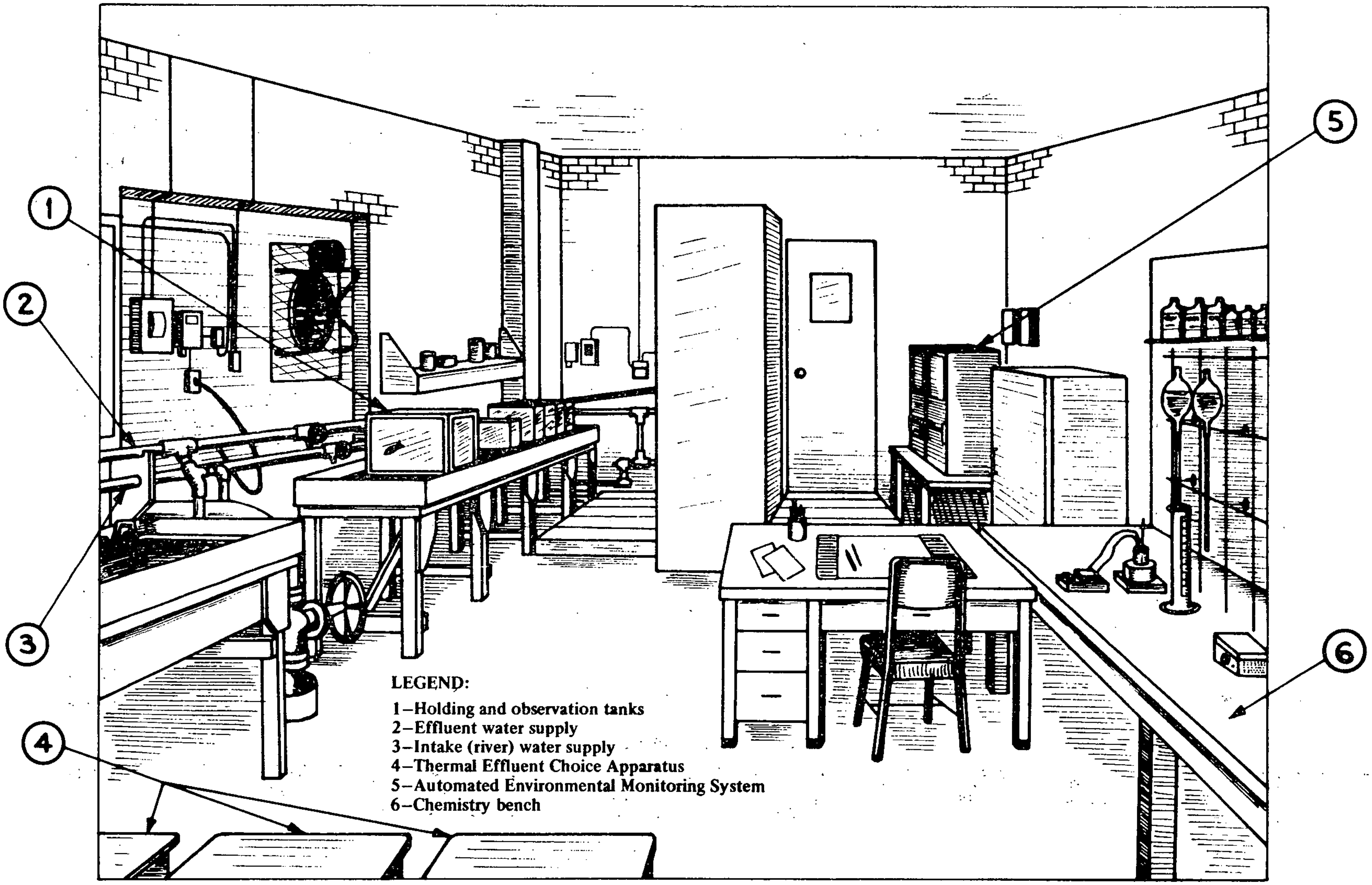


Figure 11-1. Raytheon On-Site Wet Lab at Indian Point

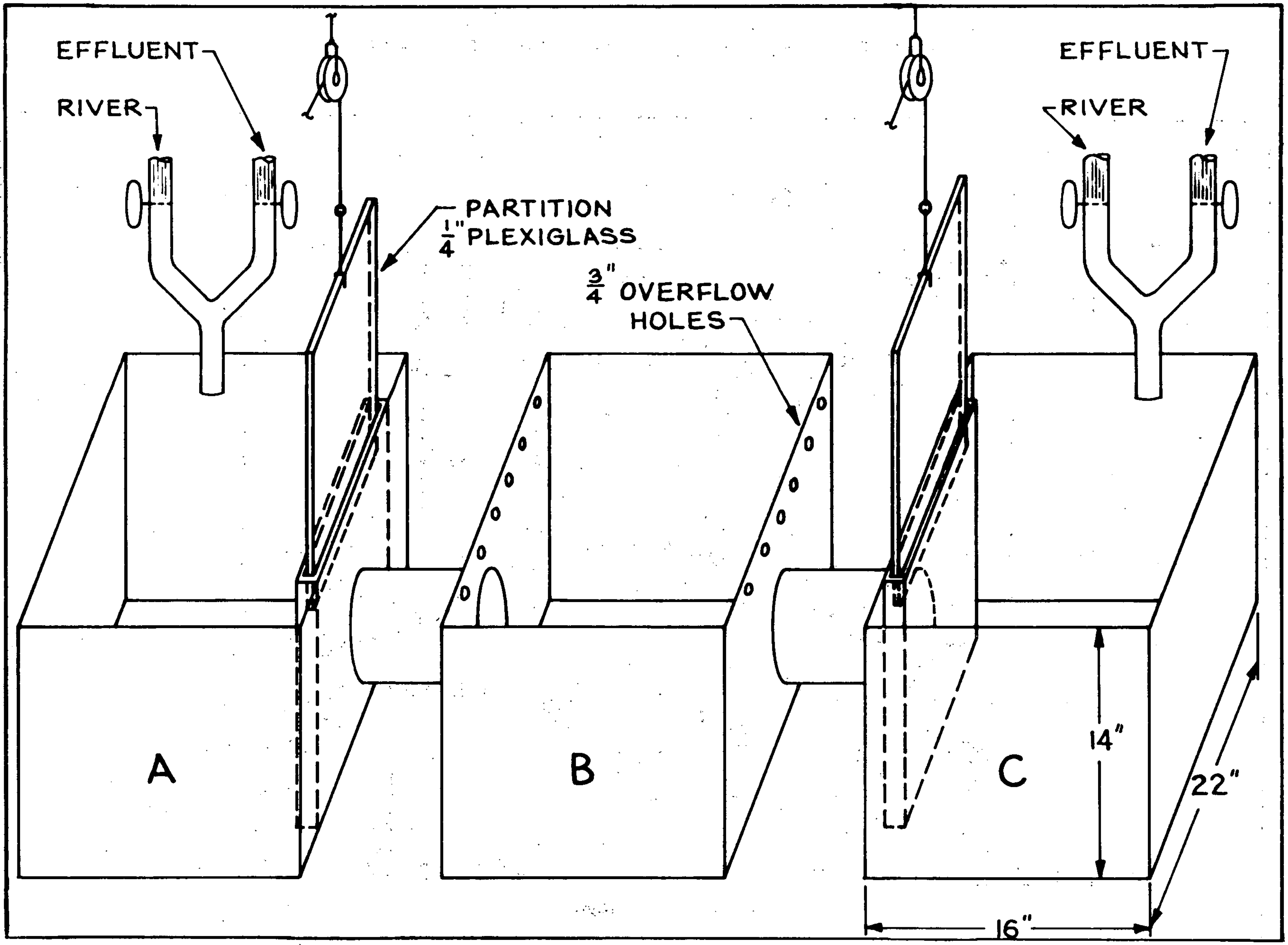


Figure 11-2. Large Thermal Effluent Choice Apparatus

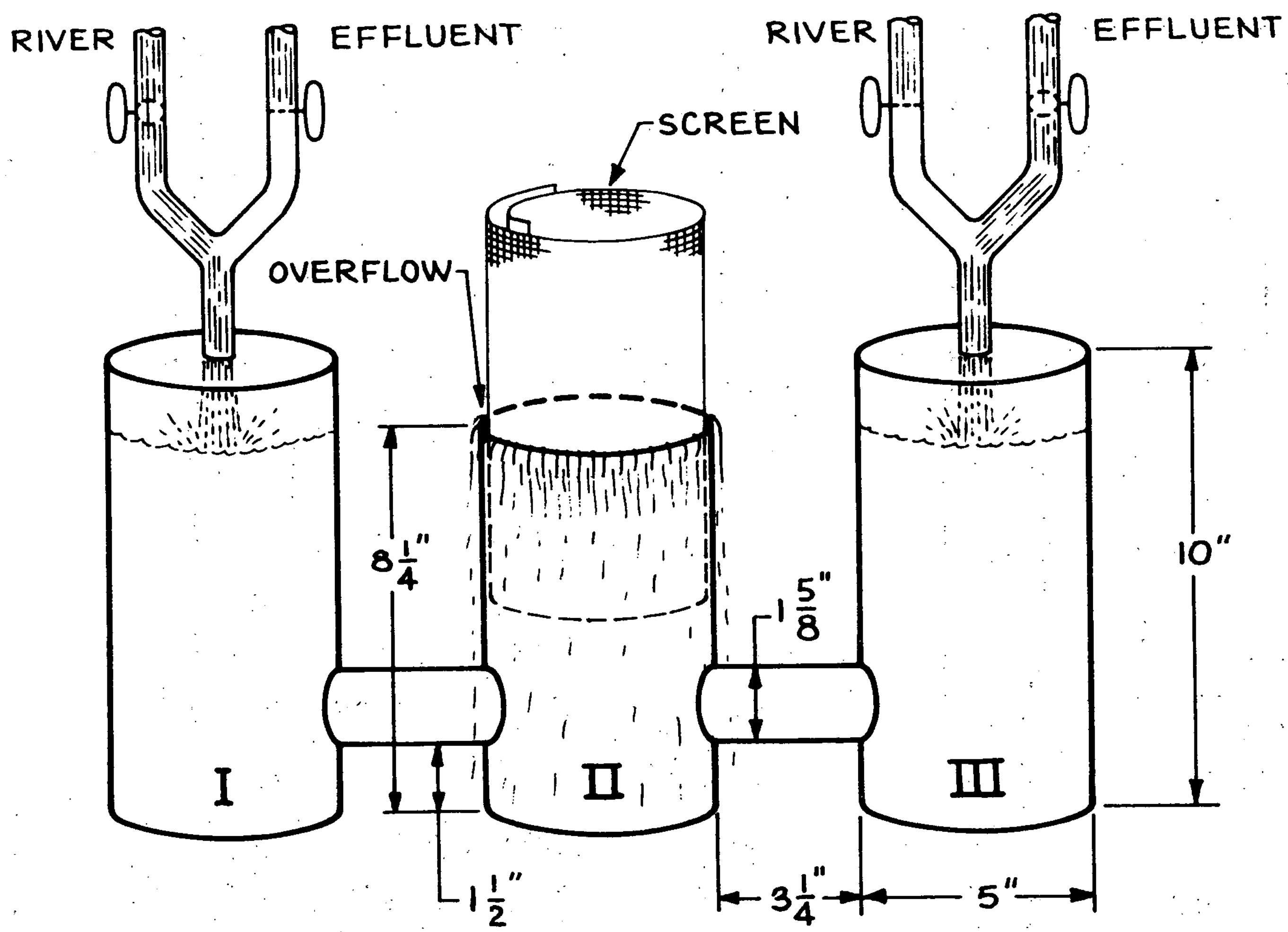


Figure 11-3. Small Thermal Effluent Choice Apparatus

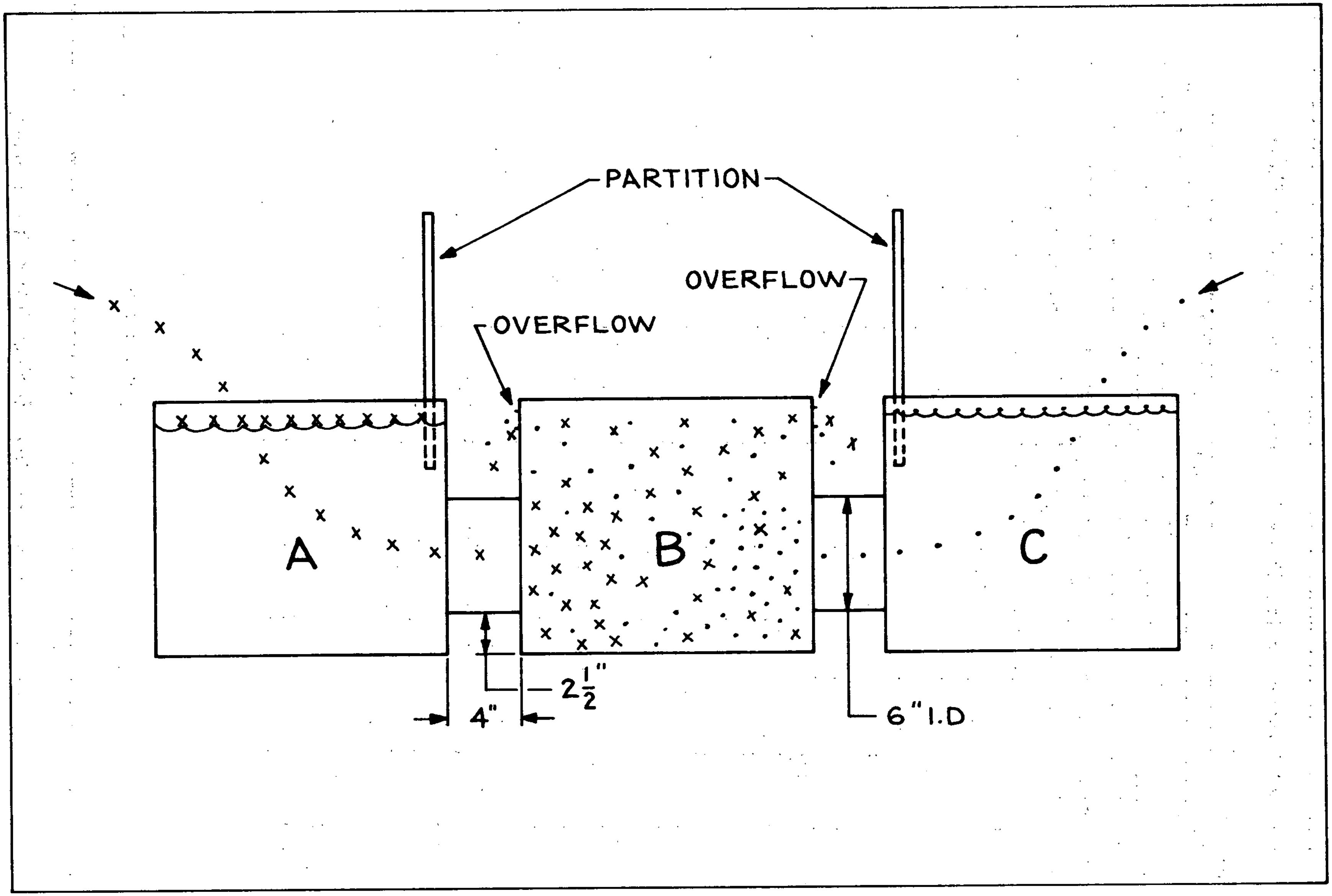


Figure 11-4. Flow Pattern Within Thermal Effluent Choice Apparatus

Thermal Effluent Choice/Shock Experiments Laboratory Data Sheet

Experiment Name ______________________________

Trial Number ______________ Species Name ______________

No. Specimens ______________ Date ______________ Time ______

Flow Rate ______________ GPM. Velocity ______ f/s Page ___ of ___

Intake Hose (s) ______________ Effluent Hose (s) ______________

DATE	TIME	TEMP °C	D.O. ppm	pH	CL- ppm	SALIN ppt	NO. OF SPECI-MENS	REMARKS

Investigator ______________

Figure 11-5. Indian Point-Hudson River Ecology Study (Data Sheet)

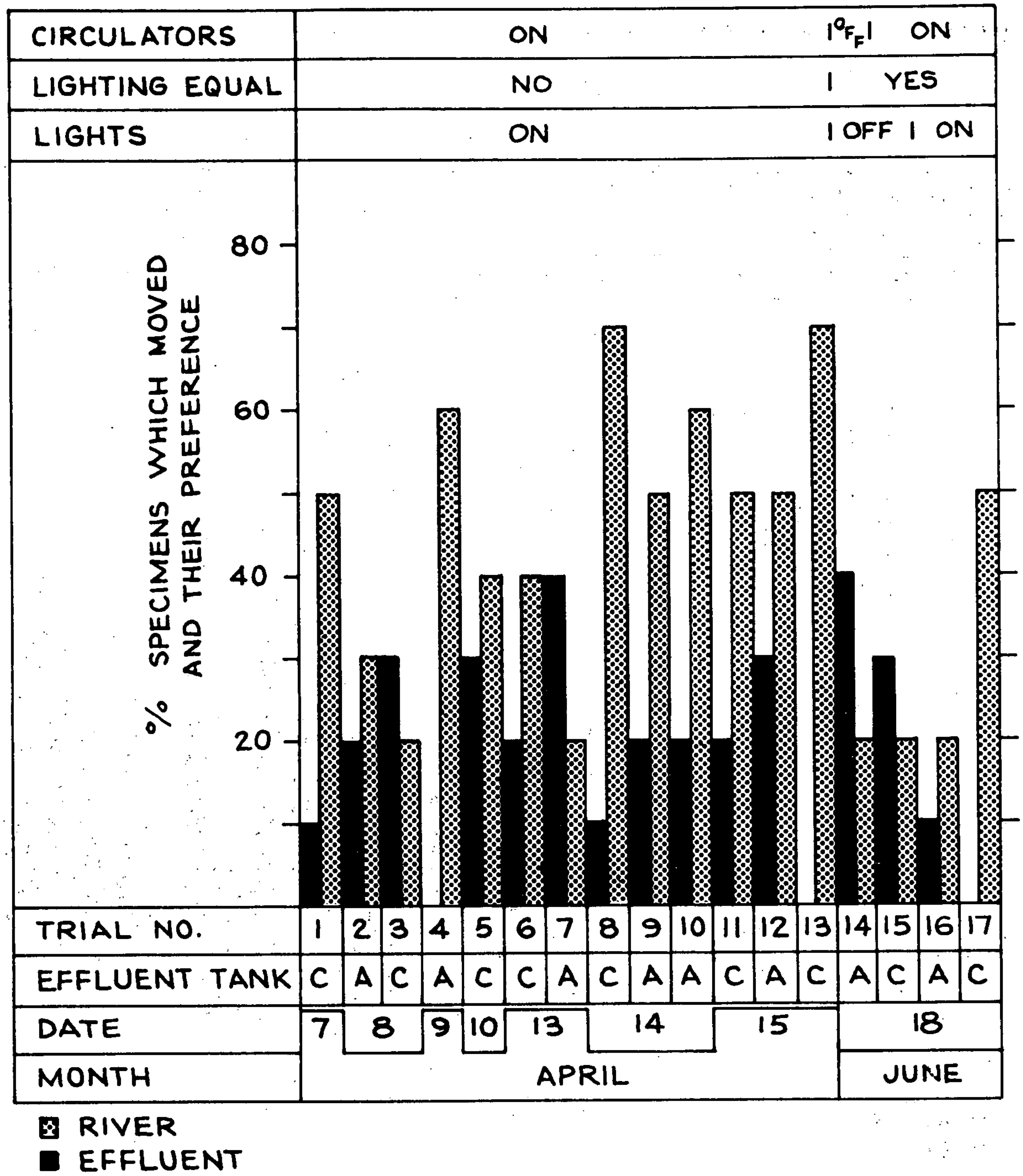


Figure 11-6. Preference Behavior of Atlantic Tomcod (Choice Experiments)

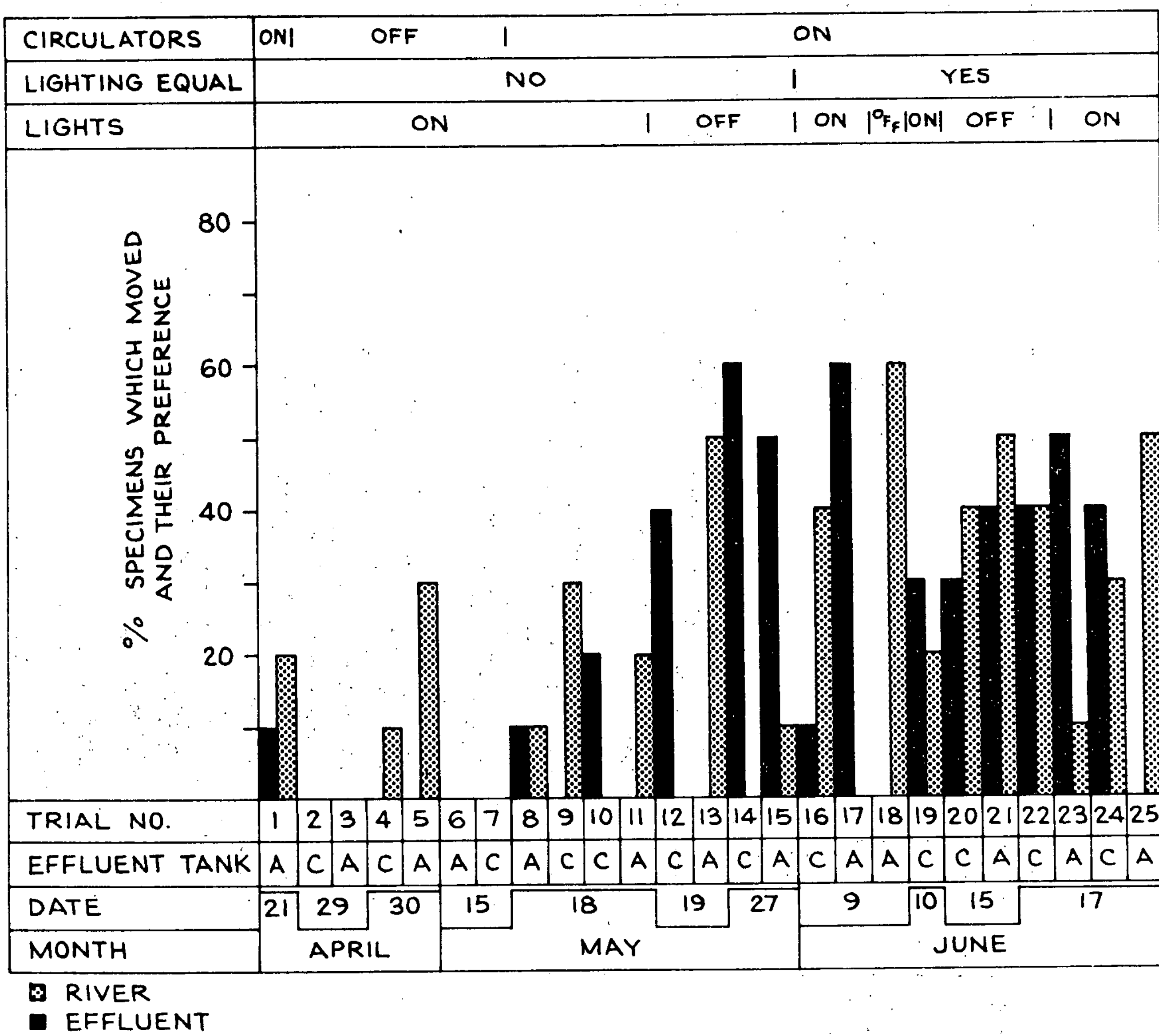


Figure 11-7. Preference Behavior of White Perch (Choice Experiments)

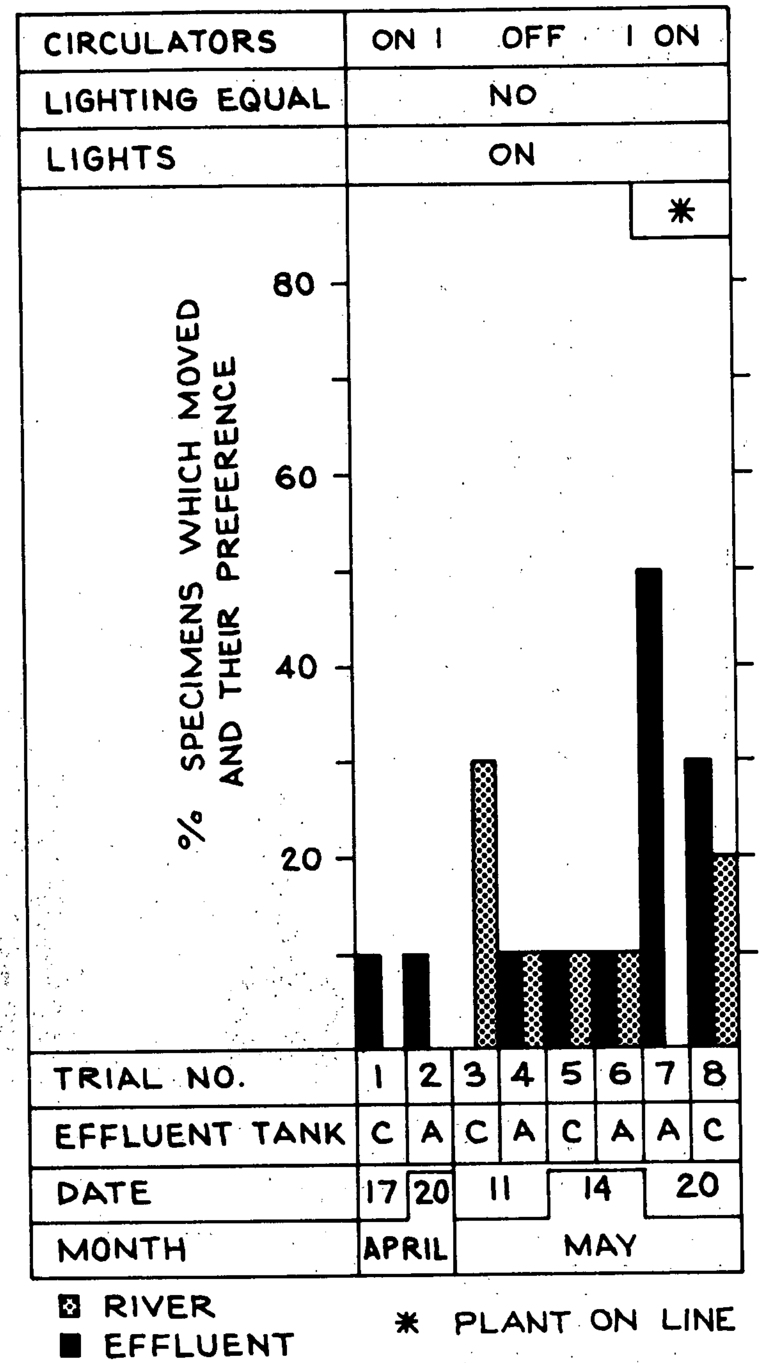


Figure 11-8. Preference Behavior of Banded Killifish (Choice Experiments)

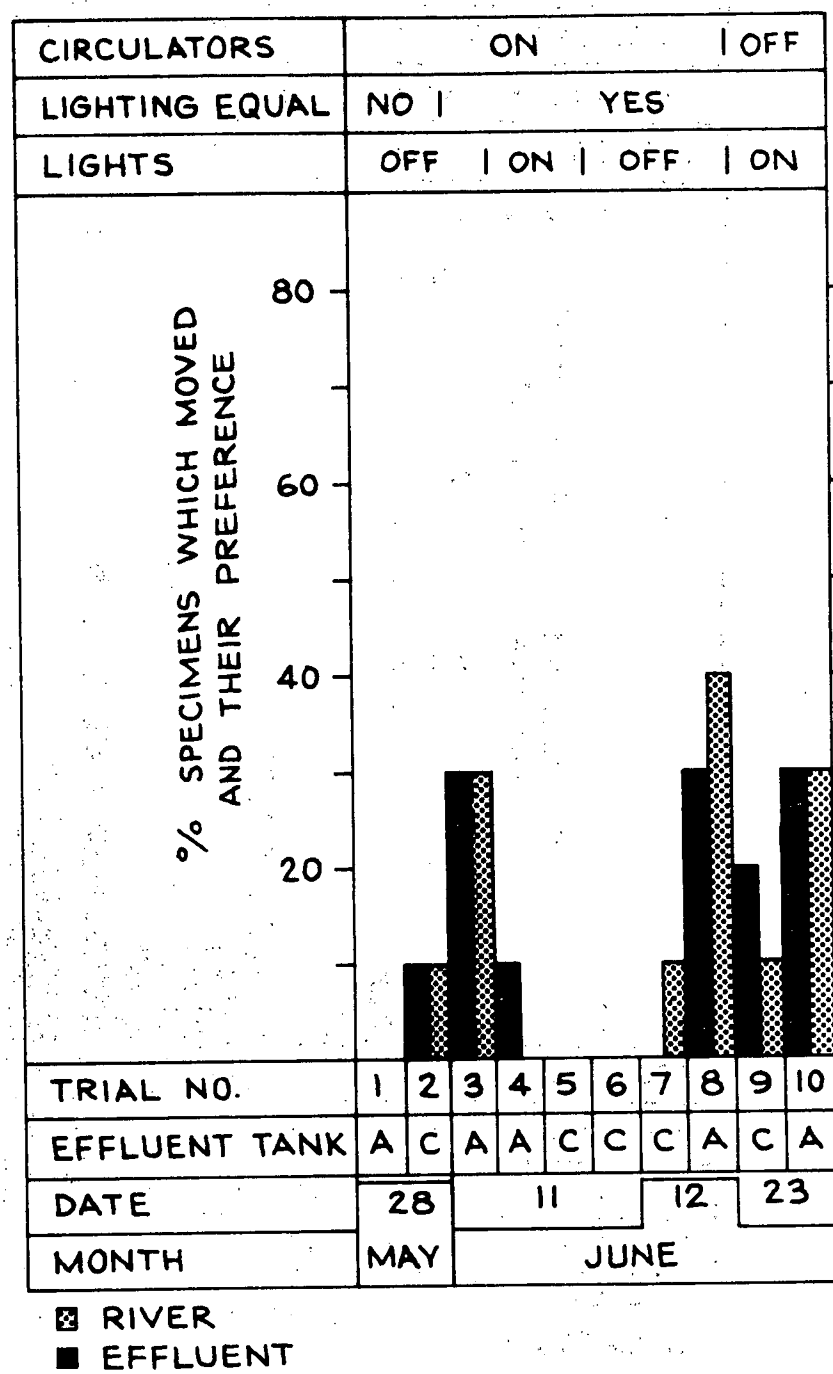


Figure 11-9. Preference Behavior of Striped Bass (Choice Experiments)

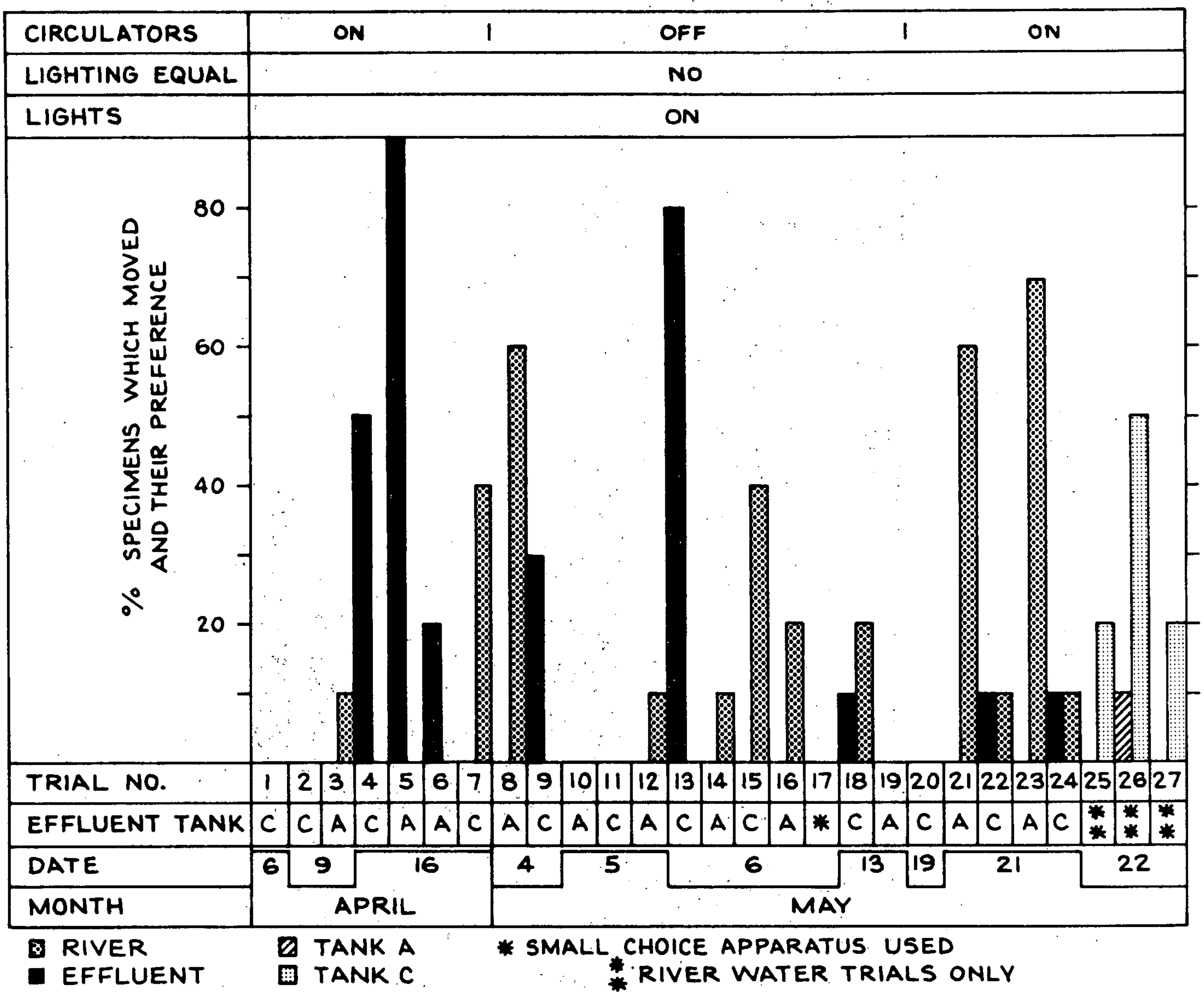


Figure 11-10. Preference Behavior of Spottail Shiner (Choice Experiments)

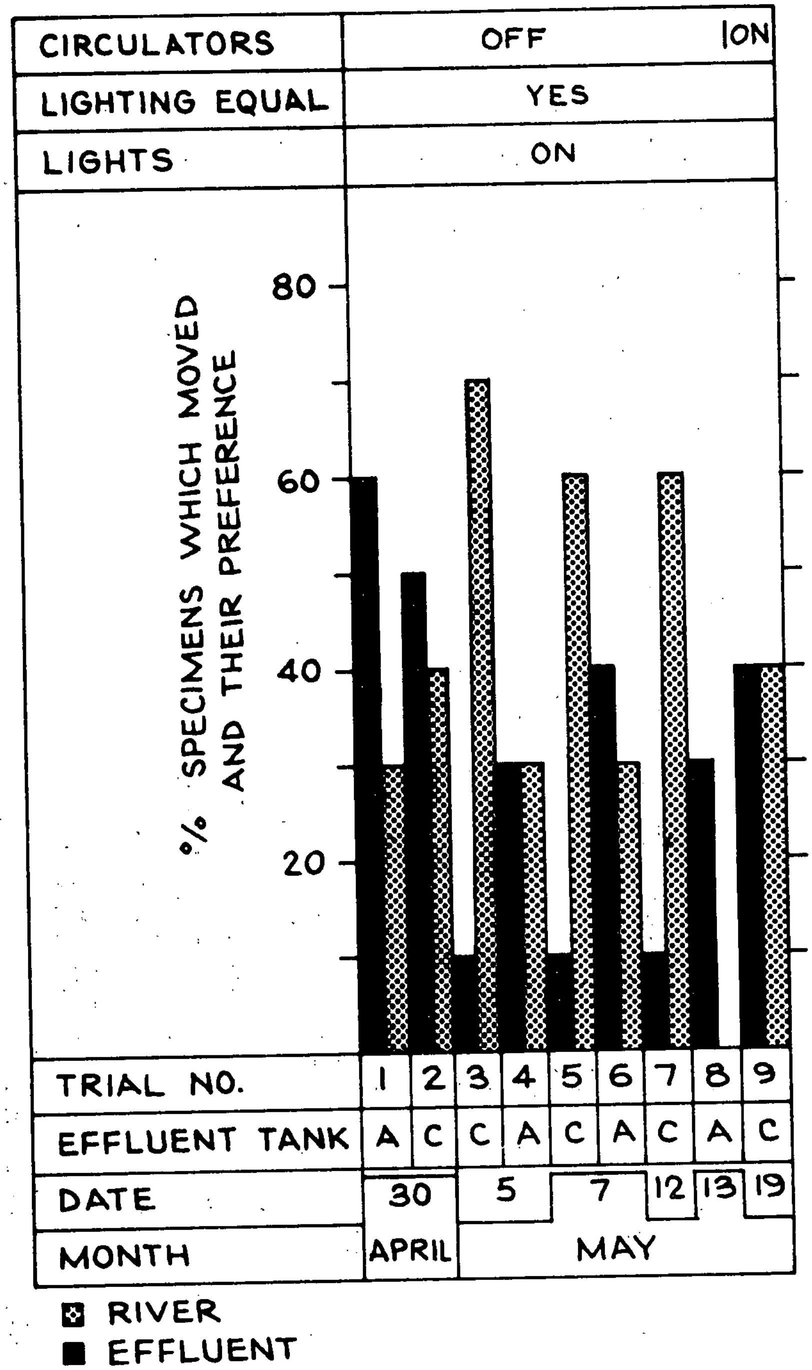


Figure 11-11. Preference Behavior of Threespine Stickleback (Choice Experiments)

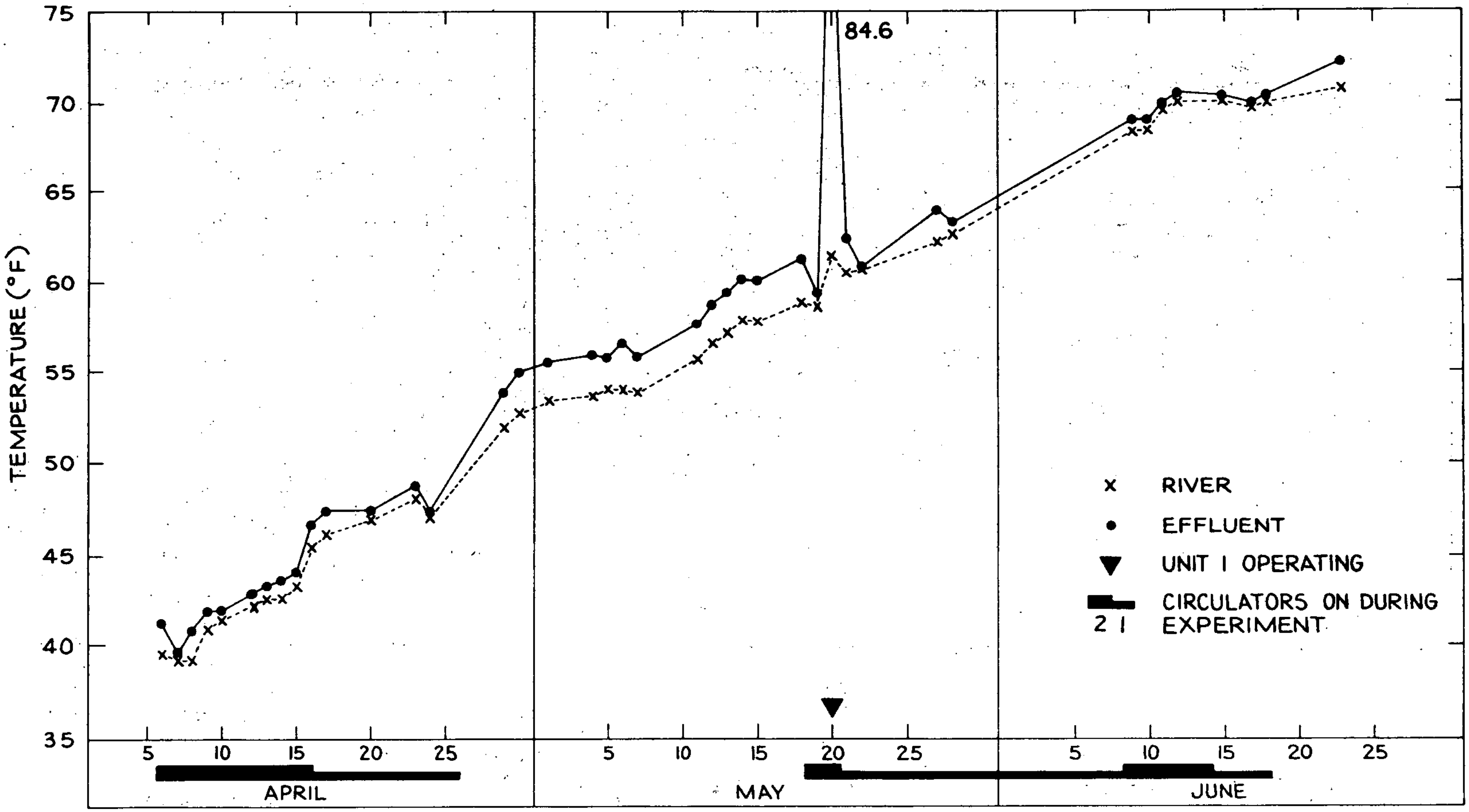


Figure 11-12. Temperature Data (°F) (Choice Experiments)

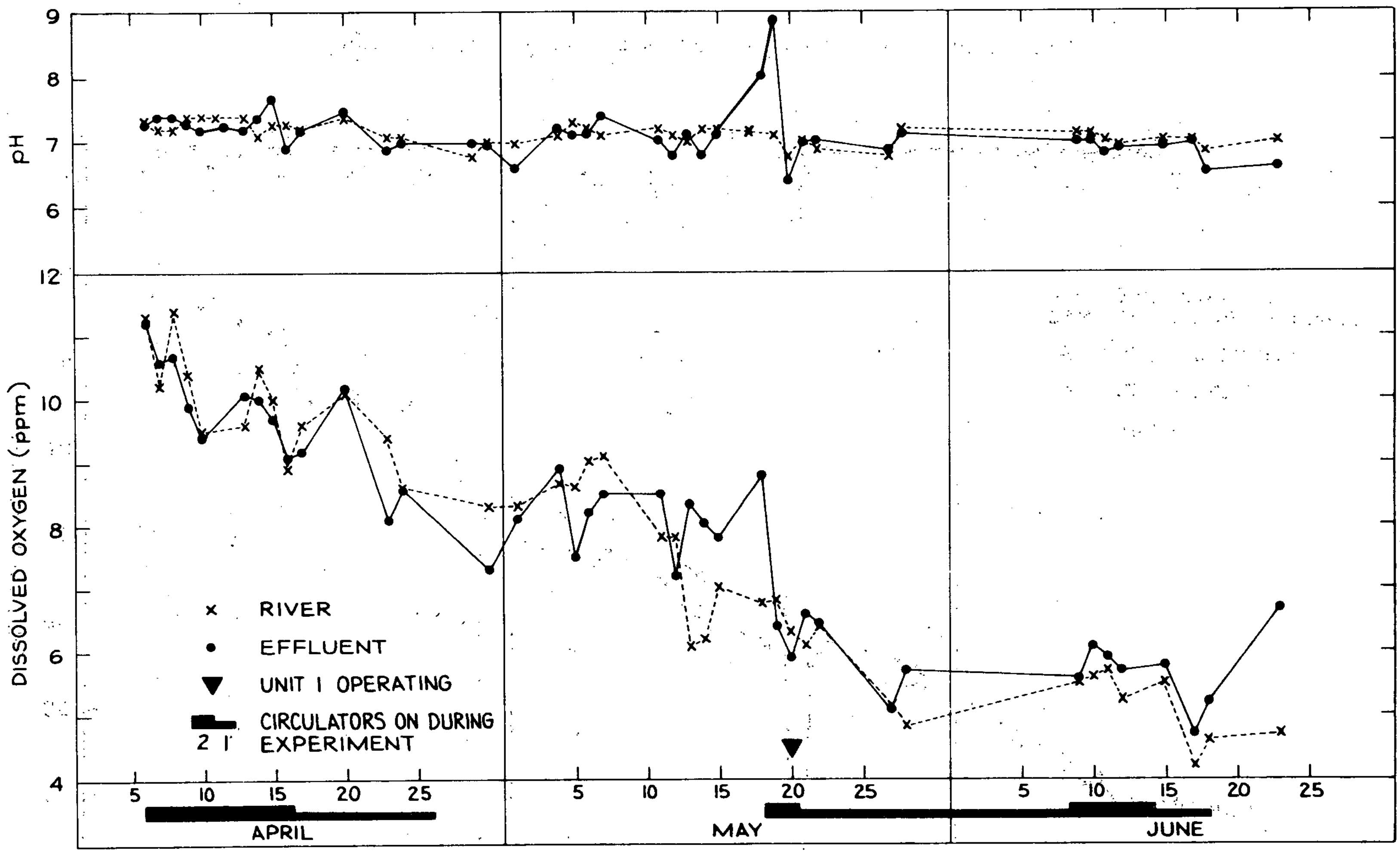


Figure 11-13. Dissolved Oxygen (ppm) and pH Data (Choice Experiments)

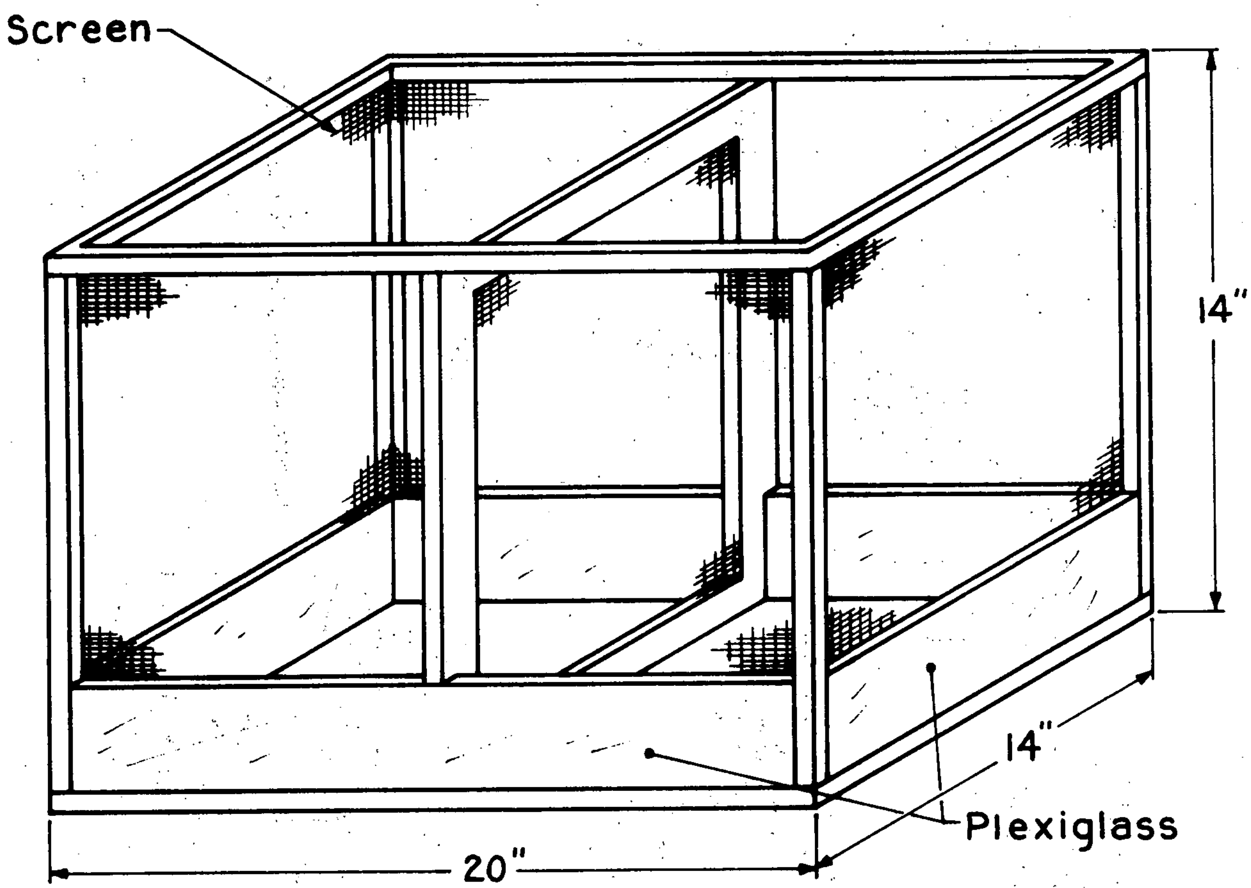


Figure 11-14. Thermal Shock Apparatus

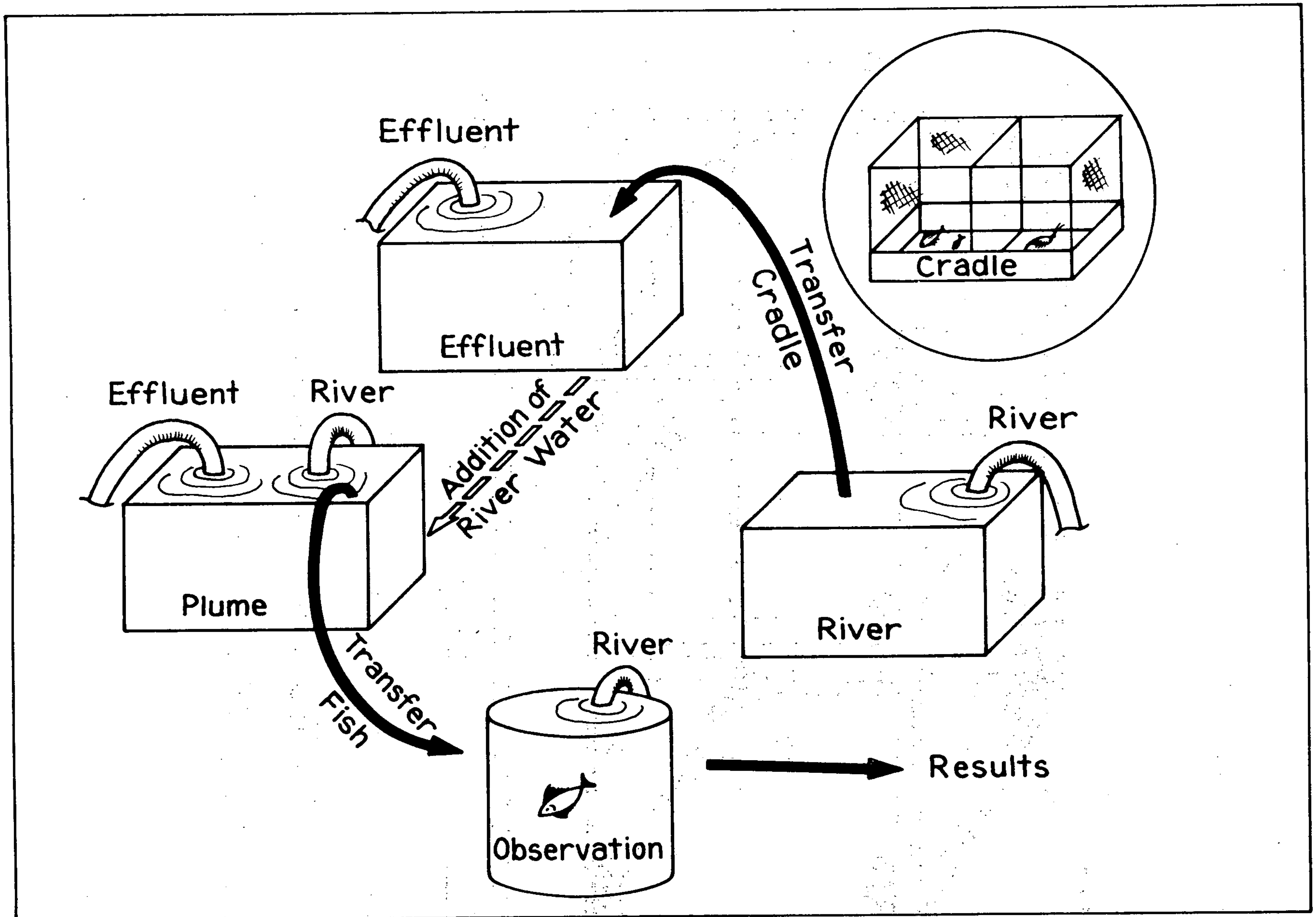


Figure 11-15. Procedural Sequence (Thermal Shock Experiment)

APPENDIX A

GLOSSARY OF TERMS

- Average Percent Occurrence (Avg. Pcnt.Occ.)—(e.g., Tables 10-5 through 10-21)

A grand average of station values of the number of samples in which a species occurred divided by the number of samples taken at a station.

$$\text{Average Percent Occurrence} = \frac{\sum_{x=1}^{N} \frac{\text{number of occurrences station } x}{\text{number of samples station } x} \times 100}{N}$$

where:

N = number of stations

- Community Overlap—A measure of the proportional overlap between percent frequency histograms of the species assemblages at two stations.

- "DPTH"—depth of the water in feet at a station

- Mile—river mile above the Battery (lower Manhattan)

- Percent Average Caught (Pcnt. Avg. Cght)—(e.g., Tables 10-5 through 10-21)

The percent of the total fish population within the study area represented by a species and based on the grand average of station averages of the number caught per unit effort for each species.

$$\text{Percent Average Caught} = \frac{\text{average number caught per unit effort of a species}}{\sum_{x=1}^{n} \text{average number caught per unit effort of species } x} \times 100$$

where:

n = number of species

- Site—1 = west, 2 = center, 3 = east side of river

APPENDIX B

IN-SITU TEMPERATURE, SALINITY AND DISSOLVED OXYGEN DATA

Table B-1. In-Situ Temperature, Salinity and Dissolved Oxygen Data (Page 1 of 6)

	Station 9	Station 20	Station 15
MARCH			
Temperature (°F)	S=36.1(3)34.5-37.0*	36.0(2)35.1-37.0	35.6(3)34.9-36.1
	B=35.9(3)34.5-37.0**	36.9(2)36.3-37.6	36.1(3)35.7-36.5
Salinity (o/oo)	S=2.4(3)1.3-3.3	2.0(2)1.8-2.1	2.1(3)1.7-2.6
	B=2.8(3)1.3-3.6	6.8(2)3.5-10.0	5.0(3)2.6-9.8
Dissolved Oxygen (mg/1)	S=10.1(3)9.1-11.1	11.0(2)10.6-11.5	10.8(3)10.7-10.8
	B=9.8(3)9.5-10.0	9.7(2)9.0-10.3	10.0(3)8.6-10.9
APRIL			
Temperature (°F)	S=42.7(7)38.1-49.5	43.0(6)37.4-50.5	43.3(7)37.9-52.2
	B=42.3(7)38.1-48.9	42.5(6)37.6-48.7	42.5(7)37.8-48.7
Salinity (o/oo)	S=0.5(5)0.1-1.4	0.2(6)0.0-0.8	0.2(7)0.0-0.8
	B=0.4(6)0.0-1.4	0.6(5)0.1-2.1	0.3(5)0.1-1.0
Dissolved Oxygen (mg/1)	S=9.7(7)8.9-10.6	9.6(6)7.9-10.3	10.0(7)8.5-10.7
	B=9.9(7)8.9-11.1	9.5(6)7.8-10.3	10.3(7)8.9-10.7

Table B-1. In-Situ Temperature, Salinity and Dissolved Oxygen Data (Page 2 of 6)

	Station 9	Station 20	Station 15
		MAY	
Temperature (°F)	S=56.5(6)52.0-60.4 B=56.0(6)52.0-60.8	57.3(8)51.8-63.5 56.1(8)52.2-60.8	56.7(8)53.4-61.0 55.9(8)52.2-61.0
Salinity (o/oo)	S=2.0(4)0.2-3.5 B=1.5(5)0.1-3.0	1.5(7)0.1-2.5 3.0(7)0.2-6.4	1.0(8)0.0-2.3 2.1(6)0.1-4.1
Dissolved Oxygen(mg/1)	S=7.6(6)6.4-9.0 B=7.5(6)6.5-8.6	7.4(8)6.3-8.9 7.2(8)6.2-8.7	7.5(8)6.3-8.6 7.4(8)6.2-9.0
		JUNE	
Temperature (°F)	S=68.9(7)66.4-72.9 B=68.6(7)66.2-72.3	69.1(8)65.9-71.8 68.2(8)65.4-70.7	68.6(8)66.1-71.5 68.5(8)66.1-71.2
Salinity (o/oo)	S=1.6(7)0.1-2.8 B=1.9(7)0.1-2.8	1.5(8)0.1-2.7 2.7(8)0.1-6.8	1.4(8)0.1-2.8 1.9(8)0.1-3.9
Dissolved Oxygen(mg/1)	S=6.0(7)5.2-6.5 B=6.3(7)5.1-8.2	6.2(8)5.6-6.9 5.6(8)3.9-6.7	5.9(8)5.1-6.6 5.7(8)5.1-6.3

Table B-1. In-Situ Temperature, Salinity and Dissolved Oxygen Data (Page 3 of 6)

	Station 21	Station 11	Station 10	Station 22
MARCH				
Temperature (°F)	S=35.8(3)34.7-36.7	34.9(5)33.4-36.5	35.1(4)34.0-36.7	35.0(4)34.0-36.5
	B=35.4(3)34.0-36.1	34.6(5)33.4-36.0	35.1(4)34.0-36.1	35.2(4)34.0-36.0
Salinity (o/11)	S=2.6(3)1.0-3.9	1.4(5)0.3-2.2	1.4(4)0.2-2.9	1.2(4)0.4-2.4
	B=3.0(3)1.2-5.1	2.3(5)0.4-3.6	2.4(4)0.2-4.8	1.3(4)0.4-3.0
Dissolved Oxygen(mg/1)	S=10.6(3)10.3-11.0	10.9(5)9.9-13.0	10.4(4)10.0-11.4	8.5(4)9.9-11.2
	B=10.3(3)9.7-11.0	10.5(5)9.1-11.3	10.1(4)9.4-11.2	9.9(4)9.8-11.5
APRIL				
Temperature (°F)	S=42.4(8)37.0-50.5	41.8(8)37.2-49.1	42.4(9)37.0-50.0	42.2(8)37.9-49.3
	B=41.9(8)37.0-49.1	41.4(8)37.0-48.7	42.0(9)36.9-49.3	42.0(8)37.8-48.9
Salinity (o/oo)	S=0.2(7)0.1-0.4	0.2(6)0.0-0.3	0.2(9)0.1-0.8	0.2(6)0.1-0.5
	B=0.3(7)0.1-0.7	0.4(6)0.0-1.8	0.4(9)0.1-0.8	0.3(8)0.0-0.8
Dissolved Oxygen(mg/1)	S=10.0(8)8.4-11.2	9.9(8)8.8-10.6	9.9(9)8.8-10.9	10.3(8)8.6-11.4
	B=10.0(8)8.8-11.4	9.6(8)8.2-11.0	9.7(9)8.8-11.0	10.0(8)8.5-11.4

Table B-1. In-Situ Temperature, Salinity and Dissolved Oxygen Data (Page 4 of 6)

	Station 21	Station 11	Station 10	Station 22
MAY				
Temperature (^{o}F)	S=57.5(9)52.2-62.2 B=56.3(9)52.0-61.0	57.1(8)52.0-62.6 55.8(8)52.0-61.0	56.2(9)52.2-61.3 55.7(9)52.0-61.5	56.3(9)52.2-61.0 56.1(9)52.2-61.2
Salinity(o/oo)	S=1.2(8)0.1-2.2 B=1.4(8)0.1-3.2	1.0(8)0.0-2.1 1.7(8)0.0-5.5	0.9(8)0.1-2.0 1.5(8)0.2-5.0	1.2(7)0.2-2.0 1.4(8)0.0-4.9
Dissolved Oxygen(mg/1)	S=7.5(9)6.1-9.0 B=7.4(9)5.8-8.8	7.6(8)6.5-8.8 7.4(8)6.2-8.8	7.4(8)6.3-8.8 7.6(9)6.0-8.7	7.5(9)5.8-8.8 7.5(9)6.1-8.7
JUNE				
Temperature (^{o}F)	S=68.4(8)64.7-71.2 B=68.1(8)64.6-71.1	69.1(8)65.7-71.8 68.3(8)64.0-71.0	68.8(10)66.9-71.2 68.1(10)64.9-70.9	68.6(10)65.5-70.9 68.2(10)64.6-70.7
Salinity (o/oo)	S=1.2(8)0.0-2.5 B=1.3(8)0.1-2.8	1.3(8)0.1-2.4 1.8(8)0.1-4.5	1.1(9)0.4-2.9 1.8(9)0.5-4.7	1.0(10)0.0-2.8 1.6(9)0.4-4.5
Dissolved Oxygen(mg/1)	S=5.7(8)5.1-6.4 B=5.8(8)5.2-6.3	6.1(8)5.2-6.8 5.7(8)4.6-6.6	5.9(10)5.3-6.6 5.5(10)4.5-6.6	5.7(10)5.1-6.3 5.8(9)4.7-6.6

Table B-1. In-Situ Temperature, Salinity and Dissolved Oxygen Data (Page 6 of 6)

	Station 13	Station 23	Station 12
MAY			
Temperature (°F)	S=56.3(6)52.0-61.3 B=55.9(6)52.0-61.5	56.2(7)52.5-61.2 55.7(7)52.2-60.8	56.3(5)52.3-61.2 56.0(5)52.3-61.0
Salinity (o/oo)	S=0.5(4)0.0-1.2 B=1.0(5)0.0-3.6	0.7(6)0.1-1.5 1.6(5)0.1-4.7	0.9(3)0.0-1.7 1.2(3)0.3-1.8
Dissolved Oxygen(mg/l)	S=7.7(6)6.4-9.0 B=7.4(6)6.4-8.9	7.8(6)6.6-9.0 7.4(7)6.5-9.0	7.8(5)6.8-8.9 7.8(5)6.5-8.9
JUNE			
Temperature (°F)	S=68.8(8)65.8-72.0 B=68.2(8)65.1-70.9	69.1(9)64.3-72.5 68.5(9)64.6-71.1	68.6(8)65.8-72.0 68.2(8)65.5-71.4
Salinity (o/oo)	S=0.9(7)0.1-1.9 B=1.5(7)0.3-3.7	1.0(8)0.3-2.3 1.6(8)0.4-4.7	1.0(7)0.3-1.6 1.3(7)0.4-2.8
Dissolved Oxygen(mg/l)	S=5.8(8)5.4-6.4 B=5.5(8)4.9-6.2	5.9(9)5.2-6.3 5.6(9)4.4-6.3	5.8(8)5.1-6.5 5.8(8)5.1-6.5

*S = Surface mean (number samples) range of values

**B = Bottom " " " " " "

Table B-1. In-Situ Temperature, Salinity and Dissolved Oxygen Data (Page 5 of 6)

	Station 13	Station 23	Station 12
		MARCH	
Temperature (°F)	S=35.1(2)34.5-35.8 B=35.0(2)34.2-35.8	35.3(2)34.5-36.1 35.5(2)34.7-36.3	35.9(3)34.5-37.2 35.6(3)34.3-37.0
Salinity (o/oo)	S=0.7(2)0.5-1.0 B=0.9(2)0.9-0.9	1.3(2)0.9-1.6 3.6(2)2.4-4.8	1.4(3)0.9-1.9 1.4(3)0.9-1.9
Dissolved Oxygen(mg/1)	S=10.6(2)10.0-11.2 B=10.4(1)10.4-10.4	10.7(2)10.5-11.0 10.1(2)9.9-10.3	10.5(3)10.1-11.2 10.0(3)9.4-10.9
		APRIL	
Temperature (°F)	S=42.5(7)37.8-49.8 B=42.1(7)37.2-49.1	42.4(7)37.9-49.3 42.7(6)37.9-48.4	42.5(8)36.7-49.6 42.2(8)36.9-48.9
Salinity (o/oo)	S=0.5(5)0.2-0.8 B=0.4(6)0.0-0.8	0.4(7)0.1-0.9 0.3(7)0.1-0.8	0.2(8)0.1-0.7 0.2(8)0.1-0.7
Dissolved Oxygen(mg/1)	S=9.8(7)8.0-11.2 B=10.1(7)8.7-11.5	10.1(6)8.2-11.1 9.9(7)8.2-11.7	9.8(8)8.7-11.2 9.8(8)7.6-11.3

APPENDIX C

SONIC TAGGED SHAD

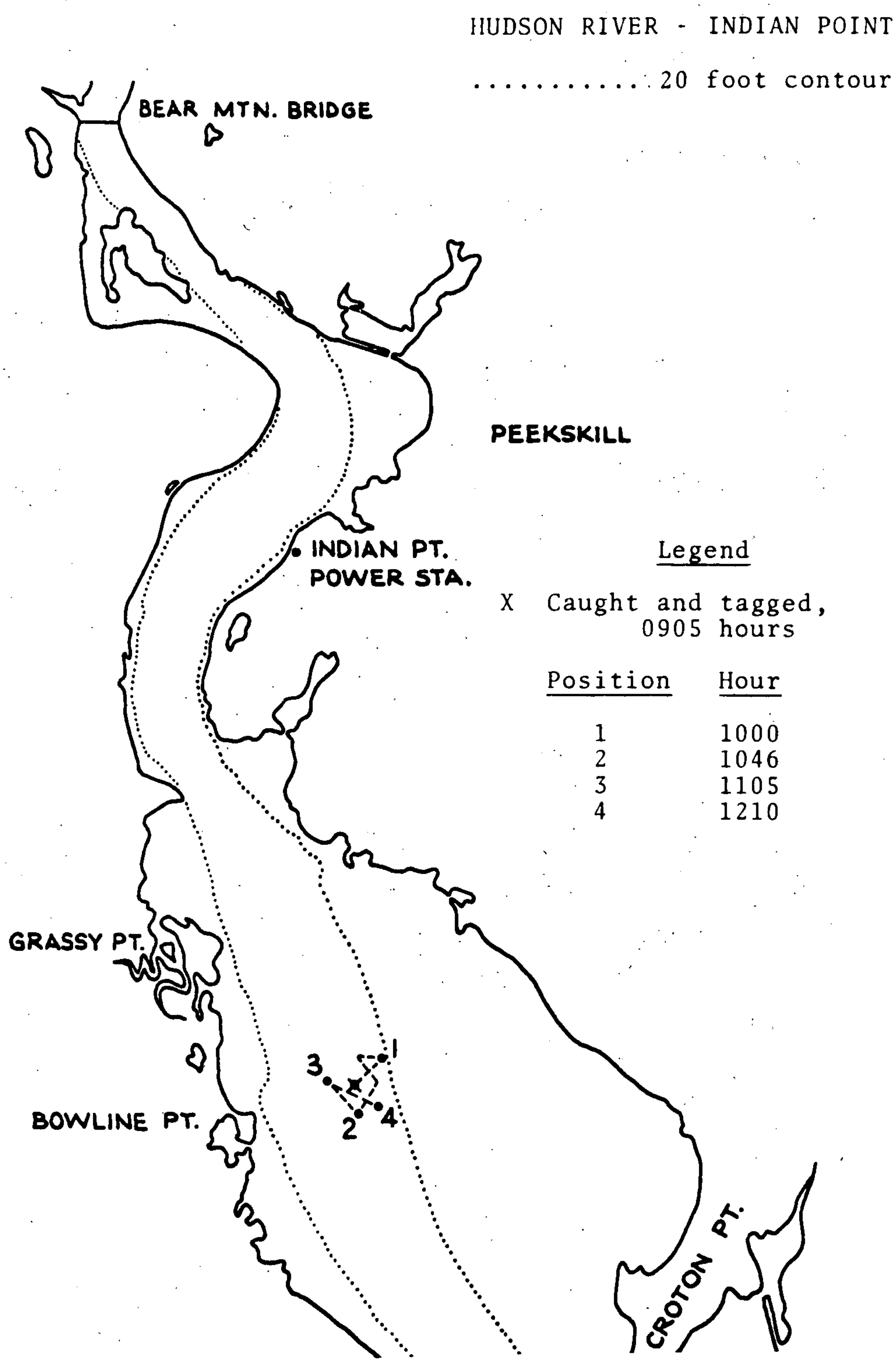


Figure C-1. Sonic Tagged Shad on April 22, 1970. Tag No. 6

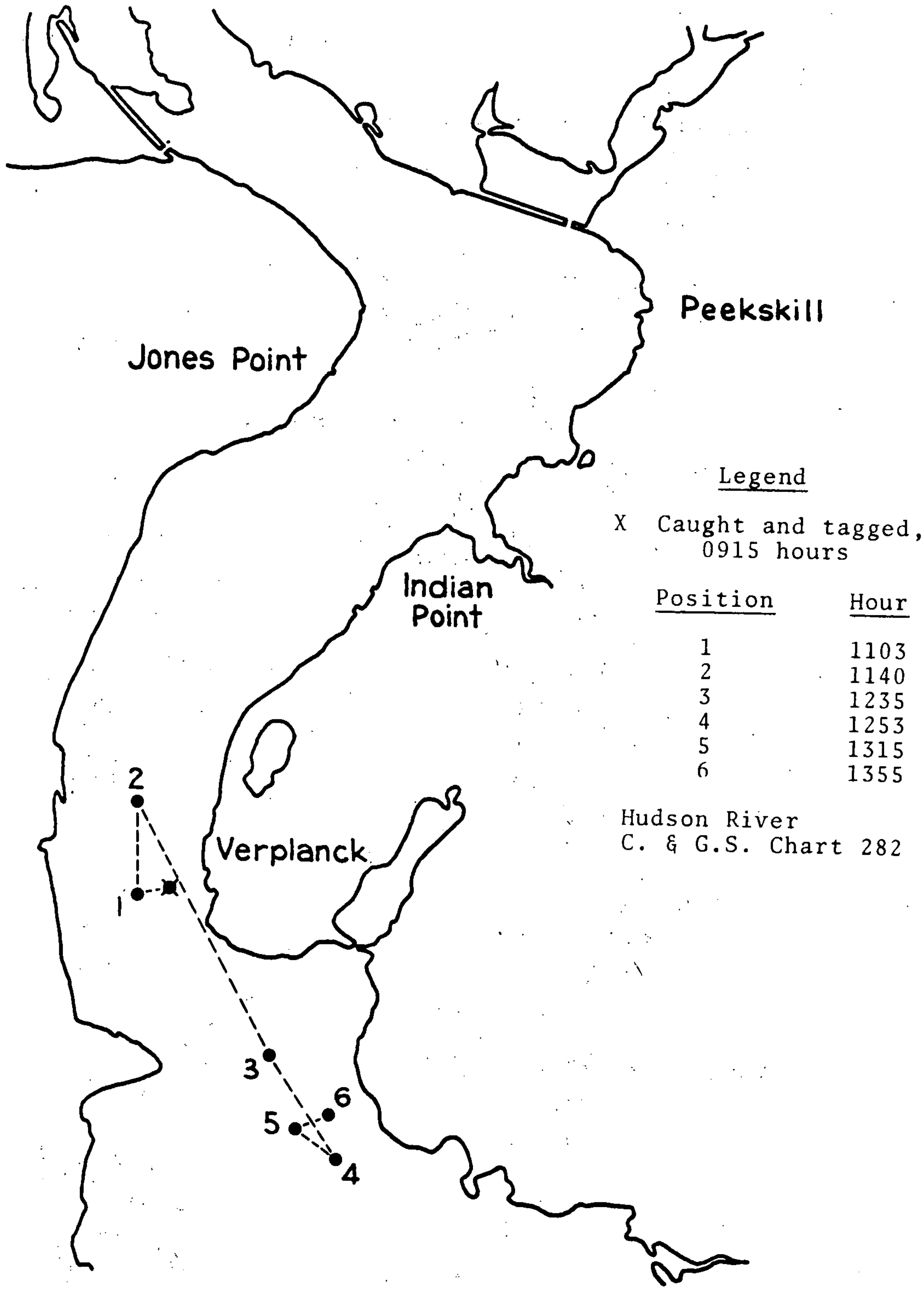


Figure C-2. Sonic Tagged Shad on May 6, 1970 (Tag No 12)

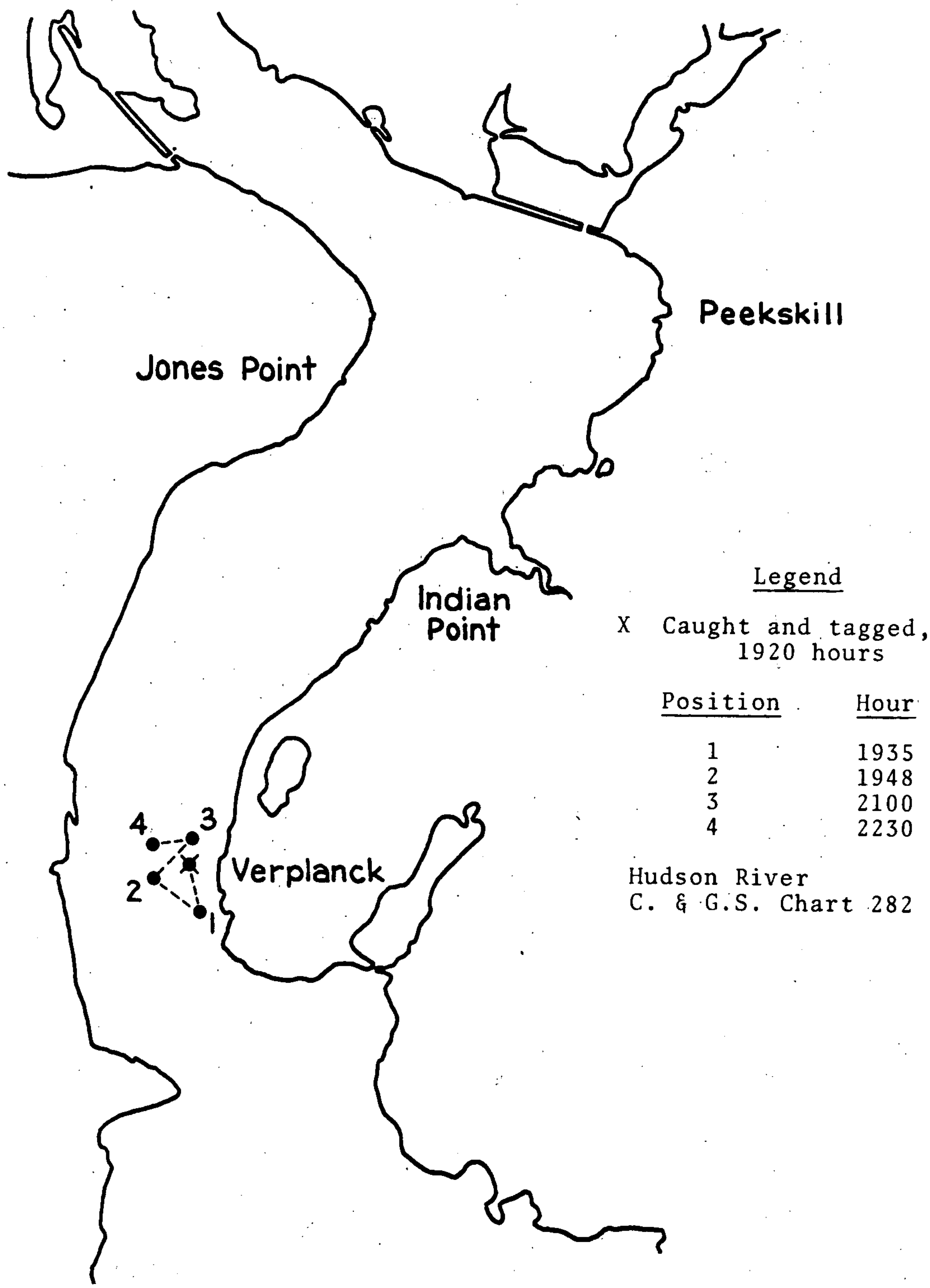


Figure C-3. Sonic Tagged Shad on May 12, 1970. Tag No. 11

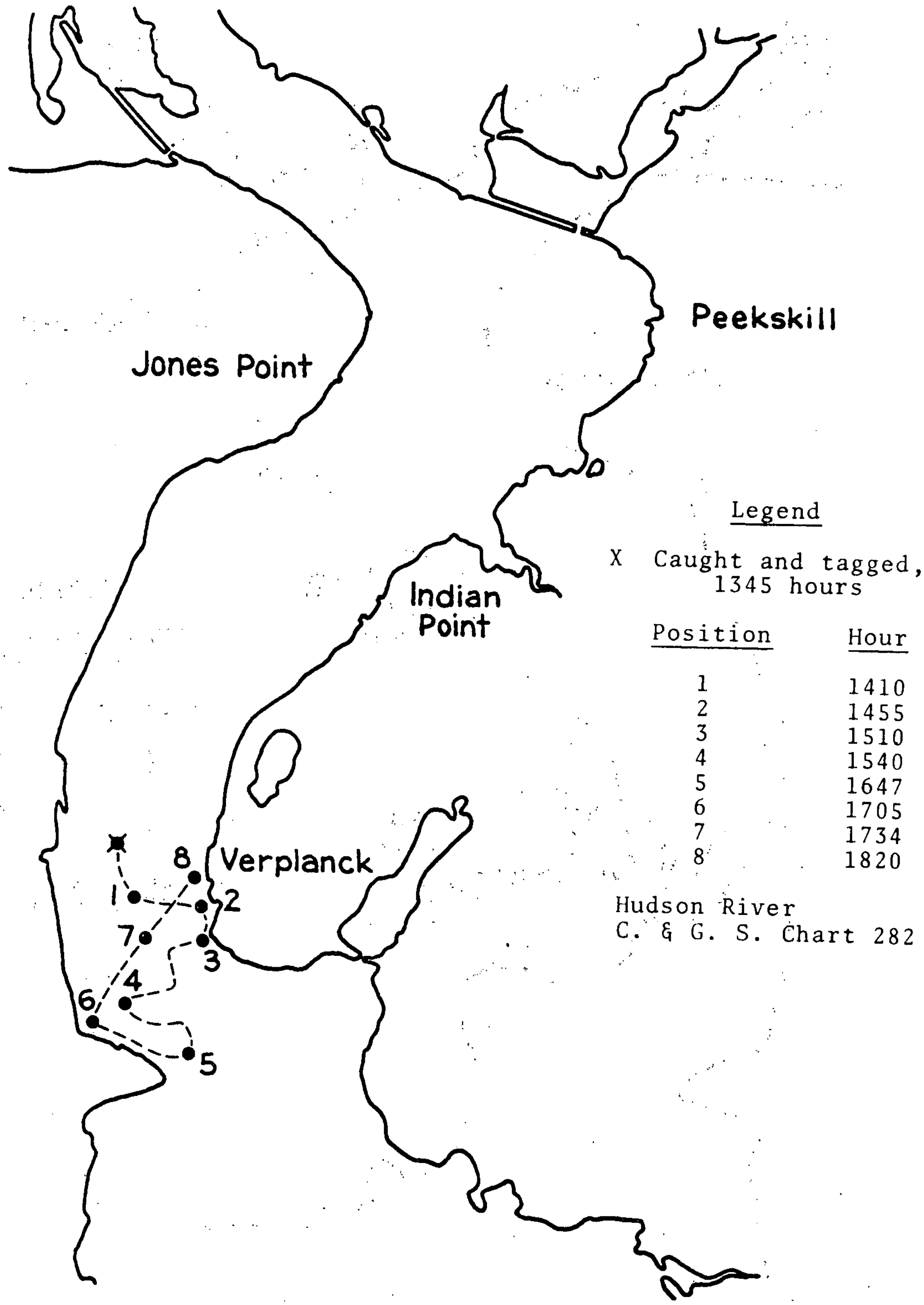


Figure C-4. Sonic Tagged Shad on May 13, 1970. Tag No. 14

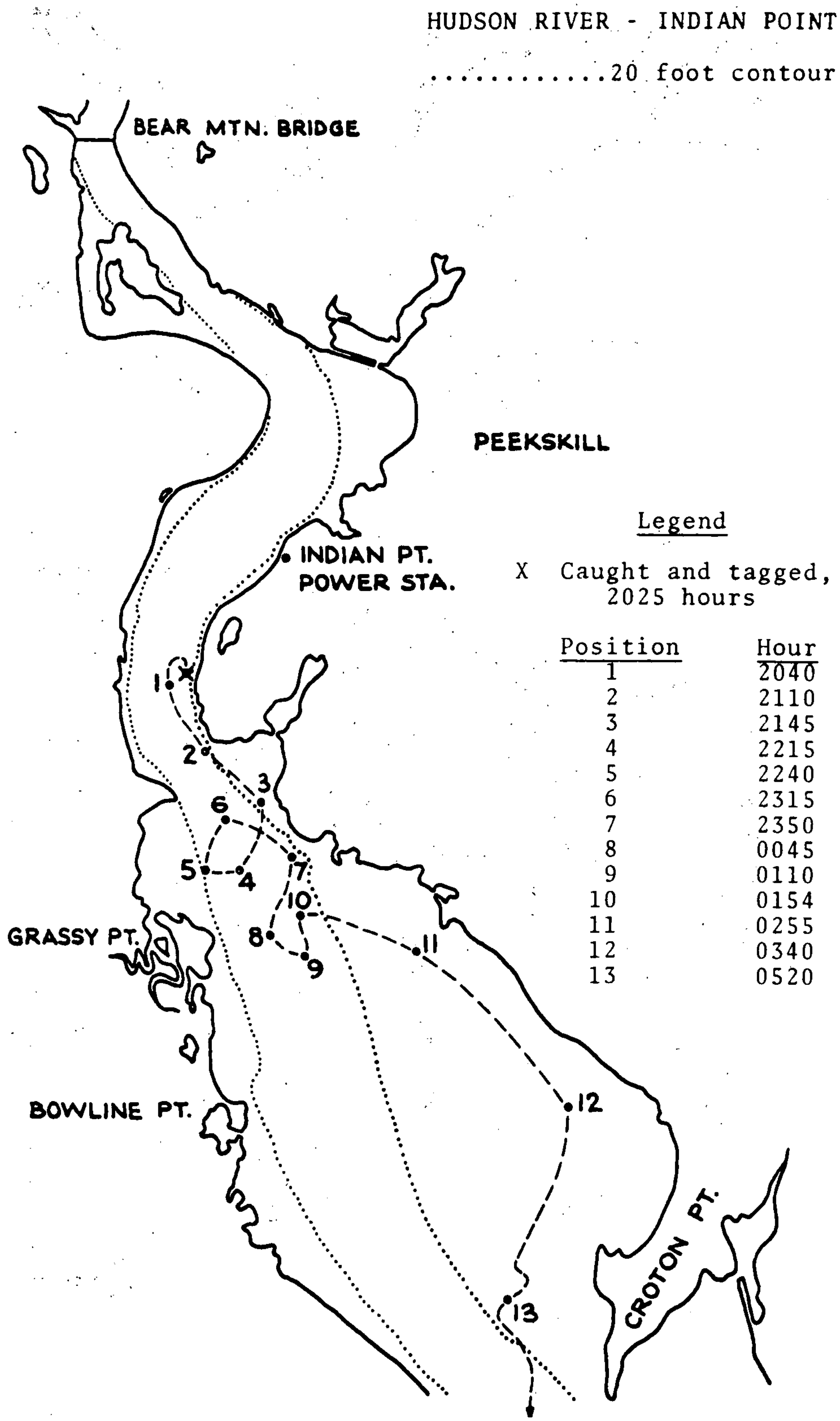


Figure C-5. Sonic Tagged Shad on May 13, 1970. Tag No. 10

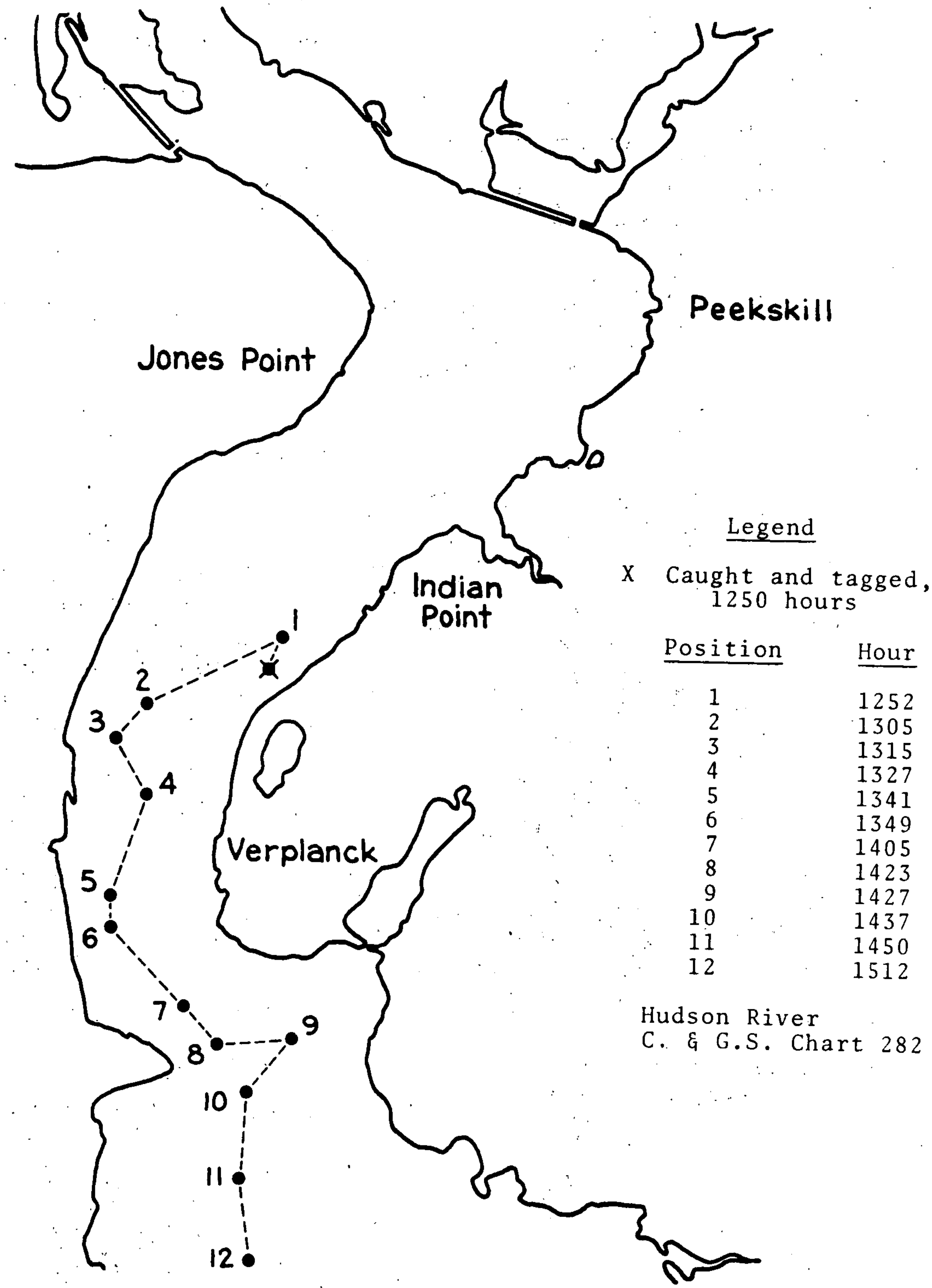


Figure C-6. Sonic Tagged Shad on May 19, 1970. Tag No. 7

APPENDIX D-1

EFFLUENT CANAL PLANKTON DATA

The data obtained from the effluent canal (Station 53) are reported separately in view of the physical restrictions and method of sampling required in this area.

Planktonic organisms entering the cooling water intake system of Unit 1 pass through the condensers and effluent canal prior to re-entering the river. Plankton collected from the canal may give an indication of species susceptibility and numbers of individuals involved. This data must be analyzed since entrainment in the cooling system may cause adverse effects on the viability of organisms. Entrained organisms will be subjected to two types of stress: a) mechanical tumbling caused by turbulence through the system, and b) an instantaneous heat rise of approximately 9—12° F while passing through the condensers. The problem of entrainment of organisms can be far more serious than entrapment of fishes on power plant intake screens (Nugent, 1970).*

The mean water velocity of the effluent canal is slightly greater than one foot per second (fps) when both cooling water circulators are operating, however, velocities as low as 0.30 fps occur near the bottom. When one circulator is operating, water velocity greatly decreases and when no circulators are operating, the water can become stagnant. Therefore, by utilizing the near-bottom areas, it is quite possible for some species to enter the effluent canal directly from the river while water is being discharged, or through the entire water column when cooling water circulators are off the line. We assume, however, the numbers of organisms capable of direct penetration are considerably fewer than the numbers introduced by cooling water when circulators are in operation. In addition, the future effluent canal configuration involves the jetting of water into the river through ports. The water velocities through the ports will make it virtually impossible for planktonic organisms to enter directly from the river.

*Nugent, Richard. 1970. Elevated Temperatures and Electric Power Plants. Transactions of the American Fisheries Society, 99 (4): 848-849

The most numerous organisms were represented by the amphipods, *Gammarus fasciatus*, *Pontocrates norvegicus*, *Leptocheirus pinguis*, and the opossum shrimp, *Neomysis americanus*. All four species are primarily benthic in habit. The numbers of larval fishes were quite small; Atlantic tomcod being the most numerous. Nine fish species were collected during the 4-month period. In general the number of species as well as the number of individuals of a given species were greater in night collections (Table D-1). The number of major species collected from the effluent canal does not parallel the number obtained from the remaining study area. Only 3, 5, 7 and 11 species were collected during March, April, May and June, respectively. The remaining 10 stations of the study area provided 8, 7, 10 and 14 species for the same period. The difference may be explained by the greater number of samples obtained from the 10 sampling stations.

Few specimens from the effluent canal were in poor condition or badly mutilated. Two of the 27 plankton samples were collected while Unit 1 was on-line (19 March).

