ENVIRONMENTAL REPORT

TO ACCOMPANY APPLICATION FOR FACILITY LICENSE AMENDMENT FOR EXTENSION OF OPERATION WITH ONCE-THROUGH COOLING FOR INDIAN POINT UNIT No. 2

June 1975

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
	)	
CONSOLIDATED EDISON COMPANY	)	Docket No. 50-247
OF NEW YORK, INC.	)	
(Indian Point Station, Unit No. 2)	)	

ENVIRONMENTAL REPORT TO ACCOMPANY APPLICATION FOR FACILITY LICENSE AMENDMENT FOR EXTENSION OF OPERATION WITH ONCE-THROUGH COOLING

JUNE 1975

TABLE OF CONTENTS

1. NATURE OF THE PROPOSED ACTION

1.1 Present Operating License

Indian Point Station, Unit No. 2 ("Indian Point 2") is a pressurized water power reactor owned and operated by Consolidated Edison Company of New York, Inc. ("Con Edison"). Pursuant to Provisional Construction Permit No. CPPR-21, issued on October 14, 1966, the facility was constructed with a once-through cooling system which draws water from the Hudson River.

A full-term, full-power operating license was issued by the Atomic Energy Commission on September 25, 1973, and, pursuant to an order of the Atomic Safety and Licensing Appeal Board dated April 4, 1974, that license provides that operation with the present once-through cooling system will be permitted during an interim period, "the reasonable termination date for which now appears to be May 1, 1979." Facility Operating License No. DPR-26, para. 2.E(1), as modified by Consolidated Edison Co. of New York, Inc. (Indian Point Station, Unit No. 2), ALAB-188, RAI-74-4 323, 407 (Apr. 4, 1974). The license also provides, in subparagraph (c) to Condition 2.E(1), as follows:

> If the applicant believes that the empirical data collected during this interim operation justifies an extension of the interim operation period or such other relief as may be appropriate, it may make timely application to the Atomic Energy Commission. The filing of such application in and of itself shall not warrant an extension of the interim operation period.

Accordingly, the present license, to the extent that it imposes a requirement for the installation of a system of closed-cycle cooling, does so only provisionally, and recognizes that in appropriate circumstances public policy may counsel a modification of the provisional requirement thus set.

1.2 Proposed License Amendment

The application for a license amendment, in support of which this Environmental Report is submitted, is being filed with the Nuclear Regulatory Commission in accordance with the provisions of subparagraph 2.E(1)(c) quoted in § 1.1 above. The requested amendment would change the terms of Condition 2.E(1) by substituting "May 1, 1981" for "May 1, 1979" wherever the latter date appears. The effect of the change would be to permit Con Edison to operate the facility with the present once-through cooling system until May 1, 1981. Since the spawning season for striped bass does not commence until approximately May 1 in any year, the modification would permit operation for two additional spawning seasons for that species, 1979 and 1980.

This application for an amendment to Facility Operating License No. DPR-26 is supported by substantial additional data and analyses arising out of Con Edison's Hudson River Ecology Study Program (described in § 3.2 below). These include the results of studies performed for Con Edison during 1973 and 1974, and other biological data that were not available for consideration incident to the proceeding leading to the issuance of a full-term, full-power license. The data gathered during the 1974 striped bass spawning season are particularly noteworthy because the facility operated at substantial power levels during that season as well as during most of the balance of that year. Results of analyses of the impact of power plant operations in 1973 and in 1974 on striped bass and other species are presented in Appendix D to this report.

Con Edison believes that this Report shows that the Company should be permitted to complete its ecological study program before irretrievable environmental and economic commitments are made toward the construction of a closed-cycle cooling system. Con Edison expects to complete the study program and report thereon by about January 1, 1977. Based upon the results of the program to date, it is concluded that completion of the study program will provide the data to satisfactorily make the ultimate decision on whether environmental considerations require modification of the present cooling system. Con Edison believes as well that there is a substantial possibility that analysis of the improved data base will demonstrate that a closed-cycle cooling system should not be required for Indian Point 2.

