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NRC Research and Technical Assistance Report

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INTERIM REPORT

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469 216

QUARTERLY PROGRESS REPORT FOR PERIOD

January 1 through March 31, 1979

ENVIRONMENTAL SCIENCES DIVISION
OAK RIDGE NATIONAL LABORATORY

PROJECT (189 No.): B0423--Methods to Assess Impacts on Hudson River White Perch

PERSON IN CHARGE: Webster Van Winkle

PRINCIPAL SCIENTIST: Lawrence W. Barnthouse

TECHNICAL OBJECTIVES: To complete the topical report on estimating and evaluating collection rates and conditional mortality rates due to impingement of white perch at the Indian Point Nuclear Station and the other power plants on the Hudson River. To collect, compile, and analyze data on white perch entrainment losses and density-dependent growth. To review data and information on white perch from other water bodies. To document in a second topical report the results of the new analyses and to make a determination whether the combined entrainment and impingement losses may have an adverse impact on the Hudson River white perch population.

STATUS OF SUBTASKS: Work on all subtasks directly related to the preparation of testimony for EPA is proceeding on schedule. Completion of subtasks A.1, A.2, and D has been deferred until after the testimony for EPA is submitted (May 14, 1979). We still expect to complete work on all subtasks on schedule.

MAJOR ACCOMPLISHMENTS:

A. Impingement

1. Evaluate collection rate as an index of population abundance.

   Work continued at a reduced rate on this subtask, due to the higher priority of preparing testimony for EPA.

2. Estimate the decrease in collection rate required to detect a statistically significant reduction.

   Work continued at a reduced rate on this subtask, due to the higher priority of preparing testimony for EPA.

3. Evaluate survival of impinged white perch based on existing data.

   Results of impingement survival studies conducted at Bowline, Roseton and Danskammer (through May, 1977) were compiled and evaluated. Our evaluation has been incorporated in testimony prepared for EPA.

4. Complete the topical report entitled "Evaluation of impingement losses of white perch at the Indian Point Nuclear Station and other Hudson River power plants."

   An essentially final version of this report has been completed and will be submitted as testimony for EPA. (a copy of this testimony is enclosed)

B. Entrainment

1. Estimate the probability of entrainment mortality (f_C).

   Estimates of f_C for white perch eggs, larvae, and juveniles entrained at Bowline, Lovett, Indian Point, Roseton, and Danskammer were developed and incorporated in testimony prepared for EPA.

2. Estimate the intake f-factor (f_I).

   Estimates of f_I for white perch eggs, larvae, and juveniles entrained at Bowline, Lovett, Indian Point, Roseton, and Danskammer were developed and incorporated in testimony prepared for EPA.

3. Estimate the temporal and spatial distribution of entrainable life stages.

   Estimates of the temporal and spatial distribution of entrainable life-stages were developed for the 1974 and 1975 white perch year classes. These estimates were incorporated in testimony prepared for EPA.

4. Estimate the conditional rate of entrainment mortality.

   Estimates of conditional entrainment mortality rates for white perch were computed using results obtained from subtasks B.1 through B.3, above. These estimates were incorporated in testimony prepared for EPA.

C. Density-dependent Growth

Results reported by Texas Instruments and by Lawler, Matusky, and Skelly Engineers were evaluated. Our evaluation has been incorporated in testimony prepared for EPA.

D. Data and Information from Other Water Bodies

Work continued at a reduced rate on this subtask, due to the higher priority of preparing testimony for EPA.

PUBLICATIONS, PRESENTATIONS, AND MEETINGS:

None.

EVALUATION OF IMPINGEMENT LOSSES OF WHITE PERCH AT HUDSON RIVER POWER PLANTS

TESTIMONY OF

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HEAD, AQUATIC ECOLOGY SECTION

and

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ENVIRONMENTAL SCIENCES DIVISION
OAK RIDGE NATIONAL LABORATORY
OAK RIDGE, TENNESSEE

NRC Research and Technical Assistance Report

PREPARED FOR THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION II

APRIL, 1979

SUMMARY AND CONCLUSIONS

This testimony presents two independent lines of evidence evaluating impingement losses of white perch at the power plants on the Hudson River. The first line of evidence involves analyzing the variation in collection rate among years over the period 1972 - 1977. The second line of evidence involves estimating the conditional mortality rate (or equivalently, the percent reduction in year-class strength in the absence of compensation) due to impingement for the 1974 and 1975 year classes.

The collection rates provide estimates of year-class strength on a relative scale. As such, they reflect the effect of entrainment and impingement losses during the preceding months, as well as the effect of any compensatory mechanisms which might alter survival during the preceding months. Regression analyses on collection rates of impinged young-of-the-year white perch among years suggest that there has been no systematic change in the size of the white perch population during the period 1972 - 1977. In particular, there is little evidence of a statistically significant downward trend. However, given the large variability in collection rates used in these regressions, the time series are relatively short (i.e., 5 to 6 years), and thus, the statistical power of the test for a trend is not high. In addition, because of the age of sexual maturity for females and the multiple age-class composition of the spawning population of females, and because impingement mortality increased appreciably starting in 1973 and 1974, a systematic decrease in year-class strength due to impingement mortality would only start to manifest itself with the 1977 (or 1978) and subsequent year classes.

Our estimates of percent reduction in year-class strength due to impingement indicate that the level of impingement impact was probably greater than 20% for the 1974 year class and was probably greater than 15% for the 1975 year class. These estimates do not include consideration of entrainment, so that the total power plant conditional mortality rate is obviously greater than the values presented in this testimony for impingement only. Given the information presently available, it is our judgment that this level of impingement impact is not acceptable from the point of view of the white perch population.

In terms of the comparability of assumptions and values for input parameters used in the utilities' methodology and in ORNL's methodology, the utilities' estimate of percent reduction due to impingement for the 1974 year class of 11.3% is best compared to ORNL's estimate of 25.5%. Five reasons for this more than factor-of-two difference are discussed. The utilities' choice at <u>every one</u> of these five "decision points" affects the results in the same direction, namely, to lower the estimate of percent reduction. ORNL's choice at each of these five decision points is scientifically more sound and defensible.

CONTENTS

LIST OF TABLES

469 222

469 223

I. INTRODUCTION

Oak Ridge National Laboratory (ORNL) performed a preliminary evaluation of impingement losses of white perch at the Indian Point Nuclear Station and other Hudson River power plants in preparing the Final Environmental Statement for Indian Point 3 (USNRC 1975). In that evaluation we stated

> A 1973 field-tagging study by a consultant for the applicant indicates that the September-October population estimates to be used for planning purposes should be 23 million white perch for the entire Hudson River. This population estimate includes all age groups and not just young-of-the-year, but the young-of-the-year account for the majority of the white perch impinged. This population estimate is tentative, it may vary by an order of magnitude from year to year, and it is based on 1973 data (whereas the impingement estimates are based on 1971-1972 data); nevertheless, the staff feels that impingement may have a significant impact on the white perch population. For example, the projected total impingement loss at all plants with once-through cooling at the three Indian Point Units is 4.1 million white perch per year. If the assumptions are made that these are all young-of-the-year and that 80% of the total white perch population of 23 million are young-of-the-year, then 20% to 25% of these young-of-the-year white perch will be impinged. (p. V-61)

In response to the above concern, the Office of Nuclear Regulatory Research, U. S. Nuclear Regulatory Commission, funded research at ORNL starting in May 1978 with the following objectives: To determine the significance of impingement losses on the white perch population at the Indian Point Nuclear Station (all units). To collect, compile, and analyze data and information on white perch impingement losses in the Hudson River. To estimate the impingement exploitation rate by power stations and the conditional rate of mortality due to impingement for the Hudson River white perch population. To document in a final report the results of the analysis and to make a determination whether the impingement losses are having a potentially adverse impact on populations of white perch in the Hudson River.

This report is organized as follows: Section II deals with the white perch impingement data *per se*, including a description of the data base and the analyses of variations in the collection rates among years, months, and power plants. Section III deals with white perch population data, including estimates of population size and monthly natural mortality rates. Section IV integrates the results from Sections II and III to estimate the conditional mortality rate and exploitation rate due to impingement, using the ORNL empirical impingement model. Section V is a discussion of our results in light of other utilities' results and concludes with consideration of whether impingement of white perch at Hudson River power plants is a problem.

469 224

II. WHITE PERCH IMPINGEMENT DATA

In this section, we first present a brief description of the data base on number of white perch impinged (collected) and on the collection rates at each power plant. Then, we present the results of our analyses of these collection rates, focusing on the pattern of variation among years, months, and power plants. Our analysis of the variation in collection rate of young-of-the-year white perch among years addresses the question of whether there has been a statistically significant and systematic trend in the size of year classes during the period 1972 - 1977. Our analysis of the variation in collection rate among months focuses on how these variations depend on location of the power plant and age of the white perch. Finally, our analysis of the variation in collection rate among power plants focuses on identifying which power plants have the highest and lowest collection rates and how the rankings of power plants depend on the age of the white perch impinged.

A. Description of the Data Base

Data on number collected and collection rate have been compiled for white perch by month for all years for which data were obtainable for each of the following power plants (moving downriver): Albany, Danskammer, Roseton, Indian Point Units 1, 2, and 3, Lovett, Bowline, and Astoria. These data are presented in the Appendix, Tables A-1 through A-9. Collection rate is defined as the number of impinged white perch counted (Indian Point) or estimated (all other power plants) to be impinged at the intake per unit intake flow. Except for Indian Point, where collection rates were adjusted upward to correct for less than 100% collection efficiency, collection rate is assumed to be approximately equivalent to impingement rate, which is defined as the number of white perch killed at the intake per unit intake flow. A detailed analysis of factors that influence impingement estimates at Hudson River power plants is given in Barnthouse (1979), including adjustment factors. We designated May 31 - June 1 (a one-day interval) as the dividing line between 12-month old young-of-the-year and 13-month old yearlings.

B. Variation in Collection Rate Among Years

Collection-rate data are available on a monthly basis for a period of 4-6 years for Bowline, Lovett, Indian Point 2, Roseton, and Danskammer. We have treated collection rate, which is equivalent to a catch per unit effort (CPUE), as an approximate index of population size. In order for a CPUE index to serve as an accurate index of population size, there must be some assurance that actual variations in effort are measured. We believe that data on power plant intake flow (= effort) satisfies this condition, since the uncertainty associated with estimates of intake flow is relatively small. Given this assumption, we have examined the time series of collection rates over years for trends in population size. The regression

469 225

model used was $Y = a + bX$, where Y is the collection rate for young-of-the-year (yoy) white perch (RATEO in Appendix), X is year, $\underline{a}$ is the Y-axis intercept, and $\underline{b}$ is the slope. A slope (b) significantly greater than 0.0 ($P \leq 0.10$) suggests an increasing trend over years in population size, while a slope significantly less than 0.0 suggests a decreasing trend in population size. A slope not significantly different from 0.0 indicates that, although year-class strength may have varied, there was no systematic trend in year-class strength over the period 1972 (or 1973) - 1977. The regression analysis was performed for each of the above five power plants and for all five power plants combined for each month separately. The reason for performing individual regressions for each power plant and month was to examine the possibility that there might be consistent patterns of variation at a power plant for certain months which were masked by averaging over power plants or over months. The regression analysis was also performed using the mean annual collection rate, which was calculated as the average of the twelve monthly collection rates for each year. In all, 78 regressions were performed. Because the twelve monthly collection rates are used to calculate the mean annual collection rate for each year, however, this set of regressions cannot be treated rigorously as a set of 78 statistically independent regressions.

The results of these regression analyses are presented in Table 1. Of the 78 regressions, the slope ($\underline{b}$) differs significantly ($P < 0.10$) from 0.0 in only 8 cases. Of these 8 cases, the slope is significantly greater than 0.0 seven times and less than 0.0 only once (Lovett, in March). In our judgment the mean annual collection rates for each of the five power plants and for all five plants combined are likely to be more reliable indices of population size than the monthly collection rates, which are more subject to variation from year to year due to temperature or salinity differences, and consequently, to differences in the spatial distribution of yoy white perch in the Hudson River, rather than due to real differences in year-class strength. None of the slopes for the six "annual" regressions differs significantly from zero. Thus, the collection rate data from these five power plants suggest that there has been no systematic change in the size of the white perch population during the period 1973 - 1977 (1972 - 1977 for Danskammer).