Table D-1. Effluent Canal (Station 53) Numbers of Major Planktonic Species Collected/1000 Cubic Meters

Date	Time	Circ+	*Gammarus fasciatus*	*Pontocrates norvegicus*	*Leptocheirus pinguis*	*Neomysis americanus*	Clupeids*	Bay anchovy	Carp	American eel	Goldfish	American smelt	Striped bass	Atlantic tomcod	White perch
19 Mar	1604	1		7										52	
19 Mar	1245	1	7											90	
26 Mar	1348	2	6	39										55	
2 Apr	0938	2	22	112										90	
7 Apr	1659	2	114	23											
7 Apr	2217	2	1000	895	53										
9 Apr	1700	2	871	581	65										
13 Apr	1449	2	296	148	74										
20 Apr	1715	1	215	1015								31		15	
22 Apr	0105	1	2714	6857	1143									179	
27 Apr	1540	0		308	77										
4 May	0930	0													
7 May	0032	0	3214	1286	214		286			143					
11 May	1730	0													
12 May	0305	0	2154	1154	77					154					
18 May	0940	0													
20 May	0155	2	455	455	91										
21 May	1423	1	7	15		97	15								7
25 May	1525	1													
1 June	1322	1	36	12			48								
2 June	2210	1	9815	338	31		15			15			46		
8 June	1510	1					42						42		
15 June	2302	1	4299	2030		119	15	45			15		179		60
16 June	1600	1	111				236	139	14						42
22 June	1541	0					98	33					16		
29 June	1305	0	7												
29 June	2142	0	1311	3016	131	21901							164		

*Blueback herring and alewife combined

+ 0 = both circulators off-line
  1 = one circulator operating
  2 = both circulators operating

Table D-2. Community Overlap (%) of Plankton Stations, March 1970

Bottom Tows

Sta	Tran-sect	Mile	Site	Depth	M	M	SP			IP				RI			M
					4	6	15	20	9	21	11	10	22	13	23	12	14
4	M	35	2	34		0	0	0	0	0	0	0	0	0	0	0	0
6	M	38	2	30	0		0	0	0	0	0	0	0	0	0	0	0
15		40	1	45	0	0		55	78	68	96	73	70	73	65	86	0
20	SP	40	2	80	0	0	55		74	24	58	38	36	41	23	59	0
9		40	3	12	0	0	78	74		46	78	51	53	63	43	81	0
21		42	1	15	0	0	68	24	46		65	85	75	68	80	63	0
11	IP	42	2	50	0	0	96	58	78	65		72	69	69	64	87	0
10		42	3	45	0	0	73	38	51	85	72		65	70	84	63	0
22		42	3	45	0	0	70	36	53	75	69	85		85	87	56	0
13		45	1	50	0	0	73	41	63	68	69	70	85		76	62	0
23	RI	44	2	80	0	0	65	23	43	80	64	84	87	76		56	0
12		44	3	12	0	0	86	59	81	63	87	63	56	62	56		0
14	M	47	3	55	0	0	0	0	0	0	0	0	0	0	0	0	

Mid-Depth Tows

Sta	M	M	SP		IP			RI		M
	4	6	15	20	11	10	22	13	23	14
4		0	0	0	0	0	0	0	0	0
6	0		0	0	0	0	0	0	0	0
15	0	0		83	93	91	73	64	35	0
20	0	0	83		85	75	69	75	47	0
11	0	0	93	85		87	66	61	32	0
10	0	0	91	75	87		78	63	34	0
22	0	0	73	69	66	78		73	50	0
13	0	0	64	75	61	63	73		71	0
23	0	0	35	47	32	34	50	71		0
14	0	0	0	0	0	0	0	0	0	

Surface Tows

Sta	M	M	SP			IP				RI			M
	4	6	15	20	9	21	11	10	22	13	23	12	14
4		0	0	0	0	0	0	0	0	0	0	0	0
6	0		0	0	0	0	0	0	0	0	0	0	0
15	0	0		38	85	88	73	57	92	63	38	94	0
20	0	0	38		33	49	24	82	47	75	100	45	0
9	0	0	85	33		72	64	51	91	58	33	80	0
21	0	0	88	49	72		74	63	91	74	49	92	0
11	0	0	73	24	64	74		38	69	49	24	71	0
10	0	0	57	82	51	63	38		65	66	92	63	0
22	0	0	92	47	81	91	69	65		72	47	97	0
13	0	0	63	75	58	74	49	[illegible]	72		75	70	0
23	0	0	38	100	33	49	24	82	47	75		45	0
12	0	0	94	45	80	92	71	63	97	70	45		0
14	0	0	0	0	0	0	0	0	0	0	0	0	

M Monthly Station
SP Stony Point
IP Indian Point
RI Round Island

Table D-3. Community Overlap (%) of Plankton Stations, April 1970

Bottom Tows

					M	M	SP			IP				RI			M
Sta	Transect	Mile	Site	Depth	4	6	15	20	9	21	11	10	22	13	23	12	14
4	M	35	2	34		0	0	0	0	0	0	0	0	0	0	0	0
6	M	38	2	30	0		0	0	0	0	0	0	0	0	0	0	0
15	SP	40	1	45	0	0		90	57	72	90	68	85	99	90	82	0
20		40	2	80	0	0	90		61	78	92	72	84	91	82	91	0
9		40	3	12	0	0	57	61		56	53	88	66	57	56	64	0
21	IP	41	1	15	0	0	72	78	56		78	67	73	72	63	85	0
11		42	2	50	0	0	90	92	53	78		65	81	91	82	89	0
10		42	3	45	0	0	68	72	88	67	65		71	88	67	76	0
22		42	3	45	0	0	85	84	66	73	81	71		85	76	83	0
13	RI	45	1	50	0	0	99	91	57	72	91	68	85		89	83	0
23		44	2	80	0	0	90	82	56	63	82	67	76	89		73	0
12		44	3	12	0	0	82	91	64	85	89	76	83	83	73		0
14	M	47	3	55	0	0	0	0	0	0	0	0	0	0	0	0	

Mid-Depth Tows

M	M	SP		IP			RI		M
4	6	15	20	11	10	22	13	23	14
	0	0	0	0	0	0	0	0	0
0		0	0	0	0	0	0	0	0
0	0		82	87	65	66	74	96	0
0	0	82		82	61	78	91	84	0
0	0	87	82		61	61	84	89	0
0	0	65	61	61		56	59	63	0
0	0	66	78	61	56		75	63	0
0	0	74	91	84	59	75		75	0
0	0	96	84	89	63	63	75		0
0	0	0	0	0	0	0	0	0	

Surface Tows

M	M	SP			IP				RI			M
4	6	15	20	9	21	11	10	22	13	23	12	14
	0	0	0	0	0	0	0	0	0	0	0	0
0		0	0	0	0	0	0	0	0	0	0	0
0	0		74	42	67	62	32	69	50	50	91	0
0	0	74		62	85	79	51	84	58	76	73	0
0	0	42	62		60	59	82	56	39	70	30	0
0	0	67	85	60		92	43	90	71	77	67	0
0	0	62	79	59	92		42	92	79	83	63	0
0	0	32	51	82	43	42		39	22	83	25	0
0	0	69	84	56	90	92	39		74	79	71	0
0	0	50	58	39	71	79	22	74		68	59	0
0	0	50	76	70	77	83	53	79	68		51	0
0	0	91	73	39	67	63	25	71	59	51		0
0	0	0	0	0	0	0	0	0	0	0	0	

M Monthly Station
SP Stony Point
IP Indian Point
RI Round Island

Table D-4. Community Overlap (%) of Plankton Stations, May 1970

Bottom Tows

					M	M	SP			IP				RI			M
Sta	Transect	Mile	Site	Depth	4	6	15	20	9	21	11	10	22	13	23	12	14
4	M	35	2	34		92	61	88	87	73	79	64	66	77	79	73	79
6	M	38	2	30	92		67	97	86	81	86	71	73	84	88	80	74
15	SP	40	1	45	61	67		68	56	81	76	93	82	75	74	67	41
20	SP	40	2	80	88	97	68		85	84	88	73	76	87	91	81	72
9	SP	40	3	12	87	86	56	85		75	78	63	68	77	77	80	72
21	IP	42	1	15	73	81	81	84	75		91	87	91	92	90	83	58
11	IP	42	2	50	79	86	76	88	78	91		82	86	94	93	86	62
10	IP	42	3	45	64	71	93	73	63	87	82		89	81	79	74	46
22	IP	42	3	45	66	73	82	76	68	91	86	89		85	82	82	50
13	RI	45	1	50	77	84	75	87	77	92	94	81	85		94	85	65
23	RI	44	2	80	79	88	74	91	77	90	93	79	82	94		82	63
12	RI	44	3	12	73	80	67	81	80	83	86	74	82	85	82		59
14	M	47	3	55	79	74	41	72	72	58	62	46	50	65	63	59	

Mid-Depth Tows

M	M	SP		IP			RI		M
4	6	15	20	11	10	22	13	23	14
	0	1	1	1	4	2	1	2	54
0		35	47	68	47	48	55	53	40
1	35		77	43	78	79	79	63	25
1	47	77		57	93	90	89	76	38
1	68	43	57		58	56	61	65	45
4	47	78	93	58		91	89	78	42
2	48	79	90	56	91		93	78	41
1	55	79	89	61	89	93		80	40
2	53	63	76	65	78	78	80		47
54	40	25	38	45	42	41	40	47	

Surface Tows

M	M	SP			IP				RI			M
4	6	15	20	9	21	11	10	22	13	23	12	14
	57	3	5	14	6	8	16	8	4	6	25	21
57		15	32	42	17	25	40	30	18	34	51	36
3	15		79	44	96	76	63	76	96	76	52	63
5	32	79		64	80	87	81	91	81	94	72	78
14	42	44	64		46	59	70	61	47	67	74	62
6	17	96	80	46		78	64	76	96	78	53	64
8	25	76	87	59	78		83	95	78	87	72	77
16	40	63	81	70	64	83		87	65	80	87	82
8	30	76	91	61	76	95	87		77	89	75	80
4	18	96	81	47	96	78	65	77		78	55	65
6	34	76	94	67	78	87	80	89	78		73	77
25	51	52	72	74	53	72	87	75	55	73		73
21	36	63	78	62	64	77	82	80	65	77	73	

M Monthly Station
SP Stony Point
IP Indian Point
RI Round Island

Table D-5. Community Overlap (%) of Plankton Stations, June 1970

Bottom Tows

					M	M	SP			IP				RI			M
Sta	Transect	Mile	Site	Depth	4	6	15	20	9	21	11	10	22	13	23	12	14
4	M	35	2	34		88	77	75	34	45	72	71	45	82	73	24	17
6	M	38	2	30	88		86	78	44	52	80	80	55	90	80	34	26
15	SP	40	1	45	77	86		69	45	57	91	80	56	93	75	36	29
20	SP	40	2	80	75	78	69		55	64	68	77	66	73	87	44	37
9	SP	40	3	12	34	44	45	55		84	45	63	88	48	58	87	80
21	IP	42	1	15	45	52	57	64	84		58	72	93	61	72	75	67
11	IP	42	2	50	72	80	91	68	45	58		81	87	88	75	43	36
10	IP	42	3	45	71	80	80	77	63	72	81		74	85	86	53	46
22	IP	42	3	45	45	55	56	66	88	93	57	74		59	70	78	71
13	RI	45	1	50	82	90	93	73	48	61	88	85	59		81	38	31
23	RI	44	2	80	73	80	75	87	58	72	75	86	70	81		48	41
12	RI	44	3	12	24	34	36	44	87	75	43	53	78	38	48		91
14	M	47	3	55	17	26	29	37	80	67	36	46	71	31	41	91	

Mid-Depth Tows

M	M	SP		IP			RI		M
4	6	15	20	11	10	22	13	23	14
	12	12	3	-1	2	-1	1	-1	13
12		42	30	13	10	6	8	8	53
12	42		80	52	53	47	54	51	42
3	30	80		61	69	59	67	68	31
-1	13	52	61		75	93	80	80	16
2	10	53	69	75		77	73	92	12
-1	6	47	59	93	77		81	83	9
1	8	54	67	80	73	81		80	11
-1	8	51	68	80	92	83	80		10
13	53	42	31	16	12	9	11	10	

Surface Tows

M	M	SP			IP				RI			M
4	6	15	20	9	21	11	10	22	13	23	12	14
	82	8	9	20	2	4	5	5	3	2	2	16
82		9	10	22	4	11	8	10	6	10	4	34
8	9		75	66	65	79	83	74	71	81	71	11
9	10	75		56	52	73	74	87	59	80	84	11
20	22	66	56		68	72	68	63	62	57	57	21
2	4	65	52	68		71	76	89	88	61	84	6
4	11	79	73	72	71		88	86	71	84	78	14
5	8	83	74	68	76	88		82	80	83	83	11
5	10	74	87	63	59	85	82		65	77	83	12
3	6	71	59	62	88	71	80	65		69	73	7
2	10	81	80	57	61	84	83	77	69		83	13
2	4	71	84	57	64	78	83	83	73	82		6
16	34	11	11	21	6	14	11	12	7	13	6	

M Monthly Station
SP Stony Point
IP Indian Point
RI Round Island

Institute of Environmental Medicine

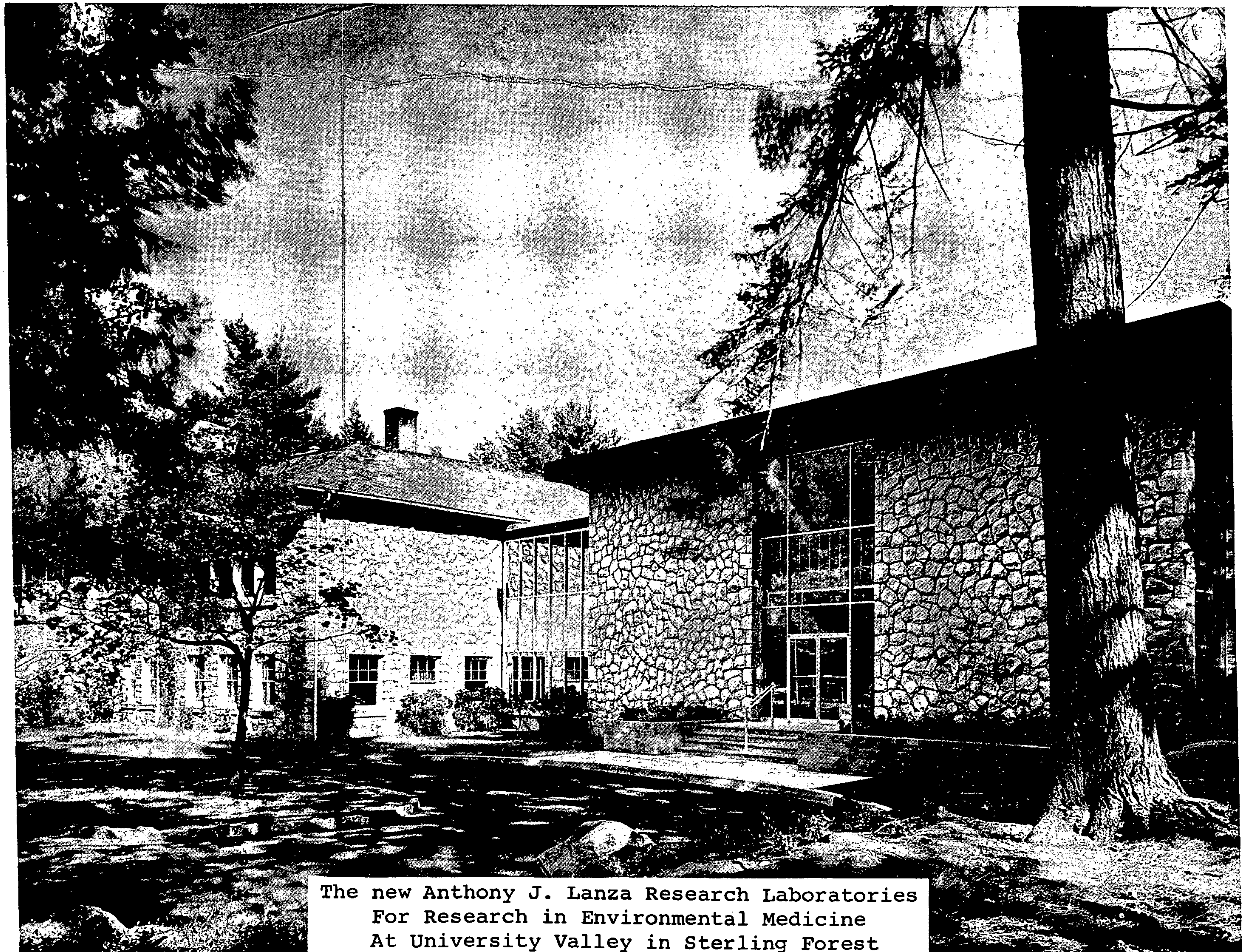
The Consolidated Edison Company
of New York

HUDSON RIVER AT INDIAN POINT

Annual Report 4/16/68 to 4/15/69

Principal Investigator: Gwyneth Parry Howells

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



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

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HUDSON RIVER AT INDIAN POINT

April 1968 - April 1969

Consolidated Edison Company

Contract Period 4/16/68 to 4/15/70

Quarterly Report 1/17/69 to 4/15/69

Annual Report 4/16/68 to 4/15/69

Principal Investigator: Gwyneth Parry Howells

Co-Investigators: Dr. Theo. J. Kneip, Dale Bath, Professor H.I. Hirshfield and assisted by Elayne Musnick, Sylvia Weaver, Arthur Goldhamer, Tony Hernandez, James Miller and Dorothy Wohlgemuth.

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INTRODUCTION

Sampling at Indian Point was begun in March 1968 and continued throughout the remaining months of the year. Collections at main channel and shore stations were monthly during the whole period, with two weekly collections during the summer months, June to September.

During the first quarter of 1969, sampling at Indian Point has been restricted by weather conditions. In January and February, monthly sampling of the river was only possible from the northern end of the pier at Consolidated Edison's plant at Indian Point. Some sampling of the discharge canal was possible in January but subsequently plant alterations interrupted our sampling program in the canal.

In March, 1969, Dr. N. Della Croce from the University of Genova, Italy, visited our laboratory to give advice on methods of collection of zooplankton and interpretation of plankton data. Dr. Della Croce is an internationally known specialist in the field of planktonic microcrustacea, and has a wide experience of both marine and freshwater aquatic environments in Europe, Africa, India and North America.

Data for the quarterly period are incorporated into the annual survey which follows. The sections include I. physical data (temperature, salinity, turbidity); II. chemical data (nutrients and trace elements); III. zooplankton data; IV phytoplankton data; V studies on discharge canal; VI. the shore-seining program for fish; VII radionuclide studies, including a summary account of data for earlier years to 1964.

The very recent acquisition of a Zeiss photomicroscope will greatly assist in the task of identifying small plankton organisms, especially the protozoans and phytoplankton. In addition, the automatic photographing attachment should allow permanent records to be made of characteristic species of the plankton, and perhaps of plankton communities typical of each month at Indian Point. Our grateful thanks are due to Consolidated Edison for their generous gift.

I. PHYSICAL DATA

Measurements of temperature, salinity and turbidity (clarity) for three mid-channel stations at Indian Point are summarized in Table I-1, and Figures I-1 to I-3. Similar data for east and west shore stations are listed in Table I-2.

Temperature range recorded through the year was from 1.1°C in January and March to 27.4°C in mid-August. During January and February much of the river was frozen, and temperatures other than at the Consolidated Edison dock must have been zero or close to freezing. Little difference in temperature was seen between shore stations and channel stations, between east, mid-channel and west-channel stations, or between surface and bottom temperatures. The maximum difference between the channel stations was 1.5°C (East > West) in mid-June, but the east channel station was not consistently higher than the other two, and the west channel station was the hottest of the three on four occasions. The bottom water across the river was, in general, cooler than surface water; the maximum difference observed was 1.8°C at the east channel station in mid-June.

Salinity through the 12-month period varied from 0.10°/oo to 5.5°/oo, with maxima appearing in September and early March. Little difference was observed between east, mid- and west-channel stations (maximum 0.6°/oo,

Sampling Date	Sampling Station (Depth, ft)	Temperature °C Top	Bottom	Salinity °/oo Top	Bottom	Clarity (ft)
July 30	East (27)	26.2	26.0	1.60	1.70	3.0
	Mid (50)	26.7	26.2	1.40	1.80	3.5
	West (27)	26.0	25.8	1.70	1.90	4.0
Aug 14	East (12)	26.8	26.7	1.35	1.34	2.5
	Mid (45)	27.4	27.0	1.20	1.50	2.5
	West (26)	27.0	26.8	1.30	1.75	3.0
Aug 27	East (13)	27.0	26.6	3.40	3.50	3.0
	Mid (52)	27.4	26.5	3.40	4.10	3.3
	West (20)	26.9	26.6	3.50	3.50	3.3
Sept 10	East (30)	25.0	24.6	3.30	3.60	3.0
	Mid (50)	25.8	24.5	3.10	3.70	4.0
	West (18)	24.8	24.5	3.40	3.90	4.0
Sept 27	East (50)	24.2	24.0	4.70	4.60	4.0
	Mid (60)	24.1	24.1	4.70	4.95	4.0
	West (30)	24.3	24.3	5.30	5.45	4.0
Oct 8	East (75)	21.0	20.5	4.25	5.15	3.0
	Mid (75)	21.4	20.9	4.32	4.58	3.5
	West (32)	21.3	21.2	4.10	4.18	2.8
Dec 3	East (72)	7.2	7.0	0.30	0.26	1.5
	Mid (52)	6.9	7.0	0.30	0.34	2.0
	West (27)	8.5	7.7	0.30	0.30	1.75
Jan 14	N. Dock (20)	1.3	1.1	0.50	0.60	-

Sampling Date	Sampling Station (Depth, ft)	Temperature °C Top	Temperature °C Bottom	Salinity °/oo Top	Salinity °/oo Bottom	Clarity (ft)
March 13	East (45)	1.82	1.38	4.32	4.70	2.0
	Mid (55)	1.52	1.52	4.45	4.92	2.5
	West (25)	1.15	1.05	4.75	4.95	2.5
April 7	East (52)	6.50	6.20	0.26	0.26	1.0
	Mid (45)	6.22	5.52	0.20	0.22	1.0
	West (27)	6.15	5.50	0.20	0.20	1.5

Table I-2: Physical Data: Hudson River at Indian Point

April 1968 - April 1969

Sampling Date	Sample Site	Temperature °C	Clarity (ft)
April 3	East	-	-
	West	6	1.2
May 15	East	16	1.5
	West	16	2.5
June 7	East	20	1.0
	West	20	2.5
July 3	East	22	2.0
	West	22	2.0
Aug 13	East	27	1.8
	West	26.5	3.5
Sept 12	East	24.0	1.0
	West	25.0	4.5
Oct 14	East	20	2.0
	West	20	3.0
Dec 3	East	8.0	1.75
	West	7.5	2.5
April 15	East	10.0	1.0
	West	10.5	1.5

west > mid and east, September) even though sampling was not related to tidal phase. In general, bottom water was slightly more saline than surface water, but this situation was sometimes reversed. The maximum difference between surface and bottom water was 0.7^{o}/oo (mid-channel) at the end of August.

Secchi disc readings to indicate water clarity showed a range in channel stations from 1 foot to 4 feet during the course of the year. The water was most turbid in the spring, and to a lesser extent in the late fall, coinciding with periods of maximum surface run-off. Shore stations in general were less clear than channel stations, but with a range similar to channel stations, 1 to 4.5 feet. West shore station readings indicated greater clarity on most occasions, but the mid-channel was the clearest of the channel stations.

Figure I-1: Surface Temperature, Hudson River at Indian Point 1968-69
(Mean of east, mid-channel and west station).

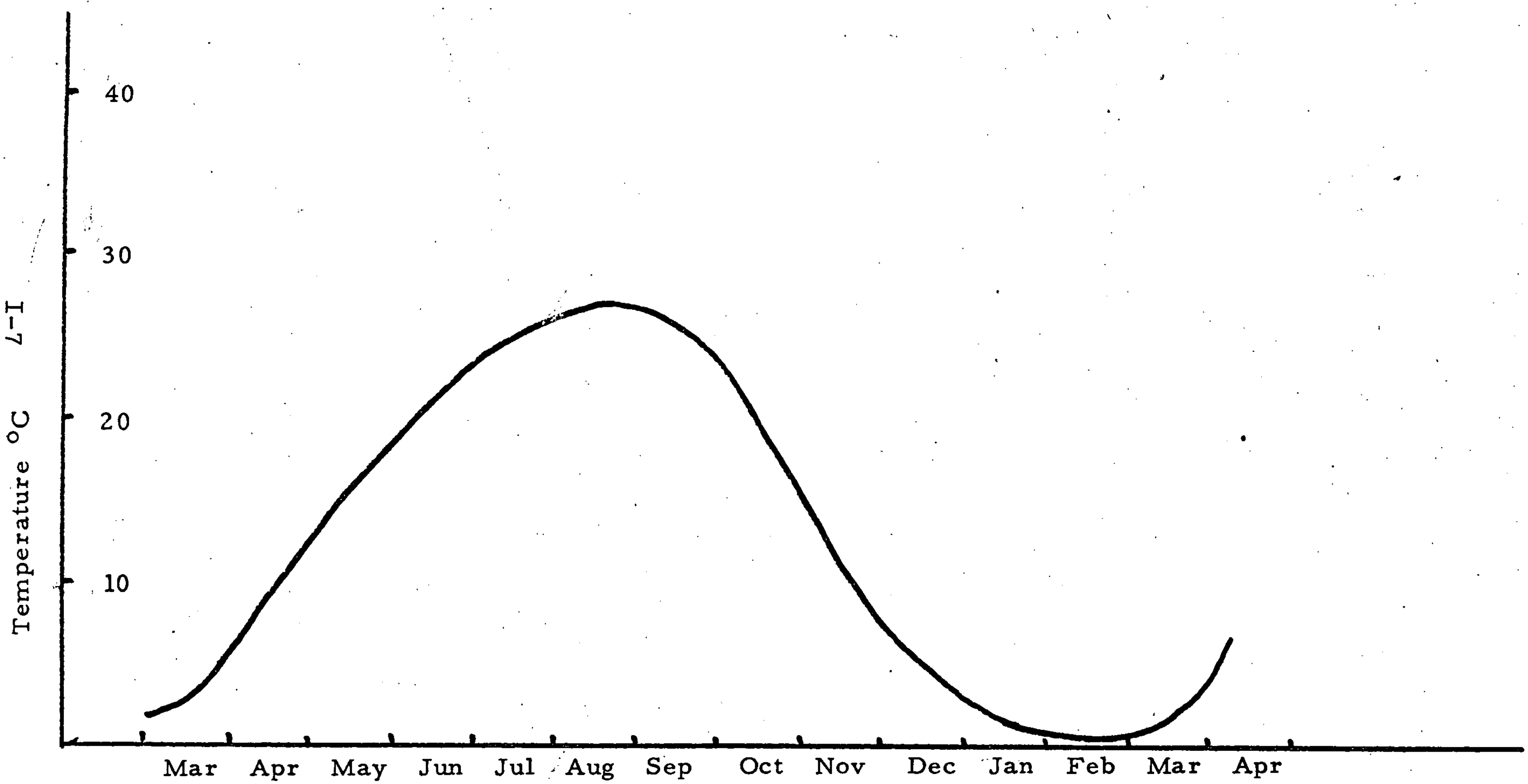


Figure I-2: Salinity at Surface, Hudson River at Indian Point 1968-69
(Mean of east mid-channel and west station).

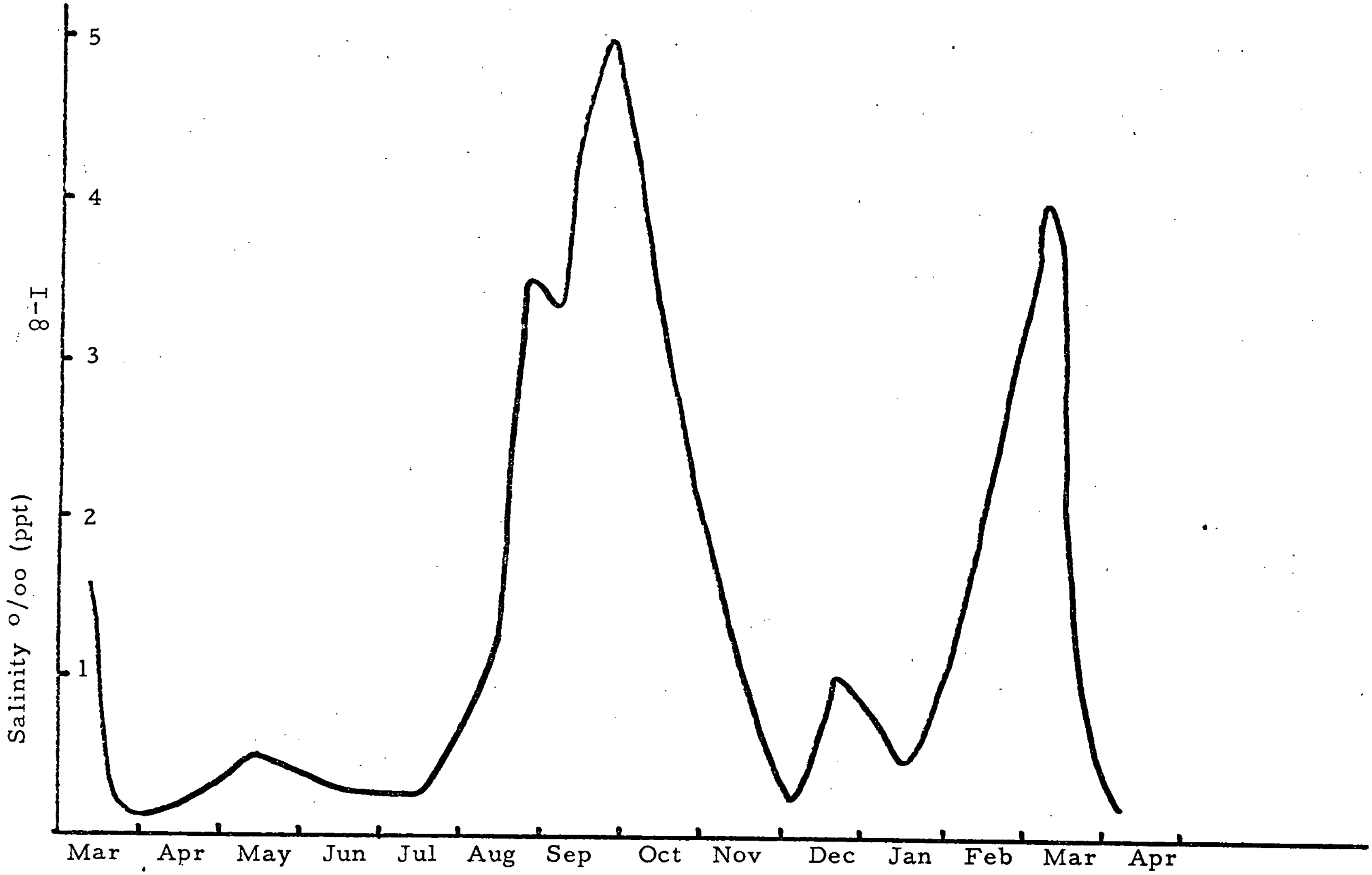
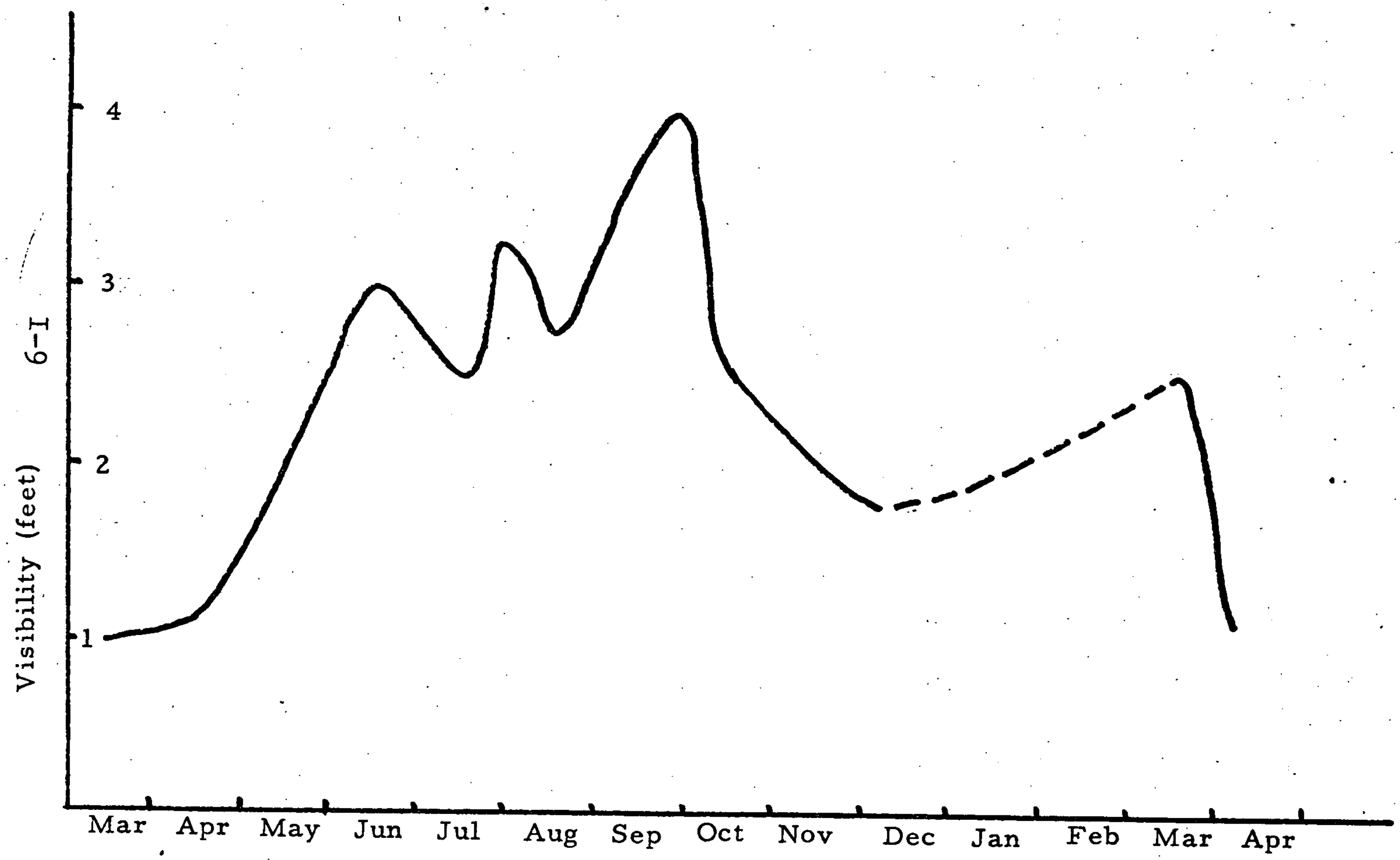


Figure I-3: Secchi Disc Readings, Hudson River at Indian Point 1968 -69
(Mean of east mid-channel and west stations).



II CHEMICAL DATA

No further samples (beyond December 1968) have been analyzed for nutrient anions or trace elements in this period, although sampling was resumed in March 1969. For the completeness of this report the data for 1968 are given in Tables II-1 and II-2, although this data has been reported previously.

The nutrient concentrations in the river water through 1968 indicate levels comparable with some other polluted waters. Phosphate ranged from non-detectable (August) to 0.74 mg PO_4/liter (April, West Station). In general the levels during the summer months appeared lower than in the spring and fall. While east, mid and west-channel stations were often quite strikingly different in phosphate concentration, there seemed little consistent pattern. The levels of concentration reported are similar to those reported (N.Y. State Health Department) for other stations on the river (Table II-3).

Nitrate concentrations seem much more variable in the Indian Point samples during 1968, with values ranging from non-detectable to 64 mg NO_3/liter, much greater than reported for the New York State Health Department's stations, which were generally about 2.2 mg NO_3/liter (Table II-4).

TABLE 1. 1: Hudson River at Indian Point, 1968

(N. Dt = not determined; N. Dd = not detected)
(N. A. = not yet available)

Anion concentrations mg/l

Sampling Date	Station	Chloride	Nitrite & Nitrate (as Nitrate)	N mg/l	Ortho Phosphate (as PO_4'')	Total Phosphate (as PO_4'')	Total P mg/l	N/P
3/6/68	East	506	2.6	0.59	0.35	0.60	0.20	3
4/2/68	East	11.6	0.22	0.05	0.13	0.54	0.18	0.3
	Midchannel	11.4	0.24	0.05	0.12	0.28	0.091	0.5
	West	9.7	0.35	0.08	0.17	0.74	0.24	0.3
5/14/68	East	135	59.8	13.5	0.11	0.26	0.085	160
	Midchannel	136	57.8	13.0	0.05	0.29	0.095	140
	West	194	43.4	9.8	0.15	0.23	0.075	130
6/5/68	East	11.4	25.7	5.8	0.17	0.26	0.085	68
	Midchannel	8.6	35.4	8.0	0.18	0.20	0.065	120
	West	9.2	30.1	6.8	0.19	0.20	0.065	100
7/2/68	East	14.8	N. Dt.	-	0.12	0.38	0.12	-
	Midchannel	9.8	"	-	0.04	0.26	0.085	-
	West	10.2	"	-	N. Dt.	0.29	0.095	-
8/14/68	East	634	0.52	0.12	0.21	N. Dt.	-	-
	Midchannel	544	1.0	0.22	0.06	"	-	-
	West	638	0.58	0.13	0.16	"	-	-
9/10/68	East	1404	0.39	0.09	0.08	0.32	0.10	0.90
	Midchannel	1337	0.11	0.02	0.01	0.26	0.085	0.023
	West	1813	N. A.	-	0.03	0.35	0.11	-

TABLE II-1 (con't)

Sampling Date	Station	Chloride	Nitrite & Nitrate (as Nitrate)	N mg/l	Ortho Phosphate (as PO_4'')	Total Phosphate (as PO_4'')	Total P mg/l	N/P
9/27/68	East	2330	N. A.	-	0.22	0.66	0.21	-
	Midchannel	2368	2.3	0.52	0.16	0.39	0.13	4.0
	West	2696	N. A.	-	0.12	0.46	0.15	-
12/3/68	East	160	53	12	0.24	0.34	0.11	109
	Midchannel	160	62	14	0.23	0.35	0.11	127
	West	160	64	14	0.31	0.38	0.12	116

TABLE II-2: Hudson River at Indian Point, 1968
Trace element concentrations, p.p.b. = μg/l.

(* = analysis discontinued)

Sampling Date	Station	Cadmium	Cobalt	Chromium	Copper	Iron	Manganese	Nickel	Lead	Zinc
4/2/68	East	1.7	0.8	<3	3.7	24	<0.5	1.4	20	10
	Midchannel	0.9	0.8	<3	3.7	5.0	<0.5	3.2	33	12
	West	0.9	<0.6	<3	4.7	3.7	1.0	5.0	43	14
5/14/68	East	1.7	1.0	<3	4.4	10	3.0	3.6	47	9.7
	Midchannel	0.9	1.7	<3	5.0	8.2	<0.5	3.2	37	7.6
	West	0.8	1.7	<3	6.3	50	<0.5	3.6	30	9.3
6/5/68	East	1.2	<0.6	<3	2.7	18	<0.5	5.0	63	8.4
	Midchannel	0.9	2.1	<3	3.7	14	2.5	2.9	20	16
	West	1.6	<0.6	<3	7.9	23	6.3	3.6	43	13
7/2/68	East	1.3	*	*	3	8.2	-	1.5	5.0	29
	Midchannel	1.4	*	*	3	4.7	-	0.6	5.0	15
	West	0.8	*	*	2	2.7	-	0.5	6.9	8.3
8/14/68	East	1.2	*	*	2	6.8	0.8	0.7	5.9	5.4
	Midchannel	0.9	*	*	2	10	1.6	0.6	4.0	6.9
	West	1.3	*	*	3	4.7	4.7	1.1	4.0	6.9
9/10/68	East	0.8	*	*	3	3.4	1.6	0.6	5.9	6.9
	Midchannel	0.9	*	*	2	5.4	2.4	0.5	5.9	5.4
	West	1.8	*	*	3	4.7	1.6	1.1	6.9	7.6
9/27/68	East	1.3	*	*	2	3.4	4.7	0.7	5.0	7.6
	Midchannel	1.7	*	*	3	2.7	12	0.9	5.9	13
	West	1.3	*	*	18	2.7	12	1.1	21	12

TABLE II-2 (con't)

Sampling Date	Station	Cadmium	Cobalt	Chromium	Copper	Iron	Manganese	Nickel	Lead	Zinc
12/3/68	East	<0.6	*	*	5.3	35	10	3.8	<10	50
	Midchannel	<0.6	-	-	4.2	34	< 3	4.2	<10	23
	West	<0.6	-	-	1.7	11	< 3	1.1	<10	7

Table II-3

PHOSPHATE (mg PO_4/liter) IN HUDSON RIVER, 1968

Sampling Station	Range	Mean
Yonkers**	0.30-7.50	1.93 (0.54, 1 high value excluded
Indian Point*	N.D.-0.74	0.32
Chelsea**	0.28-0.54	0.42
Poughkeepsie**	0.16-0.55	0.34
Catskill**	0.20-0.67	0.34
Coeymans**	0.16-0.55	0.34
Glenmont**	0.13-0.64	0.35

*Institute of Environmental Medicine.
**New York State Department of Health.

Table II-4

NITRATE (mg NO_3/liter) IN HUDSON RIVER, 1968

Sampling Station	Range	Mean
Yonkers**	0.18-2.66	1.68
Indian Point*	N.D.-64	20
Chelsea**	1.15-2.75	2.35
Poughkeepsie**	1.59-3.54	2.35
Catskill**	1.33-2.35	1.95
Coeymans**	1.11-2.57	1.73
Glenmont**	0.75-4.83	1.73

*Institute of Environmental Medicine.

**New York State Department of Health.

The reason for the hundred-fold increase is obscure: it is possible that laboratory contamination affected samples but not standards and this possibility is being checked. On the other hand it is also possible that some local source of nutrient material (as for instance from a yeast production plant just north of Indian Point) is affecting the water in this region. The levels of nitrate seen are not wholly out of line with those seen in other polluted waters- for instance the River Thames water showed values as high as 28 mg NO_3/liter (1954) for nitric nitrogen, and 50 mg NO_3/liter (1954) for total inorganic nitrogen (if all could be expressed as nitrate). Lakes (Lake Mendota 2.2 mg NO_3/l; Linsley Pond, 2.6 mg NO_3/; Esthwaite 1.7 mg NO_3/l) seem to have intermediate values. The decline of nitrate and other forms of nitrogen during the summer, when productivity is high, is well established for a number of water bodies. However, until the nitrate concentrations reported can be confirmed, it is precarious to draw conclusions from this data.

Trace element concentrations in water samples from Indian Point have revealed no great surprises (Table II-2). Comparative data may be derived for fresh water of the Hudson watershed or Poughkeepsie on the one hand, or for diluted sea water on the other (Table II-5). At Indian

TABLE II-5

Selected Minor Constituents in Sea Water[1], N. American Fresh Water[2], Hudson Watershed[3] and Hudson River Water[4] (concentrations, mg/liter)

Element	Sea Water (Mean)	N. Amer. Water (Median)	Hudson Watershed (Del./Catskill) (Mean)	Hudson River at Indian Pt. (Annual Mean-1968)	Hudson River at Poughkeepsie (Mean for 1962-69)
Lithium	0.2	0.0011			
Boron	4.6	0.01	0.009		0.034*
Fluoride	1.3		0.86		
Magnesium	1350		1.8		
Aluminum	0.01	0.238	0.02		0.032*
Silicon	3		0.46		
Phosphorus	0.07		0.062	0.118	0.023*
Calcium	400		7.3		
Titanium	0.001	0.0086			
Vanadium	0.002	0			
Chromium	0.00005	0.0058	0		0.0070
Manganese	0.002	0.02	0.05	0.003	0.0026
Iron	0.01	0.3	0.05	0.012	0.044
Cobalt	0.0005	0		0.0011	
Nickel	0.002	0.01		0.0021	0.0056
Copper	0.003	0.0053	0.07	0.0041	0.025
Zinc	0.01	0	0.01	0.013	0.043
Arsenic	0.003		0.0008		0.032
Selenium	0.004		0.002		
Rubidium	0.12	0.0015			
Strontium	8	0.06			
Molybdenum	0.01	0.00035			0.009
Silver	0.0003	0.00009	0.0003		0.00064
Cadmium	0.00011		0	0.0011	0.0068
Iodine	0.06		0.003		
Barium	0.03	0.045	0.12		0.026
Lead	0.0001	0.004	0	0.019	0.014

References:
1. E. D. Goldberg, 1961
2. W. H. Durum and J. Hafety, 1963
3. New York City, Water Department, 1967
4. Our data for Indian Point, F.W.P.C.A. data for Poughkeepsie.

* Data from U.S.P.H.S. Oct. 1962 - Sep. 1964 onl

Point, manganese (range <0.5 to 12, mean 3 μg/liter) is similar to the concentration reported at Poughkeepsie, and higher than in sea water where manganese compounds are less soluble. Iron (range 2.7 to 50, mean 12 μg/liter) is an element which has been demonstrated to control phytoplankton productivity in some fresh water environments. The concentrations reported for Indian Point samples are lower than those for Poughkeepsie, or watershed water, and may reflect the influence of sea water intrusion, which, as for manganese, would limit its solubility and promote sequestration on to the sediments. Concentrations of cobalt, nickel and copper are all low (means, 1-4 μg/liter) and it is not known how these might be of significance in this environment. The concentration of cadmium (range < 0.6 to 1.8, mean 1.1 μg/liter) is higher than that reported for either fresh waters or sea water and confirms earlier reports (by this laboratory) for higher cadmium values in water samples taken near Yonkers. This suggests an industrial source of the element (perhaps intermittent). Similarly lead concentration (range 5 to 63, mean 1.9 ug/liter) is high, as it is in Poughkeepsie samples, and suggests that there may be an industrial source of this element. Both cadmium and lead are toxic to many forms, at varying levels of concentration. While lead may not be readily available for absorption, cadmium, as an analog of zinc, is accumulated notably by oysters and other lamellibranchs, with the possibility that a food-chain concentrating effect could be of significance in the environment. The involuntary accumulation of cadmium by lamellibranch filter feeders could lead to the build-up of toxic concentrations in these animals, with subsequent depletion of the species.

III ZOOPLANKTON COLLECTIONS

Zooplankton was sampled at 3 stations (east, mid- and west channel) at Indian Point on the Hudson River during 1968, from March until December. Samples from east and west shore stations were occasionally studied, as well as at shore stations along an 80 mile extent of the west bank in June - August. The groups most intensively studied and most commonly seen were the protozoa, rotifers, crustaceans and molluscs, although representatives of other groups are also recorded. Records of the monthly sampling are given in Appendix III-1 and Appendix III-2.

Protozoa are undoubtedly an important group in the economy of the river since they are often voracious bacterial and algal feeders. However, real difficulties exist in identification of species and quantification of common soft bodied members of the group is as yet almost impossible. Other than numerous Ceratium in May large numbers of any species were not seen until June, when the shelled amoebas Difflugia and Arcella were numerous at some sites, together with ciliates Colpoda, Glaucoma and Vorticella in shore and channel collections. The presence of ciliates in samples persisted through October. In September, however, the diversity and number of ciliate species in shore samples increased, with 13 species of ciliates, flagellates and amoebas identified in this month.

Rotifers are an abundant component of the zooplankton at Indian Point, and may be important in the ecosystem as croppers of bacteria, protozoa and phytoplankton. At least 12 species have been identified at Indian Point in 1968. Most of these species were present in April, 1968 when the rotifer population seems to be at its most abundant and most diverse. In April, 1968, the number of rotifers was approximately 1500 organisms/liter, principally as a bloom of Notholca, with Trichocerca, Philodina and Keratella cochlearis contributing significantly. However, throughout the year Keratella cochlearis and K. quadrata appeared the most consistently present of all species. In the spring of 1969 (March) collections at Indian Point and Cornwall were also dominated by a bloom of Asplanchna, (instead of Notholca) suggesting that the spring abundance of rotifers is characteristic, even though the species composition may not always be identical.

Coelenterates in the samples are generally sporadic, both in species and in occurrence. Hydra oligactis is probably fairly common in appropriate ecological niches in the limnetic zone, and appeared in some numbers in the July sample at Indian Point. In September, 1968, the brackish water hydroid, Cordylophora, was recorded, and a marine immigrant from coastal waters, the medusa Blackfordia, was quite common. The presence of medusae coincided with the maximum salinity recorded at Indian Point in 1968. In earlier years, other species of hydroid medusae have been seen, notably Nemopsis, and it seems that sporadic immigration into the Hudson estuary may occur at times when they are common in coastal waters, and at a time when the saline intrusion into the estuary is maximal.

Unidentified nematode worms are often present in Hudson River samples and may be found sporadically in appreciable numbers. It is not known if this kind of fluctuation is an indication of the degree of organic pollution. They appear more common in samples from the shore stations than in those from the channel stations.

The microcrustaceans are the most consistently predominant group in the zooplankton, and are undoubtedly of great importance in the ecosystem both as grazers of phytoplankton and as food for fish. Figures III-1 to III-4 illustrate the seasonal changes observed. The group is characterized by a diversity of copepods: cyclopoid, harpacticoid, and calanoid forms. A number of species appear to be ubiquitous in the river for many miles, with a wide range of salinity, and hence are seen through the year at Indian Point, even though salinity is seasonally variable there. However, there are changes in the relative

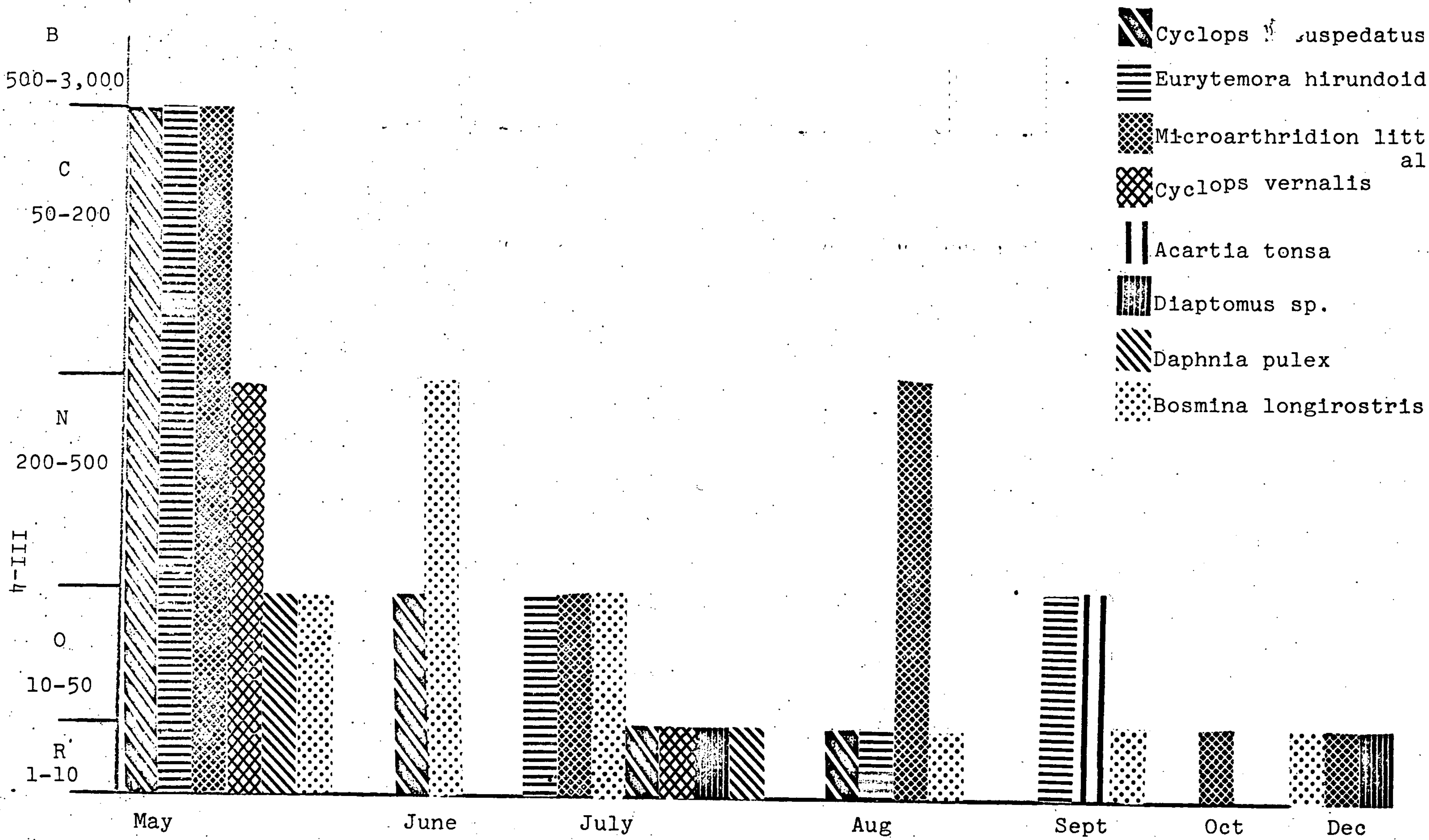
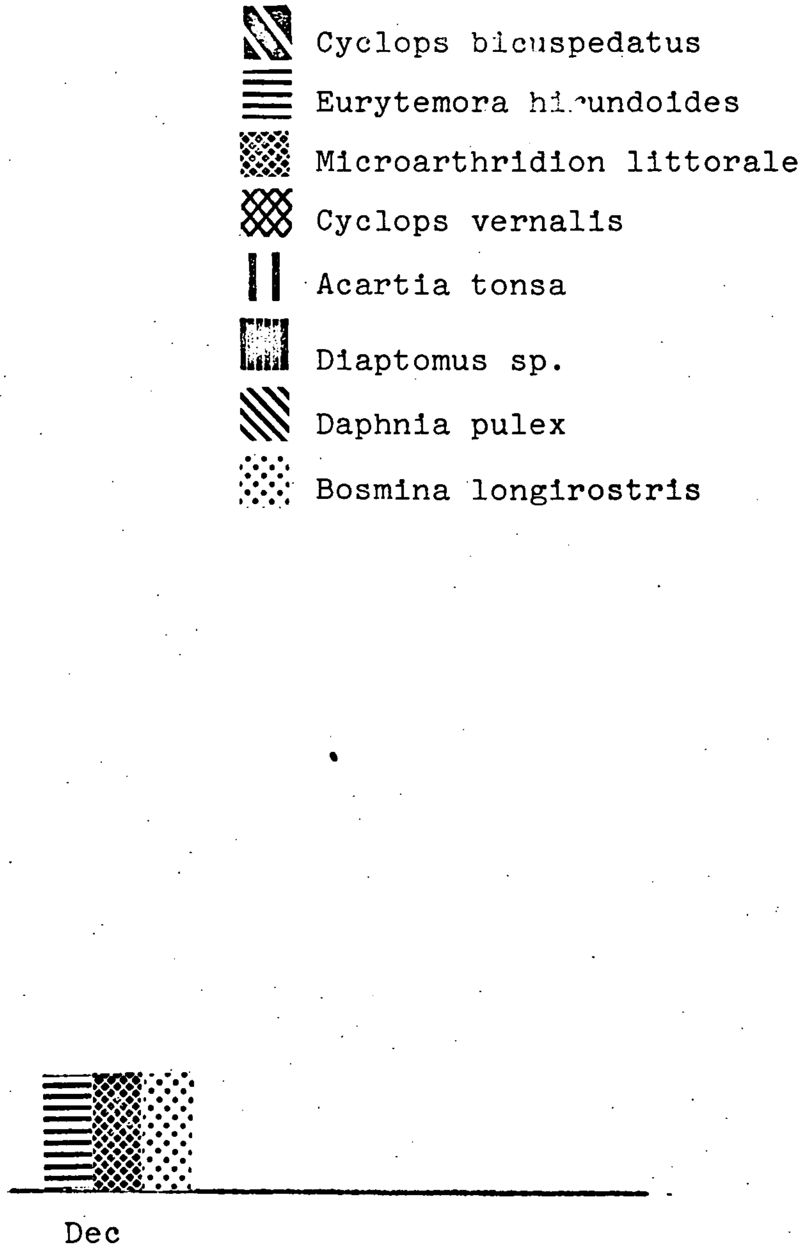
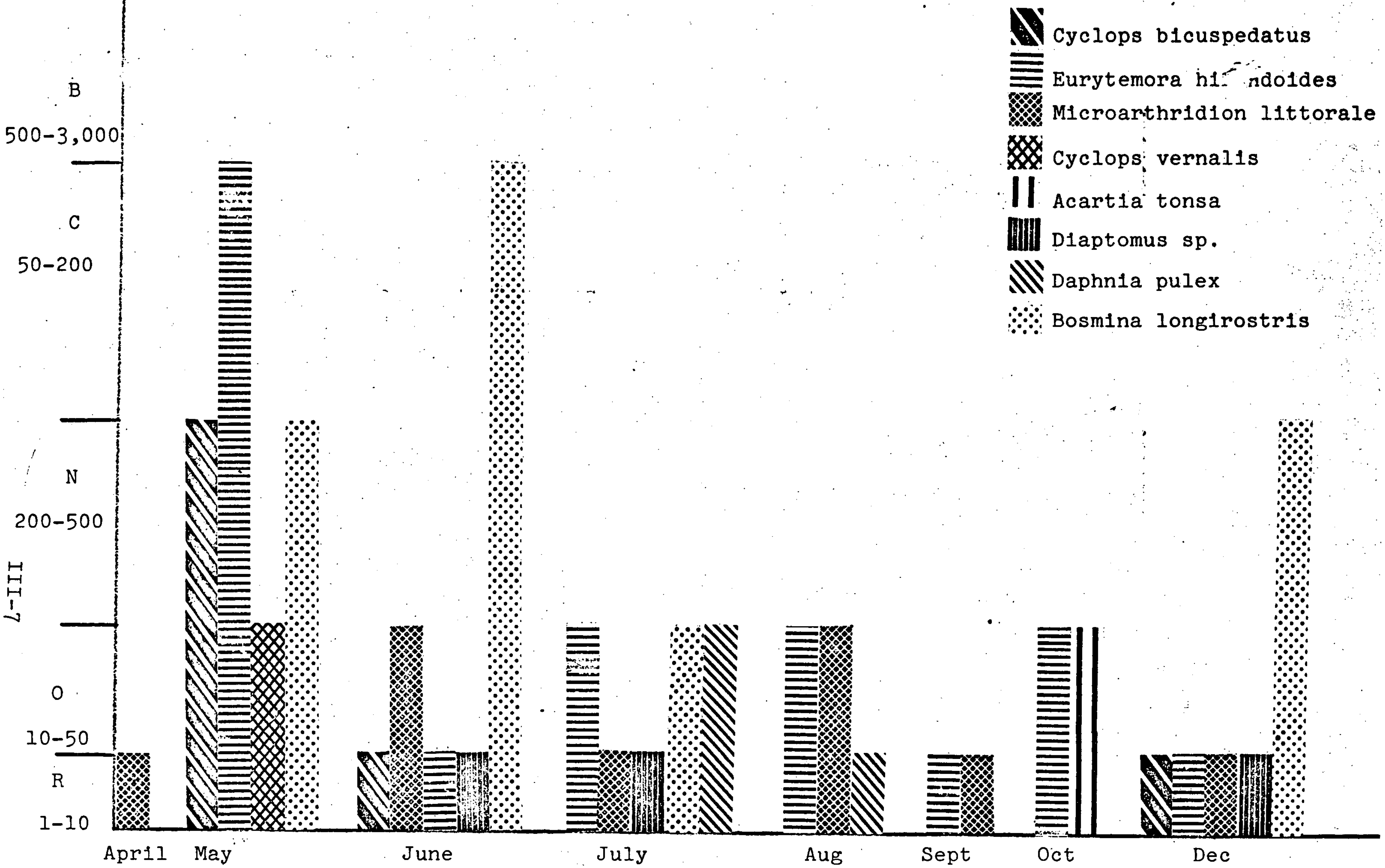


Figure III-1 Indian Point 1968 West Side station. Relative abundance of microcrustaceans in plankton tows.

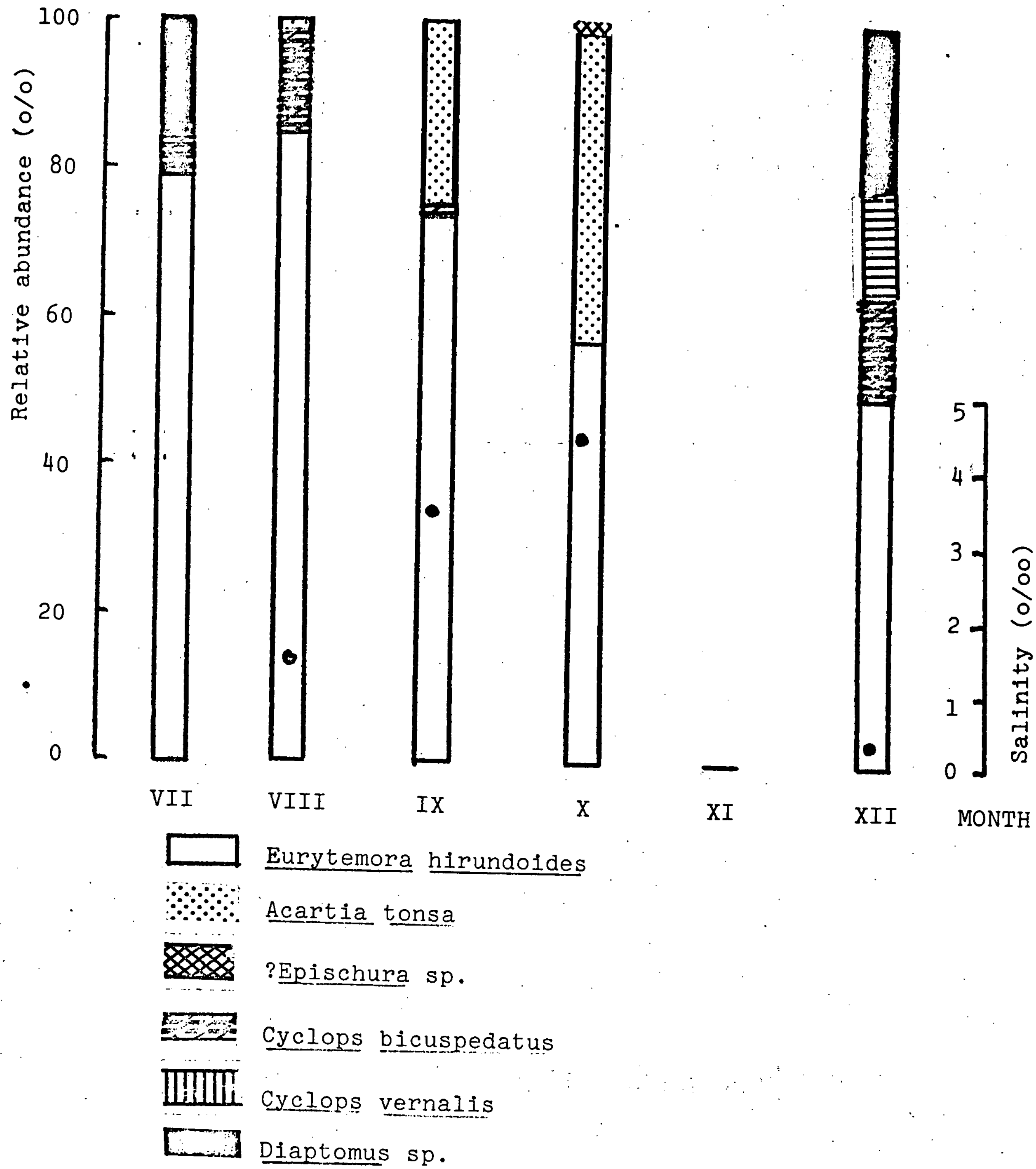
Figure III-2 Indian Point, 1968 Midchannel Station. Relative abundance of microcrustaceans in plankton tows.


Cyclops bicuspedatus
Eurytemora hirundoides
Microarthridion littorale
Cyclops vernalis
Acartia tonsa
Diaptomus sp.
Daphnia pulex
Bosmina longirostris
Dec



Fiugre III-3 Indian Point 1968 East Side station. Relative abundance of microcrustaceans in plankton tows.

Figure III-4 Seasonal changes in copepod species at Indian Point, 1968. Mid channel samples.



abundance of the different species. Through the greater part of 1968, Eurytemora hirundoides (= E. affinis?) has been the dominant copepod, with Acartia tonsa replacing it as the salinity builds up during the late summer. This latter species was also seen in the early spring, before the main spring run-off from the watershed diluted the water at Indian Point. Another species, Epischura sp., also appeared as an indicator of rising salinity, only in October. When the salinity declined in December, so that the water at Indian Point was almost "fresh", species more typical of fresh waters appeared, viz. Diaptomus spp. and Cyclops spp. (Appendix III-3, and Figure III-4).

The abundance of copepods was estimated only for the months July to December. The maximum numbers (of adult forms) were seen in October with approximately 300 organisms/cubic meter of river water. Hence the "standing crop" of these intermediates in the food web is much smaller than that of the phytoplankton on which they feed (see Section IV).

Surprising differences in abundance and variety of the collections were seen in the different mid-channel stations. (Figures III-5 and III-6; Appendices III-2 and III-3). The reasons for the paucity of species and numbers of individuals in occasional samples from the west channel

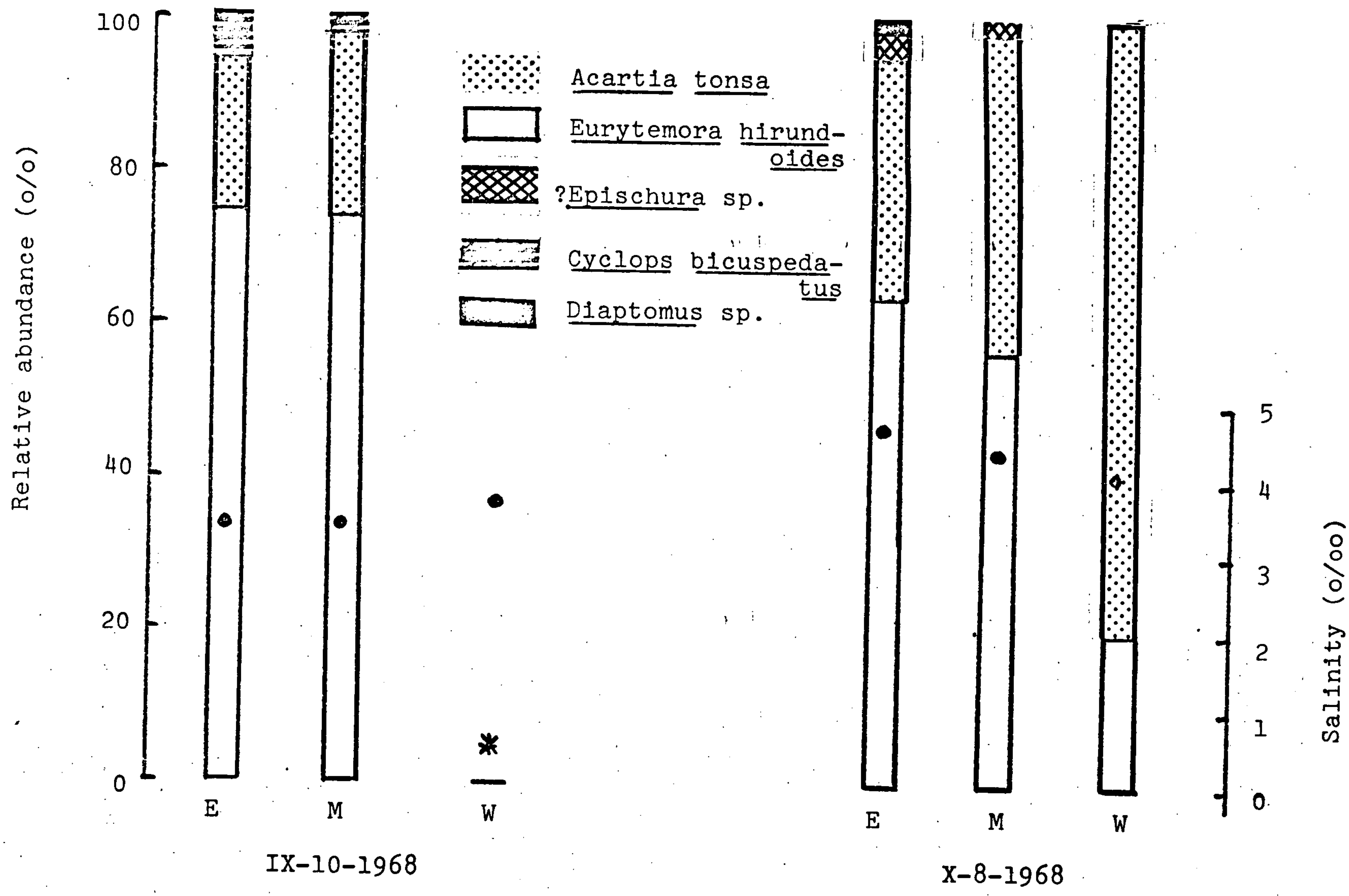
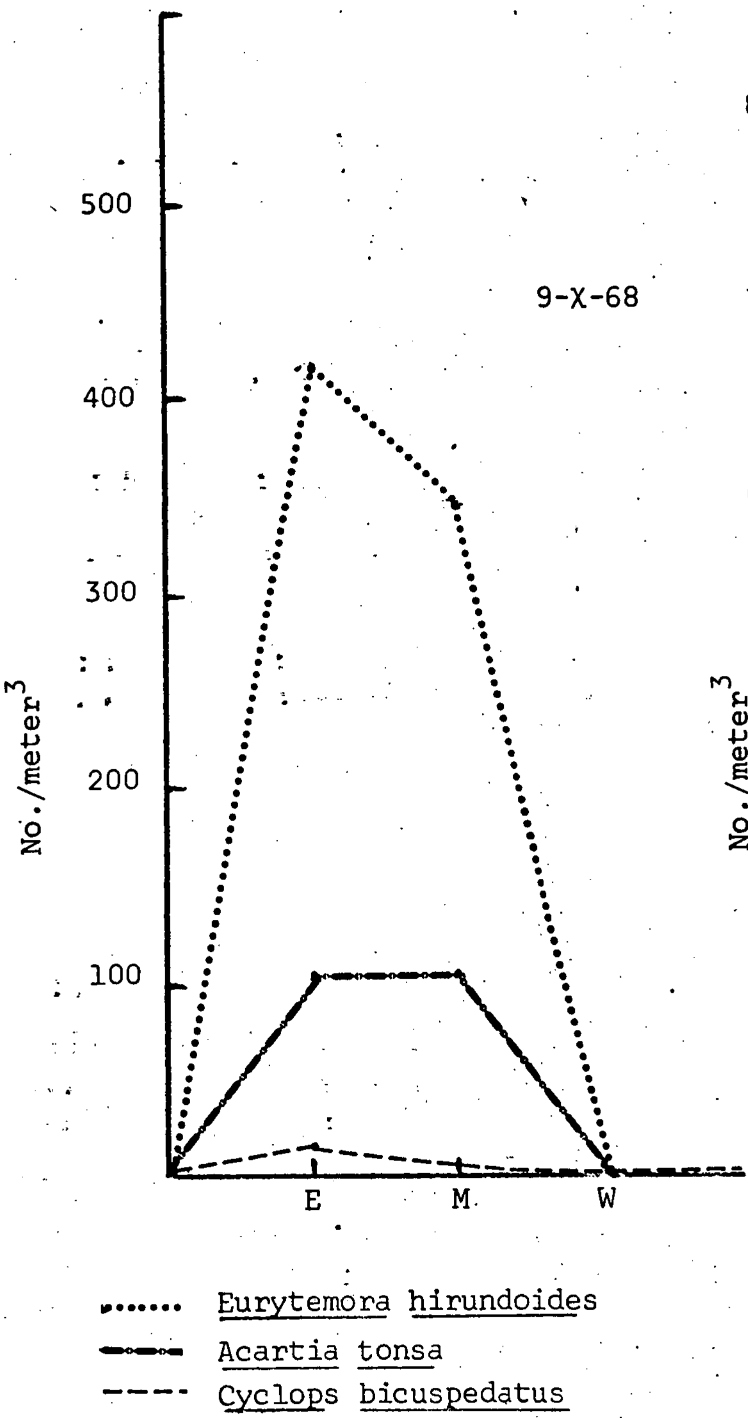


Figure III-5 Percentage composition of adult copepods. Salinity (●)
*Only one specimen of Acartia found in 31 ml sample.



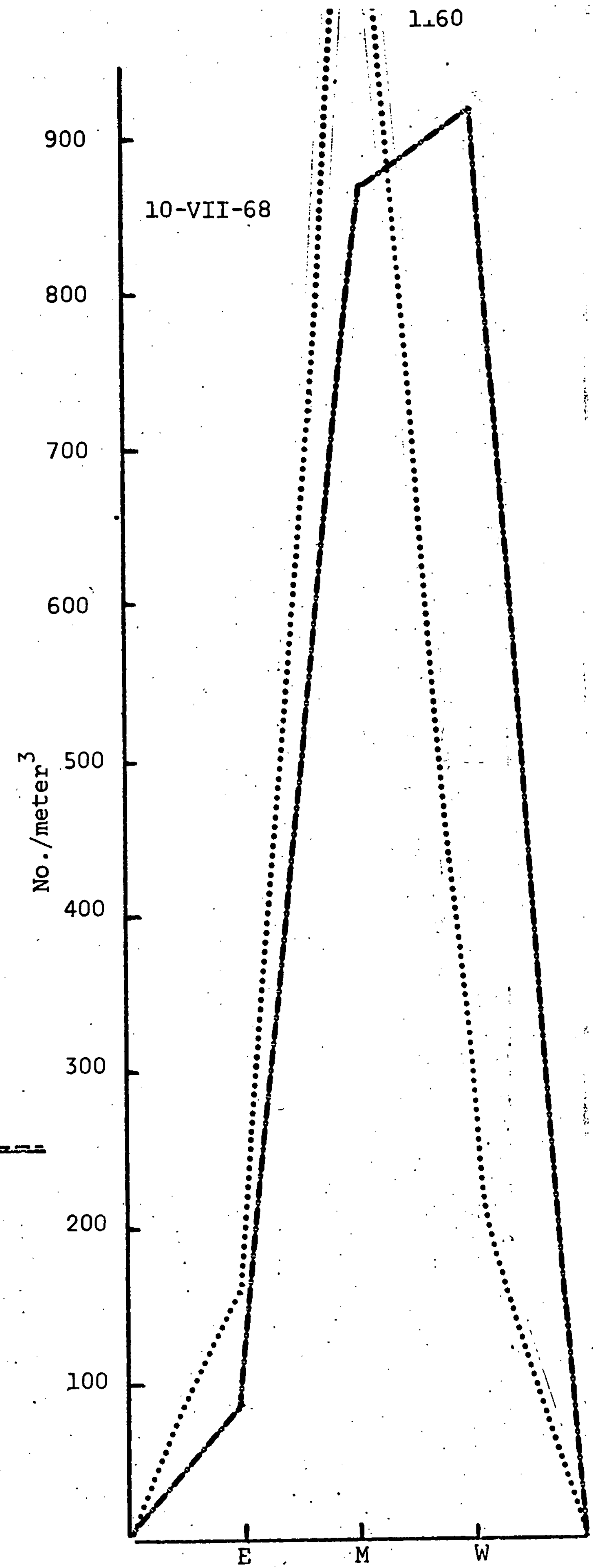


FIG. III-6 Comparison of adult copepods at different channel stations station is not known. Some attempt to consider tidal and diurnal variations in the zooplankton at this station, and at another, mid-channel, are planned for the summer of 1969.

The Cladocera, specifically Bosmina and Daphnia, are also important microcrustacea at Indian Point, and over a large extent of the river. However, the "standing crop" is consistently considerably less than that for the copepods. Their peak during the year appears in June and July and then they diminished in numbers until they were only recorded as "rare" during August to October while salinity was increasing. They reappeared in reasonable numbers and in good condition in December (Figures III-1 to III-3). The bizarre Leptodora is an occasional cladoceran species at Indian Point, but is not seen as commonly here as at Cornwall, further north. Although present in June, it was not seen during the brackish phase of the year at Indian Point, indicating that its southerly extension might be limited by salinity. However, in the summer of 1967 it was recorded at Inwood.

The amphipod, Gammarus (and the rarer Monoculoides) are other important members of the crustaceans which are significant as fish food, but little is known about their seasonal abundance. The gammarids seem most common in the summer months, June to August, and disappear in September to reappear in December in small numbers.

Insect larvae, especially <u>Chaoborus</u>, <u>Pentaneura</u> and other chironomid larvae were fairly commonly seen in the summer and autumn months.

The zooplankton analysis shows a succession of dominant groups as the year progressed. Superimposed on this seasonal change is a change in species composition which seems related to the summer salinity change. The principal phyto- and zooplankton organisms seen through the year are summarized in Table III-1.

Table III-1 Dominant organisms in plankton. Hudson River at Indian Point, 1968.

(Bracketed forms were barely dominant)

Time	West	Mid-	East	Taxonomic Group
March			Epistylis	PROTOZOA
			Nauplii	CRUSTACEA
April	Melosira Ulothrix	Melosira	Navicula	PHYTOPLANKTON
	Colorless flagellates Ciliates (varied spp.)	Vorticellids		PROTOZOA
	Notholca	Notholca		ROTIFERS
May	Melosira	Melosira	Melosira Ceratium	PHYTOPLANKTON
	Microarthidion Cyclops vernalis C. bicuspedatus Nauplii	C. bicuspedatus Nauplii	C. vernalis C. bicuspedatus Nauplii	CRUSTACEA
June	Melosira Anabaena	Melosira Anabaena	Melosira	PHYTOPLANKTON
	Difflugia		Difflugia Arcella Ciliates (varied spp.) Vorticellids	PROTOZOA
	Bosmina Nauplii	Bosmina Nauplii	Bosmina Nauplii	CRUSTACEA
July	Melosira	Melosira	Melosira	PHYTOPLANKTON
		NO DOMINANT ZOOPLANKTER		

Table III-1 (con't)

Time	West	Mid-	East	Taxonomic Group
August	(Nitzchia)	Thallassiothrix Coscinodiscus	Thallassiothrix Cocconeis	PHYTOPLANKTON
	Arcella	Arcella Difflugia Ciliates (varied spp.)	Arcella Difflugia Colorless flagellates	PROTOZOA
	Eurytemora	Eurytemora	Eurytemora	CRUSTACEA
September	Melosira	(Melosira)	Pleurosigma Nitzschia	PHYTOPLANKTON
	Arcella Difflugia	Arcella Difflugia	Arcella Difflugia Vorticellids Ciliates	PROTOZOA
	Nauplii	Nauplii	Nauplii	CRUSTACEA
	NO DOMINANT ZOOPLANKTER			
October	Thallassiothrix Pleurosigma Coscinodiscus	Thallassiothrix Chaetoceros Characium	Thallassiothrix Pleurosigma Nitzschia	PHYTOPLANKTON
	Arcella Difflugia	Difflugia	Arcella Difflugia	PROTOZOA
	Eurytemora Nauplii	Eurytemora Nauplii	Eurytemora Nauplii	CRUSTACEA

Table III-1 (con't)

Time	West	Mid-	East	Taxonomic Group
December	Melosira	Melosira	Melosira	PHYTOPLANKTON
	Amnicola			MOLLUSC
	NO DOMINANT ZOOPLANKTER			

APPENDIX III-1 Occurrence of species in zooplankton collections.

EVT	=	East channel station, vertical tow
WVT	=	West channel station, vertical tow
MVT	=	Mid-channel station, vertical tow
E Sh.	=	East shore station
W Sh.	=	West shore station
E→ W	=	Horizontal tow, from east to west.

MARCH 1968

X = Present
N = Numerous

	EVT	MVT	ESH
Protozoa			
Ciliata			
Epistylis	X		
Rotifera			
Asplanchnids	N		
Philodina			X
Arthropoda			
Copepoda			
Harpactacoid		X	
Calanoid	X	X	
Cyclopoid		X	
Nauplii	X		
Metanauplii	X		
Isopoda		X	
Amphipoda			
Gammarus fasciatus		X	

APRIL 1969

X = Present
N = Numerous

	WVT	MVT	E→W
Protozoa			
Flagellata			
Astasiid	X		
Ciliata			
Coleps	X		
Frontonia	X		
Hypotrichs	X		
Vorticellids		X	
Nematoda	N		
Rotifera		X	
Philodina	N	X	
Keratella	N	X	
Hydatina	X		
Rotaria	X		
Trichocerca		N	X
Tardigrada	X		
Arthropoda			
Cladocera			
Daphnia		X	X
Bosmina		X	
Cyclops		X	
Ostracoda	X		
Copepoda	X	N	N
Nauplii	X	N	
Calanoid		X	X
Cyclopoid		X	X
Harpactacoid		N	X
Amphipoda			
Gammarus fasciatus	X		

May 1968

	MVT	ESH	WSH
Protozoa			
Flagellata			
Ceratium	X	X	
Ciliata			
Stentor		X	
Rotifera			
Keratella quadrata	X		X
Crustacea			
Bosmina	X		
Daphnia pulex	X		
Cyclopoid copepod	X		
Nauplii, copepod	X		X

JUNE 1968

X = Present
N = Numerous

	EVT	WVT	MVT	WSH	E→W
Protozoa					
Sarcodina					
Arcella	X				
Difflugia	X	N			
Ciliata					
Colpidium					X
Colpoda				N	
Stentor	X				
Tetrahymenid	X				
Vorticella	X			N	
Nematoda	X				
Rotifera					
Kellicottia			X		
Keratella cochlearis	X				X
Keratella quadrata	X	X	X	X	X
Trichocerca			X	X	
Arthropoda					
Cladocera					
Bosmina	N	N	N		N
Daphnia	N				
Copepoda					
Metanauplii			X		
Nauplii			X		X
Calanoid	X				N
Harpactacoid				X	
Amphipoda					
Gammarus fasciatus			N		
Insecta					
Chaoborus	X				

JULY 1968

X = Present
N = Numerous

	EVT	WVT	MVT	E.Sh.	W.Sh.	E⟶W
Protozoa						
Sarcodina						
Arcella				X		X
Difflugia				X		X
Ameba proteus				X	X	
Ciliata						
Tetrahymena					X	
Colpoda					N	
Stylonychia					X	
Coelenterata						
Hydra oligactis	X			X		
Platyhelminthes						
Rhabdocoel			X	X		
Rotifera						
Brachionus				X		
Kellicottia						X
Keratella cochlearis	X	X	X	X		X
Keratella quadrata		X			X	
Trichocerca		X			X	X
Gastrotricha	X					
Arthropoda						
Cladocera						
Leptodora kindti				X		
Bosmina longirostris		N	N	N	X	N
Daphnia		N		N		X
Ostracoda						
Cypris	X	X		X		
Copepoda					X	
Nauplius		X		X	X	X
Calanoid		X	N	N		X
Cyclopoid	X	N	X			X
Harpacticoid				X	X	X
Amphipoda						
Gammarus fasciatus	X		N	X		
Insecta						
Chaoborus	X		X			
Mollusca						
Gasteropoda						
Snail	X	X	X			

AUGUST 1968

	EVT	WVT	MVT	E.SH.	W.SH.	E→W
Protozoa						
Flagellata						
Bodo	X			X		
Sarcodina						
Arcella	X	X	X		X	
Difflugia	X		X	X		X
Ciliata						
Colpidium				X		
Lionotus			X			
Urostyla				X		
Platyhelminthes						
Planaria	X					
Rhabdocoel			X			
Nematoda				X	X	
Rotifera						
Keratella cochlearis						X
Keratella quadrata	X	X	X	X		X
Gastrotricha	N					
Annelida						
Oligochaeta						
Tubifex				X	X	
Arthropoda						
Cladocera						
Bosmina longirostris			X		X	X
Daphnia	X	X	X	X		
Malacostraca						
Crago			X			
Ostracoda						
Cypris			X			
Copepoda						
Nauplius	X	N	X	X	X	N
Calanoid	X		N			
Cyclopoid	N	N	N	X	X	N
Harpactacoid	X	X	X		X	X
Amphipoda						
Gammarus fasciatus	X	X	X			
Insecta						
Chaoborus			X			
Mollusca						
Gasteropoda						
Snail	N		N		X	X
Pelecypoda						
Pisidium	X					

SEPTEMBER 1968

	EVT	WVT	MVT	E.SH.	W.SH.	E→W
Protozoa						
Flagellata						
Bodo				X	X	
Sarcodina						
Arcella	X	X	X			X
Difflugia	X	X	X		X	X
Ciliata						
Coleps				X	X	
Colpidium					X	
Euplotes					X	
Frontonia	X					
Lionotus					X	
Oxytricha					X	
Paramecium	X					
Stylonychia				X	X	
Tetrahymena				X		
Zoothamnium	N			X		
Coelenterata						
Cordylophora			X			
Blackfordia			X			
Platyhelminthes						
Rhabdocoel	X		X	X	X	
Nematoda	X					
Rotifera	X				X	
Brachionus	X		X			
Trichocerca					X	
Annelida			X		X	X
Arthropoda						
Cladocera						
Bosmina longirostris		N	X			
Ephippium		X				X
Cirripedia						
Barnacle	X		X			
Malacostraca						
Mysis			X			
Copepoda						
Nauplius	X	X	X		X	N
Calanoid	X	X	X			X
Cyclopoid	X	X	N			X
Harpacticoid	X	X	X	X	X	X
Amphipoda						
Gammarus fasciatus	X	X	X			
Insecta						
Chaoborus	X					
Insect larva			X			
Mollusca						
Gasteropoda						
Snail	X	X	X			X
Mya	X		X			X
Clam larvae	X	X	X			

OCTOBER 1968

	EVT	WVT	MVT	E.SH.	W.Sh.
Protozoa					
Sarcodina					
Arcella	X	X			X
Difflugia	X	X	X		X
Ciliata					
Euplotes					X
Frontonia					X
Prorodon discolor				X	
Stylonychia					X
Nematoda					X
Rotifera	X				
Gastrotricha	X	X	X		
Annelida				X	X
Arthropoda					
Malacostraca					
Crago	X				
Mysis	X		X		
Copepoda					
Nauplius	X	X	X		X
Calanoid	X	X	N		
Cyclopoid	X		N		
Harpacticoid			N	X	X
Amphipoda					
Gammarus fasciatus	X	X	X		X
Insecta					
Insect larva					N
Zygoptera					X
Mollusca					
Snail	N				
Clam larvae		X	X		

DECEMBER 1968

	EVT	WVT	MVT	E.SH.	W.SH.
Protozoa					
Sarcodina					
Actinocoma	X				
Difflugia				X	
Ciliata					
Coleps				X	X
Rotifera					
Keratella cochlearis	X				
Philodina	X				
Arthropoda					
Cladocera					
Bosmina longirostris				X	
Copepoda					
Nauplius	X				
Calanoid	X		X	X	
Harpacticoid	X	X		X	
Insecta					
Diptera					X
Mollusca					
Gasteropoda					
Physa			X		

Appendix III-2 Zooplankton Collections, Hudson River at Indian Point, 1968
Vertical Tows. Semi quantitative analysis.

Notes:
B = "bloom" = 400-3000 organisms/liter
N = numerous = 200-400/liter
C = common = 50-190/liter
O = occasional = 10-49/liter
R = rare = 1-9/liter

Sampling Data	Sampling Station East Side		Mid Channel		West Side
March 6, 1968 (Con-Ed dock)	Microarthridion littorale	R	No sample		No sample
	Nauplius larvae (copepoda)	O			
	Congeria				
April 3, 1968	Nothing in sample		Nematoda	O	Nematodes
			Kellicottia	R	Notholca sp.
			Notholca	B	Keratella cochlearis
			Keratella cochlearis	R	
			Keratella quadrata	R	
			Annelid larvae	R	
			Daphnia pulex	R	
			Bosmina longirostris	R	
			Nauplius larvae	R	
			Cyclops bicuspidatus	R	
May 14, 1968	Keratella quadrata	C	Keratella quadrata	R	Notholca
	Notholca sp.	R	Bosmina longirostris	R	Keratella quadrata
	Daphnia pulex	O	Gammarus fasciatus	R	Keratella cochlearis
	Bosmina longirostris	C	Monoculoides edwardsi	R	Monoculoides edwardsi
	Gammarus fasciatus	R	Nauplius larvae	O	Nauplius larvae
	Cyclops bicuspidatus	B	Ectinosoma curticorne	R	Ectinosoma curticorne
	Cyclops vernalis	N	Microarthridion littorale	O	Microarthridion littora
	Nauplius larvae (copepoda)	N	Diaptomus sanguineus	R	Cyclops vernalis
	Canuella elongata	C	Eurytemora hirundoides	R	Eurytemora hirundoides
	Eurytemora hirundoides	B	Cyclops bicuspedatus	C	Laophonte sp.
	Ectinosoma curticorne	R	Acartia tonsa	R	
	Laophonte sp.	O			

June 5, 1968	Nauplius larvae (copepoda)	O	Keratella cochlearis	R	Filinia sp.	R
	Bosmina longirostris	O	Keratella quadrata	R	Keratella quadrata	R
	Cyclops bicuspidatus	R	Gammarus fasciatus	O	Nematoda larvae (copepoda)	N
			Bosmina longirostris	C	Bosmina longirostris	N
			Leptodora kindti	R	Eurytemora lacustris	R
			Ectinosoma curticorne	R	Cyclops bicuspidatus	R
			Microarthridion littorale	O		
			Eurytemora hirundoides copepodid V	O		
			Eurytemora lacustris	R		
			Cyclops bicuspidatus	O		
July 2, 1968	Keratella cochlearis	R	Nematoda	R	Hydra oligactis	R
	Bosmina longirostris	O	Keratella cochlearis	R	Keratella cochlearis	R
	Nauplius (copepoda)	C	Daphnia	O	Gammarus fasciatus	R
	Eurytemora hirundoides	O	Bosmina longirostris	R	Microarthridion littorale	O
	Cyclops bicuspidatus	O	Chiridotea caeca	R	Cyclops vernalis	O
			Microarthridion littorale	C	Eurytemora hirundoides	O
			Ectinosoma curticorne	R	Epischura lacustris	R
			Cyclops vernalis	O	Diatomus oregonensis	R
			Eurytemora hirundoides	C	Chaoborus larvae	O
			Chaborus larvae	R		
August 14, 1968	Keratella quadrata	R	Daphnia pulex	R	Daphnia pulex	R
	Nauplius larvae	O	Nauplius (copepoda)	C	Nauplius larvae (copepoda)	O
			Ectinosoma curticorne	R	Microarthridion littorale	C
			Microarthridion littorale	O	Eurytemora hirundoides	R
			Eurytemora hirundoides	N	Immature snail	R
			Cyclops bicuspidatus	O		
			Gammarus fasciatus	O		
			Immature snail	R		
Sept. 10, 1968	Nematoda	R	Nauplius larvae (copepoda)	C	Bosmina longirostris	R
	Nauplius larvae (copepoda)	O	Acartia tonsa	O	Nauplius larvae (copepoda)	O
	Ectinosoma curticorne	R	Eurytemora copepoda V	O	Eurytemora hirundoides	R
	Canuella elongata	R	Microarthridion littorale	O	Eurytemora copepodid V	O
	Microarthridion littorale	R	Immature snail	R		
	Eurytemora hirundoides	R				
	Eurytemora copepodid V	O				

Oct. 8, 1968	Annelid larvae	O	Annelid larvae	R	Annelid larvae	O
	Nauplius larvae	C	Nauplius larvae	O	Nauplius larvae	O
	Canuella elongata	R	Canuella elongata	R	Canuella elongata	R
	Acartia tonsa	O	Acartia tonsa	O	Acartia tonsa	O
	Eurytemora hirundoides	O	Eurytemora hirundoides	C	Eurytemora hirundoides	R
	Amnicola limosa	R	Ectinosoma curticorne	R	Microarthridion littorale	O
			Mysis	R		
Dec. 3, 1968	Nematodes	R	Nematodes	R	Nematodes	R
	Annelid larvae	R	Bosmina longirostris	R	Annelid larvae	R
	Seison (rotifer)	R	Nauplius larvae	R	Nauplius larvae	R
	Nauplius larvae	R	Ectinosoma curticorne	R	Bosmina longirostris	R
	Bosmina longirostris	C	Harpacticoid (white)	R	Monoculoides edwardsi	R
	Monoculoides edwardsi	R	Microarthridion littorale	R	Microarthridion littorale	R
	Gammarus fasciatus	R	Eurytemora hirundoides	R	Canuella elongata	R
	Microarthridion littorale	R			Ectinosoma curticorne	R
	Ectinosoma curticorne	R			Eurytemora lirundoides	R
	Canuella elongata	R			Cyclops bicuspedatus	R
	Eurytemora lirundoides	R			Diaptomus sp.	R
	Cyclops bicuspedatus	R			Pentaneura monalis	O
	Diaptomus sp.	R			Amnicola limosa	C
	Pentaneura monalis	R				

APPENDIX III-3 Quantitative analysis of Copepods
July - December 1968

Date: 7/16/1968 Indian Point Depth: 40 Feet

Mid Channel Vertical Tow

Adult Copepods in 33.6 ml				Adult Copepods per ml*		Adult Copepods per liter**		Percent	
Eurytemora hirundoides	♀	101	197	3.00	5.86	0.818	1.597	40.2	78.4
	♂	96		2.86		0.779		38.3	
Cyclops vernalis	♀	7	41	0.21	1.22	0.057	0.332	2.7	16.3
	♂	34		1.01		0.275		13.5	
Cyclops bicuspidatus	♀	8	13	0.24	0.39	0.065	0.106	3.2	5.2
	♂	5		0.15		0.041		2.0	
TOTAL			251		7.47		2.036	99.9	99.9

Few young cyclops and few harpacticoids. Bosmina very numerous.

Date: 8/14/1968 — Indian Point, Mid Channel — Depth: 45 Feet, Vertical Tow

Adult Copepods in 16.6 ml	Sex	Count	Total	Adult Copepods per ml*	Total	Adult Copepods per liter**	Total	Percent	Total
Eurytemora hirundoides	♀	93	231	5.60	13.91	1.356	3.369	34.4	85.5
	♂	138		8.31		2.012		51.1	
Cyclops bicuspidatus	♀	21	37	1.26	2.23	0.305	0.538	7.7	13.7
	♂	16		0.96		0.233		5.9	
Acartia sp.	♀	2	2	0.12	0.12	0.029	0.029	0.7	0.7
	♂	0		0.00		0.000		0.0	
TOTAL			270		16.26		3.938	99.8	99.9

Harpacticoids have been found in large numbers. Bosmina was very scarce.

Date: 9/10/68 | Indian Point | Depth: 30 Feet

East Side Channel | Vertical Tow

Adult Copepods in 48.0 ml				Adult Copepods per ml*		Adult Copepods per liter**		Percent	
Eurytemora hirundoides	♀	38	70	0.79	1.46	0.287	0.530	40.3	74.5
	♂	32		0.67		0.243		34.0	
Cyclops bicuspidatus	♀	3	5	0.06	0.10	0.022	0.036	3.0	5.0
	♂	2		0.04		0.015		2.0	
Acartia sp.	♀	5	19	0.10	0.39	0.036	0.142	5.0	19.9
	♂	14		0.29		0.105		14.7	
TOTAL			94		1.96		0.712	99.0	99.4

Most of the *Eurytemora* with egg-sac.

One specimen belonging to the family Macrothricidae (Cladocera) has been found.

Date: 9/10/68 Indian Point Depth: 50 Feet

Mid Channel Vertical Tow

Adult Copepods in 47.6 ml				Adult Copepods per ml*		Adult Copepods per liter**		Percent	
Eurytemora hirundoides	♀	34	96	0.71	2.02	0.155	0.440	26.1	74.5
	♂	62		1.30		0.283		47.9	
Cyclops bicuspidatus	♀	1	1	0.02	0.02	0.004	0.004	0.6	0.6
	♂	0		0.00		0.000		0.0	
Acartia sp.	♀	20	32	0.42	0.67	0.092	0.146	15.3	24.6
	♂	12		0.25		0.055		9.1	
TOTAL			129		2.71		0.591	99.0	99.7

Sample very poor. Few young cyclopoids and few harpacticoids have been found. Many specimens of Eurytemora with egg-sac.

Few specimens belonging to the Sididae family have been found (Diaphanosoma?).

Date: 9/10/1968 Indian Point Depth: 18 Feet

West Side Channel Vertical Tow

Adult Copepods in 31.0 ml				Adult Copepods per ml*		Adult Copepods per liter**		Percent
Acartia sp.	♀	1		0.03		0.018		
			1		0.03		0.018	
	♂	0		0.00		0.000		
TOTAL			1		0.03		0.018	

Few nauplliae and few young copepodites. Barnacle nauplliae have been found.

Date: 10/8/1968 Indian Point Depth: 32 Feet

West Shore - West Side Channel Vertical Tow

Adult Copepods in 29.8 ml				Adult Copepods per ml*		Adult Copepods per liter**		Percent	
Eurytemora hirundoides	♀	14	26	0.47	0.87	0.160	0.296	10.8	20.1
	♂	12		0.40		0.136		9.2	
Acartia sp.	♀	81	103	2.72	3.46	0.926	1.178	62.8	79.9
	♂	22		0.74		0.252		17.0	
TOTAL			129		4.33		1.475	99.8	100.0

Spionid larvae were present in the sample. A Chironomidae larvae was found in the subsampling.

* per ml of net sample

**per liter of river water

Date: 10/8/1968 Indian Point Depth: 75 Feet

Mid Channel Vertical Tow

Adult Copepods in 22.6 ml				Adult Copepods per ml*		Adult Copepods per liter**		Percent	
Eurytemora hirundoides	♀	111	230	4.91	10.18	0.713	1.479	27.3	56.7
	♂	119		5.26		0.764		29.3	
Acartia sp.	♀	125	172	5.53	7.61	0.804	1.106	30.8	42.3
	♂	47		2.08		0.302		11.6	
Oithona sp.?	♀	3	3	0.13	0.13	0.019	0.019	0.7	0.7
	♂	0		0.00		0.000		0.0	
Epischura sp.	♀	1	1	0.04	0.04	0.006	0.006	0.2	0.2
	♂	0		0.00		0.000		0.0	
TOTAL			406		17.96		2.610	99.9	99.9

First sample almost without detritus. Barnacle naupliae and spionid larvae were present. Copepod population looks well established. Almost all copepods with egg-sac.

Date: 12/3/1968 | Indian Point | Depth: 52 Feet
Mid Channel | Vertical Tow

Adult Copepods in 53.2 ml				Adult Copepods per ml*		Adult Copepods per liter**		Percent	
Eurytemora hirundoides	♀	8	14	0.15	0.26	0.031	0.054	27.6	48.3
	♂	6		0.11		0.023		20.7	
Cyclops vernalis	♀	3	4	0.06	0.07	0.013	0.015	10.3	12.6
	♂	1		0.02		0.004		3.4	
Cyclops bicuspidatus	♀	2	4	0.04	0.07	0.008	0.015	6.9	12.6
	♂	2		0.04		0.008		6.9	
Diaptomus sp.	♀	3	6	0.06	0.11	0.002	0.023	10.3	20.7
	♂	3		0.06		0.002		10.3	
TOTAL			28		0.53		0.111	96.4	94.2

Few harpacticoids and cyclopoid copepods (copepodite stages) were found. Bosmina has been found for the first time in good shape and the specimens were very large.

In this sample two different species of Daphnia were found.

Date: 10/8/68 Indian Point Depth: 75 Feet

East Shore - East Side Channel Vertical Tow

Adult Copepods in 46.6 ml				Adult Copepods per ml*		Adult Copepods per liter**		Percent	
Eurytemora hirundoides	♀	51		1.09		0.158		45.7	
			70		1.50		0.218		63.1
	♂	19		0.41		0.060		17.0	
Acartia sp.	♀	22		0.47		0.068		19.5	
			36		0.77		0.112		32.1
	♂	14		0.30		0.044		12.5	
Oithona sp.?	♀	3		0.06		0.008		2.2	
			3		0.06		0.008		2.2
	♂	0		0.00		0.000		0.0	
Cyclops vernalis	♀	1		0.02		0.003		0.7	
			2		0.04		0.006		1.5
	♂	1		0.02		0.003		0.7	
TOTAL			111		2.38		0.346	98.3	98.9

Barnacle naupliae and spionid larvae were present in the sample

IV PHYTOPLANKTON ANALYSIS

Throughout the year, samples of phytoplankton have been collected by vertical tows at three midchannel stations, by a horizontal tow across a transect, and by hand-towing at east and west shore stations. For the most part, collections were made monthly, except during the summer months June to August when two weekly collections were made. However, because of the laborious work involved in counting and identifying the phytoplankton organisms, only monthly samples have been analyzed.

The method of analysis has been to sample several milliliters of concentrated field sample, and to count the organisms in a Sedgewick-Rafter counter, following the methods recommended by the Freshwater Pollution Control Administration. The organisms have been identified as to genera, and sometimes to species, and the most abundant forms recorded in terms of their relative abundance in the sample. Species appearing as threads or clumps of attached individuals have been recorded as single occurrences, following the procedure of the FWPCA.

The samples from the main channel and those from the shores show qualitative differences. Data are listed in Appendix IV-1. In general the shore collections appear to be more abundant, although it has not been possible to obtain quantitative estimates for the shore samples. The variety of species in shore samples is quite similar to that of main channel samples, but there appear to be more pollution indicating species in the former collections (Figure IV-1). For instance, the blue green Oscillatoria appears in shore collections in June and September. Anabaena was also present, but in both shore and channel samples.

Considerable differences have been seen between the west side channel collections and other channel samples (Figure IV-1), as for zooplankton samples. The differences are not always consistent, but often the west-side sample is much poorer in both species and abundance. The phytoplankton population through the year appears to be dominated by Melosira (Figure IV-2), usually several species: granulata, ambigua, italica, varians. When salinity begins to increase in the summer, this pattern broke down, overall abundance declined, and a variety of more salt-tolerant forms appeared. The dilution of the estuarine water in November by an early snowfall led to the re-establishment of Melosira dominance, but this gave way again in early spring, before appreciable thawing, to salt-tolerant species. The thaw in late March and April diluted the salinity once more, with the reappearance of Melosira.