The present Report is also addressed to the immediate environmental consequences of the requested extension of the period of operation with once-through cooling. As appears more fully in §§ 2, 4, 5, and 6 below, the benefits to be derived from granting the requested deferral of the installation of a closed-cycle cooling system far outweigh the environmental and other costs associated with such a deferral. To the extent that the costs and benefits can be quantified, the balance favors Commission approval of our request. There are, moreover, enormous costs associated with construction of a closed-cycle system that would go beyond the immediate two-year period of the extension, and the likelihood of avoiding these costs is difficult to gauge. Thus, if the ecological study program shows that a closed-cycle cooling system is not necessary, the $91,000,000 capital cost of constructing such a system on the present license schedule, and the other costs associated with such a system (see § 4.1.2) would be avoided. This possible saving that may be achieved when the decisional data base is improved is obviously far greater than the short-term net benefit achievable during the period of the extension.

The requested amendment must be evaluated in two senses: (1) the costs and benefits of two additional years of operation with the installed once-through cooling system, and (2) the costs and benefits associated with the improvement of the data base for the decision on the ultimate issue of installation of a closed-cycle system and the concomitant possibility that that improved data base will point to retention of the present cooling system. As described in the Summary Benefit-Cost Analysis in § 6 below, the balance on both accounts points sharply in favor of our request for time to complete the ecological study program and for corresponding relief from the current May 1, 1979 termination date.

1.3 Closed-Cycle Construction Schedule

This application for an amendment to the operating license is submitted at the present time because of the exigencies of the schedule for construction of a closed-cycle cooling system imposed by the present license condition, and in recognition of the time that may be required for review of the application by the Regulatory Staff and completion of the administrative process.

On December 2, 1974, pursuant to the Indian Point 2 operating license, Con Edison submitted an application for a license amendment designating the preferred alternative closed-cycle cooling system. Under that application, a natural draft cooling tower has been proposed, and that proposal is now undergoing Regulatory Staff review. The present Environmental Report assumes that the closed-cycle cooling system designated in that application is approved by the Commission in a timely fashion. The schedule currently in effect for construction and operation of the natural draft cooling tower, if required, is set forth in Figure 1-1.

A different schedule would be contemplated if the delay requested herein were granted, and if the closed-cycle cooling tower designated in the December 2, 1974 application were eventually required based on the results of the Con Edison ecological study program. That schedule, which appears in Figure 1-2, contemplates the cessation of operation of Indian Point 2 with once-through cooling on May 1, 1981. Major milestone dates are:

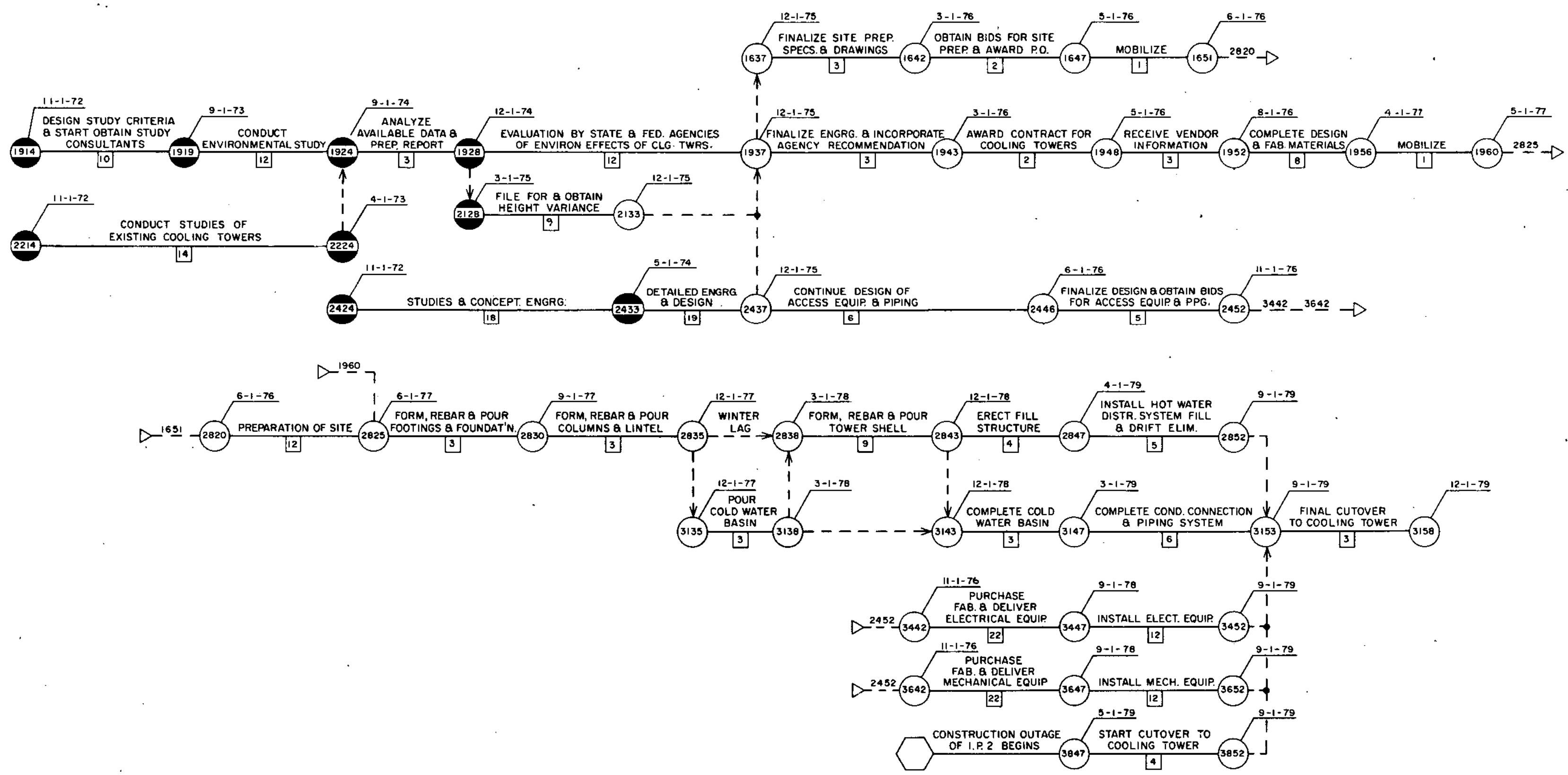

FIGURE 1-1 "THE NRC LICENSING SCHEDULE"

NOTE: All Activity Durations Are In Months

REV	DATE	PROJ ENG	PROJ MGR	REV	DATE	PROJ ENG	PROJ MGR

○ ACT. NOT STARTED or COMPL.
◐ PREDECESSOR ACT. COMPL. SUCCESSOR ACT. NOT STARTED
● PREDECESSOR ACT. COMPL. SUCCESSOR ACT. STARTED
▷ PREREQUISITE NOT COMPL.
▶ PREREQUISITE COMPLETE
⬡ MILESTONE ACT.

CONSOLIDATED EDISON CO. of NEW YORK

PROJECT ENGRG DEPT — SCHEDULING BUREAU

SCHEDULING ENGINEER	APPROVED BY PROJECT ENGR	APPROVED BY PROJECT MGR

OVERALL SCHEDULE FOR NATURAL DRAFT COOLING TOWER FOR INDIAN POINT 2 - FOR 12-1-79 START-UP

REVISION	ISSUE NO.	STATUS DATE	REQD SERV. DATE	PROJ. NO.	B. R. NO.	SHEET NO.
A				2732	3EP5	14

FORM NO - PSO 1 (rev 4-73)