Because of the age of sexual maturity for females and the multiple age-class composition of the spawning population of females, and because impingement mortality increased appreciably starting in 1973 and 1974, a systematic decrease in year-class strength due to impingement mortality would only start to manifest itself with the 1977 (or 1978) and subsequent year classes. Female white perch collected in the Indian Point region in May 1973 indicated 24% sexual maturity at age 2, 96% at age 3, 92% at age 4, and 100% at age 5 and older (Texas Instruments, 1975a, p. VII-22). The large increases in power plant intake flow occurred during 1973-1975 (Christensen et al. 1976, Fig. 6). Thus, the year classes spawned during these years were spawned by year classes that were not themselves subjected to the increased levels of impingement mortality. Assuming a median age of reproduction of 4 years, only starting in 1977 or 1978 would the compounding

Table 1. Summary of results from regression analyses to examine the time series of collection rates for trends in the Hudson River young-of-the-year white perch population[a]

Month	N	r^2	b	P	N	r^2	b	P	N	r^2	b	P
	Bowline				Lovett				Indian Point 2			
January	5	0.06	-84.5	0.68	5	0.60	208.	0.12	5	0.53	5810.	0.16
February	5	0.17	-95.1	0.49	5	0.27	95.7	0.37	5	0.44	11539.	0.22
March	5	0.21	-80.6	0.44	4	0.88	-29.8	0.06*	5	0.12	-565.	0.57
April	5	0.11	-75.7	0.58	5	0.11	-39.5	0.59	5	0.02	349.	0.82
May	5	0.53	-24.0	0.16	5	0.37	-23.1	0.27	4	0.21	-462.	0.54
June	5	0.00	0.00	-	5	0.00	0.00	-	5	0.00	0.00	-
July	5	0.05	-1.00	0.71	5	0.00	-0.02	0.99	4	0.63	8.49	0.21
August	5	0.26	13.2	0.38	5	0.25	-8.09	0.39	4	0.14	93.2	0.63
September	5	0.03	0.52	0.79	5	0.02	-0.65	0.82	5	0.04	28.5	0.75
October	5	0.26	7.[illegible]	0.39	5	0.35	33.3	0.29	5	0.81	534.	0.04*
November	5	0.16	65.2	0.51	5	0.71	93.6	0.07*	5	0.59	1795.	0.13
December	5	0.06	81.1	0.70	5	0.15	45.8	0.52	4	0.63	5625.	0.20
Annual	5	0.05	-16.1	0.72	4	0.67	29.9	0.18	4	0.74	2335.	0.14
	Roseton				Danskammer				All Five Plants			
January	4	0.83	4.65	0.09*	6	0.25	2.23	0.31	5	0.52	1149.	0.17
February	4	0.24	4.05	0.51	6	0.27	2.26	0.29	5	0.42	2261.	0.24
March	4	0.88	12.7	0.06*	6	0.54	13.0	0.10*	5	0.21	-216.	0.44
April	4	0.21	55.7	0.54	6	0.48	121.	0.13	5	0.01	33.5	0.90
May	4	0.37	77.1	0.39	6	0.08	36.0	0.58	5	0.21	-96.9	0.43
June	4	0.00	0.00	-	6	0.00	0.00	-	5	0.00	0.00	-
July	5	0.01	0.033	0.85	6	0.44	-2.82	0.15	5	0.00	-0.247	0.91
August	5	0.26	17.8	0.38	6	0.36	-14.8	0.21	5	0.06	13.4	0.68
September	5	0.42	-59.8	0.23	6	0.19	-8.83	0.39	5	0.06	-7.05	0.70
October	5	0.34	-80.8	0.30	6	0.10	25.2	0.54	5	0.84	108.	0.03*
November	5	0.04	23.7	0.76	6	0.26	109.	0.30	5	0.79	419.	0.04*
December	5	0.01	-1.67	0.87	6	0.03	-4.01	0.73	5	0.05	255.	0.73
Annual	4	0.49	14.8	0.30	6	0.40	23.2	0.18	4	0.45	402.	0.33

[a]The regression model used was $Y = a + bX$, where Y is collection rate for yoy white perch and X is year. N is the number of data points (i.e., number of years). r^2 is the coefficient of determination (i.e., the fraction of variability in Y values accounted for by X). b is the slope of the straight line. P is the probability of obtaining a slope this steep (either positive or negative) if the true slope is 0.0. P values ≤ 0.10 are indicated by an asteriak (*).

469 227

effect of entrainment and impingement mortality have an opportunity to manifest itself in reducing year-class strength.

The variability in the collection rate data already available can be used as a guideline to estimate how much of a reduction in population size (and for how many years) would be required in order to detect it statistically (i.e., statistical power of the test). However, assuming that a statistically significant decrease did occur, independent evidence indicating the same result would be required to demonstrate conclusively that such a decrease was related to "overfishing" by the power plants (Christensen et al. 1976).

C. Variation in Collection Rate Among Months

Variations in mean collection rate among months are highlighted in Table 2 for young-of-the-year white perch and in Table 3 for yearling and older white perch. The pattern among months depends quite noticeability on location. In particular, at the downriver plants (Astoria, Bowline, Lovett, and Indian Point), collection rates of white perch of all ages are highest during the months of December, January, and February, with the months of November, March, and April also being quite high an occasion. In contrast, at the upriver plants (Roseton, Danskammer, and Albany) collection rates of white perch of all ages indicate two peaks, one in April and May and a second in September, October, and November. Collection rates of yearling and older white perch also tend to be relatively high at a number of the power plants in June (Table 3), which in part is an artifact due to designating May 31 - June 1 (a one-day interval) as the dividing line between 12-month old young-of-the-year and 13-month old yearlings.

D. Variation in Collection Rate Among Power Plants

Variation among power plants in the mean annual collection rate is surprisingly great (Tables 2 and 3, last column). Although data are available for only one year at Astoria, and there is no way to estimate from the data reported the collection rates for yoy and older white perch separately, it is evident that relatively few white perch are impinged at Astoria. At the other geographical extreme, it is evident that impingement of yoy white perch is relatively low at Albany compared to the other plants (Table 2), but Albany ranks third out of eight power plants with respect to the impingement of yearling and older white perch (Table 3). In fact, at Albany the impingement of yearling and older white perch is appreciably higher in absolute numbers than for yoy white perch.

For Bowline, Lovett, Indian Point, Roseton, and Danskammer, impingement of yoy white perch is higher in absolute numbers than impingement of older white perch. The values for Indian Point Unit 2 are appreciably higher than those for any other plant (see Table 2). Although the values for Indian Point Unit 1 are also high, impingement of fish at Unit 1 is not presently

Table 2. Variation in mean collection rate of young-of-the-year white perch among months and among power plants[a]

Plant	Location[b]	Number of years of data	June	July	August	September	October	November	December	January	February	March	April	May	Annual
Astoria[c]	East River	1							6.9 (1)		4.6 (2)		3.1 (3)		1.8 (9)
Bowline	37.5	5							767.1 (1)	553.6 (3)		332.9 (4)	577.9 (2)		248.0 (4)
Lovett	42	5						394.8 (2)	273.9 (4)	558.0 (1)			315.7 (3)		177.2 (5)
Indian Point Unit 1	43	2-4							3415.3 (2)	2542.9 (4)	4196.6 (1)		3219.2 (3)		1563.7 (2)
Indian Point Unit 2	43	4-6							7942.4 (3)	12610.4 (2)	18101.3 (1)		5822.8 (4)		4565.6 (1)
Indian Point Unit 3	43	1-3						1286.7 (3)	646.0 (4)	1836.2 (2)	2973.2 (1)				666.5 (3)
Roseton	65.4	4-5					246.8 (2)	286.5 (1)					149.6 (4)	233.5 (3)	97.5 (7)
Danskammer	66	6					413.0 (2)	482.9 (1)					304.0 (4)	305.9 (3)	153.2 (6)
Albany[d]	140	2				20.8 (2)	7.7 (3)						7.7 (4)	26.3 (1)	6.24 (8)

[a]Based on analysis of RATEO values in Tables A-1 through A-9 in Appendix A. The top number of each pair of numbers in the table is the mean collection rate (number of fish collected per million cubic meters). The bottom number of each pair (in parentheses) is the ranking for that mean collection rate, with one (1) denoting the highest rate. The mean monthly collection rates are averages over all years for which estimates for that month were available; these mean monthly rates were ranked from 1 to 12 for each power plant, but only entries for the four highest months are given in this table. The mean annual collection rate for each power plant is the average of the 12 mean monthly rates; these mean annual rates were ranked from 1 to 9 over power plants.

[b]River mile (RM) on the Hudson River, with RM 0 at the Battery.

[c]All ages combined at Astoria.

[d]Based on RATEO values in Table A-1 in the Appendix only for the period April 1974 - March 1976.

469 229

Table 3. Variation in mean collection rate of yearling and older white perch among months and among power plants[a]

Plant	Location[b]	Number of years of data	June	July	August	September	October	November	December	January	February	March	April	May	Annual
Bowline	37.5	5								175.3 (1)	87.9 (3)	61.0 (4)	123.1 (2)		46.1 (6)
Lovett	42	5	70.6 (1)					14.3 (3)		35.6 (2)		13.2 (4)			15.2 (8)
Indian Point Unit 1	43	2-4	117.9 (4)						127.5 (3)	162.3 (2)		184.2 (1)			84.6 (4)
Indian Point Unit 2	43	4-6							420.0 (3)	804.9 (1)	515.3 (2)	413.6 (4)			231.9 (1)
Indian Point Unit 3	43	1-3	65.4 (3)						45.3 (4)	117.2 (1)	78.6 (2)				34.4 (7)
Roseton	65.4	4-5	55.7 (3)					50.5 (4)					164.5 (1)	155.4 (2)	48.0 (5)
Danskammar	66	6	312.9 (1)	164.9 (4)									273.4 (2)	208.7 (3)	101.4 (2)
Albany[c]	140	2	164.1 (4)	212.0 (2)		218.2 (1)	211.6 (3)								90.9 (3)

[a]Based on analysis of RATE1 values in Tables A-1 through A-9 in Appendix A. The top number of each pair of numbers in the table is the mean collection rate (number of fish collected per million cubic meters). The bottom number of each pair (in parentheses) is the ranking for that mean collection rate, with one (1) denoting the highest rate. The mean monthly collection rates are averages over all years for which estimates for that month were available; these mean monthly rates were ranked from 1 to 12 for each power plant, but only entries for the four highest months are given. The mean annual collection rate for each power plant is the average of the 12 mean monthly rates; these mean annual rates were ranked from 1 to 8 over power plants.

[b]River mile (RM) on the Hudson River, with RM 0 at the Battery.

[c]Based on RATE1 values in Table A-1 in the Appendix only for the period April 1974 - March 1976.

of major concern, since the unit is not presently generating electricity. The circulating pumps are generally only operated for experimental purposes (e.g., testing of fine-mesh screens). Impingement of yoy white perch is higher at Bowline and Lovett than at Roseton and Danskammer (Table 2), but the rankings are reversed for impingement of yearling and older white perch (Table 3).

469 231

III. WHITE PERCH ABUNDANCE AND MORTALITY

A. Abundance

No estimates have been made of the absolute abundance of yearling and older white perch in the Hudson, and none of the existing data are adequate for this purpose. However, two independent estimates of the abundance of white perch juveniles are available. The first, or combined gear estimate, is derived from a combination of data from the Texas Instruments (TI) longitudinal ichthyoplankton survey, fall shoals survey, and riverwide beach seine survey. Descriptions of these surveys can be found in the Multiplant Report (TI 1975b) and the Final Research Report (FRR) [McFadden 1977 (Exhibit UT-4) and revisions and errata]. A detailed description of the method used to calculate abundances from these data was provided through a response dated February 27, 1978 to an EPA information request dated December 27, 1977. According to that response, Texas Instruments has calculated on a weekly basis the combined gear population estimates for the months of July through December 1974 and on a biweekly basis the estimates for the months of July through December 1975. These data also were provided in the response dated February 27, 1978 to the information request of December 27, 1977.

The second estimate is derived from a mark/recapture program conducted by Texas Instruments. Descriptions of the methods used in data collection and analysis can be found in the Multiplant Report and the FRR. Mark/recapture estimates of white perch juvenile abundance in October 1974 and in October 1975 are presented in a supplement to the FRR [McFadden and Lawler 1977 (Exhibit UT-3) and revisions and errata]. A comparison of the two sets of estimates reveals substantial discrepancies for both years (Table 4). The mark/recapture estimates are far larger than the corresponding combined gear estimates, 14 times as high in 1974 and 6 times as high in 1975. We believe that the mark/recapture estimates are the more reliable of the two sets for reasons discussed below.

The combined gear estimates undoubtedly underestimate the true abundance of white perch, since TI made no corrections for gear efficiency (FRR, Sections 7.9.1.2, 7.9.1.3, and 7.9.1.4). In effect, they assumed that all of the gears (beach seine, epibenthic sled, and Tucker trawl) catch 100% of the fish in their path. In reality, no gear captures 100% of the organisms in its path. Even the smallest larval fishes possess a limited ability to evade capture. Recent tests conducted by Texas Instruments (1978) indicate that the efficiency of the 100-foot beach seine at catching juvenile white perch probably ranges between 7 and 25%. The epibenthic sled and Tucker trawl were designed primarily as ichthyoplankton gear. Since the majority of juvenile white perch are well in excess of 50 mm in length by early August, the efficiency of these gears during the period of interest here (August-December) is probably very low. Although no attempts have been made to quantify the efficiency of the epibenthic sled and Tucker trawl, Kjelson and Johnson (1978) have recently reported that the 6.1-m Otter trawl, which, because of its larger size, is probably more efficient than

469 232

Table 4. Estimates of white perch juvenile abundance in the Hudson River[a]

	October, 1974	October, 1975
Combined gear estimate[b]	1.5×10^6	5.0×10^6
Mark/recapture estimate[c]	21×10^6	30×10^6

[a]Regions included in the combined gear estimates were RM 24-61 (KM 38-98) in 1974 and RM 14-76 (KM 22-122) in 1975. The region included in the mark/recapture estimates was RM 12-152 (KM 19-243) during both years.

[b]Based on extrapolation from beach seine and epibenthic sled data. Value for 1974 is mean of five weekly estimates. Value for 1975 is mean of 3 biweekly estimates.

[c]Based on fish released in the fall and recaptured the following spring.

either of the above gears at catching juvenile fish, is only about 30-50% efficient.

An additional source of error in the combined gear estimates for white perch is the design of the sampling program itself. As described in the Multiplant Report (Section III), the longitudinal river survey, fall shoals survey, and the riverwide beach seine survey are all designed for optimal sampling of striped bass. A common result of this design has been the collection of large numbers of samples in regions that contain low densities of white perch, and the collection of few samples in regions containing high densities of white perch. For example, during the period August 19-22, 1974, 34 epibenthic sled tows were conducted in the Tappan Zee region. No white perch were caught. Virtually all of the white perch collected during this period (58 out of 64) came from five tows collected from the shoal stratum of the Cornwall region.

By comparison, the mark/recapture estimates seem to be more free of major biases. Population estimates calculated from mark/recapture data are subject to several sorts of biases (Ricker 1975). Three that seem potentially important in this application, although probably only as minor biases, are: differential mortality of marked and unmarked fish, nonhomogeneous distribution of marked and unmarked fish, and the natural occurrence of "marked" fish.