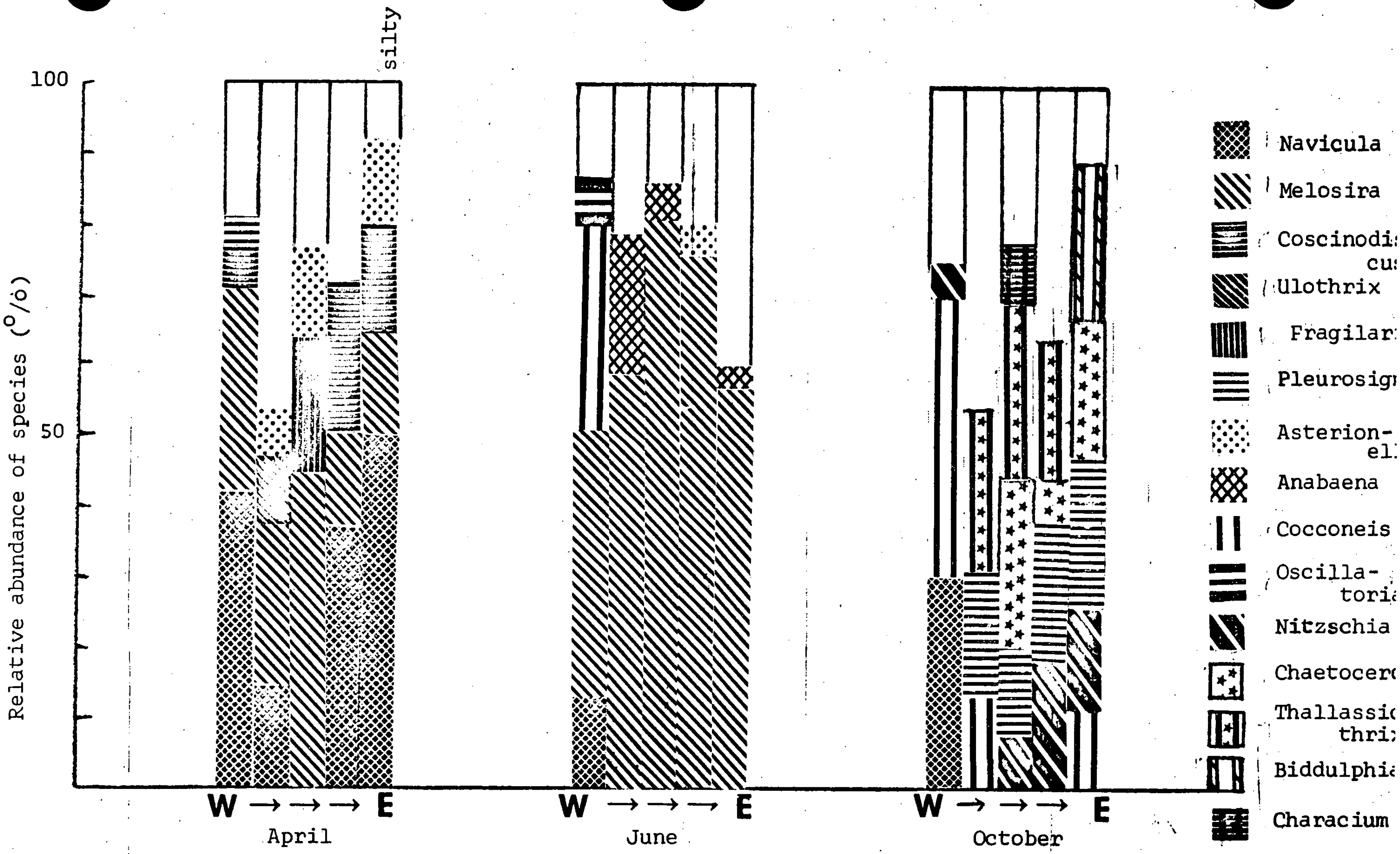


FIGURE IV-1 Comparison of relative abundance of species of shore and main channel stations, 1968

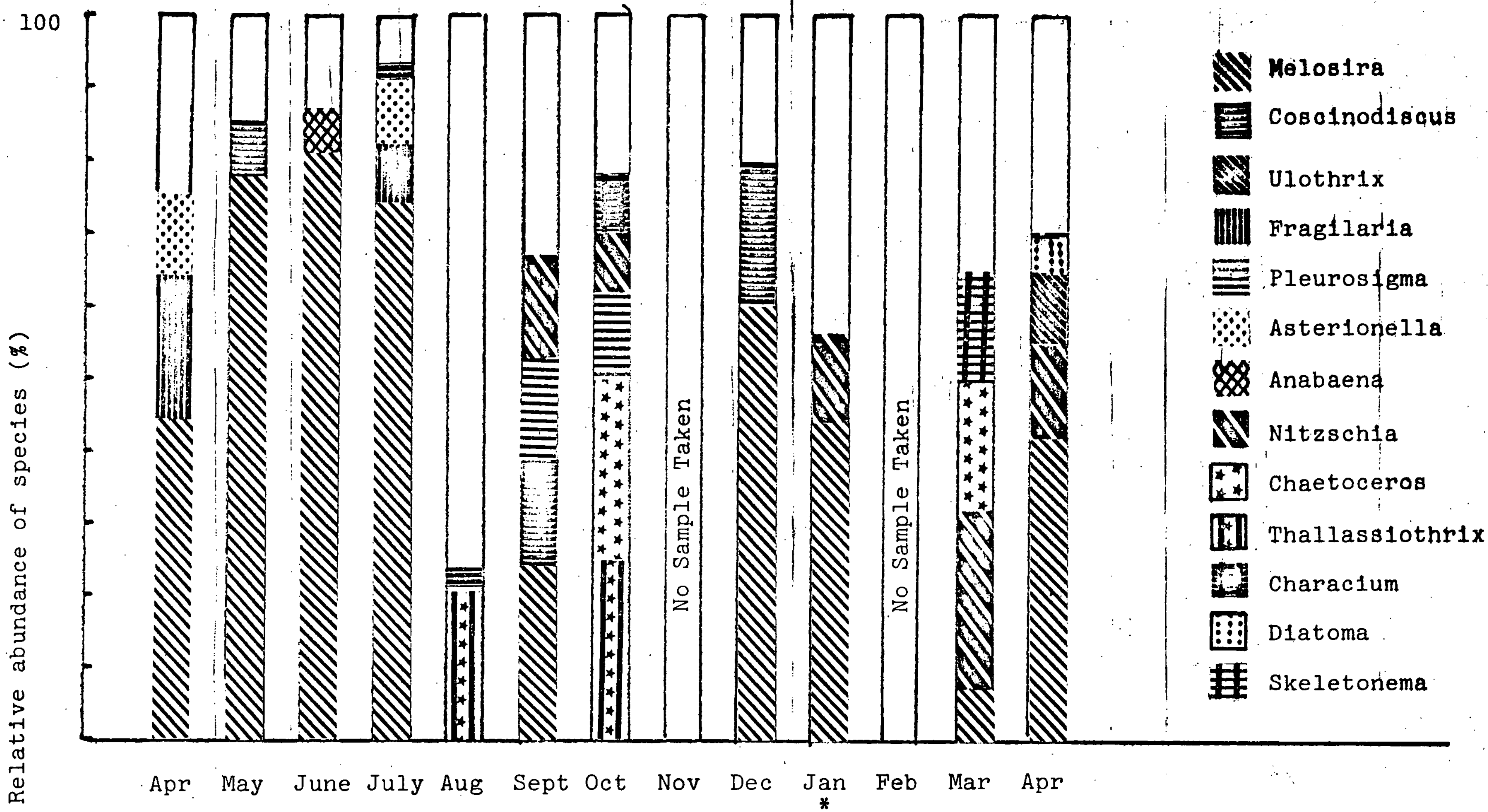


Figure IV-2 Comparison of relative abundance of species April 1968 - April 1969
Mid-channel samples at Indian Point.

* Sample from pier on east side of channel.

The monthly changes in species and abundance in the collections may be summarized:

April: Navicula (Diatom) was present in all samples, perhaps responsible for the low clarity (1 ft) of the water. There was a greater variety of species on the west side of the river and little difference between the shore and channel collections. The appearance of Asterionella (Pennate Diatom) is erratic.

May: Samples from the east side now show more variety, with some Ceratium hirundirella (green alga) present. On the west side and mid-channel in contrast, Melosira was clearly dominant.

June: Anabaena oscillatorioides (filamentous blue green alga) was ubiquitous, with Oscillatoria (blue green alga associated with highly nutrient conditions) appearing on the west shore.

July: Samples from all stations are characterized by great variety and abundance. Some benthic species, Navicula (diatom) and Cocconeis (diatom) were present in west shore samples.

August: East and west populations differ markedly in both species and abundance, while shore and channel samples are similar for each side, except for benthic species in the shore samples. The west side collections are dominated by Nitzschia (diatom) and Navicula (diatom) whereas on the east Thallassiothrix (diatom) and a variety of other diatoms are plentiful.

September: East and west side populations are again quite different, although Thallassiothrix (diatom) appears on both sides. The west side samples contain pollution indicators, Oscillatoria tenuis (blue green) and Melosira borreri (diatom). On the east side in contrast, Pleurosigma (diatom) and Nitzschia (diatom) are common in the channel, and Biddulphia (diatom) and Coscinodiscus (diatom) on the shore.

October: Samples were similar to those taken in September with east channel and east shore samples similar to each other (except for benthic species), but these were very different from west side and west shore samples.

December: Melosira ambigua became dominant in all samples for the first time since July. Channel samples were similar to each other, as were shore samples. There is now more variety in shore samples.

January: A limited sample (from the northern end of the pier at Indian Point, east shore) indicates that Melosira remains dominant.

March: Nitzschia was the most predominant diatom species overall, with Melosira occupying a subsidiary place. The species of Nitzschia has changed from N. iridula, to N. paradoxa with some N. sigmoidea. A number of other marine or brackish species were present.

April: Melosira spp. were again dominant in all samples (M. varians, M. granulata, M. ambigua). Ulothrix, Nitzschia and Diatoma were also common.

The "standing crop" of phytoplankton organisms has been calculated for vertical tows in the main channel samples (Table IV-1). The peak of abundance was seen in June, with a sharp decline in August. A minor peak was seen in December. The pattern of abundance has been compared to changes in salinity and temperature (Figure IV-3), clarity (Figure IV-4) and nutrients (Figure IV-5). There seems to be little correlation between phytoplankton abundance and salinity or temperature changes during the year. As expected, clarity increased when numbers of phytoplankton organisms decreased, but the correlation is not a close one. A much closer relationship is shown between phytoplankton abundance and nitrogen (but see p. II-8 above), although little relation to phosphate could be seen. It is known from the literature that Melosira spp. are frequently limited by nitrate concentrations rather than other environmental factors.

The abundance of phytoplankton in Hudson River samples from Indian Point is compared with that at a number of other locations in Table IV-2. Although caution must be exercised in comparing data derived from diverse sources,

Table IV-I

PHYTOPLANKTON, 1968-1969

(Vertical Tows)
HUDSON RIVER AT INDIAN POINT

Date	Sample Site	Sample No.	D	N	No/m^3 river water	Mean/m^3
March 6	N W Pier	16	15	860	623x10^3	623x10^3
March 19	"Sluiceway"	8		1540		
April 3	W. Ind. Pt.	22	30	6340	2297x10^3	
April 3	Mid Ind. Pt.	20	52	3760	786x10^3	1364x10^3
April 3	E. Ind. Pt.	27	20	1850	1005x10^3	
May 14	W. Ind. Pt.	10	30	3580	1297x10^3	
May 14	Mid Ind. Pt.	12	67	3540	574x10^3	2162x10^3
May 14	Mid Ind. Pt.	13	67	3650	592x10^3	
May 14	E. Ind. Pt.	9	20	8480	4609x10^3	
June 6	W. Ind. Pt.	4	23	9400	4443x10^3	
June 6	Mid Ind. Pt.	12	44	7040	1739x10^3	2594x10^3
June 6	E. Ind. Pt.	3	25	3680	1600x10^3	
July 2	W. Ind. Pt.	35	30	21020	7616x10^3	
July 2	Mid Ind. Pt.	33	45	20440	4937x10^3	5881x10^3
July 2	E. Ind. Pt.	36	34	15920	5090x10^3	
July 10	N W Pier	42	20	5840	3174x10^3	
July 10	In gate	43	24	8400	3805x10^3	2779x10^3
July 10	In gate	44	24	3000	1359x10^3	
Aug 14	W. Ind. Pt.	52	26	500	209x10^3	
Aug 14	Mid Ind. Pt.	56	45	740	740x10^3	676x10^3
Aug 14	E. Ind. Pt.	53	12	1080	1080x10^3	
Aug 30	N W Pier	99	29	1340	502x10^3	502x10^3
Sept 10	W. Ind. Pt.	106	18	2520	1521x10^3	
Sept 10	Mid Ind. Pt.	108	50	1180	256x10^3	732x10^3
Sept 10	E. Ind. Pt.	103	30	1160	420x10^3	
Oct 8	W. Ind. Pt.	113	32	880	299x10^3	
Oct 8	Mid Inc. Pt.	114	75	2140	310x10^3	293x10^3
Oct 8	E. Ind. Pt.	112	75	1860	270x10^3	

Date	Sample Site	Sample No.	D	N	No/m3 river water	Mean/m3
Oct 24	N W Pier	120	32	740	$251x10^3$	$251x10^3$
Dec 3	W. Ind. Pt.	127	27	6280	$2528x10^3$	
Dec 3	Mid Ind. Pt.	124	52	820	$171x10^3$	$1151x10^3$
Dec 3	E. Ind. Pt.	126	72	5000	$755x10^3$	
Dec 19	N W Pier	130	30	8340	$3022x10^3$	$3022x10^3$
Jan 17	N W Pier	134	20	1040	$565x10^3$	$565x10^3$
Mar 13	W. Ind. Pt.	138	25	2720	$1183x10^3$	
Mar 13	Mid Ind. Pt.	136	55	5600	$1107x10^3$	$1087x10^3$
Mar 13	E. Ind. Pt.	137	45	4040	$976x10^3$	
April 7	W. Ind. Pt.	146	10	760	$252x10^3$	
April 7	Mid Ind. Pt.	147	10	3120	$1033x10^3$	$777x10^3$
April 7	E. Ind. Pt.	149	10	3160	$1046x10^3$	

D = Depth of sample haul in feet.

N = Number of organisms in 1 ml, Sedgewick Rafter count.

Figure IV- 3 PHYTOPLANKTON ABUNDANCE: HUDSON RIVER, 1968-1969 CORRELATION WITH TEMPERATURE AND SALINITY

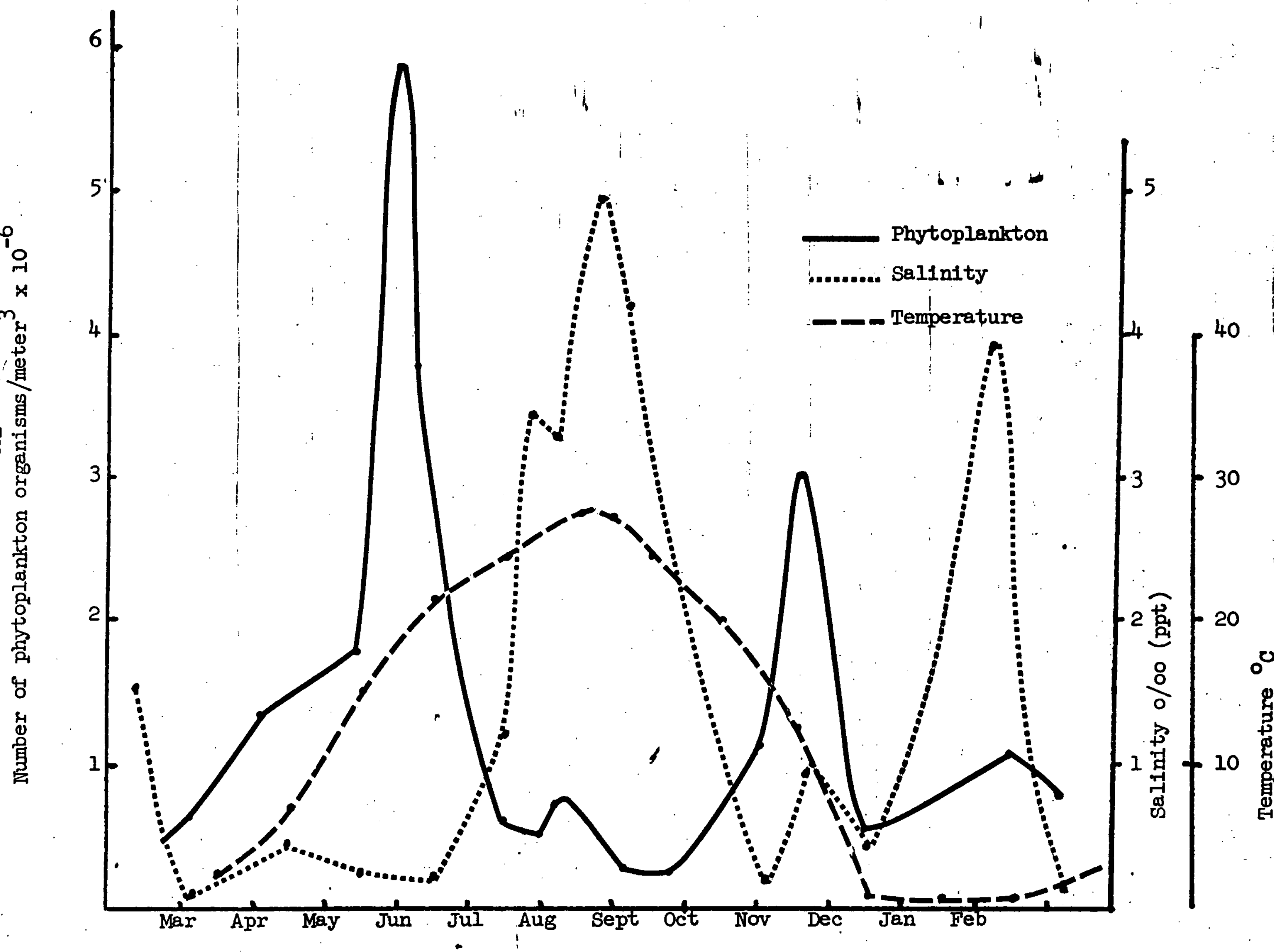


Figure IV-4 PHYTOPLANKTON ABUNDANCE: HUDSON RIVER, 1968-1969
CORRELATION WITH WATER CLARITY

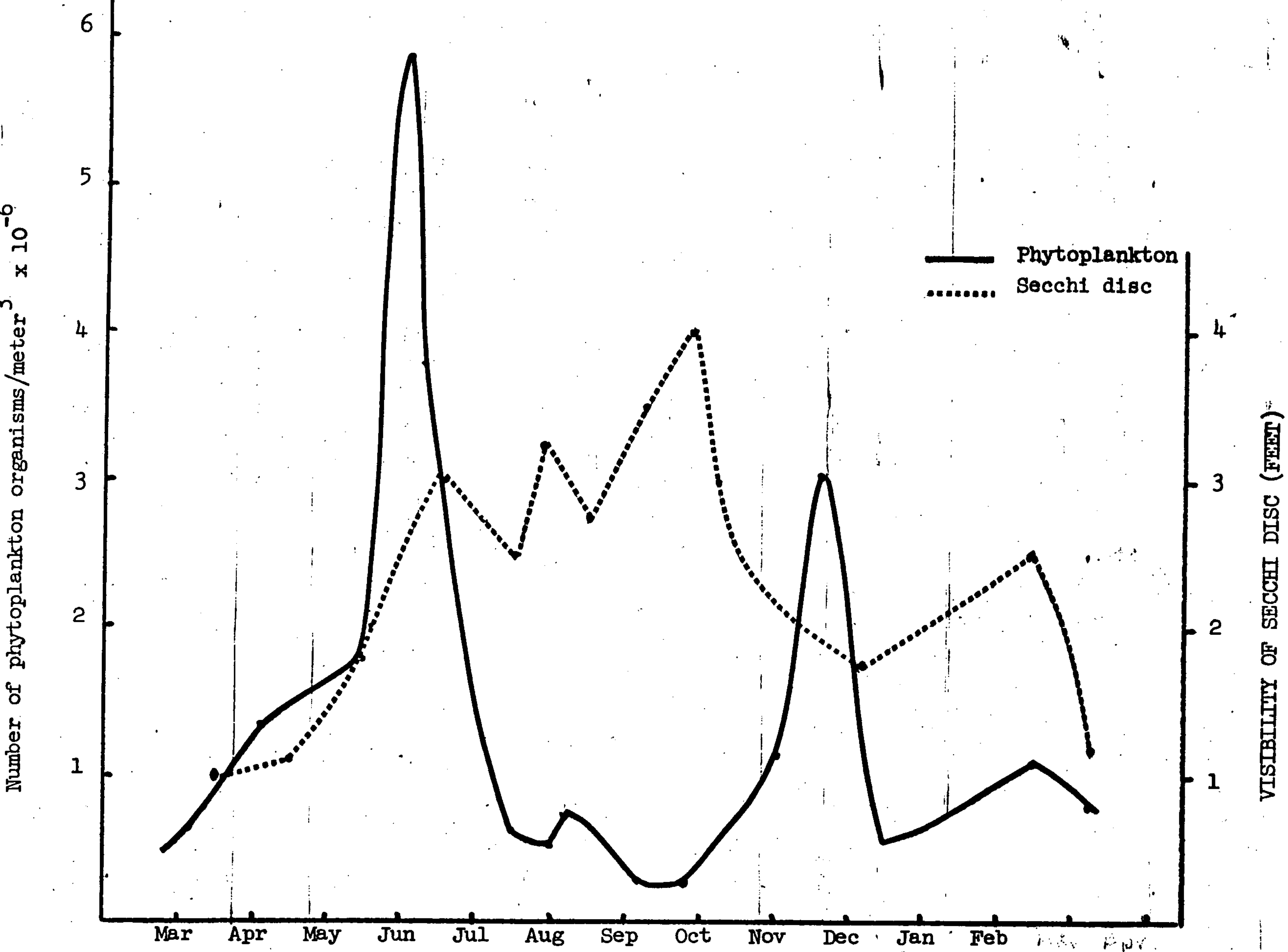


Figure IV-5 PHYTOPLANKTON ABUNDANCE: HUDSON RIVER, 1968-1969
CORRELATION WITH NUTRI

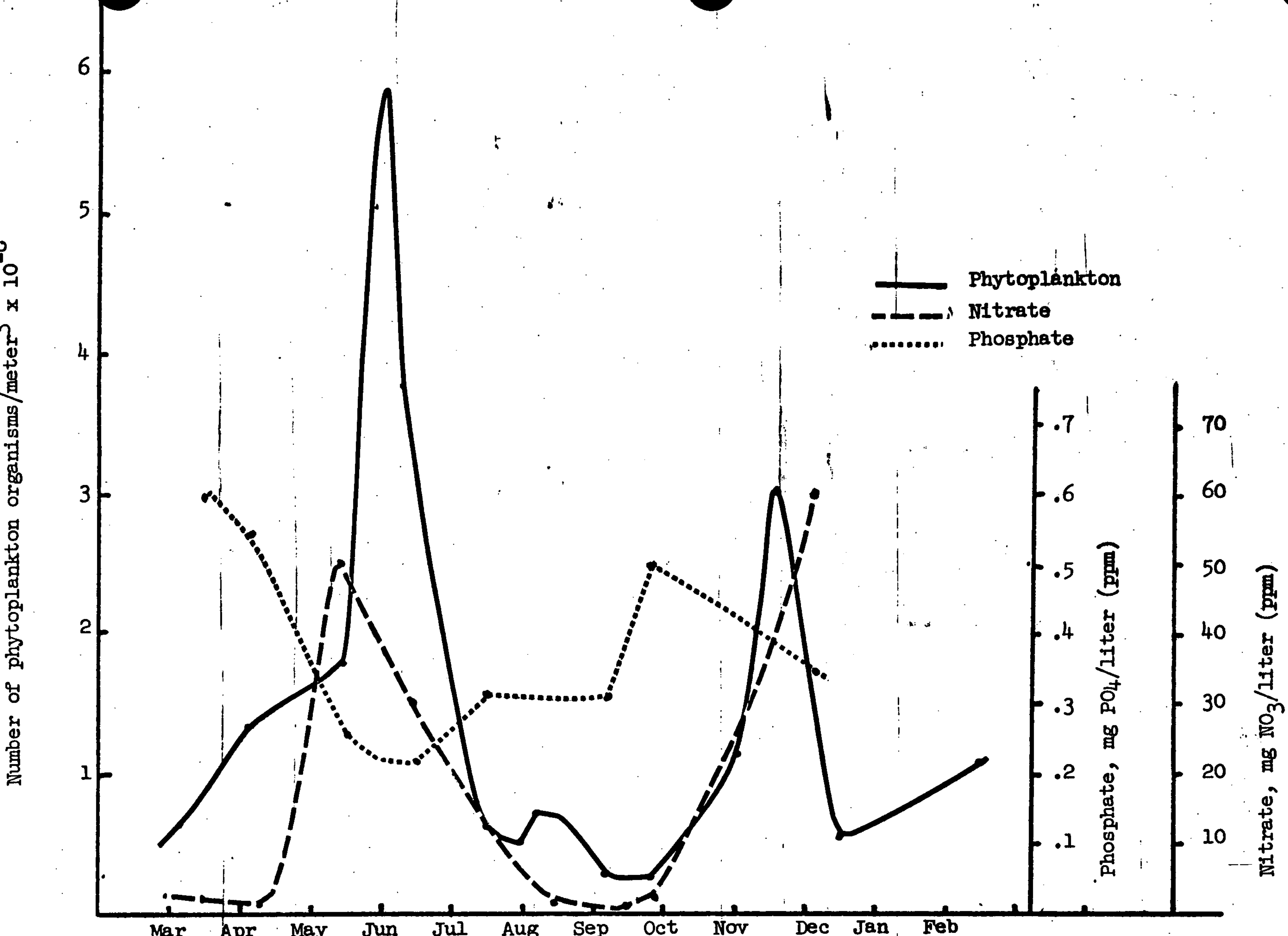


Table IV-2

PLANKTON ABUNDANCE, HUDSON RIVER AND OTHER DATA

HUDSON AT INDIAN POINT, 1968	
Phytoplankton (Diatoms and Algae)	max. $6x10^6/m^3$
Microcrustacea Adults	max. $6x10^4/m^3$
Zooplankton (TOTAL)	max. $1x10^6/m^3$
PANAMA (Allen)	
Diatoms	$5x10^8/m^3$
COLORADO LAKES (Pennak)	
Phytoplankton	$3-7x10^{10}/m^3$
LAKE ERIE, 1940-41 (Hutchinson)	
Phytoplankton	$1x10^9/m^3$
LAKE MICHIGAN, 1938-40 (Hutchinson)	
Phytoplankton	$1.5x10^9/m^3$
GREAT SOUTH BAY, 1952	
Phytoplankton and Protozoa (Lackey)	$2.4x10^5$ - $2.2x10^9/m^3$

it is clear that phytoplankton abundance at Indian Point is generally about 100 times less than in some other environments. It is not known what factors contribute to this.

Appendix IV-1

Collection to March 31st 1969

Calculation of number of plankton organisms per unit volume of water.

Volume of cylinder	=	$\pi r^2 h$
Radius of net r	=	0.25 meters
Depth of net haul h	=	D (feet) x 0.3048 (meters)
π	=	3.141

Volume of river water sampled

$$= (\pi \times (0.25)^2 \times 0.3048 \times D) m^3$$
$$= (0.0598 \times D) m^3$$

Organisms from this volume of water are concentrated into 650 ml.

Number of organisms in 1 ml, N, are counted in Sedgewick-Rafter cell.

Hence total organisms in sample $= N \times 650$

Hence, number in 1 cubic meter $= \dfrac{N \times 650}{D \times 0.0598}$

$$= \frac{N}{D} \times 10870/m^3$$

After April 1st 1969

Depth of net hauls routinely 10m

Hence volume of water sampled = $(\pi \times (0.25)^2 \times 10) m^3 = 1.963\ m^3$

Number of organisms in river water are: -

$$\frac{N \times 650}{\pi \times (0.25)^2 \times 10} = N \times 331.13/m^3$$

Appendix IV-I HUDSON RIVER AT INDIAN POINT. PHYTOPLANKTON ANALYSIS APRIL 1968

DATE	Sample Site	Depth (ft)	Total S-R count No./ml	No. genera present	Abundant Genera	% Occurrence
3-IV-68	W. Shore	1	12,780	20	Navicula	42
					Melosira	29
					Coscinodiscus	6
					Pleurosigma	4
					Others	19
3-IV-68	E. Shore	1	too silty	12	Navicula	"blooms"
					Coscinodiscus	"common"
					Melosira	"common"
					Asterionella	"common"
2-IV-68	E. Side	20	1,850	8	Navicula	37
					Coscinodiscus	22
					Melosira	13
					Others	28
2-IV-68	Mid-	52	3,760	20	Melosira	44
					Fragilaria	20
					Asterionella	13
					Others	23
2-IV-68	W. Side	30	6,340	33	Melosira	23
					Navicula	13
					Ulothrix	10
					Asterionella	7
					Others	47
2-IV-68	W ⟶ E (Horizontal)	3900 (transect)	7,850	29	Melosira	49
					Asterionella	10
					Ulothrix	8
					Fragilaria	2
					Others	10

Appendix IV-I

2-IV-68	E → W (Horizontal)	3900 (transect)	14,290	25	Melosira	81
					Asterionella	5
					Ulothrix	2
					Fragilaria	2
					Others	10

PHYTOPLANKTON ANALYSIS MAY 1968

Date	Sample Site	Depth (ft)	Total S-R count No./ml	No. genera seen	Abundant Genera	% occurrence
14-V-68	E. Side	20	8480	17	Melosira[1]	64
					Ceratium[2]	10
					Asterionella	7
					Synedra	3
					Anabaena	3
					Others	13
14-V-68	Mid-	67	3540	15	Melosira[3]	78
					Coscinodiscus	7
					Others	15
14-V-68	Mid-	67	3650	18	Melosira[4]	75
					Asterionella	5
					Others	20
14-V-68	W. Side	30	3580	16	Melosira[6]	77
					Others	22
14-V-68	E → W (Horizontal)	3900 (transect)	30200	20	Melosira[5]	84
					Asterionella	3
					Tabellaria	2
					Others	11

Notes:

1. M. italica (33%); M. granulata (21%)
2. C. hirundinella
3. M. granulata (23%); M. varians (8%); M. ambigua (8%)
4. M. varians (43%); M. italica (8%)
5. M. granulata (27%); M. ambigua (9%)
6. M. granulata (42%); M. ambigua (16%)

Other species:

Cyclotella meneghiniana
Diatoma vulgare
Navicula iridula
Asterionella formosa

PHYTOPLANKTON ANALYSIS JUNE 1968

Date	Sample Site	Depth (ft)	Total S-R count No./ml	No. genera present	Abundant Genera	% occurrence
7-VI-68	W. Shore	3	20,800	14	Cocconeis*	40
					Melosira	38
					Navicula	13
					Oscillatoria	6
					Others	3
7-VI-68	E. Shore	3	32,240	27	Melosira	57
					Anabaena	3
					Others	40
5-VI-68	E. Side	25	3,680	19	Melosira	76
					Asterionella	4
					Others	20
5-VI-68	Mid-	44	7,040	18	Melosira	81
					Anabaena	6
					Others	13
5-VI-68	W. Side	23	9,400	23	Melosira	59
					Anabaena	20
					Others	19

Notes: * = a clump

Species: *Melosira varians* (principal Melosira sp.)
Melosira ambigua (secondary)
Melosira sp. (tertiary)

Cocconeis diminuta
Fragilaria capucina

PHYTOPLANKTON ANALYSIS JULY 1968

Date	Sample Site	Depth (ft)	Total count	S-R No./ml	No. genera seen	Abundant Genera	% occurrence
3-VII-68	W. Shore	0-3	34840		19	Melosira	56
						Navicula	23
						Cocconeis	3
						Asterionella	2
						Others	16
3-VII-68	E. Shore	0-3	27260		20	Melosira	90
						Fragilaria	3
						Asterionella	2
						Others	5
2-VII-68	E. Side	34	15920		28	Melosira	75
						Asterionella	6
						Fragilaria	4
						Nitzschia	3
						Others	12
2-VII-68	Mid-	45	20440		19	Melosira	74
						Asterionella	9
						Fragilaria	7
						Coscinodiscus	2
						Others	8
2-VII-68	W. Side	30	21020		22	Melosira	65
						Asterionella	6
						Fragilaria	3
						Cyclotella	2
						Others	24
2-VII-68	W → E (Horizontal)	3900	50060		26	Melosira	78
						Asterionella	9
						Fragilaria	6
						Surirella	1
						Others	6

PHYTOPLANKTON ANALYSIS AUGUST 1968

Date	Sample Site	Depth (ft)	Total S-R count no./ml	No. of genera seen	Abundant genera	% occurrenc
13-VIII-68	W. Shore	3.5	880	15	Navicula	20
					Nitzschia	20
					Cyclotella	18
					Diatoma	18
					Others	22
13-VIII-68	E. Shore	3	200	6	Coscinodiscus	40
					Melosira	20
					Campylodiscus	20
					Others	20
14-VIII-68	E. Side	12	1080	15	Thallassiothrix	19
					Cocconeis	19
					Synedra	15
					Others	47
14-VIII-68	Mid-	45	740	14	Thallassiothrix	20
					Coscinodiscus	2
					Others	78
14-VIII-68	W. Side	26	500	13	Nitzschia	20
					Others	80
14-VIII-68	W ⟶ E (Horizontal)	3900	2140	18	Pediastrum	25
					Thallassiothrix	19
					Melosira	14
					Others	42

PHYTOPLANKTON ANALYSIS SEPTEMBER 1968

Date	Sample Site	Depth (ft)	Total count S-R No./ml	No. genera seen	Abundant genera	% occurrence
12-IX-68	W. Shore	0-5	1324	19	Navicula	50
					Oscillatoria[1]	20
					Melosira[2]	10
					Nitzschia	5
					Others	15
12-IX-68	E. Shore	0-4	260	16	Coscinodiscus	32
					Biddulphia	23
					Nitzschia	10
					Others	35
10-IX-68	E. Side	30	1160	16	Pleurosigma	13
					Nitzschia	13
					Thallassiothrix	12
					Others	62
10-IX-68	Mid-	50	1180	15	Melosira	24
					Coscinodiscus	15
					Pleurosigma	14
					Nitzschia	14
					Others	33
10-IX-68	W. Side	18	2520	15	Melosira	75
					Nitzschia	9
					Others	16
10-IX-68	E ⟶ W (Horizontal)	3900 (transect)	3000	17	Nitzschia	29
					Pediastrum	23
					Anacystis	11
					Coscinodiscus	11
					Pleurosigma	6
					Synedra	6
					Others	14

Notes: 1 <u>O. tenuis</u>
2 <u>M. borreri</u>

PHYTOPLANKTON ANALYSIS OCTOBER 1968

Date	Sample Site	Depth (ft)	Total count	S-R No./ml	No. genera seen	Abundant genera	% occurrence
14-X-68	W. Shore	3	3720		13	Cocconeis	40
						Navicula	30
						Nitzschia	5
						Others	25
14-X-68	E. Shore	2	1940		10	Biddulphia	24
						Pleurosigma	21
						Nitzschia	15
						Coscinodiscus	11
						Others	29
8-X-68	E. Side	75	1860		12	Pleurosigma	20
						Thallasiothrix	20
						Nitzschia	18
						Chaetoceros	6
						Others	36
8-X-68	Mid-	75	2140		14	Chaetoceros	25
						Thallassiothrix	25
						Pleurosigma	12
						Nitzschia	8
						Characium	8
						Others	22
8-X-68	W. Side	32	880		13	Thallassiothrix	22
						Pleurosigma	18
						Coscinodiscus	13
						Others	47

PHYTOPLANKTON ANALYSIS DECEMBER 1968

Date	Sample Site	Depth (ft)	Total S-R count No./ml	No. genera seen	Abundant genera	% occurrence
3-XII-68	W. Shore	-	10,880	18	Melosira	50
					Cocconeis	19
					Navicula	13
					Nitzschia	6
					Fragilaria	4
					Others	8
3-XII-68	E. Shore	-	4,960	17	Melosira	74
					Cyclotella	6
					Navicula	4
					Fragilaria	3
					Others	13
3-XII-68	E. Side	72	5,000	12	Melosira	80
					Nitzschia	4
					Thallassiothrix	4
					Pediastrum	3
					Others	9
3-XII-68	Mid-	52	820*	6	Melosira	60
					Coscinodiscus	20
					Others	20
3-XII-68	W. Side	27	6,280	11	Melosira	80
					Nitzschia	8
					Pediastrum	3
					Thallassiothrix	2
					Others	7

Note * silty debris. Tug passed by just before sample taken.

PHYTOPLANKTON ANALYSIS JANUARY 1969

Date	Sample Site	Depth (ft)	Total count	S-R no./ml	No. genera seen	Abundant genera	% occurrence
14-I-69	N. Pier (W. Side)	20	1040		11	Melosira[1]	44
						Nitzschia[2]	12
						Others	44
14-I-69	Effluent Canal	17	1420		12	Melosira[1]	24
						Bluegreens(?)	21
						Phormidium	17
						Nitzschia[2]	10
						Others	28

Notes: Sphaerotilus also present in canal sample

1 *M. granulata*

2 Several Species

PHYTOPLANKTON ANALYSIS MARCH 1969

Date	Sample Site	Depth (ft)	Total S-R count no./ml	No. of genera seen	Abundant genera	% occurrence
13-III-69	E. Side	45	4040	20	Nitzschia[1]	25
					Chaetoceros*	21
					Melosira	10
					Thallassiothrix	7
					Others	27
13-III-69	Mid-	55	5600	19	Nitzschia[1]	25
					Chaetoceros*	17
					Skeletonema	15
					Thallassiothrix	8
					Rhizosolenia*	7
					Melosira	7
					Others	21
13-III-69	W. Side	25	2720	15	Skeletonema*	24
					Chaetoceros*	21
					Nitzschia[1]	20
					Melosira	11
					Others	24
13-III-69	W ⟶ E (Horizontal)	3900 (transect)	8840	17	Nitzschia[1]	50
					Melosira	11
					Synedra	10
					Coscinodiscus	8
					Chaetoceros*	7
					Rhizosolenia*	5
					Others	9

Notes: 1 N. paradoxa*. N. sigmoidea also present

Other species present: Melosira granulata, Thallassiothrix longissima and T. nitzschiodes*
Asterionella japonica*-A. formosa*
Dityluis brightwelli*

* Marine or brackish forms

PHYTOPLANKTON ANALYSIS APRIL 1969

Date	Sample Site	Depth (ft)	Total count	S-R no./ml	No. of genera seen	Abundant genera	% occurrence
7-IV-69	E. Side**	52	3160		19	Melosira[1]	42
						Ulothrix	12
						Diatoma*	10
						Cyclotella	4
						Synedra	4
						Others	28
7-IV-69	Mid-**	45	3120		18	Melosira[1]	42
						Nitzschia[2]	13
						Ulothrix	10
						Diatoma*	4
						Others	31
7-IV-69	W. Side**	27	760		8	Melosira[1]	42
						Ulothrix	6
						Diatoma	5
						Others	47
7-IV-69	W ⟶ E (Horizontal)	3900 (transect)	11,100		21	Melosira[1]	40
						Ulothrix	14
						Diatoma	12
						Surirella	3
						Others	31

Notes: * Colonies
1 *Melosira* spp. are *M. varians*, *M. granulata*, *M. ambigua*
2 *N. sigmoidea*

** Plankton vertical tow through 30 feet

V STUDIES ON THE EFFLUENT CANAL

From July 1968 until January 1969, some limited biological sampling has been made of the water in the effluent canal. In most instances, samples were taken at the same time near the "in-gate" or from the northern corner of the pier at the reactor site. On one occasion water coming directly from the condensers was collected inside the plant. Within the effluent canal, samples were taken from several stations, as indicated in Figure V-1.

A quantitative analysis of phytoplankton has been made (Table V-1 and Appendix V-1) and the results for the canal compared with those for the river at Indian Point. In general, the relative abundance of species in the canal collections is very similar to that from the main channel stations of the river, although some minor differences may be seen (Figure V-2). There is no indication that blue-green algae or other undesirable forms are more predominant in the canal samples than in the main river. (Contrast the samples from the west shore). Nor is there much indication that the organisms in the samples of the canal as a whole are more abundant than in the main channel samples (Table V-1). A comparison of seasonal changes in abundance for the canal and the river

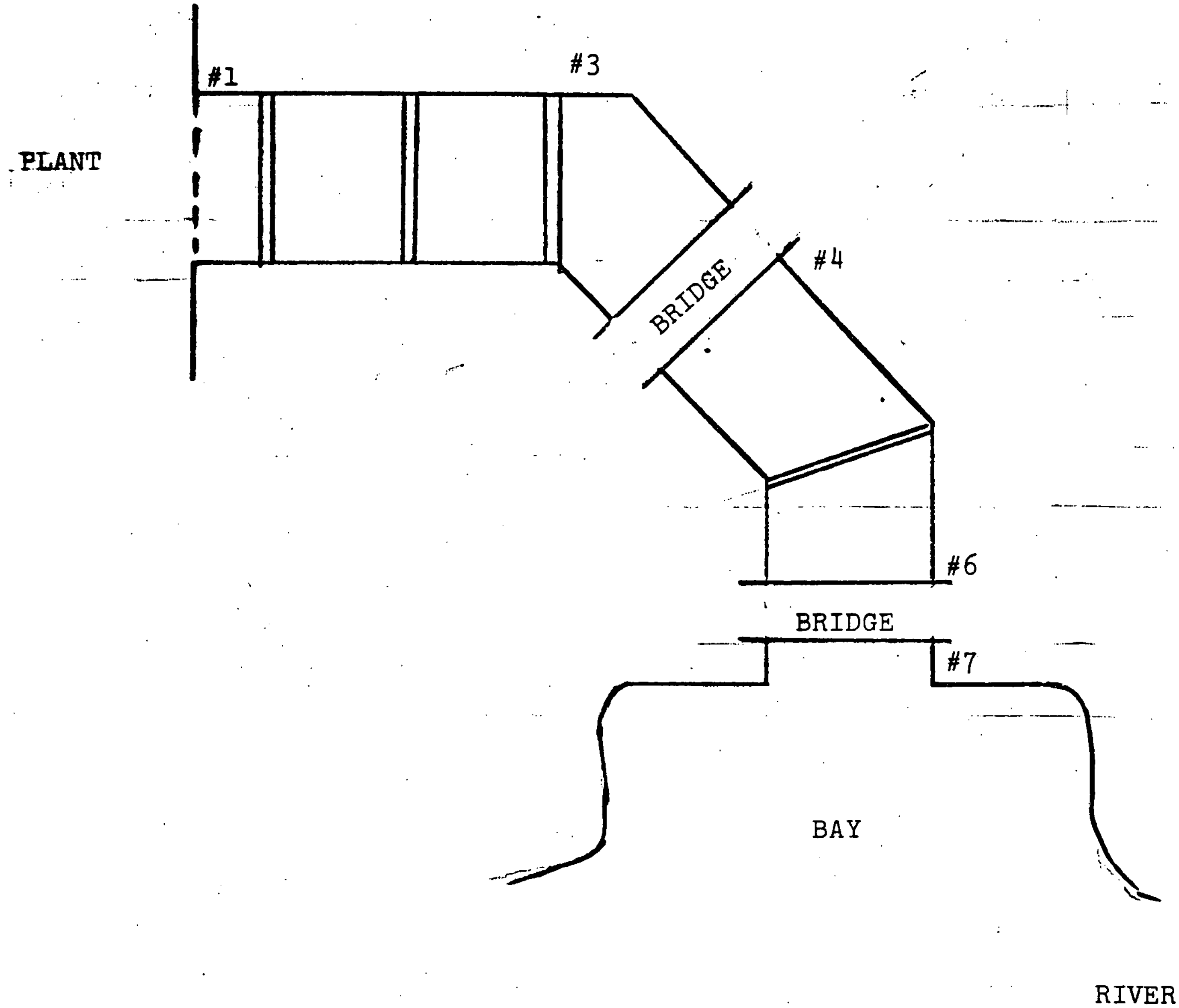
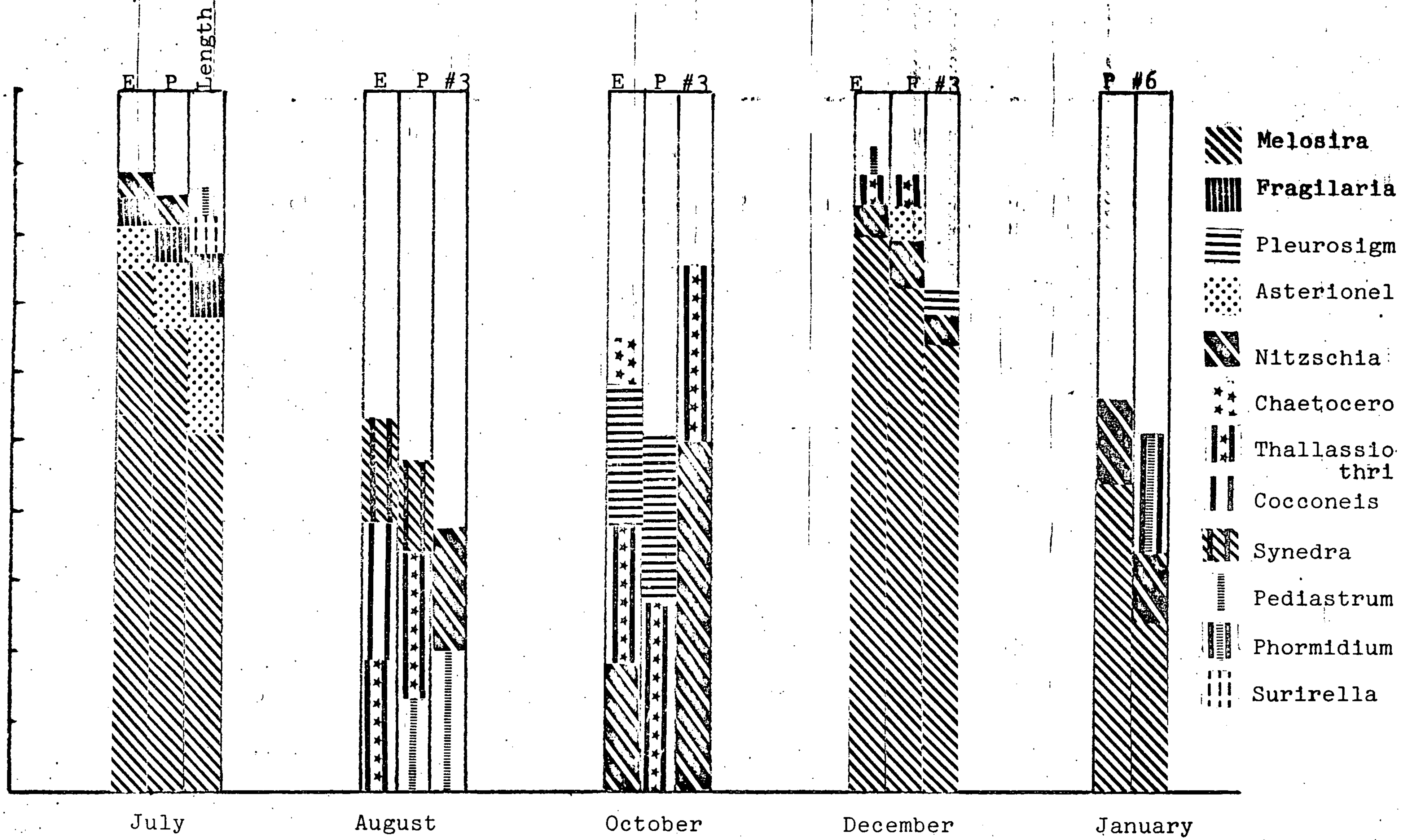


FIGURE V-1 SAMPLING SITES ON EFFLUENT CANAL, INDIAN POINT REACTOR



E = east side channel
P = pier
#3 = station in effluent canal

Figure V-2 Relative abundnace of species in canal, pier and river samples.

TABLE V-1

PHYTOPLANKTON, 1968-1969

DISCHARGE CANAL AT CON EDISON, INDIAN POINT

Date	Sample Site	Sample No.	D	N.	No/m³ River Water	Mean/m³
July 10	Canal Length	45	120	12620	1143×10^3	1143×10^3
Aug 30	Canal #1	98	18	540	326×10^3	
Aug 30	Canal #3	94	18	720	435×10^3	
Aug 30	Canal #4	96	19	1380	790×10^3	484×10^3
Aug 30	Canal #6	97	14	700	544×10^3	
Aug 30	Canal #7	95	12	360	326×10^3	
Oct 24	Canal #1	119	19	910*	260×10^3	
Oct 24	Canal #3	118	21	800*	207×10^3	
Oct 24	Canal #4	117	22	2020*	329×10^3	260×10^3
Oct 24	Canal #6	121	17	990*	316×10^3	
Oct 24	Canal #7	122	17	590*	189×10^3	
Dec 19	Canal #1	129	20	5500	2989×10^3	
Dec 19	Canal #3	131	20	9120	4957×10^3	
Dec 19	Canal #4	128	20	8740	4750×10^3	3807×10^3
Dec 19	Canal #6	133	25	6340	2757×10^3	
Dec 19	Canal #7	132	17	5600	3581×10^3	
Jan 17	Canal #6	135	17	1420	908×10^3	908×10^3

D = Depth of sample haul in feet.

N = Number of organisms in 1 ml, Sedgwick Rafter count.

* = Several tows made. Number calculated for a cubic meter has been corrected for this.

shows a remarkable similarity (Figure V-3). However, one station (#4) is consistently more productive than the others. It is thought that the reason for this lies in a complex pattern of circulation in the canal with a contribution from the river coming directly into the discharge canal and mixing with the condensers and that an area of turbulence is created, together with relative net stasis, so that the finely particulate plankton remains suspended in the water.

The findings of a larger "standing crop" in the canal could be interpreted as an increased productivity there. The numbers of phytoplankton in samples from the canal stations pooled are a little higher than in the main body of the river, for example; 4000 x $10^3/m^3$ compared with 3000 x $10^3/m^3$ in December. However, a part of this difference may lie in the difference in collecting dates, and a part in the non-validity of comparing pooled canal samples with pooled river samples. A more precise comparison would be of the canal samples with the pier or "in-gate" samples taken on the same dates (Table V-2). The abundance in these two sets of samples is remarkably similar.

It has been suggested that one of the effects of a thermal effluent to a water body or of an overall temperature rise would be an increase in productivity, such that the natural predators would not be able to keep the

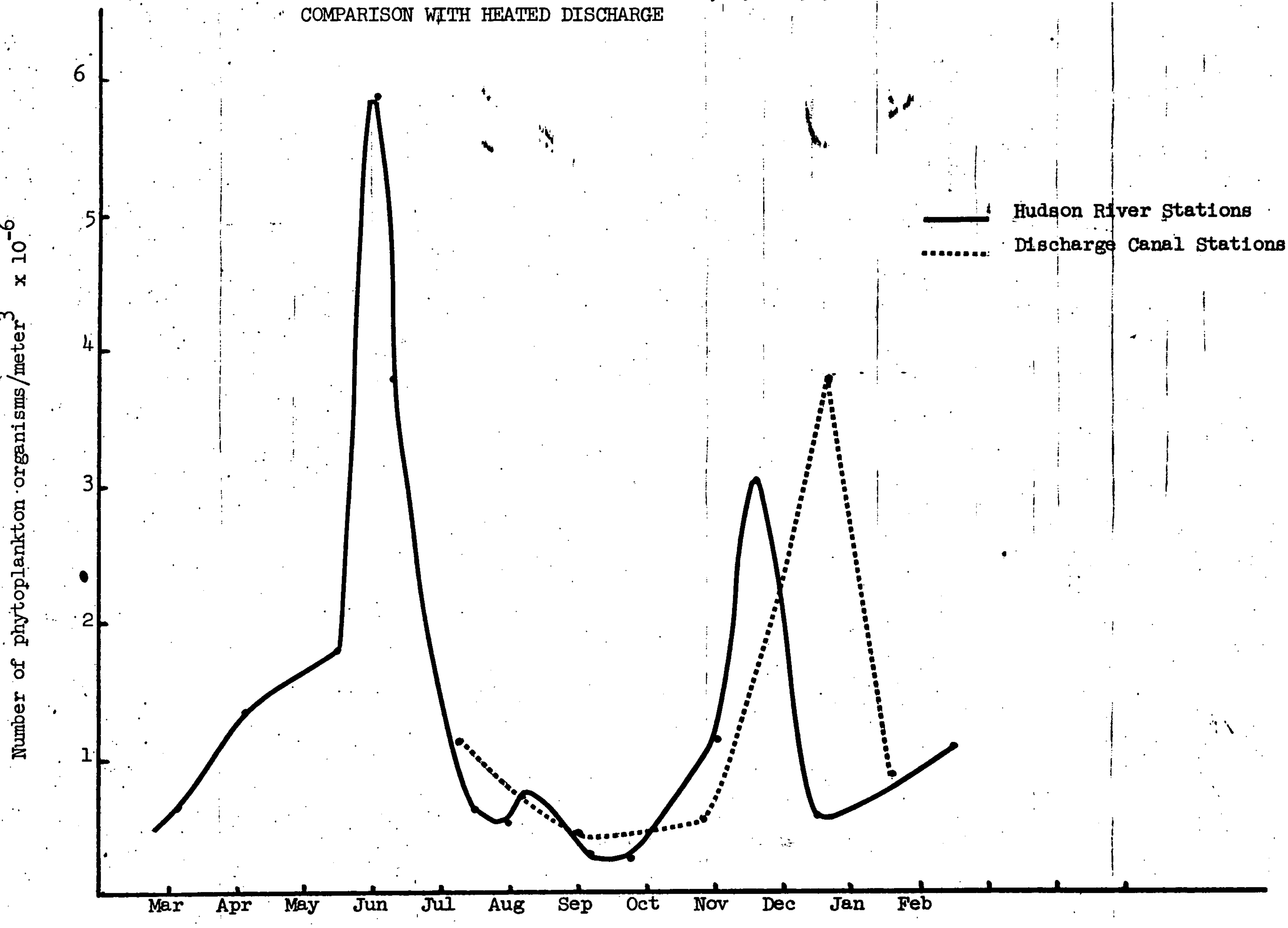
TABLE V-2 COMPARISON OF EFFLUENT CANAL AND PIER SAMPLES

	Pier Samples			Effluent Canal (Pooled) Samples		
Date	No./m³	% Abundance		No./m³	% Abundance	
10-VII-68	2645×10^3	Melosira	66	1143×10^3	Melosira	51
		Asterionella	10		Asterionella	17
		Fragilaria	5		Fragilaria	9
	T=27°C	Nitzschia	4	T=30°C	Surirella	5
		Others	4		Pediastrum	3
					Others	15
30-VIII-68	502×10^3	Thallassiothrix	21	484×10^3	Pediastrum	25
		Melosira	13		Nitzschia	14
	T=27°C	Synedra	13	T=31°C	Coscinodiscus	8
		Others	40		Others	53
24-X-68	251×10^3	Thallassiothrix	27	260×10^3	Thallassiothrix	8
		Pleurosigma	24		Pleurosigma	17
	T=19°C	Others	49	T=24°C	Nitzschia	24
					Chaetoceros	4
					Others	47
19-XII-68	3022×10^3	Melosira	65	3807×10^3	Nitzschia	13
		Pleurosigma	9		Pediastrum	15
	T=2°C	Nitzschia	7	T=12°C	Coscinodiscus	6
		Asterionella	5		Others	66
		Thallassiothrix	4			
		Others	12			
14-I-68	565×10^3	Melosira	44	908×10^3 *	Melosira	24
		Nitzschia	12		Nitzschia	10
	T=1°C	Others	44	T=8°C	Phormidium	17
					Bacteria(?)	21
					Others	28

* Collection from #6 Station Only

FIGURE V-3

PHYTOPLANKTON ABUNDANCE: HUDSON RIVER, 1968-1969
COMPARISON WITH HEATED DISCHARGE



phytoplankton population in check. The water temperatures in the canal were generally recorded as 5°C (July) to 10°C (December) higher than in the mainstream of the river.

From a purely predictive point of view, it is possible from the little data available to evaluate the effects of the present discharge on phytoplankton productivity in the river, and to consider the future effects of operation of the proposed three units at Indian Point. At present, Unit No. 1 uses about 800 cfs of cooling water, while together, units 1,2, and 3 will use about 3200 cfs, ~~four~~ times as much. If the present thermal rise across the condensers is maintained, this flow will be raised 5° to 11°C. If present flow increases phytoplankton productivity by 33%* in the discharge canal, but the volume of water is less than 10% of the mean net flow of the river, then presumably the productivity of the whole river would be increased by about 3%. When units 1,2 and 3 are operating together, and if the increase in temperature across the condensers is similar, and will have a similar effect on productivity, we might expect the increment in abundance to be increased about 4 times, to 12%. This increase is obviously small, especially when the phytoplankton abundance of the Hudson is considered in the context of data from other water bodies (see above p.IV-13)

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*Based on a comparison of standing crops in pooled canal samples with that of the river for December, 1968.

The extreme case might be argued by assuming that the temperature of the whole river flow is increased by 10°C (18°F) (considerably more than would be permitted by the proposed thermal regulations). If a $Q_{10} = 2$ is assumed, following the van't Hoff law, and a 100% efficiency of conversion of the heat energy to phytoplankton production, we could expect the abundance of organisms to rise to 1.2 x $10^6/m^3$, on average, still two orders of magnitude or more below the levels reported for eutrophic lakes.

Naturally, this is an over-simplification of a hypothetical situation. The effects of temperature on productivity cannot be considered alone without reference to nutrient and trace element levels in the water. Since industrial and domestic use of the river will develop concurrently with the demand for power, all these factors must be considered in concert, not in isolation. At the same time the cropping of phytoplankton by zooplankton organisms and their subsequent loss by predation to other trophic levels in the ecosystem are of fundamental improtance in understanding the population dynamics of the area and its relation to physical factors such as temperature.

Analysis of zooplankton in canal samples has been qualitative only, but serves for comparison with collections from the river. In general, as with the phytoplankton, the species seen are essentially similar to those seen in the river collections. A more precise comparison can be made between collections in the canal and at the pier on the east side (Table V-3). There is some indication that differences in abundance of some groups may be present, but it is thought that these are more likely to reflect differences in sampling than reality. It is possible, however, that the canal fauna is richer in variety of species, perhaps because it represents a more sheltered and varied environment than the mainstream of the river. It may be noted that a number of fragile organisms (the medusa *Blackfordia*, and the opossum shrimp, *Mysis oculata*) have been found in the discharge canal, as well as several fish species and that these must have entered directly from the river and not through the plant. A schematic diagram to illustrate collections in the canal and at the "in-gate" is presented in Figure V-4.

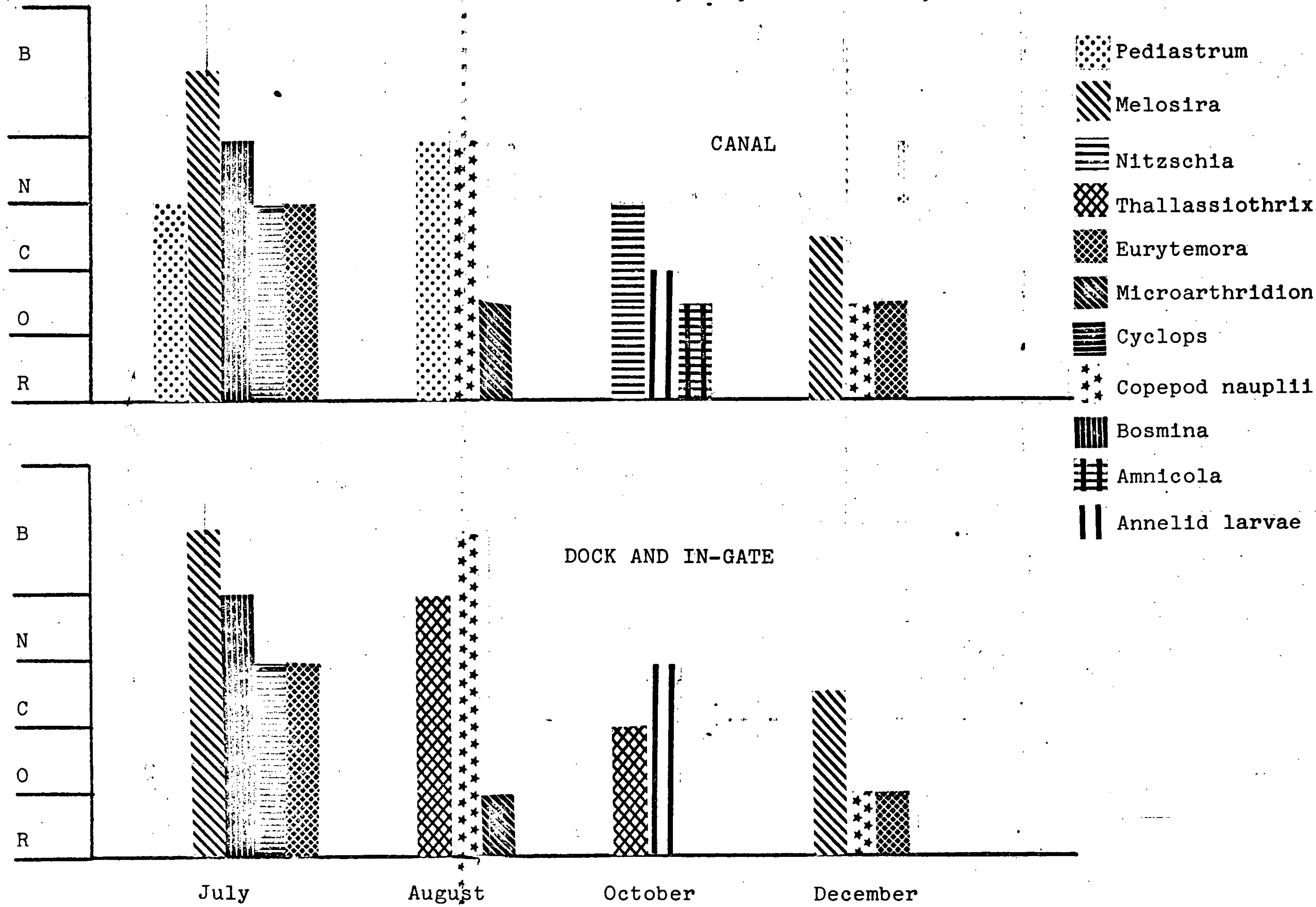
The possibility of estimating productivity *in situ* in the effluent canal has been considered in the latter part of the period reported here. A number of fixed devices designed to attract "periphyton" have been tested in the effluent canal, and at other sites. In the canal, it has been found that some sort of protective cage or basket is

TABLE V-3 COMPARISON OF HUDSON RIVER CHANNEL AND INDIAN POINT EFFLUENT CANAL

DOMINANT SPECIES, JULY TO DECEMBER 1968
(Bracketed species were common, but not dominant)

TIME	HUDSON CHANNEL WEST	HUDSON CHANNEL MID	HUDSON CHANNEL EAST	INDIAN POINT PIER	EFFLUENT CANAL	
July	Melosira	Melosira	Melosira	Melosira	Melosira	Phytoplankt
	-No dominant zoo plankter- (Eurytemora) (Cyclops)	(Eurytemora) (Cyclops)	(Eurytemora) (Cyclops)	Bosmina (Eurytemora) (Cyclops)	Bosmina (Eurytemora) (Cyclops)	Crustacea
August	Nitzschia	(Thallassio- thrix) (Coscino discus)	(Cocconeis) (Thallassio- thrix) (Synedra)	Pediastrum Varied spp.	Pediastrum Varied spp.	Phytoplankt
	Arcella	Arcella Difflugia Ciliates	Arcella Difflugia Colorless Flagellates			Protozoa
	Eurytemora	Eurytemora	Eurytemora	Microarthridion Nauplii	Microarthridion Nauplii	Crustace
October	(Thallassio- thrix) (Pleurosigma) (Coscinodiscus)	(Thallassio- thrix) (Chaetoceros) Characium	(Thallassio- Thrix) (Pleurosigma) (Nitzschia)	Varied spp.	Nitzschia	Phytoplankt
	Arcella Difflugia	Difflugia	Arcella Difflugia			Protozoa
				Annelid larvae	Annelid larvae	Worms
	Eurytemora Nauplii	Eurytemora Nauplii	Eurytemora Nauplii			Crustacea
					Amnicola	Mollusca
December	Melosira	Melosira	Melosira	Melosira	Melosira	Phytoplankt
	(Eurytemora) (Nauplii)	(Eurytemora) (Nauplii)	(Eurytemora) (Nauplii)	(Eurytemora) (Nauplii)	(Eurytemora) (Nauplii)	Crustacea
	Amnicola					Mollusca

FIGURE V-4
Schematic comparison of biota of inflow and outflow at Indian Point Reactor, July - December 1968.



necessary to protect the units from the scouring effect of the current in the canal. Several materials have been tested for the optimum growing conditions, among them, glass slides, parafilm, white and black polyvinyl chloride plastics, teflon, "Saranwrap" and photographic film. While the black polyvinyl plastic seemed to encourage the best growth of organisms, the magnitude of difference was not so great as to outweigh the advantages of the common glass microscope slide, which is most readily available and most easily handled. Photographic film and "Parafilm" proved useless for samplers. A final form for the periphyton sampler has been selected, and we plan to use these samplers in the canal during the next season. (Figure V-5)

A preliminary study of the sampling devices has indicated that such devices will be selected by species present in the phytoplankton which are not necessarily seen in any great quantity in the usual routine net samples. For instance, in January 1969, when the net samples were dominated by Melosira with Nitzschia and Phormidium, the black plastic samplers yielded a mass of bacterial (?) filaments, populated by many small ciliates and flagellates. Amoebae were present, and Vorticella. Very few algae or diatoms were seen, although diatom shells were more common. Similar observations were reported for February 1969, with

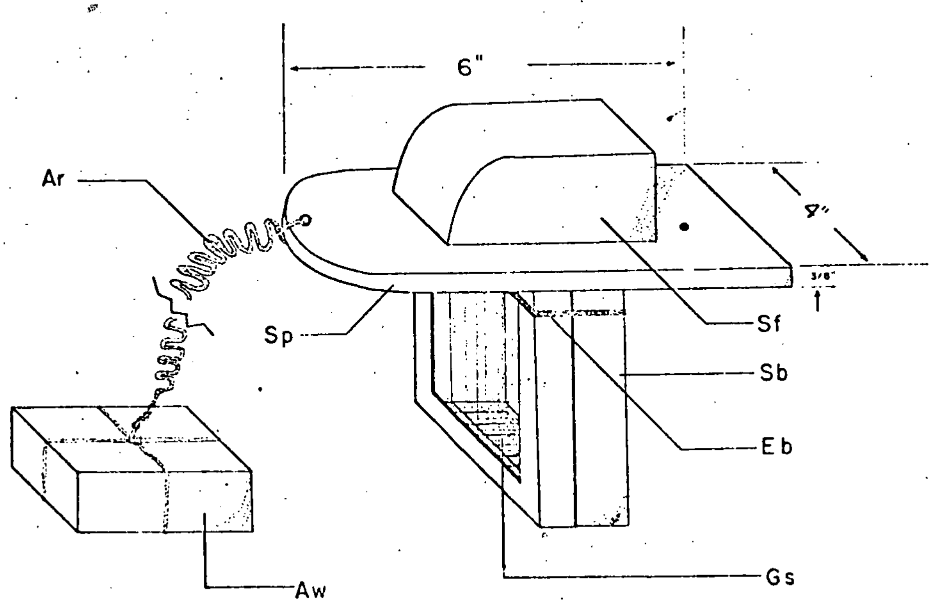


Fig. 1. The phyco-periphyton collector. Ar—anchor rope; Aw—anchor weight; Eb—elastic band; Gs—glass microscope slide; Sb—slide box (top and bottom cutout); Sf—styrofoam float; Sp—sampler platform.

Figure V-5 Proposed type of periphyton sampler.

(From J.W. Foerster "A Phyco-Periphyton Collector" Turtox News 47: 82, 1969).

a coating of bacterial filaments on all the sampling materials, together with amoebae, flagellates and a few diatoms. While these samplers will prove a useful adjunct to the routine net collections, it is clear that they will sample a different part of the canal flora. For comparative purposes a sampler will have to be set in the river, or at the inflow to the plant.

APPENDIX V-1 INDIAN POINT REACTOR - DISCHARGE CANAL

PHYTOPLANKTON ANALYSIS JULY

Date	Sample Site	Depth (ft)	S-R counts no./ml	Calc'd. no./m^3	Relative Abundance	% occurrence
10-VII-68	Canal (length)	L=120	12,620	$1143x10^3$	Melosira[1]	51
					Asterionella[2]	17
					Fragilaria[3]	9
					Surirella	5
	T = 30°C				Pediastrum	3
					Others	15
					Total genera seen	22
10-VIII-68	"In-gate"	-*	1,540	-*	Cyclotella	45
					Melosira[1]	22
					Nitzschia	9
	T = 26.6°C				Others	24
					Total genera seen	17
10-VIII-68	Pier	24	5,840	$2645x10^3$	Melosira[1]	66
					Asterionella[2]	10
					Fragilaria[3]	5
	T = 26.6°C				Nitzschia	4
					Others	15
					Total genera seen	15

Notes: 1 Melosira granulata, small quantity of M. islandica 2 Asterionella formosa

3 Fragilaria crotonensis *Not possible to measure depth of tow at gates

INDIAN POINT REACTOR - DISCHARGE CANAL

PHYTOPLANKTON ANALYSIS AUGUST

Date	Sample Site	Depth (ft)	S-R counts no./ml	Calc'd. no./m^3	Relative Abundance	% occurrence
30-VIII-68	Canal #1	18	540	326×10^3	Pediastrum	20
	T = 31°C				Nitzschia[1]	15
					Others	65
					Total genera seen	9
30-VIII-68	Canal #3	18	720	435×10^3	Pediastrum	20
	T = 31°C				Nitzschia[1]	17
					Others	63
					Total genera seen	14
30-VIII-68	Canal #4	19	1380	790×10^3	Pediastrum	12
	T = 31°C				Coscinodiscus[3]	12
					Nitzschia[1]	12
					Others	64
					Total genera seen	21
30-VIII-68	Canal #6	14	700	544×10^3	Pediastrum	23
	T = 31°C				Coscinodiscus[3]	17
					Nitzschia[1]	14
					Others	46
					Total genera seen	11

PHYTOPLANKTON ANALYSIS AUGUST continued

Date	Sample Site	Depth (ft)	S-R counts no./ml	Calc'd. no./ml^3	Relative Abundance	% occurrence
30-VIII-68	Canal #7	12	360	326x10^3	Synedra[4]	16
					Coscinodiscus[3]	11
	T = 31°C				Melosira[5]	11
					Nitzschia[2]	11
					Others	51
					Total genera seen	12
30-VIII-68	Pier	29	1340	502x10^3	Thallassiothrix	21
					Melosira[5]	13
	T = 26.9 C				Synedra[4]	13
					Pediastrum	13
					Others	40
					Total genera seen	17

Notes:

1 Nitzschia sigmoidea

2 N. paradoxa

3 Coscinodiscus denarius

4 Synedra ulna

5 Melosira granulata

Other species of diatoms present were:-

Cocconeis placentula (in clumps)

Cymbella tumida

Navicula cryptocephala

Cyclotella meneghiniana

INDIAN POINT REACTOR - DISCHARGE CANAL

PHYTOPLANKTON ANALYSIS OCTOBER

Date	Sample Site	Depth (ft)	S-R counts no./ml	Calc'd. no./m³	Relative Abundance	% occurrence
24-X-68	Canal #1	19	910	260×10^3	Pleurosigma	22
	T = 23.6°C				Nitzschia	17
					Others	61
					Total genera seen	13
24-X-68	Canal #3	21	800	207×10^3	Nitzschia	40
	T = 23.7°C				Thallassiothrix[1]	25
					Others	35
					Total genera seen	10
24-X-68	Canal #4	22	2020	329×10^3	Pleurosigma	23
					Chaetoceros	18
	T = 23.5°C				Nitzschia	16
					Thallassiothrix	13
					Coscinodiscus	8
					Others	22
					Total genera seen	12
24-X-68	Canal #6	17	990	316×10^3	Nitzschia	49
	T = 23.6°C				Pleurosigma	16
					Others	35
					Total genera seem	13

PHYTOPLANKTON ANALYSIS OCTOBER continued

Date	Sample Site	Depth (ft)	S-R counts no./ml	Calc'd. no./m^3	Relative Abundance	% occurrence
24-X-68	Canal #7	17	590	189×10^3	Pleurosigma	24
	T = 23.6°C				Others	76
					Total genera seen 13	
24-X-68	Pier	32	740	251×10^3	Thallassiothrix	27
	T = 19.2°C				Pleurosigma	24
					Others	49
					Total genera seen 9	

Notes: Blackfordia (medusa) and barnacle molts seen in most canal samples

1 Thallassiothrix longissima

INDIAN POINT REACTOR - DISCHARGE CANAL

PHYTOPLANKTON ANALYSIS DECEMBER 1968

DATE	Sample Site	Depth (ft)	S-R counts no./ml	Calc'd. no./m^3	Relative Abundance	% occurrence
19-XII-68	Canal #1	20	5500	2989x10^3	Melosira[2]	75
					Thallassiothrix	5
					Nitzschia	4
	T = 11.5°C				Pleurosigma[2]	4
					Others	12
					Total genera seen	18
19-XII-68	Canal #3	20	9120	4957x10^3	Melosira	64
					Bacteria[3]	7
					Nitzschia	5
	T = 11.5°C				Asterionella	3
					Pleurosigma	3
					Others	18
					Total genera seen	24
19-XII-68	Canal #4	20	8740	4750x10^3	Melosira	70
					Nitzschia	7
					Pleurosigma	5
	T = 12.4°C				Thallassiothrix	5
					Others	13
					Total genera seen	20
19-XII-68	Canal #6	25	6340	2757x10^3	Melosira	70
					Nitzschia	10
	T = 12.0°C				Asterionella	4

PHYTOPLANKTON ANALYSIS DECEMBER 1968 continued

Date	Sample Site	Depth (ft)	S-R counts no./ml	Calc'd. no./m^3	Relative Abundance	% occurrence
					Cyclotella	2
					Others	14
					Total genera seen	16
19-XII-68	Canal #7	17	5600	3581×10^3	Melosira	65
					Pleurosigma	9
	T = 11.9°C				Nitzschia	7
					Asterionella	4
					Thallassiothrix	7
					Others	8
					Total genera seen	16
19-XII-68	Pier	30	8340	3022×10^3	Melosira	72
	T = 2.0°C				Nitzschia	7
					Asterionella	5
					Thallassiothrix	4
					Others	12
					Total genera seen	23

Notes: 1 M. granulata

2 Mostly shells in all samples

3 Or blue-green algae, unidentified

INDIAN POINT REACTOR - DISCHARGE CANAL

PHYTOPLANKTON ANALYSIS JANUARY, 1969

Date	Sample Site	Depth (ft)	S-R counts no./ml	Calc'd. no./m^3	Relative Abundance	% occurrence
14-I-69	Canal #6	17	1420	908x10^3	Melosira	24
					Bacteria*	21
	T = 8.4°C				Phormidium	17
					Nitzschia	10
					Others	28
					Total genera seen	12
14-I-69	Pier	20	1040	565x10^3	Melosira	44
	T = 1.1°C				Nitzschia	12
					Others	44
					Total genera seen	11

Notes: * or blue-green algae, unidentified.

Melosira was M. granulata

APPENDIX V-2

ZOOPLANKTON IN DISCHARGE CANAL AND PIER OR "IN-GATE"

Date	Pier or "In-gate"		Canal (Composite)	
10-VII-68	Keratella quadrata	R	Keratella cochlearis	O
			Brachionus quadridentata	R
			Trichocerca	R
			Nematodes	R
	Ostracods	R		
	Daphnia pulex	O	Leptodora kindti	R
	Bosmina longirostris	C	B. longirostris	N
	Nauplius larvae	C	Nauplius larvae	N
	Cyclops vernalis	O-R	C. vernalis	C
	C. bicuspedatus	C		
	Eurytemora hirundoides	C	E. hirundoides	N
	Microarthridion littorale	C	M. hittorale	c
30-VIII-68			Trichocerca	R
			Brachionus quadridentata	R
			Gammarus fasciatus	R
			Nauplius larvae	C
	Ectinosoma curticorne	R	E. curticorne	R
			Canuella elongata	R
	Microarthridion littorale	R	M. littorale	O-R
			Eurytemora hirundoides	R
			E. lacustris	R
			Amnicola	R
24-X-68	Hydra oligactis	R		
	Blackfordia manhattanensis	R	B. manhattanensis	R
	Annelid (spionid) larvae	C	Annelid larvae	O-R
	Gammarus fasciatus	R		
	Canuella elongata	R	C. elongata	R
	Ectinosoma curticorne	R	E. curticorne	R
	Cyclops bicuspedatus	R		
	Eurytemora hirundoides	R	E. hirundoides	R
			Microarthridion littorale	R
			Amnicola	O-R

19-XII-68	Kellicottia	R	Seison	R
	Keratella cochlearis	R	Piscicola	R
			Nematodes	R
	Bosmina longirostris	R	B. longirostris	R
			Gammarus fasciatus	R
			Monoculoides edwardsii	R
	Nauplius larvae	R	Nauplius larvae	O-R
	Eurytemora hirundoides	R	E. hirundoides	O-R
	Diaptomus sp.	R	Diaptomus sp.	R
			Microarthridion littorale	R
			Cyclops bicuspedatus	R
			Ectinosoma curticorne	R
			Canuella elongata	R
			Acartia tonsa	R

Notes: B = Bloom

N = Numerous

C = Common

O = Occasional

R = Rare

VI FISH PROGRAM

Shore seining for fish in the Hudson River has been carried out during 1968 in two inter-related studies. First, the summer shore seining program, sampling nine stations on the west bank of the river between Tappan Zee bridge in the south, and Cementon, in the north, has been continued along the same lines as previous years. This study is limited to an intensive period of weekly sampling for 10 weeks in June, July and August (Table VI-1, Appendix VI-1). Secondly, a year-round monthly sampling program (using the same techniques) at one station on the east, and one on the west bank of the river has been followed from April to December. Collections were interrupted in January, by the freezing of the shore areas.

The data for stations in the Indian Point sector of the river through 1968 are listed in Appendix VI-1 and summarized in Table VI-2. The most common species of fish on the east bank station at Buchanan, were White Perch (*Roccus americanus*), with alewife (*Alosa pseudoharengus*) and spot-tail shiner (*Notropis hudsonius*) also relatively abundant. In contrast, on the west bank of the river (south of Jones Point) the most common species was the freshwater killifish (*Fundulus diaphanus*), with the spot-tail shiner (*Notropis hudsonius*), the summer or blue-back herring (*Alosa aestivalis*),

TABLE VI-1

Number of Tows and Computed Area (in Square Feet)

Seined at Each Station

Station (Mile)	June 17 - 18 24 - 25	July 1 - 2 7 - 8	July 15 - 16 22 - 23	July-Aug. 29 - 30 5 - 6	Aug. 12 -13 19-20	Total
South of Poughkeepsie						
IW3(26.6)						
No. of Tows	5	4	5	5	6	25
Total Area	20,000	20,000	20,000	20,000	20,000	100,000
Av. per Tow	4,000	5,000	4,000	4,000	3,333	4,000
IIW1(41.4)						
No. of Tows	5	3	3	6	5	22
Total Area	15,000	10,000	15,000	15,000	20,000	75,000
Av. per Tow	3,000	3,333	5,000	2,500	4,000	3,409
IIW2(45.2)						
No. of Tows	1	2	2	1	1	7
Total Area	5,000	5,000	10,000	5,000	5,000	30,000
Av. per Tow	5,000	2,500	5,000	5,000	5,000	4,286
IIW2A(56.5)						
No. of Tows	2	4	3	4	2	15
Total Area	10,000	15,000	15,000	20,000	10,000	70,000
Av. per Tow	5,000	3,750	5,000	5,000	5,000	4,667
IIIW2(67.3)						
No. of Tows	4	3	2	4	4	17
Total Area	10,000	10,000	10,000	15,000	10,000	55,000
Av. per Tow	2,500	3,333	5,000	3,750	2,500	3,235
North of Poughkeepsie						
IVW1(86.1)						
No. of Tows	5	3	2	7	4	21
Total Area	15,000	7,500	7,500	20,000	15,000	65,000
Av. per Tow	3,000	2,500	3,750	2,857	3,750	3,095
IVW2(95.1)						
No. of Tows	4	3	5	6	4	22
Total Area	15,000	15,000	20,000	20,000	12,500	82,500
Av. per Tow	3,750	5,000	4,000	3,333	3,150	3,750
IVW3(100.5)						
No. of Tows	3	2	2	4	5	16
Total Area	7,500	10,000	10,000	12,500	12,500	52,500
Av. per Tow	2,500	5,000	5,000	3,125	2,500	3,281
IVW4(104.7)						
No of Tows	4	3	3	5	5	20
Total Area	15,000	10,000	15,000	15,000	15,000	70,000
Av. per Tow	3,750	3,333	5,000	3,000	3,000	3,500

Table VI-2: Fish relative abundance at Indian Point. (No. caught p.u.a.)

Station II-E-1 1968.

Species	Apr	May	June	July	Aug	Sept	Oct	Dec	Allyear
Spot-tail shiner	66	640	0	160	1062	480	727	1750	464
FW Killifish	177	84	0	0	31	0	54	0	44
SW Killifish	44	0	0	0	0	22	0	0	10
Johnny Darter	0	0	18	80	0	0	90	250	30
White Perch	0	80	72	5120	250	783	1418	500	725
Striped bass	0	160	0	0	156	66	36	1375	84
Alewife									271
Blue-back herring									98
Shad									40
Total of common spp.									1,766

Station II-W-1 1968.

Species	Apr	May	June	July	Aug	Sept	Oct	Dec	Allyear
Spot-tail shiner	20	1040	346	0	3000	435	66	720	368
FW Killifish	7	140	426	2640	866	2462	2700	560	1224
SW Killifish	0	40	133	140	533	89	33	0	68
Johnny Darter	20	40	0	20	3733	711	33	280	302
Common sunfish	6	0	26	500	0	0	133	400	90
White perch	0	20	26	40	66	17	83	0	26
Striped bass	0	0	0	0	0	26	50	200	22
Shad									2
Alewife									184
Blue-back herring									360
4-spine stickle	73	100	240	180	0	0	220	1240	136
Total of common spp.									2,782

and the Johnny darter (Etheostoma nigrum) was also abundant. In total catch of fish (expressed in terms of 100,000 ft^2 unit area seined), the west bank station was more prolific than the east bank station. This and the difference in relative abundance of different species, is to be attributed to the inherent physical differences at the two stations rather than to other factors.

Considerable seasonal changes were observed, not only for the migrant anadromous population coming in to the river for spawning but also for species regarded as indigenous in the area. White perch were most often caught during the summer and fall, and this species in the catch declined to neglible numbers in the winter (and spring). The spot-tail shiner, common to both stations, was abundant in August, but big catches were also reported for December (east bank) and May (west bank). Freshwater killifish, abundant on the west bank but neglible on the east, were most abundant in July to October, in spite of the rising salinity of the water in this period. The brackish killifish, also common on the west bank, was most abundant during the same period. Johnny Darters were insignificant on the east bank, but reached very large numbers in August on the west bank.

Striped bass were seen at both stations, and seemed most abundant in December; this species was not seen at the west bank station until September, but had been observed sporadically on the east bank. In May (east bank), all the young striped bass were in the 1 + year class, but between September and October the 0 + and the 1 + year class were about equally represented at both stations. In December, the bulk of the young fish seemed to be in the 1 + year class.

The summer seining program data is summarized in Table VI-3, in which, following the practice of previous years, fish species at each station are grouped into year classes based on size frequency distribution. The catch at each station is summarized for the 15 most common species collected. The species most commonly caught in 1968 were roughly the same as those common in previous years, but some differences in the relative abundance of species can be seen, both for individual stations and for the whole river (Table VI-4). Quite wide variations can be seen in the period 1965 to 1968 in the numbers caught, not only of migrant fish, but also of some resident species. In general, the catch per unit of area in the four years is quite similar.

A closer comparison in the succeeding years may be made of station II-W-1 (Table VI-5). Summer data for the east bank station is also included, although this station

TABLE VI-3

Average Catch* at Each Station for the 15 Species Taken Most Frequently

Age Group	IW3	IIW1	IIW2	IIW2A	IIIW2	IVW1	IVW2	IVW3	IVW4	Average
Spottail Shiner										
0+	0	205	18	2	850	36	64	8	856	227
1+ or Older	10	39	4	6	334	13	133	0	13	61
Total	10	244	22	8	1184	49	197	8	869	288
Blueback Herring										
0+	0	11	0	0	0	3	5346	0	444	645
1+ or Older	0	0	0	0	0	0	1	6	12	2
Total	0	11	0	0	0	3	5347	6	456	647
Alewife										
0+	0	68	294	116	0	1148	0	33	82	193
1+ or Older	3	0	0	83	8	0	26	81	8	23
Total	3	68	294	199	8	1148	26	114	90	216
Shad										
0+	8	0	0	0	0	0	0	0	2	1
1+ or Older	0	0	0	0	0	0	0	0	0	0
Total	8	0	0	0	0	0	0	0	2	1
Goldfish										
0+	0	35	0	31	12	554	0	140	8	87
1+ or Older	0	3	0	0	8	2	0	0	14	3
Total	0	38	0	31	20	556	0	140	22	90
Carp										
0+	0	0	0	20	0	212	0	4	40	31
1+ or Older	0	1	0	1	0	0	0	0	2	0
Total	0	1	0	21	0	212	0	4	42	31

*Per Unit Area (See Text)

TABLE VI-3
(Continued)

Average Catch* at Each Station for the 15 Species Taken Most Frequently

Age Group	IW3	IIW1	IIW2	IIW2A	IIIW2	IVW1	IVW2	IVW3	IVW4	Aver
					Johnny Darter					
0+	0	103	84	2	21	111	12	430	238	111
1+ or Older	0	9	0	2	20	14	1	4	23	9
Total	0	112	84	4	41	125	13	434	271	120
					Common Sunfish					
0+	0	2	20	95	14	19	0	514	0	74
1+ or Older	3	59	118	924	86	60	1	85	10	150
Total	3	61	138	1019	100	79	1	599	10	224
					Golden Shiner					
0+	0	0	0	0	12	0	0	9	0	2
1+ or Older	5	8	4	153	325	23	24	3	19	63
Total	5	8	4	153	337	23	24	12	19	65
					White Perch					
0+	21	155	248	354	0	19	19	0	28	94
1+ or Older	74	169	108	103	20	34	70	12	106	77
Total	95	324	356	457	20	53	89	12	134	171
					Striped Bass					
0+	30	12	0	0	0	0	4	0	10	6
1+ or Older	0	0	0	0	0	0	1	0	0	0
Total	30	12	0	0	0	0	5	0	10	6
					Northern Silverside					
0+	8	1	0	0	0	0	0	0	0	0
1+ or Older	5	0	0	0	0	0	0	0	0	0
Total	13	1	0	0	0	0	0	0	0	0

*Per Unit Area (See Text)

TABLE VI-3
(Continued)

Average Catch* at Each Station for the 15 Species Taken Most Frequently

Age Group	IW3	IIW1	IIW2	IIW2A	IIIW2	IVW1	IVW2	IVW3	IVW4	Average
					Emerald Shiner					
0+	0	0	0	0	10	59	1	0	6	8
1+ or Older	1	0	0	2	50	2	96	0	0	17
Total	1	0	0	2	60	61	97	0	6	25
					Freshwater Killifish					
0+	9	275	244	81	112	25	5	619	690	229
1+ or Older	14	399	92	131	1540	92	43	34	164	279
Total	23	674	336	212	1652	117	48	653	754	508
					Saltwater Killifish					
0+	32	2	518	0	3	0	0	0	0	62
1+ or Older	25	103	518	2	231	0	2	0	1	42
Total	57	105	1036	2	233	0	2	0	1	104
TOTAL	248	1659	2250	2108	3655	2426	5849	1982	2596	2497

*Per Unit Area (See Text)

Table VI-4 Station II-W-1, Hudson River at Indian Point Summer collecting program.

Species	1965	1966	1967	1968	1968
Spot-tail shiner	253	640	799	244	407
FW Killifish	158	134	389	674	10
SW Killifish	455	303	310	105	0
Johnny Darter	19	1	63	112	33
White Perch	739	162	1642	324	1814
Striped Bass	88	9	137	12	52
Alewife	41	4	112	68	271*
Blueback herring	42	620	356	11	98*
Shad	126	8	6	0	40*
Goldfish	0	11	51	38	
Carp	0	0		1	
Common sunfish	4	49	161	61	
Golden shiner	4	4	20	8	
Northern silverside	693	3864	14	1	
Bay Anchovy	0	2			
Eel	36	21			
Tidewater silverside	4	0	32		
Mullet	0	20	0	0	
Total	2666	5852	4092	1659	2725

*Value for April to December.

Table VI- 5 All Stations, Hudson River, 1968

Species	Relative abundance (p.u.a.) 1965	1966	1967	1968
Spot-tail shiner	481	327	415	288
Blue-back herring	273	612	595	647
Alewife	65	23	103	216
Shad	73	40	3	1
Goldfish	107	70	60	90
Carp	3	1	0	31
Johnny Darter	336	166	329	120
Common sunfish	89	196	338	224
Golden shiner	7	120	62	65
White perch	372	160	302	171
Striped bass	41	60	32	6
Northern silverside	337	751	19	0
Emerald shiner	0	0	0	25
FW Killifish	470	547	1095	508
SW Killifish	364	594	419	104
Tidewater silverside	18	0	25	0
Anchovy	160	5	0	0
Mullet	32	0	0	0
Eel	28	10	0	0
Total	3281	3646	3797	2497

was not routinely sampled in previous years. The year 1968 seems to be characterized by a smaller number of fish in the catches, both in the river as a whole, and at individual stations. However, the reason for this may be that the annual movement of anadromous species which appeared in the summer collection period (mid-June to end of August) in previous years, did not take place at this time in 1968. However, species such as the blueback herring, alewife, silversides did not subsequently appear at stations II-E-1 and II-W-1 although these stations were sampled monthly. Whether this phenomenon is a temporary one or a manifestation of a long term change cannot be deduced from the present data.

Detailed data for the 1968 collections are given in Appendix VI-1 for the summer Hudson River program and in Appendix VI-2 for the year-round Indian Point program.

Appendix VI-1 Hudson River Collections, 1968

Fish seined on west bank, between Tappan Zee and Cementon.

Summary data, June-August 1968.