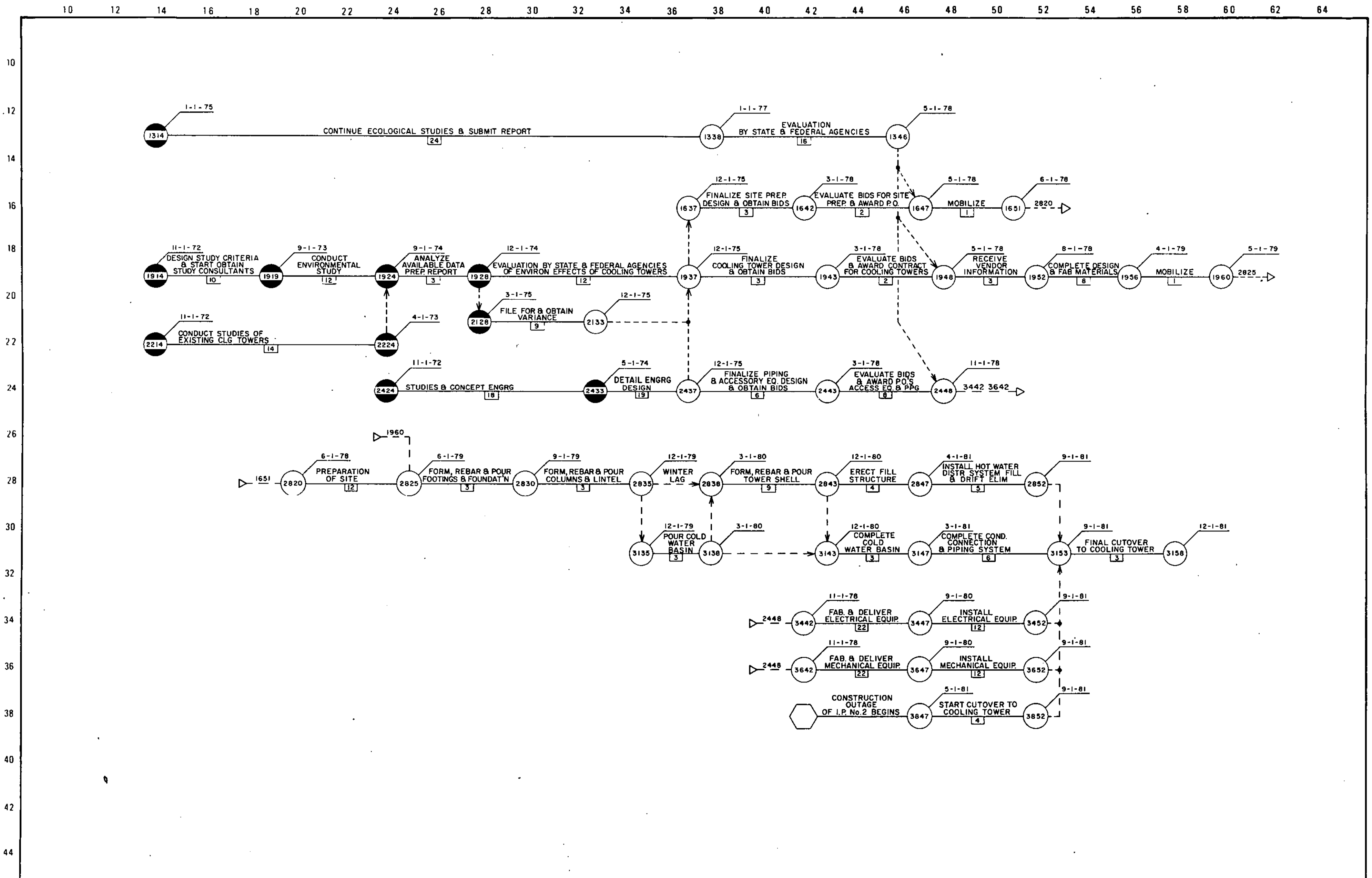

FIGURE 1-2 "PROPOSED SCHEDULE WITH TWO YEAR EXTENSION"

NOTE: All Activity Durations Are In Months

REV	DATE	PROJ ENG	PROJ MGR	REV	DATE	PROJ ENG	PROJ MGR

○ ACT. NOT STARTED or COMPL.
PREDECESSOR ACT. COMPL. SUCCESSOR ACT. NOT STARTED
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▷ PREREQUISITE NOT COMPL.
▶ PREREQUISITE COMPLETE

CONSOLIDATED EDISON CO. of NEW YORK

PROJECT ENGRG DEPT — SCHEDULING BUREAU

SCHEDULING ENGINEER | APPROVED BY PROJECT ENGR | APPROVED BY PROJECT MGR

OVERALL SCHEDULE FOR INDIAN POINT UNIT No.2 NATURAL DRAFT COOLING TOWER WITH EXTENSION FOR 2 YEARS

REVISION	ISSUE NO.	STATUS DATE	REQD SERV. DATE	PROJ. NO.	B. R. NO.	SHEET NO.
	B	1-28-75		2732	3EP5	1 of 1

FORM NO - PSD 1 (rev 4-73)