If marked fish suffer more mortality than unmarked fish, either from the stress imposed by handling and marking or because marked fish are more vulnerable to predators or disease than are unmarked fish, then an overestimate of the true population size can result. TI addressed this problem with experiments conducted in 1973 (described in the Multiplant Report) and derived correction factors to account for short-term (14 days) handling mortality of marked white perch. The possibility that long-term survival of marked white perch under natural conditions may be lower than that of unmarked fish has not been evaluated by TI.

The Peterson method of estimating population size from mark/recapture data, the method chosen by TI, requires that marked fish mix completely with the unmarked population prior to recapture. If this mixing does not occur, a bias can be introduced into the results. In particular, if sampling during the recapture period is concentrated in regions where marked fish are relatively abundant in comparison to their true proportion in the population, then the true population size will be underestimated. In the Multiplant Report, TI cited insufficient mixing as a reason for discarding estimates of the number of juvenile white perch in the Hudson in the fall of 1973. In this case fish were both marked and recaptured in the fall. Insufficient mixing is probably not a problem with the fall 1974 and 1975 estimates, because fish were released in the fall and recaptured during the following spring. From the distributional data presented in the FRR (Section 6.1) and from the seasonal patterns of impingement discussed in Section II of this report, it is evident that white perch juveniles migrate downstream to Haverstraw Bay and the Tappan Zee in the late fall and overwinter there before returning upstream in the spring. These migrations would appear to provide ample opportunity for mixing.

TI uses finclips to mark juvenile white perch and striped bass. Natural loss of fins is not uncommon, and the mistaking of fish that have lost fins for marked fish can cause underestimates of population size. TI has discovered several such "fin anomalies." According to the . plant Report, in 1974 it was discovered that about 0.3% of unmarked juvenile white perch were missing one or both pelvic fins. This finding necessitated the recalculation (by excluding fish marked with single or double pelvic finclips) of mark/recapture estimates for the 1973 year-class. Mark/recapture estimates of the August-September, 1975 abundance of white perch juveniles (presented in the FRR, Exhibit UT-4) were discarded (McFadden and Lawler 1977, Exhibit UT-3) after it was discovered that a mark type (anal finclip) used in the August-September, 1975 release also occurs among unmarked fish. To this date no fin anomalies have been noted that involve any of the finclip types (six marks were used; five of these were double finclips) used in the October-November, 1974 and October, 1975 releases. We presently believe that the Peterson mark/recapture estimates of white perch juvenile abundance in October of 1974 and 1975 are the best available estimates of the abundance of the 1974 and 1975 year-classes. It is these estimates that are used in the direct impact assessment contained in Section IV.

B. Mortality

Dew (1978) has used the catch-curve method to calculate an average annual mortality rate for age zero and older white perch (Table 5). His results are derived from bottom trawl data collected in the vicinity of the Bowline Point Generating Station between 1971 and 1976. We believe, however, that age zero fish should not have been used in this analysis, since their mortality is probably higher than that of yearling and older fish. We also believe that Dew's method of analysis was not the most appropriate application of the catch-curve methodology. Dew estimated the annual fractional mortality separately for each age-class, grouping together all fish of age 5 and older. He then averaged the individual estimates (value for A of 0.53 in Table 5). Robson and Chapman (1961) have described an entirely different method of calculating average annual mortality when all fish older than a certain age are grouped together. As Robson and Chapman's method has been proven to be unbiased (whereas Dew's method has not) under the assumptions of the catch-curve method, and since its statistical properties are known (which is not the case with Dew's method), we believe that it is superior to Dew's method. Therefore, we have redone Dew's analysis, excluding the age zero fish and using the method of Robson and Chapman (1961), to calculate an annual mortality rate for yearling and older white perch of approximately 50% (value for A of 0.49 in Table 5). This value is undoubtedly in error to some extent, since the catch-curve method is sensitive to fluctuations in year-class strength (Robson and Chapman, 1961). However, it is in good agreement with values obtained by

Table 5. Catch-curve estimates of white perch mortality based on bottom trawl data from the Bowline Point vicinity, 1971-1976

	Annual fractional mortality (A)	Annual instantaneous mortality rate (Z)
Original values[a] (ages 0 through 5+)	0.5349	0.7655
Recalculated values[b] (ages 1 through 5+)	0.4854	0.6644

[a]Calculated by Dew, 1978.

[b]Recalculated by excluding age 0 fish and using the method of Robson and Chapman, 1961.

Wallace (1971) for age I-IV white perch in the Delaware River: 54% for males and 58% for females. We believe at this time that 50% is a reasonable estimate, and this is the value used in our direct impact assessment.

None of the available data appears adequate for deriving reliable estimates of total mortality in impingeable young-of-the year white perch. Using the method employed by TI to estimate mortality in juvenile striped bass, we attempted to calculate a mortality rate using TI's weekly combined gear estimates of white perch abundance. The method involves regressing the natural logarithm of the population estimate against time (in days) from the end of July to mid-December. The slope of the regression line is an estimate of the daily instantaneous mortality rate. Using this method we obtained no useful results, because there was no discernible decline in the combined gear estimates between early August and mid-December. We performed a similar analysis using data from only a single gear, the epibenthic sled, and a single sampling program, the fall shoals survey, in the hope of eliminating variation due to pooling different gears and different sampling programs. Although the epibenthic sled samples during the fall shoals survey seemed like the best single source of data from which to derive estimates of total mortality, this analysis was even less successful: population estimates based on epibenthic sled data alone increased between August and December, both in 1974 and in 1975.

We have, therefore, used a range of values for young-of-the-year mortality in our direct impact assessment. As a high estimate we have used the value of 80% assumed by McFadden and Lawler (1977, Exhibit UT-3). Given the absence of a seasonal decline in the combined gear and epibenthic sled abundance estimates, this value may be too high. Alternatively, we have assumed that the mortality among impingeable young-of-the-year is identical to that among yearling and older fish, i.e., that the annual fractional mortality of young-of-the-year white perch is about 50%. Since, because of their smaller size, young-of-the-year should be more vulnerable to predators than are older white perch, this value may be too low.

469 237

IV. ESTIMATION OF CONDITIONAL MORTALITY RATE AND EXPLOITATION RATE DUE TO IMPINGEMENT

The empirical model of impingement impact used to estimate the conditional mortality rate and exploitation rate due to impingement for the Hudson River white perch population is described in Barnthouse et al. (1979). The model requires: (1) estimates of the initial number of young-of-the-year in the Hudson River white perch population at the time they first become vulnerable to impingement, (2) estimates of the rate of either total or natural mortality during the period of vulnerability to impingement, and (3) monthly estimates of the number of white perch impinged by year class.

For the purpose of comparing alternative assumptions about the age of impinged fish, it is desirable to formulate the model in terms of natural rather than total mortality, even though in practice only total mortality can be directly estimated from field data. This is not a major problem, however, since it is possible to calculate the conditional natural mortality rate, given the total mortality rate and the impingement exploitation rate (Barnthouse et al. 1979). In addition, when natural mortality is high relative to impingement mortality, total mortality and natural mortality are nearly numerically identical. For example, the natural conditional mortality rate calculated by Barnthouse et al. (1979) for impingeable young-of-the-year striped bass was 0.79, only slightly smaller than the total mortality rate of 0.8. Similarly, we believe that it is reasonable to use the same value (0.5) as an approximation of both the natural conditional mortality rate and total mortality rate in yearling and older white perch.

The estimates of initial population size and natural mortality rates are given in Table 6, and the bases for these estimates are discussed in the preceding section of this report (Section III). Monthly estimates of the number of white perch impinged by year class are given in Table 7. These estimates include white perch impinged at all the power plants discussed in Section II and in the Appendix, except Astoria. Although impingement data are not available for the Albany power plant except for the period April 1974 - March 1976, Albany was operating continuously during the period June 1974 through December 1977, which is the period considered in this report in estimating conditional mortality rates and exploitation rates due to impingement for the 1974 and 1975 year classes. Consequently, the number of young-of-the-year and older white perch collected at Albany was approximated for each month from April 1976 - December 1977, as described in Table A-1 of the Appendix.

The value of a sexually immature fish to a population increases with its age, because its probability of surviving to sexual maturity increases. For this reason the impact to the population of killing a sexually immature fish increases with its age. If, as the utilities assume, the total mortality of juvenile white perch between July of year 0 and July of year 1 is 80%, then a single yearling impinged in July is worth five juveniles

469 238

Table 6. Initial population sizes and mortality estimates used in the empirical model of impingement impact to estimate the conditional mortality rate and exploitation rate due to impingement for the Hudson River white perch population

Initial population size[a]		Natural mortality[b]	Year class 1974	Year class 1975
$P_{October\ 1}$[c] ($\times 10^6$)	LB		12	21
	BE		21	30
	UB		39	45
$P_{July\ 16}$[d] ($\times 10^6$)	LB	Low	13.9	24.3
		High	16.8	29.4
	BE	Low	24.3	34.7
		High	29.4	41.9
	UB	Low	45.1	52.0
		High	54.5	62.9

[a]BE denotes the best estimate of initial population size. LB and UB denote the lower and upper bounds, respectively, of the 95% confidence interval about the best estimate.

[b]Low natural mortality: r_n = 0.001899 per day for the entire period of vulnerability to impingement. This instantaneous natural mortality rate corresponds to an annual (i.e., 365 days) conditional mortality rate due to all causes of mortality other than impingement of 0.5.

High natural mortality: r_n = 0.004409 per day from July 16 as young-of-the-year to May 31 of the following year just as they become yearlings. This instantaneous natural mortality rate corresponds to an annual (i.e., 365 days) conditional mortality rate due to all causes other than impingement of 0.8. r_n = 0.001899 per day from June 1 as yearlings until the end of the period of vulnerability.

[c]$P_{October\ 1}$ denotes the size of the Hudson River young-of-the-year white perch population on October 1, as estimated by Texas Instruments using mark-recapture techniques (McFadden and Lawler, 1977, p. 2-VII-2, as modified by errata).

[d]$P_{July\ 16}$ denotes the size of the Hudson River young-of-the-year white perch population on July 16. It is calculated using the equation

$$P_{July\ 16} = P_{October\ 1}/\exp(-76\ r_n)\ ,$$

where values for $P_{October\ 1}$ and r_n are given elsewhere in this table and 76 is the number of days between July 16 and October 1.

Table 7. Monthly estimates of the number of white perch impinged at all the Hudson River power plants combined for the 1974 and 1975 year classes[a]

Age (years)	Month	Year class: 1974, Number of years of vulnerability: 2	1974: 3	1975, Number of years of vulnerability: 2	1975: 3
0	6	0		0	
	7	3,48[illegible]		8,898	
	8	14,8[illegible]7		97,910	
	9	26,239		83,980	
	10	112,957		93,888	
	11	245,492		239,150	
	12	607,434		348,596	
	1	415,724		589,206	
	2	270,751		182,891	
	3	139,751		130,261	
	4	609,090		111,820	
	5	91,910		40,1[illegible]1	
1	6	37,242	18,621	27,014	13,507
	7	22,126	11,063	13,835	6,918
	8	14,122	7,061	6,770	3,385
	9	19,924	9,962	13,791	6,896
	10	19,534	9,767	25,676	12,838
	11	28,005	14,002	12,552	6,276
	12	7,803	3,902	48,102	24,051
	1	38,078	19,039	143,010	71,505
	2	9,293	4,646	43,558	21,779
	3	[illegible]2,444	6.222	49,579	24,790
	[illegible]	[illegible]4,103	7,052	38,692	19,346
	[illegible]	7,612	3,806	56,365	28,182
2	6		13,507		35,710
	7		6,918		8,805
	8		3,385		12,662
	9		6,896		8,736
	10		12,838		17,362
	11		[illegible] 276		19,145
	12		24,051		10,890
	1		71,505		
	2		21,779		
	3		24,790		
	4		19,346		
	5		28,182		

[a]Monthly values for number of yoy white perch impinged were calculated by summing the NUMBERO values [illegible] Tables A-1, and A-3 through A-9 in Appendix A over power plants for the appropriate month and year.

Monthly values for number of yearling white perch impinged were calculated either by summing the NUMBER1 values over power plants for the appropriate month and year (2 years of vulnerability, corresponding to the assumption that 100% of the yearling and older white perch impinged were yearlings) or by summing the NUMBER1 values over power plants and dividing by 2 (3 years of vulnerability, corresponding to the assumption that 50% of the yearling and older white perch impinged are yearlings).

Monthly values for number of 2-year-old white perch impinged were calculated by summing the NUMBER1 values over power plants, dividing by 2, and tabulating the result for the given month, but one year later (3-years of vulnerability only, corresponding to the assumption that 50% of the yearling and older white perch impinged are 2-year olds).

impinged 12 months earlier. If mortality between year 1 and year 2 is 50%, then each 2-year-old white perch is worth two yearlings or ten young-of-the-year. Even though the number of yearling and older white perch impinged each year constitutes only about 10% of the total white perch impingement, the impact of killing these fish is quite substantial.

As indicated in Table 7, two alternative assumptions were made concerning the age of impinged yearling and older white perch. For one case, it was assumed that all white perch impinged that are yearlings and older are yearlings, resulting in two years of vulnerability to impingement. For the other case, it was assumed that of the yearling and older white perch impinged, 50% were yearlings and 50% were 2-year olds, resulting in three years of vulnerability to impingement. It is our judgment, based on length-frequency data of impinged white perch at Bowline, Indian Point, and Roseton (see Appendix, Tables A-3, A-5, 6 & 7, and A-9), that the true age composition of yearling and older white perch impinged (which includes some white perch older than 2 years), results in an effective split between yearlings and 2-year olds that is between the two assumptions just given, that is, between 100% yearlings - 0% 2-year olds and 50% yearlings - 50% 2-year olds. Because of the lack of 1978 impingement data for January - May, no model estimates of impingement impact assuming three years of vulnerability are given for the 1975 year class.

With this exception, estimates of conditional mortality rate and exploitation rate due to impingement are given in Table 8 for the 1974 and 1975 year classes for combinations of estimates and assumptions involving initial population size (low, best estimate, and high), natural mortality (low and high), and number of years of vulnerability (2 and 3 years).