TABLE - 1

Length-Frequency Distribution Recorded for Spottail Shiner

Standard Length (Millimeters)	North of Poughkeepsie Period 1 No.	%	Period 2 No.	%	South of Poughkeepsie Period 1 No.	%	Period 2 No.	%
10-14	-	-	-	-	1	0.3	-	-
15-19	3	2.3	1	0.5	39	12.5	29	7.4
20-24	11	8.5	2	1.0	70	22.4	131	33.5
25-29	17	13.1	24	11.8	18	5.8	60	15.4
30-34	5	3.9	73	35.8	4	1.3	55	14.1
35-39	-	-	60	29.4	1	0.3	85	21.8
40-44	-	-	35	17.2	-	-	23	5.9
45-49	-	-	9	4.4	8	2.6	8	2.0
50-54	1	0.8	1	0.5	41	13.1	-	-
55-59	3	2.3	-	-	37	11.8	-	-
60-64	16	12.3	-	-	37	11.8	-	-
65-69	28	21.6	-	-	22	7.0	-	-
70-74	19	14.6	-	-	5	1.6	-	-
75-79	12	9.2	-	-	5	1.6	-	-
80-84	5	3.9	-	-	10	3.2	-	-
85-89	7	5.2	-	-	6	1.9	-	-
90-94	2	1.5	-	-	7	2.2	-	-
95-99	1	0.8	-	-	4	1.3	-	-
TOTAL	130	100.0	205	100.6	315	100.7	391	100.1

TABLE - 2

Length-Frequency Distribution Recorded for Striped Bass

Standard Length (Millimeters)	North of Poughkeepsie				South of Poughkeepsie			
	Period 1		Period 2		Period 1		Period 2	
	No.	%	No.	%	No.	%	No.	%
10-14	-	-	-	-	-	-	-	-
15-19	-	-	-	-	-	-	-	-
20-24	-	-	-	-	-	-	1	2.8
25-29	-	-	-	-	-	-	3	8.4
30-34	-	-	-	-	-	-	11	30.8
35-39	-	-	-	-	-	-	6	16.8
40-44	-	-	1	10.0	-	-	6	16.8
45-49	-	-	1	10.0	-	-	5	14.0
50-54	-	-	-	-	-	-	2	5.6
55-59	-	-	4	40.0	-	-	1	2.8
60-64	-	-	2	20.0	-	-	1	2.8
65-69	-	-	1	10.0	-	-	-	-
70-74	-	-	-	-	-	-	-	-
75-79	-	-	-	-	-	-	-	-
80-84	-	-	-	-	-	-	-	-
85-89	-	-	-	-	-	-	-	-
90-94	-	-	-	-	-	-	-	-
95-99	-	-	-	-	-	-	-	-
100-104	-	-	1	10.0				
TOTAL	0	-	10	100.0			36	100.8

TABLE - 3

Length-Frequency Distribution Recorded for Emerald Shiner

Standard Length (Millimeters)	North of Poughkeepsie Period 1 No.	%	Period 2 No.	%	South of Poughkeepsie Period 1 No.	%	Period 2 No.	%
10-14	-	-	-	-	-	-	-	-
15-19	-	-	-	-	-	-	-	-
20-24	2	8.3	-	-	-	-	-	-
25-29	-	-	-	-	-	-	-	-
30-34	1	4.2	3	2.3	-	-	-	-
35-39	1	4.2	11	8.6	1	3.1	-	-
40-44	1	4.2	7	5.5	4	12.4	-	-
45-49	2	8.3	17	13.3	9	27.9	-	-
50-54	-	-	21	16.4	11	34.1	-	-
55-59	-	-	2	1.6	2	6.2	-	-
60-64	2	8.3	5	3.9	1	3.1	-	-
65-69	2	8.3	8	6.2	1	3.1	-	-
70-74	7	29.1	31	24.2	-	-	-	-
75-79	1	4.2	17	13.3	1	3.1	-	-
80-84	3	12.5	4	3.1	2	6.2	-	-
85-89	1	4.2	1	.8	-	-	-	-
90-94	1	4.2	1	.8	-	-	-	-
TOTAL	24	100.0	128	100.0	32	99.2	-	-

TABLE - 4

Length-Frequency Distribution Recorded for Common Sunfish

Standard Length (Millimeters)	North of Poughkeepsie Period 1 No.	%	Period 2 No.	%	South of Poughkeepsie Period 1 No.	%	Period 2 No.	%
10-14	-	-	9	4.2	-	-	9	5.9
15-19	-	-	34	16.0	-	-	54	35.6
20-24	-	-	63	29.6	-	-	13	8.6
25-29	-	-	55	25.9	-	-	4	2.6
30-34	-	-	24	11.3	1	0.3	5	3.3
35-39	1	1.2	16	7.5	1	0.3	7	4.6
40-44	3	3.5	3	1.4	1	0.3	3	2.0
45-49	1	1.2	1	0.5	2	0.5	-	-
50-54	3	3.5	1	0.5	4	1.1	1	0.7
55-59	2	2.3	-	-	10	2.7	-	-
60-64	5	5.8	-	-	9	2.4	2	1.3
65-69	-	-	-	-	9	2.4	1	0.7
70-74	1	1.2	-	-	4	1.1	9	5.9
75-79	-	-	-	-	1	0.3	2	1.3
80-84	-	-	-	-	7	1.9	5	3.3
85-89	1	1.2	1	0.5	28	7.6	6	4.0
90-94	5	5.8	-	-	41	11.1	8	5.3
95-99	11	12.7	1	0.5	65	17.5	8	5.3
100-104	6	6.9	1	0.5	55	14.9	2	1.3
105-109	14	16.1	2	0.9	59	15.9	4	2.6
110-114	13	15.0	2	0.9	34	9.2	1	0.7
115-119	8	9.2	3	1.4	23	6.2	4	2.6
120-124	5	5.8	-	-	10	2.7	2	1.3
125-129	3	3.5	-	-	3	0.8	2	1.3
130-134	1	1.2	-	-	-	-	-	-
135-139	-	-	-	-	-	-	-	-
140-144	3	3.5	-	-	-	-	-	-
145-149	-	-	-	-	-	-	-	-
150-154	1	1.2	-	-	-	-	-	-
TOTAL	87	100.8	216	101.6	367	99.3	152	100.2

TABLE -5

Length-Frequency Distribution Recorded for Golden Shiner

Standard Length (Millimeters)	North of Poughkeepsie Period 1 No.	North of Poughkeepsie Period 1 %	North of Poughkeepsie Period 2 No.	North of Poughkeepsie Period 2 %	South of Poughkeepsie Period 1 No.	South of Poughkeepsie Period 1 %	South of Poughkeepsie Period 2 No.	South of Poughkeepsie Period 2 %
10-14	-	-	-	-	-	-	-	-
15-19	-	-	-	-	-	-	-	-
20-24	-	-	-	-	-	-	4	21.2
25-29	-	-	2	28.6	1	.5	1	5.3
30-34	-	-	4	57.2	-	-	-	-
35-39	-	-	1	14.3	-	-	-	-
40-44	1	2.0	-	-	3	1.4	-	-
45-49	1	2.0	-	-	9	4.2	-	-
50-54	5	10.0	-	-	31	14.6	-	-
55-59	4	8.0	-	-	27	12.7	1	5.3
60-64	3	6.0	-	-	26	12.2	-	-
65-69	4	8.0	-	-	9	4.2	-	-
70-74	9	18.0	-	-	4	1.9	1	5.3
75-79	3	6.0	-	-	8	3.8	-	-
80-84	2	4.0	-	-	8	3.8	2	10.6
85-89	1	2.0	-	-	2	.9	-	-
90-94	3	6.0	-	-	-	-	-	-
95-99	1	2.0	-	-	3	1.4	-	-
100-104	2	4.0	-	-	2	.9	1	5.3
105-109	-	-	-	-	3	1.4	-	-
110-114	-	-	-	-	3	1.4	-	-
115-119	-	-	-	-	3	1.4	-	-
120-124	2	4.0	-	-	8	3.8	-	-
125-129	1	2.0	-	-	6	2.8	1	5.3
130-134	-	-	-	-	6	2.8	1	5.3
135-139	-	-	-	-	6	2.8	1	5.3
140-144	1	2.0	-	-	6	2.8	2	10.6
145-149	-	-	-	-	6	2.8	-	-
150-154	2	4.0	-	-	2	.9	2	10.6
155-159	2	4.0	-	-	9	4.2	-	-
160-164	-	-	-	-	10	4.7	-	-
165-169	2	4.0	-	-	5	2.4	-	-
170-174	-	-	-	-	4	1.9	2	10.6
175-179	-	-	-	-	2	.9	-	-
180-184	1	2.0	-	-	2	.9	-	-
TOTAL	50	100.0	7	100.1	214	100.4	19	100.7

TABLE - 6

Length-Frequency Distribution Recorded for Shad

Standard Length (Millimeters)	North of Poughkeepsie				South of Poughkeepsie			
	Period 1		Period 2		Period 1		Period 2	
	No.	%	No.	%	No.	%	No.	%
10-14	-	-	-	-	-	-	-	-
15-19	-	-	-	-	-	-	-	-
20-24	-	-	-	-	-	-	-	-
25-29	-	-	-	-	-	-	-	-
30-34	-	-	-	-	-	-	-	-
35-39	-	-	-	-	-	-	2	25.0
40-44	-	-	-	-	-	-	2	25.0
45-49	1	100.0	-	-	-	-	4	50.0
TOTAL	1	100.0	0	-	0	-	8	100.0

TABLE-7

Length-Frequency Distribution Recorded for Johnny Darter

Standard Length (Millimeters)	North of Poughkeepsie Period 1 No.	%	North of Poughkeepsie Period 2 No.	%	South of Poughkeepsie Period 1 No.	%	South of Poughkeepsie Period 2 No.	%
10-14	3	1.2	-	-	0	-	0	-
15-19	17	6.6	3	0.9	1	1.8	0	-
20-24	68	26.5	20	6.0	16	28.8	0	-
25-29	109	42.5	48	14.4	15	27.0	4	4.0
30-34	26	10.1	92	27.6	4	7.2	17	17.0
35-39	7	2.7	99	29.7	2	3.6	31	31.0
40-44	2	0.8	47	14.1	3	5.4	34	34.0
45-49	9	3.5	9	2.7	3	5.4	10	10.0
50-54	4	1.6	3	0.9	3	5.4	1	1.0
55-59	7	2.7	4	1.2	6	10.8	1	1.0
60-64	2	0.8	6	1.8	1	1.8	-	-
65-69	-	-	1	0.3	1	1.8	-	-
TOTAL	254	99.0	332	100.6	55	99.0	98	98.0

TABLE - 8

Length-Frequency Distribution Recorded for Carp

Standard Length (Millimeters)	North of Poughkeepsie Period 1 No.	%	Period 2 No.	%	South of Poughkeepsie Period 1 No.	%	Period 2 No.	%
10-14	2	1.7	-	-	-	-	-	-
15-19	58	48.7	-	-	-	-	-	-
20-24	38	31.9	2	18.2	-	-	-	-
25-29	6	5.0	4	36.4	-	-	3	9.6
30-34	12	10.1	4	36.4	-	-	20	64.0
35-39	2	1.7	-	-	-	-	6	19.2
40-44	-	-	-	-	-	-	1	3.2
45-49	-	-	-	-	-	-	-	-
50-54	-	-	-	-	-	-	-	-
55-59	-	-	-	-	-	-	-	-
60-64	-	-	-	-	-	-	-	-
65-69	-	-	-	-	-	-	-	-
70-74	-	-	-	-	-	-	-	-
75-79	-	-	-	-	-	-	1	3.2
80-84	-	-	-	-	-	-	-	-
85-89	-	-	-	-	-	-	-	-
90-94	-	-	-	-	-	-	-	-
95-99	-	-	-	-	-	-	-	-
100-104	-	-	-	-	-	-	-	-
105-109	-	-	-	-	-	-	-	-
110-114	-	-	-	-	-	-	-	-
115-119	-	-	1	9.1	-	-	-	-
120-124	-	-	-	-	-	-	-	-
125-129	-	-	-	-	-	-	-	-
130-134	1	.8	-	-	1	100.0	-	-
TOTAL	119	99.9	11	100.1	1	100.0	31	99.2

TABLE-9

Length-Frequency Distribution Recorded for Blueback Herring

Standard Length (Millimeters)	North of Poughkeepsie Period 1 No.	%	North of Poughkeepsie Period 2 No.	%	South of Poughkeepsie Period 1 No.	%	South of Poughkeepsie Period 2 No.	%
10-14	-	-	-	-	-	-	-	-
15-19	-	-	-	-	-	-	-	-
20-24	-	-	42	8.4	-	-	-	-
25-29	-	-	74	14.8	-	-	-	-
30-34	-	-	156	31.2	-	-	-	-
35-39	-	-	172	34.4	-	-	-	-
40-44	-	-	42	8.4	-	-	10	91.0
45-49	1	14.3	8	1.6	-	-	1	9.1
50-54	3	42.9	2	0.4	-	-	-	-
55-59	-	-	1	0.2	-	-	-	-
60-64	2	28.6	1	0.2	-	-	-	-
65-69	-	-	2	0.4	-	-	-	-
70-74	-	-	-	-	-	-	-	-
75-79	-	-	-	-	-	-	-	-
80-84	-	-	-	-	-	-	-	-
85-89	-	-	-	-	-	-	-	-
90-94	-	-	-	-	-	-	-	-
95-99	1	14.3	-	-	-	-	-	-
TOTAL	7	100.1	500	100.0	0	0	11	100.1

TABLE -10

Length-Frequency Distribution Recorded for Alewife

Standard Length (Millimeters)	North of Poughkeepsie Period 1 No.	%	Period 2 No.	%	South of Poughkeepsie Period 1 No.	%	Period 2 No.	%
10-14	-	-	-	-	-	-	-	-
15-19	4	1.6	-	-	10	4.8	-	-
20-24	65	25.4	10	5.4	121	58.1	1	0.9
25-29	84	32.8	12	6.5	45	21.6	7	6.2
30-34	56	21.8	5	2.7	24	11.5	15	13.2
35-39	29	11.3	4	2.2	5	2.4	10	8.8
40-44	5	2.0	12	6.5	0	-	8	7.0
45-49	5	2.0	18	9.7	0	-	22	19.4
50-54	6	2.3	49	26.5	1	0.5	37	32.6
55-59	5	2.0	45	24.3	0	-	9	7.9
60-64	0	-	23	12.4	0	-	4	3.5
65-69	0	-	6	3.2	0	-	-	-
70-74	0	-	2	1.1	0	-	-	-
75-79					-	-	-	-
80-84					-	-	-	-
85-89					-	-	-	-
90-94					-	-	-	-
95-99					1	0.5	-	-
100-104					1	0.5	-	-
105-109					1	0.5	-	-
110-114					-	-	-	-
115-119					-	-	-	-
120-124					1	0.5	-	-
TOTAL	259	101.2	186	100.5	210	100.9	113	99.5

TABLE -11

Length-Frequency Distribution Recorded for Northern Silverside

Standard Length (Millimeters)	North of Poughkeepsie				South of Poughkeepsie			
	Period 1		Period 2		Period 1		Period 2	
	No.	%	No.	%	No.	%	No.	%
10-14	-	-	-	-	-	-	-	-
15-19	-	-	-	-	-	-	-	-
20-24	-	-	-	-	-	-	2	14.3
25-29	-	-	-	-	-	-	2	14.3
30-34	-	-	-	-	-	-	-	-
35-39	-	-	-	-	-	-	2	14.3
40-44	-	-	-	-	-	-	1	7.1
45-49	-	-	-	-	-	-	2	14.3
50-54	-	-	-	-	-	-	-	-
55-59	-	-	-	-	-	-	-	-
60-64	-	-	-	-	-	-	2	14.3
65-69	-	-	-	-	-	-	2	14.3
70-74	-	-	-	-	-	-	1	7.1
TOTAL	0		0		0		14	100.0

TABLE -12

Length-Frequency Distribution Recorded for White Perch

Standard Length (Millimeters)	North of Poughkeepsie Period 1 No.	%	North of Poughkeepsie Period 2 No.	%	South of Poughkeepsie Period 1 No.	%	South of Poughkeepsie Period 2 No.	%
10-14	-	-	-	-	-	-	5	2.3
15-19	1	1.0	3	2.8	66	16.5	33	15.2
20-24	1	1.0	3	2.8	18	4.5	95	43.7
25-29	2	2.0	-	-	1	0.3	45	20.7
30-34	1	1.0	5	4.6	23	5.8	4	1.8
35-39	-	-	10	9.2	29	7.3	2	0.9
40-44	-	-	7	6.4	11	2.8	5	2.3
45-49	-	-	3	2.8	4	1.0	1	0.5
50-54	-	-	1	0.9	2	0.5	-	-
55-59	2	2.0	-	-	4	1.0	-	-
60-64	10	10.0	-	-	17	4.3	-	-
65-69	15	15.0	-	-	11	2.8	-	-
70-74	21	21.0	-	-	18	4.5	1	0.5
75-79	21	21.0	4	3.7	11	2.8	1	0.5
80-84	5	5.0	12	11.0	6	1.5	2	0.9
85-89	1	1.0	9	8.3	2	0.5	8	3.7
90-94	-	-	11	10.1	6	1.5	1	0.5
95-99	-	-	1	0.9	3	0.8	-	-
100-104	3	3.0	1	0.9	12	3.0	2	0.9
105-109	3	3.0	2	1.8	15	3.8	1	0.5
110-114	3	3.0	8	7.4	14	3.5	1	0.5
115-119	1	1.0	4	3.7	19	4.8	1	0.5
120-124	6	6.0	6	5.5	19	4.8	1	0.5
125-219	-	-	9	8.3	15	3.8	-	-
130-134	2	2.0	7	6.4	14	3.5	3	1.4
135-139	-	-	1	0.9	28	7.0	1	0.5
140-144	1	1.0	1	0.9	7	1.8	2	0.9
145-149	1	1.0	1	0.9	7	1.8	-	-
150-154	-	-	-	-	6	1.5	2	0.9
155-159	-	-	-	-	5	1.3	-	-
160-164	-	-	-	-	2	0.5	1	0.5
TOTAL	100	100.0	109	100.2	395	99.0	218	100.1

TABLE -13

Length-Frequency Distribution Recorded for Goldfish

Standard Length (Millimeters)	South of Poughkeepsie Period 1 No.	%	Period 2 No.	%	South of Poughkeepsie Period 1 No.	%	Period 2 No.	%
10-14	1	0.8	7	2.5	1	9.1	3	5.4
15-19	11	9.1	15	5.3	1	9.1	4	7.2
20-24	45	37.4	24	8.4	1	9.1	12	21.6
25-29	51	42.3	79	27.7	1	9.1	14	25.2
30-34	1	0.8	110	38.5	-	-	8	14.4
35-39	2	1.7	31	10.9	-	-	6	10.8
40-44	-	-	15	5.3	-	-	6	10.8
45-49	-	-	4	1.4	-	-	2	3.6
50-54	-	-	1	0.4	-	-	-	-
55-59	-	-	-	-	-	-	-	-
60-64	-	-	-	-	-	-	-	-
65-69	-	-	-	-	1	9.1	-	-
70-74	-	-	-	-	-	-	-	-
75-79	-	-	-	-	-	-	-	-
80-84	1	0.8	-	-	-	-	-	-
85-89	-	-	-	-	-	-	-	-
90-94	1	0.8	-	-	-	-	-	-
95-99	1	0.8	-	-	1	9.1	-	-
100-104	1	0.8	-	-	-	-	-	-
105-109	-	-	-	-	-	-	-	-
110-114	2	1.7	-	-	1	9.1	-	-
115-119	1	0.8	-	-	-	-	-	-
120-124	1	0.8	-	-	-	-	-	-
125-129	-	-	-	-	2	18.2	-	-
130-134	-	-	-	-	-	-	-	-
135-139	1	0.8	-	-	-	-	-	-
140-144	-				1	9.1	1	1.8
145-149	-				-	-	-	-
150-154					-	-	-	-
155-159					-	-	-	-
160-164					-	-	-	-
165-169					-	-	-	-
170-174					-	-	-	-
175-179					1	9.1	-	-
TOTAL	120	99.4	286	100.4	11	100.1	56	100.8

TABLE - 14

Length-Frequency Distribution Recorded for Freshwater Killifish

Male

Standard Length (Millimeters)	North of Poughkeepsie Period 1 No.	%	Period 2 No.	%	South of Poughkeepsie Period 1 No.	%	Period 2 No.	%
10-14	-	-	-	-	-	-	-	-
15-19	-	-	-	-	-	-	-	-
20-24	-	-	-	-	-	-	-	-
25-29	-	-	-	-	-	-	-	-
30-34	-	-	-	-	-	-	-	-
35-39	-	-	1	3.0	3	1.1	-	-
40-44	-	-	-	-	34	12.9	-	-
45-49	6	13.8	3	9.0	53	20.1	2	5.0
50-54	8	18.4	5	15.0	57	21.7	7	17.5
55-59	8	18.4	8	24.0	34	12.9	8	20.0
60-64	9	20.7	8	24.0	27	10.3	10	25.0
65-69	4	9.2	7	21.0	30	11.4	8	20.0
70-74	3	6.9	1	3.0	20	7.6	4	10.0
75-79	5	11.5	-	-	4	1.5	1	2.5
80-84					2	0.8	-	-
					2	0.8	-	-
TOTAL	43	98.9	33	99.0	266	101.1	40	100.0

TABLE - 15

Length-Frequency Distribution Recorded for Freshwater Killifish

Immature

Standard Length (Millimeters)	North of Poughkeepsie				South of Poughkeepsie			
	Period 1		Period 2		Period 1		Period 2	
	No.	%	No.	%	No.	%	No.	%
10-14	-	-	-	-	-	-	-	-
15-19	-	-	16	6.1	3	5.9	13	5.2
20-24	-	-	35	13.3	5	9.8	59	23.6
25-29	-	-	92	35.0	1	2.0	96	38.4
30-34	1	50.0	76	28.9	3	5.9	62	24.8
35-39	1	50.0	32	12.2	15	29.4	20	8.0
40-44	-	-	9	3.4	12	23.5	-	-
45-49					11	21.6	-	-
50-54					1	2.0	-	-
TOTAL	2	100.0	260	98.9	51	100.1	250	100.0

TABLE - 16

Length-Frequency Distribution Recorded for Freshwater Killifish

Female

Standard Length (Millimeters)	North of Poughkeepsie Period 1 No.	%	Period 2 No.	%	South of Poughkeepsie Period 1 No.	%	Period 2 No.	%
10-14	-	-	-	-	-	-	-	-
15-19	-	-	-	-	-	-	-	-
20-24	-	-	-	-	-	-	-	-
25-29	-	-	-	-	-	-	3	3.1
30-34	-	-	-	-	1	0.3	5	5.2
35-39	-	-	11	12.1	10	2.6	11	11.3
40-44	3	3.3	21	23.1	42	10.7	14	14.4
45-49	5	5.5	4	4.4	87	22.2	5	5.2
50-54	13	14.3	2	2.2	77	19.6	10	10.3
55-59	17	18.7	5	5.5	68	17.3	13	13.4
60-64	21	23.1	9	9.9	21	5.4	22	22.7
65-69	11	12.1	22	24.2	17	4.3	6	6.2
70-74	9	9.9	13	14.3	34	8.7	4	4.1
75-79	2	2.2	1	1.1	19	4.8	4	4.1
80-84	6	6.6	2	2.2	14	3.6	-	-
85-89	1	1.1	1	1.1	1	0.3	-	-
90-94	2	2.2	1	1.1	-	-	-	-
95-99					1	0.3	-	-
TOTAL	90	99.0	92	101.2	392	100.1	97	100.0

TABLE - 17

Length-Frequency Distribution Recorded for Saltwater Killifish

Standard Length (Millimeters)	Female							
	North of Poughkeepsie				South of Poughkeepsie			
	Period 1		Period 2		Period 1		Period 2	
	No.	%	No.	%	No.	%	No.	%
10-14	-	-	-	-	-	-	-	-
15-19	-	-	-	-	-	-	-	-
20-24	-	-	-	-	-	-	1	1.0
25-29	-	-	-	-	-	-	3	3.0
30-34	-	-	-	-	-	-	9	9.0
35-39	-	-	-	-	2	1.1	33	33.0
40-44	-	-	-	-	13	7.2	15	15.0
45-49	-	-	-	-	39	21.5	6	6.0
50-54	-	-	-	-	44	24.2	8	8.0
55-59	1	50.0	-	-	32	17.6	12	12.0
60-64	1	50.0	-	-	11	6.1	7	7.0
65-69					19	10.5	4	4.0
70-74					6	3.3	2	2.0
75-79					8	4.4	-	-
80-84					2	1.1	-	-
85-89					4	2.2	-	-
90-94					-	-	-	-
95-99					-	-	1	1.0
100-104								
TOTAL	2	100.0	0		180	99.2	101	101.0

TABLE -18

Length-Frequency Distribution Recorded for Saltwater Killifish

Standard Length (Millimeters)	Immature							
	North of Poughkeepsie				South of Poughkeepsie			
	Period 1		Period 2		Period 1		Period 2	
	No.	%	No.	%	No.	%	No.	%
10-14	-	-	-	-	-	-	-	-
15-19	-	-	-	-	-	-	-	-
20-24	-	-	-	-	3	17.7	5	8.8
25-29	-	-	-	-	10	59.9	27	47.3
30-34	-	-	-	-	3	17.7	21	36.8
35-39	-	-	-	-	1	5.9	4	7.0
TOTAL	0		0		17	101.2	57	99.9

TABLE -19

Length-Frequency Distribution Recorded for Saltwater Killifish

Standard Length (Millimeters)	North of Poughkeepsie				South of Poughkeepsie (Male)			
	Period 1		Period 2		Period 1		Period 2	
	No.	%	No.	%	No.	%	No.	%
10-14	-	-	-	-	-	-	-	-
15-19	-	-	-	-	-	-	-	-
20-24	-	-	-	-	-	-	-	-
25-29	-	-	-	-	-	-	1	1.8
30-34	-	-	-	-	-	-	5	8.8
35-39	-	-	-	-	9	6.3	20	35.0
40-44	-	-	-	-	39	27.3	9	15.8
45-49	-	-	-	-	29	20.3	5	8.8
50-54	-	-	-	-	21	14.7	5	8.8
55-59			-	-	18	12.5	5	8.8
60-64	-	-	-	-	8	5.6	3	5.3
65-69	-	-	-	-	10	7.0	3	5.3
70-74	-	-	-	-	4	2.8	1	1.8
75-79	-	-	-	-	-	-	-	-
80-84					4	2.8	-	-
85-89					1	0.7	-	-
TOTAL					143	100.0	57	100.2

Appendix VI-2 Hudson River Collections, 1968

Fish seined at Indian Point east and west shores.

Summary data, March - December 1968.

Table 1 Fish seined on east and west shore at Indian Point, 1968.

Common Name	West (II-W-1)	East (II-E-1)
Freshwater killifish	612	13
Spot-tail shiner	184	137
Summer Herring	180	29
Johnny darter	151	9
Alewife	92	80
Stickleback	68	-
Common Sunfish	45	1
Brackish water killifish	34	3
White Perch	13	214
Striped Bass	11	25
Shad	1	12

Eel	13
Spearing	8
Golden shiner	6
Common Shiner	5
Catfish	5
Yellow perch	4
Bluefill Sunfish	3
Jack fish	3
Pipe fish	2
Blue fish	1
Smelt	1
Pickerel	1

Table - 2 Collections on West Shore (II-W-1)

Major occurring species

Species	Date	# of Tows	Area Seined (sq. ft.)	# Fish caught	Relative abundance
Notropis hudsonius "Spottail Shiner"	4/3 - 12/3	19	50,000	184	368
Fundulus diaphanus "Fresh-water Killifish"	"	"	"	612	1224
Fundulus heteroclitus "Brackish-water killifish"	"	"	"	34	68
Etheostoma nigrum "Johnny darter"	"	"	"	151	302
Lepomis gibbosus "Common Sunfish"	"	"	"	45	90
Roccus americanus "White Perch"	"	"	"	13	26
Roccus saxatilis "Striped Bass"	"	"	"	11	22
Alosa sapidissima "Shad"	"	"	"	1	2
Alosa pseudoharengus "Alewife"	"	"	"	92	184
Alosa aestivalis "Blue-back herring"	"	"	"	180	360
Apeltes quadracus "4 spine Stickle back"	"	"	"	68	136

Table -3 Collections on East Shore (II-E-1)

Major occurring species

Species	Date	# of Tows	Area Seined (sq. ft.)	# Fish caught	Relative abundance
Notropis hudsonius "Spottail Shiner"	4/3 - 12/3	18	29,500	137	464
Fundulus diaphanus "Fresh-water killifish"	"	"	"	13	44
Fundulus heterolitus "Brackish-water killifish"	"	"	"	3	10
Etheostoma nigrum "Johnny darter"	"	"	"	9	30
Lepomis gibbosus "Common sunfish"	"	"	"	1	725
Roccus americanus "White Perch"	"	"	"	214	725
Roccus saxatilis "Striped Bass"	"	"	"	25	84
Alosa sapidissima "Shad"	"	"	"	12	40
Alosa pseudoharengus "Alewife"	"	"	"	80	271
Alosa aestivalis "Blue-back herring"	"	"	"	29	98

Table 4 Minor species of fish seined on West (II-W-I) and East (II-E-1) shores.

Species	Date	# of Tows	Area Seined (sq. ft.)	# Fish caught	Relative abundance
<u>Anguilla</u> <u>rostrata</u> "Eel"	4/3 - 12/3	37	79,500	13	16
<u>Notropis</u> <u>atherinoides</u> "Emerald Shiner"	"	"	"	5	6
<u>Lepomis</u> <u>macrochirus</u> "Bluegill Sunfish"	"	"	"	3	3
<u>Ictalurus</u> <u>melas</u> "Brown bullhead"	"	"	"	5	6
<u>Notemigonus</u> <u>crysoleucas</u> "Golden shiner"	"	"	"	6	7
<u>Perca</u> <u>flavescens</u> "Yellow perch"	"	"	"	4	5
<u>Menidia</u> <u>menidia</u> "Spearing"	"	"	"	8	10
<u>Caranx</u> <u>hippos</u> "Crevalle Jack"	"	"	"	3	3
<u>Syngnathus</u> <u>fuscus</u> "pipe fish"	"	"	"	2	2
<u>Pomatomus</u> <u>saltratrix</u> "Blue fish"	"	"	"	1	1
<u>Esox</u> <u>nigra</u> "Pickerel"	"	"	"	1	1

Table- 5 West Shore (II-W-I)

Spottail Shiner, Notropis hudsonius

Date	# of Tows	Area Seined (sq. ft.)	# fish caught	Total Rel. abundance	Relative 0 +	abundance 1 + and older
4/13	(4) 50 x 50 (1) 50 x 100	15,000	3	20	-	20
5/15	(2) 50 x 50	5,000	52	1040	520	520
6/7	(1) 50 x 75	3,750	13	346	26	320
7/3	(2) 50 x 50	5,000	0	-	-	-
8/13	(2) 50 x 15	15,000	45	3000	3000	-
9/12	(3) 50 x 50 (1) 50 x 75	11,250	49	435	373	62
10/14	(2) 30 x 100	6,000	4	66	-	66
12/3	(1) 50 x 50	2,500	18	720	160	560

Table- 6 East Shore (II-E-I)

Spottail Shiner, Notropis hudsonius

Date	# of Tows	Area Seined (sq. ft.)	# fish caught	Total Rel. abundance	Relative 0 +	abundance 1 + and ol
4/3	(3) 50 x 30	4,500	3	66	-	66
5/14	(2) 25 x 25	1,250	8	640	160	480
6/7	(2) 50 x 50	5,500	0	-	-	-
7/3	(1) 50 x 25	1,250	2	160	-	160
8/13	(1) 40 x 30 (1) 40 x 50	3,200	34	1062	750	312
9/12	(3) 50 x 50	7,500	36	480	400	80
10/14	(1) 50 x 50 (1) 50 x 60	5,500	40	727	309	418
12/13	(2) 40 x 10	800	14	1750	500	1250

Table -7 West Shore (II-W-1)

(4 spine) Stickleback, *Apeltes quadracus*

Date	# of Tows	Area Seined (sq. ft.)	# fish caught	Total Rel abundance
4/3	(4) 50 x 50 (1) 50 x 100	15,000	11	73
5/15	(2) 50 x 50	5,000	5	100.0
6/7	(1) 50 x 75	3,750	9	240.0
7/3	(2) 50 x 50	5,000	9	180.0
8/13	(2) 50 x 15	1,500	0	-
9/12	(3) 50 x 50 (1) 50 x 75	11,250	0	-
10/14	(2) 30 x 100	6,000	13	217
12/3	(1) 50 x 50	2,500	31	1240.0

Table -8 West Shore (II-W-I)

Fresh-water killifish, Fundulus diaphanus

Date	# of Tows	Area Seined (sq. ft.)	# fish caught	Total Rel. abundnace	Relative 0 +	abundance 1 + and older
4/3	(4) 50 x 50 (1) 50 x 100	15,000	1	7	-	7
5/15	(2) 50 x 50	5,000	7	140	-	140
6/7	(1) 50 x 75	3,750	16	426	-	426
7/3	(2) 50 x 50	5,000	132	2640	380	2260
8/13	(2) 50 x 15	1,500	13	866	666	200
9/12	(3) 50 x 50 (1) 50 x 75	11,250	277	2462	311	2151
10/14	(2) 30 x 100	6,000	162	2700	933	1767
12/3	(1) 50 x 50	2,500	14	560	240	320

Table- 9 East Shore (II-E-I)

Fresh-water killifish, <u>Fundulus diaphanus</u>

Date	# of Tows	Area Seined (sq. ft.)	# fish caught	Total Rel. abundance	Relative abundance 0 +	Relative abundance 1 + and older
4/3	(3) 50 x 30	4,500	8	177	44	133
5/15	(2) 25 x25	1,250	1	84	-	84
6/7	(2) 50 x 50 (1) 50 x 10	5,500	0	-	-	-
7/3	(1) 50 x 25	1,250	0	-	-	-
8/13	(1) 40 x 30 (1) 40 x 50	3,200	1	31	-	31
9/12	(3) 50 x 50	7,500	0	-	-	-
10/14	(1) 50 x 50 (1) 50 x 60	5,500	3	54	-	54
12/3	(2) 40 x 10	800	0	-	-	-

Table -10 West Shore (II-W-I)

Brackish-water killifish, <u>Fundulus heteroclitus</u>

Date	# of Tows	Area Seined (sq. ft.)	# fish caught	Total Rel. abundance	Relative abundance 0 +	1 + and olde
4/3	(4) 50 x 50 (1) 50 x 100	15,000	0	-	-	-
5/15	(2) 50 x 50	5,000	2	40	-	40
6/7	(1) 50 x 75	3,750	5	133	-	133
7/3	(2) 50 x 50	5,000	7	140	-	140
8/13	(2) 50 x 15	1,500	8	533	400	133
9/12	(3) 50 x 50 (1) 50 x 75	11,250	10	89	53	36
10/14	(2) 30 x 100	6,000	2	33	-	33
12/3	(1) 50 x 50	2,500	0	-	-	-

Table -11 East Shore (II-E-1)

Brackish-water killifish, _Fundulus heteroclitus_

Date	# of Tows	Area Seined (sq. ft.)	# fish caught	Total Rel. abundance	Relative abundance 0 +	Relative abundance 1 + and older
4/3	(3) 50 x 30	4500	2	44	-	44
5/15	(2) 25 x 25	1250	0	-	-	-
6/7	(2) 50 x 50 (1) 50 x 10	5500	0	-	-	-
7/3	(1) 50 x 25	1250	0	-	-	-
8/13	(1) 40 x 30 (1) 40 x 50	3200	0	-	-	-
9/12	(3) 50 x 50	7500	1	22	-	22
10/14	(1) 50 x 50 (1) 50 x 60	5500	0	-	-	-
12/3	(2) 40 x 40	800	0	-	-	-

Table -12 West Shore (II-E-1)

Johnny darter, <u>Etheostoma</u> <u>nigrum</u>

Date	# of Tows	Area Seined (sq. ft.)	# fish caught	Total Rel. abundance	Relative 0 +	abundance 1 + older
4/3	(4) 50 x 50 (1) 50 x 100	15,000	3	20	-	20
5/15	(2) 50 x 50	5,000	2	40	-	40
6/7	(1) 50 x 75	3,750	-	-	-	-
7/3	(2) 50 x 50	5,000	1	20	-	20
8/13	(2) 50 x 15	1500	56	3733	3266	466
9/12	(3) 50 x 50 (1) 50 x 75	11,250	80	711	222	489
10/14	(2) 30 x 100	6,000	2	33	-	33
12/3	(1) 50 x 50	2,500	7	280	-	280

Table -13 East Shore (II-E-1)

Johnny darter, _Etheostoma nigrum_

Date	# of Tows	Area Seined (sq. ft.)	# fish caught	Total Rel. abundance	Relative abundance 0 +	1 + and older
4/3	(3) 50 x 30	4500	0	-	-	-
5/15	(2) 25 x 25	1250	0	-	-	-
6/7	(2) 50 x 50 (1) 50 x 10	5500	1	18	-	18
7/3	(1) 50 x 25	1250	1	80	-	80
8/13	(1) 40 x 30 (1) 40 x 50	3200	0	-	-	-
9/12	(3) 50 x 50	7500	0	-	-	-
10/4	(1) 50 x 50 (1) 50 x 60	5500	5	90	-	90
12/3	(2) 40 x 10	800	2	250	-	250

Table -14 West Shore (II-W-1)

Common Sunfish, *Lepomis gibbosus*

Date	# of Tows	Area Seined (sq. ft.)	# fish caught	Total Rel. abundance	Relative abundance 0 +	1 + and older
4/3	(4) 50 x 50 (1) 50 x 100	15,000	1	6	-	6
5/15	(2) 50 x 50	5,000	0	-	-	-
6/7	(1) 50 x 75	3750	1	26	-	26
7/3	(2) 50 x 50	5000	25	500	-	500
8/13	(2) 50 x 15	1500	0	-	-	-
9/12	(3) 50 x 50 (1) 50 x 75	11,250	0	-	-	-
10/14	(2) 30 x 100	6000	8	133	-	133
12/3	(1) 50 x 50	2500	10	400	-	400

Table -15 West Shore (II-W-1)

White Perch, *Roccus americanus*

Date	# of Tows	Area Seined (sq. ft.)	# fish caught	Total Rel. abundance	Relative abundance 0 +	Relative abundance 1 + and older
4/3	(4) 50 x 50 (1) 50 x 100	15,000	0	-	-	-
5/15	(2) 50 x 50	5,000	1	20	-	20
6/7	(1) 50 x 75	3750	2	26	-	26
7/3	(2) 50 x 50	5000	2	40	-	40
8/13	(2) 50 x 15	1500	1	66	-	66
9/12	(3) 50 x 50 (1) 50 x 75	11,250	2	17	-	17
10/14	(2) 30 x 100	6,000	5	83	-	83
12/3	(1) 50 x 50	2500	0	-	-	-

Table -16 East Shore (II-E-1)

White Perch, Roccus americanus

Date	# of Tows	Area Seined (sq. ft.)	# fish caught	Total Rel. abundance	Relative 0 +	abundance 1 + and older
4/3	(3) 50 x 30	4500	0	-	-	-
5/15	(2) 25 x 25	1250	1	80	-	80
6/7	(2) 50 x 50 (1) 50 x 10	5500	4	72	-	72
7/3	(1) 50 x 25	1250	64	5120	-	5120
8/13	(1) 40 x 30 (1) 40 x 50	3200	8	250	94	156
9/12	(3) 50 x 50	7500	55	733	293	440
10/14	(1) 50 x 50 (1) 50 x 60	5500	78	1418	109	1309
12/3	(2) 40 x 10	800	4	500	205	205

Table -17 West Shore (II-W-1)

Striped Bass, <u>Roccus</u> <u>saxatilis</u>

Date	# of Tows	Area Seined (sq. ft.)	# fish caught	Total Rel. abundance	Relative abundance 0 +	1 + and older
4/3	(4) 50 x 50 (1) 50 x 100	15,000	0	-	-	-
5/15	(2) 50 x 50	5,000	0	-	-	-
6/7	(1) 50 x 75	3750	0	-	-	-
7/3	(2) 50 x 50	5,000	0	-	-	-
8/13	(2) 50 x 15	1500	0	-	-	-
9/12	(3) 50 x 50 (1) 50 x 75	11,250	3	26	18	8
10/14	(2) 30 x 100	6,000	3	50	-	50
12/3	(1) 50 x 50	2,500	5	200	40	160

Table -17 East Shore (II-E-1)

Striped Bass, Roccus saxatilis

Date	# of Tows	Area Seined (sq. ft.)	# fish caught	Total Rel. abundance	Relative 0 +	abundance 1 + and older
4/3	(3) 50 x 30	4500	0	-	-	-
5/15	(2) 25 x 25	1250	2	160	-	160
6/7	(2) 50 x 50 (1) 50 x 10	5500	0	-	-	-
7/3	(1) 50 x 25	1250	0	-	-	-
8/13	(1) 40 x 30 (1) 40 x 50	3200	5	156	63	93
9/12	(3) 50 x 50	7500	5	66	40	26
10/14	(1) 50 x 50 (1) 50 x 60	5500	2	36	18	18
12/3	(2) 40 x 10	800	11	1375	250	1125

VII RADIONUCLIDE DATA

Samples of water, mud, fish and vegetation were collected from the Indian Point region during 1968, and analyzed by γ-spectroscopy for natural and man-made nuclides. The data for individual samples appear in Appendix VII-1 and Tables 1 to 4. Summarized data, relating grouped mud and fish samples to collection time, grouped samples of fish species, and vegetation to distance from the reactor effluent, appear in Tables VII-1 to VII-6. Finally, summary data for 1968 samples of water, mud, fish and vegetation have been compared with summary data for the years 1964 to 1967 (Tables VII-7 to VII-12). These summary data have been intercompared and recalculated on the basis of radionuclide standards prepared and used for the calibration of data in 1968. However, a difference in sampling exists for the 1968 data compared with earlier years, since only the Indian Point region was sampled in 1968. This difference is hardly significant for water samples since levels of activity are so low, but it reveals considerable differences in the sediment data, since the muds in the vicinity of the reactor effluent appear to sequester some nuclides from the contaminated river water before they are dispersed widely in the estuary. The difference in sampling is again of little significance for fish since the species sampled are largely free to move up

Table VII-1

HUDSON RIVER WATER 1969 - pCi/liter Whatman Filtered Samples

SAMPLES AT INDIAN POINT STATIONS COMBINED

Average by Pooling	E, W, Mid-Channel	Cs-137	Co-60	Zn-65	Mn-54	K-40	Ce-144	Ru-106	Ra-226	Th-232
May, 1969	Mean	-.020	-.021	-.962	.613	3.97	.347	2.32	-.343	.111
(3 Samples)	± S.D.*	.024	.134	1.53	.211	1.13	.194	.77	.205	.097
	± S.D.**	.036	.053	1.05	.087	.72	.226	.62	.079	.056
August, 1968	Mean	.040	-.061	-1.34	.126	7.86	.985	.786	-.040	.128
(3 Samples)	± S.D.*	.072	.051	1.12	.110	.21	1.230	.701	.197	.185
	± S.D.**	.039	.041	.57	.058	.61	.162	.390	.063	.046

*S.D. due to pooling samples

**S.D. due to counting

Table VII-2

Hudson River Mud 1968 pCi/g Dry Weight Monthly averages at Indian Point stations combined.
± standard error due to counting

Date	Cs-137	Co-60	Zn-65	Mn-54	K-40	Ce-144	Ru-106	Ra-226	Th-232
2 April	1.39 ±.08	.36 ±.07	3.54 ±1.03	1.19 ±.11	14.5 ±1.0	-1.68 ±3.68	1.76 ±.79	.80 ±.09	.86 ±.08
14 May	1.94 ±.08	1.25 ±.08	5.42 ±1.00	4.21 ±.13	17.0 ±1.1	3.76 ±3.55	1.81 ±.77	.98 ±.10	1.07 ±.08
4 June	2.36 ±.09	1.37 ±.09	5.24 ±.99	4.46 ±.12	18.6 ±1.1	6.60 ±3.53	1.01 ±.77	.91 ±.10	1.22 ±.08
2 July	2.18 ±.10	1.74 ±.08	4.02 ±1.03	4.21 ±.13	17.0 ±1.2	7.47 ±3.66	2.23 ±.82	1.10 ±.11	1.18 ±.09
13 Aug	2.66 ±.10	2.20 ±.09	4.69 ±1.00	5.02 ±.14	17.2 ±1.2	6.79 ±3.56	2.84 ±.81	1.20 ±.12	1.07 ±.10
10 Sept	1.51 ±.05	.12 ±.05	1.66 ±.73	.71 ±.07	19.1 ±.8	1.24 ±.28	1.33 ±.48	1.12 ±.08	1.35 ±.06
8 Oct	1.37 ±.07	.86 ±.06	1.82 ±.55	1.75 ±.07	16.4 ±.90	-1.33 ±2.07	.78 ±.49	.99 ±.08	.98 ±.07
3 Dec	1.14 ±.05	.11 ±.04	.31 ±.52	.49 ±.05	19.4 ±.7	1.25 ±.20	.41 ±.37	.83 ±.07	1.12 ±.05

Table VII-3

Hudson River Fish 1968 pCi/g Wet Weight. Average of all species and stations.

Month Collected	No. Samples	Cs-137	Co-60	Zn-65	Mn-54	K-40	Ce-144	Ru-106	Ra-226	Th-232
June '68	8	.032 ±.010	.003 ±.007	-.026 ±.079	.018 ±.017	1.36 ±.26	-.113 ±.246	.070 ±.030	.009 ±.010	.010 ±.008
July '68	6	.032 ±.017	.007 ±.006	.001 ±.040	.015 ±.014	1.39 ±.38	0.42 ±.115	.049 ±.039	.009 ±.002	.003 ±.003
Sept '68	2	.019 ±.013	.009 ±.003	.036 ±.008	.093 ±.049	2.15 ±.27	.212 ±.004	.010 ±.018	.014 ±.001	-.001 ±.001
Oct '68	3	.022 ±.009	.003 ±.001	.037 ±.026	.029 ±.011	1.89 ±.36	.002 ±.040	.014 ±.027	.009 ±.007	.002 ±.002

±Standard error due to pooling of samples.

Table VII-4

Hudson River Fish 1968 pCi/g Wet Weight. All collections averaged for species (standard error for n>1 is due to pooling)

Species	No. of Samples	Cs-137	Co-60	Zn-65	Mn-54	K-40	Ce-144	Ru-106	Ra-226	Th-232
Bullheads	n = 1	.025 ±.004	.009 ±.003	.045 ±.039	.017 ±.004	1.53 ±.06	-.055 ±.135	.025 ±.032	.003 ±.004	.006 ±.004
White Perch	n = 7	.037 ±.014	.001 ±.007	.001 .037	.026 ±.018	1.68 ±.32	.083 ±.106	.058 ±.049	.011 .004	.004 ±.003
Pumpkinseed	n = 2	.033 ±.005	.002 ±.008	-.003 ±.076	.015 ±.027	1.59 ±.15	-.220 ±.116	.080 ±.025	.009 ±.001	.009 ±.003
Fresh Water Killifish	n = 3	.024 ±.020	.010 ±.005	-.069 ±.112	.059 ±.064	1.41 ±.81	-.138 ±.427	.049 ±.028	.014 ±.018	.014 ±.013
Common Sunfish	n = 2	.022 ±.006	.007 ±.002	.002 ±.059	.014 ±.017	1.11 ±.04	.076 ±.134	.025 ±.012	.008 ±.001	.003 ±.001
Red Bellied Sunfish	n = 1	.033 ±.005	.010 ±.005	.035 ±.049	.013 ±.006	1.02 ±.07	-.086 ±.177	.078 ±.044	.006 ±.006	.002 ±.005
Golden Shiner	n = 1	.017 ±.005	.006 ±.005	.008 ±.056	.006 ±.006	1.44 ±.09	.071 ±.202	.043 ±.050	.010 ±.007	.001 ±.006
Alewife	n = 1	.022 ±.033	.004 ±.003	.065 ±.025	.038 ±.003	2.25 ±.05	.008 ±.092	-.015 ±.022	.007 ±.004	.004 ±.003
Hogchoker	n = 1	.015 ±.002	.002 ±.002	.032 ±.019	.017 ±.002	1.48 ±.04	.040 ±.071	.017 ±.017	.005 ±.003	-.000 ±.002

Table VII-5 (con't)

Hudson River Vegetation 1968. Average pCi/g Wet Weight for all species Aug. 21-Sept. 17

EAST BANK ONLY

Miles from Battery Park	No. of Samples	Cs-137	Co-60	Zn-65	Mn-54	K-40	Ce-144	Ru-106	Ra-226	Th-232
52.9	3	.024 +.003 (.007)	.022 +.003 (.006)	.033 +.026 (.006)	.798 +.006 (.173)	1.95 +.04 (.34)	.332 +.102 (.332)	.109 +.053 (.037)	.091 +.004 (.012)	.027 +.003 (.009)

Table VII-6

Hudson River Vegetation 1968. Average pCi/g Wet Weight for all species Aug. 21-Sept. 17

WEST BANK ONLY

± counting standard error
(...) pooling standard error

Miles from Battery Park	No. of Samples	Cs-137	Co-60	Zn-65	Mn-54	K-40	Ce-144	Ru-106	Ra-226	Th-232
35.5	2	.009 +.012 (.008)	.105 +.011 (.054)	.168 +.104 (.045)	4.48 +.042 (2.33)	1.11 +.14 (.134)	.560 +.455 (.211)	.170 +.118 (.018)	.096 +.014 (.041)	.014 +.013 (.006)
38.1	2	.005 +.015 (0.10)	.145 +.015 (0.19)	.295 +.130 (.083)	5.49 +.054 (.57)	2.18 +.20 (.58)	1.40 +.548 (.52)	.228 +.152 (.078)	.103 +.023 (.048)	.010 +.018 (.024)
39.2	1	.008 ±.007	.002 ±.006	-.047 ±.058	.902 ±.015	.240 ±.082	1.04 ±.23	.383 ±.063	.034 ±.010	.008 ±.007
40.2	2	-.001 +.008 (.003)	.126 +.008 (.043)	.197 +.071 (.064)	4.06 +.032 (1.77)	1.37 +.11 (.33)	.533 +.307 (.140)	.112 +.086 (.069)	.047 +.013 (.000)	-.004 +.010 (.009)
44.3	4	.009 +.008 (.007)	.121 +.007 (.034)	.211 +.071 (.038)	3.24 +.024 (.908)	1.76 +.10 (.27)	.598 +.291 (.483)	.182 +.071 (.099)	.145 +.011 (.093)	.029 +.009 (.019)
45.2	3	.024 +.005 (.015)	.052 +.004 (.005)	.088 +.042 (.027)	1.48 +.01 (.26)	1.91 +.06 (.24)	.657 +.161 (.157)	.082 +.040 (.024)	.088 +.006 (.024)	.026 +.005 (.016)
48.2	3	.026 +.007 (.009)	.058 +.007 (.021)	.158 +.072 (.106)	1.76 +.02 (.80)	2.05 +.10 (.37)	.386 +.265 (.659)	.130 +.065 (0.39)	.137 +.010 (.035)	.030 +.008 (.009)
50.9	3	.016 +.005 (.009)	.038 +.005 (.006)	.131 +.047 (.058)	1.61 +.013 (.53)	1.89 +.076 (.404)	.947 +.186 (.731)	.122 +.047 (.014)	.146 +.008 (.069)	.034 +.007 (.008)

Table VII-7

Radionuclide Concentration in Hudson River Water: South of West Point

Summary Data: 1964 - 1968

Radionuclide		Concentration in pCi/liter 1964	1965	1966	1967	1968
^{40}K	Mean	29.54±2.14	34.20±3.82	16.97±0.58	7.43±0.67	5.81±0.46
	Range	ND –45.74	1.34–65.56	1.90–22.82	ND –37.42	2.66–7.86
	Ratio*	8/9	7/7	19/19	9/11	6/6
^{226}Ra	Mean	0.01±0.07	0.50±0.23	0.11±0.04	0.20±0.05	<0.05
	Range	ND –0.12	ND –2.06	ND –0.55	ND –1.48	ND -0.15
	Ratio	2/9	4/7	9/19	6/11	1/6
^{228}Ra	Mean	0.93±0.29	0.30±0.18	0.08±0.03	0.17±0.03	0.12±.04
	Range	ND –2.96	ND –1.11	ND –0.34	ND –1.10	ND –0.34
	Ratio	8/9	4/7	9/19	9/11	5/6
^{54}Mn	Mean	0.36±0.12	0.01±0.11	0.09±0.03	0.07±0.04	0.37±0.05
	Range	ND –1.25	ND –0.05	ND –0.23	ND –0.17	0.04–0.78
	Ratio	5/9	1/7	9/19	10/11	6/6
^{60}Co	Mean	0.11±0.09	0.17±0.18	0.08±0.03	0.07±0.04	0.00±0.03
	Range	ND –0.70	ND –0.60	ND –0.32	ND –0.33	ND –0.13
	Ratio	2/9	3/7	9/19	9/11	1/6
^{106}Ru	Mean	2.77±1.45	1.55±0.67	0.30±0.14	0.27±0.09	0.78±0.19
	Range	ND –13.60	ND –5.08	ND –1.92	ND –0.80	0.10–1.50
	Ratio	4/9	3/7	8/19	8/11	6/6
^{137}Cs	Mean	1.24±0.21	0.94±0.29	0.12±0.04	0.22±0.04	0.01±0.03
	Range	ND –3.70	0.01–1.90	ND –0.40	ND –1.76	ND –0.13
	Ratio	8/9	7/7	15/19	9/11	3/6
^{144}Ce	Mean	0.52±0.34	1.32±0.66	0.12±0.09	0.34±0.11	0.83±0.17
	Range	ND –3.92	ND –3.20	ND –0.48	ND –2.66	0.06–2.95
	Ratio	3/9	5/7	10/19	7/11	6/6

*Ratio = No. of samples containing measurable activity/total No. of samples analyzed.

ND = None detected.

** = Indian Point stations only for 1968, May and August samples.

Table VII-8

Radionuclide Concentrations in Hudson River Water: North of West Point

Summary Data: 1965 - 1967

Radionuclide		Concentration in pCi/liter 1965	1966	1967
^{40}K	Mean	1.55±0.49	1.57±0.44	1.23±0.24
	Range	ND -8.51	ND -5.40	ND -3.63
	Ratio*	7/18	12/19	13/15
^{226}Ra	Mean	0.09±0.04	0.11±0.05	0.04±0.02
	Range	ND -0.34	ND -0.46	ND -0.16
	Ratio	6/18	12/19	8/15
^{228}Ra	Mean	0.09±0.04	0.07±0.03	0.03±0.01
	Range	ND -0.33	ND -0.44	ND -0.14
	Ratio	13/18	9/19	6/15
^{54}Mn	Mean	0.11±0.05	0.06±0.02	0.04±0.02
	Range	ND -0.44	ND -0.36	ND -0.15
	Ratio	11/18	6/19	10/15
^{60}Co	Mean	0.08±0.04	0.06±0.03	0.02±0.01
	Range	ND -0.35	ND -0.34	ND -0.07
	Ratio	9/18	7/19	7/15
^{106}Ru	Mean	0.27±0.16	0.47±0.17	0.16±0.05
	Range	ND -1.69	ND -2.40	ND -0.49
	Ratio	7/18	11/19	9/15
^{137}Cs	Mean	0.19±0.05	0.10±0.03	0.03±0.01
	Range	ND -0.50	ND -0.27	ND -0.08
	Ratio	13/18	14/19	9/15
^{144}Ce	Mean	0.48±0.15	0.30±0.11	0.12±0.04
	Range	ND -1.68	ND -0.80	ND -0.43
	Ratio	12/18	13/19	9/15

*Ratio = No. of samples containing measurable activity/total No. of samples analyzed.

ND = None detected.

Table VII-9

Radionuclide Concentrations in Hudson River Sediments: South of West Point

Summary Data: 1964 - 1968

Radionuclide		Concentration in pCi/g Dry Weight 1964	1965	1966	1967	1968**
^{40}K	Mean	12.45+0.36	13.38+0.32	14.39+0.46	12.69+0.36	17.37+.45
	Range	5.48-16.43	6.24-21.99	8.11-18.19	3.50-21.51	14.6-21.0
	Ratio*	11/11	19/19	12/12	14/14	15/15
^{226}Ra	Mean	0.28+0.02	0.76+0.03	0.74+0.04	0.72+0.03	1.06+.05
	Range	0.09-0.42	0.30-1.24	0.41-1.08	0.28-1.01	0.74-1.27
	Ratio	11/11	19/19	12/12	14/14	15/15
^{228}Ra	Mean	0.709+0.05	0.69+0.02	0.99+0.04	0.92+0.03	1.16+.04
	Range	0.06-1.39	0.03-1.09	0.63-1.37	0.27-1.62	0.77-1.41
	Ratio	11/11	19/19	12/12	14/14	15/15
^{54}Mn	Mean	0.83+0.03	0.13+0.03	0.16+0.02	0.35+0.02	3.21+.05
	Range	ND -5.17	ND -0.37	ND -0.32	ND -2.85	0.43-10.4
	Ratio	8/11	15/19	11/12	13/14	15/15
^{60}Co	Mean		0.07+0.02	0.08+0.03	0.18+0.02	1.24+.03
	Range	ND	ND -0.25	ND -0.19	ND -0.80	ND -3.48
	Ratio	0/11	12/19	7/12	12/14	14/15
^{106}Ru	Mean	4.54+0.39	0.81+0.01	0.43+0.15	0.55+0.10	0.82+.16
	Range	1.43-11.20	ND -2.79	ND -1.98	ND -1.81	ND -2.12
	Ratio	11/11	16/19	8/12	11/14	13/15
^{137}Cs	Mean	0.94+0.03	1.12+0.02	0.88+0.05	0.91+0.02	2.16+.04
	Range	0.17-2.80	0.09-2.63	0.31-2.12	0.19-2.49	0.24-3.88
	Ratio	11/11	19/19	12/12	14/14	15/15
^{144}Ce	Mean	2.38+.12	0.99+0.08	0.47+0.07	0.28+0.06	5.14+1.62
	Range	0.52-7.73	ND -2.52	ND -2.10	0.02-0.79	ND -17.1
	Ratio	11/11	18/19	9/12	14/14	13/15

*Ratio = No. of samples containing measurable activity/total No. of samples analyzed.

ND = None detected.

** = 1968 Data for Indian Point site only. June-October samples included for comparison with past years.

Table VII-10

Radionuclide Concentrations in Hudson River Sediments: North of West Point

Summary Data: 1965 - 1967

Radionuclide		Concentration in pCi/g Dry Weight		
		1965	1966	1967
^{40}K	Mean	14.20±0.35	12.39±0.30	9.23±0.26
	Range	7.85-23.43	8.49-15.80	5.21-12.54
	Ratio*	20/20	19/19	11/11
^{226}Ra	Mean	0.76±0.07	0.74±0.03	0.55±0.02
	Range	0.43-1.13	0.55-1.04	0.25-0.77
	Ratio	20/20	19/19	11/11
^{228}Ra	Mean	0.72±0.02	0.84±0.02	0.69±0.02
	Range	0.46-1.13	0.47-1.15	0.27-1.09
	Ratio	20/20	19/19	11/11
^{54}Mn	Mean	0.08±0.03	0.08±0.02	0.05±0.02
	Range	ND -0.18	ND -0.24	ND -0.15
	Ratio	15/20	13/19	9/11
^{60}Co	Mean	0.02±0.01	<0.004	0.02±0.01
	Range	ND -0.10	ND -0.07	ND -0.07
	Ratio	7/20	4/19	5/11
^{106}Ru	Mean	0.62±0.10	0.31±0.09	0.11±0.06
	Range	ND -2.66	ND -1.41	ND -0.42
	Ratio	13/20	12/19	7/11
^{137}Cs	Mean	0.74±0.03	0.49±0.02	0.33±0.02
	Range	0.01-2.31	ND -1.30	0.07-0.93
	Ratio	20/20	15/19	11/11
^{144}Ce	Mean	0.70±0.09	0.44±0.06	0.18±0.04
	Range	ND -1.71	ND -1.05	ND -0.42
	Ratio	19/20	18/19	10/11

*Ratio = No. of samples containing measurable activity/total No. of samples analyzed.

ND = None detected.

Table VII-11

Radionuclide Concentrations in Hudson River Fish

Summary Data: 1964 - 1968

Radionuclides		Concentration in pCi/g Wet Weight 1964	1965	1966	1967	1968**
^{40}K	Mean	0.58±0.02	0.54±0.04	1.20±0.02	0.66±0.02	1.51±0.02
	Range	ND - 2.1	ND - 1.4	0.28 - 3.13	0.32 - 1.22	0.84 - 2.30
	Ratio*	47/50	41/44	50/50	16/16	19/19
^{226}Ra	Mean	0.002±0.001	0.014±0.005	0.02±0.00	0.02±0.00	0.10±0.002
	Range	ND - 0.02	ND - 0.089	ND - 0.10	0.008 - 0.03	ND - 0.032
	Ratio	28/50	26/44	35/50	16/16	18/19
^{228}Ra	Mean	0.01±0.003	0.007±0.003	0.008±0.001	0.003±0.00	0.005±0.001
	Range	ND - 0.05	ND - 0.08	ND - 0.05	ND - 0.01	ND - 0.025
	Ratio	47/50	17/44	29/50	5/16	18/19
^{54}Mn	Mean	0.017±0.001	0.023±0.006	0.016±0.002	0.003±0.00	0.027±0.002
	Range	ND - 0.04	ND - 0.16	ND - 0.06	ND - 0.02	ND - 0.127
	Ratio	48/50	33/44	38/50	6/16	18/19
^{60}Co	Mean	<0.001	0.010±0.005	0.002±0.001	0.003±0.001	0.005±0.001
	Range	ND -0.01	ND - 0.16	ND - 0.02	ND - 0.01	ND - 0.022
	Ratio	11/50	19/44	7/50	5/16	14/19
^{106}Ru	Mean	0.077±0.014	0.092±0.024	0.029±0.009	0.04±0.01	0.024±0.002
	Range	ND - 0.42	ND - 1.50	ND - 0.15	0.01 - 0.07	ND - 0.064
	Ratio	41/50	30/44	34/50	16/16	17/19
^{137}Cs	Mean	0.036±0.001	0.041±0.005	0.029±0.002	0.02±0.00	0.031±0.001
	Range	ND - 0.09	ND - 0.13	ND - 0.16	0.01 - 0.10	0.011 - 0.07
	Ratio	49/50	42/44	49/50	16/16	19/19
^{144}Ce	Mean	0.038±0.003	0.042±0.014	0.012±0.004	0.01±0.00	<0.045
	Range	ND - 0.14	ND - 0.51	ND - 0.59	ND - 0.03	ND -0.266
	Ratio	43/50	22/44	27/50	6/16	9/19

*Ratio = No. of samples containing activity/total No. of samples.

ND = None detected.

** = 1968 Samples from June to October.

Table VII-12

Radionuclide Concentration in Hudson River Vegetation

Summary Data: 1965 - 1968

Radionuclide		Concentration in pCi/g Wet Weight 1965	1966	1967	1968**
^{40}K	Mean	1.350±0.016	1.237±0.020	1.95±0.04	1.76±0.03
	Range	0.25 -3.46	0.29 -2.56	1.28-2.82	0.24-2.55
	Ratio*	75/75	61/61	37/37	50/50
^{226}Ra	Mean	0.073±0.001	0.050±0.003	0.05±0.003	0.088±0.004
	Range	ND -0.28	ND -0.29	ND -0.37	ND -0.269
	Ratio	73/75	57/61	32/37	47/50
^{228}Ra	Mean	0.039±0.001	0.016±0.002	0.05±0.002	0.027±0.003
	Range	ND -0.40	ND -0.07	0.02-0.11	ND -0.148
	Ratio	71/75	45/61	37/37	47/50
^{54}Mn	Mean	1.000±0.003	0.806±0.011	0.41±0.003	4.34±0.009
	Range	ND -15.66	ND -12.77	0.08-1.47	0.172-33.6
	Ratio	74/75	59/61	37/37	50/50
^{60}Co	Mean	0.042±0.002	0.093±0.003	0.06±0.002	0.159±0.002
	Range	ND -0.68	ND -1.37	0.01-0.28	0.002-1.15
	Ratio	35/75	38/61	37/37	50/50
^{106}Ru	Mean	0.177±0.007	0.067±0.013	0.08±0.008	0.107±0.012
	Range	ND -0.93	ND -0.65	ND -0.29	0.009-0.671
	Ratio	71/75	58/61	36/37	50/50
^{137}Cs	Mean	0.080±0.001	0.023±0.001	0.03±0.002	0.018±0.002
	Range	0.01 -0.30	ND -0.23	0.01-0.12	ND -0.056
	Ratio	75/75	49/61	37/37	45/50
^{144}Ce	Mean	0.138±0.013	0.018±0.007	0.01±0.004	0.662±0.107
	Range	ND -0.51	ND -0.15	ND -0.06	ND -2.18
	Ratio	66/75	30/61	22/37	45/50

*Ratio = No. of samples containing activity/total No. of samples.
ND = None detected
** = Samples from June to September.

and down the river. For vegetation samples, collections were made between Cold Spring in the north to Grassy Point in the south, and can be equated with the samples collected in previous years.

Water samples for May and August only were analyzed. Little consistent or significant difference can be seen between samples from east, mid or west channel stations. The major contributor to activity is the potassium-40 component of stable potassium, and this increases with increasing salinity of the water. Values of K-40 for 1968, like 1967, were considerably less than in the years 1964 to 1966 when drought conditions increased the sea water incursion. Levels of the natural nuclides, radium-226 and thorium, were similar to those seen in previous years. Manganese-54, known to be released from the reactor, was high in 1968, as it was in 1964, and this could be related to known releases from the plant. Cobalt-60, presumably derived from fall-out and present in other years, was virtually undetectable in 1968. Ruthenium-106 was higher than the previous few years, but not so high as in 1964. Cesium-137, derived from the diminishing fall-out, was very small. Cerium-144, a minor activation product, was a little higher than in most former years.

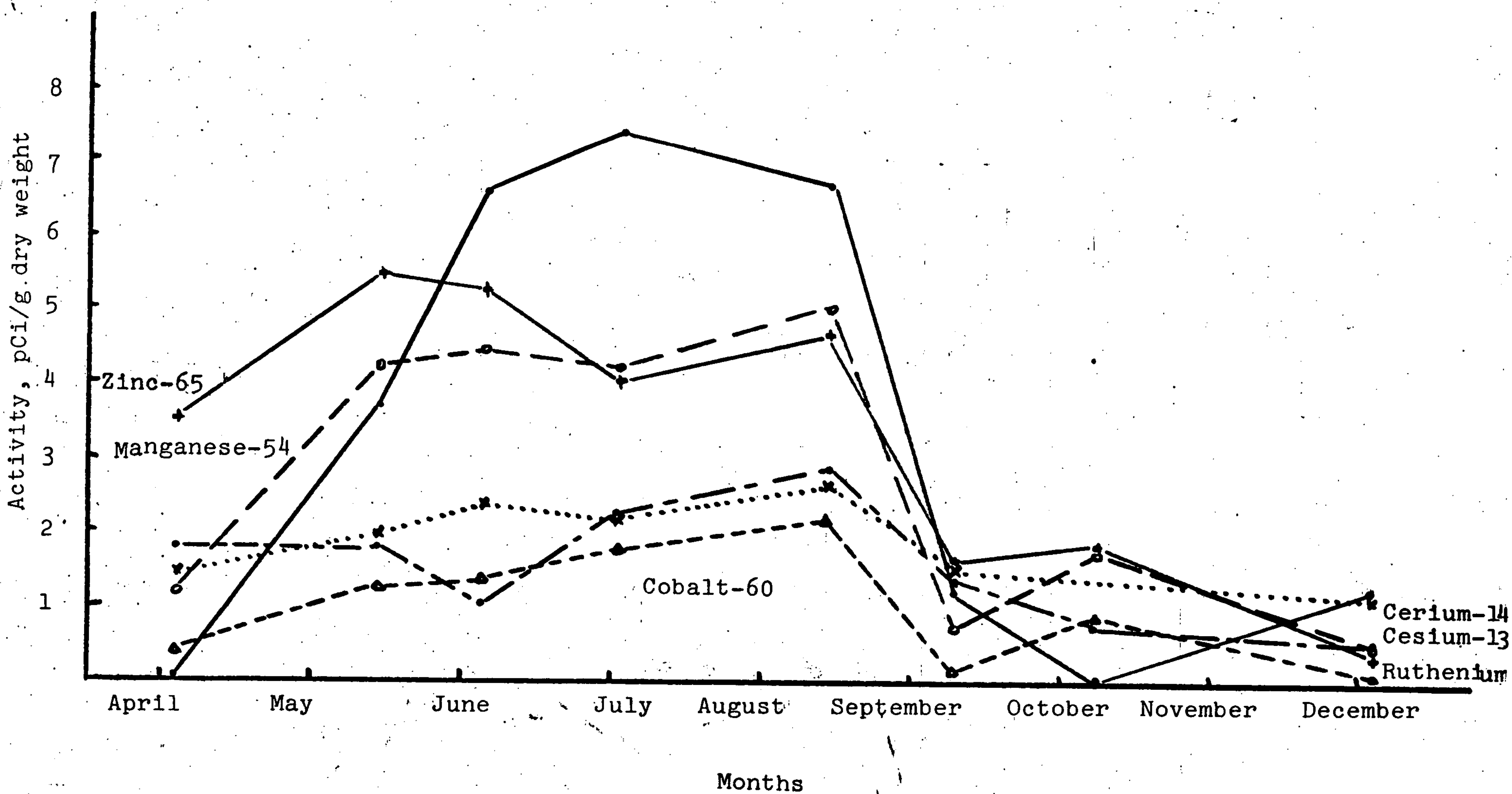
Apart from potassium-40, manganese-54 was the major nuclide in muds and was consistently high in the samples collected throughout the year. Cerium-144 was occasionally high, but the computer analysis sometimes gave negative estimates of its activity. Some zinc-65 appeared in the mud samples, presumably derived from fall-out.* East shore samples (closest to the reactor effluent) were consistently higher (especially in manganese-54) than other samples. The mud samples were higher in manganese-54 than in previous years, but this undoubtedly reflects differences in the sampling schedule (see above). Cobalt-60, cesium-137 and cerium-144 were also a little higher than in previous years.

There were observable changes in the levels of activity of manganese-54, zinc-65 and cerium-144 in the muds during the progress of the year (Figure VII-1). It is not known if this reflects only intermittent releases from the plant, or other unrelated environmental changes, such as the changing salinity which could affect sequestration of colloidal material on to the sediment particles.

Fish species were sampled individually from June through October, from both east and west shore stations. No consistent differences were observed between the nine different species, even though some of these were summer

* Reevaluation of the γ-spectroscopy suggests that the peak attributed to zinc-65 is due to iron-59 in all samples.

Figure VII-1 Pooled (E,W and Mid-channel) mud samples

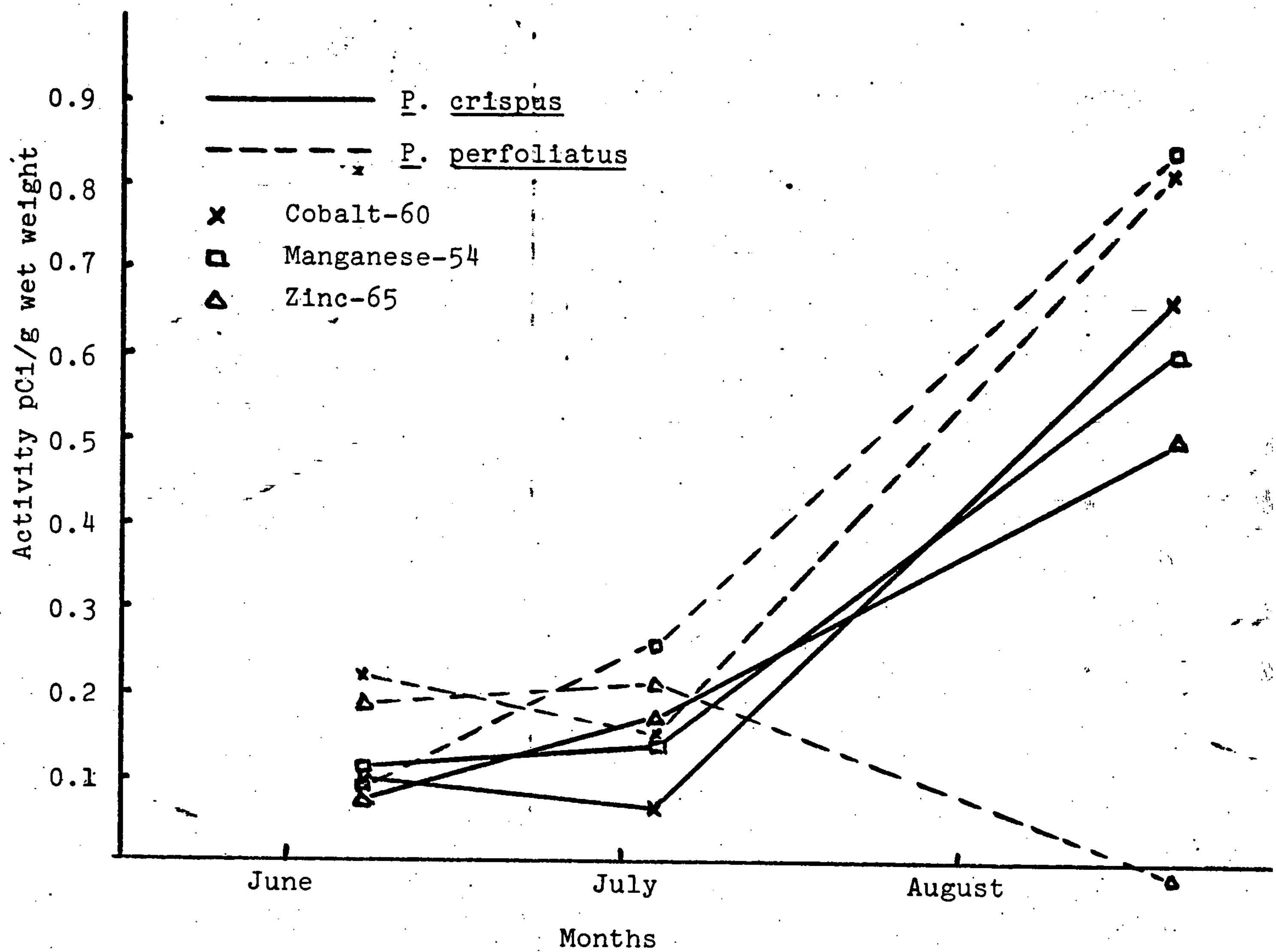


migrants and some year-round residents: some were carnivores, others mixed feeders. The principal contributor to total radioactivity was potassium-40 (0.85 - 2.34 pCi/g wet weight). Other nuclides (Zn-65, Mn-54, Cs-137, Co-60, Ra-226 and Th-232) were all 0.1 pCi/g wet weight or less. The levels of individual nuclides varied little from estimates of previous years. Such differences as were seen probably reflect the different species sampled, or different sizes of fish sampled, rather than different environmental conditions. Hence the fish do not seem to reflect environmental changes since time of collections, sampling site, or feeding regime do not seem to affect radionuclide levels in the fish significantly.

Rooted shore plants were collected from June through September (the extent of the growing season), and individual species were sampled separately (Appendix VII-1, Table 4). In the vicinity of the reactor effluent, manganese-54 was the largest contributor to the total radioactivity. There is evidence of an increase in manganese-54 levels (Figure VII-2) as well as in cobalt-60 and ruthenium-106 during the growing season. Other nuclides, for example cesium-137, do not seem to show such seasonal increases.

During the summer months, the plants were sampled extensively, not only from the routine east and west shore stations at Indian Point, but at a series of stations on both

Figure VII-2 Accumulation of nuclides in Potamogeton species during growing season.

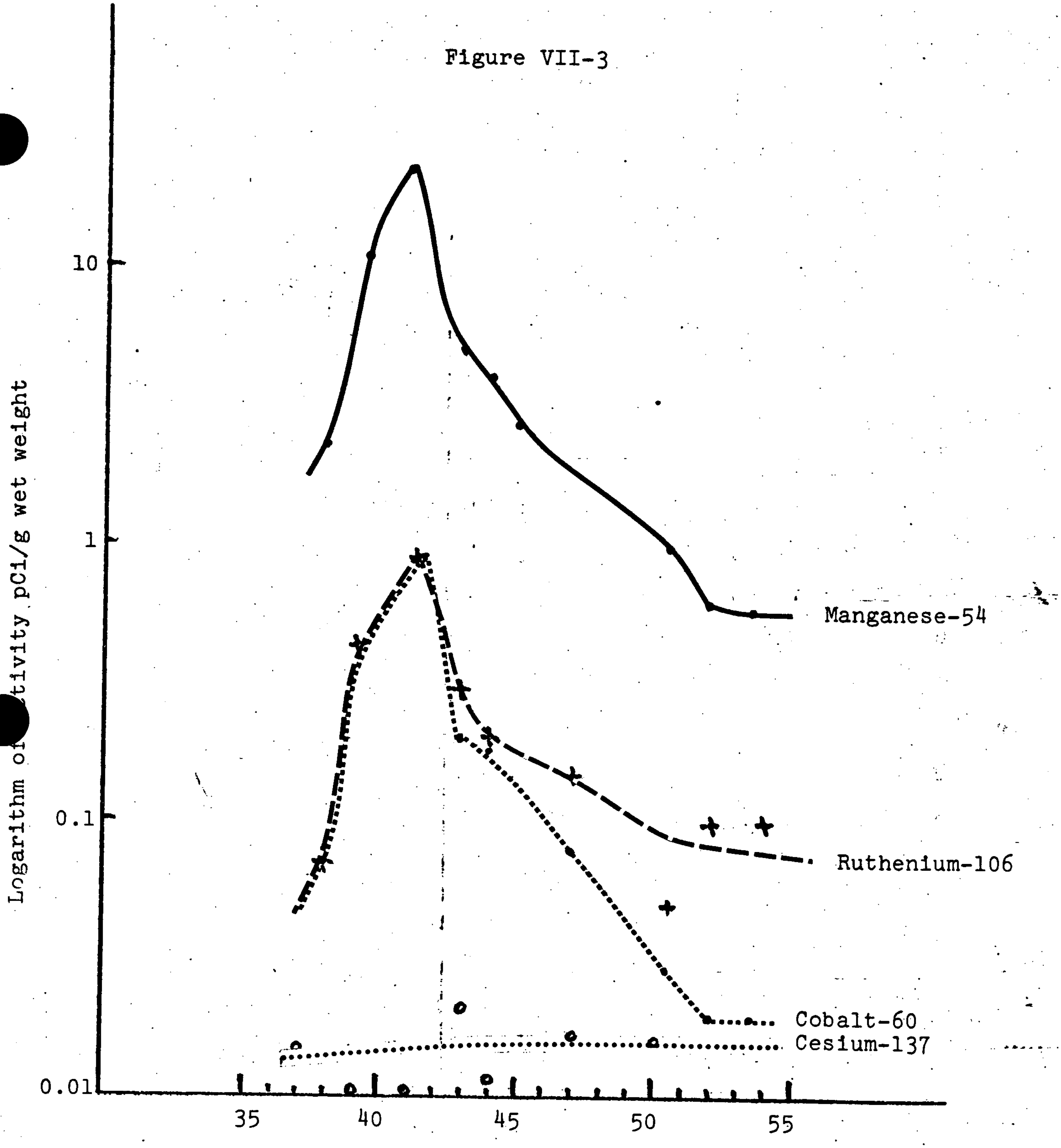


east and west banks between Grassy Point, 38 miles north of Battery Park, and Cold Spring, 53 miles north of Battery Park. The levels of manganese-54 in the plants were highest at stations nearest to the reactor effluent, as demonstrated in previous years; a similar distribution was observed for cobalt-60 and to a lesser extent for ruthenium-106. Other nuclides, for instance, cesium-137, did not show such a pattern of distribution (Figure VII-3).This pattern of distribution was much less obvious in samples collected from the west bank.

Compared with earlier years of sampling, the vegetation shows considerably higher levels of some nuclides, notably manganese-54, and to a lesser extent, cobalt-60, ruthenium-106, and cerium-144. It is thoughtthat this is related to known releases from the reactor in the early part of 1968, but since the releases apparently occurred before the initiation of the growing season, the correlation is not a simple one. Whether the plants take up the nuclides, particularly manganese, from soluble or particulate material in the ambient water, or if it is derived by a single or multiple process from the bottom sediments, is not clear.

It is certain, however, that the species of plants sampled are effective accumulators of some radionuclides, in particular manganese-54. This accumulation reflects the

Figure VII-3



Miles from Battery Park

Pooled vegetation samples, east bank only.

plants' ability to accumulate stable manganese and other similar elements. For this reason, the plants perform a useful role as environmental monitors of radioactivity in the water, often when water activity is so low as to be difficult to measure in reasonably small sample volumes. The ability of the plants, or other biota, to take up radiomanganese or other nuclides, can be predicted by their ability to take up the stable elements, as revealed by their stable element concentration.

The relation between the stable element or radionuclide concentration in animals and plants, and the level of the element or its isotope in the ambient water has been called the "concentration factor", the extent to which an animal or plant can accumulate an element or its isotope from the surrounding medium. Some attempt has been made to define this "concentration factor" for manganese for several classes of biota in the river (Table VII-13) for stable and radioactive manganese. However, a number of problems arise. In the first place, the concentration factor should be similar for all isotopes of an element since the mechanisms for accumulation are the same; only for isotopes of hydrogen, and doubtfully for carbon, is there evidence for a mass effect which would discriminate between the isotopes. Hence the

Table VII-13 MANGANESE LEVELS IN WATER, MUD AND BIOTA

HUDSON RIVER, 1965-1968

	MANGANESE	MANGANESE-54	$\frac{Mn^{54}\ pCi}{Mn^{53}\ pg}$
WATER:	soluble 0.5-12 μg/l total ca. 1 mg/l	0.18, 0.01-0.37 pCi/l	0.18×10^{-9}
MUD	1.52 mg/g dry (CF 1500)	0.93, 0.13-3.2 pCi/g (CF 5000)	0.61×10^{-9}
PLANTS	2.3 mg/g wet (CF 2300)	1.6, 0.41-4.3 pCi/g (CF 9000)	0.7×10^{-9}
FISH	0.006 mg/g wet (CF 6)	0.017, 0.003-0.027 pCi/g (CF 1000)	2.8×10^{-9}
CLAMS	ca. 0.005 mg/g wet (CF 5)	0.13 pCi/g (1965 only) (CF 7000)	26×10^{-9}

CF is concentration factor, ratio of concentration in sample to concentration in water.

concentration factors for stable manganese and radioactive manganese should be the same, if equilibrium has been reached. Secondly, the level of concentration in the ambient medium is rarely known with as much accuracy as that of the biological samples. The reason is that concentrations are generally several orders of magnitude lower, and hence the accuracy of determination is often less, unless very large samples are concentrated. Another difficulty lies in determining that part of the element which is available. For instance, in the case of manganese (Table VII-13) the soluble, stable, manganese (remaining after millipore filtration) is of the order of 10 ug/liter, but total manganese (including colloidal forms) is thought to be about 1 mg/liter. Radioactive manganese on the other hand, has been determined from a Whatman paper filtered sample, which would not retain colloids, but would retain particulates. Hence the comparable samples have 1 mg Mn/liter and 0.18 pCi Mn-54/liter. A still further complexity in determining concentration factors is that the water concentrations are rarely stable, but fluctuate so that it is difficult to define a level of concentration which may be termed characteristic of long periods.

In addition, the concentration factor implies that ambient water is the principal source of an element or nuclide, that entry through the diet is relatively insignificant, and that homeostatic mechanisms are also relatively unimportant in determining the equilibrium concentrations in animal or plant tissues.

In general, although the concentration factor gives some indication of the accumulation powers of the biota, the concept of specific activity (the ratio of radionuclide concentration to stable element concentration) seems more meaningful. In the Indian Point environment, it is clear that the rooted plants serve as efficient integrating monitors of environmental manganese (in any form) because they have mechanisms for sequestrating stable manganese. At the same time the fish, which like other vertebrates, have a limited absorption of manganese in the gut to supply the animal's requirements, do not accumulate stable or radioactive manganese to any large extent. Hence the concentration of stable manganese in fish tissues is small, and this limits the level of concentration of radiomanganese that can be acheived by the fish. Clams, on the other hand, which may contain plant foodstuffs unabsorbed, or phagocytosed in the digestive system, have greater powers of accumulation even though the element may not be physiologically incorporated into their tissues. However, the specific activities of stable to radioactive manganese still reveal inconsistencies, or lack of agreement with the theory that at equilibrium the specific activity should reach a stable level, since the ratios for fish and clams are out of line with those for mud and vegetation. The inconsistencies may be resolved with further investigation of the water and biota from Indian Point, since some of the stable manganese concentrations used in Table VII-13 are derived from literature values for other species. In addition, it is not sure whether the plants or animals sampled at Indian Point are in equilibrium with respect to manganese-54, although they must be for stable manganese.

Appendix VII-1

Radionuclide Data for individual samples of water, mud, vegetation and fish, 1968.

Table 1 Hudson River Water 1968 Indian Point Stations Whatman Filtered
Individual Samples. Mean ± standard error due to counting

pCi/liter

Sample	Site	Vol.	%Ash	Cs-137	Co-60	Zn-65	Mn-54	K	Zr-95	Ce-144	Ru-106	Ra-226	Th-23
1	Indian Pt.	17L	.0489	-0.016	-.066	-2.00	.787	4.34	-.642	.237	2.99	-.251	.111
14 May	West			±.071	±.082	±1.62	±.136	±1.11	±1.213	±.347	±.958	±.121	±.086
2													
14 May	Indian Pt.	18.3L	.0480	.001	-.127	.796	.379	4.86	.176	.232	2.49	-.201	.015
	Mid			±.068	±.078	±1.55	±.126	±1.07	±1.165	±.332	±.916	±.116	±.082
3													
14 May	Indian Pt.	13L	.0366	-.046	.129	-1.68	.674	2.70	2.49	.571	1.48	-.578	.208
	East			±.097	±.113	±2.23	±.183	±1.50	±1.69	±.478	±1.31	±.166	±.119
4	Indian Pt.	19L	.0925	.123	-.020	-1.94	.251	7.97	.854	.044	.587	-.239	.056
14 Aug	East			±.065	±.071	±1.12	±.096	±1.04	±.423	±.250	±.722	±.109	±.076
5	Indian Pt.	19L	.0957	.001	-.118	-2.03	.042	7.99	-.652	2.38	1.57	-.036	.338
14 Aug	Mid			±.071	±.079	±1.26	±.105	±1.15	±.458	±.301	±.805	±.123	±.086
6	Indian Pt.	19.4L	.0887	-.004	-.044	-.045	.086	7.62	--	.530	.207	.154	-.011
14 Aug	West			±.066	.063	±.272	±.099	±.992		±.290	±.450	±.093	±.074

Table 2

Hudson River Mud 1968 Indian Point Stations, Individual Samples
Mean ± standard error due to counting.

pCi/g Dry Weight

Sample	Site	Dry Weight	Cs-137	Co-60	Zn-65	Mn-54	K-40	Zr-95	Ce-144	Ru-106	Ra-226	Th-232
#211 2 April	II-E-1	28.31	0.245 ±0.059	0.287 ±.059	2.26 ±.867	1.75 ±.105	9.66 ±.838		3.17 ±3.05	0.259 ±.657	0.466 ±.079	0.403 ±.064
#212 3 April	II-W-1	14.06	2.54 ±.145	0.426 ±.128	4.83 ±1.89	0.635 ±.199	19.33 ±1.82		-6.53 ±6.70	3.27 ±1.44	1.13 ±.172	1.32 ±.142
#249 14 May	II-E-1	15.68	2.20 ±.174	1.99 ±.163	7.61 ±2.12	7.13 ±.289	18.7 ±2.19		7.29 ±7.47	2.02 ±1.62	0.958 ±.209	0.944 ±.169
#250 14 May	Indian Pt. Mid-Channel	17.74	1.29 ±.110	0.484 ±.102	2.96 ±1.34	2.15 ±.161	16.25 ±1.46		4.57 ±4.87	1.57 ±1.07	0.865 ±.138	1.17 ±.113
#251 14 May	II-W-1	17.05	2.35 ±.139	1.29 ±.126	5.68 ±1.64	3.36 ±.201	16.06 ±1.72		-0.578 ±5.84	1.87 ±1.26	1.13 ±.165	1.10 ±.134
#270 4 June	II-E-1	17.51	1.39 ±.169	0.265 ±.152	9.16 ±2.05	1.18 ±.223	17.46 ±2.24		4.82 ±7.07	-0.224 ±1.55	0.735 ±.210	1.09 ±.172
#271 4 June	Indian Pt. Mid-Channel	14.93	2.08 ±.136	0.308 ±.118	4.30 ±1.51	1.70 ±.175	16.87 ±1.71		13.8 ±5.55	1.62 ±1.21	1.05 ±.165	1.24 ±.134
#272 4 June	II-W-1	14.95	3.60 ±.142	3.53 ±.128	2.28 ±1.54	10.5 ±.228	21.4 ±1.64		1.18 ±5.59	1.64 ±1.22	0.952 ±.161	1.32 ±.132
#286 2 July	Indian Pt. Mid-Channel	14.81	2.26 ±.135	0.477 ±.113	1.45 ±1.37	1.55 ±.159	17.5 ±1.62		10.7 ±5.09	1.18 ±1.14	1.17 ±.160	1.24 ±.131
#287 2 July	II-E-1	15.25	2.07 ±.191	3.31 ±.185	7.54 ±2.14	6.31 ±.279	15.5 ±.232		9.95 ±7.41	3.69 ±1.66	1.01 ±.229	1.03 ±.187

Table 2 (con't) Hudson River Mud 1968 Indian Point Stations Individual Samples

Sample	Site	Dry Weight	Cs-137	Co-60	Zn-65	Mn-54	K-40	Zr-95	Ce-144	Ru-106	Ra-226	Th-232
#288 2 July	II-W-1	15.71	2.21 ±.166	1.43 ±.146	3.08 ±1.74	4.77 ±.229	18.1 ±2.01		1.78 ±6.31	1.83 ±1.41	1.11 ±.198	1.27 ±.163
#313 13 Aug	II-E-1	14.34	3.07 ±.223	3.46 ±.201	6.19 ±2.10	8.25 ±.304	17.6 ±2.59		9.83 ±7.55	3.07 ±1.72	1.17 ±.258	0.940 ±.206
#314 13 Aug	Indian Pt. Mid-Channel	15.31	2.65 ±.137	0.389 ±.111	1.00 ±1.22	1.22 ±.143	16.9 ±1.61		2.21 ±4.59	4.23 ±1.07	1.21 ±.160	1.29 ±.130
#315 13 Aug	II-W-1	17.01	2.25 ±.174	2.75 ±.160	6.86 ±1.70	5.60 ±.230	17.1 ±2.10		8.35 ±6.01	1.22 ±1.36	1.23 ±.206	0.970 ±.166
#339 10 Sept	II-E-1	18.12	0.225 ±.077	0.145 ±.086	2.39 ±1.24	0.633 ±.112	18.7 ±1.29	0.351 ±.369	1.09 ±.446	-0.244 ±.804	0.966 ±.131	1.32 ±.095
#340 10 Sept	Indian Pt. Mid-Channel	14.96	2.88 ±.104	0.221 ±.095	0.779 ±1.34	0.834 ±.123	19.2 ±1.39	1.23 ±.415	1.95 ±.557	3.16 ±.904	1.28 ±.147	1.41 ±.108
#341 10 Sept	II-W-1	16.14	1.44 ±.0847	-0.0118 ±.0837	1.80 ±1.21	0.666 ±.109	19.5 ±1.27	-0.0314 ±.360	0.672 ±.435	1.06 ±.802	1.11 ±.131	1.33 ±.0938
#59M 8 Oct	II-E-1	21.16	0.473 ±.0892	0.338 ±.0808	1.06 ±.781	0.426 ±.0903	16.4 ±1.25		0.627 ±2.89	0.585 ±.694	0.748 ±.117	0.767 ±.0936
#60M 8 Oct	Indian Pt. Mid-Channel	17.52	1.66 ±.119	0.817 ±.101	2.13 ±.958	1.64 ±.120	14.8 ±1.47		-3.23 ±3.61	1.06 ±.854	1.09 ±.145	1.12 ±.116
#61M 8 Oct	II-W-1	16.52	1.97 ±.137	1.42 ±.120	2.28 ±1.11	3.18 ±.150	18.1 ±1.71		-1.39 ±4.16	0.699 ±.986	1.13 ±.166	1.06 ±.133

Table 2 (con't) **Hudson River Mud 1968 Indian Point Stations Individual Samples**

pCi/g Dry

Sample	Site	Dry Weight	Cs-137	Co-60	Zn-65	Mn-54	K-40	Zr-95	Ce-144	Ru-106	Ra-226	Th-232
#65M 3 Dec	II-W-1	16.30	0.887 ±.0780	-0.0870 ±.0777	1.44 ±.926	0.105 ±.083	20.1 ±1.23	-0.139 ±.140	1.05 ±.35	0.211 ±.658	0.943 ±.125	1.27 ±.088
#66M 3 Dec	Indian Pt. Mid-Channel	15.98	2.09 ±.0923	0.326 ±.0861	0.878 ±.987	0.990 ±.0970	17.9 ±1.30	0.842 ±.160	2.01 ±.388	0.716 ±.713	1.04 ±.136	1.07 ±.0942
#67M 3 Dec	II-E-1	19.57	0.447 ±.0623	0.0837 ±.0648	-1.40 ±.771	0.366 ±.0704	20.29 ±1.04	0.0617 ±.118	0.692 ±.299	0.303 ±.536	0.504 ±.105	1.02 ±.0723

Table 3 Hudson River Fish 1968 pCi/g Wet Weight Individual Samples
(n is number of fish in sample)

Sample	Date Site	Cs-137	Co-60	Zn-65	Mn-54	K-40	Ce-144	Ru-106	Ra-226	Th-232
4R Bullheads n = 9	17 June II-W-1	0.025 ±.004	.009 ±.003	.045 ±.039	.017 ±.004	1.53 ±.06	-.055 ±.135	.025 ±.032	.003 ±.004	.006 ±.004
5R White Perch n = 31	17 June II-W-1	.035 ±.004	-.004 ±.004	.022 ±.046	.017 ±.005	1.35 ±.07	.184 ±.166	.060 ±.040	.006 ±.006	.005 ±.004
6R Pumpkinseed n = 10	17 June II-W-1	.036 ±.006	-.004 ±.005	.051 ±.062	.034 ±.007	1.69 ±.09	-.138 ±.223	.062 ±.054	.008 ±.008	.007 ±.006
7R Fresh Water Killifish n = 87	17 June II-W-1	.015 ±.006	.005 ±.006	-.071 ±.072	.047 ±.008	.854 ±.095	-.015 ±.760	.046 ±.065	0.004 ±.009	.018 ±.007
8R White Perch n = 20	17 June I-W-3	.028 ±.005	-0.002 ±.004	.031 ±.057	.023 ±.006	1.33 ±.08	.044 ±.201	.060 ±.048	.006 ±.007	.005 ±.005
9R White Perch n = 9	17 June II-W-2a	.043 ±.005	-.003 ±.005	-.052 ±.054	.008 ±.006	1.57 ±.08	-.009 ±.197	.128 ±.047	.011 ±.007	.004 ±.005
10R Fresh Water Killifish n = 32	17 June II-W-2a	.046 ±.014	.014 ±.013	-.180 ±.157	.003 ±.017	1.04 ±.20	-.613 ±.566	.078 ±.136	.032 ±.020	.025 ±.015
11R Pumpkinseed n = 50	17 June II-W-2a	0.029 ±.004	.007 ±.004	-.056 ±.050	-.004 ±.005	1.48 ±.07	-.302 ±.178	.097 ±.043	.010 ±.006	.011 ±.004

Table 3 (con't) Hudson River Fish 1968 pCi/g Wet Weight Individual Samples

Sample	Date Site	Cs-137	Co-60	Zn-65	Mn-54	K-40	Ce-144	Ru-106	Ra-226	Th-232
12R White Perch n = 34	3 July II-E-1	.065 ±.005	.015 ±.005	-.054 ±.054	.036 ±.006	2.03 ±.08	-.063 ±.194	.112 ±.047	.009 ±.007	.002 ±.005
18R Common Sunfish n = 16	15 July II-W-1	.026 ±.004	.008 ±.004	.044 ±.046	.026 ±.005	1.13 ±.07	-.019 ±.164	.016 ±.040	.007 ±.006	.003 ±.005
19R Common Sunfish n = 28	15 July II-W-2a	.017 ±.005	.005 ±.005	-.040 ±.048	.002 ±.005	1.08 ±.07	.170 ±.177	.033 ±.043	.009 ±.007	.002 ±.005
20R Red-Bellied Sunfish n = 7	15 July II-W-2a	.033 ±.005	.010 ±.005	.035 ±.049	.013 ±.006	1.02 ±.07	-.086 ±.177	.078 ±.044	.006 ±.006	.002 ± .005
21R White Perch n = 20	15 July II-W-2a	.031 ±.005	-.005 ±.005	.013 ±.063	.009 ±.006	1.62 ±.08	.176 ±.235	.009 ±.053	.013 ±.007	.010 ±.006
22R Golden Shiner n = 20	15 July II-W-2a	.017 ±.005	.006 ±.005	.008 ±.056	.006 ±.006	1.44 ±.09	.071 ±.202	.043 ±.050	.010 ±.007	.001 .006
45R White Perch	12 Sept II-E-1	.028 ±.005	.007 ±.004	.030 ±.045	.058 ±.005	1.96 ±.08	.209 ±.164	-.003 ±.040	.015 ±.006	.000 ±.005
46R Fresh Water Killifish	12 Sept II-W-1	.010 ±.005	.011 ±.005	.042 ±.052	.128 ±.006	2.34 ±.09	.215 ±.190	.023 ±.046	.013 ±.007	-.001 ±.006
67R White Perch n = 73	14 Oct II-W-1 II-E-1	.030 ±.004	.002 ±.004	.015 ±.036	.032 ±.004	1.93 ±.07	.039 ±.135	.039 ±.033	.016 ±.006	.001 ±.004

Table 3 (con't) Hudson River Fish 1968 pCi/g Wet Weight Individual Samples

Sample	Date Site	Cs-137	Co-60	Zn-65	Mn-54	K-40	Ce-144	Ru-106	Ra-226	Th-232
68R Alewife n = 130	14 Oct II-W-1	.022 ±.003	.004 ±.003	.065 ±.025	.038 ±.003	2.25 ±.05	.008 ±.092	-.015 ±.022	.007 ±.004	.004 ±.003
69R Hogchoker n = 35	15 Oct Mid-Channel	.015 ±.002	.002 ±.002	.032 ±.019	.017 ±.002	1.48 ±.04	-.040 ±.071	.017 ±.017	.005 ±.003	.000 ±.002

Table 4 Hudson River Aquatic Vegetation 1968. Individual Samples pCi/g Wet Weight

Sample No. Species Date Coll.	Coll. Site	Miles from Battery Park	Cs-137	Co-60	Zn-65	Mn-54	K-40	Ce-144	Ru-106	Ra-226	Th-232
#1R <u>P. crispus</u> 7 June'68	II-E-1	40.7E	0.015 +0.004	0.098 +.005	0.076 +.052	0.336 +.008	2.00 +.07	0.082 +.182	0.105 +.044	-.003 +.006	0.008 +.005
#2R <u>P. perfoliatus</u> 7 June'68	II-E-1	40.7E	0.045 +.006	0.219 +.007	0.186 +.066	1.247 +.015	2.27 +.09	0.149 +.235	0.085 +.056	-.005 +.008	0.009 +.006
#3R <u>P. perfoliatus</u> 7 June'68	II-W-1	41.5W	0.052 +.005	0.041 +.004	0.075 +.051	0.173 +.007	1.95 +.07	0.442 +.180	0.082 +.042	0.009 +.006	0.020 +.005
#13R <u>Vallisneria</u> sp. 3 July'68	II-W-1	41.5W	0.008 +.003	0.030 +.003	0.046 +.034	0.373 +.007	1.48 +.06	0.163 +.122	0.068 +.030	0.008 +.004	0.004 +.003
#14R <u>Chara</u> sp. 3 July'68	II-W-1	41.5W	0.049 +.009	0.085 +.008	0.126 +.089	0.838 +.019	1.65 +.13	1.094 +.324	0.200 +.078	0.040 +.011	0.022 +.009
#15R <u>P. perfoliatus</u> 3 July'68	II-W-1	41.5W	0.032 +.007	0.070 +.007	0.119 +.074	0.674 +.015	1.97 +.11	0.399 +.266	0.166 +.065	0.038 +.010	0.011 +.007
#16R <u>P. perfoliatus</u> 3 July'68	II-E-1	40.7E	0.046 +.012	0.148 +.012	0.217 +.122	2.076 +.037	1.89 +.17	0.830 +.465	0.265 +.118	0.044 +.017	0.015 +.013
#17R <u>P. crispus</u> 3 July'68	II-E-1	40.7E	0.032 +.006	0.067 +.006	.177 +.068	.694 +.016	1.61 +.10	.332 +.241	.143 +.059	.024 +.009	.008 +.007

Table 4 (con't)

Sample No. Species Date Coll.	Coll. Site	Miles from Battery Park	Cs-137	Co-60	Zn-65	Mn-54	K-40	Ce-144	Ru-106	Ra-226	Th-232
#16R P. perfoliatus 3 July'68	II-E-1	40.7E	0.046 ±.012	0.148 ±.012	0.217 ±.122	2.076 ±.037	1.89 ±.17	0.830 ±.465	0.265 ±.118	0.044 ±.017	0.015 ±.013
17R P. crispus 3 July'68	II-E-1	40.7E	.032 ±.006	.067 ±.006	.177 ±.068	.694 ±.016	1.61 ±.10	.332 ±.241	.143 ±.059	.024 ±.009	.008 ±.007
23R Myriophyllum sp. 13 Aug'68	II-E-1	40.7E	.005 ±.004	.165 ±.004	.185 ±.036	2.660 ±.013	1.07 ±.05	.105 ±.142	-.017 ±.038	.025 ±.006	.003 ±.005
24R Vallisneria sp. 13 Aug'68	II-W-1	41.5W	.017 ±.004	.068 ±.004	.066 ±.038	1.438 ±.012	1.90 ±.06	.792 ±.149	.099 ±.038	.077 ±.006	.033 ±.005
25R Myriophyllum sp. 21 Aug'68	Tompkins Cove	40.2W	-.003 ±.014	.156 ±.014	.242 ±.122	5.32 ±.055	1.60 ±.19	.632 ±.529	.161 ±.149	.047 ±.022	-.010 ±.018
26R P. crispus 21 Aug'68	Tompkins Cove	40.2W	.001 ±.009	.095 ±.009	.151 ±.074	2.80 ±.031	1.14 ±.11	.434 ±.310	.064 ±.085	.047 ±.013	.003 ±.010
27R Myriophyllum sp. 21 Aug'68	Stony Point	39.2W	.008 ±.007	.002 ±.006	-.047 ±.058	.902 ±.015	.240 ±.082	1.037 ±.234	.383 ±.063	.034 ±.010	.008 ±.007
28R Myriophyllum sp. 21 Aug'68	Grassy Point	38.1W	-.002 ±.019	.132 ±.019	.236 ±.163	5.088 ±.069	1.77 ±.25	1.030 ±.696	.172 ±.193	.069 ±.030	-.007 ±.023
29R Potamogeton sp. 21 Aug'68	Grassy Point	38.1W	.012 ±.024	.159 ±.023	.354 ±.202	5.89 ±.084	2.59 ±.31	1.76 ±.847	.283 ±.234	.137 ±.036	.027 ±.028

Table 4 (cont)

Sample No. Species Date Coll.	Coll. Site	Miles from Battery Park	Cs-137	Co-60	Zn-65	Mn-54	K-40	Ce-144	Ru-106	Ra-226	Th-232
#39R *Myriophyllum sp.* 26 Aug'68	Cold Spring	52.9E	0.16 ±.006	.018 ±.006	.035 ±.055	.992 ±.013	1.85 ±.09	.714 ±.212	.099 ±.052	.095 ±.008	.018 ±.006
40R *Myriophyllum sp.* 26 Aug'68	Con Hook	48.2W	.036 ±.018	.041 ±.018	.262 ±.192	1.17 ±.039	1.87 ±.26	-.335 ±.695	.151 ±.168	.156 ±.026	.028 ±.020
41R *Myriophyllum sp.* 26 Aug'68	Iona Island	45.2W	.010 ±.010	.049 ±.009	.119 ±.089	1.52 ±.02	1.69 ±.13	.827 ±.342	.110 ±.085	.082 ±.013	.011 ±.010
42R *Myriophyllum sp.* 26 Aug'68	Constitution Island	51.6E	.020 ±.008	.034 ±.008	.029 ±.076	.890 ±.016	1.89 ±.12	.356 ±.287	.142 ±.070	.110 ±.011	.018 ±.009
43R *Myriophyllum sp.* 26 Aug'68	Iona Island	44.3W	.006 ±.014	.086 ±.013	.197 ±.126	2.61 ±.04	1.70 ±.19	.914 ±.495	.113 ±.126	.088 ±.020	.011 ±.015
44R *P. perfoliatus* 26 Aug'68	Iona Island	44.3W	.005 ±.013	.097 ±.012	.201 ±.115	2.38 ±.04	1.52 ±.17	.746 ±.455	.081 ±.116	.060 ±.018	.014 ±.014
47R *P. crispus* 17 Sept'68	Constitution Island	51.6E	.027 ±.003	.013 ±.003	.003 ±.027	.449 ±.006	1.84 ±.05	.235 ±.103	.058 ±.025	.049 ±.004	.024 ±.003
48R *P. crispus* 17 Sept'68	Garrison	50.3E	.017 ±.004	.031 ±.004	.066 ±.035	.966 ±.009	1.76 ±.06	.368 ±.134	.056 ±.033	.069 ±.006	.021 ±.004
49R *P. crispus* 17 Sept'68	Con Hook	48.2W	.021 ±.006	.052 ±.006	.051 ±.053	1.43 ±.01	1.81 ±.09	.536 ±.208	.085 ±.053	.097 ±.009	.023 ±.007

Table 4 (con't)

Sample No. Species Date Coll.	Coll. Site	Miles from Battery Park	Cs-137	Co-60	Zn-65	Mn-54	K-40	Ce-144	Ru-106	Ra-226	Th-232
#50R P. pectinatus 17 Sept'68	Con Hook	48.2W	.021 ±.009	.081 ±.009	.160 ±.083	2.67 ±.03	2.48 ±.14	.957 ±.324	.155 ±.083	.160 ±.014	.040 ±.011
51R P. crispus 17 Sept'68	Iona Island	45.2W	.024 ±.005	.049 ±.005	.077 ±.049	1.20 ±.01	1.88 ±.08	.516 ±.189	.064 ±.047	.068 ±.008	.023 ±.006
52R P. pectinatus 17 Sept'68	Iona Island	45.2W	.039 ±.008	.057 ±.008	.068 ±.073	1.71 ±.02	2.17 ±.12	.629 ±.286	.073 ±.071	.114 ±.012	.043 ±.009
53R P. crispus 17 Sept'68	Manitou	47.0E	.023 ±.008	.072 ±.008	.071 ±.071	2.17 ±.02	2.37 ±.12	.651 ±.283	.100 ±.072	.126 ±.012	.039 ±.009
54R Myriophyllum sp. 17 Sept'68	Manitou	47.0E	.013 ±.008	.082 ±.008	.155 ±.075	2.48 ±.02	1.98 ±.12	.668 ±.291	.182 ±.076	.135 ±.013	.037 ±.009
55R P. pectinatus 17 Sept'68	Manitou	47.0E	.018 ±.010	.090 ±.009	.243 ±.089	3.05 ±.029	2.35 ±.14	.896 ±.345	.162 ±.090	.208 ±.015	.053 ±.011
56R P. crispus 17 Sept'68	Cold Spring	52.9E	.026 ±.003	.019 ±.003	.038 ±.032	.661 ±.007	1.67 ±.05	.162 ±.124	.079 ±.028	.077 ±.005	.028 ±.003
57R P. perfoliatus 17 Sept'68	Cold Spring	52.9E	.029 ±.004	.028 ±.005	.027 ±.046	.740 ±.010	2.32 ±.08	.119 ±.181	.150 ±.040	.101 ±.007	.035 ±.005

ble 4 (con't)

Sample No. Species Date Coll.	Coll. Site	Miles from Battery Park	Cs-137	Co-60	Zn-65	Mn-54	K-40	Ce-144	Ru-106	Ra-226	Th-232
#30R P. perfoliatus 21 Aug'68	Cable House	35.5W	.003 ±.013	.066 ±.012	.136 ±.110	2.83 ±.042	1.01 ±.16	.709 ±.459	.183 ±.123	.067 ±.019	.009 ±.015
31R Potamogeton sp. 21 Aug'68	Cable House	35.5W	.014 ±.019	.143 ±.019	.200 ±.176	6.13 ±.072	1.20 ±.22	.410 ±.786	.157 ±.201	.125 ±.020	.018 ±.022
32R Myriophyllum sp. 21 Aug'68		38.1E	.016 ±.009	.074 ±.008	.117 ±.083	2.51 ±.027	1.73 ±.12	.285 ±.348	.070 ±.085	.056 ±.013	.018 ±.010
33R P. perfoliatus 21 Aug'68	Montrose	39.5E	.019 ±.013	.348 ±.013	-.086 ±.110	11.19 .056	2.06 ±.15	1.48 ±.50	.455 ±.142	.051 ±.020	.065 ±.016
34R Myriophyllum sp. 21 Aug'68	Montrose	39.5E	-.006 ±.020	.294 ±.020	.362 ±.153	10.70 ±.084	1.59 ±.22	1.19 ±.721	.391 ±.212	.078 ±.031	.016 ±.075
35R P. crispus 21 Aug'68	Buchanan	40.7E	-.002 ±.024	.670 ±.024	.506 ±.168	18.64 ±.100	1.82 ±.23	1.42 ±.823	.616 ±.251	.057 ±.036	.001 ±.029
36R Myriophyllum sp. 21 Aug'68	Buchanan	40.7E	-.022 ±.018	.852 ±.019	.561 ±.131	21.98 ±.081	1.83 ±.17	-.428 ±.646	.533 ±.200	-.020 ±.028	-.012 ±.023
37R Potamogeton sp. 21 Aug'68	Buchanan	40.7E	.015 ±.073	1.17 ±.07	-.127 ±.498	33.76 ±.31	2.06 ±.61	.548 ±2.53	1.34 ±.77	.055 ±.106	.148 ±.086
38R P. perfoliatus 21 Aug'68	Buchanan	40.7E	.011 ±.048	.819 ±.047	-.086 ±.329	22.58 ±.20	1.95 ±.42	.094 ±1.658	.841 ±.498	.025 ±.069	.115 ±.056

Table 4 (con't)

Sample No. Species Date Coll.	Coll. Site	Miles from Battery Park	Cs-137	Co-60	Zn-65	Mn-54	K-40	Ce-144	Ru-106	Ra-226	Th-232
#58R *P. perfoliatus* 17 Sept'68	Fish Island	44.0E	.013 ±.011	.179 ±.012	.144 ±.104	3.99 ±.04	1.75 ±.14	.075 ±.440	.198 ±.106	.161 ±.017	.038 ±.013
59R *Myriophyllum sp.* 17 Sept'68	Fish Island	44.0E	.011 ±.015	.183 ±.016	.225 ±.143	4.56 ±.06	1.64 ±.19	-.293 ±.607	.216 ±.149	.161 ±.024	.034 ±.018
60R *P. pectinatus* 17 Sept'68	Iona Island	44.3W	.006 ±.019	.151 ±.019	.267 ±.182	4.31 ±.06	2.15 ±.25	.851 ±.754	.274 ±.181	.269 ±.030	.050 ±.022
61R *P. perfoliatus* 17 Sept'68	Iona Island	44.3W	.020 ±.014	.149 ±.015	.180 ±.139	3.67 ±.05	1.67 ±.19	-.120 ±.579	.261 ±.139	.161 ±.022	.039 ±.016
62R *P. perfoliatus* 17 Sept'68	West Point	50.9W	.026 ±.007	.032 ±.006	.064 ±.059	1.02 ±.02	2.26 ±.11	.252 ±.232	.106 ±.058	.083 ±.009	.036 ±.007
63R *P. pectinatus* 17 Sept'68	West Point	50.9W	.008 ±.011	.039 ±.010	.166 ±.096	2.04 ±.03	1.96 ±.15	1.71 ±.38	.130 ±.096	.219 ±.016	.041 ±.015
64R *Potamogeton* sp. 17 Sept'68	West Point	50.9W	.013 ±.009	.043 ±.009	.162 ±.084	1.78 ±.02	1.46 ±.13	.880 ±.337	.130 ±.086	.135 ±.014	.025 ±.011
65R *P. perfoliatus* 17 Sept'68	Peekskill	43.0E	.038 ±.008	.271 ±.008	.095 ±.104	5.36 ±.03	1.79 ±.11	.069 ±.041	.294 ±.084	.201 ±.014	.083 ±.009
66R *Myriophyllum* sp. 17 Sept'68	Peekskill	43.0E	.008 ±.070	.137 ±.021	.299 ±.194	3.73 ±.07	1.04 ±.25	-.664 ±.814	.291 ±.201	.141 ±.032	.024 ±.024

November 12, 1970

FISH PROTECTION AT INDIAN POINT UNIT NO. 1

CONSOLIDATED EDISON COMPANY
OF NEW YORK, NEW YORK

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SUMMARY

The Indian Point plant began operation in October, 1962. It was the first commercial nuclear power plant in the Empire State and the fourth -- and for some years later the largest -- in the nation.