June 1, 1978	Commence excavation
June 1, 1979	Commence installation
May 1, 1981	Commence cutover to cooling tower
December 1, 1981	Commence operation with tower

However, the economic impact of the requested licensing action has been analyzed on the assumption that Indian Point 2 will be out of service for cut-over of the cooling tower system during the winter of 1980-81. See § 4.1.2. This is an appropriate basis for the economic analysis because, if construction of a cooling tower should be necessary, Con Edison would make every effort to expedite licensing and construction schedules to avoid a summer outage of the plant. The proposed extension affords the necessary flexibility. As indicated in § 4.2, the interim costs to the fisheries have been calculated on the assumption that Indian Point 2 will continue to operate with once-through cooling until May 1, 1981.

1.4 Conclusion

The proposed action is a limited one: extension of the period of operation with once-through cooling from May 1, 1979 to May 1, 1981. During this two-year period, based on the evidence obtained from Con Edison's ecological study programs before and after the Indian Point 2 operating license hearing, there would be no irreversible adverse effect on Hudson River biota. The requested extension is supported by a favorable benefit-cost analysis required under the National Environmental Policy Act of

1969, and would permit a rational decision on the need for closed-cycle cooling because of the improved data base made available by completion of the ecological study program.

2. ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION

2.1 Effects on Aquatic Biota

The potential ecological impacts of Indian Point Unit 2 operation with a once through cooling water system have been thoroughly reviewed elsewhere. *See* Applicant's Environmental Report for Indian Point Unit 2; Proceedings of Atomic Safety and Licensing Board, Indian Point Unit 2, NRC Dkt. No. 50-247. Since the conclusion of the Indian Point 2 operating license hearings, more than 20 reports on ecological studies, data assessments and explanatory documents have been provided the Regulatory Staff. *See* § 8.1 for a listing of these materials. These materials constitute new and relevant information which can be used to assess the real need for the cessation of operation with the present once-through cooling system at Indian Point 2.

Data collected in 1974 on the distribution and abundance of various life stages of striped bass and other species as well as analyses of power plant impacts on these species is presented in Appendix D to this environmental report. This data, gathered in 1974, is especially significant relative to the requested extension as it presents data collected during the period of full power operation of Indian Point Unit 2.

This Report by Con Edison will show, based on the sound ecological research principles set forth during the above noted proceedings, and supporting data gathered since those proceedings, that the requested two-year extension of operation of the once-through cooling system at Indian Point 2 will have no irreversible direct or indirect adverse impacts on the aquatic biota of the Hudson River.

This report provides in summary form the conclusions drawn to date on the potential impacts of the once through cooling system operation on benthic organisms, bacteria, phytoplankton, zooplankton and fishes. Emphasis is placed primarily on striped bass as it is widely considered to be the most important species in the Hudson River from the point of economic and social considerations.

2.1.1 Benthic Organisms

Benthic studies at Indian Point are designed to assess the effects of thermal and chemical effluents from the Indian Point Station. This is being accomplished through the determination of community composition, diversity, biomass, and relative abundance; assessment of naturally occurring variation in community structure; comparison of community variations between the test site and a control site beyond the influence of plant operation (see Figure 2-1); and the evaluation of the population dynamics of a key species, the isopod *Cyathura polita*.

The methodology of the studies is described in detail in the "Hudson River Ecology Study-First Semi-Annual Report," Volumes I and II, dated July 1972, and in the "Hudson River Ecology Study - 1973 Annual Report" dated July 1974.

The mean number of organisms captured in a test area in front of the station increased substantially in 1974 over the mean of those caught in 1973. See Table 2-1. The 1974 means were also greater than those captured in 1972. The total number of taxa collected in the test area increased from 31 in 1973 to 40 in 1974. A total of 38 had been collected in the test area during 1972. The number of taxa and individuals collected in the control area increased in 1974 relative to what had been found in 1973. The number of taxa and total number of individuals collected in the test area were lower in 1973 than they were in 1972. Similar collections in the control area were also lower in 1973 than they were in 1972.