Estimates of the conditional mortality rate due to impingement are especially relevant in assessing the effects of power plant impingement, since they are equivalent to estimates of the fractional (or percent) reduction in the size of a year class due to impingement, assuming no compensation (see Barnthouse et al. 1979). As indicated by the values in Table 8, percent reduction values (obtained by multiplying by 100) are greater (1) the smaller the initial population size, (2) with high natural mortality rates as opposed to low, and (3) assuming three years of vulnerability instead of two. Furthermore, assuming approximately comparable degrees of uncertainty in the choices of low and high estimates of initial population size, natural mortality, and number of years of vulnerability, it appears that the estimates of percent reduction are most sensitive to (i.e., vary most widely depending on) estimates of initial population size, least sensitive to the number of years of vulnerability assumed, and intermediately sensitive to estimates of natural mortality.

The percent reduction values range from 9.5 - 45% for the 1974 year class and from 7.7 - 24% for the 1975 year class, assuming only two years of vulnerability. Assuming three years of vulnerability, the percent reduction values range from 12-59% for the 1974 year class. For the 1975 year class, percent reduction values cannot be calculated because 1978 impingement data are not presently available.

Table 8. Estimates of conditional mortality rate and exploitation rate (in parentheses) due to impingement for the 1974 and 1975 year classes of the Hudson River white perch population for combinations of estimates and assumptions involving initial population size, natural mortality, and number of years of vulnerability[a]

		Initial Population Size[c]					
		Low		Best estimate		High	
		Natural mortality rate[d]		Natural mortality rate[d]		Natural mortality rate[d]	
Number of years of vulnerability[b]	Year class	Low	High	Low	High	Low	High
2	1974	0.309	0.446	0.177	0.255	0.095	0.137
		(0.163)	(0.200)	(0.094)	(0.114)	(0.051)	(0.061)
	1975	0.166	0.245	0.116	0.172	0.077	0.115
		(0.082)	(0.099)	(0.057)	(0.069)	(0.038)	(0.046)
3	1974	0.387	0.588	0.221	0.336	0.119	0.181
		(0.172)	(0.209)	(0.099)	(0.119)	(0.053)	(0.064)
	1975	--	--	--	--	--	--

[a]Total conditional impingement mortality rate calculated using Eq. (11) in Barnthouse et al. (1979), i.e.,

$$m_T = 1 - \prod_{i=1}^{12} (1 - m_i)$$

, except with the index i running from 1 to 24 (2 years of vulnerability) or 1 to 36 (3 years of vulnerability). The individual monthly m_i values were calculated in sequence using Eq. (2) and then Eq. (10) in Barnthouse et al. (1979). Total conditional impingement mortality rates are equal to fractional (or percent) reductions in year-class strength due to impingement, assuming no compensation.

Exploitation rate calculated by dividing the total number of white perch impinged in a year class during the entire period of vulnerability by the size of the yoy population at the start of the period of vulnerability.

[b]See Table 7.

[c]See Table 6.

[d]See footnote b to Table 6.

469 242

Exploitation rates show the same pattern of variation as the conditional mortality rates with respect to values used for initial population size, natural mortality, and number of years of vulnerability (Table 8). The exploitation rates range from 5.1 - 20.0% for the 1974 year class and from 3.8 - 9.9% for the 1975 year class, assuming only two years of vulnerability. Assuming three years of vulnerability, the exploitation rates range from 5.3 - 20.9% for the 1974 year class, and, although they cannot be calculated at this time, they would be expected to be lower for the 1975 year class. As discussed in Barnthouse et al. (1979), because there are competing sources of mortality and each an organism can die only once, an exploitation rate is always lower than the corresponding conditional mortality rate. However, as stated above, it is the conditional mortality rate due to impingement that is equivalent to percent reduction in the size of the year class. Because of this equivalence, the conditional mortality rate is a more meaningful measure of impact than is the exploitation rate.

V. DISCUSSION

A. Comparison With Utilities' Results

The utilities have estimated the conditional mortality rate and exploitation rate due to impingement of white perch for the 1974 year class (Table 9).

> Impingement impact for the 1974 year class was estimated assuming that 90% of the July 1974-June 1975 impingement consisted of the 1974 year class. Exploitation of this year class was calculated to be 4.4% at Indian Point Unit 2 and 5.9% for the multiplant case (Table 2-VII-1). These exploitation rates are equivalent to conditional mortality rates of 8.5% for Indian Point ar 11.2% for multiplant with an assumed total mortality rate of 80%. (McFadden and Lawler 1977, p. 2-VII-3)

In terms of the comparability of assumptions and input values used in the utilities' methodology and our methodology, the utilities' conditional mortality rate of 11.3% and exploitation rate of 5.9% in Table 9 for the multiplant case can be compared with our estimates in Table 8 (two years of vulnerability, best estimate of initial population size, and high natural mortality) of a conditional mortality rate of 25.5% and an exploitation rate of 11.4%. The two sets of estimates differ by approximately a factor of 2 for several reasons (we have not attempted to estimate how much of the two-fold difference is due to each of the following reasons):

(1) We included the Albany, Danskammer, and Lovett Steam Electric Generating Stations, while they did not. These three plants were operating during the years 1974 - 1977 and were impinging white perch. Thus, they should be included in any evaluation of the impact of impingement on the Hudson River white perch population.

(2) We included Indian Point Unit 1, which operated continuously (at least the circulating water pumps) from June 1974 through August 1975, while they did not. Since this unit was operating during part of the period of interest and was impinging white perch, it also should be included in any evaluation of the impact of impingement on the Hudson River white perch population.

(3) Our values reflect two years of vulnerability to impingement, while their values reflect only one year of vulnerability (i.e., they ignored impingement of yearling and older white perch from the 1974 year class past June 1975). Since yearling and older white perch, in fact, are impinged in appreciable numbers, they must be considered as such in any credible evaluation of the impact of impingement on the Hudson River white perch population. There is no scientifically justifiable methodological reason or biological reason for not including these yearling and older white perch in such an evaluation.

469 244

Table 9. Relevant parts of Table 2-VII-1 in McFadden and Lawler (1977)

Power plant	Number impinged[a]	Exploitation rate (u)	Conditional mortality (m)
Bowline	473,043	0.0137	0.0273
Roseton	52,025	0.0015	0.0030
Indian Point Unit 2	1,520,317[b]	0.0441	0.0849
Multiplant	2,045,385	0.0594	0.1126

[a]Total impingement, of which 90% are assumed to be 1974 year class.

[b]Includes 948 impinged at Indian Point Unit 3.

(4) We used available data to estimate on a monthly and plant-specific basis the percent of white perch impinged from June 1974 - June 1975 that were from the 1974 year class, whereas they assumed 90%. As the PERCENTO values in Tables A-1, and A-3 through A-9 indicate, their assumption of 90% young-of-the-year may be justified for Lovett and for the three Indian Point units. However, the utilities' assumption of 90% young-of-the-year is clearly too high for Albany, Bowline, Danskammer, and Roseton.

(5) We used the methodology presented in Barnthouse et al. (1979), which permitted us to take into account monthly variations in collection rates, whereas the utilities' methodology implicitly assumes a constant vulnerability. In reality, as discussed in Section II, the collection rate fluctuates appreciably on a monthly basis, with rates being substantially higher from December - May than from June - November (Tables 2 and 3). (Also see Table 3 and associated text in Barnthouse et al. (1979) for a comparison using constant versus variable collection rates to estimate the conditional mortality rate due to impingement.)

The utilities' choices at <u>every one</u> of the above five "decision points" affect the results in the same direction, namely, to lower the estimates of impingement impact. Yet, given that the purpose of the utilities' analysis and of our own analysis ought to be to realistically and objectively estimate the percent reduction in the strength of the 1974 year class of white perch in the Hudson River due to impingement at power plants, our choices at each of the five decision points is scientifically more sound and defensible for the reasons we have given.

B. <u>Is there a problem?</u>

This testimony presents two independent lines of evidence evaluating the impingement losses of white perch at the power plants on the Hudson River. The first line of evidence, the analysis of the variation in collection rate among years (Section II.B), suggests that there is not yet an obvious problem, but that it is too soon to be sure. The second line of evidence, the estimates of conditional mortality rate due to impingement (Section IV), suggests that the level of impingement impact cannot be assessed as acceptable from the point of view of the white perch population. These two lines of evidence are briefly elaborated on in the following two paragraphs.

The collection rates provide estimates of year-class strength on a relative scale. As such, they reflect the effect of entrainment and impingement losses during the preceding months, as well as the effect of any compensatory mechanisms which might alter survival during the preceding months. Regression analyses on collection rates of impinged young-of-the-year white perch suggest that there has been no systematic change in the size of the white perch population during the period 1972 - 1977 (Section II.B). In particular, there is little evidence of a statistically significant downward trend. However, given the large variability in collection rates used in these regressions, the time series are relatively short (i.e., 5-6 years), and thus, the statistical power of the test for a trend is not high. In addition, because of the age of sexual maturity for females and the multiple age-class composition of the spawning population of females, and because impingement mortality increased appreciably starting in 1973 and 1974, a systematic decrease in year-class strength due to impingement mortality would only start to manifest itself with the 1977 (or 1978) and subsequent year classes.

The estimates of percent reduction in year-class strength due to impingement that are presented in Table 8 cover a broad range, as discussed in Section IV. Our analysis shows that the level of impingement impact was probably greater than 20% for the 1974 year class and was probably greater than 15% for the 1975 year class. These estimates do not include consideration of entrainment, so that the total power plant conditional mortality rate is obviously greater than the values given here for impingement only. Given the information presently available, it is our judgment that this level of impingement impact is not acceptable from the point of view of the white perch population.

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469 248

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APPENDIX

IMPINGEMENT DATA BASE

The data base is presented by power plant, arranged in alphabetical order

TABLE A-1

WHITE PERCH IMPINGEMENT DATA FOR THE ALBANY STEAM ELECTRIC GENERATING STATION

April 1974 - March 1975: Ref. (1)

RATE (collection rate):[1] calculated from monthly data on average observed number of fish of all species collected per million gallons of intake flow at all units (from Table 3, Column B, Plant Av.), and monthly data on percentage composition by species of the fish collected (from Table 4).

NUMBER (number collected): calculated from monthly data on estimated number of fish of all species collected at all units (from Table 2, Column D, Total) and monthly data on percentage composition by species of the fish collected (from Table 4).

PERCENTO (percent of the white perch collected that were young-of-the-year): calculated with the aid of graph paper and a dissecting microscope from the monthly plots in Fig. 10 of frequency versus length intervals of white perch collected at the Albany Steam Electric Generating Station for each month April through November 1974. The "DIVISION" criteria specified by Texas Instruments were used as the cut-off length between young-of-the-year and yearling white perch (see Table A-10 in this appendix).

April 1975 - March 1976: Ref. (2)

RATE (collection rate):[1] calculated from monthly data on average observed number of fish of all species collected per million gallons of intake flow at all units (from Table IVC-16) and monthly data on percentage composition by species of the fish collected (from Table IVC-14).

NUMBER (number collected): calculated from the monthly collection rates (RATE) described immediately above and monthly values of average daily plant flow for all units in millions of gallons per day times the number of days in the particular month.

469 251

TABLE A-1 (continued)

PERCENTO (percent of the white perch collected that were young-of-the-year): calculated with the aid of graph paper and a dissecting microscope from the plots in Fig. IVC-6 of relative frequency versus length intervals of white perch collected at the Albany Steam Electric Generating Station for each month May through November 1975. The "DIVISION" criteria specified by Texas Instruments were used as the cut-off point between young-of-the-year and yearling white perch (see Table A-10 in this appendix).

RATE, NUMBER, and PERCENTO values were approximated as follows for each month during 1974 through 1977 for which estimates were not directly available from Refs. (1) and (2). These approximations were necessary in order to have a complete data set with which to estimate exploitation rates and the conditional rates of mortality due to impingement (see Section IV).

RATE and NUMBER: approximations for each month were calculated as the average of the two monthly estimates available from the period April 1974 through March 1976. These approximations were used for January-March 1974 and April 1976 - December 1977.

PERCENTO: for May through November approximations were calculated as just described for RATE and NUMBER. The approximation for November was also used for the months of December and January of all years. The April 1974 value (no estimate for April 1975 was available) was used as the approximation for April 1975, 1976, and 1977 and for the months of February and March of all years.

RATEO = PERCENTO · RATE/100 and RATE1 = RATE - RATEO.

NUMBERO = PERCENTO · NUMBER/100 and NUMBER1 = NUMBER - NUMBERO.

RATE, NUMBER, and PERCENTO are defined above. RATEO and RATE1 are the collection rates for young-of-the-year and for yearling and older white perch, respectively. NUMBERO and NUMBER1 are number collected for young-of-the-year and for yearling and older white perch, respectively.

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[1]All collection rates were converted from number of white perch collected per million gallons to number of white perch collected per million cubic meters by multiplying by 264.17 gallons per cubic meter. Collection rates were assumed to equal impingement mortality rates.