One problem has marred the plant's record. Despite the Company's efforts, including the expenditure of approximately two million dollars, fish have been killed at the plant, a perplexing problem not only for the people at Con Edison but for concerned State and Federal agencies, sports enthusiasts, and conservationists. The attached report discusses the problem and the Company's efforts to resolve it.

Like all steam-electric generating plants, whether nuclear or conventional, Indian Point takes in river water to condense the steam that produces electricity and discharges that river water after it has been used for this cooling purpose. Because the Hudson River is a tidal estuary some of the warm water discharged downstream can be carried a short distance upstream during flood tide into the vicinity of the cooling water intake area where it may attract fish especially during the winter. Fish have not been killed as a direct result of this warm water discharge. Nor were the fish killed because the Indian Point station is nuclear fueled. Evidence indicates that the swimming performance of the fish, particularly white perch, is impaired in cold

water, preventing them from escaping impingement on protective screens even by relatively low intake flow velocities, (average approach velocity of 0.8 fps). The major change, therefore, consists of introducing a throttling procedure during the operation which will reduce the average intake velocity substantially (to approximately 0.5 fps). This is being done by partially closing the condenser outlet valves for Unit No. 1. Tests run in April, 1970 on Unit No. 1 (when the intake water temperature was 40°F) indicate that this throttling procedure was effective in lowering the number of fish collected on the traveling screens.

The problem has been further compounded by the periodic fouling of the protective screens with trash, leaves, and fibrous material, which has reduced the effectiveness of these screens. As the screens have become fouled, the intake velocity of the water has increased, making it more difficult for the small fish to swim away from the area. Attempts to keep these screens clean during these periods of heavy fouling have been only partially successful.

Most promising at present is a new intake water concept developed by Con Edison's engineers. This scheme will include a new screening structure built farther out from the shore into the main longitudinal flow of the river. The new structure will screen water for all three units at Indian Point and permit lower intake velocities than now exist. This will be particularly helpful during the colder parts of the year when it is believed a large number of fish congrégate in the area. It is planned that this work will be completed and in operation by the spring of 1973, at an estimated cost of $12 million.

The Company has offered to replace by stocking fish that have been killed if appropriate officials think it would be advisable and productive to do so.

The immediate need is to resolve the problem of the fish protection at Indian Point. The problem will call for continued effort and the implementation of an effective scheme.

INTRODUCTION

At various times since Indian Point Unit No. 1 ("Unit No. 1") commenced operation in October, 1962, there has been a problem with fish being killed at the intake of the station. This report provides a narrative description of this problem. The narrative is presented in chronological order and shows the continuing efforts made during the past eight years to improve the intake structure of Unit No. 1 so as to protect fish against injury from plant operation. Structural alterations and changes in operating procedures are explained and the effect of these changes is described.

Appendix A to this report contains data on the numbers of fish collected at the intake structure and the dates of collection. The appendix also includes data on species composition and average weight and length of the fish collected. Appendix B lists certain ecological and other studies which have been sponsored by Con Edison to date and their approximate cost to the Company. These studies are providing information useful to an understanding and resolution of the fish protection problem at Unit No. 1.

ORIGINAL CONFIGURATION OF UNIT NO. 1 INTAKE AND DISCHARGE STRUCTURES

Large volumes of water are needed by both nuclear and fossil fired power plants to condense the waste steam used in the electrical generation process. This water must be screened to prevent debris from clogging the narrow passages of the cooling system. Two types of screens are commonly used at power plants. Widely spaced heavy bars known as a trash rack prevent large debris such as logs and floating ice from entering the intake structure and making contact with a fine mesh screen used for barring the entry of small debris. This fine mesh traveling screen consists of an endless belt of screen panels which move vertically through the inflowing water picking up the small debris. The debris which is picked up by the traveling screen is washed off by a spray system.

The original configuration of the Unit No. 1 intake structure and discharge channel is important to an understanding of the fish protection problem at this unit (Figures 1, 2A, and 3). The original arrangement consisted of four open intakes each 11 feet 2 inches wide, positioned at the water's edge. The depth of the water at the intakes is approximately 26 feet at low tide and varies with tidal changes.

A concrete skimmer wall extended from above the water level to a depth of 13 feet and 6 inches below the water surface across the front of each intake. The water was, therefore, withdrawn from the river at the bottom of each intake forebay.

Each open forebay led to a traveling screen, recessed approximately 30 feet from the water's edge. The traveling screens consisted of sections of screening with a 0.375 inch square wire mesh and a narrow lip along the length of the lower edge

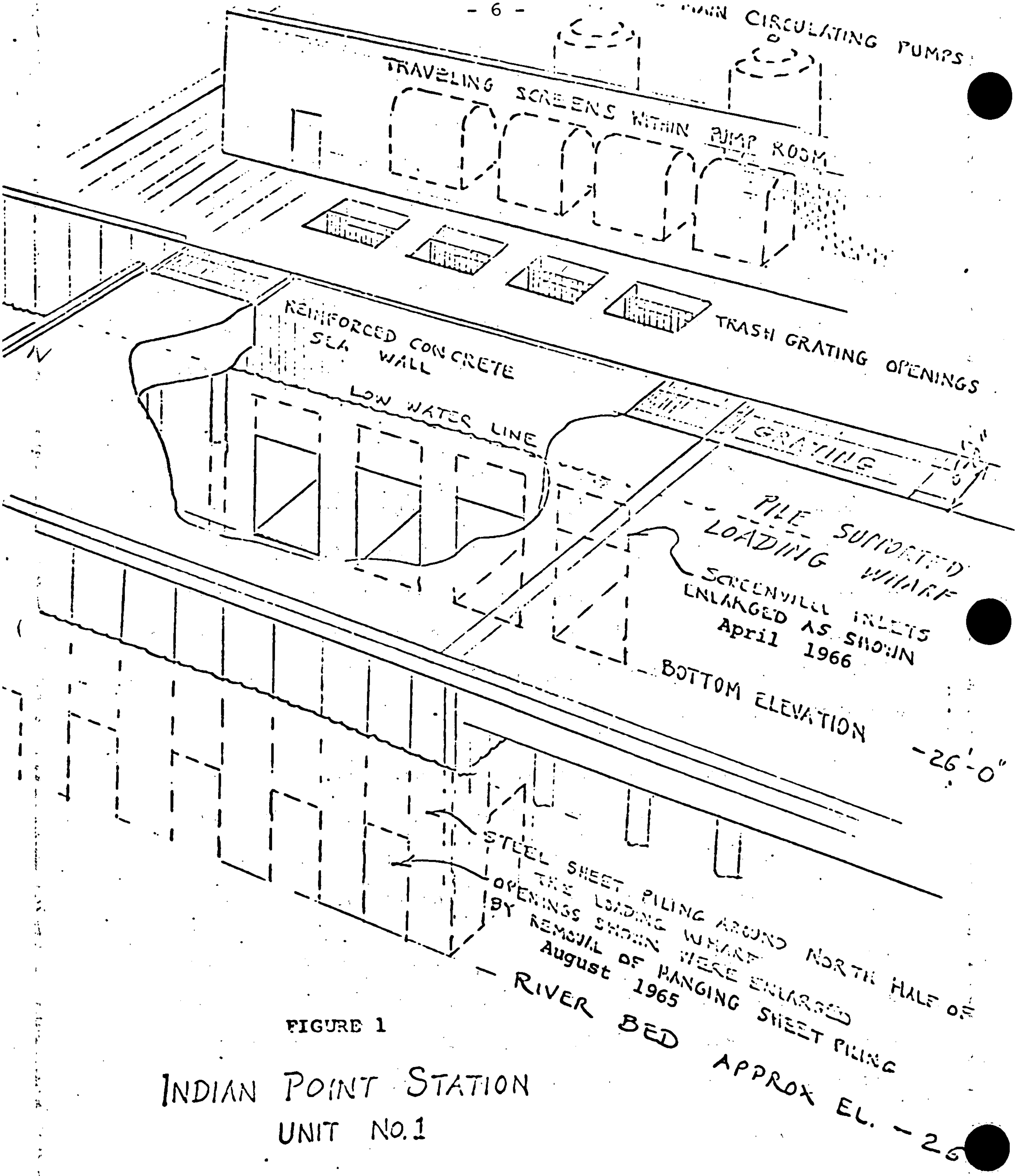


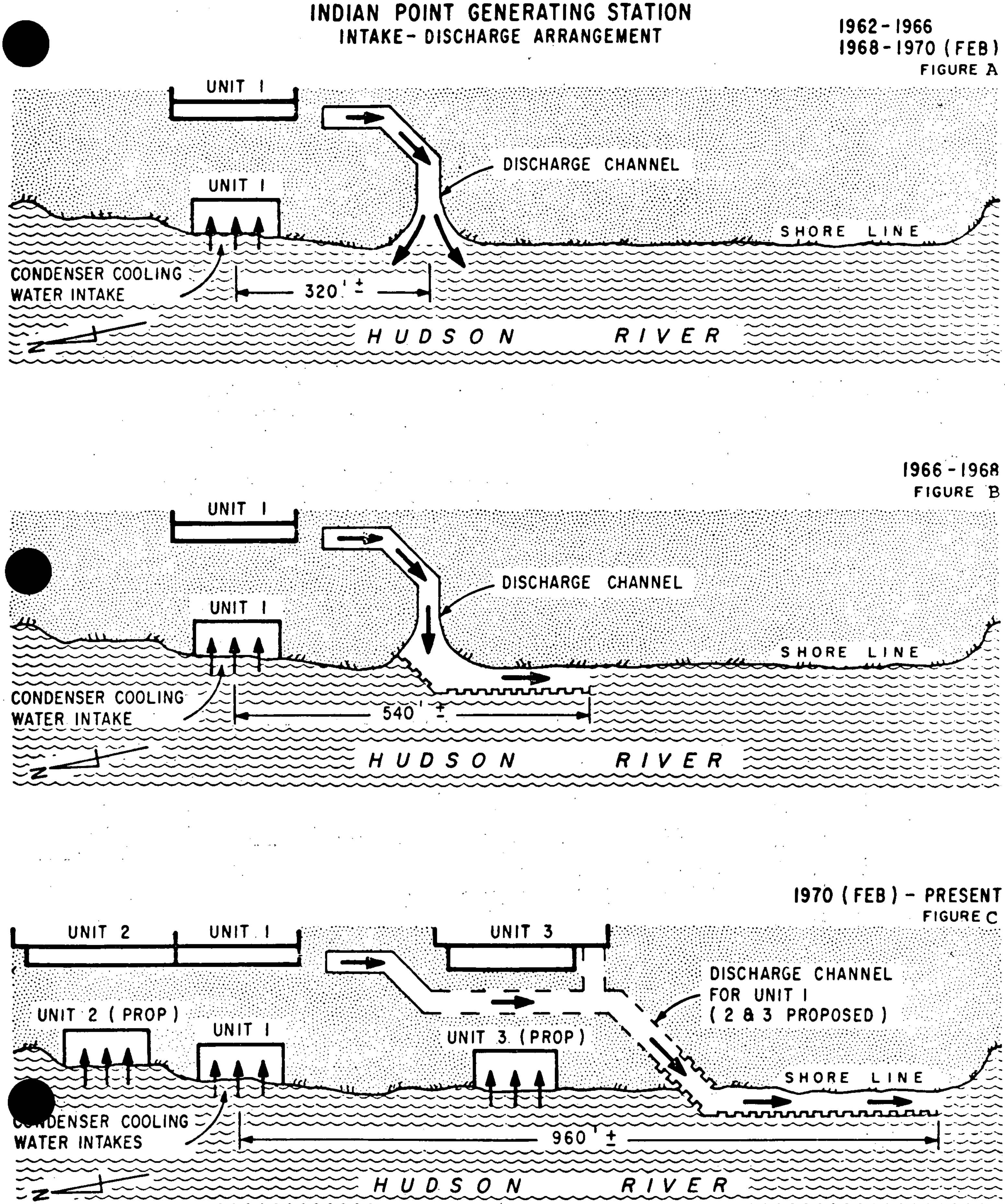
FIGURE 1

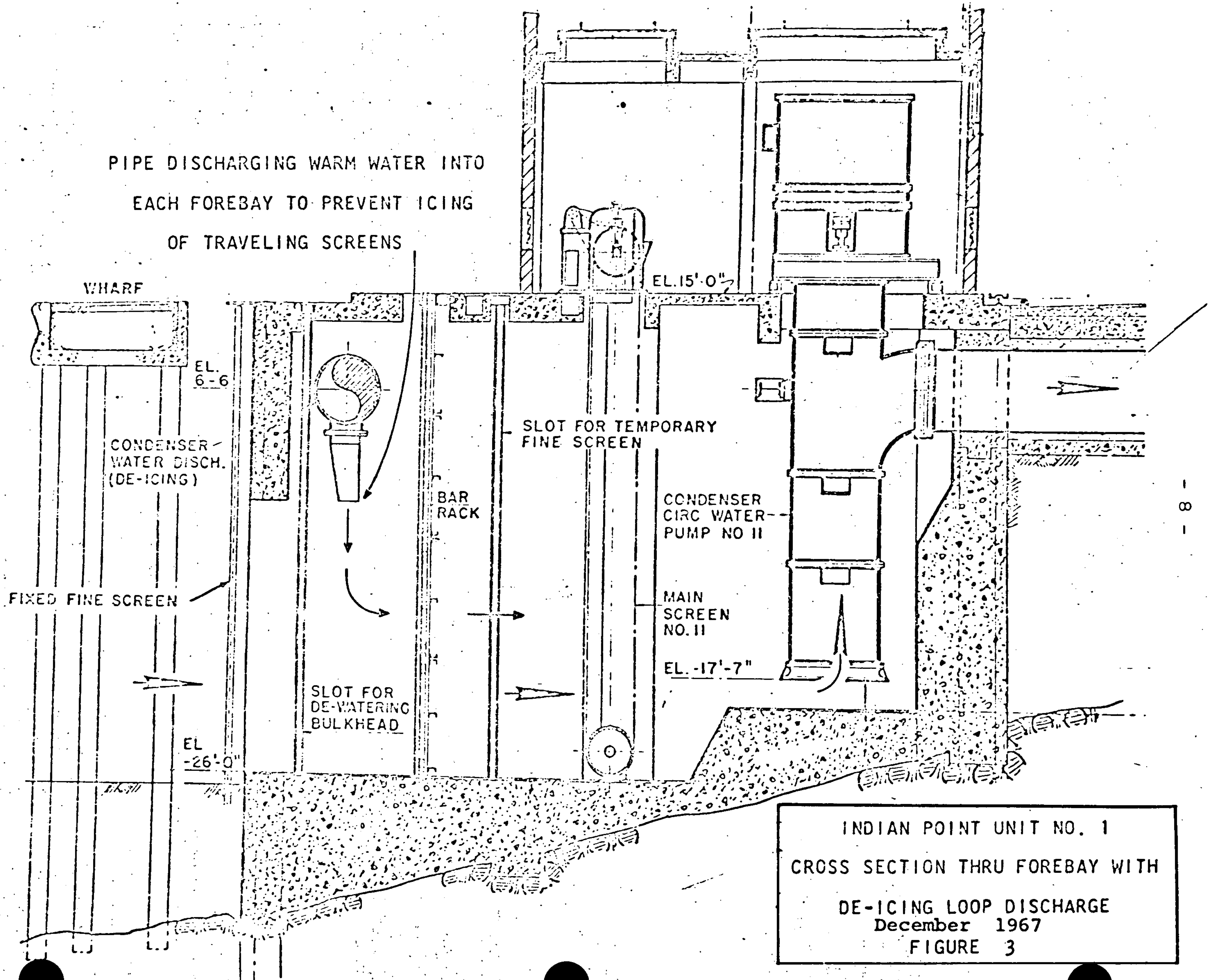
INDIAN POINT STATION
UNIT NO. 1

COOLING WATER INTAKE CONFIGURATION

FIGURE 2

INDIAN POINT GENERATING STATION
INTAKE- DISCHARGE ARRANGEMENT





INDIAN POINT UNIT NO. 1

CROSS SECTION THRU FOREBAY WITH

DE-ICING LOOP DISCHARGE

December 1967

FIGURE 3

of each section. In each forebay, approximately midway between the opening and the traveling screen there was a trash rack. Between the opening and the trash rack there was a pipe which could discharge heated condenser water into the intake flow to prevent icing of the traveling screens.

In front of the intake forebays there was a 247 foot long wharf. The intakes were located behind the north end of the wharf. This wharf was supported by many pilings and was surrounded by steel sheet piling that extended to the bottom. Slots in the bottom of sheet piling allowed water to be drawn under the wharf to the intakes.

The original discharge (Figure 2A) was located approximately 320 feet to the south of the center of the four intakes. The effluent water was discharged straight into the river.

The Unit No. 1 intake and discharge structures described above were constructed in accordance with accepted design criteria for plants in this area at the time. The changes which occurred in this original intake-discharge arrangement will be discussed later in this report along with the results of the changes in terms of fish protection.

EARLY EFFORTS AND DIFFICULTIES WITH FISH PROTECTION

Unit No. 1 went into operation in October, 1962. In March, 1963, it was observed that fish were entering the open intake forebays.

The fish congregated in these forebays and did not leave via the opening to the river. Many of the large fish were subsequently collected on the traveling screens. Striped bass (Roccus saxatilis), tomcod (Microgadus tomcod), and white perch (Roccus americanus) were the species observed in greatest numbers.

As a result of this situation Con Edison initiated attempts to prevent the fish from entering the intake forebays. Air bubble curtains installed in front of the forebay openings in April, 1963 were completely ineffective as fish barriers. An electrical fish screen was considered in May, 1963 and the Electric Fish Screen Company of Hollywood, California was contacted for information. This idea was not adopted because of the operating difficulties in water of changing salinity and the harmful effects to large fish when voltages are adjusted to be suitable for small fish. In July, 1963, foxwire netting was placed across all openings in the sheet piling around the wharf. These measures were ineffective as a physical barrier to the fish because the wire netting was constantly clogged with debris and gave way under heavy water hammer. Fish that congregated in the intake forebays were netted and released to the river.

Dr. Alfred Perlmutter, Professor of Fishery Biology at New York University was consulted in February, 1964. He believed that the fish were being attracted to the wharf and the intake forebays. The warm water from the discharge carried upstream by the tide to the intakes and the sanctuary of the wharf were considered the factors attracting the fish.

Also in February, 1964, a contract was entered into with Alden Hydraulic Laboratory of Worcester Polytechnic Institute to construct a hydraulic model of a portion of the Hudson River in the vicinity of Indian Point. The purpose of this study was to determine the conditions necessary for recirculation of discharge water into the intakes and the amount of recirculation under various conditions. In addition, means of reducing or eliminating recirculation were to be evaluated.

During the major portion of the year 1964, Unit No. 1 was not in operation due to required maintenance. Cooling water pumps were not operated during this period and hence fish were not collected on the traveling screens.

Tests were conducted by Alden Hydraulic Laboratory over a 6 month period and reported in April, 1965. The results confirmed that warm water from the discharge was being recirculated through the intakes. As a result the intake water temperature could increase as much as 6°F over ambient river temperature. Temperature rise was greatest near the time of high tide. A wall was then constructed which diverted the discharge flow to the south along the river bank and reduced the temperature rise to less than 1°F in the research model.

Dr. Perlmutter also conducted an investigation into the effect of the discharge water on the depth distribution of fish in front of the wharf from October 16, 1964 to January 13, 1965. The results were reported in February, 1965. The experiments consisted of sampling fish with two experimental fish traps at various depths in front of the wharf. The sampling was conducted for 15 days while the discharge was not operating and a subsequent period of 21 days when the discharge was operating. Two additional sampling periods of 38 days and 8 days occurred while the discharge was operating. White perch, striped bass and tomcod were the numerically dominant species of the catch. Although the data were considered fragmentary, the conclusion was that the discharge water was causing the fish to concentrate on or near the bottom. This could result in the fish finding their way under the wharf and into the intakes.

In the spring of 1965 a pneumatic sound source to repel the fish away from the intakes was rented from Bolt Associates, Inc. of East Norwalk, Connecticut. The device was employed until September, 1965 with inconclusive results. The underwater sound initially repelled fish but gradually lost its effectiveness.

Two of the trash racks were modified in 1965 with a smaller mesh to produce a screen with openings of 1 x 2 inches. These screens were tested in two of the intake forebays and found unsuitable because the fish became "gilled" in the screen.

In June, 1965, it was noted that coincidental with the addition of sodium hypochlorite to the intake forebays (a regular plant procedure to prevent biological growth on condenser tubes) many fish were collected on the traveling screens. The point of addition of the sodium hypochlorite line which up to this time had been in the forebay was subsequently moved to a point behind the traveling screens. Following this change it was observed that large fish were no longer collected on the traveling screens. However, small fish sometimes were unable to avoid the intake flow and were confined in the intake forebays.

In the summer of 1965, it was observed that many of the fish washed off the traveling screens were still alive. In order to protect these fish an extension was added to the sluice which carried the fish back to the river. This was not completely satisfactory because many of the dead fish discharged from the sluice were carried by the tide back to intakes.

In an effort to eliminate the sanctuary and enclosure effect of the wharf the hanging sections of sheet piling at the north and south ends of the wharf were removed by August, 1965. This change helped the fish to swim away from intakes but small fish sometimes were still found on the traveling screens.

Beginning in the summer of 1966, efforts were made to determine what, if any, effects lighting might have in repelling the fish. First, the area beneath the wharf was kept continuously illuminated by floodlights. This approach was unsuccessful in repelling the fish. The wharf was then kept in darkness but this too had no measurable effect in repelling the fish.

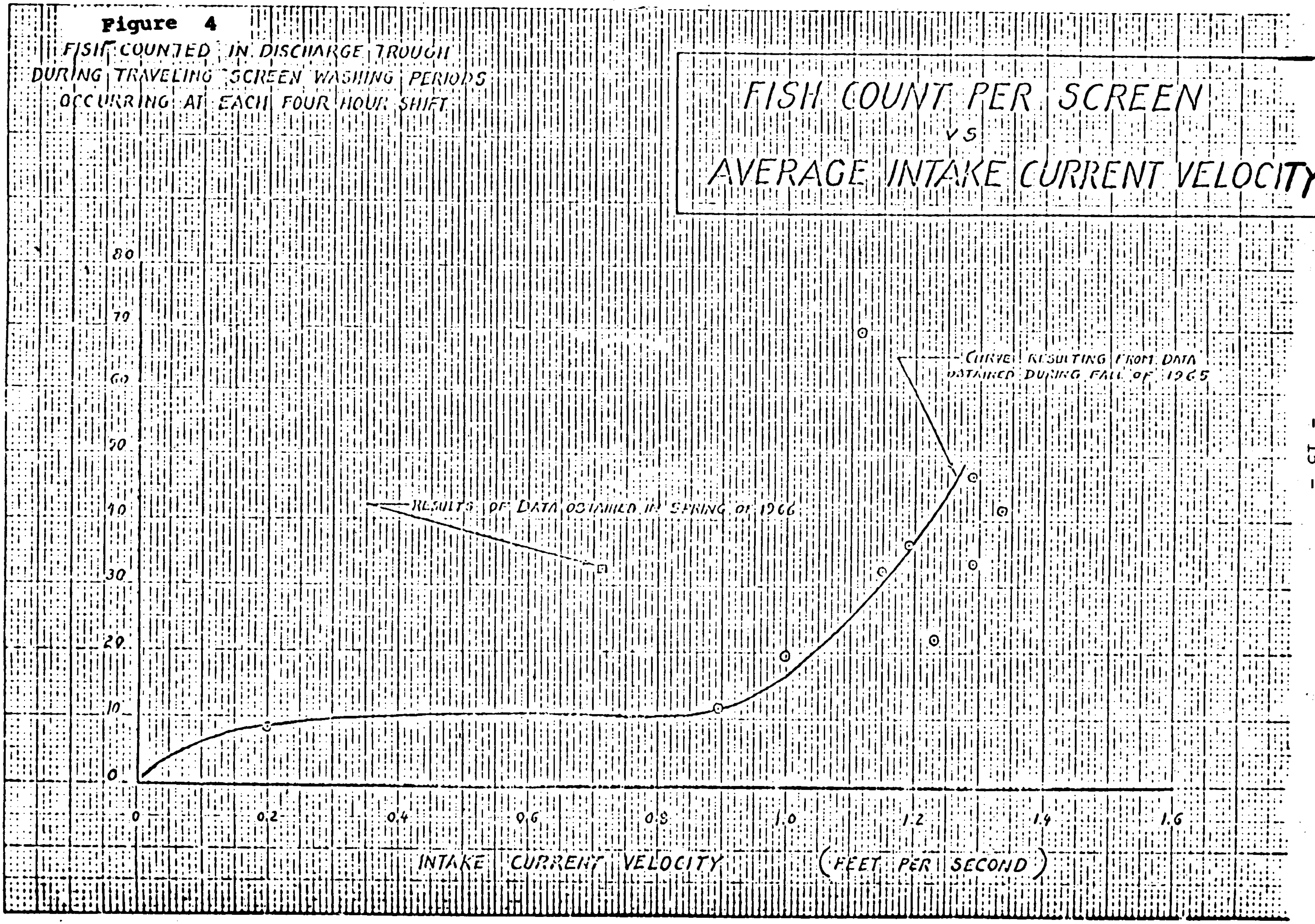
In response to the results of the Alden Study, the discharge canal was extended downstream parallel to the shoreline (Figure 2B, page 7A) a distance of 214 feet (540 feet from intakes) during the spring of 1966 to prevent recirculation of the heated effluent. Notwithstanding this change fishes still entered the forebays.

In addition to the above alteration, the lower 8 feet of the ice wall in front of each intake were removed. This increased the openings to the forebays and reduced the average approach intake velocity from approximately 1.3 feet per second to 0.8 feet per second. This alteration was made in April, 1966 in response to tests conducted in October and November, 1965. These tests showed a substantial increase in the number of small fish collected during traveling screen washings when the intake current velocity exceeded 1 foot per second (Figure 4).

It is difficult to assess the relative effectiveness of the fish protection efforts during the period 1963-1966 which are described above. These attempts to solve the problem were made at different times of the year during which the natural abundance of fish probably varied. The extended discharge was successful in reducing recirculation at high tides, and the en-

Figure 4

FISH COUNTED IN DISCHARGE TROUGH DURING TRAVELING SCREEN WASHING PERIODS OCCURRING AT EACH FOUR HOUR SHIFT



larged intake opening reduced intake velocities. However, it seemed that as long as the forebays were open fish would enter, sometimes in large numbers, and would be collected on the traveling screens.

THE DEVELOPMENT AND INSTALLATION OF FINE MESHED FIXED SCREENS

An important change in the configuration of the intakes occurred in the spring and summer of 1967 with the installation of fixed fine screens at the mouth of the intake forebays. These screens were of a 0.375 inch square wire mesh and were set at the river edge end of the intake structure. They covered the intake openings completely and left no recesses in which fish could become enclosed in the forebays. The decision to install these screens resulted from tests conducted from January through March, 1967 by Northeastern Biologists Inc. under the direction of Mr. Frank Carlson, Technical Advisor, Bureau of Sport Fisheries and Wildlife of the U. S. Department of Interior. A 0.375 inch square mesh screen was placed across the opening of forebay 11 while forebays 12, 13 and 14 were left unscreened. For 27 days between January 27 and March 8 the number of fish washed off the traveling screens (0.375 inch square mesh) at each 4 hour washing was recorded (Table 1). Traveling screens 11 and 12 were counted individually. The counts of washings of traveling screens 13 and 14 were combined. Although every possible 4 hour count was not sampled during the test period (January 27 - March 8), on only two occasions were comparable counts for each

TABLE 1

INDIAN POINT STATION

TABULATION OF FISH WASHED OFF THE TRAVELING SCREENS AND RETURNED TO THE HUDSON RIVER DURING A TEST WITH A 3/8 INCH MESH SCREEN INSTALLED IN FRONT OF THE SCREENWELL INLET OF BAY No 11 JANUARY 27 THROUGH MARCH 8 1967

						WATER TEMPERATURES				
Date	Time	BAY #11	BAY #12	BAYS #13 AND #14	Remarks	AMBIENT	INLET	DISCHARGE	TIME	TIDE
JAN 27	8 AM	19	725	870	TEST SCREEN INSTALLED AT 3:30 P.M. JAN 26. 1967	36.5°	36.1°	47.1	11:00AM	
	12 NOON	[illegible]	[illegible]	[illegible]80	LIFTED SCREEN AT 10:00 A.M. NO DEBRIS. REVERSING NOT NECESSARY					
	4 PM				INCOMPLETE COUNT DURING 3:30 WASHING FOR CONSERVATION DEPT.					
JAN 28	8 AM	36	[illegible]	300 +						
	12 NOON	34	282	610						
	4 PM	63	580	1500						
JAN 29	8 AM	33	630	480						
	12 NOON	74	550	350						
	4 PM	28	280	230						
JAN 30	8 AM	110	1900	1380		33.4°	32.8°	44.0°	10:00AM	LW SLACK
	12 NOON	79	810	570						
	4 PM	92	330	210						
JAN 31	8 AM	85	1010	820						
	12 NOON	42	880	610		35.3°	35.7°	47.0°	2:30PM	
	4 PM	835 305	123	285	SCREEN LIFTED AND REVERSED AT 3:30 PM. AFTER 4 PM ROGS SCREEN WAS AGAIN LIFTED AND RETURNED TO PROPER POSITION. ADDITIONAL WASH AT 4:20PM					
FEB 1	8 AM	218	1660	2100						
	12 NOON	180	1120	1080						
	4 PM	105	870	840						
FEB 2	8 AM	171	900	1175						
	12 NOON	980	1200	1140	SCREEN WAS LIFTED AND REVERSED AT 10:00AM, RETURNED TO PROPER POSITION AT 11:20 AM	33.6°	33.5°	45.1°	10:00 AM	
	4 PM	135	350	980		33.2°	33.0°	44.1°	2:40 PM	
FEB 3	8 AM	145	650	970		ICE	32.3	43.7	9:45 AM	
	12 NOON	85	720	750	DE ICING LOOP ACTIVATED BEGINNING AT 4-12 SHIFT					
	4 PM					ICE	32.5	44.0	3:30 PM	
FEB 4	8 AM	91	65	161						
	12 NOON	95			STATION TRIPPED OUT DUE TO TRANSMISSION LINE DAMAGE IN ROCKLAND COUNTY					
	4 PM									
FEB 5	8 AM									
	12 NOON				REVERSED SCREEN AT 11 AM RETURNED TO PROPER POSITION AT 1 PM NO READINGS TAKEN					
	4 PM	44	232	203						
FEB 6	8 AM	13	400	370						
FEB 8	8 AM	109	870	1410	CONSERVATION DEPT NETTING OF 260 FISH	32°	34.1°	45.0°	3:30 PM	
	12 NOON	51	430	610		ICE	32.6°	49.0°	3:45 PM	
	4 PM	63	800							
FEB 9	8 AM	52	540	1120						
	1 PM	290	610	975	REVERSED SCREEN AT 11:00 AM RETURNED TO PROPER POSITION AT 12:30 PM FINE SLIME ON LOWER SCREEN PANEL ONLY, EASILY CLEANED OFF	ICE	32.8°	48.6°	3:20 PM	
	4 PM	33	285	NO COUNT						
FEB 10	8 AM	142	1120	2060						
FEB 14	8 AM	11	93	445						
	12 NOON	200	330	560	REVERSED SCREEN AT 10:30 AM RETURNED TO PROPER POSITION BEFORE NOON					
	4 PM	25	73	325						
FEB 15	8 AM	52	189	525						
	12 NOON	19	202	775						
	4 PM	21	126	302						
FEB 16	8 AM	36	225	375						
	12 NOON				NO COUNT DURING WASHING					
	4 PM				STATION TRIPPED OUT					
FEB 17	8 AM	19	87	240						
	12 NOON	73	62	202	REVERSED SCREEN AT 10:30 AM RETURNED TO PROPER POSITION BEFORE NOON					
	4 PM									
FEB 21	8 AM		285	730	CIRCULATING PUMPS SHUT DOWN OVER WEEKEND No. 11 TRAVELING SCREEN UNDER REPAIR REVERSED SCREEN AND RETURNED TO PROPER POSITION DURING MORNING					
	12 NOON									
	4 PM				NO COUNTS MADE					
FEB 23	8 AM									
	12 NOON				NO COUNTS MADE DUE TO SNOW STORM					
	4 PM	23	18	138						
FEB 24	8 AM	32	123	135						
	12 NOON	155	205	190	REVERSED SCREEN AND RETURNED TO PROPER POSITION BEFORE NOON					
	4 PM	35	110	165						
FEB 27	8 AM	28	480	910						
	12 NOON	37	1270	1650						
	4 PM	49	510	1360		32.1°	32.3°	47.0°	3:00 PM	
FEB 28	8 AM	NO WASH	510	710 * 13 NOT WASHED						
	12 NOON	202	558	720 * 13 NOT WASHED	REVERSED SCREEN AND RETURNED TO PROPER POSITION BEFORE NOON					
	4 PM	23	226	2400	TWELVE HOUR WASH FOR NO. 13 SCREEN WITH FOUR HOUR WASH FOR NO. 14	32.5°	32.8°	48.2°	3:30 PM	
MAR 1	8 AM	56	440	1750						
	12 NOON	42	90	1400						
	4 PM		320	1175		ICE	34.2°	49.7°	2:40 PM	
MAR 2	8 AM	62	660	1550						
	12 NOON	29	122	570						
	4 PM	24	355	1625		ICE	34.8°	50.2°	1:45 PM	
MAR 3	8 AM	31	335	1800						
	12 NOON	12	195	730						
	4 PM				NO WASH	33.5	34.5°	50.0°	3:30 PM	
MAR 8	8 AM	25	101	410	NO COUNTS MADE REMOVED TEST SCREEN					

traveling screen incomplete. The fish were collected with a screen as they passed down the outlet sluice.

The total number of fish collected for all washings was much higher for the unscreened forebays (12, 13 and 14) than the screened forebay (11) (Table 2). In addition, the total for forebay 11 included three very high counts that occurred after the fixed screen had been raised for washing. The total for forebay 11, not including these three counts, was 3926 and gave a fish per screen wash average of 67 fish. These data indicated that the 0.375 inch square mesh screen was a very effective barrier to the fish entering the forebays.

TABLE 2 Summarized results of tests conducted (January - March, 1967) to determine the effectiveness of a 0.375 inch square mesh screen at Indian Point intakes.

	Screened	Unscreened	
	Bay 11	Bay 12	Bay 13 and 14 combined
Number of washes	59	61	59
Total fish collected	7016	30180	48811
Average fish per wash	119	495	827

The fact that the counts in forebay 11 did not go to zero indicated either fish could pass through the screen or that they could enter through some other opening. The overwhelming majority of fish collected were 2 to 3 inch (less than 1/4 oz. each) white perch. Presumably, white perch of this size should be held out by a 0.375 inch square mesh screen. Since the fixed screen on bay 11 was raised periodically for cleaning, a portal of entry was provided and this could account for the collections staying above zero.

It appeared as a result of these tests that the installation of fixed screens prevented entry of fish in large numbers into the forebays. By December, 1967 all four intake forebays were equipped with fixed screens of 0.375 inch square mesh. The screens were at the mouth of the intakes and permitted the fish to move to either side to avoid the intake flow. The approach velocity to these screens was less than 1 foot per second when the screens were clean.

1969-1970 FISH PROTECTION PROBLEM

A change in the discharge canal for Unit No. 1 was completed in November, 1967 when the downstream extension was removed to facilitate the construction of Unit No. 3 (Figure 2A, page 7).
This change resulted in warm water from Unit No. 1 being discharged through the original canal.

The fixed screens functioned successfully until the winter of 1969-70 as evidenced by the periodic surveillance of the traveling screen washings. In the fall of 1969 leaf clogging of the fixed screens became severe and the screens were removed to permit the flow of cooling water to enter the plant.

Two fish counts are available for the period in which the fixed screens were out of service. On December 9, 1969 a New York State Conservation Department Officer inspected the intakes and reported that between 1,000 and 1,200 fish were collected from a single traveling screen washing. Raytheon Company (refer to page 27) employees collected fish from a traveling screen wash on December 16, 1969. There were an estimated 500 small fish with a total weight of 6 pounds. This collection consisted of 92% white perch, 4% striped bass, and 4% of five other species.

The fixed screens were returned to service on December 26 and positioned to leave an 18 inch and later a 36 inch opening at the bottom of the intake. This was an effort to keep the screens in position but allow for the intake of cooling water in the event the screens froze. Observations indicated that the fixed screens positioned 36 inches above the bottom were ineffective as a barrier to the fish. The fish obviously had no trouble entering the intakes. A decision, therefore, was made to keep the stationary screens positioned at the bottom of the intakes except during cleaning. In order to prevent ice formation on the screens, steam was released into the water a short distance in front of the fixed screens. Unit No. 1 was shut down from January 19 to January 22, 1970 because of fish entering the forebays and to allow time for installation of the steam lines to prevent icing of the fixed screens.

On January 26 a diver made an inspection and found that two screens were being held off the bottom by debris caught under the lower edge. This debris was removed. In an effort to clean the fixed screens and collect a minimum of the fish on the traveling screens the circulator pumps (which create the intake current) were turned off while the screens were raised.

It was apparent from these changes in operating procedure that the fish would enter any opening in the fixed screens. The fixed screens were therefore placed permanently on the bottom on January 28. A decision was made that the screens would not be raised until the clogging problem became serious.

A diver again inspected the screens for holes and discovered a large hole under the screen frame of intake 11. The hole was caused by scouring of the river bottom beneath the screens. This hole was plugged with sand cement bags. On subsequent inspections the diver found more holes under other screens and these were also plugged.

A significant change occurred in the discharge configuration on February 6. The original discharge was blocked off and the discharge water from Unit No. 1 was carried by a new discharge structure to a point 960 feet from the intake (Figure 2C, page 7). This discharge will serve all three units when Units 2 and 3 are completed.

After the holes under the fixed screens were plugged the counts of fish from the traveling screens dropped rapidly from a peak in late January. With the fixed screens permanently positioned on the bottom debris clogging became a serious problem. An underwater jet of water directed outward from behind a screen, when the pump for that screen was shut off, did not effectively remove the debris. This debris build-up aggravated the fish problem by increasing the approach velocity to the screens. The jet washing procedure was used until February 23 and during this time 3,000 to 5,000 fish per day were netted from in front of the fixed screens.

Beginning on February 24, the fixed screen washing procedure was modified to make use of the back-up fixed screens, which are located approximately 4 feet behind the outer fixed screens and are used to screen the intake channels while the outer screens are raised to be washed.

On March 7, the plant was shut down and the outer screens were raised slowly and the fish and debris were removed. An estimated total of 120,000 small fish were netted during this cleaning of the screens.

The fibrous debris removed from the screens during early March was analyzed by the Astoria Chemical Laboratory and found to contain a high percentage of nylon fibers. The source of this material is unknown.

In an attempt to learn more about the cause of death of the fish collected at the intake, during the spring of 1970 samples of fish were sent to biologists and pathologists for examination. The four examinations performed were in agreement that there was no indication of a specific cause of death. Mucus clogging of the gills was listed as a cause of death in one case but the cause of this condition could not be established. Necropsy techniques for fish are limited and it is therefore difficult to establish the cause of death with any degree of certainty.

TECHNICAL TASK FORCE AND INDIAN POINT FISH ADVISORY BOARD

A Technical Task Force has been formed within the Company, headed by the Company's Chief Civil Engineer and including its Environmental Engineer and the General Superintendent of the Indian Point Station. The purpose of the task force is to concentrate and coordinate Con Edison's efforts in implementing the plans and studies on fish protection. To assist the Task Force, an Indian Point Fish Advisory Board consisting of expert biologists and engineers from the United States and Great Britain was first brought together on April 19, 1970 by Con Edison.

The Board consists of:

1. Dr. Merril Eisenbud (Chairman), Director, Institute of Environmental Medicine, New York University, New York.

2. Dr. Gerald Lauer (Scientific Secretary), Assistant Director, Institute of Environmental Medicine, New York University, New York.
3. Dr. Gwyneth Howells (Member), Environmental Conservation Council, London, U. K.
4. Dr. Edward Raney (Member), Professor, Cornell University, Ithaca.
5. Mr. Herbert Riesbol (Member), Bechtel Associates, San Francisco.

The Board has been requested to provide advice to Con Edison on how to protect fish from damage from the operation of Indian Point power plant cooling systems and to evaluate the effects of the fish catch on the ecology of Hudson River. The Board has held a number of meetings with the Task Force and with other individuals and organizations outside of Con Edison.

Con Edison has reviewed with the Indian Point Fish Advisory Board the Company's overall program for Fish Protection in connection with operations of the Indian Point Plant. The Board is of the opinion that in light of present knowledge, the program provides the best immediate approach to the fish protection problem at Unit No. 1 and the most promising long range solutions to these problems for all units at Indian Point. Additional studies to expand present knowledge and assessment of ecological risks in this area are under way and the Board believes that the planned program of study is adequate to provide design parameters for future plant modifications.

SPECIAL STUDIES RELATING TO FISH PROTECTION PROBLEM AT UNIT NO. 1

Con Edison has sponsored the studies listed below and other related studies which pertain to the fish protection at Unit No. 1. The total approximate cost to the Company of these studies is $1,398,428.00.

Subsequent to the formation of Indian Point Fish Advisory Board in April, 1970 Bechtel Associates was retained by the Company to conduct a survey of fish screening systems. This survey was requested as a part of the Company's current efforts to improve the fish protection facilities at Indian Point. This study reviewed both the biological and engineering aspects of screening fish from water flows. The biological factors of importance pointed out in this study were the swimming performance of the species involved, their behavior in relation to water flows, and their density distribution in relation to the location of the intake. The important engineering aspects included an intake approach velocity geared to the swimming ability of the species present, an intake structure without recesses in which fish could become enclosed and a uniform intake flow without areas of high velocity.

Since debris is a problem at power plants a physical screen barrier of some sort is needed. Results of the Bechtel study indicate that non-physical barriers to fish such as electrical screens, air bubble curtains, and light arrays are considered impractical because of their proven inefficiency at deflecting fish under all environmental conditions. A non-physical barrier, if used, would be an addition to the required debris screen.

There is no single fish protection system available which will work dependably at all plant sites. Each intake system is unique and requires a design geared to the existing biological and physical conditions.

Since June, 1970, the Ichthyological Associates is studying the swimming performance and temperature avoidance and preference of the major species of fish in the vicinity of Indian Point.

The investigation for white perch (*Roccus americanus*), tide water silver side (*Menidia beryllina*), silverside (*Membras martinica*), bluefish (*Pomatomus saltratrix*), and mummichog (*Fundulus heteroclitus*) have indicated a maximum swim speed from 0.5 feet per second to 1.6 feet per second differing with size and temperature. It has also been indicated that fish prefer higher than the acclimation temperature for a wide range of temperature acclimation.

Norman Porter Associates was retained by Con Edison to provide data on water flow velocities at the intake of Unit No. 1 and to survey and map the river bottom at Indian Point. A study of water movements in the vicinity of the intakes (Units No. 1 and 2) is also being conducted.

The velocity of water approaching the intake screens at Unit No. 1 is considered a critical factor in the fish problem. Norman Porter Associates is providing data on the approach velocity under a variety of operating conditions so that this factor can be correlated with the numbers of fish collected under each set of conditions. This information in combination with studies of the swimming speed of fish will help establish a suitable intake approach velocity.

The information on bottom contours and water movements is being gathered in preparation for the construction of a new intake structure farther out in the river. The data on water movements will be used to position the new intake structure in such a way that it will be exposed to strong tidal currents. Many fish species avoid strong tidal currents and therefore they are not likely to be in the vicinity of the intake structure.

A detailed study of the ecology of the Hudson River in the general vicinity of Indian Point supported by Con Edison has been undertaken by the Raytheon Company. This study began June, 1969 and is being carried out under the direction of the Hudson River Policy Committee, an independent body made up of representatives of the New York State Department of Environmental

Conservation, the New Jersey Department of Conservation and Economic Development, the Connecticut Department of Conservation, the U. S. Bureau of Sport Fisheries and Wildlife and the U. S. Bureau of Commercial Fisheries. The study team is resident at Indian Point.

The distribution of fishes in the Hudson River varies seasonally. A study is being conducted on the possible effects of plant operation on such distribution. Extensive sampling of small organisms in the river is being performed at intervals along a 13-mile stretch of the river, including Indian Point. Their presence will be determined by employing surface, mid-water and bottom nets of appropriate mesh size and benthos samplers. Small organisms entering Unit No. 1 through the intake and exiting through the discharge will also be sampled. The presence of large fishes throughout the same area is being determined by employment of anchored and towed nets. Key zooplankton are being separated to species. Fish in net collections are separated by species, enumerated and measured. Specimens of each species are being retained. Data from routine sampling are being entered on coded reports for automatic data processing. This phase of the program will provide valuable information on the environmental effect of operation of Unit Nos. 1, 2 and 3.

Bioassay tests are in progress to determine effects of chemicals on fish under Hudson River ambient conditions.

In 1968, the New York University Institute of Environmental Medicine began a program of investigation of the ecology of the Hudson River for Con Edison. This study is a continuation and expansion of continuing ecological studies of the river begun in 1963 with support from the U. S. Public Health Service, the New York State Department of Health, and the New York City Board of Water Supply.

The New York University ecological survey encompasses physical, chemical, biological, and radiological investigations of the aquatic habitat in the middle reaches of the river. Temperature, salinity, and turbidity are the physical parameters being measured. Nutrients and trace elements are the chemical features being investigated. Phosphate and nitrate concentrations as well as cadmium, cobalt, chromium, copper, iron, manganese, nickel, lead and zinc were monitored through 1969. Phytoplankton, zooplankton and fish are being sampled as part of the biological work. The plankton sampling will identify the species present and the seasonal cycles of abundance for this area. The fish sampling consists of shore seining at a single station on each side of the river at Indian Point. This sampling will provide data on the species composition and relative abundance of fish in the shore areas.

The Division of Fish and Game of the New York State Department of Environmental Conservation has sent representatives (biologists and enforcement officers) to Unit No. 1 periodically to observe and make counts of fishes collected in the plant on the traveling screens. Meetings between Con Edison and representatives of the Division of Fish and Game and the Health Department have been held from time to time to review the steps taken to solve the fish protection problem.

The Company has offered to replace by restocking all of the fish that have been killed, either in kind or in other higher grade types of fish if the appropriate officials think it would be advisable and productive to do so.

CONCLUSIONS AND PROPOSED LONG RANGE SOLUTIONS

When fish enter an enclosed area through a narrow opening they have difficulty relocating the opening through which they entered and may be unable to leave the area. The original Unit No. 1 intake structure was built in such a way that fish which entered could not readily leave the structure. The fish were then forced to swim against the intake flow and eventually fatigued and were collected on the traveling screens. This feature of the intake has been eliminated by opening the structure to the flow of the river and by screening the narrow forebays which lead to the intake pumps.

The fish protection problem that exists today at Indian Point is quite different from the original one when the plant began operation in 1962.

The present problem is confined to small fish which are at times unable to swim against the intake flow and become impinged against the outermost set of fixed screens.

The fishes being collected in recent years are small - generally 2 to 3 inches in length (less than 1/4 oz. each). The overwhelming majority of fishes are white perch. It is believed that the change is the result of structural modifications and changes in operating procedures at Unit No. 1 which are described throughout the body of this report. Some fish still enter the intake forebays when the outer screens are raised to be cleaned. The fish are then subject to impingement on the traveling screens.

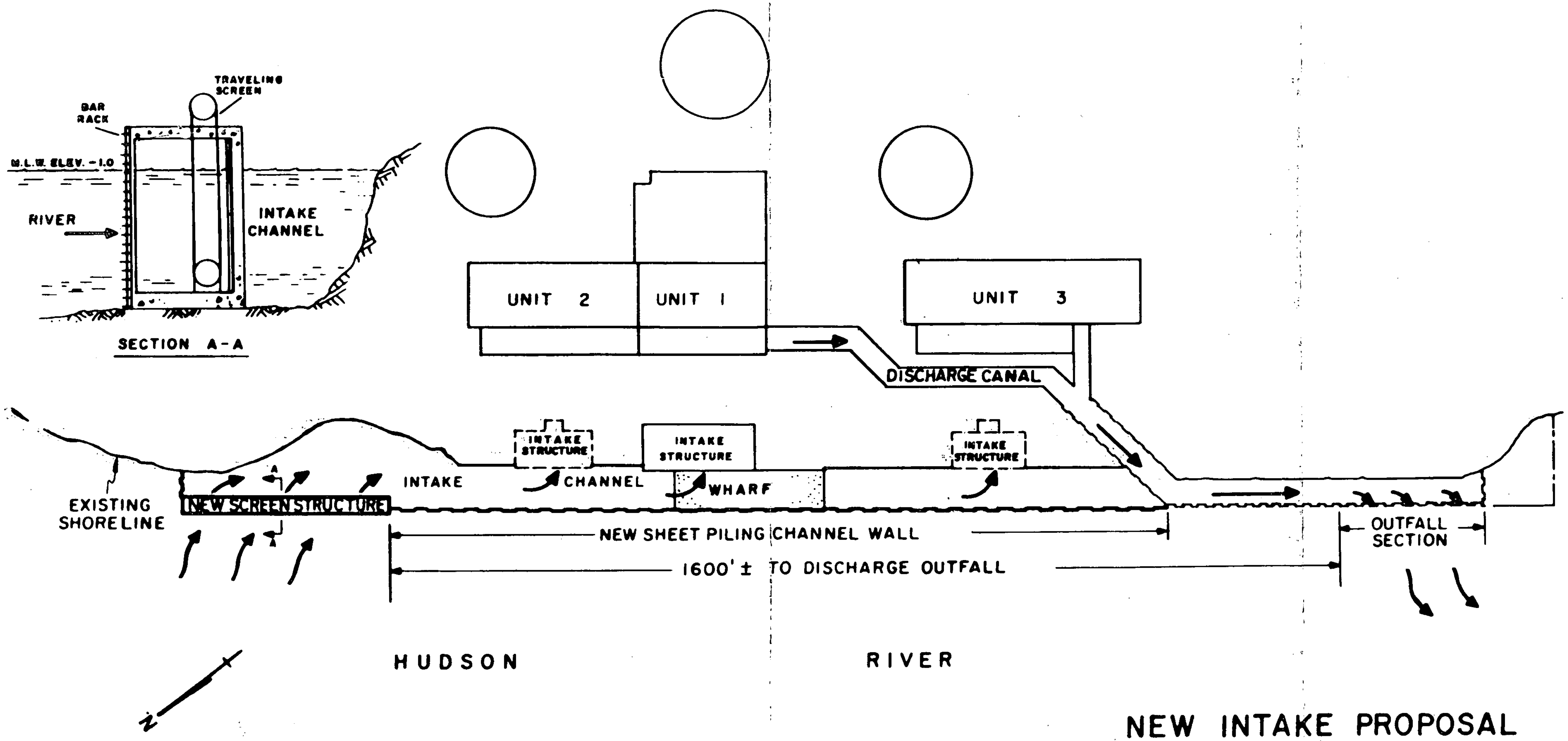
Fish are generally abundant in the area of Indian Point and may at times congregate at the intake of Unit No. 1. The discharge of warm water from any source is known to attract fish during the winter months and this could contribute to the abundance of fish life in the vicinity of the plant. The point of discharge of the warm water at Indian Point has been moved downstream away from the intake thereby decreasing the probability that fish attracted to the outfall will come within the influence of the intake.

During the winter of 1969-1970 when water temperatures were about 33°F the majority of fish collected were small white perch (2 to 3 inches in length). Evidence indicates that the swimming performance of the fish, particularly white perch, is impaired in cold water, preventing them from escaping impingement even by relatively low intake flow velocities. Preliminary results of laboratory tests of the swimming performance of white perch confirm this hypothesis.

The fixed screens presently employed to prevent fishes from entering the intake forebays are effective barriers, but the approach velocity to these screens exceeds the ability of some of the small fishes (i.e., those less than 2 to 3 inches in length) to escape the flow.

During the winter of 1970-1971, the volume of water used by the plant will be reduced by using valves to reduce the flow through the condenser. This reduction in flow will reduce the average approach velocity to the fixed screens to approximately 0.5 feet per second - a point where all but the weakest fish should be able to escape. Preliminary tests of throttled flow indicate this to be an effective method of fish protection.

As a long term solution in the area of fish protection for Unit No. 1 as well as for the other units at Indian Point, Con Edison engineers are developing a new intake water concept. This scheme will include a new screen structure built farther out from the shore (75 to 100 feet) and more into the main longitudinal flow of the river. This structure would screen water for all three Units at Indian Point and would be designed to permit intake velocities below 0.5 feet per second during the colder parts of



NEW INTAKE PROPOSAL
INDIAN POINT STATION
FIGURE 8

the year. The attached sketch (Figure 8) shows a plan of the proposed scheme.

The main advantages of the proposed structures are:

1. To minimize recirculation effects to the intake point from the discharge outfall which is an attraction mechanism.
2. To deny access under the unloading wharf to fish, thereby eliminating the probability that the wharf is acting as an attraction.
3. To place the traveling screens out where the river's stronger currents can longitudinally wash the face of the screens.
4. To achieve low intake velocities.
5. To provide other operational benefits not directly related to fish protection such as greater unit efficiency with reduced recirculation, and removal of the existing eddying conditions which lead to greater accumulation of river debris in front of the individual units.

Engineering design and associated research and development have already begun on this project and it is hoped that the work will be completed and in operation by the spring of 1973. It is currently estimated that cost of this project will be in the range of $12,000,000. Further work on this project will take fully into account the ecological and engineering studies referred to in this report.

APPENDIX A

The following tables contain a compilation of all available recorded fish counts made at Unit No. 1 since the plant began operation in 1962. The records relate to two types of collections. The bulk of the counts refer to fishes collected from the traveling screens. For a period of approximately two months (February through March 1970) fishes were netted from in front of the fixed screens. The number of fishes netted was estimated and is presented in Table 3. For most of the tabulated counts reported no determination was made as to the percentage of fishes collected on the traveling screens which were alive.

The method of determining the number of fishes collected from the traveling screens prior to 1970 is not known for each set of data. The traveling screens at Unit No. 1 physically pick up the fish which are in the intake forebays. The fish are then washed into a sluice by the screen cleaning spray. The fish can be enumerated by blocking the sluice with a screen and collecting them as they accumulate on the screen or they can be enumerated visually as they pass down the sluice. Both these methods were employed for the fish counts before January 1970, the latter procedure being used most of the time. From January 1970 to the present both fishery biologists and Unit No. 1 personnel have been employed to count fishes.

The number of times fishes are enumerated each day is variable but this usually occurs after each period during which the traveling screens are rotated and sprayed. The traveling screens are usually rotated 6 times daily for 15 minutes each approximately 4 hours apart.

Many changes were made in the operating procedure of the Unit No. 1 intakes particularly during the winter of 1969-70. Therefore, the collections reported herein were not made under a consistent set of conditions.

The following data are presented in this appendix:

Table 3. Estimated number of fishes netted from in front of the fixed screens at Indian Point Unit No. 1 (January 28 - April 2, 1970).

Table 4. Fish collected at Indian Point Unit No. 1. A compilation of fishes from the traveling screens.

Table 5. Average length and weight, and species composition of fishes collected during various intervals in April 1970 at Unit No. 1.

Figure 5. A plot of the total number and weight of fishes collected from the traveling screens at Unit No. 1 from January 12, 1970 through February 2, 1970.

Figure 6. A plot of the total number and weight of fishes collected from the traveling screens at Unit No. 1 from February 1, 1970 through February 28, 1970.

Figure 7. A plot of the total number and weight of fishes collected from the traveling screens at Unit No. 1 from March 1, 1970 through March 27, 1970.

Data on the species composition and average length and weight of fish collected from January 12, 1970 to the present by Raytheon Co. employees have been received by Con Edison and are now being summarized.

Table 3. Estimated number of fish netted from infront of the fixed screens at Indian Point Unit No. 1 for the period January 28 - April 2, 1970.

DATES	COUNT (Approximate Numbers)
January 28 to February 22	3,000 to 5,000 Daily
February 23	30,000
February 24 to February 26	3,000 to 5,000 Daily
February 27	No Count
February 28	3,000
March 1	No Count
March 2	No Count
March 3	24,000
March 4	15,000
March 5	30,000
March 6 and March 7	120,000
March 8	15,000
March 9	500 to 600
March 10	4,000
March 11	900
March 12	1,000 to 2,000
March 13	5,000
March 14	1,000
March 15	550
March 16	1,000
March 17	100
March 18	200
March 19	100
March 20	No Count
March 21	No Count
March 22	No Count
March 23	1,000
March 24	300
March 25	275
March 26	300
March 27	500
March 28	600
March 29	400
March 30	500
March 31	200
April 1	200
April 2	12

Table 4 Fish collected at Indian Point Unit No. 1 on the traveling screens

YEAR 1965

Date	Count	Date	Count	Date	Count	Date	Count
25 March	343	27 April	1064	July 3	189	July 17	2237
26 March	1675	31 April	200	July 4	933	July 18	2105
29 March	1874	June 8	90	July 5	1200	July 19	1396
30 March	375	June 9	341	July 6	974	July 20	3046
31 March	500	June 10	544	July 7	1892	July 21	2957
1 April	2250	June 11	276	July 8	2512	July 22	2268
2 April	2015	June 16	39	July 9	2782	July 23	4342
3 April	1620	June 17	396	July 10	1279		
4 April	3600	June 18	121	July 11	133		
5 April	580	June 28	908	July 12	3390		
8 April	835	June 29	1093	July 13	2986		
12 April	405	June 30	903	July 14	1922		
13 April	1440	July 1	1166	July 15	1796		
16 April	1200	July 2	1105	July 16	2435		

North=Forebays 13 & 14
South=Forebays 11 & 12

Date	Bay	12 Mid.	4 A.M.	8 A.M.	12 Noon	4 P.M.	8 P.M.	Total Count
24 July	North	1,000	500	500		90	422	4,869
	South	900	500	450		57	450	
25 July	N	1,100	350	1,500		212	314	7,240
	S	1,550	500	1,500		119	95	
26 July	N	1,200	800	575	210	107	176	6,599
	S	1,500	1,200	550	110	82	89	
27 July	N	1,150	1,000	200		250	95	5,115
	S	1,000	850	210		250	110	
28 July	N	950	2,300	390	245	204	209	7,300
	S	400	1,400	750	150	139	163	
29 July	N	1,030	2,190	900	150	325	330	8,219
	S	460	950	1,300	150	189	245	
30 July	N	590	1,650	660	200		260	6,400
	S	370	1,500	700	170		300	
31 July	N	670	1,600	550	180	250	185	5,795
	S	450	630	700	170	175	235	
1 Aug	N	610	700	550	150	220	150	4,945
	S	580	670	720	165	230	200	
2 Aug	N	1,180	1,260	459	193	210	200	8,834
	S	1,450	1,600	1,600	347	170	165	

Table 4 Continued

YEAR 1965

Date	Bay	12 Mid.	4 A.M.	8 A.M.	12 Noon	4 P.M.	8 P.M.	Total Count
3 Aug	N	1,200	900	330	160	90	130	6,585
	S	1,700	1,200	400	240	135	100	
4 Aug	N	800	650	600	300	165	170	7,510
	S	1,630	1,200	1,000	500	300	200	
5 Aug	N	1,250	380	300		85	220	6,125
	S	2,000	450	1,000		220	220	
6 Aug	N	750	750	500	500	249	188	8,751
	S	1,670	1,300	2,000	328	253	263	
7 Aug	N							
	S							
8 Aug	N							
	S							
				1,000				
9 Aug	N	225	140	500		465	90	5,120
	S	170	130	2,200		100	100	
10 Aug	N	200	300	365		165	85	3,645
	S	270	230	1,650		285	95	
11 Aug	N	85	843	300		253	125	4,632
	S	95	1,176	1,500		105	150	
12 Aug	N	290	864	1,600		400	180	7,632
	S	457	991	2,600		150	100	
13 Aug	N	415	587	1,600	150	115	120	7,267
	S	470	700	2,600	260	110	140	
14 Aug		465	965	310	284	100	140	5,553
		311	1,390	975	233	140	240	
15 Aug		355	445	1,150	208	150	130	7,536
		980	1,370	1,545	263	200	240	
16 Aug		375	845	1,250	380	155		9,575
		1,790	2,140	2,100	290	250		
17 Aug	N	645	410	692		570	200	5,305
	S	1,915	1,260			140	165	
18 Aug	N	250	300			160	310	3,100
	S	670	950	1,265		145	315	
19 Aug	N	180	550			180	620	2,605
	S	390	410			115	160	
20 Aug	N	375	285	225	375	490	480	5,030
	S	785	490	210	250	550	515	
21 Aug		960	650	800	450	84	53	5,684
		1,140	730	400	250	92	70	
22 Aug		950	210	510	375	250	200	5,610
		980	655	720	260	300	200	
23 Aug		1,000	400	420	160	390	200	5,941
		1,100	1,200	660	230	81	100	
24 Aug		700	350	820	53	105	200	8,075
		1,850	1,600	1,430	287	380	300	
25 Aug		1,100	1,000	1,850	572	565	180	12,656
		1,400	1,600	2,200	950	839	400	

Table 4 Continued

YEAR 1965

Date	Bay	12 Mid.	4 A.M.	8 A.M.	12 Noon	4 P.M.	8 P.M.	Total Count
26 Aug		1,030 1,160	960 1,220	845 1,460	510 735	630 900	380 470	10,300
27 Aug	N S	760 840	820 1,120	730 1,034	390		280 340	6,314
28 Aug	N S	420 620	360 630	640 1,195	340 624	280 350		5,459
29 Aug	N S	440 920	620 1,015	407 950	334 475	80 180	55 900	6,376
30 Aug	N S	130 480	210 350	700 500	100 110	130 300	70 700	3,780
31 Aug	N S	110 215	90 260	225 260	85 95	60		2,368
1 Sept	N S	289	785	355	405	600	500	2,434
2 Sept	N S	930	1,190	450	185	286	148	3,189
3 Sept	N S	578	449	415	400	185	130	2,157
4 Sept	N S	174 219	297 224	300 175	575 275	115 70	170 95	2,159
5 Sept	N S	1,000 217	800 400	650 475	247 87	170 65	100 55	4,782
6 Sept	N S	120 115	150 125	379 35	247 87	110 70	105 35	1,578
7 Sept	N S	90 75	275 55	226	55	90	75	916
8 Sept	N S	140	235	68 33	23 27	40 55	40 15	676
9 Sept	N S	110 25	105 35	88 17	53 12	36 12	24 8	525
10 Sept	N S	75 25	50 15	59 17	24 15	87 43	47 35	492
11 Sept	N S	120 60	85 25	54 29	54 13	17 26	44 15	542
12 Sept	N S	90 30	90 20	54 15	33 13	14 11	55 15	440
13 Sept	N S	95 35	93 20	47 29	42 7-13	28 8-16	32 8-15	488
14 Sept	N S	145 24-28	100 23-18	92 32-34	37 14-23	40 15-20	65 22-19	751
15 Sept	N S	28 17	42 51	75 69-51	26 29-20	51 20-29	52 16-25	581
16 Sept	N S	73 17-38	52 22-14	73 35-80	11 20-27	14 19-12	14 9-8	538

Table 4 Continued

YEAR 1965

Date	Bay	12 Mid.	4 A.M.	8 A.M.	12 Noon	4 P.M.	8 P.M.	Total Count
17 Sept	N S	43 51-39	41 15-20	39 43-55	29 34	7 38-45	15 20-15	476
18 Sept	N S	25 35-31	23 33-27	21 39-73	12 30-23	20 19-26	25 24-27	492
19 Sept		23 38-26	12 21-18	49 50-78	17 17-37	12 14-12	14 6-15	458
20 Sept		23 38-25	19 33-44	14 30-33	9 38-30	21 8-23	37 23-44	476
21 Sept		59	15	51	47	18	95	778
22 Sept		156 215	60 365-93	50 125-94	43 49-39	18 38-41	38 29-35	1,488
23 Sept		260 320-270	75 190-185	63 190-209	46-30 63-68	27-19 81	35-38 104	2,348
24 Sept		465 165-290	225-395 320	202-285 157	172 118	56 53	55 24	2,982
25 Sept		235 100	265 85	667 82	209 382	59 51	84 31	2,250
26 Sept		265 90	410 135	864 96	197 114	115 48	145 33	2,532
27 Sept		240 65	385 80	1,250 1,101	100 85	22 13	20 38	2,399
28 Sept		78 45	215 105	170 95	100 45	33 26	47 19	713
29 Sept		151 43	287 76	175 75	115 50	47 24	57 19	1,119
30 Sept		113 26	236 55	295 85	60 50	9 24	22 26	1,001
1 Oct		169 42	217 71	100 80	110 48	61 26	74 25	1,021
2 Oct		96 31	109 57	275 90	65 54	66 29	110 27	1,009
3 Oct		120 50	175 75	150 62	65 53	67 55	41 29	932
4 Oct		57 30	100 60	127 61	57 33	13 58	206 35	837
5 Oct		100 60	150 100	100 100	175 100	100 63	45 27	1,120
6 Oct		150 100	185 95	210 58	96 47	94 65	63 24	1,187
7 Oct		120 75	115 50	119 81	100 32	19 18	39 29	777
8 Oct		30 20	27 20	5 40	98 54	110 60	58 36	558
9 Oct		108 44	118 55	213 92	170 51	61 38	75 43	1,068

Table 4 Continued

YEAR 1965

Date	Bay	12 Mid.	4 A.M.	8 A.M.	12 Noon	4 P.M.	8 P.M.	Total Count
10 Oct		150 40	90 45	200 42	77 44	55 32	114 25	1,068
11 Oct		104 35	60 32	225 41	56 44	37 48	35 33	887
12 Oct		170 70	98 68	320 245	83 28	60 44	126 64	750
13 Oct		210 86	280 111	312 142	92 56	116 65	130 44	1,644
14 Oct		350 200	190 86	290 125	95 75	78 65	111 71	1,736
15 Oct		210 140	162 55	295 93	94 56	25 75	93 60	1,358
16 Oct		189 160	130 150	335 100	98 42	70 59	90 64	1,487
17 Oct		57 43	180 120	170 91	72 38	57 33	146 112	1,119
18 Oct		159 88	88 26	225 81		19 40	120 65	1,254
19 Oct		165 286	96 80	137	62 82	35 40	14 77	853
20 Oct		0 185	0 275	0 142	9 80	3 99	0 60	597
21 Oct		2 138	0 115	2 114	1 72	2 107	2 42	847
22 Oct		0 225	2 187	0 107	14 92	 61	17 42	925
23 Oct		27 94	86 271	18 123	11 78	20 74	11 118	894
24 Oct		32 151	37 215	20 156	9 88	 58	15 113	781
25 Oct		41 148	26 136	15 205	2 88	16 40	17 55	789
26 Oct		14 142	24 243	28 215	21 85	27 110	93 114	1,116
27 Oct	N S	78 108	62 114	320 208	42 104	 45	232 126	1,439
28 Oct		66 111	81 126	330 200	110 135	110 168	51 62	1,750
29 Oct		43 71	26 41	79 270	27 86	18 63	74 148	946
30 Oct		24 72	21 63	26 135	11 85	18 42	24 24	545
31 Oct		14 31	22 63	42 87	87 127	40 63	38 72	586

TABLE 4 CONTINUED

YEAR 1965

Date	Bay	12 Mid.	4 A.M.	8 A.M.	12 Noon	4 P.M.	8 P.M.	Total Count
1 Nov		94	76	87	16	18	87	1,006
		122	89	175	175	31	36	
2 Nov		37	22	75	10	27	20	411
		51	32	50	8	41	36	
3 Nov		37	110	45	5	12	18	588
		45	125	65	30	62	34	
4 Nov		57	27	25	10	90	152	906
		62	45	50	20	130	238	

YEAR 1966

Date	Bay	12 Mid.	4 A.M.	8 A.M.	12 Noon	4 P.M.	8 P.M.	Total Count
19 April	S							
	N							
20 April	S	2		133		130	4	347
	N	1		80		5	2	
21 April		3	0	51	64	17	17	290
		5	60	24	30	22	7	
22 April		21	27	34	31	20	2	290
		37	56	35	15	10	2	
23 April						57	57	214
						61	69	
24 April		26	21			23		172
		32	30			40		
25 April		180	85	230	130	31	40	1,549
		210	250	175	65	87	66	
26 April		210			55	31	30	650
		180			50	47	47	
27 April		70	21	37	30		19	373
		35	21	70	60		12	
28 April				70	62			572
				400	40			
29 April				60	40			265
				140	25			
1 May	S	60	44	120	100	13	27	1,003
	N	85	70	240	120	44	80	
2 May		33	42	31	27	26	22	564
		40	80	134	36	49	44	
3 May				88	32	18	23	367
				92	20	34	60	
4 May		75	35	175		50		1,002
		115	45	310		197		
5 May		68	20	132		27	40	648
		105	55	115		39	47	

TABLE 4. (Continued)

YEAR 1966

Date	Bay	12 Mid.	4 A.M.	8 A.M.	12 Noon	4 P.M.	8 P.M.	Total Count
6 May		30	30	131	41	15	21	737
		55	30	300	28	16	40	
7 May		20	35	200	100	12	9	950
		65	20	100	41	7	42	
8 May		15	18	141	58	43		503
		30	45	182	50	21		
9 May		58	21	62	48	14	18	448
		65	43			87	32	
10 May		27	14	29	10			239
		110	14	27	8			
11 May				135	25	15	9	420
				163	43	10	20	
12 May		72	40	31	30	11	10	973
		340	200	140	45	19	35	
13 May		40	160	70	40	46	51	1,107
		180	120	127	63	97	13	
14 May	S	140	200	145	10	65	22	1,616
	N	240	340	265	41	80	68	
15 May		71	68	25	10	11	18	653
		123	190	46	30	21	40	
16 May		27	80	61	61	80	55	663
		69	112	105	105	150	90	
17 May		87	42	10	9	14	11	575
		212	68	22	15	55	30	
18 May		75	38	18	20	30	15	478
		73	56	34	26	58	35	
19 May		83	173	140	24	50	30	1,081
		133	250	170	44	85	115	
20 May		112	82	13	11	17	28	539
		135	41	24	18	20	38	
21 May		118	98	20	65	28	60	769
		131	108	44	89	42	120	
22 May		137	117	36	26	10	90	895
		150	130	66	51	20	62	
23 May		131	98	131	118	215	95	1,242
		109	142	117	155	103	76	
24 May		187	190	250	108	12	58	1,454
		165	155	205	54	24	46	
25 May		70	32	54	17	8	17	458
		92	56	45	29	12	26	
26 May		22	18	46	19	22	16	305
		36	34	43	24	10	15	
27 May	S	20	14	42	34	19	62	380
	N	38	22	47	52	16	14	
28 May		38	16	36	46	21	19	392
		54	30	65	32	19	16	
29 May		46	34	17	16	29	24	334
		62	26	26	15	21	18	

A-12

TABLE 4 CONTINUED

YEAR 1966

Date	Bay	12 Mid.	4 A.M.	8 A.M.	12 Noon	4 P.M.	8 P.M.	Total Count
30 May		14 26	13 14	44 68	54 44	19 28	14 9	347
31 May		30 28	12 18	60 71	26 18	36 29	21 22	371
1 June		48 36	28 18	271 145	97 53	31 15	21 9	772
2 June		36 27	27 18	54 113	19 41	11 27	23 13	408
3 June		27 19	32 26	67 156		36 26	10 14	413
4 June		21 36	27 42	57 98	81 120	32 56	28 34	632
5 June		27 42	29 56	23 40	29 47	26 38		357
6 June		15 21	18 36					90

During week of 7 June through 14 June counts taken on 8 hr. basis were consistently low about 15 or 20.

Date	Bay	12 Mid.	4 A.M.	8 A.M.	12 Noon	4 P.M.	8 P.M.	Total Count
16 June	S N				9 41			50
17 June					14 24			38
18 June					25 60			85
19 June								
20 June					48 200			248
21 June						22		31
22 June					68 134			202
23 June								
24 June						60 135		195
25 June			No Counts					
26 June			No Counts					
27 June						32 35		67
28 June			No Counts					
29 June	S N			410 715 At 9 A.M.				1,125

Table 4 Continued

YEAR 1966

Date	Bay	8 A.M.	12 Noon	4 P.M.	8 P.M.	Total Count
30 June	S N	875 1,500			330	2,375
1 July	S N	1,200 at 6 A.M.	125 At 2 P.M.			1,325
2 July						
3 July						
4 July						
5 July	S N	59 705	40 60	35 37		936
6 July	S N	311 530	23 1 P.M. 53	19 4:30 P.M. 27		963
7 July	S N	127 9 A.M. 336	8 2P.M. 34			505
8 July	S N	68 102	15 9			194
9 July		No Counts				
10 July		No Counts				
11 July	S N	21 13	3 8	2 9		56
12 July		21		11 5		40
13 July		20 72	14 15			121
14 July		31 32		9 15		87
15 July		51 35	9 15			110
16 July	No Counts					
17 July	No Counts					
18 July	S N	118		82 118		200
19 July		325 245	181 215	103 154		1,223
20 July	S N	760 1,015	305	30 37		2,147
21 July		840 860		117 (#11 Screen Only) 87(#13 & 14 Screens)		1,904

Table 4 Continued

YEAR 1966

Date	Bay	8 A.M.	12 Noon	4 P.M.	Total Count
22 July		670 525		165 111	1,471
23 July	No Counts - Weekend				
24 July	No Counts - Weekend				
25 July	S N	580 600		62 53	1,295
26 July		39 63		2,033 28	183
27 July					
28 July		211 92			303
29 July		306 105	(216) (105)	126 105	642
30 July		No Counts			
31 July		No Counts			
1 Aug		122 103	(110) (104)	97 104	426
2 Aug		170 75			
3 Aug		130 178	(130) 155	(130) (167)	463
4 Aug		173 210	(173) (210)	(173) (210)	383
5 Aug			624	314	938
6 Aug	No Counts				
7 Aug	No Counts				
8 Aug	S(#11 & 12) N(#13 & 14)	54+69 126		18+57 30	354
9 Aug		65+74 188		11+47 63	448
10 Aug		165+141 189	53+72 88	36+60 46	850

Table 4 Continued

Year 1966

Date	Bay	8 A.M.	12 Noon	4 P.M.	Total Count
11 Aug		93+118 125		29+97 25	487
12 Aug		198+298 202	32+79 64	23+45 24	965
13 Aug	No Counts				
14 Aug	No Counts				
15 Aug	S(#11 & #12) N(#13 & #14)	263+145 142		132+180 189	909
16 Aug		610+560 950	223+190 255	110+190 150	3,238
17 Aug		510+305 200	340+212	155+233 240	2,247
18 Aug		195+240 210	198+195 150	88+157 112	1,545
19 Aug		482+362 405		81 107	1,437
20 Aug		255 235	75 65	86 61	777
21 Aug		279 310	120 125	95 97	1,026
22 Aug		110 205	62 116	41 112	646
23 Aug		76 177	95 162		510
24 Aug		132	172	88	866
25 Aug		127 155		615 765	1,622
26 Aug		138	125		553
27 Aug		135 114	76 87	75 43	530
28 Aug		183 132	72 65	51 60	563
29 Aug		232 155		72 70	529
30 Aug		371 194		91 81	737
31 Aug		381 202	122 107	82 93	987

Table 4 Continued

YEAR 1966

Date	Bay	8 A.M.	12 Noon	4 P.M.	Total Count
1 Sept.	S	657	116	133	1,484
	N	378	93	107	
2 Sept.		1,015	127		1,912
		632	138		
3 Sept.		197	67	114	706
		158	79	91	
4 Sept.		392	109	58	1,101
		347	117	78	
5 Sept.		114	32	71	488
		95	86	90	
6 Sept.		361	97	61	891
		224	107	41	
7 Sept.		147	67	41	629
		166	147	61	
8 Sept.		221	82	23	642
		208	46	62	
9 Sept.		103		178	680
		117		282	
10 Sept.		147	55	38	401
		85	44	32	
11 Sept.		335	65	27	768
		260	50	31	
12 Sept.		160	101	57	593
		125	107	43	
13 Sept.		255	71	71	680
		182	49	52	
14 Sept.	S	402	72	78	1,007
	N	137	265	53	
15 Sept.		605	108		1,053
		282	58		
16 Sept.		334	78	107	730
			190	21	
17 Sept.		187	81	96	696
		145	67	120	
18 Sept.		221	91	76	757
		225	59	85	
19 Sept.		251	143	54	943
		354	83	58	
20 Sept.		454	107	43	1,203
		397	134	68	
21 Sept.		172		170	813
		403		68	
22 Sept.		355	118	107	1,198
		406	134	78	

TABLE 4. (Continued)

YEAR 1966

Date	Bay	8 A.M.	12 Noon	4 P.M.	Total Count
23 Sept.		605	37	13	1,551
		614	145	137	
14 Oct.	S			150	200
	N			50	
15 Oct.					
16 Oct.					
17 Oct.	S	570	115		1,110
	N	375	50		
18 Oct.	S	500	120		982
		310	52		
19 Oct.					
20 Oct.	S	775		152	1,300
	N	320		53	
21 Oct.	S	1,130		555	2,703
		740		278	
22 Oct.					
23 Oct.					
24 Oct.	S	1,032		235	1,917
	N	563		87	
25 Oct.	S	682		260	1,561
		479		140	
26 Oct.	S	320	148	119	969
	N	210	93	79	
27 Oct.	S	352		253	886
	N	154		127	
28 Oct.		708			890
		182			
29 Oct.					
30 Oct.					
31 Oct.		1,320		445	2,458
		189		504	
1 Nov.	S	367		512	1,253
	N	187		187	
2 Nov.	S	212		204	1,002
	N	204		382	
3 Nov.	S			230	525
	N			295	
4 Nov.	S	478			668
	N	190			
5 Nov.					

TABLE 4. (Continued)

YEAR 1966

Date	Bay	8 A.M.	12 Noon	4 P.M.	Total Count
6 Nov.					
7 Nov.	S N			522 317	839
8 Nov.	S N				
9 Nov.	S N	1,412 679		776 473	3,340
10 Nov.		817 305			1,122
11 Nov.					
12 Nov.					
13 Nov.					
14 Nov.	S N	883 885			1,768
15 Nov.					
16 Nov.	S N	579 245		526 195	1,545
17 Nov.	S N	403 453			856
18 Nov.	S N	473 545			1,018
19 Nov.	S N	350 400	330 245	205 118	1,318
20 Nov.	No Count				
21 Nov.	S N	552 437		267 202	1,458
22 Nov.	S N	590 437	287 327	243 135	2,019
23 Nov.	S N	508 318	211 201	201 137	1,576
24 Nov.	No Count				
25 Nov.		No Count	No Wash	258 308	566
26 Nov.	No Count				
27 Nov.	No Count				
28 Nov.	S N	226 117	111 56	137 87	734
29 Nov.		321 67	178 187	137 125	1,015
30 Nov.	S N	398 58 + 221	309 197 + 93	121 22 + 87	1,506

Table 4 Continued

YEAR 1966

Date	Bay	8 A.M.	12 Noon	4 P.M.	Total Count
1 Dec.	S N	603 105/222	452 849/77	182 122/124	2,736
2 Dec.		418 37/208	530 319/117	613 53/119	2,414
3 Dec.	No Count				
4 Dec.	No Count				
5 Dec.	S N	200 607	1210 1103/115	1267 232/76	4,810
6 Dec.		1535 315/410	2055 734/176	1210 128/67	6,630
7 Dec.		1610 405/870	1265 175/235	945 1240/230	6,975
8 Dec.		1730 188/895	745	1175 932/122	5,787
9 Dec.		2300 289/603	890 1000/1600		6,682
10 Dec.	No Count				
11 Dec.	No Count				
12 Dec.	No Count				
13 Dec.	No Count				
14 Dec.	S N		281 235	161 102	1,169
15 Dec.	S N		524 365		889
16 Dec.		717 502	507 434		2,160
17 Dec.	No Count				
18 Dec.	No Count				
19 Dec.		403 610	572 807		2,392
20 Dec.		673 1023	478 732		2,906
21 Dec.	No Count				
22 Dec.		511 832	523 578	383 446	3,273

Table 4 Continued

YEAR 1966

Date	Bay	8 A.M.	12 Noon	4 P.M.	Total Count
23 Dec.		576 393			969
24 Dec.	No Count				
25 Dec.					
26 Dec.					
27 Dec.		680 1142	2030 2910	1040 615	8,417
28 Dec.		1180 3500	2700 3800	1330 620	13,130
29 Dec.				880	1,720
30 Dec.		2020 1550			3,570

Table 4 Continued

YEAR 1967

Date	Bay	8 A.M.	12 Noon	4 P. M.	Total Count
3 Jan.	S N	2900 4300	775 960		8,935
4 Jan.		5800 6300		2752	12,100
5 Jan.	No Count				
6 Jan.	" "				
7 Jan.	" "				
8 Jan.	" "				
9 Jan.	S N		2800	1800	4,600
10 Jan.		1800 1650	5500 4200	1560 1360	16,070
11 Jan.		1220 1260		1120 1070	4,670

Table 4 Continued

YEAR 1967

Date	Bay	8 A.M.	12 Noon	4 P.M.	Total Count
12 Jan.		1550 2025	1970 2500	4600 4200	16,845
13 Jan.		2500 2250	1700 1370	2850 2400	13,070
14 Jan.	No Count				
15 Jan.	No Count				
16 Jan.		2350 2300	760 610	1100 1500	8,620
17 Jan.		2125 2200	 1020	1550 2400	9,295
18 Jan.	S N	800 780	830 560	460 205	3,635
19 Jan.		820 1125	1550 1100	790 980	6,365
20 Jan.		1325 1100	930 620	305 155	4,435
21 Jan.	No Count				
22 Jan.	No Count				

Date	Bay - No.	8 A. M.	12 Noon	4 P. M.	Total Count
23 Jan.		2600 2250	1200 940	680 590	8,260
24 Jan.		680 730	470 820	850 370	3,920
25 Jan.		640 480	820 910	520 510	3,880
26 Jan.		390 540	1550 1700	920 1200	6,300

FINE SCREEN TEST INSTALLATION IN FRONT OF BAY #11

Date	Bay - No.	8 A. M.	12 Noon	4 P. M.	Total Count
27 Jan.	S #11/#12 N #13 & 14	98/725 870	970/750 1280		4,693
28 Jan.		36/200 300	34/280 610	63/580 1500	3,603

Table 4 Continued

YEAR 1967

Date	Bay	8 A. M.	12 Noon	4 P. M.	Total Count
29 Jan.		33/630 480	74/550 350	28/280 230	2,655
30 Jan.		110/1900 1380	75/810 570	32/330 210	5,417
31 Jan.		85/1010 820	42/820 610	835/123 235	4,580

FINE SCREEN TEST INSTALLATION IN FRONT OF BAY #11

Date	Bay	No.	8 A. M.	12 Noon	4 P. M.	Total Count
1 Feb.	S N	#11/#12 #13& 14	218/1660 2100	180/1120 1080	105/870 840	8,173
2 Feb.			121/900 1175	980/1200 1140	135/350 980	6,981
3 Feb.			145/650	85/720		3,320
4 Feb.			31/65 161	95/		352
5 Feb.					44/252 203	499
6 Feb.			13/400 370			783
7 Feb.						
8 Feb.			109/870 1410	51/450 670	63/800	4,423
9 Feb.						
10 Feb.			142/1120 2060			2,202
11 Feb.	No Counts					
12 Feb.	" "					
13 Feb.	" "					

TABLE 4 CONTINUED

YEAR 1967

FINE SCREEN TEST INSTALLATION IN FRONT OF BAY #11

Date	8 A.M. #11	8 A.M. #12	8 A.M. #13 & #14	12 Noon #11	12 Noon #12	12 Noon #13 & #14	4 P.M. #11	4 P.M. #12	4 P.M. #13 & #14	Total Count
14 Feb.				200	330	560	23	73	325	1,511
15 Feb.	32	189	525	19	202	795	21	196	302	2,281
16 Feb.	36	225	375	- No Count - Station Tripped Out						636
17 Feb.	19	87	240	73	62	202				683
18 Feb.	Circulator off During Plant Downtime over weekend									
19 Feb.										
20 Feb.										
21 Feb.		285	730							1,015
22 Feb.	No Count									
23 Feb.	No Count - (Snow Storm)						23	18	138	179
24 Feb.	32	123	135	155	205	170	35	110	165	1,130
25 Feb.										
26 Feb.										
27 Feb.	28	480	910	37	1270	1650	49	510	1350	6,284
28 Feb.		510	710	202	558	720	23	226	2400	5,349
1 March	56	440	1750	42	90	1400	38	320	1175	5,311
2 March	62	660	1550	29	122	570	29	355	1625	5,002
3 March	31	295	1800	*12	195	730	No. Wash.			3,063
4 March										
5 March										
6 March										
7 March										
8 March	25	101	410							

TABLE 4 CONTINUED

YEAR

Date	Bay	8 A.M.	12 Noon	4 P.M.	Total Count
14 Aug.	S. #11 & #12	13	15		92
	N. #13 & #14	42	22		
15 Aug.			23	18	130
			40	49	
16 Aug.		17	15	11	186
		36	45	62	
17 Aug.					
18 Aug.		13	17	15	475
		365	28	37	
19 Aug.					
20 Aug.					
21 Aug.		22	360	175	836
		180	42	57	
22 Aug.		31	342		533
		113	47		
23 Aug.		23	10	21	400
		187	73	86	
24 Aug.		62	17	13	1,497
		1275	98	32	
25 Aug.					
26 Aug.					
27 Aug.					
28 Aug.		12	165	31	367
		67	51	41	
29 Aug.		7	6	7	91
		40	31		
30 Aug.		17			
		42			

YEAR 1970

Date	Time of Day	Fish Count	Total Fish
12 January	9:30 A.M.	4,251	
	12:45 P.M.	1,865	
	4:30 P.M.	2,747	13,226
	8:45 P.M.	4,363	
13 January	1:00 A.M.	8,091	
	4:15 A.M.	13,802	28,592
	8:30 A.M.	6,699	

Table 4 Continued

YEAR 1970

Date	Time of Day	Fish Count	Total Fish
16 January	8:45 A. M.	1,561	
	12:45 P. M.	6,389	19,381
	4:05 P. M.	6,228	
	8:10 P. M.	5,203	
17 January	1:30 A. M.	6,314	6,314
27 January	8:20 A. M.	4,823	
	12:53 P. M.	4,734	
	4:40 P. M.	1,570	15,071
	8:35 P. M.	3,944	
28 January	1:01 A. M.	2,895	
	6:15 A. M.	3,545	
	8:48 A. M.	2,255	12,895
	12:41 P. M.	1,423	
	4:24 P. M.	1,033	
	8:33 P. M.	1,744	
29 January	8:40 A. M.	7,900	21,303
	12:52 P. M.	3,650	
30 January	12 Midnight	2,321	
	4:00 A. M.	1,233	10,270
	8:00 A. M.	5,683	
	4:00 P. M.	1,033	
		2,568	

Date	Time	Fish Count 15 min. Act. Count
31 January	0001	114
	0400	34
	0800	82
	1200	--
	1600	34
	2000	88
		352
1 February	0001	97
	0400	81
	0800	86
	1200	73
	1600	38
	2000	193
		568

TABLE 4 CONTINUED
YEAR 1970

Date	Time	Fish Count 15 Min. Act. Count
2 February	0001	192
	0400	712
	0800	1,086
	1200	
	1600	470
	2000	81
		2,540
3 February	0001	570
	0400	262
	0800	
	1100	1,159
	1600	32
	2000	140
		2,163
4 February	0000	283
	0400	37
	0800	32
	1200	200
	1600	17
	2000	12
		581
5 February	0000	42
	0400	19
	0800	6
	1200	192
	1600	27
	2000	6
		292
6 February	0000	5
	0400	157
	0800	5
	1200	7
	1600	30
	2000	5
		209
7 February	0000	8
	0400	55
	0800	1
	1300	17
	1600	8
	2000	8
		97
8 February	0000	6
	0400	13
	0800	4
	1200	1
	1600	3
	2000	3
		30
9 February	0000	3
	0400	29
	0800	8
	1200	4
	1600	9
	2000	27
		80
10 February	0000	6
	0400	9
	0800	11
	1200	4
	1600	13
	2000	23
		66
11 February	0000	251
	0400	1
	0800	5
	1200	5
	1600	
	2000	23
		285

TABLE 4 CONTINUED
YEAR 1970

Fish Count

Date	Time	15 Min. Act. Count
12 February	0000	6
	0400	6
	0800	6
	1200	18
	1600	2
	2000	25
		63
13 February	0000	9
	0400	4
	0800	5
	1200	2
	1600	6
	2000	10
		36
14 February	0000	2
	0400	2
	0800	2
	1200	3
	1600	1
	2000	6
		16
15 February	0000	3
	0400	3
	0800	2
	1200	2
	1600	1
	2000	2
		13
16 February	0000	8
	0400	12
	0800	10
	1200	12
	1600	5
	2000	7
		73
17 February	0000	23
	0400	3
	0800	3
	1200	
	1600	5
	2000	17
		51
18 February	0000	1
	0400	1
	0800	
19 February	0800	1
20 February	0800	1
21 February	0800	8
22 February	0800	12
23 February	0800	4
24 February	0800	9
25 February	0800	5
26 February	0800	1
27 February	0800	9
28 February	0800	12

TABLE 4. (Continued)

YEAR 1970

Date	Count	Date	Count
1 March	0	17 March	48
2 March	64	18 March	24
3 March	18	19 March	12
4 March	801	20 March	59
5 March	59	21 March	31
6 March	66	22 March	-
7 March	322	23 March	18
8 March	8	24 March	40
9 March	53	25 March	27
10 March	118	26 March	38
11 March	210	27 March	73
12 March	15	28 March	-
13 March	83	29 March	-
14 March	70	30 March	21
15 March	45	31 March	-
16 March	-		

Date	Time	Bay 11	Bay 12	Bay 13	Bay 14	Total day
4 April	0800	10	100	100	-	
	1200	-	-	-	-	
	1600	1	3	4	-	
	2000	1	0	9	-	
		12	103	113	-	228
5 April	0000	4	6	19	5	
	0400	0	1	2	1	
	0800	0	2	15	9	
	1200	151	254	101	9	
	1600	11	11	12	4	
	2000	7	9	16	0	
		173	283	165	28	649
6 April	0000	9	21	8	7	
	0400	0	0	1	1	
	0800	3	5	2	7	
	1200	102	354	323	34	
	1600	5	22	12	4	
	2000	9	22	13	14	
		128	424	359	67	973
7 April	0000	6	4	2	5	
	0400	0	2	1	2	
	0800	3	6	9	10	
	1200	111	142	302	18	
	1600	12	24	7	3	
	2000	2	3	3	3	
		134	181	324	41	680
8 April	0000	1	4	2	2	
	0400	2	5	2	2	
	0800	6	8	5	-	
	1200	5	14	305	170	
	1600	0	1	11	6	
	2000	0	1	3	7	
		14	33	321	187	562

TABLE 4 CONTINUED

YEAR 1970

Date	Time	Bay 11	Bay 12	Bay 13	Bay 14	Total Day
9 April	0600	3	7	4	2	
	0400	2	4	5	1	
	0800	1	1	7	13	
	1200	1	6	195	215	
	1600	1	1	6	5	
	2000	0	2	1	2	
		8	21	218	238	485
10 April	0000	1	0	0	3	
	0400	1	2	1	3	
	0800	3	3	21	7	
	1200	7	19	521	264	
	1600	1	1	6	5	
	2000	0	2	1	2	
		13	27	550	284	874
11 April	0000	2	4	5	8	
	0400	5	3	2	7	
	0800	25	10	9	9	
	1200	360	220	55	14	
	1600	3	1	6	3	
	2000	3	0	1	2	
		398	233	78	43	752
12 April	0000	11	14	30	18	
	0400	6	8	11	5	
	0800	12	18	7	3	
	1200	199	268	10	4	
	1600	2	2	3	1	
	2000	1	3	2	2	
		231	313	63	33	640
13 April	0000	5	7	9	12	
	0400	4	7	2	3	
	0800	-	-	-	-	
	1200	134	99	6	6	
	1600	0	1	2	1	
	2000	0	0	1	0	
		143	114	20	22	299
14 April	0000	1	4	8	10	
	0400	2	1	5	4	
	0800	3	9	1	0	
	1200	25	30	7	0	
	1600	0	2	3	1	
	2000	1	1	2	1	
		32	47	26	16	121
15 April	0000	1	3	2	0	
	0400	2	2	5	1	
	0800	0	2	1	1	
	1200	13	12	12	0	
	1600	2	0	1	1	
	2000	1	3	2	1	
		19	22	23	4	68
16 April	0000	2	1	3	1	
	0400	1	2	3	2	
	0800	2	1	1	0	
	1200	2	1	5	7	
	1600	1	0	0	2	
	2000	1	2	0	1	
		9	7	12	13	41
17 April	0000	1	1	0	2	
	0400	2	0	3	2	
	0800	Test ended:				
	1200					
	1600					
	2000					
		3	1	3	4	11

18 & 19 April Circulator Pumps alternately shutdown

Table 4 Continued

YEAR 1970

Date	Time	Bay 11	Bay 12	Bay 13	Bay 14	Total day
20 April	0000	0	0	1	0	
	0400	8	5	3	4	
	0800	1	0	1	1	
	1200	2	3	3	16	
	1600	236	116	97	196	
	2000	166	25	37	207	
		413	149	142	424	1128
21 April	0000	235	20	15	50	
	0400	300	7	5	135	
	0800	754	3	5	103	
	1200	250	31	19	51	
	1600	975	18	11	510	
	2000	450	3	5	320	
		2964	82	60	1169	4295
22 April	0000	350	3	5	60	
	0400	600	5	1	180	
	0800	-	-	-	-	
	1200	-	-	-	-	
	1600	838	75	46	210	
	2000	480	8	10	140	
		2268	91	62	590	3011
23 April	0000	350	3	5	95	
	0400	245	4	3	115	
	0800	380	7	0	125	
	1200	266	18	17	32	
	1600	195	11	9	62	
	2000	175	8	9	60	
		1611	51	43	489	7194
24 April	0000	23	0	1	7	
	0400	14	2	0	9	
	0800	29	1	2	5	
	1200	6	3	10	0	
	1600	9	0	0	4	
	2000	11	2	4	6	
		92	8	17	31	148
25 April	0000	2	0	0	3	
	0400	3	0	0	3	
	0800	7	2	0	4	
	1200	4	6	1	1	
	1600	6	1	2	5	
	2000	8	0	1	3	
		30	9	4	19	62
26 April	0000	4	1	0	1	
	0400	2	0	0	1	
	0800	11	2	0	4	
	1200	11	0	4	3	
	1600	Test Ended				
	2000					
		28	3	4	9	44

Table 4 Continued

YEAR 1970

Date	Time	Bay 11	Bay 12	Bay 13	Bay 14	Total day
19 May	0000	-	-	-	-	
	0400	-	-	-	-	
	0800	1	0	0	1	
	1200	3	2	0	1	
	1600	-	-	-	-	
	2000	-	-	-	-	
		4	2		2	8
20 May	0000	-	-	-	-	
	0400	-	-	-	-	
	0800	1	1	0	4	
	1200	2	0	0	4	
	1600	-	-	-	-	
	2000	-	-	-	-	
		3	1		8	12
21 May	0000	-	-	-	-	
	0400	-	-	-	-	
	0800	2	1	-	-	
	1200	Plant shutdown with				
	1600	mechanical problems				
	2000					
		2	1			3
9 June	0000	-	-	-	-	
	0400	-	-	-	-	
	0800	0	0	0	0	
	1200	0	0	0	0	
	1600	-	-	-	-	
	2000	-	-	-	-	
		0	0	0	0	0
10 June	0000	-	-	-	-	
	0400	-	-	-	-	
	0800	1	2	0	0	
	1200	7	2	0	0	
	1600	-	-	-	-	
	2000	-	-	-	-	
		8	4	0	0	12
11 June	0000	-	-	-	-	
	0400	-	-	-	-	
	0800	7	61	7	5	
	1200	-	-	-	-	
	1600	-	-	-	-	
	2000	-	-	-	-	
		7	61	7	5	30
12 June	0000	-	-	-	-	
	0400	-	-	-	-	
	0800	1	17	10	22	
	1200	26	30	2	5	
	1600	-	-	-	-	
	2000	-	-	-	-	
		27	47	12	27	113

TABLE 4. (Continued)

YEAR 1970

Date	Time	Bay 11	Bay 12	Bay 13	Bay 14	Total Day
13 June	0000	2	6	4	2	
	0400	4	3	2	5	
	0800	2	0	0	0	
	1200	-	-	-	-	
	1600	0	1	0	0	
	2000	2	5	1	0	
		10	15	7	7	39
14 June	0000	-	-	-	-	
	0400	-	-	-	-	
	0800	-	-	-	-	
	1200	-	-	-	-	
	1600	-	-	-	-	
	2000	-	-	-	-	
		-	-	-	-	-
15 June	0000	1	3	0	0	
	0400	-	-	-	-	
	0800	0	8	5	0	
	1200	-	-	-	-	
	1600	-	-	-	-	
	2000	-	-	-	-	
		1	11	5	0	17

TABLE 5. AVERAGE LENGTH, AVERAGE WEIGHT, AND PERCENT SPECIES COMPOSITION OF FISH COLLECTED ON THE TRAVELING SCREENS.