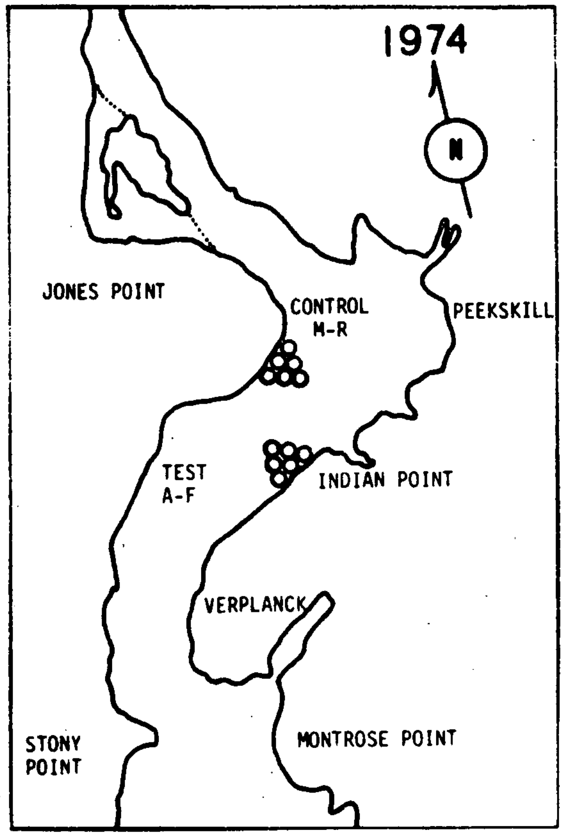

FIGURE 2-1

INDIAN POINT BENTHIC SAMPLING STATIONS

Source: Texas Instruments - 1974
Annual Report Hudson River Ecological Study

TABLE 2-1

Annual Mean Numbers of Individuals/m^2 at Indian Point Test and Control Regions during 1972, 1973