TABLE A-1 (continued)

PLANT=ALBANY

YEAR	MONTH	RATE	NUMBER	PERCENTO	RATEO	RATE1	NUMBERO	NUMBER1
1974	1	0.000	3.5	10.70	0.0000	0.000	0.37	3.1
1974	2	0.528	15.5	19.60	0.1036	0.425	3.04	12.5
1974	3	6.868	260.5	19.60	1.3462	5.522	51.05	209.4
1974	4	77.138	3923.0	19.60	15.1190	62.019	768.91	3154.1
1974	5	95.101	5518.0	35.50	33.7609	61.340	1958.89	3559.1
1974	6	133.934	7717.0	0.00	0.0000	133.934	0.00	7717.0
1974	7	211.072	12518.0	0.00	0.0000	211.072	0.00	12518.0
1974	8	105.932	6294.0	5.88	6.2288	99.703	370.09	5923.9
1974	9	178.051	9868.0	2.44	4.3444	173.706	240.78	9627.2
1974	10	305.381	17325.0	1.79	5.4663	299.914	310.12	17014.9
1974	11	61.023	3516.0	9.43	5.7545	55.259	331.56	3184.[illegible]
1974	12	0.264	21.0	10.70	0.0283	0.236	2.25	18.8
1975	1	0.000	7.0	10.70	0.0000	0.000	0.75	6.3
1975	2	0.793	31.0	19.60	0.[illegible]553	0.637	6.08	24.9
1975	3	0.264	10.0	19.60	0.0518	0.212	1.96	8.0
1975	4	1.057	45.0	19.60	0.2071	0.850	8.82	36.2
1975	5	285.568	11717.0	6.58	18.7904	266.777	770.98	10946.0
1975	6	118.084	5583.0	0.00	0.0000	118.084	0.00	5583.0
1975	7	212.921	8336.0	0.00	0.0000	212.921	0.00	8336.0
1975	8	29.851	1467.0	6.12	1.8269	28.024	89.78	1377.2
1975	9	299.833	14714.0	12.40	37.1793	262.654	1824.54	12889.5
1975	10	133.406	6036.0	7.52	10.0321	123.374	453.91	5582.1
1975	11	69.213	2906.0	11.90	8.2363	60.976	345.81	2560.2
1975	12	0.264	16.0	10.70	0.0283	0.236	1.71	14.3
1976	1	0.000	0.0	10.70	0.0000	0.000	0.00	0.0
1976	2	0.000	[illegible]	19.60	0.0000	0.000	0.00	[illegible]
1976	3	13.208	511.0	19.60	2.5889	10.620	100.15	410.8
1976	4	39.097	1984.0	19.60	7.6630	31.434	388.86	1595.1
1976	5	190.202	8617.5	21.00	39.9425	150.260	1809.63	6807.8
1976	6	126.009	8026.5	0.00	0.0000	126.009	0.00	8026.5
1976	7	211.864	10427.0	0.00	0.0000	211.864	0.00	10427.0
1976	8	67.892	3880.5	6.00	4.0735	63.818	232.83	3647.7
1976	9	238.810	12291.0	7.42	17.7197	221.090	911.99	11379.0
1976	10	219.261	11580.5	4.66	10.2176	209.044	544.31	11136.2
1976	11	64.986	3211.0	10.70	6.9535	58.032	343.58	2867.4
1976	12	0.264	18.5	10.70	0.0283	0.236	1.98	16.5
1977	1	0.000	3.5	10.70	0.0000	0.000	0.37	3.1
1977	2	0.528	15.5	19.60	0.1036	0.425	3.04	12.5
1977	3	6.868	260.5	19.60	1.3462	5.522	51.05	209.4
1977	4	39.097	1984.0	19.60	7.6630	31.434	388.86	1595.1
1977	5	190.202	8617.5	21.00	39.9425	150.260	1809.68	6807.8
1977	6	126.009	8026.5	0.00	0.0000	126.009	0.00	8026.5
1977	7	211.864	10427.0	0.00	0.0000	211.864	0.00	10427.0
1977	8	67.892	3880.5	6.00	4.0735	63.818	232.83	3647.7
1977	9	238.810	12291.0	7.42	17.7197	221.090	911.99	11379.0
1977	10	219.261	11580.5	4.66	10.2176	209.044	544.31	11136.2
1977	11	64.986	3211.0	10.70	6.9535	58.032	343.58	2867.4
1977	12	0.264	18.5	10.70	0.0283	0.236	1.98	16.5

REFERENCES FOR TABLE A-1

1. Lawler, Matusky & Skelly Engineers. Albany Steam Electric Generating Station Impingement Survey (April 1974 - March 1975). LMS Project No. 191-027, prepared for Niagara Mohawk Power Corporation, June 1975.

2. Lawler, Matusky & Skelly Engineers. Albany Steam Electric Generating Station, 316(a) Demonstration Submission, NPDES Permit NY 0005959. Prepared for Niagara Mohawk Power Corporation, 1976.

TABLE A-2

WHITE PERCH IMPINGEMENT DATA
FOR THE ASTORIA GENERATING STATION (Ref. 1)

RATE (collection rate):[1] calculated from monthly data on observed number of fish and crustaceans of all species collected per million gallons of intake flow at Units 1-5 (from Table 12) and monthly data on the percent of the total number of fish and crustaceans collected that were white perch (calculated from data in Table 4).

NUMBER (number collected): calculated from the collection rate (RATE) described immediately above and the value for full flow through Units 1-6 in gallons per minute (from Table 1) times the number of minutes in the particular month.

Data with which to calculate RATE and NUMBER values were available only for the period January 1972 - December 1972. No data were available from which to estimate PERCENTO, the percent of the white perch collected at Astoria that were young-of-the-year. The white perch impingement data for Astoria have been used only in Section II.B on seasonal variations in collection rates among the different power plants.

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[1]All collection rates were converted from number of white perch collected per million gallons to number of white perch collected per million cubic meters by multiplying by 264.17 gallons per cubic meter. Collection rates were assumed to equal impingement mortality rates.

469 255

TABLE A- (continued)

PLANT=ASTORIA

YEAR	MONTH	RATE	NUMBER	PERCENT0	RATE0	RATE1	NUMBER0	NUMBER1
1972	1	1.04611	251	.	.	.	.	.
1972	2	4.62297	1041	.	.	.	.	.
1972	3	1.60087	399	.	.	.	.	.
1972	4	3.13570	757	.	.	.	.	.
1972	5	2.09223	522	.	.	.	.	.
1972	6	0.84534	204	.	.	.	.	.
1972	7	0.87440	218	.	.	.	.	.
1972	8	0.00000	0	.	.	.	.	.
1972	9	0.00000	0	.	.	.	.	.
1972	10	0.00000	0	.	.	.	.	.
1972	11	0.00000	0	.	.	.	.	.
1972	12	6.94767	1733	.	.	.	.	.

REFERENCE FOR TABLE A-2

1. Quirk, Lawler and Matusky Engineers. A Study of Impinged Organisms at the Astoria Generating Station. QL&M Project No. 115-16, prepared for Consolidated Edison Company of New York, Inc., September 1973.

TABLE A-3

WHITE PERCH IMPINGEMENT DATA FOR THE BOWLINE POINT GENERATING STATION

January 1973 - December 1976: Ref. (1)

Values for RATE (collection rate)[1] and NUMBER (number collected) were taken directly from data sheets in Ref. (1).

January 1977 - December 1977: Ref. (2)

Values for RATE (collection rate)[1] and NUMBER (number collected) were taken directly from data sheets in Ref. (2).

PERCENTO (percent of the white perch collected that were young-of-the year):

January 1975 - December 1976: Calculated from monthly data on length-frequency in 1-centimeter length intervals of white perch in impingement collections (from Tables 10.2-13 and 10.2-14 in Ref. (3)). The "DIVISION" criteria specified by Texas Instruments were used as the cut-off length between young-of-the-year and yearling white perch (see Table A-10 in this appendix).

January 1973 - December 1974 and January 1977 - December 1977: in the absence of monthly values during these two periods, estimates were calculated as the average of the 1975 and 1976 PERCENTO values for each month.

$$RATE0 = PERCENT0 \cdot RATE/100 \text{ and } RATE1 = RATE - RATE0.$$

$$NUMBER0 = PERCENT0 \cdot NUMBER/100 \text{ and } NUMBER1 = NUMBER - NUMBER0.$$

RATE, NUMBER, and PERCENTO are defined above. RATEO and RATE1 are the collection rates for young-of-the-year and for yearling and older white perch, respectively. NUMBERO and NUMBER1 are number collected for young-of-the-year and for yearling and older white perch, respectively.

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[1]All collection rates were converted from number of white perch collected per million gallons to number of white perch collected per million cubic meters by multiplying by 264.17 gallons per cubic meter. Collection rates were assumed to equal impingement mortality rates.

TABLE A-3 (continued)

PLANT=BOWLINE

YEAR	MONTH	RATE	NUMBER	PERCENT0	RATE0	RATE1	NUMBER0	NUMBER1
1973	1	296.13	17021	82.6	244.51	51.527	14059	2961.7
1973	2	353.99	15194	78.8	278.94	75.045	12753	3431.0
1973	3	288.74	4476	84.8	244.85	43.839	3796	680.4
1973	4	462.56	23903	84.8	392.25	70.309	20270	3633.3
1973	5	235.90	14739	69.0	162.77	73.130	10170	4569.1
1973	6	19.55	809	0.0	0.00	19.549	0	809.0
1973	7	13.74	692	44.8	6.15	7.583	310	382.0
1973	8	45.44	2724	78.2	35.53	9.905	2130	593.8
1973	9	4.76	285	81.6	3.88	0.875	233	52.4
1973	10	5.02	326	92.6	4.65	0.371	302	24.1
1973	11	9.51	500	96.0	9.13	0.380	480	20.0
1973	12	373.01	18060	98.3	366.67	6.341	17753	307.0
1974	1	1092.87	58425	82.6	902.71	190.150	48259	10166.0
1974	2	1219.94	47008	78.8	961.31	258.627	37042	9965.7
1974	3	968.98	51689	84.8	821.59	147.234	43832	7856.7
1974	4	922.48	55907	84.8	782.26	140.217	48257	8649.9
1974	5	91.40	2901	69.0	63.07	28.335	2002	899.3
1974	6	18.49	1423	0.0	0.00	18.492	0	1423.0
1974	7	5.28	533	44.8	2.37	2.915	239	294.2
1974	8	3.43	372	78.2	2.69	0.749	291	81.1
1974	9	4.49	529	81.6	3.66	0.825	432	97.3
1974	10	29.32	3697	92.6	27.15	2.170	3423	273.6
1974	11	497.17	43360	96.0	477.28	19.887	41626	1734.4
1974	12	845.08	90095	98.3	830.71	14.366	88563	1531.6
1975	1	1898.58	176382	69.4	1317.62	580.958	122409	53972.9
1975	2	97.21	7354	68.0	66.11	31.109	5001	2353.3
1975	3	303.00	24651	71.8	217.56	85.447	17699	6951.6
1975	4	1350.70	113509	72.2	975.21	375.495	81953	31555.5
1975	5	173.82	9488	38.1	66.23	107.597	3615	5873.1
1975	6	15.06	1228	0.0	0.00	15.058	0	1228.0
1975	7	19.28	1809	89.5	17.26	2.025	1619	189.9
1975	8	4.23	446	66.7	2.82	1.407	297	148.5
1975	9	1.85	190	75.0	1.39	0.452	143	47.5
1975	10	2.38	133	85.2	2.03	0.352	113	19.7
1975	11	20.34	1051	96.5	19.63	0.7119	1014	36.79
1975	12	622.38	54906	99.1	616.78	5.5015	54412	494.15
1976	1	61.55	2936	95.7	58.90	2.6467	2810	126.25
1976	2	94.84	3805	89.7	85.07	9.7682	3413	391.92
1976	3	261.00	13906	97.7	255.00	6.0030	13586	319.84
1976	4	687.90	57131	97.5	670.70	17.1975	55703	1428.28
1976	5	22.98	1996	100.0	22.98	0.0000	1996	0.00
1976	6	9.25	812	0.0	0.00	9.2459	0	812.00
1976	7	2.91	308	0.0	0.00	2.9059	0	308.00
1976	8	113.86	10878	89.7	102.13	11.7273	9758	1120.43
1976	9	15.32	1512	88.2	13.51	1.8030	1334	178.42
1976	10	1.06	49	100.0	1.06	0.0000	49	0.00
1976	11	610.50	32966	95.4	582.41	28.0829	31450	1515.44
1976	12	1711.03	149371	97.5	1668.25	42.7757	145637	3734.28
1977	1	295.29	25081	82.6	243.91	51.3803	20717	4364.09
1977	2	306.57	24051	78.8	241.58	64.9927	18952	5098.81
1977	3	147.91	12697	84.8	125.43	22.4821	10767	1929.94
1977	4	81.73	7068	84.8	69.31	12.4236	5994	1074.34
1977	5	91.35	8520	69.0	63.03	28.3135	5879	2641.20
1977	6	24.57	1952	0.0	0.00	24.5678	0	1952.00
1977	7	5.26	338	44.8	2.36	2.9019	151	186.58
1977	8	66.36	7822	78.2	51.89	14.4664	6117	1705.20
1977	9	1.90	164	81.6	1.55	0.3500	134	30.18
1977	10	59.17	6122	92.6	54.80	4.3789	5669	453.03
1977	11	294.47	24756	96.0	282.59	11.7739	23765	990.24
1977	12	359.43	31056	98.3	353.32	6.1103	30528	527.95

469 260

REFERENCES FOR TABLE A-3

1. Letter dated March 3, 1978, from William J. Cahill, Jr. of Consolidated Edison Company of New York, Inc. (Con Ed) to Robert P. Geckler of the U. S. Nuclear Regulatory Commission (US NRC), including a response to Question X.1, which is the identification number for a question in Enclosure 2 of a letter dated July 26, 1977, from George W. Knighton (US NRC) to William Cahill, Jr. (Con Ed).

2. Letter dated May 5, 1978, from Edward G. Kelleher of Consolidated Edison Company of New York, Inc. (Con Ed) to Henry Gluckstern of the U. S. Environmental Protection Agency (US EPA), including a response to Question A-4, which is the identification number for a question in the enclosure of a letter dated March 23, 1978, from Henry Gluckstern (US EPA) to Kenneth L. Marcellus (Con Ed).

3. Ecological Analysts, Inc. Bowline Point Generating Station. Near-field Effects of Once-through Cooling System Operation on Hudson River Biota. Prepared for Orange and Rockland Utilities, Inc., July 1977 (Exhibit UT-7).

TABLE A-4

WHITE PERCH IMPINGEMENT DATA FOR
THE DANSKAMMER POINT GENERATING STATION

RATE (collection rate):[1]

January 1972 - December 1976: average of the daily collection rates for each month were copied directly from data sheets in Ref. (1).