	Bay 11				Bay 12			
Date	Species	Average Length (mm)	Average Weight (g)	% Composition	Species	Average Length (mm)	Average Weight (g)	% Composition
Apr 4-5	White Perch	74.82	5.17	77.9	White Perch	75.83	4.95	74.51
Apr 6-7 1970	Smelt	135.5	9.53	3.87	Smelt	135.7	17.3	3.34
	Spottail Shiner	79.2	4.58	9.2	Spottail Shiner	80.88	4.97	11.28
	Tomcod	173.3	40.0	.72	Tomcod	135.75	16.75	.55
	White Catfish	150.0	37.0	.48	White Catfish	253.8	486.0	.27
	Striped Bass	89.36	6.89	4.6	Striped Bass	100.64	9.35	4.87
	Yellow Bullhead	94.0	10.0	.48	Yellow Bullhead	186.05	167	.27
	Pumpkinseed	104.6	31.6	1.21	Pumpkinseed	80.55	11.55	1.25
	Killifish	0	0	0	Killifish	58.5	Neg.	.27
	Stickleback	0	0	0	Stickleback	0	0	0
	Eel	0	0	0	Eel	304.8	Did Not Take	.13
	Golden Shiner	0	0	0	Golden Shiner	118.0	14.66	1.11
	Catfish	93.0	11.0	.72	Catfish	128.5	74.0	1.39
	Yellow Perch	0	0	0	Yellow Perch	192.0	86.0	.13
	Goldfish	0	0	0	Goldfish	84.33	11.0	.41
	Unidentified	98.0	9.5	.72	Unidentified	85.5	8.0	.13
	BAY 13				BAY 14			
	White Perch	75.64	5.17	75.80	White Perch	75.80	6.15	76.53
	Smelt	137.8	13.5	3.33	Smelt	135.3	15.0	6.12
	Spottail Shiner	79.15	3.3	11.91	Spottail Shiner	72.0	3.85	10.20
	Tomcod	153.55	21.77	1.19	Tomcod	0	0	0
	White Catfish	74.0	Neg.	.11	White Catfish	0	0	0
	Striped Bass	96.11	9.73	3.21	Striped Bass	101.4	10.2	6.12
	Yellow Bullhead	97	1.3	.11	Yellow Bullhead	0	0	0
	Pumpkinseed	77.0	9.0	.11	Pumpkinseed	133.0	44.0	1.02
	Killifish	0	0	0	Killifish	0	0	0
	Stickleback	61.0	Neg.	.47	Stickleback	0	0	0
	Eel	482.6	262.0	.23	Eel	0	0	0
	Golden Shiner	162.33	43.83	.71	Golden Shiner	0	0	0
	Catfish	157.15	81.07	1.66	Catfish	0	0	0
	Yellow Perch	0	0	0	Yellow Perch	0	0	0
	Goldfish	80.0	9.12	.95	Goldfish	0	0	0
	Unidentified	50.0	8.0	.11	Unidentified	0	0	0

TABLE 5. Continued

Date	Bay 11 Species	Average Length (mm)	Average Weight (g)	% Composition	Bay 12 Species	Average Length (mm)	Average Weight (g)	% Composition
Apr 8,9, 10,1970	White Perch	73.84	5.23	72.22	White Perch	73.91	5.12	64.86
	Smelt	0	0	0	Smelt	144.33	22.33	8.10
	Spottail Shiner	61.0	Neg.	5.55	Spottail Shiner	82.33	7.0	16.21
	Tomcod	212.0	56.50	11.11	Tomcod	148.0	17.5	10.81
	Striped Bass	0	0	0	Striped Bass	0	0	0
	Sunfish	0	0	0	Sunfish	0	0	0
	Killifish	0	0	0	Killifish	0	0	0
	Stickleback	0	0	0	Stickleback	0	0	0
	Golden Shiner	0	0	0	Golden Shiner	0	0	0
	Catfish	0	0	0	Catfish	0	0	0
	Yellow Perch	0	0	0	Yellow Perch	0	0	0
	Goldfish	0	0	0	Goldfish	0	0	0
	Johnny Darter	78.5	6.0	11.11	Johnny Darter	0	0	0
	BAY 13				BAY 14			
	White Perch	76.64	4.74	50.00	White Perch	78.49	5.09	37.16
	Smelt	122.66	12.33	5.88	Smelt	141.29	14.81	9.12
	Spottail Shiner	75.50	4.20	23.52	Spottail Shiner	78.30	4.43	31.75
	Tomcod	0	0	0	Tomcod	117.36	11.72	3.71
	Striped Bass	85.66	6.66	2.94	Striped Bass	96.0	7.33	2.02
	Sunfish	136.0	56.5	1.96	Sunfish	84.0	12.25	1.35
	Killifish	52.0	Neg.	.98	Killifish	82.0	6.0	1.68
	Stickleback	0	0	0	Stickleback	67.0	3.0	.67
	Golden Shiner	145.0	34.5	1.96	Golden Shiner	131.9	24.8	3.37
	Catfish	119.2	27.0	4.90	Catfish	158.5	64.7	3.37
	Yellow Perch	0	0	0	Yellow Perch	87.5	8.5	.67
	Goldfish	94.71	15.85	6.86	Goldfish	90.66	13.26	5.06
	Johnny Darter	77.0	7.0	.98	Johnny Darter	0	0	0

Table 5 Continued

Date	Species	Bay 11 Average Length (mm)	Bay 11 Average Weight (g)	Bay 11 % Composition	Species	Bay 12 Average Length (mm)	Bay 12 Average Weight (g)	Bay 12 % Composition
Apr. 11, 12,13,1970	White Perch	82.80	8.13	39.60	White Perch	80.08	5.79	40.16
	Smelt	135.50	14.11	7.05	Smelt	144.71	18.07	6.14
	Spottail Shiner	76.36	3.55	28.23	Spottail Shiner	71.79	3.00	25.81
	Tomcod	141.72	16.54	4.31	Tomcod	134.35	13.17	6.96
	Striped Bass	90.75	6.00	1.56	Striped Bass	96.76	6.92	5.32
	Sunfish	111.50	27.50	1.56	Sunfish	81.00	20.20	2.04
	Killifish	84.33	5.33	1.17	Killifish	88.50	8.00	1.63
	Stickleback	0	0	0	Stickleback	61.00	Neg.	.40
	Eel	234.0	22.0	.78	Eel	0	0	0
	Golden Shiner	112.33	15.77	3.52	Golden Shiner	142.44	21.88	3.68
	Catfish	168.52	86.89	7.45	Catfish	148.61	62.61	5.32
	Yellow Perch	82.00	7.00	.39	Yellow Perch	128.50	13.50	.81
	Goldfish	100.30	31.30	3.92	Goldfish	77.50	6.75	1.63
	Johnny Darter	58.00	Neg.	.39	Johnny Darter	0	0	0
	Alewife	0	0	0	Alewife	0	0	0
	BAY 13				**BAY 14**			
	White Perch	81.20	7.80	50.00	White Perch	76.18	4.81	57.89
	Smelt	0	0	0	Smelt	0	0	0
	Spottail Shiner	91.00	7.20	20.00	Spottail Shiner	82.00	4.25	21.05
	Tomcod	140.50	24.50	6.66	Tomcod	0	0	0
	Striped Bass	81.00	6.00	3.33	Striped Bass	88.00	5.00	5.26
	Sunfish	0	0	0	Sunfish	0	0	0
	Killifish	0	0	0	Killifish	0	0	0
	Stickleback	0	0	0	Stickleback	0	0	0
	Eel	0	0	0	Eel	0	0	0
	Golden Shiner	122.0	13.00	3.33	Golden Shiner	146.0	30.00	5.26
	Catfish	167.0	66.00	10.00	Catfish	0	0	0
	Yellow Perch	113.0	17.00	3.33	Yellow Perch	0	0	0
	Goldfish	91.00	12.00	3.33	Goldfish	87.00	9.00	5.26
	Johnny Darter	0	0	0	Johnny Darter	0	0	0
	Alewife	0	0	0	Alewife	300.0	290.0	5.26

Table 5 Continued

Date	Species	Average Length (mm)	Average Weight (g)	% Comp.	Species	Average Length (mm)	Average Weight (g)	% Comp.
	Bay 11				Bay 12			
Apr. 14,15, 16, 1970	White Perch	78.58	6.57	64.86	White Perch	78.36	5.94	69.76
	Smelt	129	17	2.70	Smelt	0	0	0
	Spottail Shiner	69.55	2.81	24.32	Spottail Shiner	79	4.67	20.93
	Sunfish	0	0	0	Sunfish	66	4.20	2.32
	Killifish	87	7.80	2.70	Killifish	65	2.40	2.32
	Catfish	0	0	0	Catfish	0	0	0
	Yellow Perch	0	0	0	Yellow Perch	68	3.10	2.32
	Goldfish	87	11.00	2.70	Goldfish	69	4.30	2.32
	Sturgeon	152.4	Did Not Take	2.70	Sturgeon	0	0	0
	BAY 13				BAY 14			
	White Perch	75.87	5.46	57.14	White Perch	60.00	2.80	100.00
	Smelt	140	24.2	14.28	Smelt	0	0	0
	Spottail Shiner	75.66	4.30	21.42	Spottail Shiner	0	0	0
	Sunfish	0	0	0	Sunfish	0	0	0
	Killifish	0	0	0	Killifish	0	0	0
	Catfish	277	256.50	7.14	Catfish	0	0	0
	Yellow Perch	0	0	0	Yellow Perch	0	0	0
	Goldfish	0	0	0	Goldfish	0	0	0
	Sturgeon	0	0	0	Sturgeon	0	0	0
	Bay 11				Bay 12			
Apr. 20, 1970	White Perch	0	0	0	White Perch	60.50	2,45	100.00
	Smelt	72.50	2.35	100.00	Smelt	0	0	0
	Catfish	0	0	0	Catfish	0	0	0
	Bay 13				Bay 14			
	White Perch	70.0	4.40	50	White Perch	76.55	6.96	95.23
	Smelt	0	0	0	Smelt	0	0	0
	Catfish	342.90	561.8	50	Catfish	131	17.2	4.76

Table 5 Continued

Date	Bay 11 Species	Average Length (mm)	Average Weight (g)	% Comp.	Bay 12 Species	Average Length (mm)	Average Weight (g)	% Comp.
Apr. 21, 22, 23, 1970	White Perch	98.28	18.92	52.51	White Perch	79	5.66	30
	Smelt	109.86	8.85	15.82	Smelt	90.28	5.85	70
	Spottail Shiner	84	5.13	4.31	Spottail Shiner	0	0	0
	Tomcod	144.83	17.65	4.31	Tomcod	0	0	0
	Striped Bass	94.09	8.80	15.10	Striped Bass	0	0	0
	Sunfish	93	12.80	.71	Sunfish	0	0	0
	Catfish	86.16	5.33	4.31	Catfish	0	0	0
	Goldfish	88	9.90	.71	Goldfish	0	0	0
	Shad	130	15.3	.71	Shad	0	0	0
	Blueback Herring	171	30	.71	Blueback Herring	0	0	0
	Crappie	0	0	0	Crappie	0	0	0
	Yellow Perch	93	9.10	.71	Yellow Perch	0	0	0
	Alewife	0	0	0	Alewife	0	0	0

Bay 13 Species	Average Length (mm)	Average Weight (g)	% Comp.	Bay 14 Species	Average Length (mm)	Average Weight (g)	% Comp.
White Perch	91.25	15.07	80.0	White Perch	93.01	15.19	69.31
Smelt	0	0	0	Smelt	122.58	10.90	19.31
Spottail Shiner	0	0	0	Spottail Shiner	73	3.80	1.13
Tom Cod	0	0	0	Tom Cod	14.5	26.70	1.13
Striped Bass	107	8.60	20.0	Striped Bass	92	7.24	5.68
Sunfish	0	0	0	Sunfish	0	0	0
Catfish	0	0	0	Catfish	0	0	0
Goldfish	0	0	0	Goldfish	0	0	0
Shad	0	0	0	Shad	0	0	0
Blueback Herring	0	0	0	Blueback Herring	74	2.50	1.13
Crappie	0	0	0	Crappie	155	40.60	1.13
Yellow Perch	0	0	0	Yellow Perch	0	0	0
Alewife	0	0	0	Alewife	280	185.50	1.13

Table 5 Continued

Date	Bay 11 Species	Average Length (mm)	Average Weight (g)	% Composition	Bay 12 Species	Average Length (mm)	Average Weight (g)	% Composition
Apr 24,25, 26, 1970	White Perch	110.40	24.09	75.75	White Perch	73.20	4.36	71.42
	Smelt	105.2	7.30	7.57	Smelt	0	0	0
	Spottail Shiner	69	2.0	1.51	Spottail Shiner	0	0	0
	White Catfish	144.50	53.45	3.03	White Catfish	0	0	0
	Striped Bass	110.33	15.13	4.54	Striped Bass	0	0	0
	Eel	304	54.80	1.51	Eel	381	149.90	14.28
	Golden Shiner	140	18.4	1.51	Golden Shiner	161	57.30	14.28
	Catfish	67	3.00	1.51	Catfish	0	0	0
	Johnny Darter	0	0	0	Johnny Darter	0	0	0
	Alewife	116	11.4	1.51	Alewife	0	0	0
	Hogchoker	72	6.20	1.51	Hogchoker	0	0	0

Date	Bay 13 Species	Average Length (mm)	Average Weight (g)	% Composition	Bay 14 Species	Average Length (mm)	Average Weight (g)	% Composition
	White Perch	78.71	7.34	63.63	White Perch	155.22	57.44	62.50
	Smelt	70	2.20	9.09	Smelt	147	16.50	6.25
	Spottail Shiner	83.5	5.50	9.09	Spottail Shiner	79	3.30	6.25
	White Catfish	0	0	0	White Catfish	320	440.9	6.25
	Striped Bass	93	6.90	9.09	Striped Bass	0	0	0
	Eel	355.60	114.70	9.09	Eel	0	0	0
	Golden Shiner	0	0	0	Golden Shiner	0	0	0
	Catfish	0	0	0	Catfish	60	1.80	6.25
	Johnny Darter	0	0	0	Johnny Darter	0	0	0
	Alewife	0	0	0	Alewife	291	256.2	6.25
	Hogchoker	0	0	0	Hogchoker	137	43.7	6.25

TABLE 5 CONTINUED

./. Composition / Average Length (MM)
Species

Date	Time	Bay 11	Bay 12	Bay 13	Bay 14	Total Day	Bay	Tomicod	Anchovy	Striped Bass	White Perch	Other & Unidentified
August 7, 1970	0800	3	5	2	0		11	96.9/73.7				3.1
	1200	26	30	4	0		12	98.0/77.5				2.0
	1600	7	39	5	2		13	76.9/81.4				33.1
	2000	10	32	1	0		14	-/-				-
		46	106	12	2	166						
August 8, 1970	0000	4	5	7	3		11					
	0400	2	8	8	1		12					
No F-screen wash	0800	0	22	1	2		13	No observations				
	1200	6	3	5	0		14					
	1600	0	1	0	0							
	2000	1	3	0	0							
		13	42	21	6	82						
August 9, 1970	0000	1	4	2	5		11					
	0400	0	5	3	4		12					
No F-screen wash	0800	1	3	5	0		13	No observations				
	1200	0	6	3	3		14					
	1600	0	15	6	1							
	2000	1	8	2	0							
		3	41	21	13	78						
August 10, 1970	0000	1	3	6	3		11					
	0400	2	6	4	2		12					
	0800	1	18	6	5		13	No observations				
	1200	39	58	4	2		14					
	1600	20	32	1	0							
	2000	5	19	3	1							
		68	136	24	13	241						
A[illegible] 11, 1970	0000	7	3	4	7		11	44.4/84.5	11.1/81.5	5.5/246.5	5.5/81.0	33.3
	0400	3	5	0	2		12	48.5/89.0	17.8/76.4	7.9/70.3	3.9/47.8	21.8
	0800	-	50	74	36		13	3.9/119.7	32.9/77.7	35.5/50.9	23.7/53.1	3.9
	1200	36	51	2	3		14	33.3/96.2	33.3/77.9	10.3/44.8	7.7/52.0	15.4
	1600	0	0	0	0							
	2000	2	7	3	1							
		48	116	83	49	296						

TABLE 5 CONTINUED

Date	Time	Bay 11	Bay 12	Bay 13	Bay 14	Total Day	Bay	% Composition / Average Length (MM) Species: Tomicod	Anchovy	Striped Bass	White Perch	Other & Unidentified
August 12, 1970	0000	11	15	9	36		11	23.2/104.5	57.3/75.0	1.2/53.0	1.2/54.0	17.1
	0400	8	11	0	4		12	3.8/ 97.3	79.7/57.3	11.5/52.4	2.2/49.8	2.9
	0800	82	1376	82	52		13	2.4/ 98.0	55.4/77.3	24.1/52.4	14.6/45.3	3.6
	1200	7	36	0	1		14	8.0/ 97.8	69.2/74.0	9.6/52.2	-/-	13.5
	1600	5	10	2	4							
	2000	4	9	1	3							
		117	1457	94	100	1768						
August 13, 1970	0000	2	6	0	3		11	45.2/ 90.1	23.8/76.6	2.4/62	2.4/47	26.2
	0400	0	8	2	5		12	38.4/ 97.5	14.3/75.9	1.8/43.2	1.8/43.2	44.6
	0800	42	112	7	8		13	-/-	71.4/75.5	14.3/45.0	-/-	14.3
	1200	-	-	-	-		14	25.0/-	12.5/73.0	25.0/44.5	-/-	37.5
	1600	1	4	0	0							
	2000	9	19	11	2							
		54	149	20	18	241						
August 14, 1970	0000	5	15	12	7		11	-/-	66.6/77.3	-/-	16.6/45	16.7
	0400	2	8	8	0		12	64.3/92.6	7.1/76	-/-	7.1/60	21.4
	0800	5	5	3	0		13	33.3/16.0	33.3/60	-/-	-/-	33.3
	1200	54	50	2	4		14	60.0/96.3	20.0/79	-/-	20.0/53	-
	1600	1	1	0	0							
	2000	0	8	0	5							
		67	87	25	16	195						
August 15, 1970	0000	9	102	10	11		11	66.2/88.2	16.9/61.8	1.4/110	2.8/49.0	12.7
	0400	4	50	6	2		12	89.6/90.0	6.0/73.7	0.4/43	0.4/55	4.0
	0800	5	21	3	1		13	63.0/106.8	14.8/74.8	3.7/55	3.7/45	14.8
	1200	47	59	2	5		14	54.2/91.8	33.3/65.8	4.2/44	-/-	8.3
	1600	2	8	4	1							
	2000	4	9	2	4							
		71	249	27	24	371						
August 16, 1970	0000	45	414	55	432		11	85.7/87.9	10.9/77.4	0.4/266.0	0.4/46.5	2.6
	0400	71	566	26	79		12	95.4/89.2	2.5/77.3	0.4/158.8	0.07/45	1.6
	0800	11	99	8	8		13	85.4/88.2	8.9/71.6	0.8/55	0.8/41	4.1
	1200	378	280	21	22		14	94.6/89.3	3.9/75.7	0.2/230	0.9/49.0	0
	1600	13	44	7	13							
	2000	9	38	6	5							
		547	1441	123	559	2670						

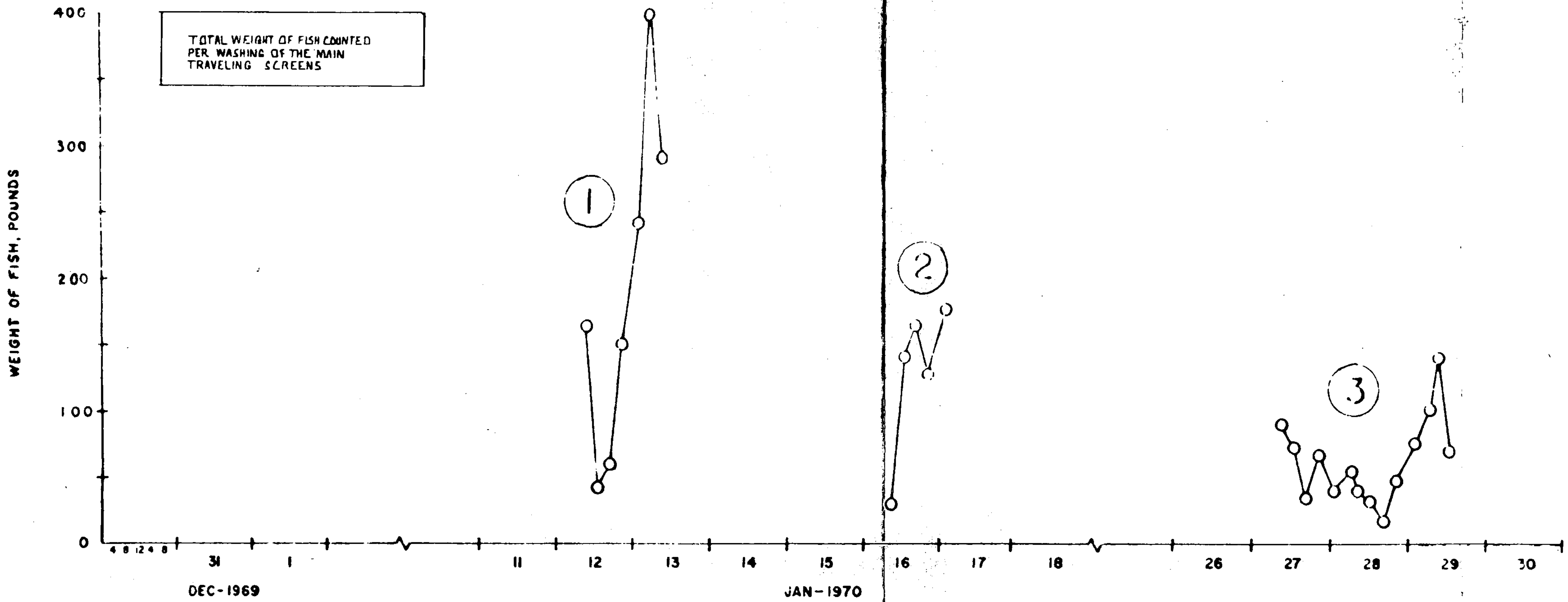
TABLE 5 CONTINUED

Date	Time	Bay 11	Bay 12	Bay 13	Bay 14	Total Day
August/ 7, 1970	0000	39	438	72	415	
	0400	125	1003	62	197	
	0800	29	232	19	29	
		203	1673	153	641	2660
Grand Totals		1237	5497	603	1441	8768
Avg. number/day		112.5	499.7	54.8	131.0	797.0
Grand Totals excluding 8/12,16,17		370	926	233	141	1670
Avg. number/day excluding 8/12,16,17		46.3	115.7	29.1	17.6	208.8

./. Composition / Average Length (MM)

	Species				
Bay	Tomicod	Anchovy	Striped Bass	White Perch	Other & Unidentified
11	82.3/82.7	13.3/71.4	-/-	0.5/40	3.9
12	99.1/85.9	0.6/80.4	-/-	0.1/105	0.2
13	89.5/85.2	7.2/70.5	-/-	-/-	3.3
14	96.6/89.7	2.7/69.1	-/-	0.3/50	0.5

FIGURE 5. A plot of the total number and weight of fish collected from the traveling screens at Unit No. 1 from January 12, 1970 through February 2, 1970.


TOTAL WEIGHT OF FISH COUNTED PER WASHING OF THE MAIN TRAVELING SCREENS
WEIGHT OF FISH, POUNDS
400
300
200
100
0
31
1
11
12
13
14
15
16
17
18
26
27
28
29
30
DEC-1969
JAN-1970
1
2
3

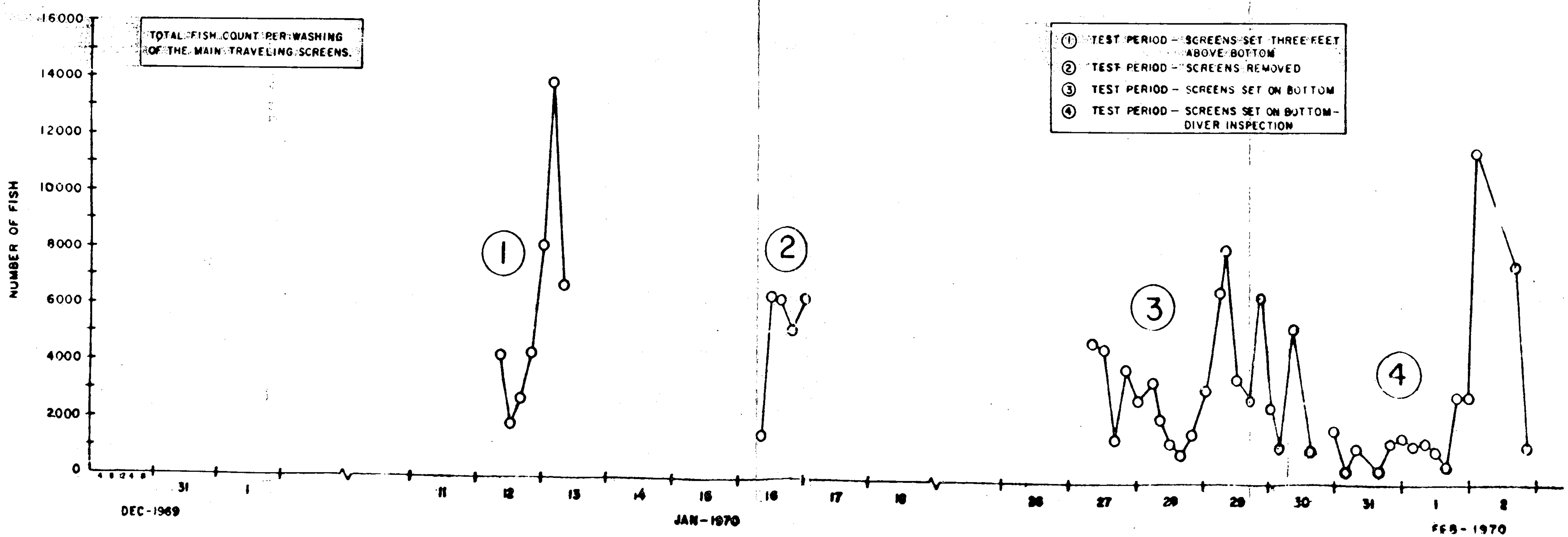

TOTAL FISH COUNT PER WASHING OF THE MAIN TRAVELING SCREENS.
NUMBER OF FISH
16000
14000
12000
10000
8000
6000
4000
2000
0
① TEST PERIOD – SCREENS SET THREE FEET ABOVE BOTTOM
② TEST PERIOD – SCREENS REMOVED
③ TEST PERIOD – SCREENS SET ON BOTTOM
④ TEST PERIOD – SCREENS SET ON BOTTOM – DIVER INSPECTION
DEC-1969
JAN-1970
FEB-1970
1
2
3
4

FIGURE 6. A plot of the total number and weight of fishes collected from the traveling screens at Unit No. 1 from February 1, 1970 through February 28, 1970.

INDIAN POINT FISH SITUATION

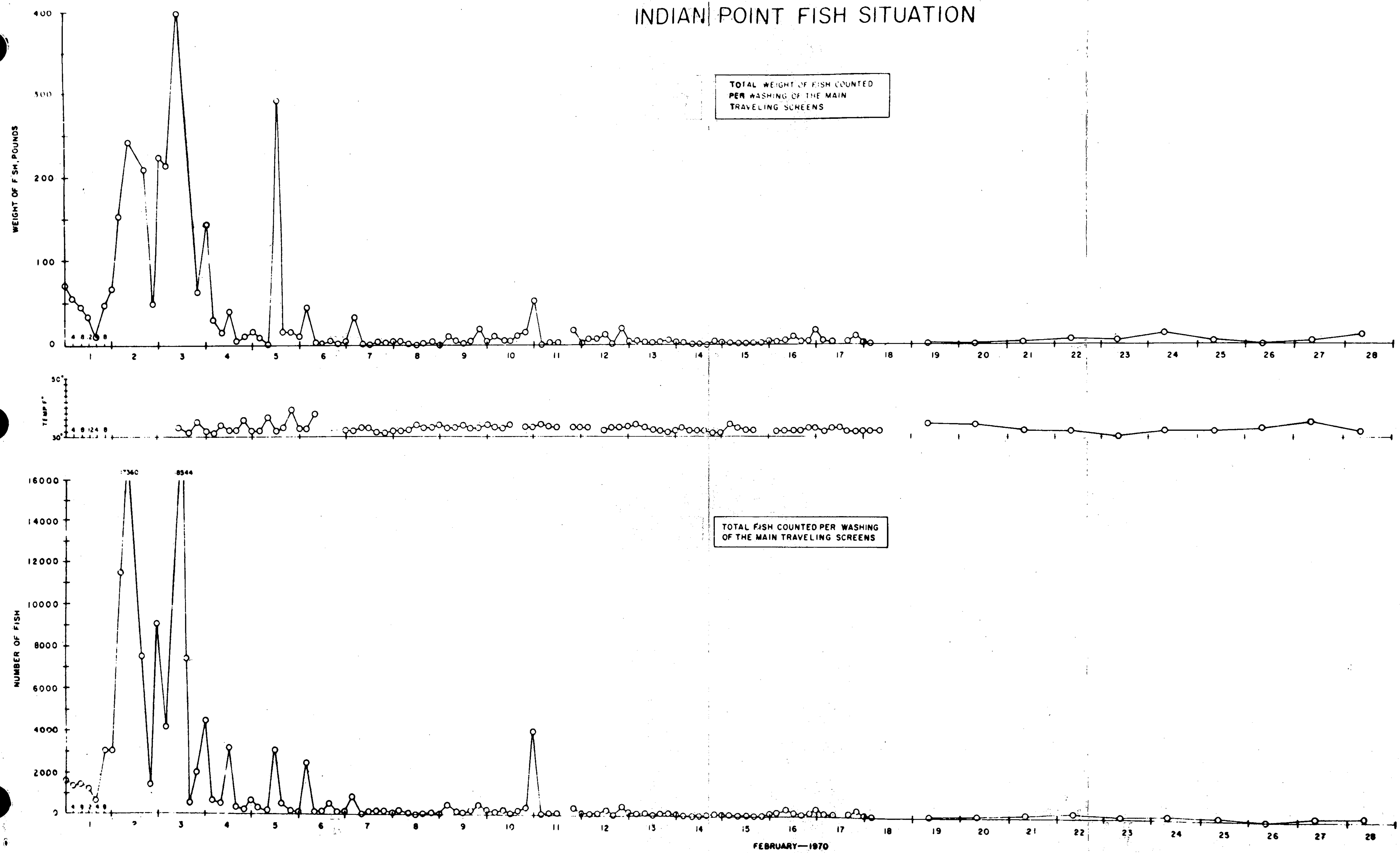
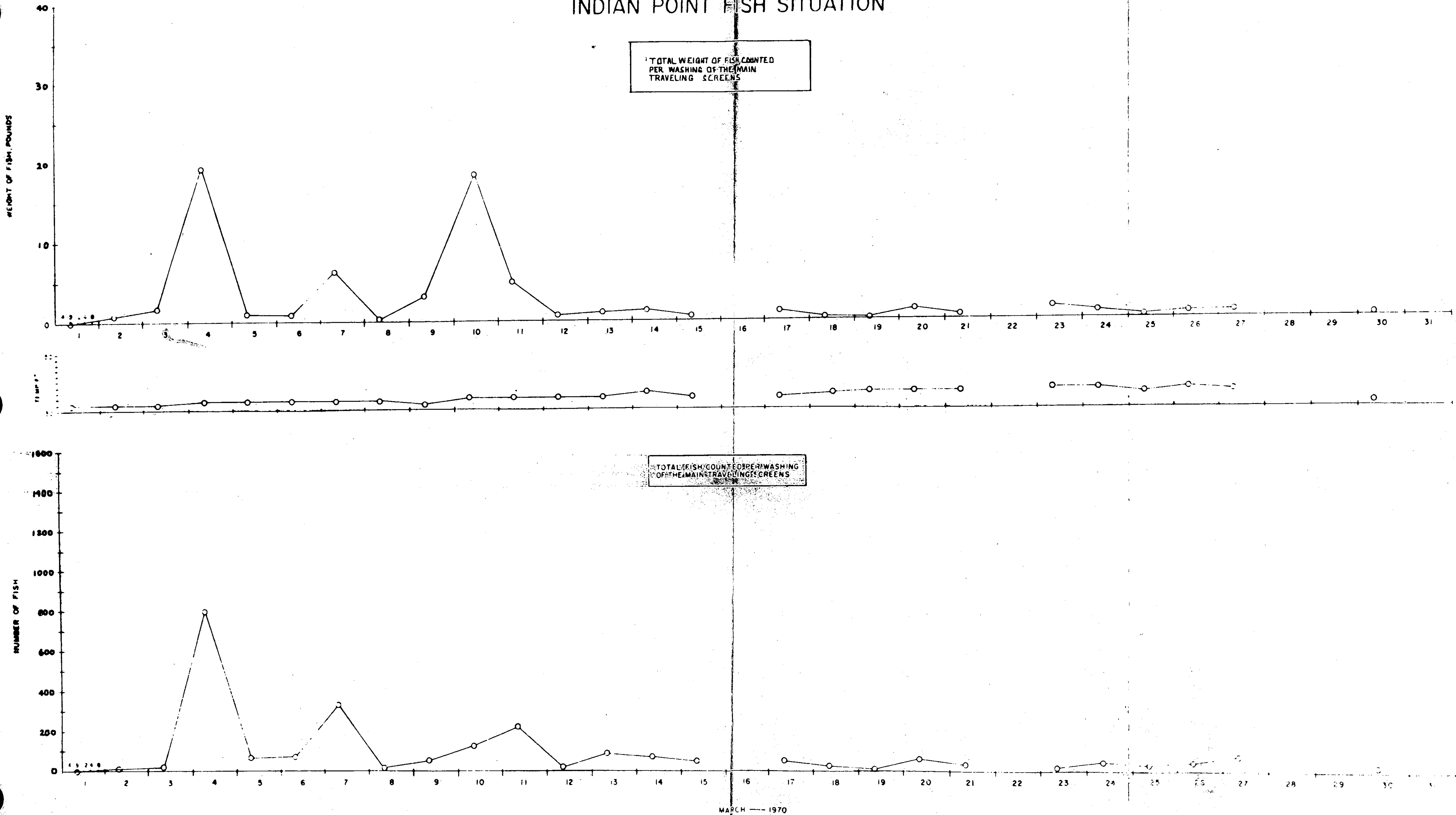


FIGURE 7. A plot of the total number and weight of fishes collected from the traveling screens at Unit No. 1 from March 1, 1970 through March 28, 1970.

INDIAN POINT FISH SITUATION



APPENDIX B

Following is a list of certain ecological and other studies which have been sponsored by Con Edison to date and their approximate cost to the Company.

(a) Studies by Raytheon Company .... $ 591,600.00

1. Fish community studies
2. Plankton communities
3. Benthic samples
4. Water chemistry

(b) Studies by New York University .... $ 168,725.00

1. Fish community studies
2. Plankton communities
3. Aquatic radioecology
4. Aquatic microbiology
5. Water chemistry

(c) Studies by Ichthyological Associates .... $ 43,500.00

1. Swimming speed investigations
2. Temperature preference and avoidance studies

(d) Studies by Northeastern Biologists, Inc.. $ 385,340.00

1. Studies of striped bass egg and larval stages
2. Studies of young of the year of major species of fish

(e)	Studies by Bechtel Corporation	$	35,000.00
	1. Fish protection devices		
(f)	Studies by Norman Porter Associates	$	37,300.00
	1. Studies on intake velocity		
	2. Studies on water movement at intakes		
(g)	Alden Hydraulic Labs	$	76,963.00
	1. Hudson River Hydraulic Model No. 1		
(h)	Other Miscellaneous Studies	$	60,000.00
	Total		$1,398,428.00

APPENDIX - T

COST EXPENDITURES ON ENVIRONMENTAL STUDIES

Following is a list of certain ecological and other studies which have been sponsored by Con Edison to date and their approximate cost to the Company.

(a)	Studies by Raytheon Company	$ 591,600.00
(b)	Studies by New York University	$ 168,725.00
(c)	Studies by Ichthyological Associates	$ 43,500.00
(d)	Studies by Northeastern Biologists, Inc.	$ 385,340.00
(e)	Studies by Bechtel Corporation	$ 35,000.00
(f)	Studies by Norman Porter Associates	$ 37,300.00
(g)	Alden Research Laboratories*	$ 262,757.00
(h)	Studies by QLM*	$ 69,847.00
(i)	Other Miscellaneous Studies	$ 60,000.00
	Total	$1,654,069.00

* Indian Point Studies only

4.10 ENVIRONMENTAL MONITORING SURVEY

Applicability

Applies to routine testing of the plant environs.

Objective

To establish a sampling schedule which will recognize changes in radioactivity in the environs, and assure that effluent releases are kept as low as practicable and within allowable limits.

Specification

1. Liquid Discharges

   The survey for liquid discharges shall be conducted in accordance with Table 4.10-1 as specified below:

   a. If the gross beta-gamma activity of the station releases to the river is less than 1% of MPC during the month just ended, the environmental survey shall be conducted in accordance with Program 1 for the subsequent month.

   b. If the gross beta-gamma activity of the station releases to the river is greater than 1% of MPC but less than 10% of MPC during the month just ended, the environmental survey shall be conducted in accordance with Program 2 for the subsequent month. If the samples taken under Program 2 do not indicate any significant increase in environmental radioactivity, the survey shall revert to Program 1.

   c. If the gross beta-gamma activity of the station releases to the river is greater than 10% of MPC during the month just ended, the environmental survey shall be conducted in accordance with Program 3 for the subsequent month. If the samples taken under Program 3 do not indicate any significant increase in environmental radioactivity, the survey shall revert to Program 2.

d. Irrespective of release levels, once each year the survey shall be taken under Program 3 for a 3 month continuous period.

2. Gaseous Discharges

The survey for the gaseous discharges shall be conducted in accordance with Table 4.10-2 as specified below:

a. If the average release rate from the plant vent is less than 1% of the annual allowable release rate as specified in Paragraph 3.9-C1 during the month just ended, the environmental survey shall be conducted in accordance with Program 1 for the subsequent month.

b. If the average release rate from the plant vent is greater than 1% but less than 10% of the annual allowable release rate as specified in Paragraph 3.9-C1 during the month just ended, the environmental survey shall be conducted in accordance with Program 2 for the subsequent month. If the samples taken under Program 2 do not indicate any significant increase in environmental radioactivity, the survey shall revert to Program 1.

c. If the average release rate from the plant vent is greater than 10% of the annual allowable release rate as specified in Paragraph 3.9-C1 during the month just ended, the environmental survey shall be conducted in accordance with Program 3 for the subsequent month. If the samples taken under Program 3 do not indicate any significant increase in environmental radioactivity, the survey shall revert to Program 2.

d. Irrespective of release levels, once each year the survey shall be taken under Program 3 for a 3 month continuous period.

Basis

Programs for monitoring the adjacent area of the Hudson River will be conducted by the Consolidated Edison Company, by the New York State Department of Health, and by the New York University Institute of Environmental Medicine. The New York State program includes measurement of samples of air, water, milk and wildlife. The New York University Medical Center research program includes the biology of the Hudson River, the distribution and abundance of fish in the river, pesticides and radio-ecological studies.

A nineteen month study which began in June, 1969 is being conducted by Raytheon for the Hudson River Policy Committee. The Committee consists of the New York State Conservation Department, the New Jersey Department of Conservation and Economic Development, the U. S. Bureau of Sport Fisheries and Wildlife, the U. S. Bureau of Commercial Fisheries, and the Connecticut Conservation Department. The objectives of the study are; (1) to determine the seasonal distribution of fish and key organisms within and outside of the areas to be exposed to the heated and otherwise altered discharge from Units 1, 2, and 3; (2) to determine the effects of temperature rise and chemical additives on the survival and behavior of screenable and non-screenable fish and organisms in the area; (3) to catalog physical and chemical characteristics of the estuary often associated with observed changes in the biota; i.e., temperature, salinity, conductivity, dissolved and suspended solids, dissolved oxygen, and physical alternations.

The various studies mentioned above include measurements of radioactivity in fresh water, river water, river sediments, fish, milk, aquatic vegetation, vegetation, soil, and air in the vicinity of the Indian Point Station.

The environmental monitoring program conducted by the Consolidated Edison Company will supply sufficient data to determine the compliance of the Indian Point Station with the requirements of 10CFR20. The schedules for liquid and gaseous discharges will insure that changes in the environmental radioactivity will be detected.

Although the design of the proposed facility and administrative controls will be such that gaseous and liquid effluents will be released in accordance with the requirements of 10CFR20, the environmental monitoring program of the Consolidated Edison company provides a redundant means of insuring that the operation of the proposed facility does not pose any undue risk to the health and safety of the public. The New York State and New York University programs provide an independent means of verifying the proposed facilities compliance with 10CFR20.

Table 4.10-1

Environmental Monitoring Survey - Liquid Discharges+

Media of Sample	No. of Samples/ Collection	Programs 1 Collection Frequency	Programs 1 Analysis*	Programs 2 Collection Frequency	Programs 2 Analysis*	Programs 3 Collection Frequency	Programs 3 Analysis
Hudson River Water	2	W	GBG	TW	GBG	D	GBG
	1	MC	T		GSA		GSA
				MC	T	MC	RA
							T
Hudson River Aquatic Vegetation	15	SSF	GBG	MDGS	GBG GSA	MDGS	GBG GSA RA
Hudson River Bottom Sediment	5	SSF	GBG	M	GBG GSA	M	GBG GSA RA
Hudson River Fish	1	M	GBG	TM	GBG GSA	W	GBG GSA RA

+Samples will be taken whenever biologically available.

*Minimum equipment sensitivity shall be those given in FSAR Table 11.11-1.

Nomenclature for Sample Frequency

W - Weekly
TW - Twice Weekly
D - Daily
M - Monthly
MC - Monthly Composite
TM - Twice Monthly
SSF - Once each in Spring, Summer and Fall
MDGS - Monthly During the Growing Season

Nomenclature for Analysis

GBG - Gross Beta-Gamma   GSA - Gamma Spectrometer Analysis   T - Tritium
RA - Radiochemical Analysis to determine biologically important isotopes.

Table 4.10-2 (Continued)

		PROGRAMS					
		1		2		3	
Media of Sample	No. of Samples/ Collection	Collection Frequency	Analysis*	Collection Frequency	Analysis**	Collection Frequency	Analysis
Direct Gamma (Peripheral Monitoring)	15	M	GGB	TM	GGB	W	GGB
Milk	1					M	GBG GSA RA

+Samples will be taken whenever biologically available.

*Tritium analysis will be performed provided sufficient wet deposition occurs.

**Minimum equipment sensitivities shall be those given in FSAR Table 11.11-1

Table 4.10-2 (Continued)

		PROGRAMS					
		1		2		3	
Media of Sample	No. of Samples/ Collection	Collection Frequency	Analysis*	Collection Frequency	Analysis**	Collection Frequency	Analysis
Direct Gamma (Peripheral Monitoring)	15	M	GGB	TM	GGB	W	GGB
Milk	1					M	GBG GSA RA

+Samples will be taken whenever biologically available.

*Tritium analysis will be performed provided sufficient wet deposition occurs.

**Minimum equipment sensitivities shall be those given in FSAR Table 11.11-1

Table 4.10-2 (Continued)

Environmental Monitoring Survey - Gaseous Discharge

Nomenclature for Sample Frequency

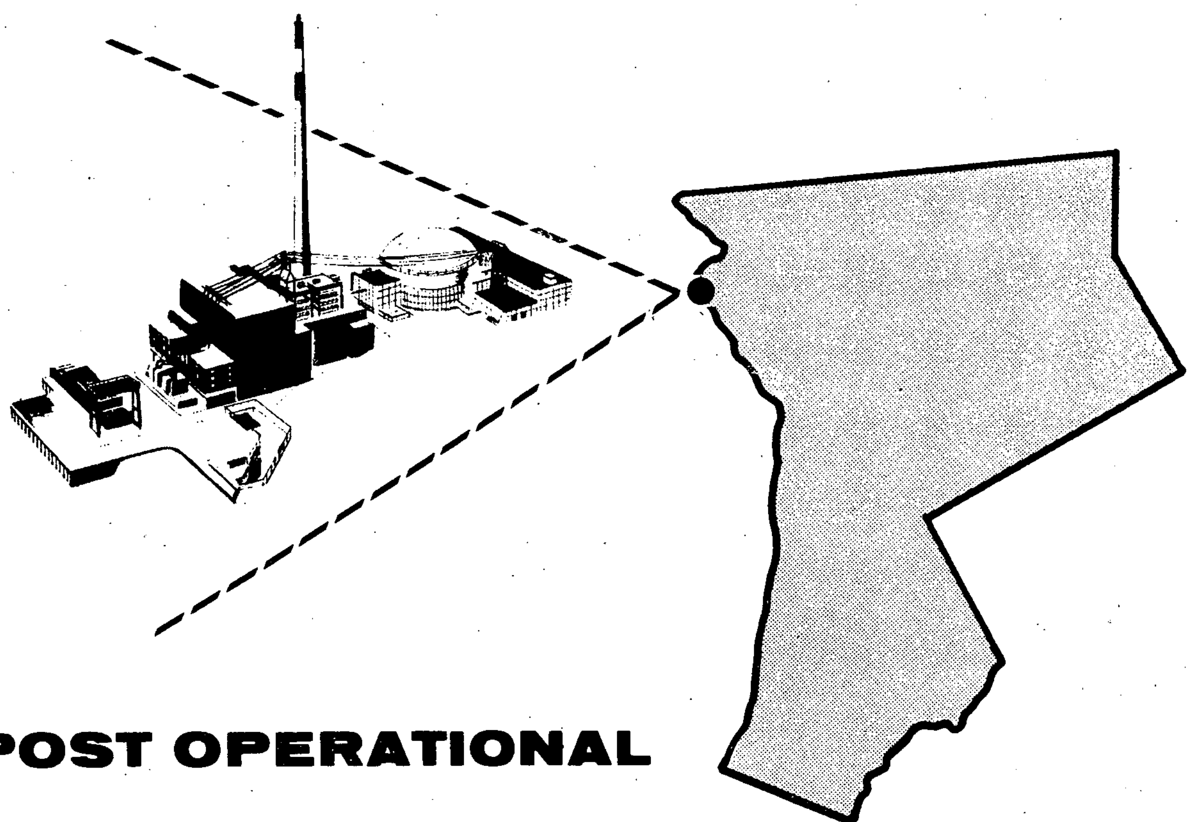
M - Monthly
TM - Twice Monthly
W - Weekly
TW - Twice Weekly
MC - Monthly Composite
A - Annually
SSF - Once each in Spring, Summer and Fall
MDGS - Monthly During the Growing Season
MSL - Monthly at Selected Locations
WSL - Weekly at Selected Locations

Nomenclature for Analysis

GBG - Gross Beta-Gamma
GSA - Gamma Spectrometer Analysis
RA - Radiochemical Analysis to determine biologically important isotopes
T - Tritium
GGB - Gross Gamma Background

CONSOLIDATED EDISON

INDIAN POINT REACTOR



POST OPERATIONAL SURVEY

AUGUST 1965

DIVISION OF ENVIRONMENTAL HEALTH SERVICES

NEW YORK STATE DEPARTMENT OF HEALTH

HOLLIS S. INGRAHAM, M.D. *Commissioner*

HOLLIS S. INGRAHAM, M.D.
COMMISSIONER

STATE OF NEW YORK
DEPARTMENT OF HEALTH

84 HOLLAND AVENUE
ALBANY, NEW YORK 12208

DIVISION OF
ENVIRONMENTAL HEALTH SERVICES

MEREDITH H. THOMPSON, D. ENG.
ASSISTANT COMMISSIONER

BUREAU OF
RADIOLOGICAL HEALTH SERVICES
SHERWOOD DAVIES, B.C.E., M.P.H.
DIRECTOR

August 30, 1965

Dr. Meredith H. Thompson
Assistant Commissioner
Division of Environmental Health Services
84 Holland Avenue
Albany 8, New York

Re: Post-Operational Environmental Survey
Village of Buchanan, Westchester County

Dear Doctor Thompson:

This is the first report on the post-operational survey in the vicinity of the Consolidated Edison Thorium Reactor located in the Village of Buchanan, Westchester County. Descriptions of survey sites and analyses performed are contained and sampling results are brought up-to-date.

The report was prepared by David J. Romano, Assistant Sanitary Engineer under the direction of William J. Kelleher, Associate Sanitary Engineer, both from the Bureau of Radiological Health Services. Field work was done by representatives of the New York State Conservation Department and local health departments.

Very truly yours,

Sherwood Davies

Sherwood Davies, P.E.
Director of
Bureau of Radiological Health Services

Consolidated Edison Indian Point Reactor

POST OPERATIONAL SURVEY

August, 1965

Division of Environmental Health Services

New York State Department of Health

Hollis S. Ingraham, M.D.
Commissioner

TABLE OF CONTENTS

Consolidated Edison Company of New York, Inc.

Post-Operational Survey

In The Vicinity Of

Indian Point Station

Introduction

The Division of Environmental Health Services in cooperation with the Consolidated Edison Company of New York, the Rockland County Health Department and the Westchester County Department of Health has been monitoring environmental radioactivity in the vicinity of the Indian Point Station since the reactor went into operation on August 2, 1962. This report summarizes the environmental sampling data for the period of August 2, 1962, to December 24, 1964.

Pre-operational monitoring and site surveillance were compiled in two previous reports of the Division of Environmental Health Services both entitled, "Pre-Operational Environmental Survey In The Vicinity Of The Consolidated Edison Thorium Reactor" dated November, 1959, and June, 1962.

Survey Description

The Westchester County Department of Health, and the Rockland County Department of Health collected samples from sites in the vicinity of the reactor. Valuable assistance in sample collection from the Hudson River was provided by the Bureau of Marine Fisheries of the New York State Department of Conservation. The type of samples taken, frequency of sampling, and sampling sites are listed below:

1. Air — Weekly Composite Sample

   Peekskill - Camp Field Filter Plant

2. Fallout — Weekly Composite Sample

   Peekskill - Camp Field Filter Plant

3. Milk — Monthly Grab Sample

   Yorktown - Hanover Hill Farm
   Clarkstown - Strawtown Dairy
   Bedford - Guard Hill Farm
   Mt. Pleasant - Grasslands

4. Water — Monthly Grab Sample

   Clarkstown - Lake De Forest
   Highland Falls - Bog Meadow Brook
   Yorktown - Croton Reservoir
   Clarkstown - Congers Lake
   Peekskill - Camp Field Filter Plant Reservoir
   Ossining - Indian Brook Reservoir
   Bedford - Byram Lake

Weekly Composite Sample

Peekskill - Hudson River at Standard Brands
Ossining - Hudson River at Sing Sing

5. Mud

Twice Yearly Sample

Croton-on-Hudson - Croton Bay
Iona Island - North End
Peekskill - Peekskill Bay
Nyack - West end of Tappan Zee Bridge
Stony Point - Hudson River opposite Con Edison

6. Vegetation

Monthly Grab Sample

Haverstraw - Letchworth Village Reservoir
Clarkstown - Dreyfus Reservoir
Yorktown - Croton Reservoir
Peekskill - Camp Field Filter Plant
Ossining - Indian Brook Reservoir
Bedford - Byram Lake

7. Algae

Twice Yearly Sample

Croton-on-Hudson - Croton Bay
Iona Island - North End
Nyack - West end of Tappan Zee Bridge
Cortlandt - Greens Cove

8. Fish

Twice Yearly Sample

Croton-on-Hudson - Croton Bay
Iona Island - North End
Peekskill - Peekskill Bay
Nyack - West end of Tappan Zee Bridge
Cortlandt - Greens Cove

9. Gamma Background

A Reuter-Stokes RSG-9 Pressurized Ionization Chamber was used to determine gamma backgrounds at nineteen different sites in the vicinity of the reactor.

Sampling Methods

1. Air - Approximately 1 cubic foot per minute of air was drawn through a fiberglass filter paper of 2 inch diameter for a weekly period using a Gast Air Pump and the filter was analyzed at the Division of Laboratories and Research. The total measured radionuclide content of air was expressed as pc/M^3 of gross beta activity.

2. Fallout - A sample was collected over a week's time using a polyethylene container with an exposure area of 0.101 ft^2 and a depth of approximately 9 inches from the rim. The container was placed in an exposed, outside location for a period of seven days. The top was then replaced and the entire unit sent to the Division of Laboratories and Research for analysis for Iodine-131, Strontium-89 and 90, Barium Lanthanum-140, Cesium-137 and Zirconium Niobium-95.

3. Milk - Two liter samples were taken monthly from several farms in the area of the reactor for analysis in the Marinelli-type configuration used in the gamma spectrometer at the Division of Laboratories and Research. Tests were made for I-131, Ba-La-140, Cs-137 and Potassium. Sr-89 and 90 were analyzed by chemical separation and beta counting.

4. Water - Weekly composite and monthly grab samples were obtained at selected stations. These were analyzed for gross beta, I-131, Cs-137, Ba-La-140, Zr-Nb-95, Sr-89 and 90.

5. Vegetation- Samples were obtained monthly during the growing season - usually May to November. The samples consisted of various grasses. These were placed in plastic bags and analyzed at the Division of Laboratories and Research for Cs-137, I-131, Ba-La-140, Mn-54, Zr-Nb-95 and Potassium.

6. Algae - Twice yearly samples consisting of assorted algae were collected in May and November from the Hudson River above and below the reactor site. These were placed in plastic bags and sent to the Division of Laboratories and Research. The analyses performed for vegetation were also performed on algae samples.

7. Mud - Mud was collected twice yearly in plastic jars at the same time as the algae samples. The amount collected varied. These samples were analyzed for gross gamma.

8. Fish - Assorted species of fish were collected by netting twice yearly at the same time as algae and mud samples. At the Laboratory, the sample was ground into a meal and analyzed for I-131, Ba-La-140, Cs-137, Zr-Nb-95 and Potassium.

Gamma scans of samples were made in the gamma spectrometer facility. This is a four port-top loading instrument. Each port houses a 4" x 4" NaI-Thallium activated crystal. Constant geometry for counting is maintained by using a Marinelli configuration sample container. The information from each crystal is fed into 256 channels of a 512 channel

Nuclear Data Multi-Channel Analyzer. The range of the instrument is 0-2.56 Mev with an energy scale of 10 Mev per channel.

9. Gamma Background - In August of 1964, personnel of the New York State Department of Health, Bureau of Radiological Health Services conducted a gamma background survey at various sites in the area around the reactor. The Reuter-Stokes RSG-9 Pressurized Ionization Chamber was used. This instrument can detect gamma radiation in the range of 1-200 microroentgens per hour.

The instrument consists of two parts: the ionization chamber and the electronic housing which is positioned directly above the ionization chamber. The chamber is a 1/8" thick steel pressure tank with a volume of 8.2 liters filled with pure argon at 43.5 atmospheric pressure or 625 psig. The electronic housing contains its own power supply and employs a vibrating reed electrometer read out device.

The pressurized ionization chamber was calibrated with a one millicurie Radium 226 point source in equilibrium with its progeny.

The measured gamma exposure rate is due to both terrestrial, fallout and cosmic radiation. It is possible to separate the total exposure rate into these two components by reading a pressure altitude versus cosmic exposure rate chart which was derived from Atomic Energy Commission formula relating pressure altitude and cosmic ray exposure rate. The pressure altitude is determined by means of an altimeter. The terrestrial fallout portion is the difference of the total and the cosmic portion.

Discussion of Results

The gross beta activity levels in air (Figure 1) show that there were no significant differencesbetween the Peekskill station and the average for the entire State. The graphs of each are in close agreement. The higher values from the summer of 1962 to June, 1963, were due to nuclear bomb test fallout and were approximately the same as the pre-operational survey values which also showed the effects of nuclear test fallout.

Strontium 89 and 90 fallout values were practically the same for both Peekskill and the State average. Strontium 89 peaks occur identically on both Figures 2 and 5 in the late winter-early spring of 1963; these were due to atmospheric nuclear testing during 1962.

The gross beta activity levels in water (Figure 3) were approximately the same as those reported in the June, 1962 pre-operational report. The Glenmont Station is located on the Hudson River, south of Albany. The Lake De Forest Station is a surface water reservoir in Rockland County.

A comparison of Figures 4 and 6 indicates that there is no significant difference between the values of the Albany and Hanover Hill Farm milk stations. The spring, 1963, peaks of Strontium 89 and 90 were noted for all milk stations and were due primarily to fallout from the 1962 nuclear tests.

A summary of environmental discharges from the Indian Point Reactor has been supplied by the Consolidated Edison Company and has been included in the Appendix of this report. The values given in this table indicate that the Plant has been operating within its allowable limits.

Summary

The data collected indicates that no significant increase in the background radioactivity levels can be attributed to the operation of the Indian Point Reactor since August 2, 1962. Fallout from the nuclear bomb tests late in 1962 was the prime cause of the activity increases observed in air, fallout, water and milk for the early spring of 1963. Since nuclear testing has ceased, the activity levels in these environmental samples has decreased considerably.

APPENDIX

Air Samples

Consolidated Edison Post-Operational Survey

Westchester County

Sampling Point - Camp Field Filter Plant

Collection	Gross Beta Activity (pc/M^3)	Collection	Gross Beta Activity (pc/M^3)
8/2/62	2.0	6/27/63	8.0
8/9/62	1.0	7/3/63	9.0
8/16/62	3.0	7/11/63	6.0
8/23/62	3.0	7/18/63	5.0
8/30/62	4.0	7/25/63	7.0
9/6/62	7.0	8/1/63	8.0
9/13/62	5.0	8/8/63	7.0
9/20/62	4.0	8/15/63	4.0
9/27/62	5.0	8/22/63	3.0
10/4/62	3.0	8/29/63	4.0
10/11/62	6.0	9/5/63	4.0
10/18/62	8.0	9/12/63	3.0
10/28/62	4.0	9/19/63	2.0
11/1/62	5.0	9/26/63	3.0
11/8/62	22.0	10/3/63	3.0
11/15/62	13.0	10/10/63	2.0
11/21/62	9.0	10/31/63	1.0
11/29/62	14.0	11/7/63	< 1.0
12/6/62	3.0	11/21/63	2.0
12/13/62	6.0	12/5/63	1.0
12/20/62	6.0	12/12/63	1.0
12/27/62	9.0	12/19/63	1.0
1/3/63	6.0	12/26/63	1.0
1/10/63	6.0	1/2/64	1.0
1/17/63	10.0	1/9/64	1.0
1/24/63	10.0	1/16/64	1.0
1/31/63	8.0	1/23/64	1.0
2/7/63	5.0	1/28/64	1.0
2/14/63	9.0	2/6/64	1.0
2/21/63	10.0	2/13/64	1.0
2/28/63	8.0	2/20/64	2.0
3/7/63	5.0	2/27/64	2.0
3/14/63	5.0	3/5/64	1.0
3/21/63	9.0	3/12/64	2.0
3/28/63	11.0	3/19/64	1.0
4/4/63	9.0	3/26/64	2.0
4/11/63	13.0	4/2/64	2.0
4/18/63	13.0	4/9/64	2.0
4/25/63	8.0	4/16/64	2.0
5/2/63	6.0	4/23/64	1.0
5/9/63	6.0	4/30/64	3.0
5/16/63	8.0	5/7/64	2.0
5/23/63	5.0	5/14/64	2.0
5/29/63	7.0	5/21/64	3.0
6/6/63	6.0	5/28/64	2.0
6/13/63	11.0	6/4/64	3.0
6/20/63	13.0	6/11/64	1.0

Air Samples Continued

Collection	Gross Beta Activity (pc/M^3)
6/18/64	2.0
6/25/64	3.0
7/2/64	1.0
7/9/64	1.0
7/16/64	1.0
7/30/64	1.0
8/6/64	1.0
8/13/64	1.0
8/20/64	1.0
8/27/64	< 1.0
9/3/64	1.0
9/10/64	1.0
9/17/64	< 1.0
9/24/64	< 1.0
10/1/64	< 1.0
10/8/64	< 1.0
10/15/64	< 1.0
10/22/64	2.0
10/29/64	1.0
11/5/64	< 1.0
11/12/64	2.0
11/19/64	< 1.0
11/25/64	< 1.0
12/3/64	< 1.0
12/10/64	< 1.0
12/17/64	< 1.0

Fallout Samples

Consolidated Edison Post-Operational Survey

Westchester County

Sampling Point - Camp Field Filter Plant

Collection	Results (pc/ft²/day)					
	I-131	Sr-90	Sr-89	Ba-La-140	Cs-137	Zr-Nb-95
8/2/62		< 3	< 3			
8/9/62		< 3	< 3			
8/16/62		< 3	< 3			
8/23/62		< 3	< 3			
8/30/62		< 3	< 3			
9/6/62		< 3	< 3			
9/13/62		< 3	< 3			
9/20/62		< 3	< 3			
9/27/62		< 3	< 3			
10/4/62		< 3	< 3			
10/11/62		< 3	< 3			
10/18/62		< 3	< 3			
10/25/62		< 3	< 3			
11/1/62		< 3	< 3			
11/8/62		< 3	< 3			
11/15/62		< 3	< 3			
11/22/62		< 3	< 3			
11/29/62		< 3	< 3			
12/6/62		< 3	< 3			
12/13/62		< 3	< 3			
12/20/62		< 3	< 3			
12/27/62	< 20	< 3	20	< 20	28	
1/3/63	< 20	< 3	7			
1/10/63	< 20	< 3	98	125	82	
1/17/63	< 20	< 3	35	57	24	
1/24/63	< 20	< 3	39	100	24	
1/31/63	< 20	< 3	49	38	65	
2/7/63	< 20	< 3	3	< 20	< 20	
2/14/63	< 20	< 3	10	< 20	< 20	66
2/21/63	< 20	10	22	< 20	120	< 20
2/28/63	< 20	< 3	14	< 20	< 20	< 20
3/7/63	< 20	12	74	< 20	< 20	21
3/14/63	< 20	7	35	71	< 20	< 20
3/21/63	< 20	< 3	28	< 20	< 20	< 20
3/28/63	< 20	< 3	34	< 20	< 20	22
4/4/63	< 20	< 3	31	< 20	< 20	31
4/11/63	< 20	2	21	< 20	< 20	125
4/18/63	< 20	5	22	< 20	< 20	124
4/25/63	27	< 3	23	< 20	< 20	193
5/2/63	< 20	3	11	< 20	< 20	146
5/9/63	< 20	7	94	238	< 20	400
5/16/63	< 20	7	16	< 20	20	74
5/23/63	39	< 3	23	< 20	31	107
5/29/63	< 20	< 3	20	27	< 20	20
6/6/63	< 20	6	94	184	74	214

Fallout Samples

Consolidated Edison Post-Operational Survey

Continued

Collection	Results ($pc/ft^2/day$)					
	I-131	Sr-90	Sr-89	Ba-La-140	Cs-137	Zr-Nb-95
6/13/63	< 20	4	10	< 20	< 20	70
6/20/63	< 20	3	28	85	32	46
6/27/63	< 20	< 3	13	< 20	< 20	< 20
7/3/63	< 20	< 3	19	< 20	< 20	< 20
7/11/63	< 50	< 3	40	59	< 50	58
7/18/63	< 50	11	13	< 50	< 50	< 50
7/25/63	< 50	< 3	< 3	< 50	< 50	< 50
8/1/63	< 50	8	< 3	< 50	< 50	< 50
8/8/63	< 50	14	46	< 50	< 50	87
8/15/63	< 50	8	< 3	< 50	< 50	< 50
8/22/63	< 50	< 3	< 3	< 50	< 50	< 50
8/29/63	< 20	< 3	< 3	< 20	< 20	< 20
9/5/63	< 50	< 3	26	< 50	< 50	< 50
9/12/63	< 50	< 3	< 3	< 50	< 50	< 50
9/19/63	< 50	< 3	< 3	< 50	< 50	< 50
9/26/63	< 50	< 3	< 3	< 50	< 50	< 50
10/3/63	< 50	< 3	< 3	< 50	< 50	< 50
10/10/63	< 50	< 3	< 3	< 50	< 50	< 50
10/17/63	< 50	3	< 7	< 50	< 50	< 50
10/24/63	< 50	< 3	< 3	< 50	< 50	< 50
10/31/63	< 50	< 3	< 3	< 50	< 50	< 50
11/7/63	< 50	< 3	< 3	< 50	< 50	< 50
11/14/63	< 50	< 3	< 3	< 50	< 50	< 50
11/21/63	< 50	< 3	< 3	< 50	< 50	< 50
11/27/63	< 50	< 3	< 3	< 50	< 50	< 50
12/5/63	< 50	< 3	< 3	< 50	< 50	< 50
12/12/63	< 50	< 3	< 3	< 50	< 50	< 50
12/19/63	< 50	< 3	< 3	< 50	< 50	< 50
12/26/63	< 50	< 3	< 3	< 50	< 50	< 50
1/2/64	< 50	< 3	< 3	< 50	< 50	< 50
1/9/64	< 50	< 3	< 3	< 50	94	< 50
1/16/64	< 50	5	3	< 50	< 50	< 50
1/23/64		5	< 3			
1/28/64	< 50	< 3	3	< 50	< 50	< 50
2/6/64	< 50	4	4	< 50	< 50	< 50
2/13/64	< 50	5	< 3	< 50	< 50	< 50
2/20/64	< 50	< 3	< 3	< 50	< 50	< 50
2/27/64	< 50	< 3	< 3	< 50	< 50	< 50
3/5/64	< 50	12	< 3	< 50	< 50	< 50
3/12/64	< 50	< 3	< 3	< 50	< 50	< 50
3/19/64	< 50	< 3	< 3	< 50	< 50	< 50
3/26/64	< 50	5	< 3	< 50	< 50	< 50
4/2/64	< 50	4	10	< 50	< 50	< 50
4/9/64	< 50	15	< 3	< 50	< 50	< 50
4/16/64	< 50	3	5	< 50	< 50	< 50
4/23/64	< 50	4	< 3	< 50	< 50	< 50

Fallout Samples

Consolidated Edison Post-Operational Survey

Continued

Collection	Results (pc/ft²/day)					
	I-131	Sr-90	Sr-89	Ba-La-140	Cs-137	Zr-Nb-95
4/30/64	< 50	3	< 3	< 50	< 50	< 50
5/7/64	< 50	3	< 3	< 50	< 50	< 50
5/14/64	< 50	28	< 3	< 50	< 50	< 50
5/21/64	< 50	< 3	< 3	< 50	< 50	< 50
5/28/64	< 50	< 3	< 3	< 50	93	< 50
6/4/64	< 50	< 3	4	< 50	< 50	< 50
6/11/64	< 50	< 3	< 3	< 50	< 50	< 50
6/18/64	< 50	< 3	< 3	< 50	< 50	< 50
6/25/64	< 50	< 3	< 3	< 50	< 50	< 50
7/2/64	< 50	5	< 3	< 50	< 50	< 50
7/9/64	< 50	< 3	4	< 50	< 50	< 50
7/16/64	< 50	< 3	< 3	< 50	< 50	< 50
7/23/64	< 50	< 3	< 3	< 50	< 50	< 50
7/30/64	< 50	< 3	4	< 50	< 50	< 50
8/6/64	< 50	< 3	< 3	< 50	< 50	< 50
8/13/64	< 50	4	< 3	< 50	< 50	< 50
8/20/64	< 50			< 50	< 50	< 50
8/27/64	< 50	< 3	< 3	< 50	< 50	< 50
9/3/64	< 50	< 3	< 3	< 50	< 50	< 50
9/10/64	< 50	< 3	< 3	< 50	< 50	< 50
9/17/64	< 50	9	< 3	< 50	< 50	< 50
9/24/64	< 50	< 3	< 3	< 50	< 50	< 50
10/1/64	< 50			< 50	< 50	< 50
10/8/64	< 50	< 3	< 3	< 50	< 50	< 50
10/15/64	< 50	< 3	< 3	237	< 50	< 50
10/22/64	< 50			< 50	< 50	< 50
10/29/64	< 50	< 3	< 3		< 50	< 50
11/5/64	< 50	< 3	< 3	< 50	< 50	< 50
11/12/64	< 50	12	< 3	< 50	< 50	< 50
11/19/64	< 50	< 3	< 3	< 50	< 50	106
11/25/64	< 50	< 3	< 3	< 50	< 50	72
12/3/64	< 50			< 50	< 50	< 50
12/10/64	< 50			< 50	< 50	< 50
12/17/64	< 20			< 20	< 20	< 20
12/23/64	< 50			< 50	< 50	< 50

Water Samples

Consolidated Edison Post-Operational Survey

Rockland County

Congers Lake		Lake DeForest	
Collection	Gross Beta (pc/ml)	Collection	Gross Beta (pc/ml)
8/10/62	0.023	8/10/62	0.004
9/19/62	0.018	9/19/62	0.008
10/31/62	0.040	10/31/62	0.019
12/14/62	0.099	12/14/62	0.042
1/11/63	0.016	1/11/63	0.019
2/13/63	0.065	2/13/63	0.020
3/29/63	0.042	3/29/63	0.09
4/22/63	0.023	4/22/63	0.016
5/21/63	0.062	5/21/63	0.041
6/14/63	0.027	6/14/63	0.009
7/10/63	0.042	7/10/63	0.024
8/9/63	0.035	8/9/63	0.019
9/12/63	0.027	9/12/63	0.015
10/9/63	0.015	10/9/63	0.013
11/13/63	0.033	11/13/63	0.003
1/17/64	0.022	1/7/64	0.018
2/24/64	0.015	2/24/64	0.020
3/13/64	0.025	3/13/64	0.013
4/15/64	0.056	4/15/64	0.021
5/21/64	0.026	5/21/64	0.012
6/9/64	0.028	6/9/64	0.010
7/7/64	0.022	7/7/64	0.011
7/21/64	0.021	7/21/64	0.012
8/6/64	0.022	8/6/64	0.008
8/27/64	0.017	8/27/64	0.009
9/9/64	0.016	9/9/64	0.011
9/24/64	0.023	9/24/64	0.011
		11/9/64	0.008
		12/3/64	0.006

Water Samples

Consolidated Edison Post-Operational Survey

Orange County

Sampling Point - Bog Meadow Brook

Collection	Gross Beta (pc/ml)
9/4/62	*
9/17/62	*
10/8/62	*
11/13/62	*
12/10/62	*
2/18/63	0.009
3/11/63	0.008
4/12/63	0.016
5/13/63	0.010
6/17/63	0.026
7/16/63	0.049
8/19/63	0.028
9/16/63	0.004
10/15/63	0.006
11/19/63	0.004
12/16/63	0.005
1/20/64	0.006
2/12/64	< 0.003
3/16/64	0.011
4/14/64	0.005
5/15/64	0.012
6/15/64	0.005
7/15/64	0.004
8/17/64	0.004
9/17/64	0.004
10/19/64	0.005
11/17/64	0.006
12/15/64	0.005

*Sample Not Analyzed.

Water Samples

Consolidated Edison Post-Operational Survey

Westchester County

Sampling Point - Croton Reservoir

Collection	Gross Beta (pc/ml)
8/9/62	0.006
10/10/62	0.013
11/21/62	0.002
12/13/62	< 0.006
1/17/63	0.009
2/19/63	0.005
3/26/63	0.003
4/17/63	0.008
5/14/63	0.008
6/14/63	0.006
7/15/63	0.036
8/19/63	0.021
9/16/63	0.009
10/16/63	0.016
11/14/63	0.014
12/18/63	0.009
1/15/64	< 0.003
2/17/64	0.003
3/16/64	0.014
4/16/64	0.021
5/14/64	0.019
6/12/64	0.010
7/14/64	0.013
8/20/64	0.009
9/14/64	0.009
10/14/64	0.009
11/17/64	0.008
12/15/64	0.006

Water Samples

Consolidated Edison Post-Operational Survey

Westchester County

Sampling Point - Hudson River at Sing Sing

Collection	Gross Beta (pc/ml)	Collection	Gross Beta (pc/ml)
8/3/62	0.010	11/22/63	0.047
8/17/62	0.018	11/28/63	0.079
8/31/62	0.008	12/5/63	0.044
9/14/62	0.012	12/13/63	0.016
9/28/62	0.014	12/20/63	< 0.006
10/12/62	0.033	12/27/63	0.007
10/26/62	0.028	1/3/64	0.031
11/9/62	0.06	1/10/64	0.035
11/22/62	0.05	1/17/64	0.105
12/7/62	< 0.03	1/24/64	0.062
12/21/62	0.07	1/31/64	0.044
1/4/63	< 0.06	2/7/64	0.033
1/18/63	< 0.06	2/14/64	0.109
2/1/63	0.06	2/21/64	0.034
2/15/63	< 0.06	2/28/64	0.026
3/1/63	< 0.06	3/6/64	0.010
3/15/63	< 0.06	3/13/64	0.014
3/28/63	0.028	3/20/64	0.026
4/12/63	< 0.06	3/27/64	0.023
4/26/63	< 0.03	4/3/64	0.017
5/10/63	< 0.006	4/10/64	0.021
5/24/63	< 0.03	4/17/64	0.013
5/30/63	< 0.03	4/24/64	0.002
6/7/63	0.038	5/1/64	0.006
6/14/63	0.021	5/8/64	0.023
6/21/63	< 0.006	5/15/64	0.068
6/28/63	0.03	5/22/64	0.012
7/4/63	0.034	5/29/64	0.029
7/12/63	0.020	6/5/64	0.038
7/18/63	0.045	6/12/64	0.032
7/26/63	0.072	6/19/64	0.034
8/2/63	0.083	6/19/64	0.047
8/9/63	0.090	7/3/64	0.057
8/16/63	0.098	7/10/64	0.054
8/23/63	0.091	7/17/64	0.048
8/30/63	0.072	7/24/64	0.052
9/6/63	0.062	7/31/64	0.058
9/13/63	*	8/7/64	0.054
9/20/63	0.031	8/14/64	0.064
9/27/63	0.071	8/21/64	0.051
10/4/63	< 0.006	8/28/64	0.069
10/11/63	0.053	9/4/64	0.061
10/18/63	0.089	9/11/64	0.054
10/25/63	0.121	9/18/64	0.068
11/1/63	0.065	9/25/64	0.064
11/8/63	< 0.006	10/2/64	0.086
11/15/63	0.095	10/2/64	0.052

Water Samples Continued

Collection	Gross Beta (pc/ml)
10/16/64	0.061
10/23/64	0.078
10/30/64	0.050
11/6/64	0.083
11/13/64	0.050
11/20/64	0.057
11/26/64	0.060
12/4/64	0.074
12/11/64	0.056
12/18/64	0.057
12/24/64	*

*Sample Not Analyzed.

Water Samples

Consolidated Edison Post-Operational Survey

Westchester County

Sampling Point - Hudson River at Standard Brands

Collection	Gross Beta (pc/ml)	Collection	Gross Beta (pc/ml)
8/2/62	0.006	11/21/63	0.040
8/16/62	0.023	11/28/63	0.048
8/30/62	0.033	12/5/63	0.030
9/13/62	0.026	12/12/63	0.020
9/27/62	0.010	12/19/63	0.020
10/11/62	*	12/26/63	0.012
10/25/62	0.030	1/2/64	0.015
11/8/62	0.080	1/9/64	0.025
11/22/62	0.030	1/16/64	0.024
12/6/62	0.030	1/23/64	0.031
12/20/62	0.030	1/30/64	0.032
1/3/63	0.065	2/6/64	< 0.006
1/17/63	0.030	2/13/64	< 0.006
1/31/63	0.060	2/20/64	0.006
2/14/63	0.060	2/27/64	0.012
2/28/63	0.060	3/5/64	0.007
3/14/63	0.060	3/12/64	0.007
3/28/63	0.060	3/19/64	0.016
4/11/63	0.021	3/26/64	0.020
4/25/63	0.015	4/2/64	0.014
5/9/63	0.008	4/9/64	< 0.012
5/23/63	0.010	4/16/64	0.045
5/30/63	0.040	4/23/64	0.007
6/6/63	0.006	4/30/64	0.005
6/13/63	0.028	5/7/64	0.008
6/20/63	0.009	5/14/64	0.005
6/27/63	0.019	5/21/64	0.012
7/4/63	0.023	5/28/64	0.016
7/11/63	0.062	6/4/64	0.029
7/18/63	0.054	6/11/64	0.015
7/25/63	0.056	6/18/64	0.022
8/1/63	0.095	6/25/64	0.022
8/8/63	< 0.003	7/2/64	0.035
8/15/63	0.057	7/9/64	0.031
8/22/63	0.085	7/16/64	0.036
8/29/63	0.072	7/23/64	0.040
9/5/63	0.077	7/30/64	0.038
9/12/63	0.010	8/6/64	0.036
9/19/63	0.019	8/13/64	0.023
9/26/63	0.012	8/20/64	0.041
10/3/63	< 0.012	8/27/64	0.038
10/10/63	< 0.006	9/3/64	0.036
10/17/63	< 0.006	9/10/64	0.042
10/24/63	0.031	9/17/64	0.052
10/31/63	< 0.012	9/25/64	0.036
11/7/63	< 0.003	10/2/64	0.048
11/14/63	< 0.031	10/19/64	0.032

Water Samples Continued

Collection	Gross Beta (pc/ml)
10/16/64	0.043
10/23/64	0.038
10/30/64	0.024
11/6/64	0.048
11/13/64	0.088
11/20/64	0.045
11/26/64	0.046
12/4/64	*
12/11/64	0.030
12/18/64	0.058
12/24/64	*

*Sample Not Analyzed.

Water Samples

Consolidated Edison Post-Operational Survey

Westchester County

Indian Brook Reservoir		Byram Lake	
Collection	Gross Beta (pc/ml)	Collection	Gross Beta (pc/ml)
8/9/62	0.005	8/9/62	*
9/5/62	0.013	9/5/62	*
10/11/62	0.013	10/10/62	0.015
11/21/62	0.021	11/21/62	0.001
12/13/62	0.053	12/13/62	0.028
1/17/63	0.042	1/17/63	*
2/19/63	0.029	2/19/63	0.009
3/26/63	0.028	3/26/63	0.012
4/18/63	0.012	4/17/63	*
5/14/63	< 0.06	5/14/63	*
6/14/63	0.036	6/14/63	*
7/16/63	0.079	7/15/63	*
8/19/63	0.026	8/19/63	*
9/16/63	0.013	9/16/63	*
10/16/63	0.012	10/15/63	0.031
11/14/63	0.028	11/14/63	0.018
11/21/63	< 0.006	12/8/63	0.008
12/18/63	*	1/15/64	0.009
1/15/64	0.013	2/17/64	0.003
1/23/64	0.035	3/16/64	0.023
2/17/64	0.016	4/16/64	0.015
3/16/64	0.015	5/14/64	0.015
4/16/64	0.020	6/12/64	0.010
5/14/64	0.013	7/14/64	0.004
6/12/64	0.007	8/21/64	0.010
7/14/64	0.017	9/14/64	0.009
8/20/64	0.004	10/14/64	0.010
9/14/64	0.012	11/17/64	0.013
10/14/64	0.007	12/15/64	0.008
11/17/64	0.006		
12/15/64	0.007		

*Sample Not Analyzed.

Water Samples

Consolidated Edison Post-Operational Survey

Westchester County

Sampling Point - Camp Field Filter Plant

Collection	Gross Beta (pc/ml)
8/9/62	0.007
9/5/62	0.004
10/11/62	0.012
11/21/62	0.006
12/13/62	0.022
1/16/63	0.029
2/19/63	0.051
3/26/63	0.053
4/18/63	0.008
5/14/63	0.010
618/63	0.015
7/16/63	0.020
8/19/63	0.020
9/16/63	0.012
10/15/63	0.012
11/14/63	0.021
12/18/63	0.011
1/15/64	0.009
2/17/64	0.013
3/16/64	0.010
4/16/64	0.019
5/14/64	0.008
6/12/64	0.010
7/14/64	0.010
8/20/64	0.012
9/14/64	0.006
10/14/64	0.005
11/17/64	0.004
12/15/64	0.007

Water Samples

Consolidated Edison Post-Operational Survey

Analyses for I-131, Ba-La-140, Cs-137 and Zr-Nb-95 were also made on all water samples. The results were less than 20 pc/l unless listed in the following table.

Collection	Sampling Point	Isotope	Result (pc/l)
1/11/63	Lake DeForest	Cs-137	28
2/15/63	Hudson River at Sing Sing	Ba-La-140	21
2/19/63	Camp Field Filter Plant	Cs-137	34
3/14/63	Hudson River at Standard Brands	Ba-La-140	27
3/26/63	Camp Field Filter Plant	Zr-Nb-95	27
3/26/63	Indian Brook Reservoir	Zr-Nb-95	37
3/28/63	Hudson River at Standard Brands	Cs-137	35
3/29/63	Congers Lake	I-131	21
3/29/63	Congers Lake	Ba-La-140	32
6/6/63	Hudson River at Standard Brands	Zr-Nb-95	26
6/13/63	Hudson River at Standard Brands	Zr-Nb-95	145
6/14/63	Congers Lake	Zr-Nb-95	21
7/18/63	Hudson River at Standard Brands	Ba-La-140	41

Milk Samples

Consolidated Edison Post-Operational Survey

Westchester County

Sampling Point - Grasslands

	Results					
	(pc/1)					g/1
Collection	I-131	Sr-90	Sr-89	Ba-La-140	Cs-137	K
8/8/62	< 20	8	19			
9/6/62	26	< 3	17			
10/30/62	< 20	11	21	< 20	52	
12/13/62	< 20	7	< 3	< 20	58	
12/26/62	< 20	10	< 3	< 20	59	
1/31/63	< 20	5	5	< 20	< 20	
2/19/63	< 20	6	< 3	< 20	78	
3/26/63	< 20	5	< 3	< 20	20	
4/17/63	51	6	9	< 20	26	
5/14/63	< 20	7	22	< 20	54	1.1
6/14/63	< 20	16	88	< 20	114	
7/16/63	< 20	20	52	< 20	129	1.3
8/19/63	< 20	21	40	< 20	117	1.2
9/16/63	< 20	7	15	< 20	94	1.4
10/16/63	< 20	18	< 3	< 20	94	1.3
11/14/63	< 20	16	< 3	< 20	103	1.7
12/18/63	< 20	13	< 3	< 20	121	1.4
1/15/64	< 20	10	5	< 20	143	1.8
2/17/64	< 20	15	< 3	< 20	122	1.6
3/16/64	< 20	14	< 3	< 20	108	1.4
4/16/64	< 20	11	< 3	< 20	102	1.9
5/14/64	< 20	11	3	< 20	75	1.6
6/12/64	< 20	14	6	< 20	106	1.5
7/15/64	< 20	15	< 3	< 20	83	1.4
9/14/64	< 20	13	< 3	< 20	59	1.5
10/15/64	< 20	10	< 3	< 20	66	1.7
11/17/64	< 20	11	< 3	< 20	45	1.4
12/15/64	< 20	28	< 3	< 20	47	1.6

Milk Samples

Consolidated Edison Post-Operational Survey

Rockland County

Sampling Point - Strawtown Diary

Collection	Results					
	(pc/1)					g/1
	I-131	Sr-90	Sr-89	Ba-La-140	Cs-137	K
10/31/62	< 20	21	3	< 20	53	
2/8/63	< 20	3	< 3	< 20	36	
3/8/63	< 20	< 3	4	< 20	37	
4/9/63	22	4	7	< 20	< 20	
5/16/63	< 20	4	4	< 20	30	
6/12/63	< 20	13	26	< 20	26	
8/2/63	25			< 20	68	1.6
9/10/63	< 20	12	13	< 20	72	1.4
10/14/63	< 20	13	8	< 20	67	1.7
11/13/63	< 20	15	4	< 20	120	1.5
2/24/64	< 20	11	< 3	< 20	92	1.3
5/19/64	< 20	12	< 3	< 20	77	1.3
6/16/64	< 20	13	3	< 20	119	1.5
7/14/64	< 20	21	< 3	< 20	62	1.8
8/18/64	< 20	10	< 3	< 20	43	1.6
10/5/64	< 20	10	< 3	< 20	33	1.6
11/16/64	< 20	8	< 3	23	36	1.6
12/8/64	< 20	9	< 3	< 20	37	1.6

Milk Samples

Consolidated Edison Post-Operational Survey

Westchester County

Sampling Point - Guard Hill Farm

Collection	Results					
	(pc/l)					g/l
	I-131	Sr-90	Sr-89	Ba-La-140	Cs-137	K
8/7/62	< 20	7	25			
10/30/62	46	8	26	< 20	6.6	
12/13/62	< 20	7	4	< 20	93	
12/27/62	< 20	6	6	< 20	94	
1/31/63	< 20	9	9	< 20	69	
2/17/63		17	4			
3/26/63	< 20	5	< 3	20	44	
4/18/63	< 20			< 20	58	1.5
5/14/63	< 20	18	58	< 20	91	
6/14/63	< 20	42	158	< 20	169	
7/16/63	< 20	54	139	< 20	209	1.1
8/19/63	< 20	70	134	< 20	177	0.8
9/16/63	< 20	20	26	< 20	123	1.7
10/15/63	< 20	35	42	< 20	150	1.6
11/14/63	< 20	28	20	< 20	164	1.5
12/18/63	< 20	19	9	< 20	172	1.3
1/15/64	< 20	25	8	< 20	180	1.4
2/17/64	< 20			< 20	110	1.7
3/16/64	< 20	24	< 3	< 20	126	1.4
4/16/64	< 20	31.0	< 3.0	< 20	172	1.5
5/14/64	< 20	28	13	< 20	110	1.4
6/12/64	< 20	41	< 3	< 20	144	1.5
7/14/64	< 20	26	< 3	< 20	115	1.2
8/21/64	< 20	10	< 3	< 20	50	1.3
9/14/64	< 20	18	< 3	< 20	53	1.6
10/14/64	< 20	20	< 3	< 20	63	1.6
11/17/64	< 20	18	< 3	< 20	61	1.5
12/15/64	< 20	16	< 3	< 20	43	1.2

Milk Samples

Consolidated Edison Post-Operational Survey

Westchester County

Sampling Point - Hanover Hill Farm

Collection	Results					
	(pc/l)					g/l
	I-131	Sr-90	Sr-89	Ba-La-140	Cs-137	K
8/7/62	< 20					
8/12/62		14	40			
9/6/62	< 20	17	17			
10/30/62	37	13	33		43	
12/13/62	< 20	4	16	< 20	63	
12/27/62	< 20	8	8	< 20	71	
1/31/63	< 20	10	< 3	< 20	59	
2/19/63	< 20	3	9	< 20	66	
3/26/63	< 20	10	8	< 20	62	
4/17/63	< 20	10	22	< 20	46	
5/14/63	< 20	22	73	< 20	90	1.1
6/14/63	< 20	32	84	< 20	154	
7/16/63	< 20	27	57	< 20	172	1.4
8/19/63	< 20	32	28	< 20	113	1.6
9/16/63	< 20	11	24	< 20	83	1.4
10/15/63	< 20	22	< 3	< 20	87	1.3
11/14/63	< 20	17	14	< 20	99	1.4
12/18/63	< 20	19	< 3	< 20	95	1.5
1/16/64	< 20	22	5	< 20	121	1.7
2/17/64	< 20	16	3	< 20	125	1.7
3/16/64	< 20	10	4	< 20	159	1.5
4/16/64	< 20	90	3	< 20	127	1.4
5/14/64	< 20	26	< 3	< 20	107	1.5
6/12/64	< 20	34	4	< 20	153	1.4
7/9/64	< 20			< 20	89	1.7
7/14/64	< 20	16	< 3	< 20	79	1.3
8/20/64	< 20	19	< 3	< 20	65	1.5
9/14/64	< 20	13	3	< 20	50	1.6
10/14/64	< 20	16	< 3	< 20	73	1.7
11/17/64	< 20	18	< 3	< 20	51	1.5
12/15/64	< 20	26	< 3	< 20	52	1.5

Vegetation Samples

Consolidated Edison Post-Operational Survey

Rockland County

Sampling Point - Letchworth Village Reservoir

Collection	Results (pc/kg)			(g/kg)
	Cs-137	Mn-54	Zr-Nb-95	K
5/21/63	< 20		67,500	7.4
6/14/63	< 20		47,000	5.9
7/10/63	660		22,300	5.8
8/9/63	3900		32,800	4.4
9/12/63	3640		1,000	-
10/9/63	4900		10,500	17.6
11/13/63	< 20		8,743	4.3
1/17/64	4750	3900	5,200	1.8
5/21/64	932	1853	1,092	2.6
6/9/64	1126	1192	< 860	1.6
7/21/64	811	3844	< 695	1.7
8/27/64	896	2287	< 430	1.2
11/9/64	864	1686	< 375	4.03
12/3/64	1140	2877	< 430	2.8

Note: Analyses for Iodine-131 and Ba-La-140 were made. The results indicated that the amounts of these nuclides present were less than the limit of sensitivity of the spectrometer.

Vegetation Samples

Consolidated Edison Post-Operational Survey

Rockland County

Sampling Point - Dreyfus Reservoir

Collection	Results (pc/kg) Cs-137	Mn-54	Zr-Nb-95	(g/kg) K
5/21/63	< 20		25000	4.4
6/14/63	< 20		18400	12.8
7/10/63	1850		18050	8.6
8/9/63	272		18400	5.5
9/12/63	2610		5210	-
10/9/63	2720		9250	5.7
11/13/63	1659		797	3.3
1/17/64	< 2000	< 2000	2958	5.8
5/21/64	< 770	< 770	995	6.7
6/9/64	< 955	< 955	955	4.0
7/21/64	< 770	< 770	< 770	1.2
8/27/64	597	< 463	< 463	2.5
11/9/64	689	612	< 400	2.1
12/3/64	946	828	< 500	2.7

Note: Analyses for Iodine-131 and Ba-La-140 were made. The results indicated that the amounts of these nuclides present were less than the limit of sensitivity of the spectrometer.

Fish Samples

Consolidated Edison Post-Operational Survey

Collection	Sampling Point	County	Results (pc/kg) I-131	(pc/kg) Ba-La-140	(pc/kg) Cs-137	(pc/kg) Zr-Nb-95	(g/kg) K
5/27/63	Iona Island	Rockland	49	< 20	166	81	-
10/2/63	Iona Island	Rockland	< 20	< 20	67	200	2.8
7/7/64	Iona Island	Rockland	< 20	< 20	30	< 20	0.6
10/14/64	Iona Island	Rockland	< 64	73	66	< 64	2.5
5/27/63	Peekskill Bay	Westchester	66	< 20	128	169	-
10/2/63	Peekskill Bay	Westchester	-	-	-	-	-
7/7/64	Peekskill Bay	Westchester	< 40	< 40	< 40	< 40	0.6
5/28/63	Green's Cove	Westchester	61	< 20	102	182	-
10/3/63	Green's Cove	Westchester	< 20	< 20	51	96	3.7
7/8/64	Green's Cove	Westchester	< 50	< 50	< 50	< 50	1.7
10/15/64	Green's Cove	Westchester	< 64	< 64	< 64	< 64	2.9
5/27/63	Tappan Zee	Rockland	58	< 20	145	256	-
10/2/63	Tappan Zee	Rockland	-	-	-	-	-
7/7/64	Tappan Zee	Rockland	< 77	< 77	< 77	< 77	2.0
10/14/64	Tappan Zee	Rockland	< 64	< 64	< 64	< 64	2.8
5/28/63	Croton Bay	Westchester	< 20	< 20	243	32	-
10/3/63	Croton Bay	Westchester	< 20	< 20	45	69	-
7/8/64	Croton Bay	Westchester	< 44	< 44	< 44	< 44	-
10/15/64	Croton Bay	Westchester	< 64	< 64	65	< 64	3.3

Algae Samples

Consolidated Edison Post-Operational Survey

Collection	Sampling Point	County	Results (pc/kg) Mn-54	(g/kg) K	(pc/kg) Zr-Nb-95
10/2/63	Tappan Zee	Rockland	-	3.3	7450
7/7/64	Tappan Zee	Rockland	1819	5.9	730
10/3/63	Green's Cove	Westchester	-	-	-
7/8/64	Green's Cove	Westchester	707	6.6	< 180
10/2/63	Iona Island	Rockland	-	-	-
7/7/64	Iona Island	Rockland	2494	2.1	241
10/14/64	Iona Island	Rockland	845	-	59
7/8/64	Croton Bay	Westchester	356	2.4	189
10/15/64	Croton Bay	Westchester	72	-	< 20

Note:

Iodine-131, Ba-La-140, and Cs-137 analyses were also performed. These nuclides were not detected with the exception of the following samples:

Collection	Sampling Point	Isotope	Result (pc/kg)
5/27/63	Tappan Zee	Cs-137	540
7/7/63	Iona Island	Cs-137	340
10/2/63	Tappan Zee	Cs-137	565
7/8/64	Green's Cove	Cs-137	372
10/15/64	Croton Bay	Cs-137	43

Mud Samples

Consolidated Edison Post-Operational Survey

Collection	Sampling Point	County	Gross Gamma (pc/kg)
10/2/63	Iona Island	Rockland	2860
7/7/64	Ioná Island	Rockland	7416
10/2/63	Tappan Zee	Rockland	5990
7/7/64	Tappan Zee	Rockland	3160
10/2/63	Peekskill Bay	Westchester	18000
7/7/64	Peekskill Bay	Westchester	3150
10/3/63	Croton Bay	Westchester	7820
7/8/64	Croton Bay	Westchester	720
10/3/63	Green's Cove	Westchester	5780
7/8/64	Green's Cove	Westchester	1420
7/7/64	Stony Point	Rockland	2160

Pressurized Ionization Chamber

Consolidated Edison Post-Operational Survey

Westchester County

Station	Date	Inst. Reading (Volts)	Cosmic Portion (ur/hr)	Total (ur/hr)
Indian Point	8/25/64	2.05	3.4	10.2
St. Patrick's Church	8/25/64	2.10	3.4	10.5
Buchanan	8/25/64	2.20	3.4	11.0
Peekskill	8/25/64	2.35	3.4	11.8
Bear Mountain Road	8/24/64	2.15	3.5	10.8
Dregon Road	8/25/64	2.10	3.5	10.5
Mill Pond	8/25/64	2.20	3.5	11.0
St. Mark's School	8/25/64	2.40	3.5	12.0
Route 9W	8/24/64	2.30	3.4	11.5
West Haverstraw	8/24/64	2.20	3.4	11.0
New City Park	8/24/64	2.10	3.4	10.5
Nelson Park	8/26/64	2.50	3.5	12.5
Pines Bridge	8/26/64	2.20	3.6	11.0
Granite Springs	8/27/64	2.00	3.6	10.0
Taconic Parkway	8/24/64	2.60	3.9	13.0
Hastings-on-the-Hudson	8/26/64	2.20	3.5	11.0
Westchester County Airport	8/26/64	2.20	3.6	11.0
Blue Heron Lake	8/26/64	2.50	3.6	12.5
North Salem	8/27/64	2.10	3.6	10.5

Consolidated Edison Post-Operational Survey

Summary Of Environmental Discharges From The Consolidated Edison Reactor

Year	Total Activity* Released		Amount Needed To Dilute To Operational Limits**	
	Water (curies)	Air (curies)	Water (gal/yr)	Air (ft^3/yr)
1962	0.131	None	1.72×10^7	None
1963	0.164	0.0072	2.17×10^7	8.46×10^8
1964	11.03	13.180	1.46×10^9	1.6×10^{12}

*Exclusive of Tritium

**Operational Limits

1) Water = $2 \times 10^{-6} \mu c/ml$

2) Air = $3 \times 10^{-10} \mu c/ml$

In normal plant operations 435,000,000 gpd. is discharged * into the Hudson River while 300,000 cfm of gas is discharged up stack.

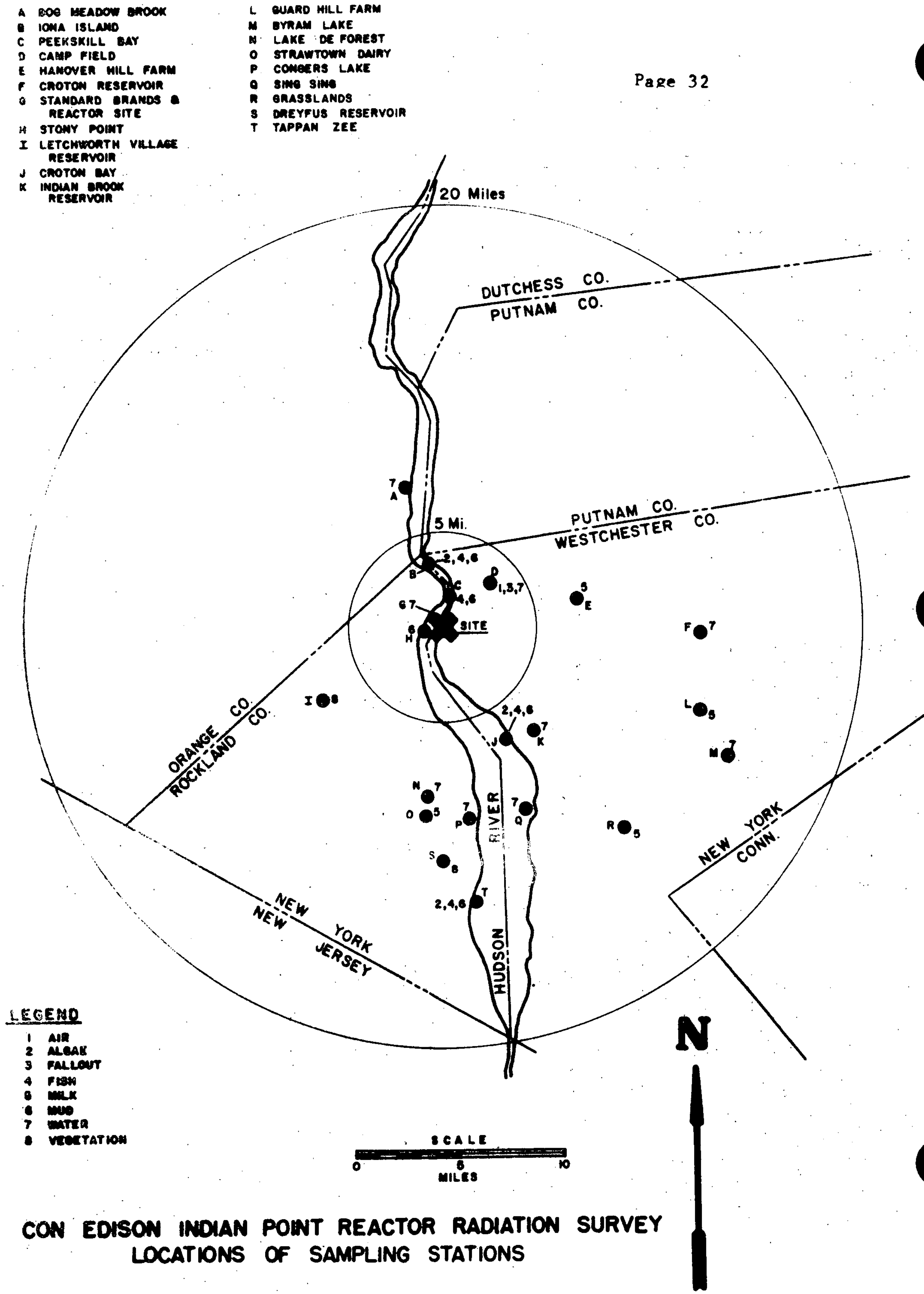
<u>Dilution Available</u>

Water - 4×10^5 gal/day = 1.59×10^{11} gallons.

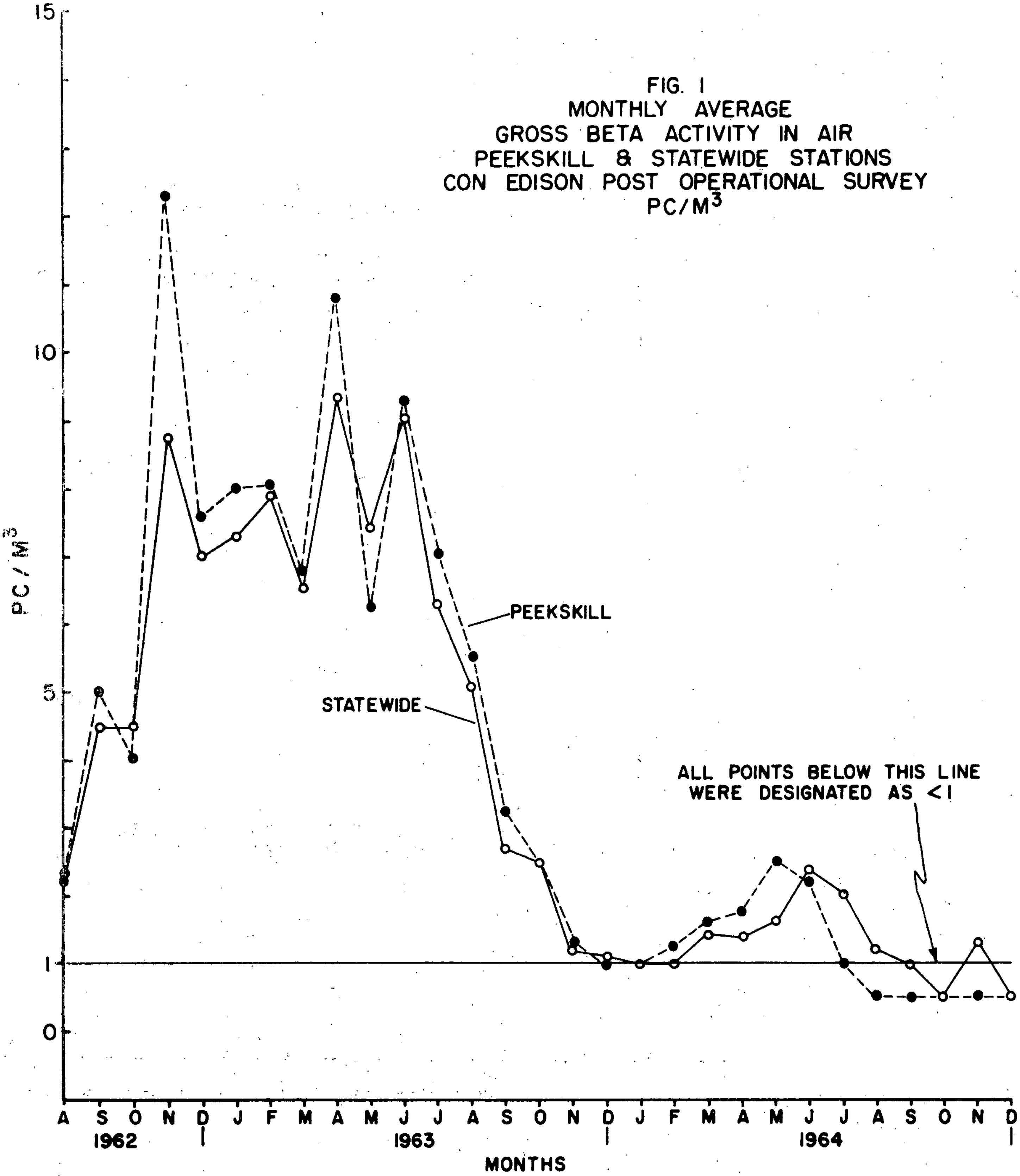
Air - 3×10^5 ft^3/min = 1.6×10^{11} ft^3/yr

Meteorological conditions, from a two year on site survey by New York University, provide for a further dilution factor of 3000 under the worst conditions.

* This is the normal rate of cooling water discharged daily.



CON EDISON INDIAN POINT REACTOR RADIATION SURVEY
LOCATIONS OF SAMPLING STATIONS


15
10
5
1
0
PC / M³
FIG. 1
MONTHLY AVERAGE
GROSS BETA ACTIVITY IN AIR
PEEKSKILL & STATEWIDE STATIONS
CON EDISON POST OPERATIONAL SURVEY
PC/M³
PEEKSKILL
STATEWIDE
ALL POINTS BELOW THIS LINE
WERE DESIGNATED AS <1
A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1962
1963
1964
MONTHS

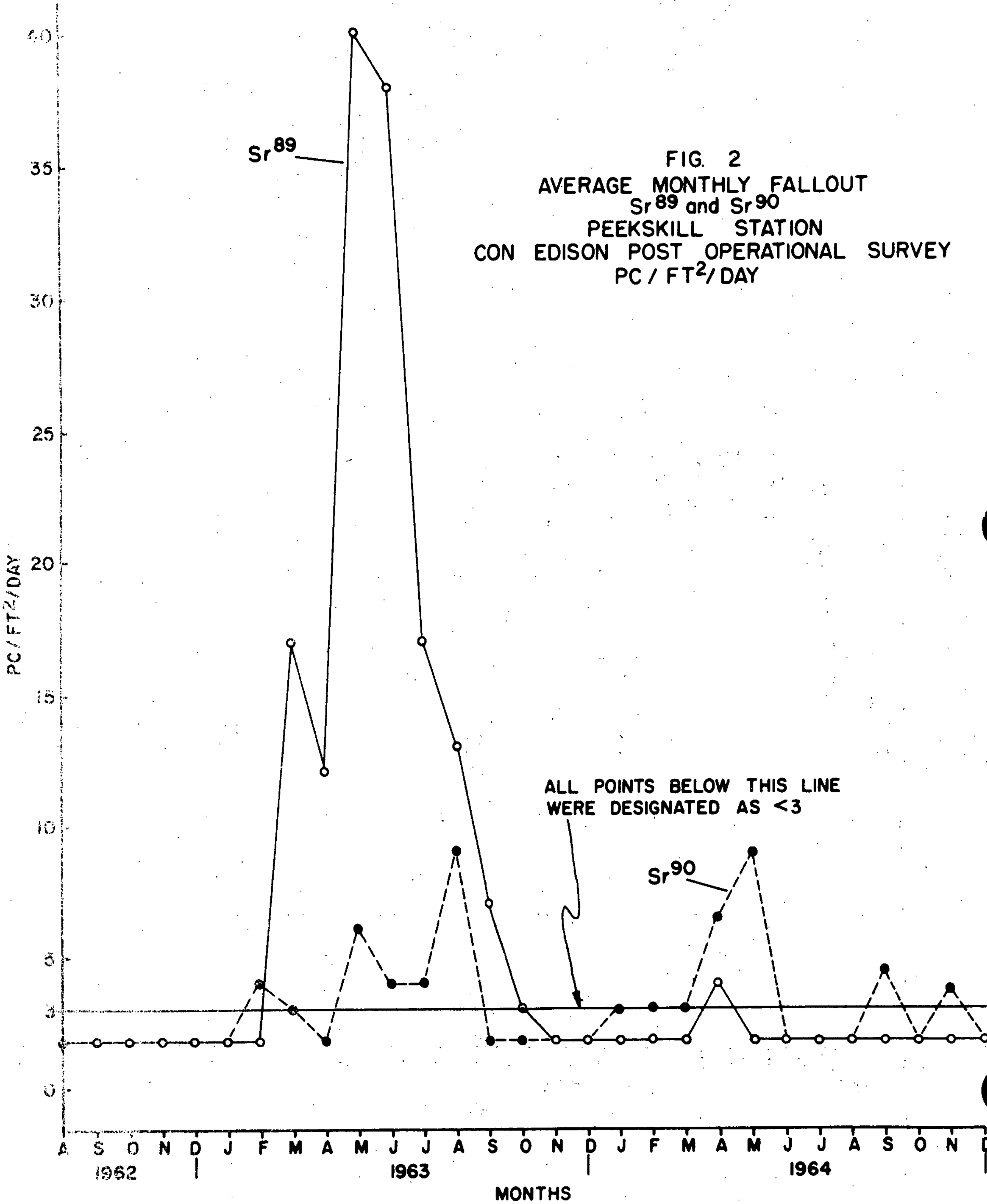


FIG. 2
AVERAGE MONTHLY FALLOUT
Sr^{89} and Sr^{90}
PEEKSKILL STATION
CON EDISON POST OPERATIONAL SURVEY
PC / FT^2/ DAY
Sr^{89}
Sr^{90}
ALL POINTS BELOW THIS LINE
WERE DESIGNATED AS <3
PC / FT^2/DAY
40
35
30
25
20
15
10
5
3
0
A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1962
1963
1964
MONTHS

FIG. 3
GROSS BETA ACTIVITY IN WATER
LAKE DE FOREST & GLENMONT
CON EDISON POST OPERATIONAL SURVEY
PC/ML

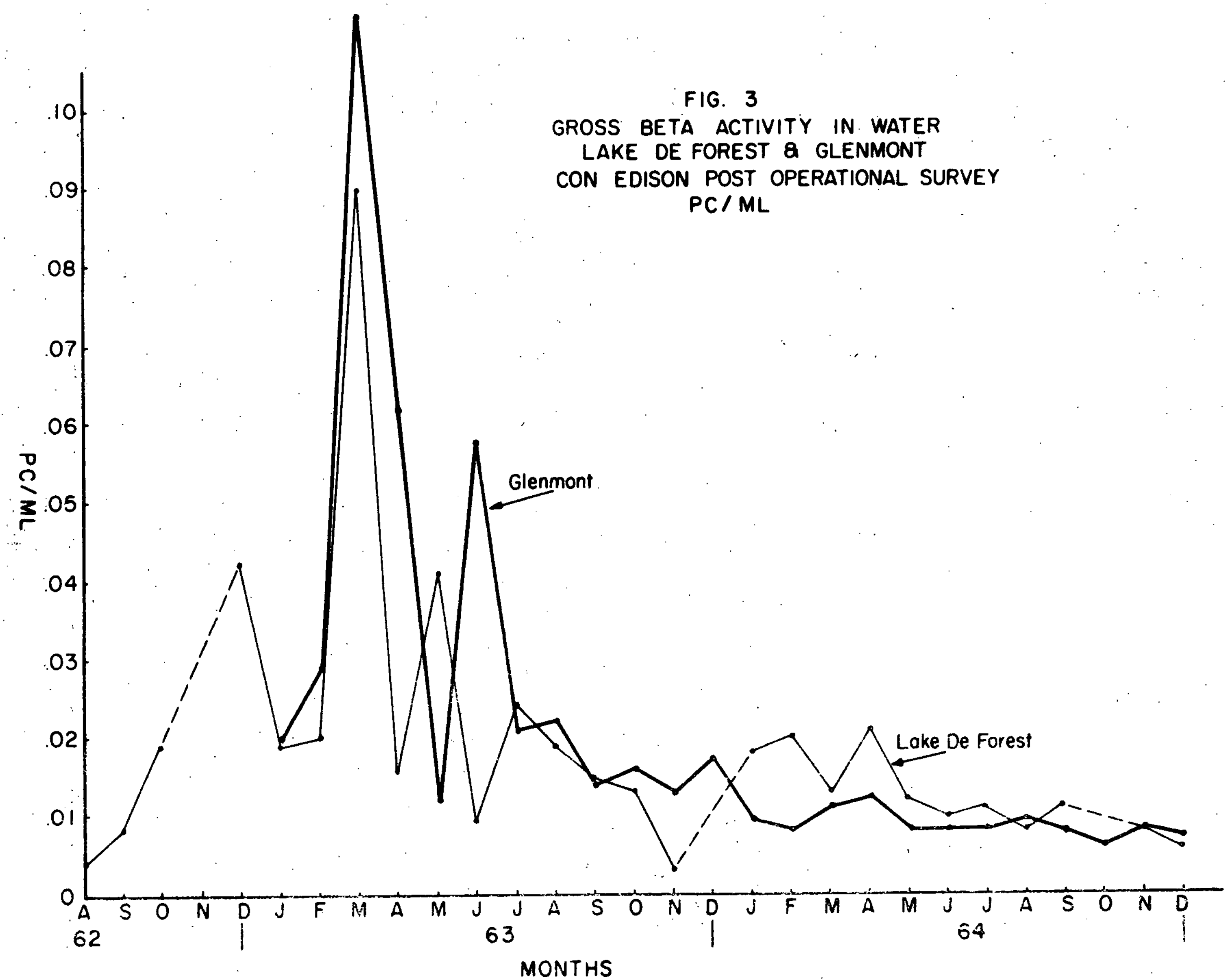
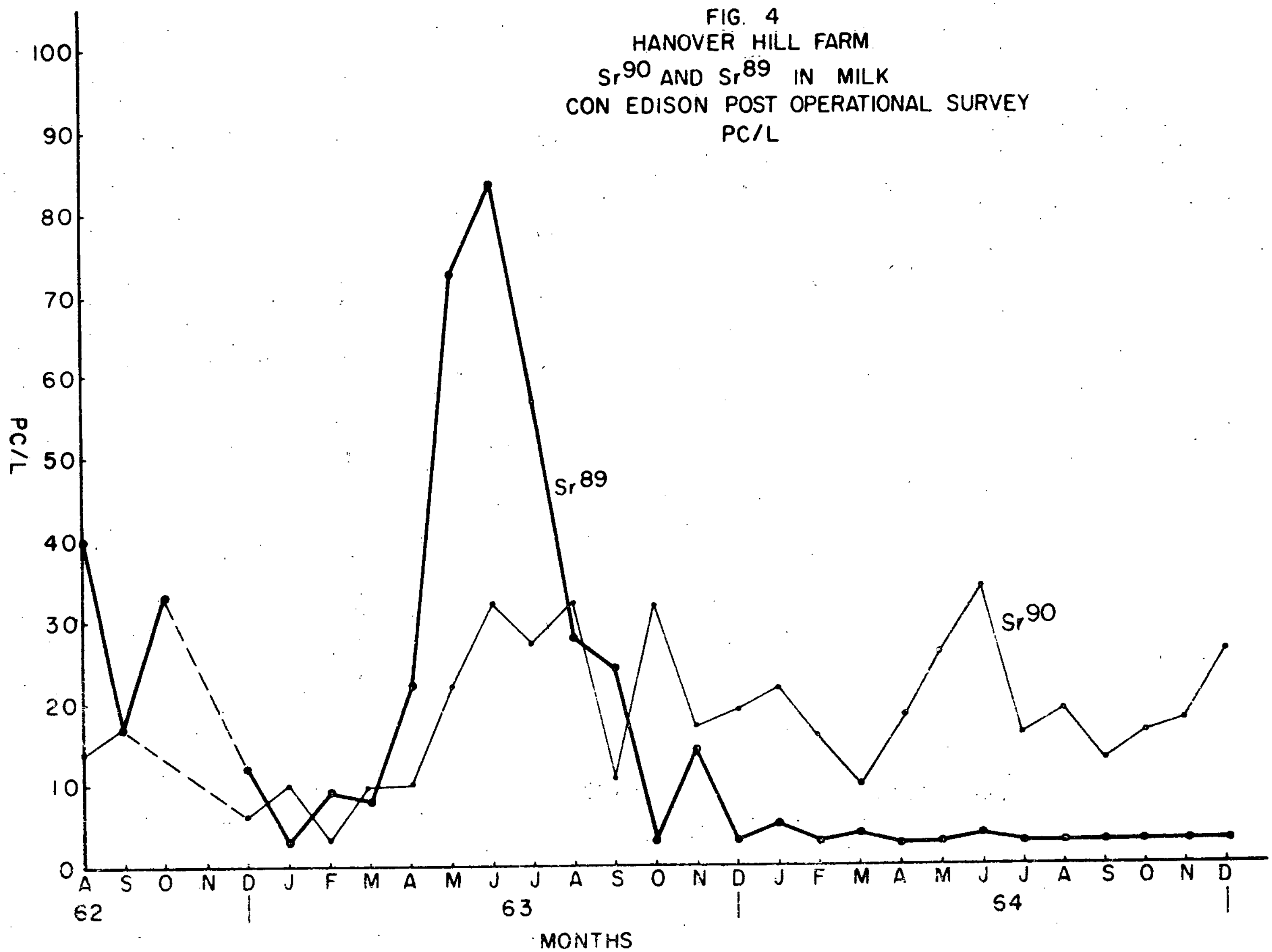


FIG. 4
HANOVER HILL FARM
Sr^{90} AND Sr^{89} IN MILK
CON EDISON POST OPERATIONAL SURVEY
PC/L



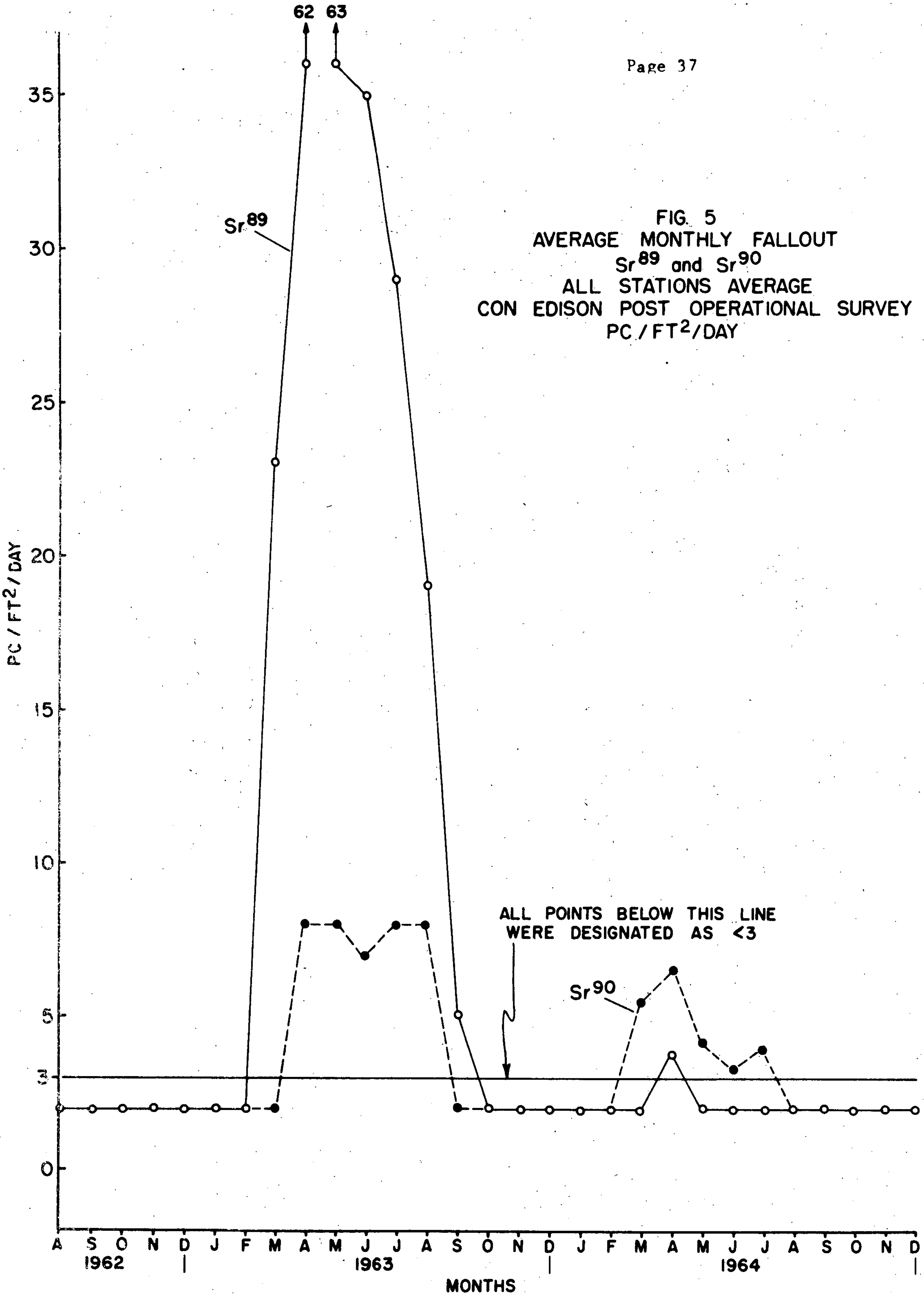
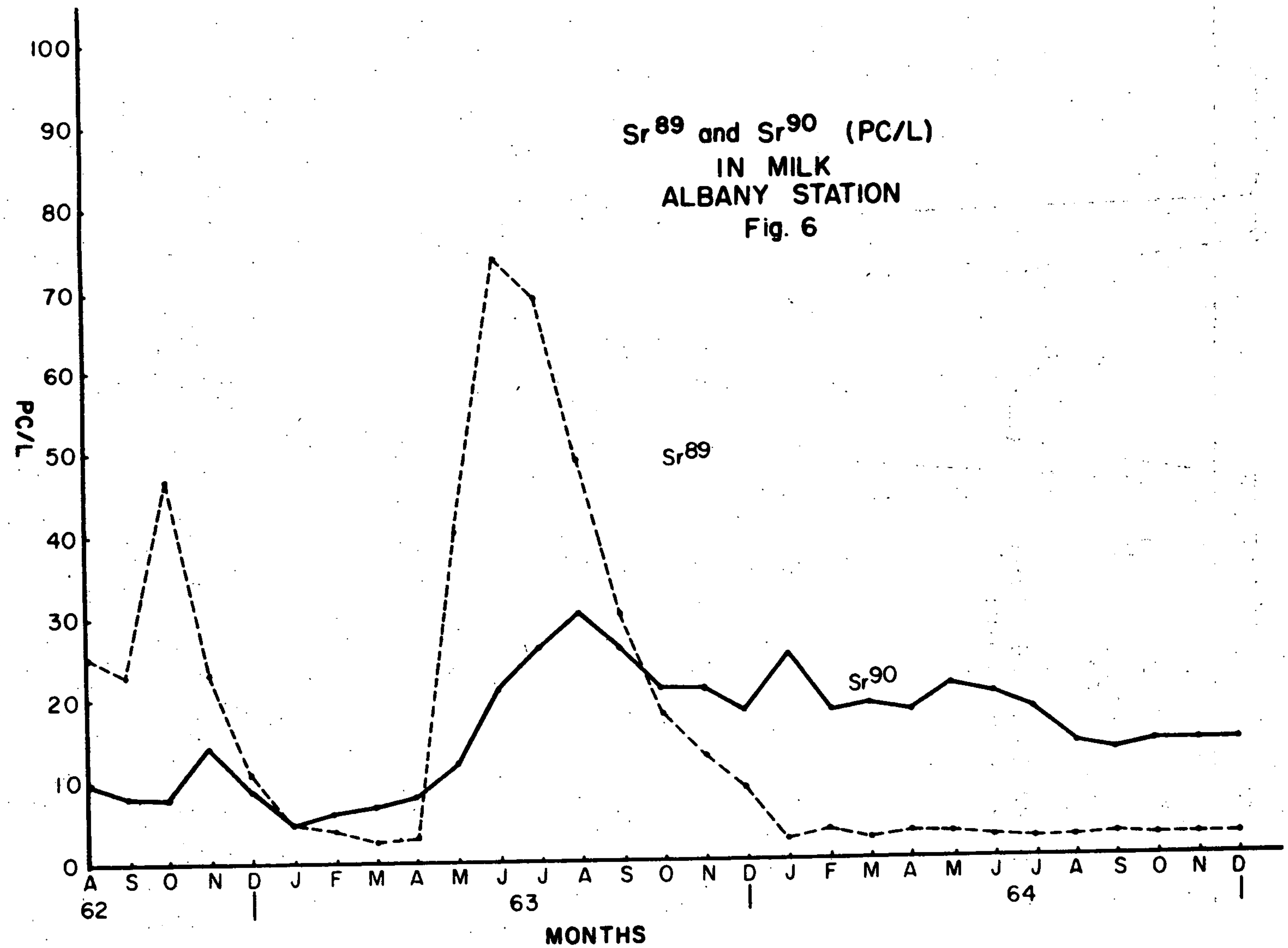
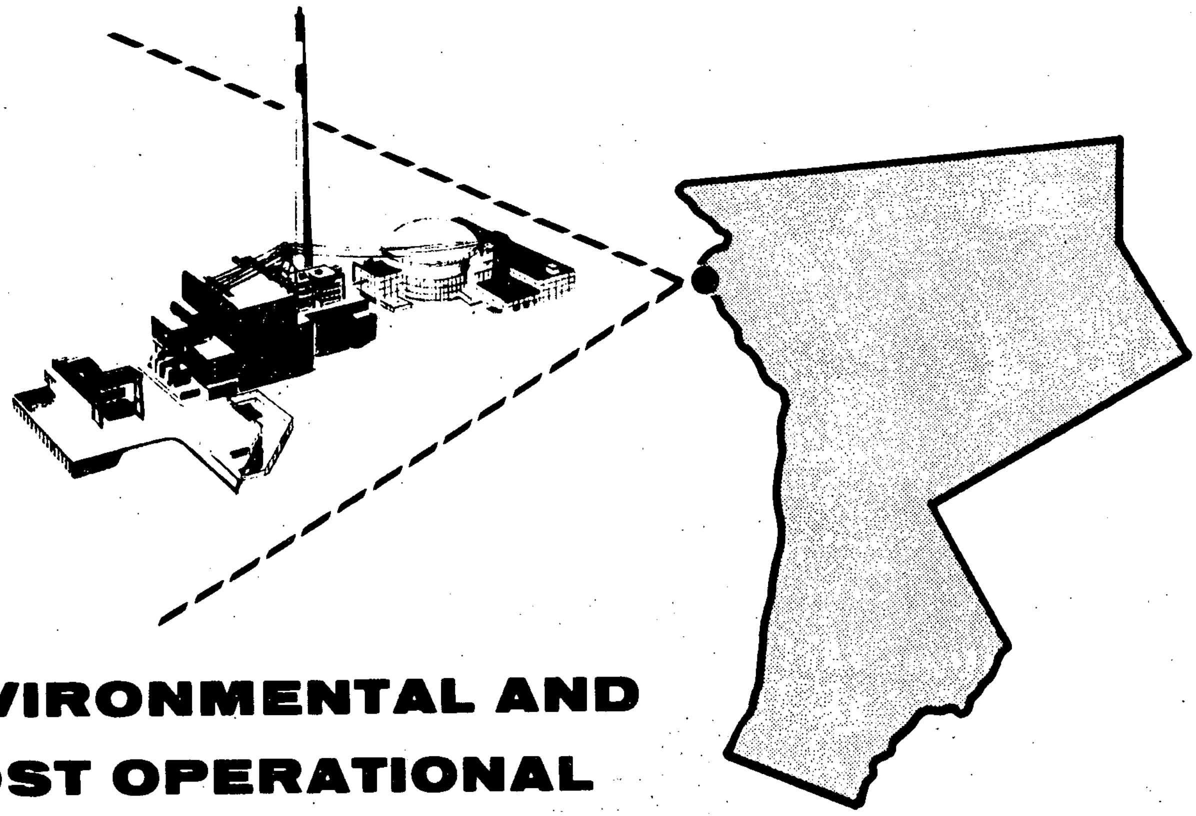


FIG. 5
AVERAGE MONTHLY FALLOUT
Sr89 and Sr90
ALL STATIONS AVERAGE
CON EDISON POST OPERATIONAL SURVEY
PC / FT2 / DAY
62
63
Sr89
Sr90
ALL POINTS BELOW THIS LINE
WERE DESIGNATED AS <3
35
30
25
20
15
10
5
3
0
PC / FT2 / DAY
A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1962
1963
1964
MONTHS


Sr89 and Sr90 (PC/L)
IN MILK
ALBANY STATION
Fig. 6
PC/L
100
90
80
70
60
50
40
30
20
10
0
Sr89
Sr90
A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
62
63
64
MONTHS

CONSOLIDATED EDISON

INDIAN POINT REACTOR



ENVIRONMENTAL AND POST OPERATIONAL SURVEY

JULY 1966

DIVISION OF ENVIRONMENTAL HEALTH SERVICES

NEW YORK STATE DEPARTMENT OF HEALTH

HOLLIS S. INGRAHAM, M.D. *Commissioner*

HOLLIS S. INGRAHAM, M.D.
COMMISSIONER

STATE OF NEW YORK
DEPARTMENT OF HEALTH

84 HOLLAND AVENUE
ALBANY, NEW YORK 12208

DIVISION OF
ENVIRONMENTAL HEALTH SERVICES

MEREDITH H. THOMPSON, D. ENG.,
ASSISTANT COMMISSIONER

BUREAU OF
RADIOLOGICAL HEALTH SERVICES
SHERWOOD DAVIES, B.C.E., M.P.H.
DIRECTOR

Dr. Meredith H. Thompson
Assistant Commissioner
Division of Environmental Health Services
84 Holland Avenue
Albany 8, New York

Re: Environmental and Post Operational Surveys, Consolidated Edison Thorium Reactor, Village of Buchanan, Westchester County.

Dear Doctor Thompson:

This report updates the environmental factors to be considered in the event of a nuclear incident, such as the location of surface water supplies, downstream industrial water users, milk processing or receiving plants, and residential areas which were published in an earlier report in April, 1962.

Post operational sampling data is also included in this report. Various environmental samples were collected during 1965. Sampling results to date have shown that there has been no noticable increase in radiation levels in the vicinity of the plant.

Very truly yours,

Sherwood Davies

Sherwood Davies, P.E.
Director of
Bureau of Radiological Health Services

Consolidated Edison Indian Point Reactor

Environmental And Post Operational Survey

July 1966

Division of Environmental Health Services

New York State Department of Health

Hollis S. Ingraham, M.D.
Commissioner

Acknowledgments

This report was prepared through the cooperation of the following State and local Department personnel:

Central Office - Bureau of Radiological Health Services

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Middletown District Office

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Rockland County Health Department

Mr. George O'Keefe, Assistant Commissioner
Mr. George Giacobbe, Sanitarian

Westchester County Health Department

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Mr. Peter Cordier, Conservation Biologist
Mr. John DeRosa, Marine Fishery Aide

Table of Contents

Consolidated Edison Company of New York, Inc.

Environmental And Post Operational Survey

Introduction

This report updates two earlier reports on environmental factors and on environmental surveys in the vicinity of the Consolidated Edison nuclear power reactor at Indian Point on the Hudson River. The Division of Environmental Health Services in the New York State Department of Health conducts this sampling in cooperation with Consolidated Edison, the Middletown District Office of the State Health Department, and the Rockland and Westchester County Health Departments.

Two earlier reports were entitled, "Environmental Factors To Be Considered After An Accidental Release Of Radioactivity From The Consolidated Edison Thorium Reactor," issued in April, 1962, and "Post-operational Survey," in August, 1965. Two summaries of monitoring and site surveillance before the plant went into operation on August 2, 1962, were issued in November, 1959, and June, 1962.

Environmental Factors

From the beginning the study area has been arbitrarily limited to a 314 square mile area in a 20-mile radius from the reactor. This includes parts of five New York State counties and small areas in New Jersey and Connecticut. The following is the most recent environmental information:

1. The area has more than one million permanent residents.

2. The twelve milk processing or receiving plants in the study area receive milk from 69 dairy farms, 43 of them within the 20-mile radius. Seven other plants located outside the study area which serve New York City receive part of their milk supply from 64 dairy farms in the study area.

Tabular Data

Table 1 lists water sources which could be contaminated by radioactive materials accidentally released into the atmosphere - surface water supplies and some shallow wells or springs. It includes ground water supplies which would not be easily contaminated. The code number in the first column uses the initial of the county and a number assigned arbitrarily to each water works within that county. Other columns list the name of the water works, its source and the community it serves.

Table 2 is a list of industrial water users on the Hudson River located downstream from the Indian Point Reactor.

The latest data on the number of milk processing and receiving plants in the study area is included in Table 3. The number of dairy farms in each county and township is given in Table 4.

Table 5 gives population figures for various cities, towns and villages - updated census figures where these are available, population estimates otherwise.

Post Operational Sampling Data (January, 1965 - December, 1965)

The isotopic analyses on the samples taken during 1965 are found in Tables 6-9. Weekly composite samples for air and fallout were taken at the Peekskill site. Monthly water samples at different locations in the reactor vicinity were obtained. Collections were also made in the Hudson River of weekly composite samples at Peekskill and Ossining. Monthly milk samples were collected at various sites in the area.

Gamma background levels were measured by personnel of the New York State Department of Health, Bureau of Radiological Health Services in the area around the reactor site in October, 1965. The locations of the pressurized ionization chamber survey sites are given on page 30. The data obtained from these stations is found in Table 10.

A summary of the environmental discharges from the Indian Point Reactor is in Table 11. This table was prepared from data which the Bureau of Radiological Health Services receives from the Indian Point Reactor on a monthly basis.

A revised map showing locations of sampling stations and wind rose data is included. Wind data was obtained from a report entitled, "Air Pollution In Westchester," published by the New York State Air Pollution Control Board in December, 1965.

Conclusion:

The graphs in the report show that the Hudson River gross beta readings downstream from the reactor (at Ossining) are higher than those upstream (at Peekskill) and that the natural chloride or sea water content of the Hudson River, including Potassium-40, is also higher for the downstream station. The drought of the past few years has increased the concentration of sea water in the lower Hudson, thereby increasing the amount of K^{40} and its gross beta activity.

Isotopic analyses of fish, algae and vegetation samples revealed that few, if any isotopes, could be found in significant concentrations or above the limit of sensitivity. The concentrations (activity per unit weight) found are much smaller than the maxium permissible concentration (MPC) allowed in drinking water for each isotope. These results agree with an independent survey in 1964 by a team of faculty and students from New York University.

The pressurized ionization chamber data shows that there has been no increase in gamma background since the last survey in 1964.

The summary of environmental discharges indicates that the plant has been operating within the allowable limits.

No increase in radioactivity was observed in this peroid which can be attributed to the operation of the Indian Point Reactor. Positive results in milk are associated with past nuclear weapons testing.

DIRECTORY OF HEALTH DEPARTMENTS

The following is a list of Health Departments and personnel who could be consulted if an accidental release of radioactive materials from the reactor were to occur:

WESTCHESTER COUNTY HEALTH DEPARTMENT (White Plains Region) County Office Building, 148 Martine Avenue, White Plains		WH 9-1300 Ext. 451
Health Commissioner	William A. Brumfield, Jr., M.D.	WH 8-4141
Director, Div. of Sanitation	Richard M. McLaughlin, P.E.	WH 8-1871
Senior Sanitary Engineer, Radiological Health and Air Pollution	Calvin E. Weber, P.E.	245-2562
ROCKLAND COUNTY HEALTH DEPARTMENT (White Plains Region) County Office Building, New City, New York		New City 4-4663 or 4-4911
Health Commissioner	Donald G. Dickson, M.D.	New City 4-7901
Assistant Commissioner	George E. O'Keefe, P.E.	New City 4-7901
Asst. Director, Division of Environmental Sanitation	Donald Grosso	
MIDDLETOWN DISTRICT OFFICE (White Plains Region) 34 South Street, Middletown		DIamond 2-2511
Health Officer	John A. Degen, Jr., M.D.	DIamond 3-8782
Sanitary Engineer	Matthias Schleifer, P.E.	DIamond 2-1691
DUTCHESS COUNTY HEALTH DEPARTMENT (White Plains Region) 236 Main Street, Poughkeepsie		485-9800
Health Commissioner	Matthew A. Vassallo, M.D.	
Director, Environmental Sanitation	H.W. Scoralick, P.E.	485-9800
WHITE PLAINS REGIONAL OFFICE 55 Church Street, White Plains		WH 9-6315
Regional Health Director	William R. Donovan, M.D.	WH 9-3796
Regional Director of Public Health Engineering	John Harrison, P.E.	LA 8-3738
BUREAU OF RADIOLOGICAL HEALTH SERVICES 84 Holland Avenue, Albany		
Director	Sherwood Davies, P.E.	GR 4-7411
Assoc. Sanitary Engineer	William Kelleher, P.E.	GR 4-2065
Assoc. Sanitary Engineer	Harry Farkas, P.E.	GR 4-2067
Senior Sanitary Engineer	Allan Raymond, P.E.	GR 4-2055

Directory of Health Departments (cont.)

Assistant Sanitary Engineer	David Romano	GR 4-2064
Assistant Sanitary Engineer	Bernard Heald	GR 4-2067
Assistant Sanitary Engineer	Ralph Dykstra	GR 4-2064
Assistant Sanitary Engineer	Kurt Anderson	GR 4-2003
Junior Sanitary Engineer	Robert Hannaford	GR 4-2055

VICINITY INDIAN POINT REACTOR

WATER SUPPLY DATA

Code No.	Water Works	Source	Type of Treatment	Communtiy Served
0-19	Stewart Field	Catskill Aqueduct	Diam. E, Cl_2 Open Storage	Stewart Field - U.S. Air Force Base
0-3	Cornwall (V)	Lake	Cl_2	Cornwall (V)
0-6	Newburgh (C)	Silver & Patton Brooks	Cl_2, RSF, AC, F	Newburgh (C) New Windsor WD# 1-5 (Aux)
D-1	Fishkill (V)	Hell Hollow & Clover Brooks	Cl_2	Fishkill (V) Glenham WD
0-4	Highland Falls (V)	2 Reservoirs on Highland Brook	Cl_2, RSF	Highland Falls (V) Aux. intake on P23 ne
0-11	U.S. Military Academy	Popolopen & Queensboro Brooks (see map P23 se)	RSF, Cl_2	U.S. Military Academy, West Point
B-1	Beacon City	Melsingah Res.	Cl_2	Beacon City
B-2	Beacon City	Mt. Beacon Res.	Cl_2	Beacon City
B-3	Beacon City	Cargill Res. or Beacon Res.	Cl_2	Beacon City
P-6	Cold Springs (V)	Foundry Brook 2 Intakes	Cl_2	Cold Springs Nelsonville
P-7	Hiawatha Improvement Co.	Lake Oscawanna	Cl_2	Land of Hiawatha Improvement Co.
P-8	Hilltop WD	Lake Oscawanna	PSF, AC, Cl_2	Hilltop WD
P-9	Wildwood Knolls WD	Lake Oscawanna	PSF, CC, Cl_2	Wildwood Knolls

VICINITY INDIAN POINT REACTOR Cont.

WATER SUPPLY DATA

Code No.	Water Works	Source	Type of Treatment	Community Served
P-10	Oscawanna Lake	Lake Oscawanna	Unknown	Private Usage
P-21	Fahnestock St. Park	Pelton Pond	Cl_2, RSF	Fahnestock St. Park
P-4	Carmel WD #2	Lake Gleneida	Cl_2	Carmel WD #2
P-11	Kirkwood Park	Infil. Gallery	Cl_2	Kirkwood Park
P-12	Sedgewood Club	China Pond	Cl_2	Sedgewood Property
P-13	Lake Gardens	Lake Mahopac	Cl_2	Lake Gardens Subdivision
P-16	Lake Mahopac Woods	Lake Mahopac	Cl_2, SSF	Lake Mahopac Woods Subdivision
P-17	Mahopac Hills	Lake Mahopac	Cl_2	Mahopac Hills Subdivision
P-20	Lake Mahopac	Lake Mahopac	Unknown	Private Usage
O-1	Arden Farms	Echo Lake	Cl_2	Arden
O-2	Chester (V)	Walton Lake	Cl_2	Chester (V)
O-5	Monroe (V)	Lake Mombasha	Cl_2	Monroe (V)
O-10	Woodbury WD	Wells, Cromwell Lake for emergency use	Cl_2, CC	Woodbury WD
O-12	Bear Mountain-Palisades Inter-State Park Supply	Queensboro Lake	Cl_2, RSF	Bear Mountain Park USMA (Aux)
O-16	Summit, Twin & Barnes Palisades Inter-State Park Supply	Summit Lake	Cl_2	Summit, Twin and Barnes Parks
O-11	U.S. Military Academy West Point	Popolopen & Queensboro Brooks (see map P24 nw)	RSF, Cl_2	U.S. Military Academy, West Point

VICINITY INDIAN POINT REACTOR Cont.

WATER SUPPLY DATA

Code No.	Water Works	Source	Type of Treatment	Community Served
O-17	Tiorati & Cohasset Palisades Inter-State Park	Lake Tiorati	Cl_2	Tiorati & Cohasset Areas
O-20	Silver Mine & Queensboro Palisades Inter-State Park	Silver Mine Lake	PSF	Silver Mine, Queensboro Areas
W-2	Camp Smith	Wells	Cl_2	Camp Smith (National Guard)
W-4	Peekskill (C)	Peekskill Hollow Brook	Cl_2, SSF and Ammon, Diam E	Peekskill (C) Buchanan (V) NYCRR Watering Point Roe Park, Cortland (T) in part Montrose Improvement District (Aux.) Standard Brands Inc.
W-28	Standard Brands, Inc.	Hudson River	Industrial Cooling Water	Standard Brands, Inc.
W-1B	Yorktown WSDD	Amawalk Res.	Cl_2 and Aeration	Amawalk Heights WD, Somers (T) Yorktown (T) WD's (13)
W-3	Yorktown WSDD	Shallow Infiltration Gallery	Cl_2	Yorktown (T) WD's (13)
P-5	Carmel WD #5	Lake Secor	RSF, Cl_2	Carmel WD #5
P-14	Lake Mahopac Ridge	Lake Mahopac	Cl_2, SSF	Lake Mahopac and Lake Mahopac Old Village
P-15	Lake View Park	Lake Mahopac	Cl_2	Lakeview Park
P-19	Mahopac School	Lake Mahopac	Cl_2	Carmel School District
W-5	Amawalk-Shenorock WD	Infil. Galleries	Ferro Sand Filtration & Cl_2	Amawalk-Shenorock WD
W-6	Lincoln Hall School	Wells	No treatment-Open Storage	Lincoln Hall School
W-12	Bedford WSDD #1	Gravel Wells	No treatment	Bedford (T) WD's

VICINITY INDIAN POINT REACTOR Cont.

WATER SUPPLY DATA

Code No.	Water Works	Source	Type of Treatment	Community Served
W-22	Croton Falls Water Dept.	Drilled Wells	No treatment	Croton Falls-No. Salem(T)
W-21	Butlerville	Shallow Springs	No treatment	Butlerville-Somers (T)
W-7	Mead Properties	Waccabuc Lake on N.Y.C. Watershed	Cl_2	Mead Properties Lewisboro (T)
W-25	Ward Poundridge Reservation	Springs & Shallow Wells (25)	No treatment	West. Co., Park Comm. Ward, Poundridge Reservation Camping Areas
O-7	Sterling Forest	Reservoir	Cl_2, RSF, AC	Sterling Forest Industrial Sites & Subdivisions
	Sterling Lake	Sterling Lake	Cl_2, CC	Sterling Lake
	Blue Lake	Blue Lake	Cl_2, CC, RSF	Blue Lake
	Greenwood Lake (V)	Greenwood Lake Emergency Use	Cl_2, SF	Greenwood Lake (V)
	Sterling Forest Forest Park	Greenwood Lake	Cl_2, PSF	Forest Park
O-8	Tuxedo (H)	Tuxedo Lake	Cl_2, CC, PSF	Tuxedo (H)
O-9	Tuxedo Park (V)	Tuxedo Lake	Cl_2, CC, PSF	Tuxedo Park (V)
R-14	Sebago Lake - Palisades Inter-State Park Supply	Lake Sebago	Cl_2, PSF	Lake Sebago Camp Area
O-15	Stahahe Lake - Palisades Inter-State Park Supply	Lake Stahahe	Cl_2	Lake Stahahe Camp Area
R-7	Hillburn (V)	Hillburn Res.	Cl_2 & open storage (see map Q23 sw)	Hillburn (V)
R-8	Pothat Water Co.	Potake Pond & Cranberry Pond(Aux.)	Cl_2	Sloatsburg (V) Ramapo (H) Sterlington (H)
R-9	St. Joseph's Home	Sheppard Pond	Cl_2	St. Joseph's Home - St. Mary's Villa

VICINITY INDIAN POINT REACTOR Cont.

WATER SUPPLY DATA

Code No.	Water Works	Source	Type of Treatment	Community Served
R-13	Breakneck Lake Palisades Inter-State Park Supply	Breakneck Pond	Cl_2, PSF	Breakneck Pond Camp Area
R-18	Welsh Lake	Lake Welsh	Proposed Cl_2, RSF	Lake Welsh Campsite
R-1	Utilities & Industries Stony Point Supply	Res. & Well	PSF, Sed., Cl_2, Open Storage	Stony Pt. (T) Haverstraw (T) Haverstraw (V) W. Haverstraw (V)
R-3	Letchworth Village, N.Y. St. Dept. of Social Welfare	First Res.	RSF, Cl_2	Letchworth Village
R-5	Utilities & Industries Thiells Res. Supply	Thiells Res.	Cl_2	Haverstraw (Aux.) W. Haverstraw (Aux.)
W-1	N.Y.C. Dept. Water Supply Gas & Elec. - Croton System	Reservoirs - Croton System	Nat. Settling, Aeration, Cl_2	New York City Westchester Co. Communities as Noted
W-8	Ossining Water Board	Indian Brook Res.	Aeration RSF, excess Cl_2, de Cl_2, Open Storage	Ossining (V) Ossining (T) Sing Sing Prison
W-1C	Ossining Water Board	Old Croton Aqueduct	Same as W-8 Q24 ne	Same as W-8 Q24 ne
W-9	Croton-on-Hudson (V)	Infil. Galleries	Cl_2	Croton-on-Hudson (V) - NYCRR - Watering point at Harmon Croton Point Park
W-1D	Ossining Water Board	New Croton Aqueduct	Cl_2 & de Cl_2	Ossining (V) Ossining (T) Sing Sing Prison

WATER SUPPLY DATA

Code No.	Water Works	Source	Type of Treatment	Community Served
W-15	Briarcliff Manor (V)	Shallow Wells Driven Well Gravel Packed Well	Nat. Fil., Cl_2, and Aeration	Briarcliff Manor (V) Morningside WD Ossining(T) Archville WD, Mt. Pleasant (T) Briar Hills WD, Mt. Pleasant (T)
W-1S	No. Tarrytown (V)	New Croton Aqueduct	Cl_2	No. Tarrytown (V)
W-1I	New Rochelle Water Company Pocantico Division	NYC Aqueducts Catskill or New Croton thru New Rochelle Division	Cl_2	Same as W-18-Q24 se
W-1J	New Rochelle Water Company New Rochelle Division	New Croton Aqueduct & Catskill Aqueduct (Aux.)	Cl_2, CC, & F	Bronxville (V) Eastchester (T) N. Pelham (V) Pelham (V) Pelham Manor (V) Tuckahoe (V)
W-1K	Irvington (V)	New Croton Aqueduct	Cl_2	Same as W-19-Q24 se
W-1E	Briarcliff Manor (V)	New Croton Aqueduct	Cl_2	Same as W-15 (Aux.)Q24 ne
W-1F	Briarcliff Manor (V)	Old Croton Aqueduct	Cl_2	Same as W-15 (Aux.)Q24 ne
W-1Q	New Castle District #1	New Croton Aqueduct	Cl_2	New Castle(T)Water Districts
W-23	Pine Hill Crystal Springs	Springs	Cl_2	Pine Hills-Crystal Springs Bottled Water Co.
W-1R	Sing Sing Prison	Old Croton Aqueduct	Cl_2	Sing Sing Prison
W-1T	Tarrytown (V)	New Croton Aqueduct	Same as W-13 Q24 se	Same as W-13 Q24 se

VICINITY INDIAN POINT REACTOR Cont.

WATER SUPPLY DATA

Code No.	Water Works	Source	Type of Treatment	Community Served
W-1A	Stanwood WD	Croton Res.	Cl_2	Stanwood WD, Bedford (T), New Castle (T)
W-10	New Castle Water Co.	Guinzburg Pond	Diam. E., & Cl_2	Parts of (T's) New Castle & No. Castle
W-11	Mt. Kisco (V)	Byram Lake	Cl_2 & Open Storage	Mt. Kisco (V), New Castle #1 (Aux.)
W-11A	Mt. Kisco (V)	Shallow Wells	Cl_2	Same as W-11 Q25 nw
W-27	Greenwich, Conn. Port Chester Water Works	Mianus River	Ammon, Cl_2, RSF & AC	Greenwich (C) Port Chester (V)
NJ-3	Hackensack Water Co.	Woodcliff Lake	Cl_2, RSF	55 communities in New Jersey
R-6	Nyack Water Supply Upper Hackensack River	Hackensack River & De Forest Lake	Sed., Cl_2, RSF	Nyack (V) S. Nyack (V) Upper Nyack Clarkstown (T)
NJ-3	Hackensack Water Co.	DeForest Lake Hackensack River	Cl_2, RSF	55 municipalities in New Jersey
W-29	NYC Dept. Water Supply Gas Elec. - Kensico System	Reservoirs-Kensico System	Nat. Sett., Aeration, Cl_2	New York City and Westchester County communities as noted
W-13	Tarrytown (V)	Local Lakes	PSF, Cl_2, Open Storage (See Q24ne)	Tarrytown (V) Glenville WD, Greenburg(T) Eastview, Mt. Pleasant(T) No. Tarrytown (V)
W-14	Pocantico Hills Estates	Lakes	Pre., Cl_2,RSF, CC	Pocantico Hills Estates
W-19	Irvington (V)	Local (Aux.) Reservoirs	Cl_2, Open Storage	Irvington (V) E. Irvington (V)

VICINITY INDIAN POINT REACTOR Cont.

WATER SUPPLY DATA

Code No.	Water Works	Source	Type of Treatment	Community Served
W-20	White Plains (C)	Local Lakes & Wells	Cl_2, CC	White Plains (C)
W-29M	White Plains (C)	Kensico Res.	Same as W-20	White Plains (C)
W-29N	No. Castle Dist. #1	Kensico Res.	Cl_2 & CC	No. Castle #1
W-18	New Rochelle Water Co. Pocantico Division	Pocantico Lake	Cl_2, PSF & CC	Ardsley (V) Dobbs Ferry (V) Greenburgh (T) Hastings (V) Scarsdale (V) Eastchester (V)
W-29V	Grasslands, DPW	Catskill Aqueduct	Cl_2	Grasslands Reservation
W-29X	Hawthorne Improvement District	Catskill Aqueduct	Cl_2, CC	Hawthorne, Mt. Pleasant (T)
W-29P	Valhalla WD	Catskill Aqueduct	Cl_2	Valhalla, Mt. Pleasant (T)
W-29T	Yonkers (C)	Catskill Aqueduct	Cl_2, F	Yonkers (C)
W-29U	Scarsdale (V)	Catskill Aqueduct	Cl_2, F	Scarsdale (V)
W-1I	New Rochelle Water Co. Pocantico Division	Catskill Aqueduct	Cl_2, CC	Same as W-18-Q24 se
W-1J	New Rochelle Water Co. New Rochelle Division	Catskill Aqueduct	Cl_2, CC, F	Same as W-1J(Aux.) - Q24 ne
W-17	Westchester Joint Water Works #1	Mamaroneck River Watershed-Intake Downstream Outside Study Area	Aeration, pre & post Cl_2, RSF, F	Mamaroneck (V) Harrison (T) Mamaroneck (V) Rye (C) New Rochelle (C) Larchmont (V) Scarsdale (V) Pelham Manor (V)

VICINITY INDIAN POINT REACTOR Cont.

WATER SUPPLY DATA

Code No.	Water Works	Source	Type of Treatment	Community Served
W-29H	Westchester Joint Water Works #1	Rye Lake (Kensico Res.)	Cl_2, F, & CC	Same as W-17
W-16	Harrison Dist. #1	Wells	Open Storage	Harrison WD #1
W-29G	Harrison Dist. #1	Rye Lake (Kensico Res.)	CC & Cl_2	Same as W-16-Q25 sw
W-24	Yonkers (C)	Saw Mill River & Grassy Sprain Brook	Ammon, Cl_2, SSF	Yonkers (C)
	ADDITIONAL NEW JERSEY SUPPLIES WITH WATERSHED AREA WITHIN 20 MILE RADIUS			
NJ-1	North Jersey Water Supply Commission and Passaic Valley Water Commission	Wanaque River		Newark City & 8 other municipalities Total population served 875,000 including Newark City
NJ-2	North Jersey Water Supply Commission	Ramapo River-40 mgd. Pumped from Pompton Lakes to Wanaque Res.		+ 9 municipalities total population served 355,000
NJ-3	Hackensack Water Co.	Hackensack River		55 municipalities Total population served 500,000
	ADDITIONAL CONNECTICUT SUPPLIES WITH WATERSHED AREA WITHIN 20 MILE RADIUS			
W-26	Stamford	Tributary of Rippowam River	Cl_2, Microstrainer	Stamford, Conn.

WATER SUPPLY DATA

Code No.	Water Works *	Source	Type of Treatment	Community Served *
W-30A	Greenburgh Consolidated Water District No. 1	Delaware Aqueduct	Cl_2, Act. Carbon	Greenburgh (T)
W-30B	Larchmont	Delaware Aqueduct	Cl_2, Coag., RSF, Act. Carbon, F (supply from Aqueduct normally bypasses coagulation & filtration - equipment available)	Larchmont (V)
W-29Y	Mt. Vernon City	Hillview Reservoir	Cl_2	Mt. Vernon (C)
W-30C	Westchester Joint Water Works #1	Delaware Aqueduct	Cl_2, F	Same as W-17
W-29Z	Yonkers (C)	Hillview Reservoir	Cl_2	Yonkers (C)

* The water works and communities listed on this page take water from the Delaware Adueduct system. Part of the water in this system comes from the New York City Pumping Station at Chelsea, New York which uses the Hudson River as its water source and is located Within the 20 mile study area. Preliminary treatment includes chlorination and the addition of alum.

Table 2

Consolidated Edison's Indian Point Reactor
Buchanan Village, Westchester County
1965

INDUSTRIAL WATER USERS ON HUDSON RIVER BELOW INDIAN POINT

Name	Use	Quantity		Location In Miles From Indian Point
Consolidated Edison of New York, New York	Cooling	165	M.G.D.	+38.4
Refined Syrups and Sugars, Yonkers	Cooling	7	M.G.D.	+26.1
Consolidated Edison of New York, Hastings	Cooling	.65	M.G.D.	+24.3
Anaconda Wire and Cable, Hastings	Cooling	.2	M.G.D.	+21.4
Nevis Laboratories, Columbia University, Irvington (V)	Cooling	1000	G.P.M.	+15.3
Rock Industries, Haverstraw	Stone Washing	1.5	M.G.D.	+ 6.0
Rockland Light and Power, Stony Point	Cooling And Ash Handling	260	M.G.D.	+ 1.8
Rock Industries, Tomkins Cove	Stone Washing	1	M.G.D.	+ 1.8
Consolidated Edison of New York, Indian Point	Cooling	400	M.G.D.	0.0
Standard Brands* Peekskill	Cooling	4	M.G.D.	- 0.3

*Upstream

VICINITY INDIAN POINT REACTOR Cont.

MILK PROCESSING AND/OR RECEIVING PLANT DATA

Processing and/or Receiving Plant	Source of Milk		Total Milk Production Qts/Day	Milk Prod. From Study Area Qts/Day	Health Unit
	Total No. of Dairy Farms	No. of Dairy Farms Within 20 Mile Radius			
DPW West. Co., Mt. Pleasant	1	1	1500	1500	Westchester County
Strawtown Dairy, New City	1	1	2000	2000	Rockland County
Penwood Farm (b), Mt. Kisco	1	1	100	100	Westchester County
Miller Dairy, W. Nyack	(c)	(c)	20000	0	Rockland County
Crowley Milk Co., Newburgh	32	32	28000	28000	Westchester County
Petelinz Dairy, Newburgh	13	2	6000	942	Middletown District
Lakeside Dairy, Newburgh	2	2	350	350	Middletown District
Matteawan State Hospital, Beacon	1	1	1800	1800	Middletown District
Brookside Farms, Haverstraw	15 (e)	0	6000	0	Rockland County
Grey Ridge Farms, Stony Point	1	1	400	400	Rockland County
Sunny Hill, Spring Valley	1	1	450	450	Rockland County
Julia Dyckman Andrus, Home Hastings	1	1	200	200	Westchester County

VICINITY INDIAN POINT REACTOR Cont.

MILK PROCESSING AND/OR RECEIVING PLANT DATA

Processing and/or Receiving Plant	Source of Milk		Total Milk Production Qts/Day	Milk Prod. From Study Area Qts/Day	Health Unit
	Total No. of Dairy Farms	No. of Dairy Farms Within 20 Mile Radius			
<u>Outside 20 Mile Radius</u>					
Ferndale Farms, Circleville	99	3	62000	2000	New York City
Deltown Foods, Slate Hill	142	6	96600	3800	New York City
Borden Farm Products, Warwick	109	35	66000	21000	New York City
Terwilleger & Wakefield (f), Ridgewood, New Jersey	29	2	9750	650	New York City
Sealtest, Webster Ave., Bronx	159 (g)	7	138600	3900	New York City
Dairymen's League, Woodside, Long Island	121	25	121398	12600	New York City
Sussex Milk & Cream, Sussex, New Jersey	74	1	36100	560	New York City

* Indicates production was obtained by using percentage of dairy farms within study area to total dairy farms serving plant.

(b) Special A Raw Milk - Code number not available.
(c) One local herd outside 20 mile radius, remainder is purchased in a prepasturized state from a Newark, New Jersey concern.
(e) Estimate.
(f) Ice Cream only to New York City - fluid milk to local market.
(g) Estimated from average figures.
NA Not available.

Consolidated Edison's Indian Point Reactor
Buchanan Village, Westchester County
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Table 4

Dairy Farms - By townships

County and Townships	Farms
Westchester County	
Bedford	4
Harrison	1
Lewisboro	4
Mt. Pleasant	1
Newcastle	1
North Salem	6
Somers	4
Yorktown	2
Yonkers	1
Rockland County	
Clarkstown	13
Orangetown	3
Ramapo	3
Stony Point	2
Putnam County	
Carmel	7
Kent	1
Patterson	10
Phillipstown	2
Putnam Valley	2
Southeast	11
Orange County	
Blooming Grove	46
Chester	36
Cornwall	8
Goshen	76
Hamptonburg	55
Monroe	10
Montgomery	99
Newburgh	18
New Windsor	39
Tuxedo	2
Warwick	125
Woodbury	2
Dutchess County	
Wappinger	12
Fishkill	3
East Fishkill	25

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Table 5

CENSUS

Civil Subdivision	Population	Civil Subdivision	Population
Westchester County		Putnam County	
Bedford (T)	15,867	Carmel (T)	13,892
Mt. Kisco (V) pt	2,607	Kent (T)	4,961
Cortland (T)	31,340	Patterson (T)	3,434
Buchanan (V)	2,168	Philipstown (T)	6,835
Croton-on-Hudson (V)	6,941	Cold Springs (V)	2,014
Greenburgh (T)	82,882	Putnam Valley (T)	4,286
Ardsley (V)	4,486	Southeast (T)	8,403
Dobbs Ferry (V)	10,076	Brewster (V)	1,574
Elmsford (V)	4,031	Nelsonville (V)	2,014
Hastings-on-Hudson (V)	9,777		
Irvington (V)	5,686	Rockland County	
Tarrytown (V)	11,280	Clarkstown (T)	51,549
Harrison (T)	20,433	Upper Nyack (V)	2,037
Lewisboro (T)	5,123	Haverstraw (T)	20,325
Mt. Pleasant (T)	37,220	Haverstraw (V)	7,263
Briarcliff Manor (V) pt	603	W. Haverstraw (V)	6,743
No. Tarrytown (V)	8,600	Orangetown (T)	49,624
Pleasantville (V)	6,361	Nyack (V) pt	5,403
Mt. Vernon (C)	72,918	Piermont (V)	1,804
New Castle (T)	16,351	So. Nyack (V)	3,382
Mt. Kisco (V) pt	4,334	Ramapo (T)	58,254
North Castle (T)	7,738	Hillburn (V)	1,011
North Salem (T)	2,924	Sloatsburg (V)	2,805
Ossining (T)	31,455	Sp. Valley (V)	12,854
Briarcliff Manor (V) pt	6,185	Suffern (V)	6,117
Ossining (V)	21,241	Stony Point (T)	11,409**
Peekskill (C)	18,504		
Pound Ridge (T)	2,962	Orange County	
Scarsdale (T&V)	18,345	Blooming Grove (T)	6,380**
Somers (T)	6,655	Chester (T)	3,984**
White Plains (C)	50,040	Cornwall (T)	9,037**
Yonkers (C)	201,573	Goshen (T)	7,202**
Yorktown (T)	22,044	Hamptonburgh (T)	1,857**
		Highlands (T)	12,270***
Dutchess County		Monroe (T)	6,916**
Beacon (C)	14,382*	Newburgh (C)	30,620***
East Fishkill (T)	7,696	New Windsor (T)	18,000**
Fishkill (T)	9,518	Tuxedo (T)	2,694***
Fishkill (V)	997	Warwick (T)	14,176**
Wappinger (T)	12,036	Woodbury (T)	3,158**
Wappingers Falls (V)	4,816		

* - Population estimate 1965
** - Preliminary Figures 1966 Census.

*** - Population Estimate 1966

Post Operational Sample Data - 1965

Consolidated Edison's Indian Point Reactor
Buchanan Village, Westchester County
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AIR RESULTS

Station And Type	Period Ending	Gross Beta (pc/M^3)
Peekskill (Continuous Weekly)	1/7	< 1.0
	1/14	< 1.0
	1/21	< 1.0
	1/28	< 1.0
	2/4	< 1.0
	2/18	< 1.0
	2/25	< 1.0
	3/4	< 1.0
	3/11	< 1.0
	3/18	< 1.0
	3/25	< 1.0
	4/1	< 1.0
	4/8	1.0
	4/15	< 1.0
	4/22	< 1.0
	4/29	< 1.0
	5/6	< 1.0
	5/13	< 1.0
	5/20	< 1.0
	5/27	No Result
	6/3	1.0
	6/10	1.0
	6/17	1.0
	6/24	1.0
	7/1	1.0
	7/8	1.0
	7/15	< 1.0
	7/22	< 1.0
	7/29	< 1.0
	8/5	No Result
	8/12	< 1.0
	8/19	< 1.0
	8/26	< 1.0
	9/2	< 1.0
	9/9	< 1.0
	9/23	< 1.0
	9/30	< 1.0
	10/7	< 1.0
	10/14	< 1.0
	10/21	< 1.0
	10/28	< 1.0
	11/4	< 1.0
	11/12	< 1.0
	11/18	< 1.0
	11/24	< 1.0
	12/2	< 1.0
	12/9	< 1.0
	12/16	< 1.0
	12/23	< 1.0
	12/31	< 1.0

FALLOUT SAMPLES

Station	Period Ending	Sr-89 (pc/ft^2/day)	Sr-90
Peekskill (Continuous Weekly)	1/7	< 3.0	4.0
	1/14	< 3.0	< 3.0
	1/21	< 3.0	< 3.0
	1/28	< 3.0	< 3.0
	2/4	< 3.0	< 3.0
	2/11	< 3.0	11.0
	2/18	< 3.0	< 3.0
	2/25	< 3.0	< 3.0
	3/4	< 3.0	< 3.0
	3/11	< 3.0	< 3.0
	3/18	< 3.0	< 3.0
	3/25	< 3.0	< 3.0
	4/1	< 3.0	< 3.0
	4/8	< 3.0	< 3.0
	4/15	< 3.0	< 3.0
	4/22	< 3.0	4.0
	4/29	< 3.0	< 3.0
	5/6	< 3.0	< 3.0
	5/13	5.0	< 3.0
	5/20	< 3.0	< 3.0
	5/27	< 3.0	< 3.0
	6/3	< 3.0	5.0
	6/10	4.0	< 3.0
	6/17	< 3.0	6.0
	6/24	5.0	< 3.0
	7/1	< 3.0	< 3.0
	7/8	No Result	No Result
	7/15	< 3.0	< 3.0
	7/22	< 3.0	4.0
	7/29	No Result	NoResult
	8/5	< 3.0	< 3.0
	8/12	< 3.0	8.0
	8/19	No Result	NoResult
	8/26	No Result	NoResult
	9/2	No Result	NoResult
	9/9	< 3.0	< 3.0
	9/16	< 3.0	< 3.0
	9/23	< 3.0	< 3.0
	9/30	< 3.0	< 3.0
	10/7	< 3.0	< 3.0
	10/14	< 3.0	< 3.0
	10/21	< 3.0	< 3.0
	10/28	< 3.0	< 3.0
	11/4	< 3.0	< 3.0
	11/18	< 3.0	< 3.0
	11/24	< 3.0	4.0
	12/2	< 3.0	< 3.0
	12/9	< 3.0	< 3.0
	12/16	< 3.0	< 3.0
	12/23	< 3.0	< 3.0

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Table 7

WATER SAMPLES

Station	Period Ending	Gross Beta (pc/l)
Highland Falls (Grab)	1/19	3.0
	2/15	3.0
	3/16	3.0
	4/21	3.0
	5/19	2.0
	6/15	4.0
	7/20	8.0
	8/17	3.0
	9/14	4.0
	10/19	4.0
	11/16	3.0
	12/13	3.0
Clarkstown (Grab)	2/2	12.0
	3/22	6.0
	4/15	7.0
	6/1	13.0
	8/6	16.0
	12/10	6.0
Peekskill (Camp Field Filter Plant) (Grab)	1/18	4.0
	2/15	12.0
	3.15	3.0
	4/16	5.0
	5/17	4.0
	6/16	4.0
	7/15	3.0
	8/17	7.0
	9/15	13.0
	10/13	2.0
	11/15	-
	12/15	22.0
Peekskill (Standard Brands) (weekly composite of continuous drip)	1/7	33.0
	1/14	30.0
	1/21	34.0
	1/28	31.0
	2/4	29.0
	2/11	34.0
	2/18	10.0
	2/25	9.0
	3/4	18.0
	3/11	11.0
	3/18	2.0
	3/25	7.0
	4/1	23.0
	4/8	30.0
	4/15	16.0
	4/22	8.0

Consolidated Idison's Indian Point Reactor
Buchanan Village, Westchester County
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Table 7

WATER SAMPLES Cont.

Station	Period Ending	Gross Beta (pc/l)
Peekskill Cont.	5/6	7.0
	5/20	5.0
	5/27	10.0
	6/3	15.0
	6/10	18.0
	6/17	-
	6/24	29.0
	7/1	38.0
	7/8	42.0
	7/15	36.0
	7/22	30.0
	7/29	32.0
	8/5	53.0
	8/12	34.0
	8/19	39.0
	8/26	30.0
	9/2	36.0
	9/9	39.0
	9/16	84.0
	9/23	44.0
	9/30	41.0
	10/7	27.0
	10/14	28.0
	10/21	45.0
	10/28	14.0
	11/4	-
	11/12	24.0
	11/18	-
	11/25	1.0
	12/2	-
	12/9	10.0
	12/16	36.0
	12/31	32.0
Ossining (Sing Sing) (weekly composite of daily grab)	1/7	15.0
	1/14	40.0
	1/21	40.0
	1/28	34.0
	2/4	50.0
	2/11	36.0
	2/18	9.0
	2/25	13.0
	3/4	35.0
	3/11	28.0
	3/18	10.0
	3/25	14.0
	4/1	30.0
	4/8	46.0
	4/15	33.0
	4/22	17.0
	4/29	14.0
	5/6	15.0

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Buchanan Village, Westchester County
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Table 7

WATER SAMPLES Cont.

Station	Period Ending	Gross Beta (pc/l)
Ossining Cont.	5/13	14.0
	5/20	14.0
	5/27	13.0
	6/3	23.0
	6/10	43.0
	6/17	51.0
	6/24	37.0
	7/1	49.0
	7/8	62.0
	7/15	42.0
	7/22	48.0
	7/29	61.0
	8/5	39.0
	8/12	56.0
	8/19	54.0
	8/26	54.0
	9/2	27.0
	9/9	59.0
	9/16	55.0
	9/23	62.0
	9/30	56.0
	10/7	43.0
	10/14	54.0
	10/21	34.0
	10/28	28.0
	11/4	32.0
	11/12	-
	11/18	-
	11/24	-
	12/2	17.0
	12/9	13.0
	12/16	19.0
	12/23	13.0
Ossining (Indian Brook Reservoir) (Grab)	1/18	8.0
	2/10	9.0
	3/15	8.0
	4/13	7.0
	5/17	4.0
	6/16	8.0
	7/15	6.0
	8/17	8.0
	10/13	6.0
	11/15	6.0
	12/15	6.0

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Table 7

WATER SAMPLES Cont.

Station	Period Ending	Gross Beta (pc/l)
Bedford (Byram Lake) (Grab)	1/18	6.0
	2/16	6.0
	3/15	8.0
	4/16	12.0
	5/17	4.0
	6/16	10.0
	7/15	7.0
	8/17	6.0
	9/16	7.0
	10/13	7.0
	11/18	10.0
	12/15	9.0
Yorktown (Croton Reservoir) (Grab)	1/18	6.0
	2/10	3.0
	3/15	2.0
	4/13	4.0
	5/17	2.0
	6/16	7.0
	7/15	6.0
	8/17	5.0
	9/16	4.0
	10/13	3.0
	11/15	2.0
	12/15	3.0

Consolidated Edison's Indian Point Reactor
Buchanan Village, Westchester County
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Table 8

MILK SAMPLES

Station	Period Ending	Results (pc/l)				
		I-131	Sr-90	Sr-89	Ba-La-140	Cs-137
Clarkstown	1/12	< 20	14.0	< 3.0	15.6	39.0
(Grab)	2/16	24.9	10.0	< 3.0	37.7	36.0
	4/26	< 20	-	-	43.6	57.3
	5/11	< 20	8.0	< 3.0	< 20	53.7
	6/7	< 20	6.0	< 3.0	< 20	43.0
	8/5	< 20	6.0	< 3.0	< 20	23.7
	10/6	< 20	11.0	< 3.0	< 20	< 20
	12/2	-	9.0	< 3.0	-	-
Bedford	1/18	< 20	17.0	< 3.0	< 20	64.8
(Grab)	2/10	< 20	14.0	< 3.0	32.7	45.6
	3/15	< 20	19.0	< 3.0	< 20	51.3
	5/17	31.6	28.0	3.0	< 20	41.7
	6/17	30.2	30.0	7.0	< 20	46.4
	7/15	< 20	22.0	9.0	< 20	50.9
	8/17	< 20	21.0	< 3.0	< 20	49.7
	9/15	< 20	19.0	< 3.0	< 20	28.5
	10/13	< 20	27.0	< 3.0	< 20	26.3
	11/15	< 20	14.0	< 3.0	< 20	38.9
	12/15	< 20	11.0	< 3.0	< 20	26.5
Mt. Pleasant	1/18	< 20	16.0	< 3.0	< 20	61.7
(Grab)	2/10	< 20	10.0	3.0	< 20	53.2
	3/15	< 20	13.0	< 3.0	< 20	49.8
	4/13	< 20	11.0	< 3.0	59.7	64.9
	5/17	< 20	11.0	< 3.0	< 20	46.1
	6/16	< 20	13.0	< 3.0	< 20	38.8
	7/15	< 20	12.0	< 3.0	< 20	35.3
	8/17	< 20	10.0	< 3.0	< 20	34.8
	9/15	< 20	7.0	< 3.0	< 20	28.7
	10/13	< 20	-	-	< 20	25.5
	11/15	< 20	10.0	< 3.0	< 20	26.9
	12/15	< 20	7.0	< 3.0	< 20	27.1
Yorktown	1/18	< 20	17.0	< 3.0	< 20	46.4
(Grab)	2/10	< 20	21.0	< 3.0	< 20	46.2
	3/15	< 20	18.0	< 3.0	< 20	58.0
	4/16	< 20	23.0	< 3.0	21.0	70.1
	5/17	< 20	21.0	< 3.0	< 20	63.7
	6/14	< 20	18.0	5.0	< 20	48.0
	7/15	< 20	26.0	< 3.0	< 20	52.0
	8/17	< 20	16.0	< 3.0	< 20	49.9
	9/15	< 20	< 3.0	18.0	< 20	38.0
	10/13	< 20	18.0	< 3.0	< 20	53.9
	11/15	< 20	9.0	< 3.0	< 20	31.0
	12/15	< 20	19.0	< 3.0	< 20	40.5

*Minimum Sensitivity = 20 pc/l

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Buchanan Village, Westchester County

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Table 9

Station	Collection Date	Results (pc/kg) Cs-137	Mn-54	Zr-Nb-95
	ALGAE			
Greens Cove	5/19	55	106	< 20
Iona Island	5/18	201	647	167
Tappan Zee	5/18	132	660	< 20
Croton Bay	5/19	57	701	87
	FISH			
Greens Cove	5/19	92	< 20	< 20
Peekskill Bay	5/18	45	< 20	< 20
Croton Bay	5/19	56	27	< 20
Tappan Zee	5/18	43	< 20	< 20
Iona Island	5/18	59	32	< 20
Croton Bay	9/15	36	< 20	< 20
Iona Island	9/14	56	< 20	< 20
Peekskill Bay	9/14	62	< 20	< 20
	VEGETATION			
Byram Lake	5/17	62	57	< 20
	6/16	< 20	< 20	366
	7/15	< 20	< 20	99
	8/17	< 20	< 20	< 20
Dreyfus Reservoir	6/1	< 20	483	< 20
	8/6	380	328	217
	9/16	< 20	387	< 20
	12/10	-	-	-
Tappan Zee	9/14	< 20	-	-
Letchworth Reservoir	6/1	-	-	< 20
	8/6	382	356	< 20
	12/10	-	-	-
Indian Brook Reservoir	5/17	127	130	< 20
	6/16	67	45	125
	7/15	69	59	113
	8/17	50	< 20	< 20
	9/12	59	< 20	< 20
	10/13	101	65	< 20
Camp Field Filter Plant	5/17	66	42	< 20
	6/16	< 20	108	406
	7/15	77	< 20	289
	8/17	52	< 20	< 20
	9/15	< 20	< 20	< 20
	10/13	< 20	67	< 20
Croton Reservoir	5/17	142	213	< 20
	6/16	< 20	< 20	367
	7/15	110	179	359
	9/16	< 20	38	< 20
	10/13	79	113	< 20
	MUD	Gross Gamma (pc/kg)		
Greens Cove	5/19		3522	
Peekskill Bay	5/19		3879	
Iona Island	5/18		2589	
Croton Bay	5/18		4000	
Tappan Zee	5/18		4662	
Hudson River opp. Con. Ed.	5/18		3695	

*Note MPC values for drinking water are: Cs-137 - 20,000 pc/l Zr-95 - 60,000 pc/l
Mn-54 -100,000 pc/l Sr-90 - 100 pc/l

Consolidated Edison's Indian Point Reactor

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Table 10

Station	Date	Cosmic Portion (mr/hr)	Total (μr/hr)
1	10/14	3.4	9.6
2	10/14	3.4	9.9
3	10/13	3.4	9.8
4	10/13	3.4	10.3
5	10/13	3.4	9.9
6	10/14	3.4	10.1
7	10/14	3.4	8.9
8	10/14	3.4	10.4
9	10/13	3.4	10.2
10	10/13	3.4	10.0
11	10/13	3.4	9.9
12	10/14	3.4	11.1
13	10/14	3.4	9.7
14	10/14	3.5	9.1
15	10/13	3.7	11.0
16	10/14	3.4	9.9
17	10/14	3.5	10.1
18	10/14	3.4	10.4
19	10/14	3.5	9.1

Table 11

Consolidated Edison's Indian Point Reactor
Buchanan Village, Westchester County
1965

Summary Of Environmental Discharges From The Indian Point Reactor

Year	Total Activity Released		Volume Of Water Or Air Needed For Dilution	
	Water*(curies)	Air(curies)	Water(2×10^{-6} μc/ml (gal/yr)	Air(3×10^{-10} μc/ml)(ft^3/yr)
1962	0.131	None	1.72×10^7	None
1963	0.164	0.0072	2.17×10^7	8.46×10^8
1964	11.03	13.180	1.46×10^9	1.6×10^{12}
1965	26.31	33.048	3.48×10^9	3.9×10^{12}

*Exclusive of Tritium.

The total amount of Tritium released to the Hudson River in 1965 = 455.4 curies or 7.6×10^{-7} μc/ml based upon normal rate of cooling water discharge or 1.59×10^{11} gal/yr.

The maximum permissible concentration (MPC) for Tritium as given in 10 CFR 20 = 3×10^{-3} μc/ml.

Normal rate of cooling water flow is 435,000,000 gallons per day (1.59×10^{11} gal/yr) into the Hudson River.

Normal atmospheric discharge from plant stack is 300,000 cubic feet per minute (1.6×10^{11} ft^3/yr). A two year site survey of meteorological conditions by New York University indicates a further dilution factor of 3,000.

Explanation of Symbols and Abbreviations

c = curie = 3.7×10^{10} disintegrations per second.

pc = picocurie = 1×10^{-12} curie = 2.22 disintegrations per minute.

uc or μc = microcurie = 1×10^{-6} curie.

M^3 = cubic meter = 35.31 cubic feet.

l = liter = 1.06 quarts.

ml = milliliter = 1×10^{-3} liter.

g = gram.

kg = kilogram = 1×10^3 grams.

< = less than.

AC = Activated Carbon.

Ammon = Ammoniation.

Cl_2 = Chlorination.

Coag = Coagulation.

CC = Corrosion Control.

de Cl_2 = De-chlorination.

Diam E = Diatomaceous Earth Filtration.

F = Fluoridation.

Nat Filt = Natural Filtration.

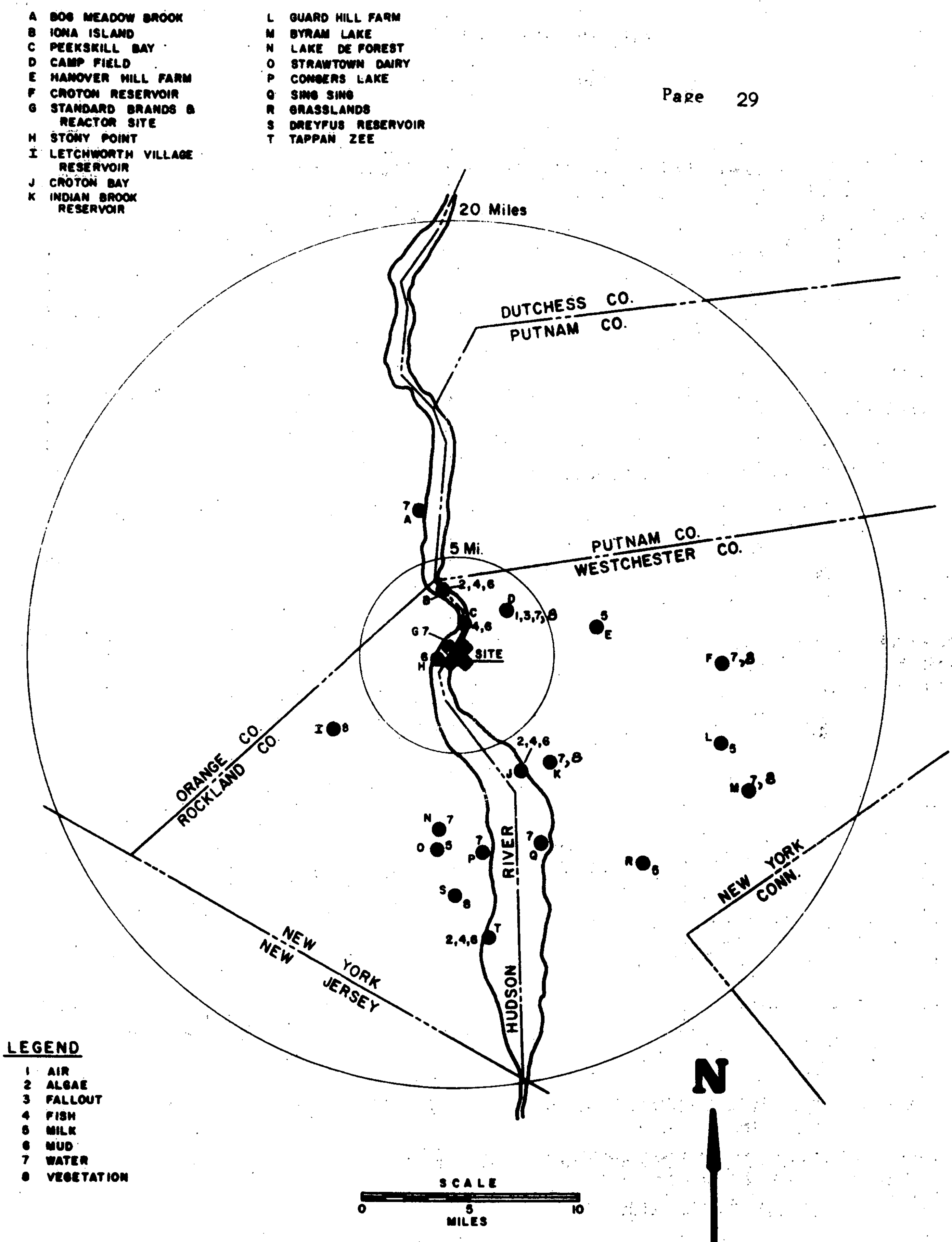
P & P Cl_2 = Pre & Post Chlorination.

PSF = Pressure Sand Filtration.

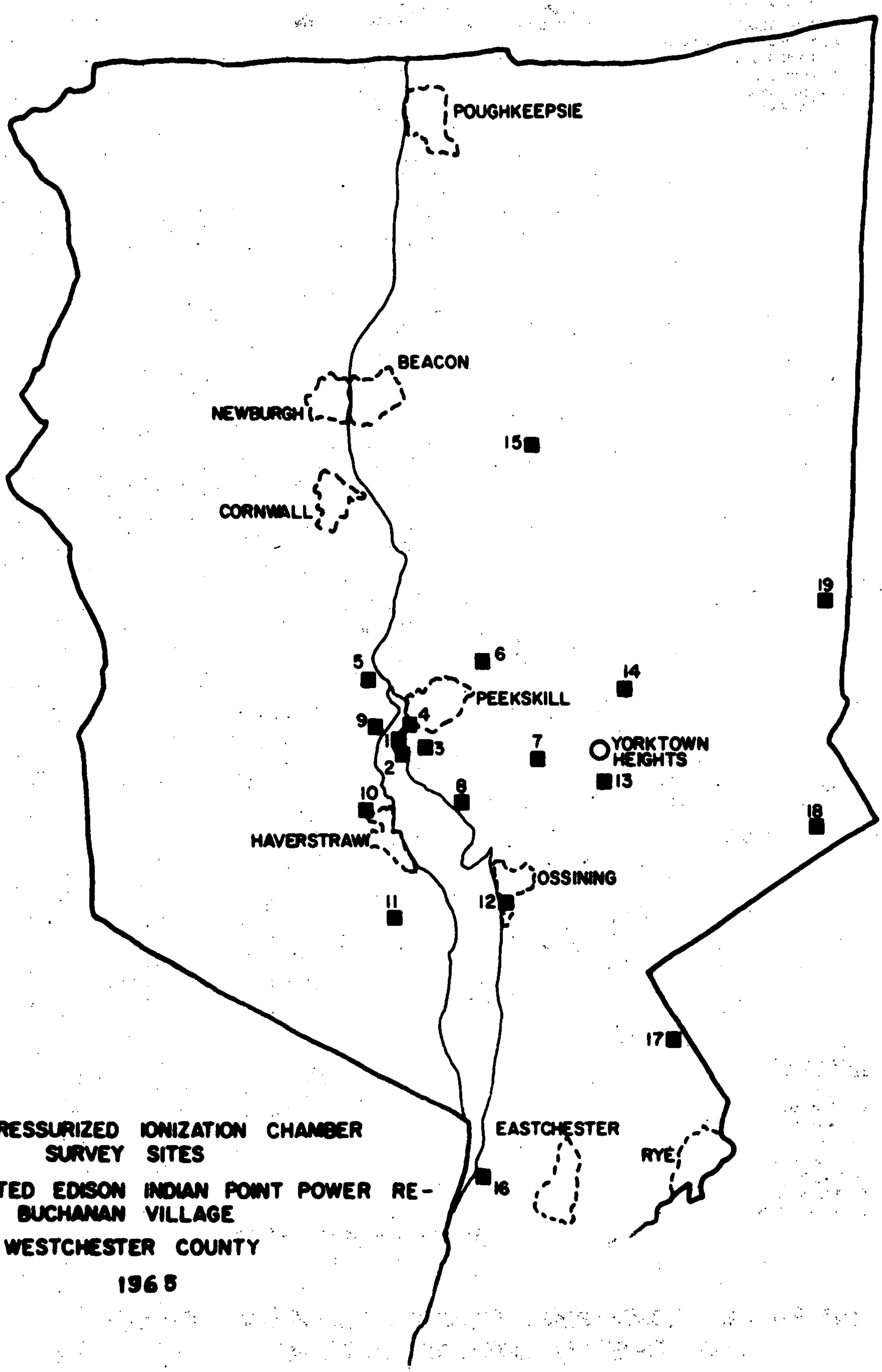
RSF = Rapid Sand Filtration.

SSF = Slow Sand Filtration.

Soft = Softening.