January 1977 - December 1977: average of the daily collection rates for each month were copied dirctly from data sheets in Ref. (2).

NUMBER (number collected):

January 1972 - December 1977: calculated from the monthly collection rates (RATE) described immediately above and monthly values of actual total plant intake flow in millions of gallons for the particular month, from data sheets in Ref. (3) for 1972 - 1976 and from data sheets provided by the U. S. Environmental Protection Agency, Region II, New York, New York for 1977.

PERCENTO (percent of the white perch collected that were young-of-the-year):

No estimates of PERCENTO were available for Danskammer. Consequently, all monthly values for PERCENTO were approximated based on data from Roseton, which is adjacent to Danskammer. (See Table A-9 in this appendix. Monthly PERCENTO values tabulated for Danskammer are exactly the same as those tabulated for Roseton for July 1973 - December 1977; monthly PERCENTO values for January 1972 - June 1973 were calculated as the average of the 1975 and 1976 Roseton values for each month.)

RATEO = PERCENTO · RATE/100 and RATE1 = RATE - RATEO.

NUMBERO = PERCENTO · NUMBER/100 and NUMBER1 = NUMBER - NUMBERO.

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[1]All collection rates were converted from number of white perch collected per million gallons to number of white perch collected per million cubic meters by multiplying by 264.17 gallons per cubic meter. Collection rates were assumed to equal impingement mortality rates.

469 202

RATE, NUMBER, and PERCENT0 are defined above. RATE0 and RATE1 are the collection rates for young-of-the-year and for yearling and older white perch, respectively. NUMBER0 and NUMBER1 are number collected for young-of-the-year and for yearling and older white perch, respectively.

TABLE A-4 (continued)

------------------------------ PLANT=DANSKAM ------------------------------

YEAR	MONTH	RATE	NUMBER	PERCENT0	RATE0	RATE1	NUMBER0	NUMBER1
1972	1	22.67	748	66.0	14.959	7.706	493.7	254.3
1972	2	11.23	318	53.0	5.950	5.277	168.5	149.5
1972	3	29.45	768	59.0	17.378	12.077	453.1	314.9
1972	4	137.32	4544	44.0	60.419	75.897	1999.4	2544.6
1972	5	744.57	28668	58.0	431.908	312.761	16627.4	12040.6
1972	6	546.04	23235	0.0	0.000	546.039	0.0	23235.0
1972	7	206.74	9696	4.8	9.923	196.816	465.4	9230.6
1972	8	253.34	12723	64.2	162.644	90.695	8168.2	4554.8
1972	9	172.82	7143	86.5	149.489	23.331	6178.7	964.3
1972	10	477.65	19732	88.6	423.194	54.452	17482.6	2249.4
1972	11	273.07	11098	85.3	232.931	40.142	9466.6	1631.4
1972	12	110.45	3775	73.8	81.512	28.938	2785.9	989.1
1973	1	9.09	281	66.0	5.998	3.090	185.5	95.5
1973	2	3.22	78	53.0	1.708	1.515	41.3	36.7
1973	3	24.22	719	59.0	14.292	9.932	424.2	294.8
1973	4	203.89	6959	44.0	89.710	114.175	3062.0	3897.0
1973	5	352.80	15344	58.0	204.623	148.176	8899.5	6444.5
1973	6	167.48	7931	0.0	0.000	167.484	0.0	7931.0
1973	7	485.17	25608	4.8	23.288	461.886	1229.2	24378.8
1973	8	88.76	4726	64.2	56.985	31.776	3034.1	1691.9
1973	9	171.21	8631	86.5	148.10	23.113	7465.8	1165.2
1973	10	505.41	20165	88.6	448.68	57.731	17866.2	2298.8
1973	11	451.36	17855	85.3	385.01	66.350	15230.3	2624.7
1973	12	77.24	2248	73.8	57.01	20.238	1659.0	589.0
1974	1	20.34	625	66.0	13.43	6.915	412.5	212.5
1974	2	1.29	37	53.0	0.69	0.608	19.6	17.4
1974	3	5.02	153	59.0	2.96	2.058	90.3	62.7
1974	4	668.35	19511	44.0	294.07	374.276	8584.8	10926.2
1974	5	393.96	15508	58.0	228.49	165.452	8994.5	6513.4
1974	6	381.57	12926	0.0	0.00	381.567	0.0	12926.0
1974	7	135.89	6273	4.8	6.52	129.365	301.1	5971.9
1974	8	119.96	5958	64.2	77.01	42.946	3825.0	2133.0
1974	9	53.18	2302	86.5	46.00	7.179	1991.2	310.8
1974	10	134.46	6577	88.6	119.13	15.329	5827.2	749.8
1974	11	137.74	5857	85.3	117.49	20.248	4996.0	861.0
1974	12	200.51	8525	73.8	147.97	52.532	6291.4	2233.6
1975	1	31.78	1006	59.9	19.04	12.744	602.6	403.4
1975	2	15.01	344	35.6	5.70	10.310	122.5	221.5
1975	3	15.93	224	38.5	6.13	9.797	86.2	137.8
1975	4	253.95	3935	7.0	17.78	236.170	275.4	3659.6
1975	5	139.98	3937	17.2	24.08	115.906	677.2	3259.8
1975	6	321.57	14827	0.0	0.00	321.574	0.0	14827.0
1975	7	103.45	4621	2.8	2.90	100.552	129.4	4491.6
1975	8	181.17	8899	39.7	71.92	109.244	3532.9	5366.1
1975	9	150.26	6861	77.7	116.75	33.508	5331.0	1530.0
1975	10	592.61	25015	79.7	472.31	120.300	19937.0	5078.0
1975	11	667.45	26385	76.2	508.50	158.954	20105.4	6279.6
1975	12	79.04	2175	66.0	52.17	26.873	1435.5	739.5
1976	1	43.35	1224	72.0	31.21	12.138	881.3	342.7
1976	2	32.76	766	70.4	23.06	9.696	539.3	226.7
1976	3	56.35	1440	79.6	44.85	11.495	1146.2	293.8
1976	4	1064.18	25709	81.0	861.99	202.195	20824.3	4884.7
1976	5	250.51	8845	98.7	247.26	3.257	8730.0	115.0
1976	6	232.81	8363	0.0	0.00	232.813	0.0	8363.0
1976	7	40.87	1387	6.9	2.82	38.047	95.7	1291.3
1976	8	26.05	972	88.9	23.13	2.917	863.1	108.9
1976	9	106.67	4719	95.3	101.66	5.014	4497.2	221.8
1976	10	553.73	19888	97.5	539.88	13.843	19390.8	497.2
1976	11	1329.25	39827	94.4	1254.81	74.438	37596.7	2230.3
1976	12	140.01	4588	81.5	114.11	25.902	3739.2	848.8
1977	1	21.71	668	66.0	14.33	7.383	440.9	227.1
1977	2	15.00	363	53.0	7.95	7.052	192.4	170.6
1977	3	152.08	4263	59.0	89.73	62.354	2515.2	1747.8
1977	4	1136.41	36174	44.0	500.02	636.388	15916.6	20257.4
1977	5	1205.75	48386	58.0	699.34	506.415	28063.9	20322.1
1977	6	227.74	5808	0.0	0.00	227.741	0.0	5808.0
1977	7	66.07	2725	4.8	3.17	62.898	130.8	2594.2
1977	8	125.01	5329	64.2	80.25	44.752	3421.2	1907.8
1977	9	117.24	4408	86.5	101.41	15.827	3812.9	595.1
1977	10	535.58	18026	88.6	474.52	61.056	15971.0	2055.0
1977	11	467.00	13191	85.3	398.35	68.649	11251.9	1939.1
1977	12	51.96	1490	73.8	38.35	13.614	1099.6	390.4

469 264

REFERENCES FOR TABLE A-4

1. Letter dated March 3, 1978, from William J. Cahill, Jr. of Consolidated Edison Company of New york, Inc. (Con Ed) to Robert P. Geckler of the U. S. Nuclear Regulatory Commission (US NRC), including a response to Question IX.1, which is the identification number for a question in Enclosure 2 of a letter dated July 26, 1977, from George W. Knighton (US NRC) to William Cahill, Jr. (Con Ed).

2. Letter dated April 14, 1978, from Kenneth L. Marcellus of Consolidated Edison Company of New York, Inc. (Con Ed) to Henry Gluckstern of the U. S. Environmental Protection Agency (US EPA), including a response to Question A-5, which is the identification number for a question in the enclosure of a letter dated March 23, 1978, from Henry Gluckstern (US EPA) to Kenneth L. Marcellus (Con Ed).

3. Letter dated October 31, 1977, from Kenneth L. Marcellus of Consolidated Edison Company of New York, Inc. to Henry Gluckstern of the U. S. Environmental Protection Agency, including in Attachment 2 a response to Question 7 (9/27/77) of Attachment C which accompanied the October 12, 1977 EPA "Motion to Specify Area of Requestors' Testimony To Be Cross-Examined During Initial Phase of Hearing."

TABLES A-5, A-6, A-7

WHITE PERCH IMPINGEMENT DATA FOR INDIAN POINT UNITS 1, 2, AND 3

RATE (collection rate):[1]

June 1972 - December 1975: Copied directly from data sheets provided in Ref. (1).

January 1976 - December 1977: Copied directly from data sheets provided in Ref. (2).

NUMBER (number collected):

May 1972 - December 1976: Copied directly from appendix tables in Refs. (3) - (6). However, if a NUMBER value in these Texas Instruments (TI) appendix tables was lower than the corresponding NUMBER value in Refs. (1) and (2), then the updated NUMBER value in Refs. (1) and (2) was used. For example, such substitutions were made for Indian Point Unit 2 (Table A-6 in this appendix) for all months of 1973. In general, the NUMBER values presented in the TI appendix tables are the same as or higher than the NUMBER values presented in Refs. (1) and (2), for the reason discussed by Con Edison in their response to Question VI.2 in Ref. 1. Thus, the substituted, higher values from Refs. (1) and (2) can still be low, because they were selected by TI to include only data that represented known flow volumes and associated impingement collections.

January 1977 - December 1977: Copied directly from data sheets proveded in Refs. (7) and (8).

PERCENTO (percent of the white perch collected that were young-of-the-year):

June 1975 - December 1976: Calculated from data on magnetic tapes provided by Consolidated Edison. The two tapes used were Texas Instruments 1975 Impingement Data (Record Type D) and Texas Instruments 1976 Impingement Data (Record Type D). Monthly estimates of PERCENTO were calculated for each unit for which there were white perch impingement data as follows:

$$\text{PERCENTO} = \frac{\text{Number of impinged white perch in Length Class 1}}{\text{Total number of impinged white perch}} \cdot 100 ,$$

469 266

where the bounds on Length Class 1 are 0 mm to DIVISION, where DIVISION is the seasonally-varying, total body length in millimeters which is used as the cut-off length between young-of-the-year and yearling white perch (see Table A-10 of this appendix).

RATE0 = PERCENT0 · RATE/100 and RATE1 = RATE - RATE0.

NUMBER0 = PERCENT0 · NUMBER/100 and NUMBER1 = NUMBER - NUMBER0.

RATE, NUMBER, and PERCENT0 are defined above. RATE0 and RATE1 are the collection rates for young-of-the-year and for yearling and older white perch, respectively. NUMBER0 and NUMBER1 are number collected for young-of-the-year and for yearling and older white perch, respectively.

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[1]All RATE [illegible] are given in the original sources in units of number of white [illegible]h collected per million cubic meters, and thus multiplication by 2[illegible].17 was not necessary.

Collection rates were not assumed to equal impingement mortality rates. Rather, the collection rates were adjusted upward to account for the calculated efficiencies of less than 100%. For Units 1 and 2, RATE = RATE/0.15 (i.e., 15% efficiency) and for Unit 3, RATE = RATE/0.70 (i.e., 70% efficiency). These efficiency estimates are based on data presented in Ref. (9) for Units 2 and 3; Unit 1 was assumed to have the same collection efficiency as Unit 2, since Units 1 and 2 have similar intake structures.