CON EDISON INDIAN POINT REACTOR RADIATION SURVEY
LOCATIONS OF SAMPLING STATIONS



RSG-9 PRESSURIZED IONIZATION CHAMBER SURVEY SITES

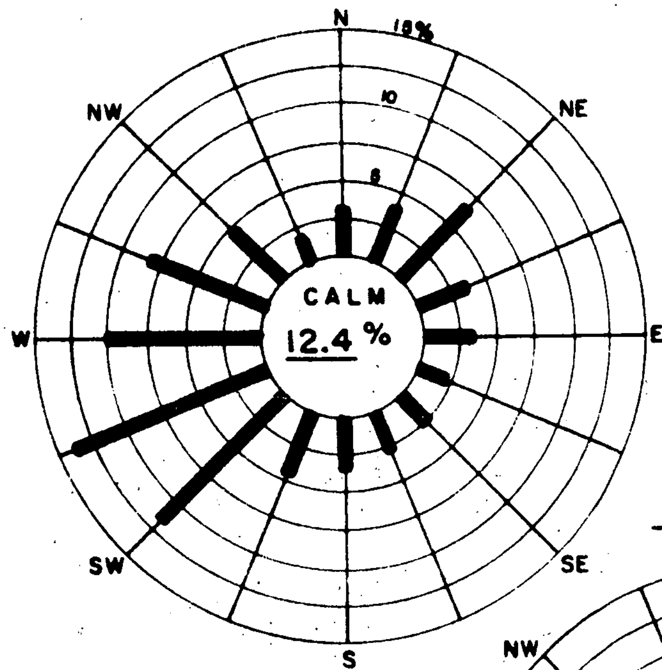
CONSOLIDATED EDISON INDIAN POINT POWER RE-ACTOR - BUCHANAN VILLAGE

WESTCHESTER COUNTY

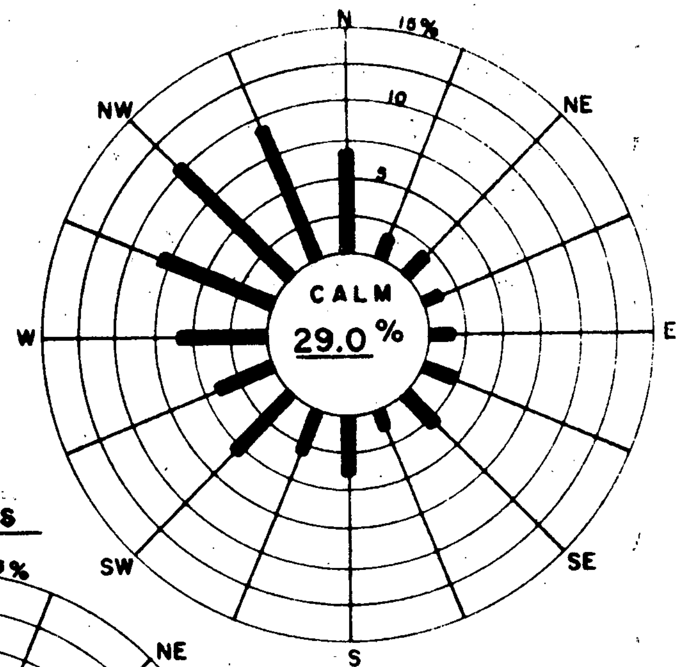
1965

WIND ROSES

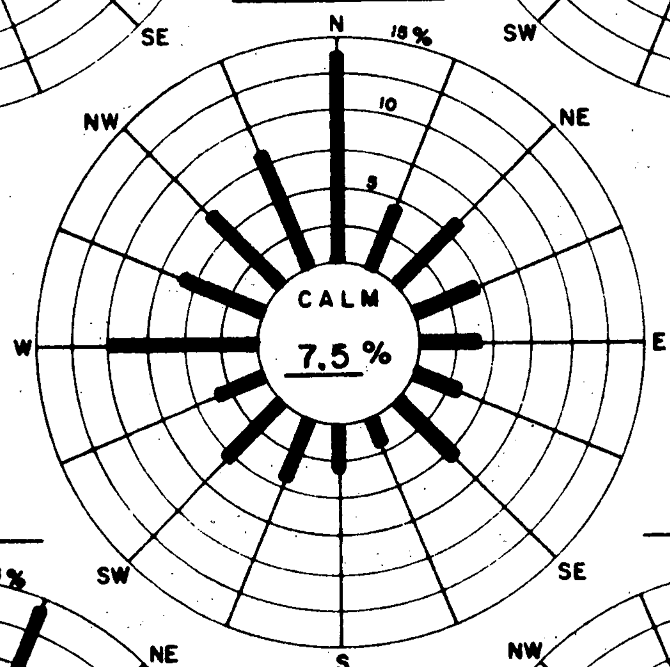
Stewart AFB



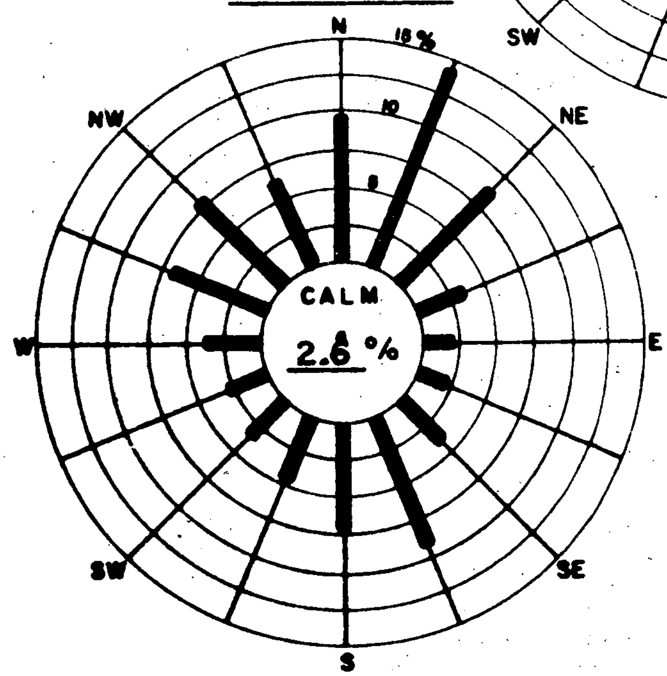
West. Co. Airport



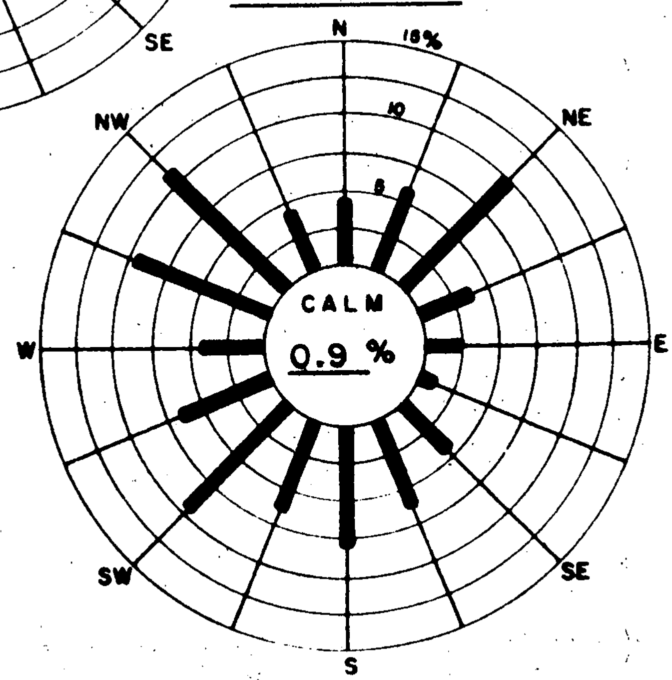
Grasslands



Buchanan



La Guardia



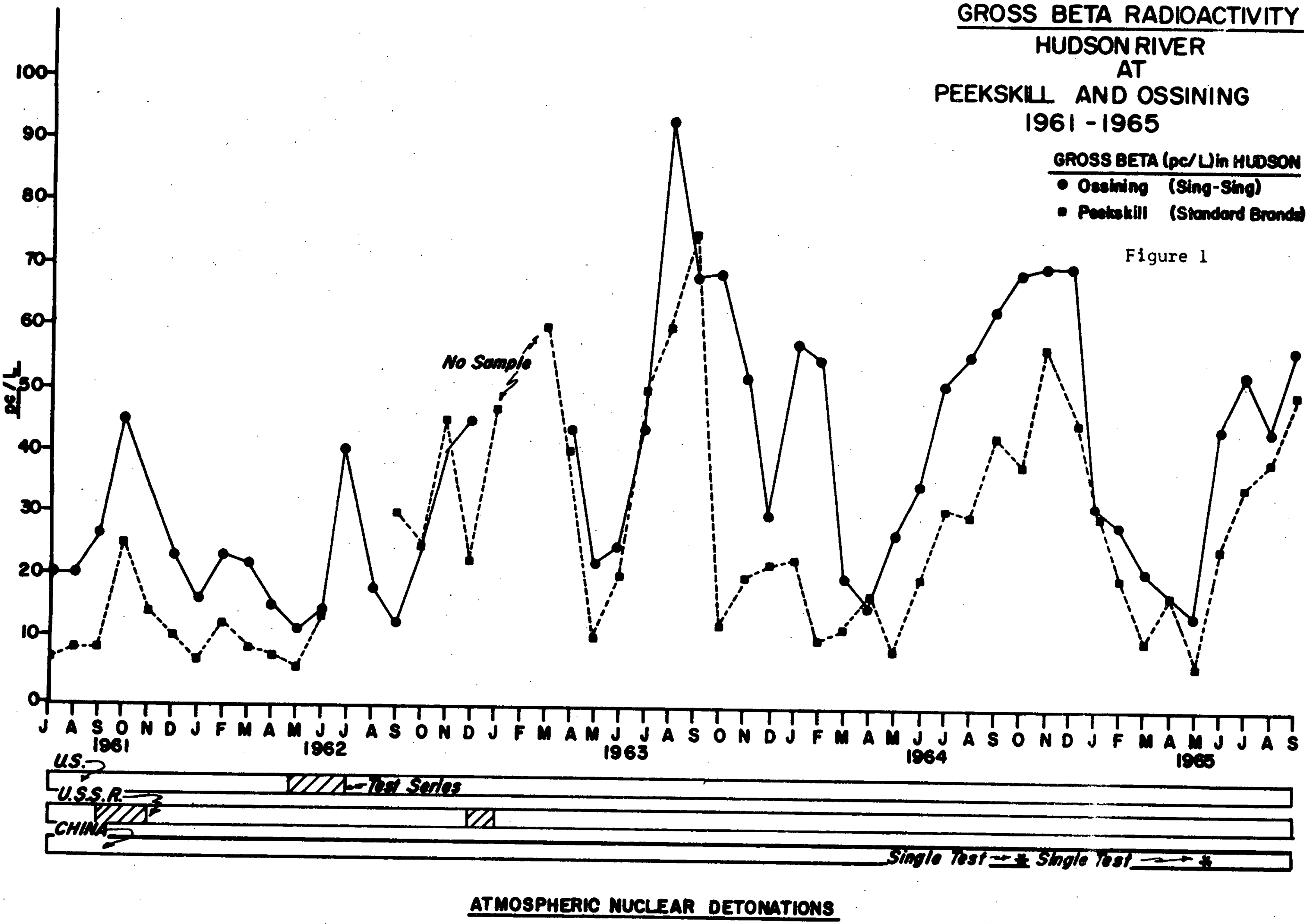
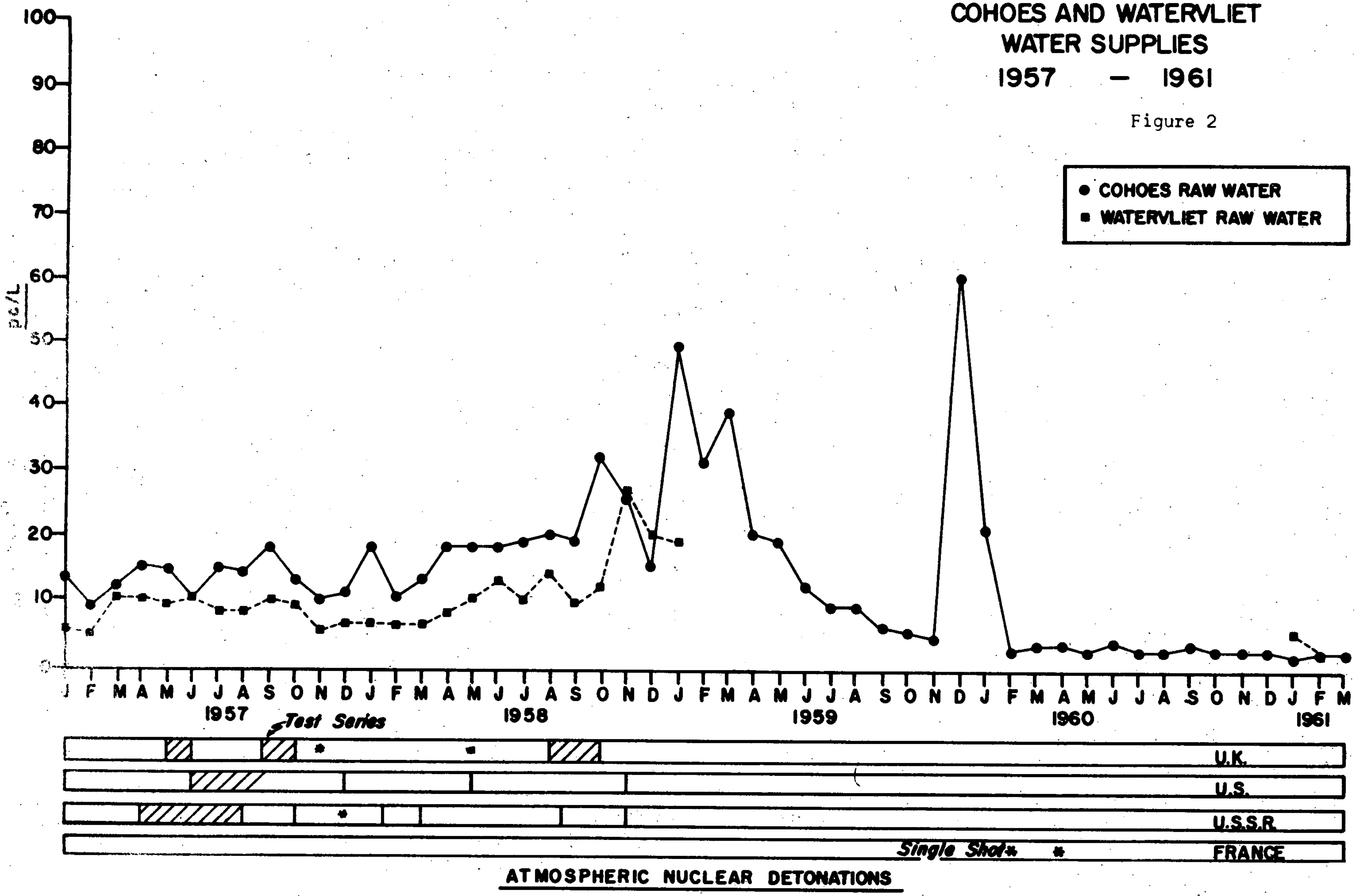

GROSS BETA RADIOACTIVITY
HUDSON RIVER
AT
PEEKSKILL AND OSSINING
1961 - 1965
GROSS BETA (pc/L) in HUDSON
Ossining (Sing-Sing)
Peekskill (Standard Brands)
No Sample
pc/L
100
90
80
70
60
50
40
30
20
10
0
J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
1961
1962
1963
1964
1965
U.S.
Test Series
U.S.S.R.
CHINA
Single Test
Single Test
ATMOSPHERIC NUCLEAR DETONATIONS

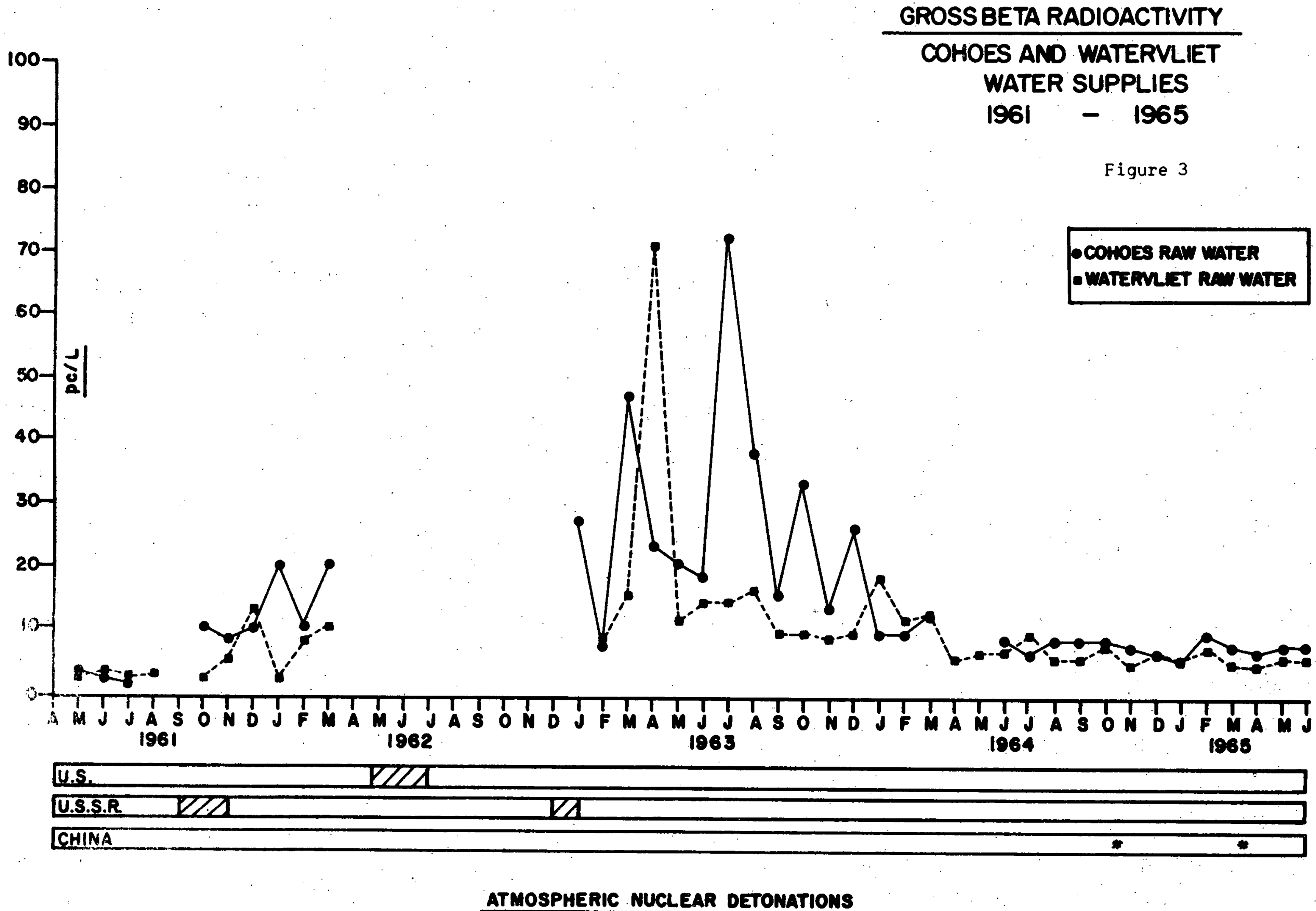
Figure 1

GROSS BETA RADIOACTIVITY

COHOES AND WATERVLIET WATER SUPPLIES 1957 — 1961

Figure 2



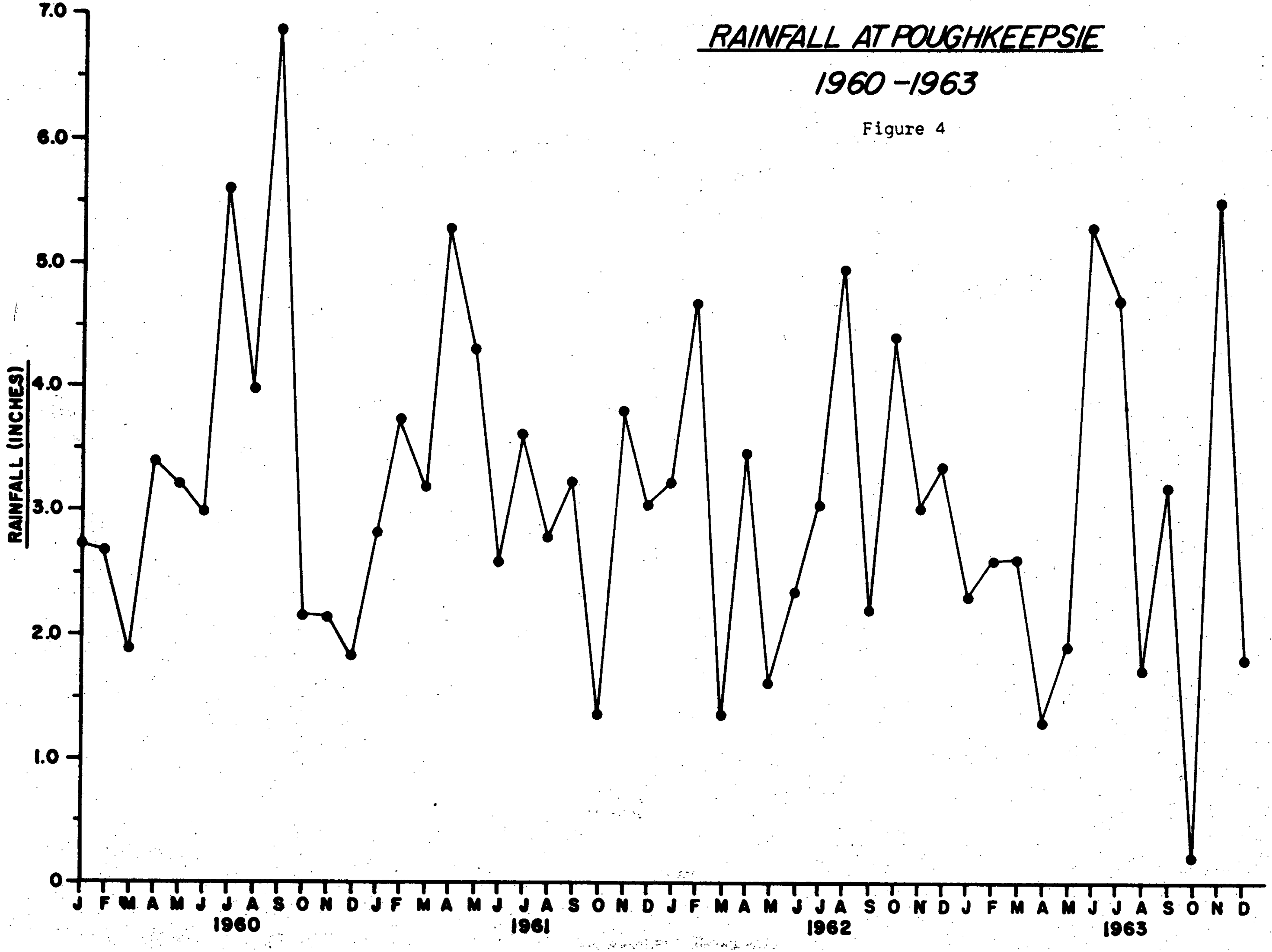


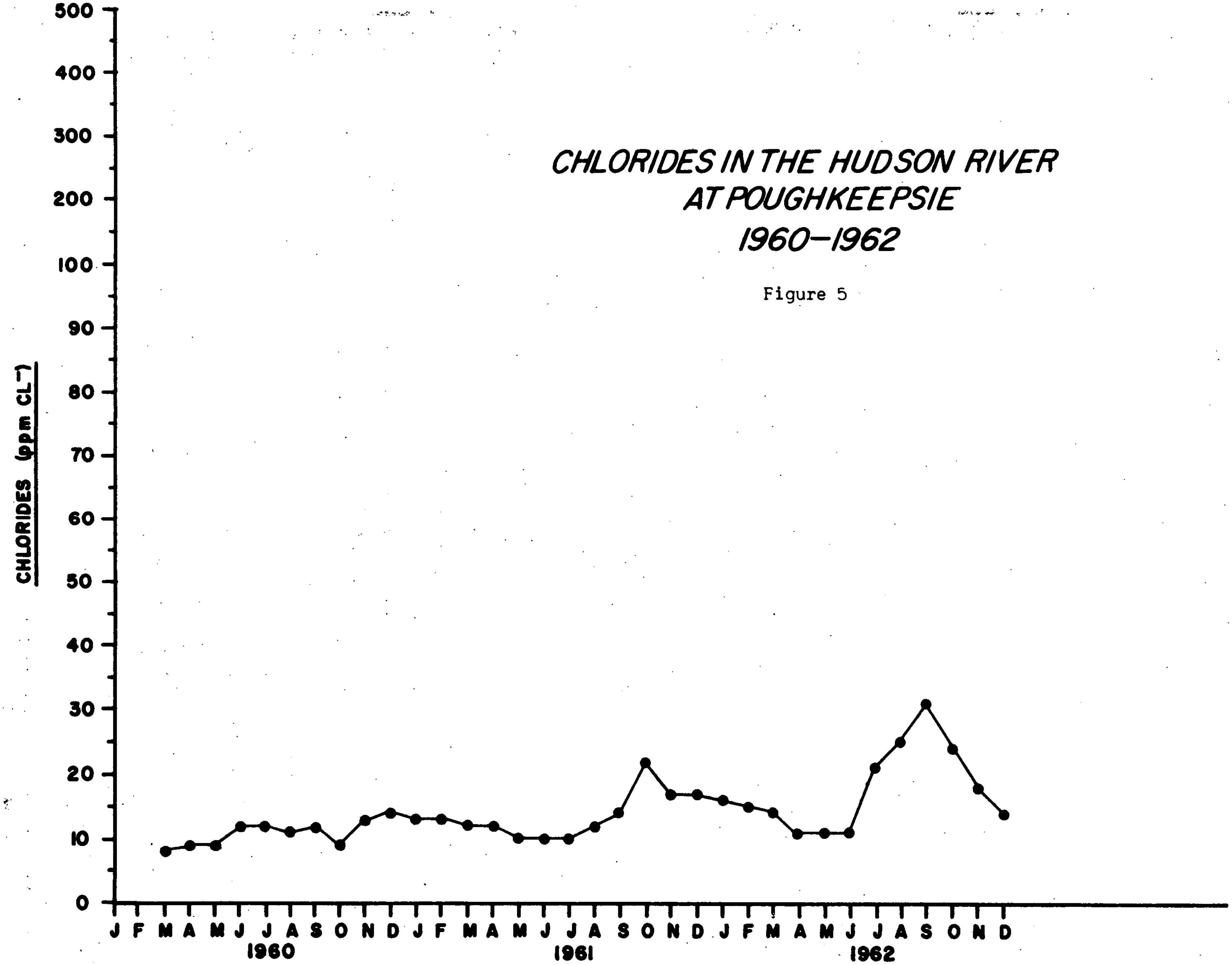
GROSS BETA RADIOACTIVITY
COHOES AND WATERVLIET
WATER SUPPLIES
1961 - 1965
COHOES RAW WATER
WATERVLIET RAW WATER
pc/L
100
90
80
70
60
50
40
30
20
10
0
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J
1961
1962
1963
1964
1965
U.S.
U.S.S.R.
CHINA
ATMOSPHERIC NUCLEAR DETONATIONS

Figure 3

RAINFALL AT POUGHKEEPSIE
1960 – 1963

Figure 4





CHLORIDES IN THE HUDSON RIVER
AT POUGHKEEPSIE
1960–1962
CHLORIDES (ppm CL⁻)
500
400
300
200
100
90
80
70
60
50
40
30
20
10
0
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1960
1961
1962

Figure 5

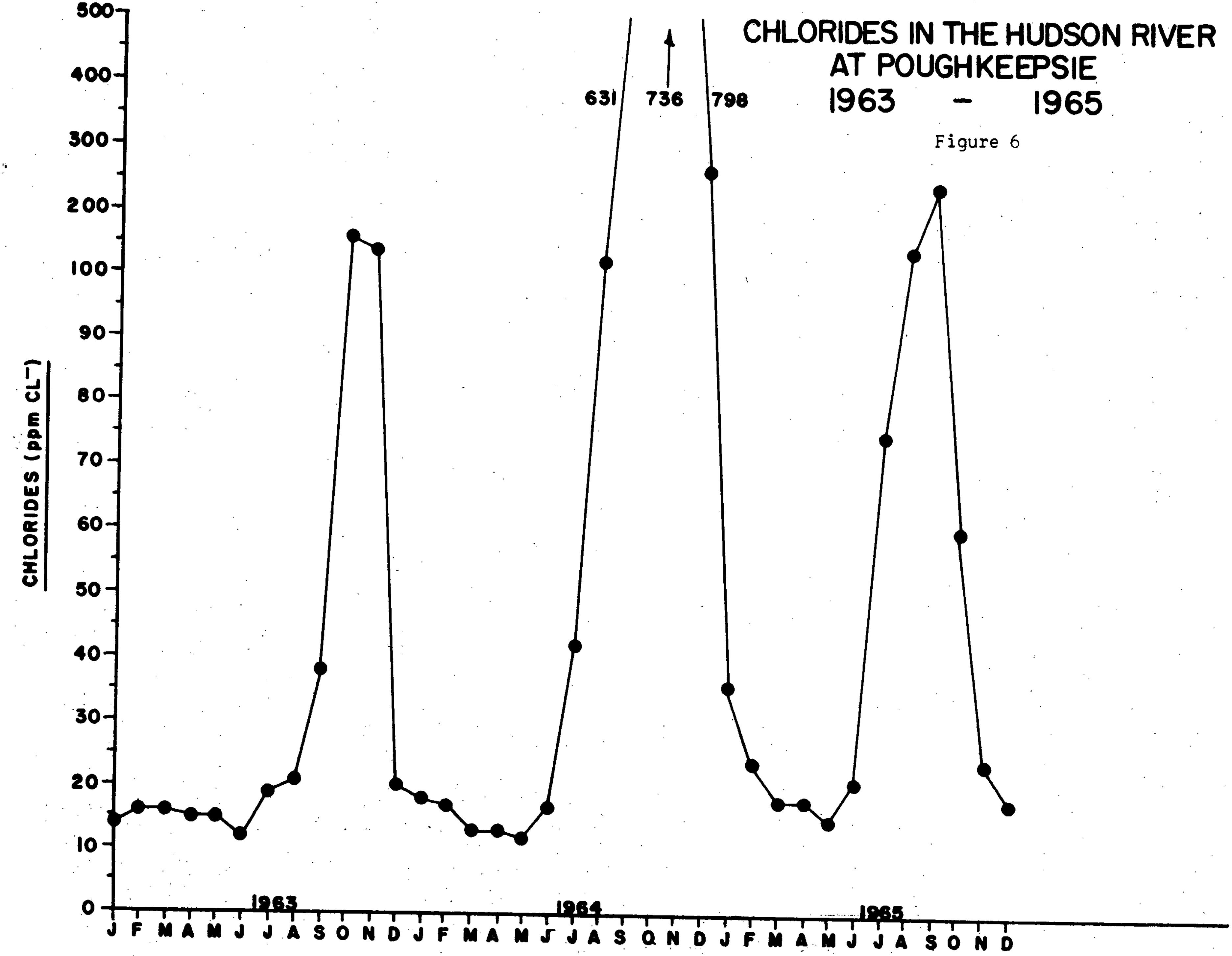

CHLORIDES IN THE HUDSON RIVER AT POUGHKEEPSIE 1963 - 1965
CHLORIDES (ppm CL⁻)
500
400
300
200
100
90
80
70
60
50
40
30
20
10
0
631
736
798
1963
1964
1965
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D

Figure 6

3.9 EFFLUENT RELEASE

Applicability

Applies to the release of radioactive liquids and gases from the plant.

Objective

To define the conditions for release of radioactive wastes to the circulating water discharge and to the plant vent to assure that any radioactive material released is kept as low as practicable and, in any event within the limits of 10CFR20.

Specification

A. General

1. It is expected that releases of radioactive material in effluents will be kept at small fractions of the limits specified in 20.106 of 10CFR20. At the same time the licensee is permitted the flexibility of operation, compatible with considerations of health and safety, to assure that the Public is provided a dependable source of power even under unusual operating conditions which may temporarily result in releases higher than such small fractions, but still within limits specified in 20.106 of 10CFR20. It is expected that in using this operational flexibility under unusual operating conditions the licensee will exert his best efforts to keep levels of radioactive material in effluents as low as practicable.

2. Plant equipment shall be used in conjuction with developed operating procedures to maintain surveillance of radioactive gaseous and liquid effluents produced during normal reactor operations and expected operational occurences in an effort to maintain radioactive releases to unrestricted areas as low as practicable.

3. A report shall be submitted to the Commission at the end of each six-months' period of operation as required under Specification

6.6.4. If quantities of radioactive material released during the reporting period are unusual for normal reactor operations, including expected operational occurences, the report shall cover this specifically. On the basis of such reports and any additional information the Commission may obtain from the licensee or others, the Commission may from time to time require the licensee to take such action as the Commission deems appropriate.

B. Liquid Effluents

1. The maximum instantaneous release rate of radioactive liquid effluents from the site shall be such that the concentration of radionuclides in the circulating water discharge does not exceed the limits specified in 10CFR20, Appendix B, for unrestricted areas.

2. Prior to release of radioactive effluents, a sample shall be taken, and analyzed to provide the data necessary to assure compliance with B.(1) above.

3. During release of radioactive liquid effluents, at least one condenser circulating water pump shall be in operation.

4. During release of radioactive liquid effluents, the gross activity liquid discharge monitor shall be in operation, except that the monitor may be out-of-service for 48 hours, provided that a sample shall be taken during release of each batch of discharge line effluent and analyzed.

C. Gaseous Effluents

1. The maximum instantaneous release rate of gaseous effluents for the site shall be limited as follows:

$$\left(\frac{X}{Q}\right)_1 \sum_i \frac{Q_{1i}}{(MPC)_i} + \left(\frac{X}{Q}\right)_2 \sum_i \frac{Q_{2i}}{(MPC)_i} \leq 1.0$$

where:

i refers to any radioisotope

Q_{1i} is the release rate (Ci/sec) of any radioisotope i from Unit No. 1

Q_{2i} is the release rate (Ci/sec) of any radioisotope i from Unit No. 2

$(MPC)_i$ in units of μCi/cc as listed in Column 1, Table II of Appendix B 10CFR20, except that for isotopes of iodine and particulates with half lives greater than 8 days, the values of $(MPC)_i$ shall be reduced by a factor of 700.

$(\frac{X}{Q})_1$ and $(\frac{X}{Q})_2$ are the meterological dispersion coefficients (Sec/m^3) for Units No. 1 and No. 2 respectively at the site releasing the effluent from the plant vent, air ejector discharge, and blowdown tank vent when applicable.

$$(\frac{X}{Q})_1 = 5.88 \times 10^{-7} \ sec/m^3$$

$$(\frac{X}{Q})_2 = 2.5 \times 10^{-5} \ sec/m^3$$

2. Prior to release of gaseous effluents, the contents of the gas holdup tank shall be sampled and analyzed to provide the necessary data to assure compliance with Specification 3.9.C.1 above.

3. During release of gaseous effluent to the plant vent, the following conditions shall be met:

   a. At least one auxiliary building exhaust fan shall be in operation.

   b. The plant vent monitor shall be in operation and the vent halogen particulate monitor shall be in operation except that the plant vent monitor may be out-of-service for 48 hours. Should the vent monitor fail immediate action to stop gas decay tank release will be made.

4. The inventory of noble gases in any gas tank shall not exceed 16,500 curies of equivalent Xe-133.

5. Gaseous waste in the gas decay tank shall have as a mininum 20 days of decay time except for low radioactivity gaseous waste resulting from purge and fill operations associated with refueling and reactor startup.

6. During power operation the air ejector discharge monitor may be inoperable for 48 hours. When the monitor is inoperable samples shall be taken from the air ejector discharge and analyzed for gross activity on a daily basis, except when there is indication of primary to secondary leakage the sample shall be taken and analyzed for gross activity once per shift.

7. During the first indication of primary to secondary leakage, a determination of the partition factor for the blowdown tank shall be made. Whenever there is indication of primary to secondary leakage and any steam generator is being blown down, the blowdown line monitor shall be operable, except that it may be inoperable for 48 hours provided samples shall be taken once per shift of the blowdown effluent and analyzed for gross activity.

Basis

Liquid wastes from the radioactive Waste Disposal System are diluted in the Circulating Water System discharge prior to release to the river.[1] With all six pumps operating, the rated capacity of the Circulating Water System is 840,000 gpm. Loss os one circulating water pump reduces the nominal flow rate by about 20%. The actual circulating water flow under various operating conditions will be calculated from the head differential across the pumps and the manufacturer's head-capacity curves. The concentrations in the circulating water discharge will be calculated from the measured concentration in the waste condensate tank, the flow rate of the waste condensate pumps, and the flow in the Circulating Water System.

It is expected that the Plant Operating Procedures will allow releases of radioactive material and effluents to be small fractions of the limits specified in 10CFR20 and it is expected that the actual liquid release rates will result in a concentration in the circulating water discharge of less than 1/10 MPC. Thus, discharge of liquid wastes at the specified concentrations will not result in significant exposure to members of the Public as a result of consumption of drinking water from the river, even if the effects of potable water treatment systems on reducing radioactive concentration of the water supply is neglected.

Buildup of long-lived radioisotopes in the river and reconcentration by aquatic organisms in the human food chain has also been considered. Using conservatively high estimates of reconcentration of radioisotopes in fish and of human consumption of fish, it is concluded that the release of liquid wastes may equal the 10CFR20 guidelines without causing any identificable problems. While some species of rooted vegetation, and filter feeding molluscs, concentrate some of the radioactive components of a reactor effluent in the Hudson, none of these species are used for human or animal consumption. Fish, on the other hand, while possible sources of food, do not demonstrate accumulation of the nuclides in question. For both maganese and cobalt there is a natural barrier to absorption in the gut of fish which restricts their uptake of these elements. In fact, much of the reported concentration of the radio elements may be located only in undigested gut residues rather than in the fish flesh which may be consumed. Hence, the potential contamination of diet from this source is miniscule.(4) This will be continually monitored by the environmental surveillance program (as defined in Specification 4.10). However, because of the flow in the Hudson River(2), it is not anticipated that any appreciable reconcentration will occur.

Prior to release to the atmosphere, gaseous wastes from the radioactive Waste Disposal System are mixed in the plant vent with the flow from at least one of two auxiliary building exhaust fans. Further dilution then occurs in the atmosphere.

The formula prescribed in Specification 3.9.C.1 takes into account combined releases from the site, and assures that at any point on or beyond the site boundary the requirements of 10CFR20 will be satisfied. Atmospheric dilution is taken into account with the χ/Q's for Indian Point Units No. 1 and No. 2 being based on the worst combination of sector yearly average meteorology and sector distance to the site boundary. For Indian Point Unit No. 1 alone, the value of χ/Q of 5.88×10^{-7} Sec/m^3 would result in just achieving 10CFR20 limits at the site boundary. For Indian Point Unit No. 2 alone, the value of χ/Q of 2.5×10^{-5} sec/m^3 would result in just achieving 10CFR20 limits at the site boundary. The combined formula in Specification 3.9.C.1, however, would require the release rates for any radioisotope, Q_{1i} and Q_{2i}, to be limited for consideration of joint releases being limited to 10CFR20 from the site.

Restricting the maximum inventory of noble gases in any gas or liquid tank to 16,500 curies equivalent Xe-133 (or 15% of the total maximum Reactor Coolant System inventory), will result in a total off-site exposure of less than 0.5 rem for complete release of the noble gas activity stored in the tank.(3)

References

(1) FSAR Section 10.2.4

(2) FSAR Section 2.5

(3) FSAR Section 14.2.3

(4) Development of a biological monitoring system and pesticide residues in the lower Hudson River. - M. Eisenbud and G. P. Howells - Institute of Environmental Medicine New York University Medical Center - October 10, 1969.

Fifth Annual Health Physics Society

Mid-Year Topical Symposium

Health Physics Aspects of Nuclear Facility Siting

Idaho Falls, November 1970

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ABSTRACT

As part of a large scale ecological research program, in progress since 1964, we have examined the identity, abundance, and distributions of natural, fallout, and reactor produced radionuclides in the Hudson River estuarine environment. The annual rates of introduction of the most commonly detected radionuclides have been estimated for the purpose of placing the importance of the various artificial and natural sources in perspective, and explaining the measured distributions in space and time.

Radionuclides investigated include isotopes of cesium, cobalt, and manganese. The Cs-137 content of fish is in part related to the cumulative deposition in sediments. However, cesium of recent origin appears to be more biologically available. Co-60 accumulates in estuarine sediments with limited, if any, transfer back into aquatic food chains. Mn-54 deposits by sedimentation in the fresh-water regions of the estuary, but leaches from sediments during seasonal salt water intrusions. Sedimentary build-up of Mn-54 is limited by its 303 day half-life. The maintenance of constant stable manganese concentrations by fish during periods of highly variable aqueous manganese concentrations is indicative of regulated uptake and loss of this element. Accordingly, the use of concentration factors to predict radionuclide concentrations in fish is not strictly appropriate for manganese. The finding that most radionuclides are at least partially associated with sediments further limits the applicability of the concentration factor approach, particularly for cesium.

Rooted aquatic plants concentrate all of the radionuclides measured except tritium and are useful stationary integrators of aqueous radioactivity levels.

The most important radionuclides with respect to exposure of man from reactor releases appear to be Cs-137 and Cs-134, and the critical pathway ingestion of fish. The fraction of maximum permissible intake during 1969 was less than 10^{-4}. It appears that present regulations restricting the concentrations of radionuclides in cooling water effluents are more than adequate for this aquatic environment.

INTRODUCTION

The Hudson River Estuary, a major body of water draining southwardly through New York State, has been the recipient of radioactive fallout from nuclear weapons tests and low-level discharges of radioactivity from a pressurized water nuclear power plant, Indian Point Unit 1. Measurements of the types and quantities of radionuclides from these manmade sources, together with measurements of radionuclides present naturally in the river system, have been underway since 1964. Results are used to ascertain the relative and absolute importance of the radionuclides with respect to human radiation exposure. Samples measured routinely have included water, bottom sediment, and the more abundant biological organisms.

The main region of the river selected for the study is located from HRM 30 (Hudson River mileage measured north from the Battery in New York Harbor) to HRM 50 and is centered about the Indian Point location at HRM 42 where the Indian Point Unit 1 reactor has been in operation since 1962. In addition to Indian Point Unit 1 (615 MWt), two reactors are under construction and two additional reactors are in the planning stage. The total generating capacity of all five reactors upon completion will be 12,984 MWt, only slightly less than the total of all commercial U. S. reactors presently in operation.

The Hudson River has an abundant fish population and is fished moderately by local inhabitants above the heavily polluted waters near New York City, mostly for anadromous species, during the spring and summer months. The water quality of the river has declined over the years, but substantial reductions of municipal and industrial pollutant sources will be achieved by about 1976 and should help restore the river. Such a restoration of water quality would attract many more of the 10½ million local inhabitants to the Hudson for fishing, swimming, boating, and enjoyment of the river's natural scenic beauty.

Assurance of the safe operation of future multiple nuclear facilities by adherence to release standards, and maintenance of well-designed monitoring programs serve to minimize hazards to local inhabitants and, thereby, avoid any restrictions placed on river usage from radioactive contamination.

Many of the radionuclides present in weapons fallout are also present in liquid reactor wastes. Accordingly, radioecological processes observed for radionuclides from either source can be applied in assessing the potential impact of future reactor releases. Measurements of both past and existing radionuclide levels provide first-hand information on the types, behaviors, and relative importance of those radionuclides anticipated from nuclear power expansion. Other approaches which can be taken to assess future reactor releases can be based upon stable element data or experimentally determined values of concentration factors. Results from this study indicate, however, that these latter methods are of limited value when applied to waters such as the Hudson having highly variable conditions of salinity and stable element composition. The use of concentration factors is useful and strictly appropriate only when the content of stable elements or radionuclides in biota is proportional to a steady state content in the water. Whenever biologically available sedimentary deposits exist, this condition is not necessarily fulfilled, and the use of concentration factors alone may not produce a reasonable estimate of reconcentration.

SOURCES OF RADIOACTIVITY IN THE HUDSON RIVER

Radionuclides occur in the Hudson from natural sources, weapons fallout, and aqueous releases at nuclear facilities along the river. Amongst the naturally occurring radionuclides, K-40, Ra-226, and Ra-228 are most abundant. Potassium, a major constituent of seawater, accounts for elevated K-40 levels in water from the more brackish areas of the system nearest the Atlantic, whereas potassium leached from terrestrial minerals contributes lesser amounts of K-40 to the freshwater areas. In the region of highest salinity near the mouth of the estuary, K-40 concentrations of about 300 pCi/l are typical, while about 2 pCi/l of K-40 are found in the freshwater regions. Seasonal fluctuations in freshwater flows, rates of evaporation, and tidal influences result in seasonally variable K-40 concentrations at any given location. Longitudinal salinity profiles as measured along the length of the estuary during the summer of 1959[1] indicate that 100-200 Curies of K-40 existed in the estuary at that time.

Both Ra-226 and Ra-228 are carried into the river as natural constituents of suspended material, or in soluble forms from the leaching of soils. From analysis of water one can estimate that about 0.5 Curies of Ra-226 and 0.5 Curies of Ra-228 in the form of suspended material, and from one to five Curies of dissolved Ra-226 and Ra-228, respectively, are introduced into the estuary each year.

The periodic testing of nuclear weapons in the atmosphere has contributed readily detectable quantities of artificial radionuclides to the Hudson. The intermittancy of such tests, and the paucity of fallout deposition measurements, together with uncertainties about the contribution of terrestrial runoff to surface water radioactivity, complicate estimation of the amount of radioactivity contributed to the Hudson by fallout. However, an upper and lower bound to such fallout contributions can be arrived at by utilizing available fallout data and assuming deposition either on the river surface alone or on the entire drainage basin. Table 1 shows the results of such a calculation for the fission products Sr-90, Cs-137, and Ce-144, and the activation product Mn-54, as well as for tritium. Many other radionuclides, most notably Zr-Nb-95, I-131, Ce-141, Ru-103, Ru-106, Sb-125, Ba-140, La-140, Co-60, Zn-65, and Fe-55, have been similarly introduced into the Hudson River from weapons fallout.

The only major nuclear facility discharging low-level radioactive waste directly into the Hudson River is the Indian Point Unit 1 reactor. Knolls Atomic Power Laboratory in Schenectady, New York, contributes such wastes indirectly by way of discharge into the Mohawk River, a northern tributary of the Hudson. Measurements indicate, however, that in spite of measurable radionuclide levels in the Mohawk downstream from K.A.P.L.[5], at the point of discharge into the Hudson these radionuclides are not measurable above natural and fallout radioactivity levels.[6]

At Indian Point low-level releases are first diluted by a normal condenser water flow of 300,000 gpm prior to release into the Hudson. Prior to the time that individual isotope analyses were performed, the percentages of MPC, 10^{-7} μCi/ml, for the unidentified mixture during 1962, 1963, 1964, 1965, and 1966 were 0.22, 0.26, 22, 43, and 70 respectively, as summarized by the USPHS.[7] Detailed radiochemical analyses which were initiated in mid-1966 revealed that the MPC for the mixture released was much larger than 10^{-7} μCi/ml. The percentages of MPC during the following years of 1967, 1968, and 1969 were 1.6, 1.7, and 4.1 respectively.[8]

The average monthly composition of undiluted aqueous radioactive wastes at Indian Point during 1969 is indicated in Table 2.[8] The relative magnitudes of the undiluted fractional MPC's for the individual nuclides, i.e., C_i/MPC_i, indicate the relative importance of each radionuclide with respect to radiation exposure from drinking of water. The sum of the entries under $C_i \times MPC_i/\Sigma C_i$ is the MPC for the identified mixture, 8×10^{-5} μCi/ml in 1968 and 4.6×10^{-5} μCi/ml in 1969. The quantities of Sr-90, Cs-137, Mn-54, Co-60, and tritium released at Indian Point on the year of maximum discharge are shown in Table 3.[8]

Overlooking differences in the manner of introduction of natural, fallout, and reactor-released radionuclides, one may compare the quantities of these radionuclides which have been introduced annually into the Hudson. It is seen from Table 3 that fallout on the river surface contributed approximately the same quantities of Cs-137, Mn-54, and tritium during the peak year of 1963 as did Indian Point Unit 1 on the year of maximum discharge, while 400 times more Sr-90 fell out on the river surface in 1963 than the maximum annual discharge at Indian Point. The leaching of terrestrial fallout deposits could result in up to 200-fold greater introduction rates of fallout nuclides than surface deposition on the river alone, as indicated in Table 3. The ratio of the introduction rate of each nuclide to its MPC_W (Table 3) is proportional to the dose contributed by each nuclide if only the drinking of water is considered. As seen in Table 3, this dose-related ratio is more than 1000-fold higher for the natural radium isotopes than for any reactor-produced nuclide, and is about 10-fold higher for radium isotopes than for Sr-90 falling out on the river surface. In addition to placing the various sources in perspective, the rates of radionuclide introduction are useful in interpreting observed radioactivity levels, and assessing the consequences of future introductions of similar radionuclides.

RADIOACTIVITY MEASUREMENTS

Our measurements were designed to determine the identity and spatial distribution of the radionuclides present in the physical and biological components of the Hudson River ecosystem, and to assess the resultant temporal changes associated with variable radionuclide inputs into the river. From 1964-1967, samples were collected only between late spring and autumn. Our primary objective then was to survey a large diversity of samples from as large an area of the river as possible (from HRM 20 to HRM 100). Except for the activation products Mn-54 and Co-60 in the immediate vicinity of Indian Point, located at HRM 42, the concentration of radionuclides in samples of water, biota, and sediments throughout the river was quite uniform, prompting us to concentrate our efforts in the following years on a region near Indian Point, while still maintaining several upstream stations for control purposes.

Gamma-ray spectroscopy has been the principal method of radionuclide analysis. Spectral information obtained with a multichannel analyzer coupled to a 4" x 4" NaI well crystal shielded by a 4" mercury incasement is processed by a computerized linear weighted least squares analysis described elsewhere.[9] A limited number of samples have been periodically analyzed radiochemically for Sr-90 (EHPA solvent extraction and beta counting of Y-90),[10] Fe-55 (solvent extraction and electroplating),[11] and tritium (distillation electrolytic enrichment).[12]

Annual average concentrations of the gamma emitters, Cs-137, Co-60, and Mn-54, which were measured in samples of bottom sediment, water, whole fish, and rooted aquatic plants collected near Indian Point are shown in Figures 1, 2 and 3. Samples of fish, plants, mud, and water used in computing the annual averages were collected at the same sites and with approximately the same frequency in the different years. Similar species of fish and plants were analyzed each year. Values given for radionuclide concentrations in water are for the dissolved fraction of grab samples. Water samples varied in volume from 6 to 40 liters, and were collected either on a biweekly or monthly basis. Radioactivity values measured in water are a better indication of the slowly varying fallout contributions than the variable releases from Indian Point. Bottom sediment radioactivities pertain to dredgings of the upper 10-12 cm of channel and near shore areas known to have sediments of fine textures, and for this reason probably represent samples of higher activity than would samples collected at random locations including sandy as well as silty-clayey bottoms.

Available data on annual fallout deposition and reactor releases of Cs-137, Mn-54, and Co-60 are shown in Figure 1, 2, and 3 for comparison with the resultant levels of these nuclides appearing in river samples.

From Figure 1 it is seen that during a period of decreasing deposition of Cs-137 from weapons fallout, 1964-1966, the concentration of Cs-137 dissolved in Hudson River water decreased approximately an order of magnitude. During this same period of time, the concentrations of Cs-137 in bottom sediments remained almost constant while levels in fish declined only slightly. From measurements of fish at upstream control stations (Table 5), it appears that weapons fallout was the source of Cs-137 at Indian Point during 1964, 1965, and 1966. Since the Cs-137 content of fish did not parallel the order of magnitude drop of Cs-137 dissolved in water, but instead followed more closely the Cs-137 concentrations in bottom sediments, it appears that the fish are indirectly obtaining most of their Cs-137 directly from river sediments or from food chains dependent on the bottom sediments. Gustafson studying freshwater lakes also came to the conclusion that bottom sediments act as a reservoir of Cs-137 which can be assimilated by fish.[13] Three-fold higher Cs-137 concentrations were found in bottom-feeding fish species such as carp, suckers, and catfish than in open water feeders such as white perch, bass, and sunfish. This supports our hypothesis that part of the Cs-137 in river sediments is biologically available.

Recent sampling has shown the Cs-137 content of suspended sediments (>0.45μ) is greater than for bottom sediment. For instance, in 1969 we found suspended sediments at upstream stations contained 3900 pCi/kg dry, while bottom sediments from similar locations averaged 2200 pCi/kg dry. This may reflect the differing particle size distributions of suspended and bottom sediments. In 1970 the Cs-137 content of plankton ranged from 65-200 pCi/kg wet or 1300-2000 pCi/kg dry. Thus, a hypothetical food chain for a pelagic feeding fish could be: resuspension of bottom sediments, uptake of suspended material by plankton, and subsequent ingestion of plankton by fish. A shorter food chain such as direct ingestion of bottom organisms or other bottom detritus relatively high in Cs-137 might account for the approximate three-fold higher content of Cs-137 in bottom feeders.

During the later years of this study, 1966-1970, Cs-137 concentrations at upriver control stations declined below detectability in water (<.02-.03 pCi/l), but remained constant in bottom sediments. As shown in Table 5, the Cs-137 content of upstream fish decreased with an approximate 2 year half-life reaching 16 pCi/kg in 1970. Similar observations were made for Cs-137 concentrations in samples from the vicinity of Indian Point, except during 1969 and 1970 when the Cs-137 content of fish from Indian Point was approximately twice the Cs-137 content of upstream fish (Table 5). This was presumably the result of a larger than usual release of Cs-137 at Indian Point during 1969 and 1970.

Co-60, one of the more abundant activation products in reactor wastes (Table 2) has been found only infrequently in upriver control samples, presumably as a result of its limited production in nuclear weapons tests. The concentrations observed in fish and water at Indian Point are only slightly above our detection limits of 4 and 0.04 pCi/kg respectively. The ability of aquatic plants to concentrate cobalt has been shown in various laboratory uptake experiments[14] and the concentration factor according to the usual definition was found to range from 10^4 to 10^5 for the plant species included in our measurements, Potamogeton, Myriophyllum and Vallisneria. As a result, aquatic plants reflect Co-60 concentrations in water that could not otherwise be easily measured.

Except for a five-fold decrease in Co-60 concentrations in aquatic plants from 1964 to 1965, the annual levels of this radionuclide in aquatic plants from the Indian Point vicinity has remained reasonably constant from 1965 through 1970. This is in agreement with a fairly constant reactor release of Co-60 during the same time period.

Noteworthy amongst the Co-60 measurements is the apparent accumulation of Co-60 in bottom sediments which has taken place through 1968. The decline of sedimentary Co-60 in 1969 may be an indication of the attainment of equilibria between introduction and removal rates.

Weapons fallout has contributed appreciable quantities of the activation product Mn-54 to the Hudson both during and immediately after the period of peak thermonuclear testing (Table 1 and Figure 3). Releases of this nuclide from Indian Point Unit 1 have contributed larger quantities to the Hudson on a yearly basis, however, than fallout on the river surface alone. This has accounted for Mn-54 levels in biota and sediment at Indian Point (Figure 3) in excess of those found at upstream locations. During 1965 and 1966, for example, two-fold higher concentrations of Mn-54 were found in fish (Table 5) and bottom sediments near Indian Point, as compared to upstream samples, while aquatic plants from Indian Point showed twenty-fold higher Mn-54 concentrations. Since bottom sediments and plants were not collected upstream in 1964, and isotopic analyses of reactor wastes were not performed until 1966, it is not possible to assign the origin of the higher levels occurring in 1964 to either fallout or reactor operations. Measurements of water, bottom sediments, fish and aquatic plants on subsequent years correlate fairly well with available annual Mn-54 release data at Indian Point. Owing to its 303 day half-life, continued accumulation of Mn-54 in sediments would not be expected after several years of reasonably constant release, and in fact such accumulations have not been found.

Detailed studies of the radioecology of manganese have been feasible due to the presence of an identifiable source of Mn-54 in the Hudson at Indian Point, and measurable levels existing in various phases of the Hudson near Indian Point.[15] Of most interest to date has been a rather unusual observation relating to the effect of periodic saltwater intrusion into a previously freshwater area on the chemistry of stable manganese. We have found that unexpectedly, such saltwater intrusions result in a pronounced elevation of manganese concentrations dissolved in water, as shown in Figure 4 for the summer and fall of 1969. As a result of the dissolved manganese depression in the latter part of August when salinity decreased due to an unusually large but transient freshwater discharge, the concentration of stable manganese in the aquatic plant Potamogeton fell by a factor of about 5 (Figure 5). When seawater intrusion reached Indian Point in mid-September, dissolved stable manganese concentrations resumed the previously elevated values, and the manganese content of aquatic plants increased in like fashion, reflecting the manganese content of the surrounding water. Both the concentration, pCi/kg wet, and the specific activity, pCi/mg Mn, of Mn-54 in these same plant samples, together with biweekly continuous measurements of the Mn-54 concentrations in reactor waste provide some insight into the mechanism accounting for manganese elevation in Hudson water during periods of salt water intrusion. From Figure 4 it is seen that a sustained release of Mn-54 occurring at Indian

Point throughout most of August was followed by a reduction of more than an order of magnitude from late August through mid-November. As a result, both the Mn-54 concentration and specific activity in aquatic plants dropped from late August through early September. However, in mid-September the Mn-54 concentration in aquatic plants increased rapidly without a corresponding increase in release at Indian Point Unit 1, while the Mn-54 specific activity slightly decreased. This observation can only imply that stable manganese and Mn-54 were both introduced from a similar source which was not the reactor directly. Upstream control samples indicated no fallout input of Mn-54. We have, therefore, concluded that the influx of seawater into a previously freshwater area resulted in the mobilization of both stable manganese and Mn-54 in bottom sediments. That manganese can be leached from bottom sediments by seawater has previously been shown by simulated leaching studies of Columbia River sediments.[16]

Mn-54 specific activities in fish at Indian Point during 1969 followed quite closely the specific activities measured for aquatic plants and indicate that no dilution of Mn-54 specific activities by stable manganese occurs between uptake by plants and uptake by fish. Stable manganese concentrations remained quite constant in fish during the observed period of rapidly changing manganese concentration in water. This implies a manganese concentration factor for fish that is inversely related to the stable manganese concentration in water. Of course, if water is not the direct source of manganese in fish, then the concept of concentration factor has limited applicability.

Samples of water, sediment, fish, aquatic plants, and crabs were analyzed for Sr-90 during 1964, 1965, and 1966 (Table 4). The concentration of Sr-90 in water decreased two-fold during this time period, while the fallout rate of Sr-90 decreased by a factor of about 6 during the same time period (Table 1). The near absence of Sr-90 in reactor wastes (Table 2 and Table 3) together with the decreasing fallout of this nuclide and the limited remaining sedimentary reservoir permit us to conclude that Sr-90 will not be among the more important radionuclides in this estuarine environment in the years to come.

Sizeable quantities of tritium have been introduced annually into the Hudson by weapons fallout and lesser amounts from reactor releases (Table 1 and Table 3). As a result predominantly of the fallout contribution, levels of tritium in Hudson River waters during 1967 were 1800-1900 pCi/l, almost identical to tritium levels in surrounding freshwater lakes, 1900 pCi/l, and northern Hudson tributaries, 2000 pCi/l.[12] Cessation of atmospheric weapons testing resulted in a decline of concentrations of tritium in surface waters, and during the early months of 1970 Hudson River water averaged approximately 500 pCi/l, with no observable increase in water near Indian Point as compared to remote upstream locations.[17]

Fe-55, one of the more abundant weapons fallout activation products having half-lives greater than about one year, has been periodically measured in Hudson River samples as part of a broader program to determine dietary sources of Fe-55 in man.[11] During 1968 and 1969 Fe-55 specific activities ranging from 1.5 to 3.8 pCi/mg Fe were measured in Hudson River fish and aquatic plants.[18] Expressed in terms of wet weight concentrations, these specific activities translate to 2000-3000 pCi/kg for aquatic plants and 200-250 pCi/kg for fish (white perch and sunfish). These activities are low compared to those reported in Pacific tuna during 1966 of 955 pCi/mg Fe.[11] A single analysis of primary coolant at Indian Point Unit 1 indicated that Fe-55 and Mn-54 were present in an approximate 1 to 6 ratio of activities,[18] while deposition data for fallout of recent origin shows a Fe-55/Mn-54 ratio of about 2 to 1.[3] The predominance of Fe-55 from fallout as compared to reactor releases accounts for the rather uniform specific activities observed throughout the Hudson.

Among the many other gamma-emitting radionuclides which are present in weapons fallout, the only ones detected with sufficient frequency to warrant mention here are the fission products Ce-144, Zr-Nb-95, and Ru-103. None of these radionuclides have been identified in liquid reactor wastes. The short physical half-lives of the latter two nuclides, 65 days and 40 days respectively, generally result in substantial measurement errors for samples not processed soon after collection. The low energy emissions from Ce-144 cannot be accurately quantitated in the majority of bulk samples. However, as an indication of the present levels of these three radionuclides, measurements made during 1969 are shown in Table 6 for samples from the vicinity of Indian Point and samples from our upstream control stations. Interestingly, significantly higher levels of all three nuclides occurred in samples collected upstream from Indian Point. This observation is possibly explained by the depletion of these radionuclides from the aqueous phase during their transport down the estuary. The higher concentrations of Ce-144, Zr-Nb-95, and Ru-103 in aquatic plants and bottom sediment as compared to fish and water may be interpreted to imply that surface adsorption processes play an important role in removing these radionuclides from solution, and hence from direct biological availability.

Only two radionuclides, Co-58 and Cs-134, have been identified in samples near Indian Point and not in upstream control samples. Since the presence of both of these nuclides is attributable to reactor releases, they serve as the only unique tracers of wastes discharged into the Hudson at Indian Point. Neither of these radionuclides are generally found in significant amounts in fallout from nuclear weapons testing.

Long term accumulation of Co-58 is limited by its half-life, 71 days, since it reaches rapid equilibrium between release rate and rate of physical decay. The long lived cobalt isotope Co-60 which has a half-life of 5.26 years, has undergone a gradual accumulation in Indian Point sediments (Figure 2). By comparing the ratio of Co-58 to Co-60 in water at the point of reactor release with the ratio of their concentrations in fish, aquatic plants, and bottom sediments (Table 7), one may conclude that the concentration of both these isotopes in biota is a reflection of the biological availability of radio-cobalt in "fresh" reactor releases, and of the non-availability of sedimentary radio-cobalt accumulations; i.e., if bottom sediments were an important source of Co-58 and Co-60 in biota, then one would expect to find a Co-58/Co-60 ratio in biota similar to that found in bottom sediments.

A similar calculation of the ratio of Cs-134 to Cs-137 in water at the point of reactor release and in biota and bottom sediments (Table 7) would seemingly lead to a similar conclusion; that freshly introduced cesium isotopes are more biologically available than the same isotopes present in bottom sediments. However, the difference between the Cs-134/Cs-137 ratio in biota and that in bottom sediment is not nearly as marked as is the case for Co-58/Co-60. Furthermore, measurement of the Cs-134/Cs-137 ratio in primary coolant at Indian Point Unit 1 yielded a value of 0.60, compared to 0.38 in water of lower activity which was sampled continuously from the condensor discharge canal. If the Cs-134/Cs-137 ratio were 0.60 at the release point, one could conclude that during 1969 approximately 75 per cent of the Cs-137 in fish from Indian Point was due to recent reactor releases, and approximately 25 per cent, or 14 pCi/kg wet, was due to other sources, presumably past weapons fallout. Cs-137 content of fish collected upstream during 1969 and 1970 amounted to 22 and 16 pCi/kg wet (Table 5), respectively. It would thus seem that radiocesium in fish can be attributed both to reactor releases of recent origin, as well as to residual sedimentary deposits from weapons fallout.

Among the radionuclides released in reactor wastes the largest contribution to the fraction of MPC is made by I-131 (Table 2). We have not been able to detect this radionuclide in any Hudson River samples. However, our detection limit for I-131 in biota is higher than for most other gamma emitters, 15 pCi/kg wet as compared to 5 pCi/kg wet for Cs-137. The higher detection limit arises from the necessity of switching to a different counting system with a less favorable geometry, an 8" x 4" NaI crystal, in order to measure large volume samples of unashed biota.

The concentration of naturally occurring K-40 (Table 8) has consistently exceeded the concentrations of artificial radionuclides, both of fallout and reactor origin, in all Hudson River samples, except for aquatic plants in which higher Mn-54 activities have been measured in the vicinity of Indian Point. This observation provides convincing evidence that non-specific radioactivity measurements such as gross-beta analysis yield little information about existing levels of artificial radionuclides in the Hudson River.

Relatively constant amounts of the naturally occurring radium isotopes, Ra-226 and Ra-228, have been observed in samples of bottom sediment and aquatic plants, while concentrations in water and fish have been more variable. Average concentrations in these samples are presented in Table 8. Both Ra-226 and Ra-228 have been found to be uniformly distributed spatially in the Hudson over an 80 mile length of river.

DOSIMETRIC EVALUATION

The exposure to man resulting from radioactivity in the Hudson River consists of a component from natural radioactivity and a component from artificial radioactivity. Neither dietary surveys nor bioassays of local populations are felt to be warranted by the low levels of artificial radionuclides in the Hudson. Edible shellfish are absent in the Hudson, and the abundant aquatic plants of the Hudson are not consumed by man. Accordingly, there is no opportunity for biological organisms of high concentrating ability to enter directly into human food supplies. Consumption of indigenous and migratory fishes caught both recreationally and commercially in the Hudson is apparently the most important pathway by which radionuclides can be recycled to man via the aquatic food chain. Based upon average concentrations of the radionuclides Cs-137, Cs-134, Co-58, Co-60, and Mn-54 in fish at Indian Point during 1969 (Table 5) we have calculated the yearly whole-body and gastrointestinal doses to man to be 0.04 mrem/year and 0.05 mrem/year respectively, assuming an average daily intake of 30 grams of fish taken solely from this location. Of the estimated 0.04 mrem/year whole-body dose, 0.02 mrem/year is due to Cs-134 and 0.02 mrem/year is due to Cs-137. Measurements of fish upstream from Indian Point during 1969 showed Cs-137 and Zr-Nb-95 to be the only gamma emitters present. The whole-body and G-I doses from consumption of such fish are estimated as 0.01 and 0.003 mrem/year, respectively. We thus conclude that during 1969 fallout Cs-137 in fish delivers a whole-body dose of 0.01

mrem/year and releases of radioactivity at Indian Point result in radionuclide levels in fish that deliver about 0.03 mrem/year to the whole body.

Concentrations of Ra-226 and Ra-228 in water (Table 8) amount to 1.6 and 0.4 per cent of permissible drinking water concentrations.[19] In addition, 0.7 and 0.2 per cent of the permissible intake of Ra-226 and Ra-228, respectively, would result from the consumption of 30 grams of whole fish per day.

Levels of fallout Sr-90 which were measured in whole fish during 1964, 1965, and 1966 would result in bone doses of 9, 20, and 7 mrem/year respectively, if 30 grams of whole fish were consumed each day. Fe-55, the major source of which is also fallout, as measured in Hudson River fish during 1968 contributes about 0.06 mrem/year to the spleen which is the critical organ, or 0.008 mrem/year to the whole body.

In spite of the fact that the Hudson River water is potentially potable in the freshwater areas, it is used to only a limited extent as a municipal drinking water supply, mainly because of inadequate treatment of introduced sewage. The water in the vicinity of Indian Point is sufficiently brackish throughout the summer, fall, and winter months to preclude its use for drinking purposes. The closest drinking water intake is approximately 23 miles upstream from Indian Point at Chelsea where a reserve pumping station for the New York City water supply is located, but which to date has not been used. In order for operational wastes discharged at Indian Point to be flushed by the tides upstream to Chelsea, evaporative losses in the Hudson have to approach freshwater discharge. This is a fairly common occurrence in the late summer months. When such conditions of flow prevail, the water salinity alone at Chelsea would prevent water use for drinking. Therefore, it is not conceivable that present reactor wastes could enter into a drinking water supply.

Based upon an estimated whole-body dose of 0.03 mrem/year from low-level releases at Indian Point in 1969, it is possible by a simple extrapolation to estimate the dose expected if discharges were at 100 per cent of the present MPC (mixture). During 1969 releases amounted to 4% of MPC. Discharge at 100 per cent MPC would then increase the 1969 dose estimates by about 25 times, to 0.8 mrem/year. Furthermore, assuming proportionality between electrical generation capacity, liquid radioactive waste composition, and available coolant dilution flows, the resultant dose from future multiple nuclear reactors can be estimated. For example, upon completion of the four new reactors on the Hudson, two at Indian Point and two directly downstream, the total generation capacity of

12,984 MWt would be about 21 times the present capacity at Indian Point Unit 1. The above assumptions then imply that 21 times the presently maximum permissible discharge of radionuclides would be possible, and the approximate dose from fish consumption would be about 21 x 0.8 mrem/ year or 17 mrem/year. We consider this estimate to be more realistic than estimates based upon considerations of dilution and aquatic concentration factors.

SUMMARY

Measurements of radioactivity in samples of water, bottom sediment, and biota from the Hudson River have been performed over a seven year period from 1964 to 1970. Natural radioactivity levels generally exceed the levels of artificial radioactivity. The concentrations of most natural and artificial radionuclides are higher in bottom sediments than in water. These sediment-bound nuclides exist in physical states not available for direct uptake by consumable Hudson River biota. It appears, however, that recycling of at least one radionuclide, Cs-137, does occur from the sediments, a pathway not accounted for in the "concentration-factor" approach. Co-60, on the other hand, apparently has accumulated in bottom sediments at the Indian Point location on the Hudson, but appears to be effectively removed from biological availability by sediment sorption. Sr-90 has been found not to be as significantly bound by sediments as Cs-137, but the diminishing contribution of Sr-90 from weapons fallout and its near absence in reactor waste do not warrant continued assessment. Both Mn-54 and stable manganese seem to be leached from fresh-water sedimentary deposits during seasonal periods of salt water intrusion characteristic of the Hudson.

Aquatic plants have been found to concentrate Mn-54, Co-60, Co-58, Fe-55, Zr-95-Nb-95, Ce-144, and Ru-103, but are of no dosimetric consequence since they are not consumed by man, and since much lower concentrations of these nuclides are found in higher organisms of the aquatic food chain. These aquatic plants do serve, however, as good stationary integrators of radionuclide levels in the aqueous phase.

The critical nuclides with respect to human exposure from reactor releases at Indian Point Unit 1 have been Cs-137 and Cs-134. During 1969, the year of highest radiocesium discharges at Indian Point, a person consuming about 30 grams of fish a day, all taken from this limited portion of the river, would have received a whole-body dose from reactor-produced cesium isotopes of 0.03 mrem.

A whole-body dose from fish consumption of about 0.8 mrem/ year would result from maximum permissible aqueous discharge at Indian Point Unit 1. Further extrapolation to hypothetical 100 per cent MPC release at all five Indian Point reactors

allows one to conclude that, the whole-body dose from fish consumption would be 17 mrem/year. Thus, it appears that present aqueous discharge standards as formulated by the USAEC are sufficient to insure exposure below the permissible 500 mrem/year whole-body limit, even as applied to releases from multiple adjacent power reactors, and to radionuclide transfers into human food supplies.

ACKNOWLEDGEMENTS

The authors wish to acknowledge Dale Bath, Dorothy Wohlgemuth, Jose A. Hernandez, and Steven Jinks for their assistance in sampling and analysis. Portions of this investigation were supported by the United States Public Health Service Bureau of Radiological Health, the New York State Department of Health and the Consolidated Edison Company of New York. The project is part of a center program supported by the National Institute of Environmental Health Sciences, Grant No. ES 00260.

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TABLE 1

Annual deposition in Curies of selected weapons fallout radionuclides on the Hudson River drainage basin and river surface. The areas of the basin and surface were taken to be 34,700 km^2 and 155 km^2, respectively.

YEAR	^{90}Sr [2]		^{137}Cs [3]		^{144}Ce [3]		^{54}Mn [3]		^{3}H [4]	
	Basin	Surf.	Basin	Surf.	Basin	Surf.	Basin	Surf.	Basin	Surf.
1954	96	0.4	140	0.6	–	–	–	–	–	–
1955	120	0.6	180	0.8	–	–	–	–	–	–
1956	150	0.7	230	1.0	–	–	–	–	–	–
1957	150	0.7	230	1.0	–	–	–	–	–	–
1958	210	1.0	310	1.4	–	–	–	–	–	–
1959	300	1.3	440	2.0	–	–	–	–	–	–
1960	55	0.3	81	0.4	220	1	–	–	–	–
1961	84	0.4	124	0.6	1600	7	–	–	7700	34
1962	430	1.9	630	2.8	11000	47	200	0.9	97000	430
1963	830	3.7	1300	5.9	18000	78	1200	5.5	210000	920
1964	550	2.5	660	3.0	4500	20	360	1.6	110000	510
1965	190	0.9	280	1.3	760	3	57	0.3	44000	200
1966	84	0.4	120	0.6	140	1	–	–	–	–
1967	57	0.3	84	0.4	–	–	–	–	–	–
1968	46	0.2	67	0.3	–	–	–	–	–	–
1969	46	0.2	68	0.3	–	–	–	–	–	–
1970	–	–	–	–	–	–	–	–	–	–
Cumulative through 1969: (Decay corrected)	2860	12.8	4190	18.7	–	–	–	–	–	–

Table 2

Isotopic composition of liquid wastes at Indian Point Unit 1 during 1969. Average of undiluted monthly concentrations, C_i, and undiluted fractional MPC's.

Nuclide	C_i x 10^5 μCi/ml	MPC_i x 10^5 μCi/ml	$\frac{C_i}{MPC_i}$	$\frac{C_i}{\Sigma C_i}$ x MPC_i x 10^5 μCi/ml
^{3}H	2300	300	7.6	-
^{24}Na	0.29	20	0.015	0.052
^{54}Mn	19	10	1.9	1.7
^{58}Co	21	9	2.3	1.7
^{60}Co	15	3	5.0	0.41
^{89}Sr	0.14	0.3	0.47	0.00038
^{90}Sr	0.0066	0.03	0.22	2×10^{-6}
^{134}Cs	15	0.9	17	0.12
^{137}Cs	25	2	13	0.45
^{131}I	12	0.03	390	0.0031
^{132}I	0.14	0.8	0.18	0.0010
^{133}I	3.5	0.1	34	0.0031

Table 3

The quantities of natural, fallout, and reactor-produced radionuclides introduced into the Hudson either annually or during the year of maximum fallout or maximum reactor release, expressed both as Curies/year and Curies/year/MPC.[19]

Nuclide	Maximum Weapons Fallout (Ci/yr) * (†)	Maximum Reactor Release (Ci/yr)	Natural Influx (Ci/yr)	Curies/year / MPC: Fallout * (†)	Curies/year / MPC: Reactor	Curies/year / MPC: Natural
Sr-90	4 (830)	0.009	-	$4x10^6$ ($8x10^8$)	$9x10^3$	-
Cs-137	6 (1300)	6	-	$3x10^4$ ($7x10^6$)	$3x10^4$	-
Ce-144	80 (18000)	-	-	$8x10^5$ ($2x10^8$)	-	-
Mn-54	6 (1200)	14	-	$6x10^3$ ($1x10^6$)	$1x10^4$	-
H-3	920 (210000)	1100	-	$3x10^4$ ($7x10^6$)	$4x10^4$	-
Co-60	-	5	-	-	$1x10^4$	-
Ra-226	-	-	~3	-	-	$3x10^7$
Ra-228	-	-	~3	-	-	$1x10^7$
K-40	-	-	>>100	-	-	-

* Deposition on river surface.

† Deposition on entire drainage basin.

TABLE 4

^{90}Sr concentrations in various Hudson River Samples during 1964, 1965 and 1966.

YEAR		pCi/kg Wet
1964	Water	2.2
	Bottom Sediment (pCi/kg dry)	< 10
	Fish	130
	Aquatic Plants	300
	Crabs	900
1965	Water	1.5
	Bottom Seciment (pCi/kg dry)	180
	Fish	320
1966	Water	1.0
	Fish	100
	Aquatic Plants	50

TABLE 5

Comparison of the concentration of gamma-emitting radionuclides in fish collected near the Indian Point reactor with concentrations in fish collected upstream above salt water boundary.

pCi/kg Wet

Year	^{137}Cs Indian Point	^{137}Cs Upstream	^{54}Mn Indian Point	^{54}Mn Upstream	^{60}Co Indian Point	^{60}Co Upstream
1964	39	32	19	18	N.D.	N.D.
1965	43	42	30	12	11	N.D.
1966	30	30	24	13	2	3
1967	20	-	4	-	3	-
1968	28	31	40	5	5	5
1969	56	22	32	N.D.	11	N.D.
1970	26	16	8	N.D.	3	N.D.

TABLE 6

Concentrations of the fallout radionuclides ^{95}Zr-^{95}Nb, ^{144}Ce, and ^{103}Ru in samples of Hudson River water, bottom sediments, aquatic plants, and fish collected during 1969 at Indian Point and at upstream control stations. pCi/kg wet.

	^{95}Zr-^{95}Nb		^{144}Ce		^{103}Ru	
	INDIAN POINT	UP-STREAM	INDIAN POINT	UP-STREAM	INDIAN POINT	UP-STREAM
WATER	0.06	0.09	ND	0.06	ND	0.05
BOTTOM SEDIMENTS (pCi/kg dry)	160	550	430	570	150	230
AQUATIC PLANTS	110	800	70	250	5	162
FISH	7.6	8.4	ND	ND	ND	ND

TABLE 7

Average concentrations of Co-58, Co-60 and Cs-134, Cs-137, and computed isotopic ratios in Hudson River samples at Indian Point during 1969.

	^{58}Co	^{60}Co	$^{58}Co/^{60}Co$	^{134}Cs	^{137}Cs	$^{134}Cs/^{137}Cs$
INDIAN POINT DISCHARGE CANAL WATER	1.9	2.3	0.83	0.46	1.2	0.38
BOTTOM SEDIMENTS	70	550	0.13	350	1820	0.19
FISH	7.8	11.4	0.68	25.6	55.8	0.46
AQUATIC PLANTS	305	404	0.76	24	57	0.42

TABLE 8

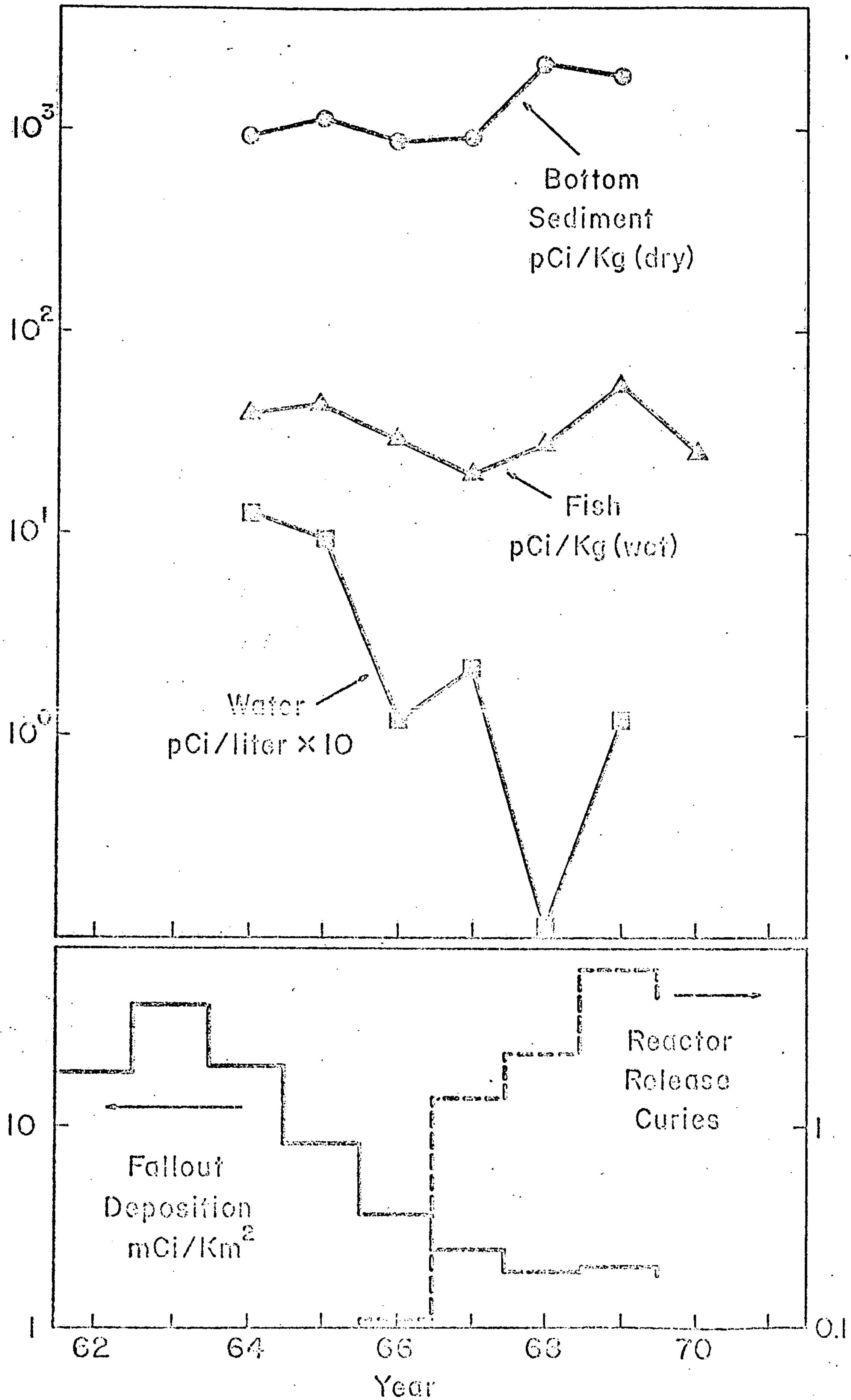
Average concentrations of the naturally occurring radionuclides ^{40}K, ^{226}Ra, and ^{228}Ra in samples of water, biota, and bottom sediments of the Hudson River

pCi/kg

	^{40}K	^{226}Ra	^{228}Ra
WATER	1 - 70	0.16	0.12
BOTTOM SEDIMENTS	14,000	810	940
FISH	1,300	5	4
AQUATIC PLANTS	2,000	150	50

FIGURE 1

Average concentrations of Cs-137 measured annually in Hudson River samples collected at Indian Point, annual fallout deposition of Cs-137, and annual release of Cs-137 at Indian Point Unit 1.

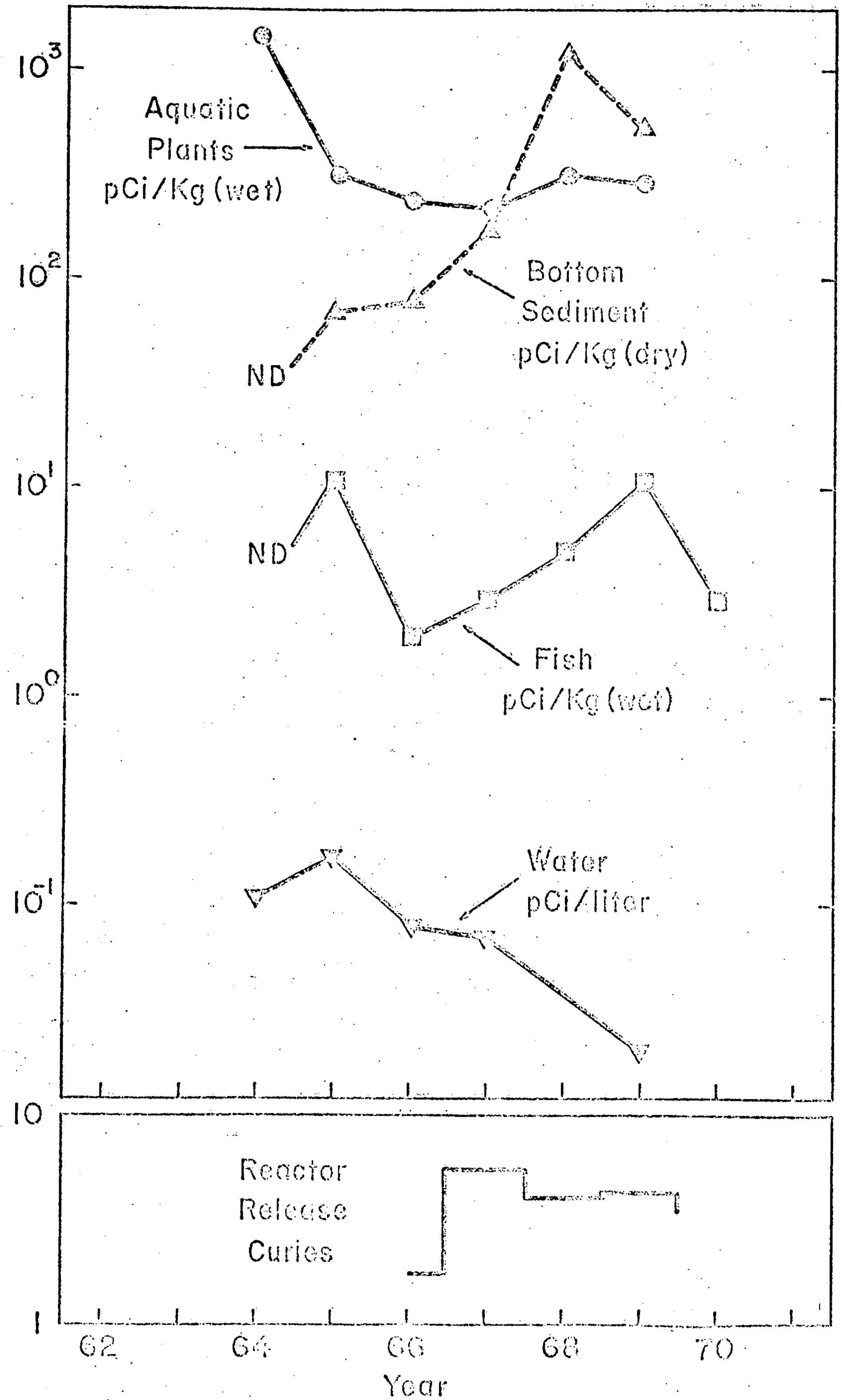


10³
10²
10¹
10⁰
Bottom
Sediment
pCi/Kg (dry)
Fish
pCi/Kg (wet)
Water
pCi/liter × 10
10
1
Fallout
Deposition
mCi/Km²
Reactor
Release
Curies
1
0.1
62
64
66
68
70
Year

FIG 1

FIGURE 2

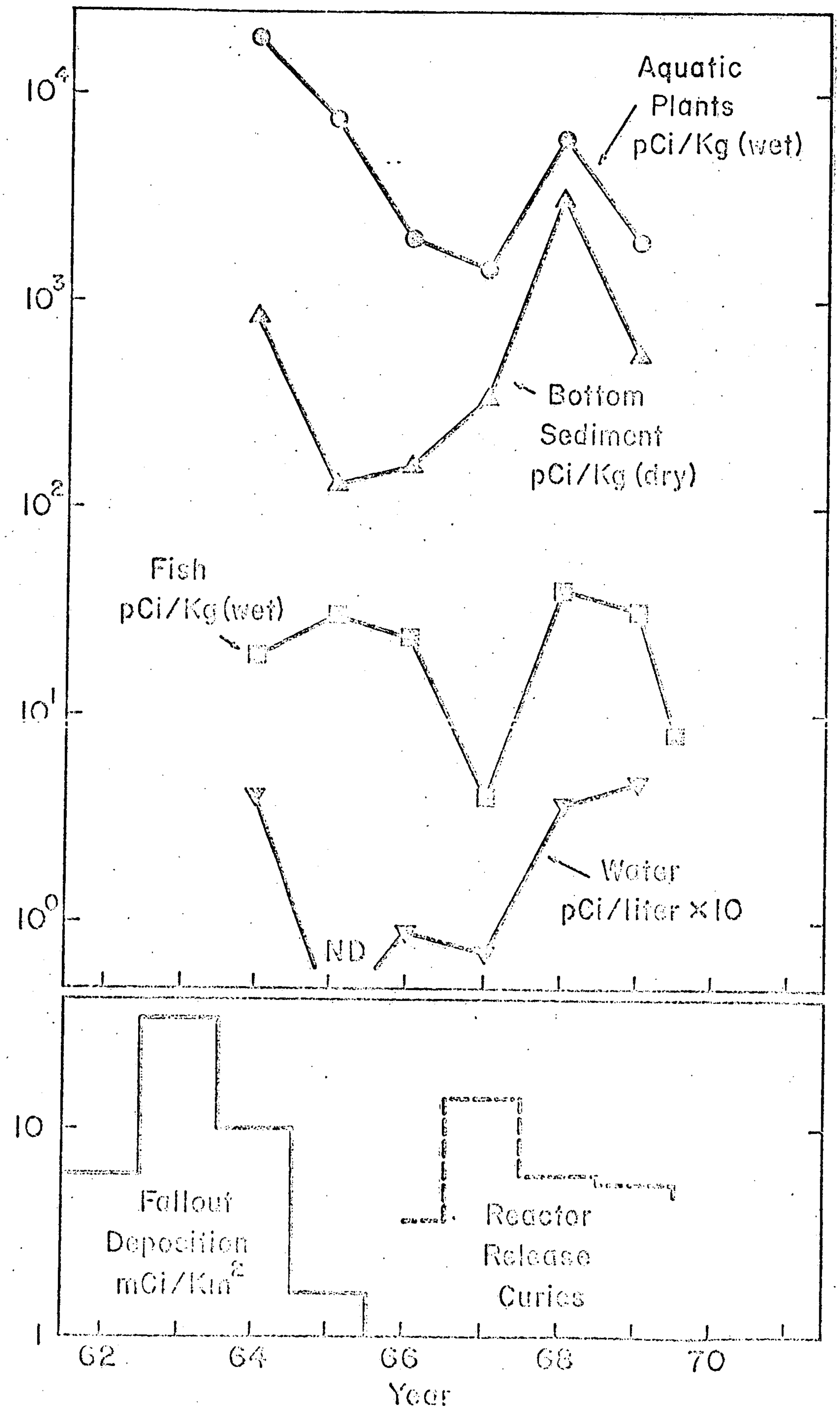
Average concentrations of Co-60 measured annually in Hudson River samples collected at Indian Point, and annual release of Co-60 at Indian Point Unit 1.



10³
10²
10¹
10⁰
10⁻¹
Aquatic
Plants
pCi/Kg (wet)
Bottom
Sediment
pCi/Kg (dry)
ND
ND
Fish
pCi/Kg (wet)
Water
pCi/liter
10
1
Reactor
Release
Curies
62
64
66
68
70
Year

FIGURE 3

Average concentrations of Mn-54 measured annually in Hudson River samples collected at Indian Point, annual fallout deposition of Mn-54, and annual release of Mn-54 at Indian Point Unit 1.

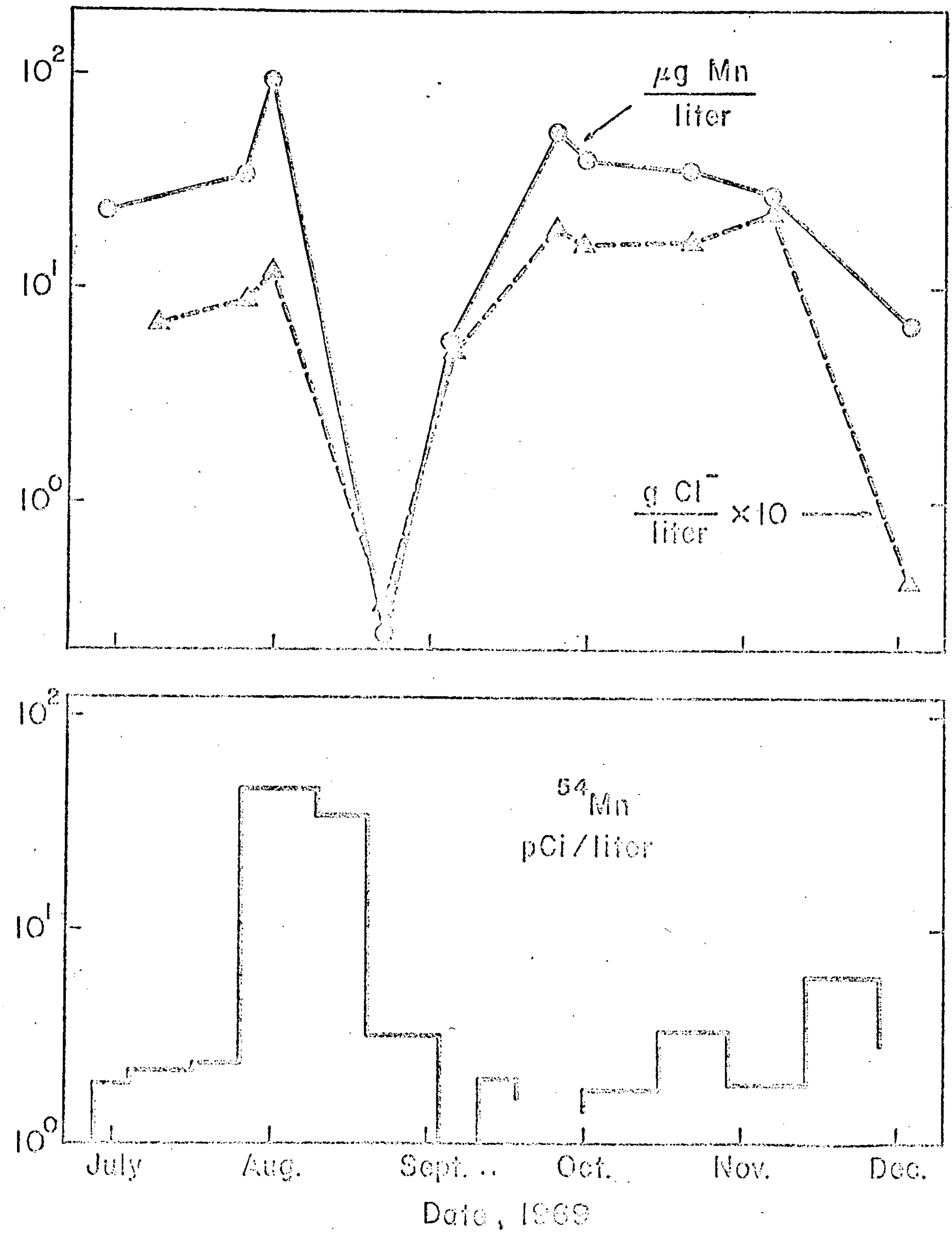


Aquatic Plants pCi/Kg (wet)
Bottom Sediment pCi/Kg (dry)
Fish pCi/Kg (wet)
Water pCi/liter ×10
ND
Fallout Deposition mCi/Km^2
Reactor Release Curies
62
64
66
68
70
Year

F-3

FIGURE 4

Concentrations of stable manganese in Hudson River water at Indian Point during 1969 illustrating the strong positive correllation with water salinity expressed as chloride concentration. Releases of Mn-54 at Indian Point as measured in continuous samples from the condensor discharge canal.

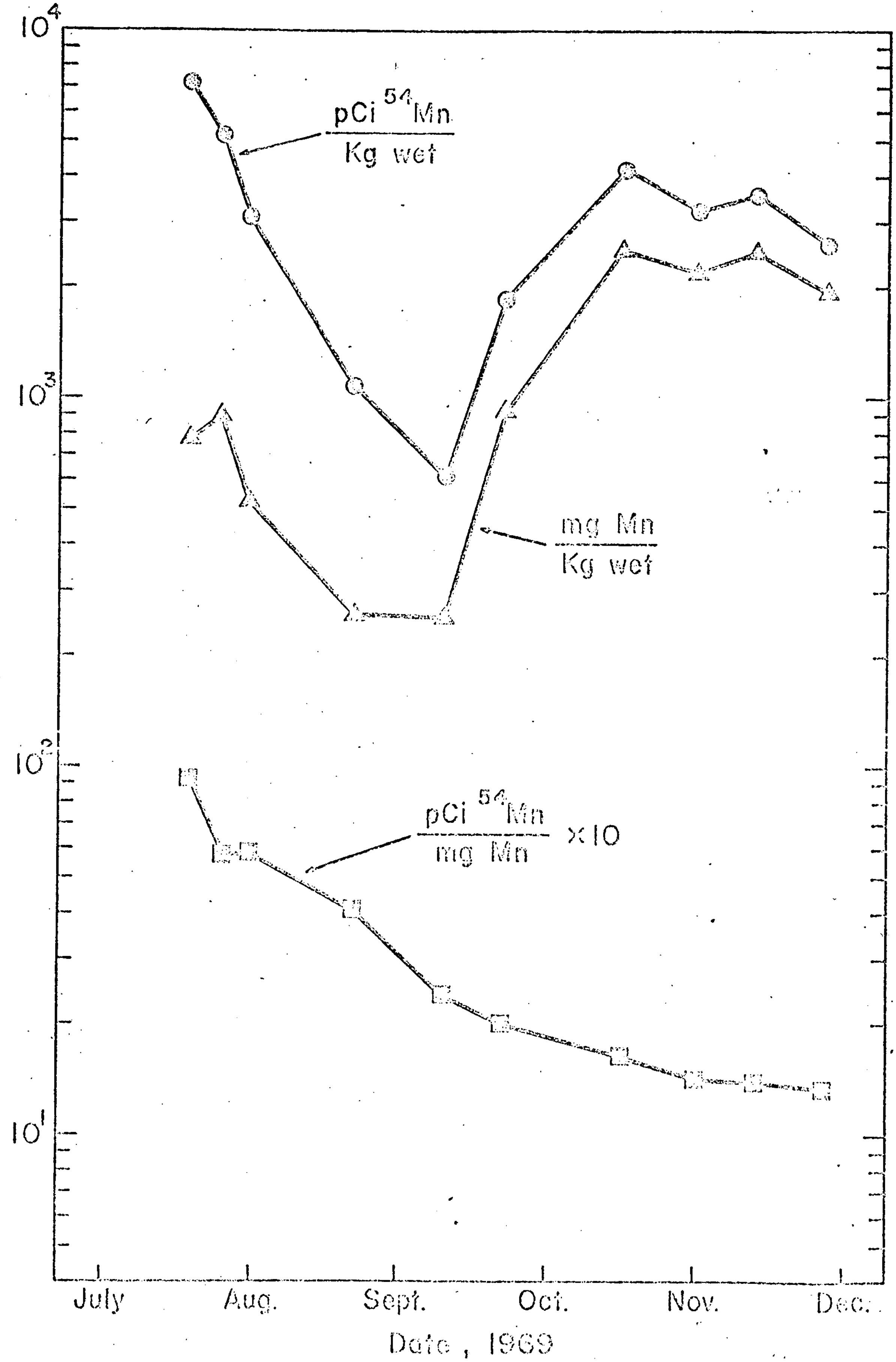


10^2
10^1
10^0
μg Mn / liter
g Cl⁻ / liter ×10
10^2
10^1
10^0
54Mn pCi/liter
July
Aug.
Sept.
Oct.
Nov.
Dec.
Date, 1969

FIG - 4

FIGURE 5

Stable manganese and Mn-54 content of the aquatic plant Potamogeton Perfoliatus, expresed both on a wet weight basis and as Mn-54 specific activity. 1969 measurements near Indian Point.



10^4
10^3
10^2
10^1
pCi ⁵⁴Mn / Kg wet
mg Mn / Kg wet
pCi ⁵⁴Mn / mg Mn ×10
July
Aug.
Sept.
Oct.
Nov.
Dec.
Date, 1969

F-5