TABLE A-5 (continued)

---------------------------------- ----- PLANT=IP1 --

YEAR	MONTH	RATE	NUMBER	PERCENT0	RATE0	RATE1	NUMBER0	NUMBER1
1972	5	.	1927	94.4	.	.	1819	107.9
1972	6	65.80	11320	0.0	0.00	65.800	0	11320.0
1972	7	52.40	2127	45.1	23.63	28.768	959	1167.5
1972	8	232.93	10560	84.8	197.53	35.406	8955	1605.1
1972	9	380.07	12087	84.5	321.16	58.910	10213	1873.4
1972	10	2236.00	84607	94.0	2101.84	134.150	79530	5076.4
1972	11	1705.60	35933	96.7	1649.32	56.285	34748	1185.8
1972	12	844.20	17420	96.4	813.81	30.391	16793	627.1
1973	1	62.40	7933	94.0	58.66	3.744	7457	476.0
1973	2	.	64540	97.3	.	.	62797	1742.6
1973	3	.	206400	91.1	.	.	188030	18369.6
1973	4	.	163253	97.8	.	.	159662	3591.6
1973	5	885.50	20633	94.4	836.01	49.594	19478	1155.5
1973	6	186.27	4527	0.0	0.00	186.257	0	4526.7
1973	7	.	2540	45.1	.	.	1146	1394.5
1973	8	11.53	15367	84.8	9.78	1.753	13031	2335.7
1973	9	.	1460	84.5	.	.	1234	226.3
1973	10	.	287	94.0	.	.	269	17.2
1973	11	.	4273	96.7	.	.	4132	141.0
1973	12	.	12187	96.4	.	.	11748	438.7
1974	1	3798.07	32107	94.0	3570.18	227.884	30180	1926.4
1974	2	1661.33	44567	97.3	1616.48	44.856	43363	1203.3
1974	3	1680.33	43213	91.1	1530.78	149.550	39367	3846.0
1974	4	1826.13	56220	97.8	1785.96	40.175	54983	1236.8
1974	5	594.67	15680	94.4	561.37	33.301	14802	878.1
1974	6	161.20	7647	0.0	0.00	161.200	0	7646.7
1974	7	35.73	1573	45.1	16.12	19.618	710	863.8
1974	8	22.60	1140	84.8	19.16	3.435	967	173.3
1974	9	60.20	2973	84.5	50.87	9.331	2512	460.9
1974	10	631.87	30227	94.0	593.95	37.912	28413	1813.6
1974	11	896.00	15733	96.7	866.43	29.568	15214	519.2
1974	12	6241.47	143867	96.4	6016.77	224.693	138687	5179.2
1975	1	4255.13	62007	94.0	3999.83	255.308	58286	3720.4
1975	2	6964.67	102447	97.3	6776.52	188.146	99681	2766.1
1975	3	2460.07	39213	91.1	2241.12	218.946	35723	3490.0
1975	4	4757.20	74073	97.8	4652.54	104.658	72444	1629.6
1975	5	471.73	5180	94.4	445.32	26.417	4890	290.1
1975	6	58.27	827	0.0	0.00	58.257	0	826.7
1975	7	63.87	407	66.0	42.15	21.715	268	138.3
1975	8	63.13	287	90.9	57.39	5.735	261	26.1

469 268

TABLE A-6 (continued)

------------------------------------ PLANT=IP2 ------------------------------------

YEAR	MONTH	RATE	NUMBER	PERCENTO	RATEO	RATE1	NUMBERO	NUMBER1
1972	6	42.4	960	0.0	0.0	42.40	0	960
1972	9	34.3	1347	84.5	29.0	5.31	1138	209
1972	10	135.1	1687	94.0	127.0	8.11	1585	101
1973	1	3868.1	7933	94.0	3636.0	232.09	7457	476
1973	2	4578.3	63693	97.3	4454.7	123.62	61974	1720
1973	3	4280.1	201547	91.1	3899.2	380.93	183609	17938
1973	4	4696.1	11764	97.8	4592.8	103.31	115091	2589
1973	5	1136.1	2056	94.4	1072.4	63.62	19409	1151
1973	6	97.9	45[illegible]	0.0	0.0	97.93	0	4527
1973	7	38.6	2540	45.1	17.4	21.19	1146	1394
1973	8	187.0	15180	84.8	158.6	28.42	12873	2307
1973	9	31.3	1453	84.5	26.4	4.85	1228	225
1973	10	5.3	287	94.0	5.0	0.32	259	17
1973	11	273.3	4200	96.7	264.3	9.02	4061	139
1973	12	1264.1	12187	96.4	1218.6	45.51	11748	439
1974	1	12814.7	147813	94.0	12045.8	768.88	138945	8869
1974	2	12823.3	153027	97.3	12477.1	346.23	148895	4132
1974	3	9218.7	259980	91.1	8398.2	820.46	236842	23138
1974	4	8378.7	471647	97.8	8194.3	184.33	461270	10376
1974	5	4351.4	395840	94.4	4107.7	243.68	373673	22167
1974	6	420.5	49560	0.0	0.0	420.53	0	49560
1974	7	42.3	4753	45.1	19.1	23.24	2144	2610
1974	8	69.7	8160	84.8	59.1	10.60	6920	1240
1974	9	206.0	23360	84.5	174.1	31.93	19739	3621
1974	10	805.3	75780	94.0	757.0	48.32	71233	4547
1974	11	1887.3	166967	96.7	1825.1	62.28	161457	5510
1974	12	6787.3	370153	96.4	6543.0	244.34	356828	13326
1975	1	4416.0	212387	94.0	4151.0	264.96	199643	12743
1975	2	3496.1	165833	97.3	3401.7	94.40	161356	4478
1975	3	3171.2	89973	91.1	2889.0	282.24	81966	8008
1975	4	5900.1	451100	97.8	5770.3	129.80	441176	9924
1975	5	807.0	83373	94.4	761.8	45.19	78704	4669
1975	6	90.5	12207	0.0	0.0	90.47	0	12207
1975	7	92.7	11713	56.4	52.3	40.40	6606	5107
1975	8	1030.1	89720	98.5	1014.7	15.45	88374	1346
1975	9	640.0	73693	95.0	608.0	32.00	70009	3685
1975	10	657.5	47720	95.8	629.9	27.61	45716	2004
1975	11	1728.9	179340	95.2	1645.9	82.99	170732	8608
1975	12	2847.1	294000	97.9	2787.3	59.79	287826	6174
1976	1	9597.3	610240	94.0	9021.5	575.84	573626	36614
1976	2	3731.8	180087	95.6	3567.6	164.20	172163	7924
1976	3	1563.0	123027	91.1	1423.9	139.11	112077	10949
1976	4	245.0	287	97.7	239.4	5.64	280	7
1976	6	[illegible]	493	0.0	0.0	36.93	0	493
1976	9	290.3	8227	90.7	263.3	27.00	7462	765
1976	10	2332.7	256380	95.4	2225.4	107.30	244587	11793
1976	11	1432.5	20900	98.3	1408.1	24.35	20545	355
1976	12	22551.3	690520	94.1	21220.8	1330.53	649779	40741
1977	1	36380.7	2164740	94.0	34197.8	2182.38	2034856	129884
1977	2	68453.3	1251797	97.3	66605.1	1848.24	1227718	34068
1977	3	5005.5	458480	91.1	4560.0	445.49	417675	40805
1977	4	10549.3	237347	97.8	10317.2	232.09	232125	5222
1977	5	339.73	26053	94.4	320.71	19.025	24594	1459.0
1977	6	299.87	37567	0.0	0.00	299.857	0	37566.7
1977	7	104.47	947	45.1	47.11	57.352	427	519.7
1977	8	463.07	43460	84.8	392.68	70.385	36854	6605.9
1977	9	146.87	22920	84.5	124.10	22.764	19367	3552.6
1977	10	2064.00	322480	94.0	1940.16	123.840	303131	19348.8
1977	11	9770.67	939973	96.7	9448.23	322.432	908954	31019.1
1977	12	.	543540	96.4	.	.	523973	19567.4

TABLE A-7 (continued)

PLANT=IP3

YEAR	MONTH	RATE	NUMBER	PERCENTO	RATEO	RATE1	NUMBERO	NUMBER1
1974	3	38.93	6	91.1	35.46	3.455	5	0.5
1974	4	999.84	4371	97.8	977.85	21.997	4275	96.2
1974	5	458.90	677	94.4	433.20	25.698	639	37.9
1974	6	84.73	1430	0.0	0.00	84.729	0	1430.0
1974	7	5.71	20	45.1	2.58	3.137	9	11.0
1974	8	0.53	3	84.8	0.53	0.096	2	0.4
1974	9	2.20	13	84.5	1.86	0.341	11	2.0
1974	10	19.13	90	94.0	17.98	1.148	85	5.4
1976	2	446.86	3974	99.0	442.39	4.469	3935	39.7
1976	4	333.39	4554	97.8	326.05	7.338	4454	100.2
1976	5	[illegible]	7373	94.4	99.66	5.912	6960	412.9
1976	6	26.51	2254	0.0	0.00	26.514	0	2254.3
1976	7	16.81	1509	13.0	2.19	14.528	196	1312.5
1976	8	45.43	4170	64.9	29.48	15.945	2706	1463.7
1976	9	39.27	3199	67.8	26.53	12.645	2169	1029.9
1976	10	221.57	21866	90.9	201.41	20.163	19876	1989.8
1976	11	1332.03	118493	96.6	1286.74	45.239	114464	4028.8
1976	12	819.24	56426	97.2	796.30	22.939	54846	1579.9
1977	1	1953.43	92889	94.0	1836.22	117.206	87315	5573.3
1977	2	5655.71	127396	97.3	5503.98	152.731	123956	3[illegible]39.7
1977	3	352.47	29314	91.1	321.10	31.370	26705	[illegible]509.0
1977	4	559.00	55819	97.8	546.70	12.298	55569	1250.0
1977	5	346.41	62640	94.4	327.02	19.399	59132	3507.8
1977	6	34.86	11370	0.0	0.00	84.857	0	11370.0
1977	7	32.23	4756	45.1	14.54	17.693	2145	2610.9
1977	8	94.06	13183	84.8	79.76	14.297	11179	2003.8
1977	9	40.06	5931	84.5	33.85	5.209	5012	919.4
1977	10	119.64	4010	94.0	112.46	7.179	3769	240.6
1977	12	514.26	18124	96.4	495.74	18.513	17472	652.5

469 270

REFERENCES FOR TABLES A-5, A-6, AND A-7

1. Letter dated March 3, 1978, from William J. Cahill, Jr. of Consolidated Edison Company of New York, Inc. (Con Ed) to Robert P. Geckler of the U. S. Nuclear Regulatory Commission (US NRC), including a response to Question VI.3, which is the identification number for a question in Enclosure 2 of a letter dated July 26, 1977, from George W. Knighton (US NRC) to William Cahill, Jr. (Con Ed).

2. Letter dated May 3, 1978, from Kenneth L. Marcellus of Consolidated Edison Company of New York, Inc. (Con Ed) to Henry Gluckstern of the U. S. Environmental Protection Agency (US EPA), including a response to Question A-3, which is the identification number for a question in the enclosure of a letter dated March 23, 1978, from Henry Gluckstern (US EPA) to Kenneth L. Marcellus (Con Ed).

3. Texas Instruments, Inc. Indian Point Impingement Study Report for the Period 15 June 1972 through 31 December 1973. Prepared for Consolidated Edison Company of New York, Inc., December 1974. (Tables A-1.5 through A-1.8).

4. Texas Instruments, Inc. Indian Point Impingement Study Report for the Period 1 January 1974 through 31 December 1974. Prepared for Consolidated Edison Company of New York, Inc., November 1975. (Tables B-2 through B-4).

5. Texas Instruments, Inc. Indian Point Impingement Study Report for the Period 1 January 1975 through 31 December 1975. Prepared for Consolidated Edison Company of New York, Inc., November 1976. (Tables A-4 and A-5).

6. Texas Instruments, Inc. Hudson River Ecological Study in the Area of Indian Point. 1976 Annual Report. Prepared for Consolidated Edison Company of New York, Inc., December 1977. (Tables A-2 and A-3).

7. Monthly letters from Eugene R. McGrath of Consolidated Edison Company of New York, Inc. to Peter A. A. Berle of the New York State Department of Environmental Conservation, which are sent as specified in Section 401 Certification and which include data sheets giving daily fish counts by species for each unit at Indian Point.

8. Monthly letters from William J. Cahill, Jr. of Consolidated Edison Company of New York, Inc. to James P. O'Reilly of the U. S. Nuclear Regulatory Commission, which are sent as specified in Appendix B of Unit Nos. 1, 2 and 3 Technical Specifications and which include data sheets giving daily fish counts by species for each unit at Indian Point.

9. Exhibit UT-105. Table 1. Summary of Collection Efficiency Tests and Related 95% Confidence Intervals at Indian Point Units 2 and 3, 1974-1977. U. S. Environmental Protection Agency, Region II, Adjudicatory Hearing, Docket No. C/II-WP-77-01, introduced into evidence on June 6, 1978.

TABLE A-8

WHITE PERCH IMPINGEMENT DATA FOR THE LOVETT GENERATING STATION

January 1973 - December 1976: Ref. (1)

Values for RATE (collection rate)[1] and NUMBER (number collected) were taken directly from data sheets in Ref. (1).

January 1977 - December 1977: Ref. (2)

Values for RATE (collection rate)[1] and NUMBER (number collected) were taken directly from data sheets in Ref. (2).

PERCENTO (percent of the white perch collected that were young-of-the-year):

No estimates of PERCENTO were available for Lovett. Consequently, all monthly values for PERCENTO were approximated based on data from Indian Point, which is located only 1½ miles upriver and across the river from Lovett.

June 1975 - December 1976

Used the average of the observed monthly values for the units at Indian Point for the corresponding month and year (see Tables A-5 to A-7 in this appendix).

January 1973 - May 1975 and January 1977 - December 1977

Used the monthly approximations calculated for Indian Point (same for all units at Indian Point) (see Tables A-5 to A-7 in this appendix).

$$RATE0 = PERCENTO \cdot RATE/100 \text{ and } RATE1 = RATE - RATE0.$$

$$NUMBER0 = PERCENTO \cdot NUMBER/100 \text{ and } NUMBER1 = NUMBER - NUMBER0.$$

RATE, NUMBER, and PERCENTO are defined above. RATE0 and RATE1 are the collection rates for young-of-the-year and for yearling and older white perch, respectively. NUMBER0 and NUMBER1 are number collected for young-of-the-year and for yearling and older white perch, respectively.

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[1]All collection rates were converted from number of white perch collected per million gallons to number of white perch collected per million cubic meters by multiplying by 264.17 gallons per cubic meter. Collection rates were assumed to equal impingement mortality rates.

469 273

TABLE A-8 (continued)

PLANT=LOVETT

YEAR	MONTH	RATE	NUMBER	PERCENTO	RATEO	RATE1	NUMBERO	NUMBER1
1973	1	70.80	3536	94.0	66.55	4.248	3323.8	212.16
1973	2	81.63	3585	97.3	79.42	2.204	3488.2	96.80
1973	3	222.43	11055	91.1	202.63	19.796	10071.1	983.90
1973	4	196.54	8569	97.8	192.22	4.324	8380.5	188.52
1973	5	66.04	2703	94.4	62.34	3.698	2551.6	151.37
1973	6	49.40	2247	0.0	0.00	49.400	0.0	2247.00
1973	7	16.38	817	45.1	7.39	8.992	368.5	448.53
1973	8	85.86	4417	84.8	72.81	13.050	3745.6	671.38
1973	9	13.74	600	84.5	11.51	[illegible]	507.0	93.00
1973	10	2.64	93	94.0	2.48	0.159	87.4	5.58
1973	11	142.12	6037	96.7	137.43	4.690	5837.8	199.22
1973	12	389.65	17292	96.4	375.62	14.027	16669.5	622.51
1974	1	458.33	20058	94.0	430.83	27.500	18854.5	1203.48
1974	2	399.16	12695	97.3	388.38	10.777	12352.2	342.77
1974	4	522.26	18835	97.8	510.77	11.490	18420.6	414.37
1974	5	163.26	6243	94.4	154.11	9.142	5893.4	349.61
1974	6	40.68	1519	0.0	0.00	40.632	0.0	1519.00
1974	7	8.98	184	45.1	4.05	4.931	83.0	101.02
1974	8	12.15	492	84.8	10.30	1.847	417.2	74.78
1974	9	10.57	395	84.5	8.93	1.638	334.6	61.38
1974	10	108.84	2921	94.0	102.31	6.530	2745.7	175.26
1974	11	302.74	11753	96.7	292.75	9.990	11365.2	387.85
1974	12	311.72	12071	96.4	300.50	11.222	11636.4	434.56
1975	1	850.36	35169	94.0	799.34	51.022	33998.9	2170.14
1975	2	121.52	4325	97.3	118.24	3.281	4208.2	116.78
1975	3	168.80	4249	91.1	153.78	15.024	3870.8	378.16
1975	4	546.30	11864	97.8	534.28	12.019	11603.0	261.01
1975	5	25.15	786	94.4	24.69	1.465	742.0	44.02
1975	6	26.68	958	0.0	0.00	26.631	0.0	958.00
1975	7	7.40	273	61.2	4.53	2.870	167.1	105.92
1975	8	42.80	1642	94.7	40.53	2.258	1555.0	87.03
1975	9	24.30	642	95.0	23.09	1.215	609.9	32.10
1975	10	30.38	977	95.8	29.10	1.276	936.0	41.03
1975	11	540.49	16622	95.2	514.55	25.944	15824.1	797.86
1975	12	143.97	4458	97.9	140.95	3.023	4364.4	93.62
1976	1	362.71	11876	94.0	340.94	21.762	11163.4	712.56
1976	2	42.27	1265	97.3	41.13	1.141	1230.8	34.16
1976	3	94.04	2692	91.1	85.67	8.370	2452.4	239.59
1976	4	186.50	4765	97.8	182.40	4.103	4660.2	104.83
1976	5	8.19	90	94.4	7.73	0.459	85.0	5.04
1976	6	26.68	610	0.0	0.00	26.631	0.0	610.00
1976	7	10.30	221	13.0	1.34	8.963	28.7	192.27
1976	8	17.70	554	64.9	11.49	6.212	359.5	194.45
1976	9	22.19	514	79.2	17.57	4.616	407.1	106.91
1976	10	12.42	167	93.2	11.57	0.844	155.6	11.36
1976	11	570.08	10200	97.4	555.26	14.822	9934.8	265.20
1976	12	534.94	13166	95.6	511.41	23.538	12586.7	579.30
1977	1	1225.33	39689	94.0	1152.28	73.550	37307.7	2381.34
1977	2	751.96	13633	97.3	731.66	20.303	13264.9	368.09
1977	3	106.46	1719	91.1	96.99	9.475	1566.0	152.99
1977	4	162.62	2783	97.8	159.05	3.578	2721.8	61.23
1977	5	21.24	370	94.4	20.05	1.189	349.3	20.72
1977	6	209.355	4732	0.0	0.000	209.355	0.00	4732.00
1977	7	19.179	576	45.1	8.650	10.529	259.78	316.22
1977	8	37.433	1408	84.8	31.743	5.690	1193.98	214.02
1977	9	4.755	121	84.5	4.018	0.737	102.24	18.76
1977	10	227.847	5519	94.0	214.176	13.671	5187.86	331.14
1977	11	490.405	9767	96.7	474.222	16.183	9444.69	322.31
1977	12	42.716	568	96.4	41.179	1.538	643.[illegible]	24.05

REFERENCES FOR TABLE A-8

1. Letter dated March 3, 1978, from William J. Cahill, Jr. of Consolidated Edison Company of New York, Inc. (Con Ed) to Robert P. Geckler of the U. S. Nuclear Regulatory Commission (US NRC), including a response to Question X.1, which is the identification number for a question in Enclosure 2 of a letter dated July 26, 1977 from George W. Knighton (US NRC) to William Cahill, Jr. (Con Ed).

2. Letter dated May 5, 1978 from Edward G. Kelleher of Consolidated Edison Company of New York, Inc. (Con Ed) to Henry Gluckstern of the U. S. Environmental Protection Agency (US EPA), including a response to Question A-4, which is the identification number for a question in the enclosure of a letter dated March 23, 1978 from Henry Gluckstern (US EPA) to Kenneth L. Marcellus (Con Ed).

TABLE A-9

WHITE PERCH IMPINGEMENT DATA FOR THE ROSETON GENERATING STATION

RATE (collection rate):[1]

July 1973 - December 1976: average of the daily collection rates for each month were copied directly from data sheets in Ref. (1).

January 1977 - December 1977: average of the daily collection rates for each month were copied directly from data sheets in Ref. (2).

NUMBER (number collected):

July 1973 - December 1976: copied directly from Table 10.2-14 of Ref. (3).

January 1977 - December 1977: calculated from the monthly collection rates (RATE) described immediately above and monthly values of actual total plant intake flow in millions of gallons for the particular month (from data sheets provided by the U. S. Environmental Protection Agency, Region II, New York, New York).

PERCENTO (percent of the white perch collected that were young-of-the-year):

January 1975 - December 1976: Calculated from monthly data on length-frequency in 1-centimeter length intervals of white perch in impingement collections (from Tables 10.2-15 and 10.2-16 in Ref. (3)). The "DIVISION" criteria specified by Texas Instruments were used as the cut-off length between young-of-the-year and yearling white perch (see Table A-10 in this appendix).

July 1973 - December 1974 and January 1977 - December 1977: calculated as the average of the 1975 and 1976 PERCENTO values for each month.

RATE0 = PERCENTO · RATE/100 and RATE1 = RATE - RATE0.

NUMBER0 = PERCENTO · NUMBER/100 and NUMBER1 = NUMBER - NUMBER0.

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[1]All collection rates were converted from number of white perch collected per million gallons to number of white perch collected per million cubic meters by multiplying by 264.17 gallons per cubic meter. Collection rates were assumed to equal impingement mortality rates.

TABLE A-9 (continued)

RATE, NUMBER, and PERCENTO are defined above. RATE0 and RATE1 are the collection rates for young-of-the-year and for yearling and older white perch, respectively. NUMBER0 and NUMBER1 are number collected for young-of-the-year and for yearling and older white perch, respectively.

TABLE A-9 (continued)

PLANT=ROSETON

YEAR	MONTH	RATE	NUMBER	PERCENT0	RATE0	RATE1	NUMBER0	NUMBER1
1973	7	9.272	81	4.8	0.445	8.827	3.9	77.1
1973	8	98.430	980	64.2	63.192	35.238	629.2	350.8
1973	9	428.008	1094	86.5	370.227	57.781	946.3	147.7
1973	10	654.270	4522	88.6	579.583	74.537	4006.5	515.5
1973	11	197.837	1996	85.3	168.755	29.082	1702.6	293.4
1973	12	27.527	484	73.8	20.315	7.212	357.2	126.8
1974	1	1.162	5	66.0	0.767	0.395	3.3	1.7
1974	2	0.000	0	53.0	0.000	0.000	0.0	0.0
1974	3	0.423	5	59.0	0.249	0.173	2.9	2.1
1974	4	148.701	4897	44.0	65.429	83.273	2154.7	2742.3
1974	5	413.637	6272	58.0	239.910	173.728	3637.8	2634.2
1974	6	106.566	1105	0.0	0.000	106.556	0.0	1105.0
1974	7	0.687	10	4.8	0.033	0.654	0.5	9.5
1974	8	54.023	3263	64.2	34.583	19.340	2094.8	1168.2
1974	9	23.617	1131	86.5	20.429	3.188	978.3	152.7
1974	10	43.007	1039	88.6	38.104	4.903	919.7	118.3
1974	11	188.829	12313	85.3	161.071	27.758	10503.0	1810.0
1974	12	104.030	7351	73.8	76.774	27.256	5425.0	1926.0
1975	1	18.228	1307	59.9	10.918	7.309	782.9	524.1
1975	2	14.318	1059	35.6	5.097	9.221	377.0	682.0
1975	3	14.926	1047	38.5	5.746	9.179	403.1	643.9
1975	4	340.092	23288	7.0	23.806	315.286	1630.2	21657.8
1975	5	164.314	14599	17.2	28.262	136.052	2511.0	12088.0
1975	6	19.707	1613	0.0	0.000	19.707	0.0	1613.0
1975	7	42.928	3865	2.8	1.202	41.726	108.2	3756.8
1975	8	128.413	9571	39.7	50.980	77.433	3799.7	5771.3
1975	9	118.348	7804	77.7	91.957	26.392	6063.7	1740.3
1975	10	442.960	32541	79.7	353.039	89.921	26732.2	6808.8
1975	11	615.727	40851	76.2	469.184	146.543	31128.5	9722.5
1975	12	21.107	844	66.0	13.931	7.176	557.0	287.0
1976	1	19.575	1008	72.0	14.094	5.481	725.8	282.2
1976	2	34.712	2287	70.4	24.437	10.275	1610.0	677.0
1976	3	17.779	1129	79.6	14.152	3.627	898.7	230.3
1976	4	463.513	31493	81.0	375.445	88.057	25509.3	5983.7
1976	5	242.719	20841	98.7	239.564	3.155	20570.1	270.9
1976	6	75.870	6455	0.0	0.000	75.870	0.0	6455.0
1976	7	3.408	326	6.9	0.235	3.173	22.5	303.5
1976	8	22.692	2100	88.8	20.151	2.542	1864.8	235.2
1976	9	28.927	2346	95.3	27.567	1.360	2235.7	110.3
1976	10	140.459	9927	97.5	136.948	3.511	9678.8	248.2
1976	11	563.316	23006	94.4	531.770	31.546	21717.7	1288.3
1976	12	63.876	3258	81.5	52.059	11.817	2655.3	602.7
1977	1	23.036	1696	66.0	15.204	7.832	1119.4	576.6
1977	2	13.314	851	53.0	7.057	6.258	451.0	400.0
1977	3	67.178	5183	59.0	39.635	27.543	3058.0	2125.0
1977	4	303.954	16486	44.0	133.740	170.214	7253.8	9232.2
1977	5	735.106	51444	58.0	426.361	308.744	29837.5	21606.5
1977	6	20.552	1964	0.0	0.000	20.552	0.0	1964.0
1977	7	10.620	1004	4.8	0.510	10.110	48.2	955.8
1977	8	248.346	25808	64.2	159.438	88.908	16568.7	9239.3
1977	9	78.247	7248	86.5	67.684	10.563	6269.5	978.5
1977	10	142.493	10176	88.6	126.249	16.244	9015.9	1160.1
1977	11	119.484	7834	85.3	101.920	17.564	6682.4	1151.6
1977	12	32.942	2296	73.8	24.311	8.631	1694.4	601.6

469 278

REFERENCES FOR TABLE A-9

1. Letter dated March 3, 1978, from William J. Cahill, Jr. of Consolidated Edison Company of New York, Inc., (Con Ed) to Robert P. Geckler of the U. S. Nuclear Regulatory Commission (US NRC), including a response to Question IX.1, which is the identification number for a question in Enclosure 2 of a letter dated July 26, 1977, from George W. Knighton (US NRC) to William Cahill, Jr. (Con Ed).

2. Letter dated April 14, 1978, from Kenneth L. Marcellus of Consolidated Edison Company of New York, Inc. (Con Ed) to Henry Gluckstern of the U. S. Environmental Protection Agency (US EPA), including a response to Question A-5, which is the identification number for a question in the enclosure of a letter dated March 23, 1978, from Henry Gluckstern (US EPA) to Kenneth L. Marcellus (Con Ed).

3. Ecological Analysts, Inc. Roseton Generating Station. Near-field Effects of Once-through Cooling System Operation on Hudson River Biota. Prepared for Central Hudson Gas & Electric Corporation, July 1977.

TABLE A-10. "DIVISION" CRITERIA SPECIFIED BY TEXAS INSTRUMENTS AS THE CUT-OFF LENGTH BETWEEN YOUNG-OF-THE-YEAR AND YEARLING WHITE PERCH[1]

DATE[2]	DIVISION[3] (mm)	YEAR CLASSES[4]	DATE[2]	DIVISION[3] (mm)	YEAR CLASSES[4]
750101	95	1973-1974	760105	105	1974-1975
750101	95		760119	105	
750116	95		760202	105	
750116	95		760216	105	
750201	95		760301	105	
750201	95		760315	105	
750215	95		760405	105	
750215	95		760419	105	
750301	95		760419	105	
750301	95		760503	105	
750315	95		760517	105	
750315	95		760607	50	1975-1976
750401	95		760607	50	
750401	95		760621	50	
750415	95		760705	50	
750415	95		760719	60	
750501	95		760802	60	
750501	95		760816	85	
750515	95		760816	85	
750515	95		760830	100	
750601	29	1974-1975	760830	100	
750601	29		760913	100	
750615	50		760913	100	
750615	50		760927	100	
750701	50		760927	100	
750701	50		761011	100	
750715	60		761011	100	
750715	60		761025	100	
750805	85		761025	100	
750805	85		761108	100	
750818	95		761108	100	
750901	95		761122	100	
750915	100		761206	100	
751006	105		761206	100	
751020	105		761220	100	
751103	105		761220	100	
751117	105				
751201	105				
751215	105				

[1] Obtained from computer data tapes entitled Texas Instruments 1975 Impingement Data (Record Type E) and Texas Instruments 1976 Impingement Data (Record Type E).

[2] The format for DATE is year-month-day.

[3] The seasonally-varying, total body length which is used to discriminate between young-of-the-year and yearling white perch.

[4] The two year classes separated by DIVISION.

469 280