Dominant Taxa	1972 Survey	1972 Test	1972 Control	1973 Test	1973 Control	1974 Test	1974 Control
Limnodrilus sp	547.7	324.7	415.7	1349.5	2870.8	2730.9	3601.6
Cyathura polita	162.0	201.3	219.9	244.6	137.8	467.5	434.6
Boccardia hamata	215.0	132.2	783.9	221.4	767.1	133.6	955.0
Scolecolepides viridis	74.6	89.9	69.1	212.4	244.0	2824.5	2086.8
Gammarus sp	82.8	156.1	93.0	442.4	219.1	287.4	154.4
Amnicola sp	992.1	662.8	486.9	15.7	3.5	4008.3	975.8
Balanus improvisus	133.4	240.9	22.9	47.8	108.9	1016.9	825.8
Congeria leucophaeta	123.9	290.2	11.0	97.6	35.4	295.9	74.3
Chironomid larvae	191.1	129.3	43.4	121.7	26.2	226.9	52.0
Corophium sp	56.8	48.8	15.2	57.8	27.2	150.2	158.7
Chaoborus sp	2.6	5.1	1.6	26.8	12.1	46.2	43.4
Peloscolex sp	56.8	85.9	62.1	23.5	13.8	8.2	3.6
Chiridotea almyra	2.6	2.3	6.3	2.9	12.2	21.9	30.1
Edotea sp	2.6	1.1	5.3	6.3	25.1	12.8	32.1
Nematoda	25.7	18.4	21.2	7.6	0.9	12.5	4.0
Rhithropanopeus harrisi	6.3	17.5	1.2	10.9	1.1	18.7	18.9
Hypaniola sp	4.8	2.7	5.1	5.1	4.4	10.7	2.0
Nudibranchia	2.8	1.1	1.1	1.7	1.8	21.0	4.6
Monoculodes sp	0.2	0.3	0.2	1.9	2.2	5.4	4.0
Paleonemertea	0.4	0.4	0.2	0.5	0.9	3.8	2.8
Hydracarina	0.7	1.1	0.2	0.1	0.1	0.3	0.3
Piscicola sp	0.3	0.5	1.0	0.2	0.2	0.5	0.1
Trichoptera - adult	0.1	0.1	0.3	0.2	0.1	0.7	1.0
Leptocheirus sp	1.4	0.9	-	2.0	0.7	18.9	5.8
Planaridae	8.9	13.3	2.9	-	-	0.4	0.2
Sphaerium sp	0.3	-	0.2	-	-	4.5	1.6
Collembola	0.1	-	0.2	-	-	0.3	0.2
Chironomid pupae	0.1	-	0.2	-	-	3.1	0.4
Hydra americana	0.1	-	-	-	0.6	0.2	-
Daphnia sp	0.1	0.1	-	-	-	0.1	1.2
Cassidina lunifrons	0.1	0.1	-	-	-	0.2	0.4
Acanthocephala	0.1	0.1	-	0.1	-	-	-
Nereis succinea	0.1	0.1	-	-	-	-	0.2
Sipunculida	0.1	0.1	-	-	-	-	-
Dugesia sp	0.1	0.2	-	-	-	-	-
Palpomyia sp	0.1	0.1	-	-	-	-	-
Enallagma sp	0.1	-	-	-	-	-	-
Decapod - larva	0.1	0.1	-	-	-	-	-
Turbellaria	0.1	0.3	-	-	-	-	-
Neomysis americana	-	-	-	0.1	0.1	0.2	-
Odonata - larva	-	-	-	0.1	-	-	0.1
Agraylea sp	-	-	-	0.1	-	-	-
Glossiphoniidae	-	-	-	-	0.1	-	-
Elliptio sp	-	-	-	-	-	0.2	-
Ceratopogonidae	-	-	-	-	-	0.1	0.2
Ferrissia sp	-	-	-	-	-	0.1	0.1
Crangonyx sp	-	-	-	-	-	0.1	-
Crangon septemspinosus	-	-	-	-	-	-	0.3
Ephemeroptera - adult	-	-	-	-	-	-	0.2
Naididae	-	-	-	-	-	-	0.1
Leptodora sp	-	-	-	-	-	-	0.1
Harpacticoida	4344.1	7836.7	2527.2	0.2	0.1	52.5	10.3
Ostracoda	208.3	198.8	82.9	-	-	0.1	0.1
Cyclopoida	17.6	23.6	11.4	0.4	-	34.5	18.9
Calanoida	1.0	1.2	1.3	0.2	-	11.1	0.3
Macrothricidae	0.3	-	2.0	-	-	-	0.3
Total No. of Taxa	44	38	32	31	28	40	43
Mean Total No/m^2	7268.5	10488.5	4895.1	2901.7	4516.5	12409.2	9500.7

Source: Texas Instruments - 1974 Annual Report
Hudson River Ecological Study

These fluctuations illustrate that the benthic fauna respond to natural conditions of the river and are in general uninfluenced by the presence of the plant or its operation. This fact is further evidenced by the fluctuation in abundance of halophilic (salt-loving) benthic organisms such as _Congeria leucophaeta_, _Balanus improvisus_ and _Corophium sp_., which declined slightly in abundance 1973 when the estuarine salt water was present in the Indian Point area only briefly. In 1974, however, salt water was present for a longer period than in 1973, and larger numbers of halophilic organisms were found. Texas Instruments, Incorporated - Hudson River Ecological Study 1974 Annual Report.

Diversity indices calculated for the test area and the control area in both 1973 (Table 2-2) and 1974 (Table 2-3) showed similar patterns of seasonal changes in populations of benthic organisms. Diversity indices for the test area were similar between 1973 and 1974.

Biomass measurements made in 1972, 1973, and 1974 suggest that the Indian Point Station operation is having no effect on the benthic community. The mean total biomass was generally higher in the test area than in the control area in each of the three study years 1972, 1973 and 1974. In addition the biomass in the test area was much greater in 1974 than in 1973. _See_ Figure 2-2.

The estuarine isopod _Cyathura polita_ has been intensively studied in 1973 and 1974. Seasonal variation in population densities during 1974 was consistent between test area and the control area, with both regions exhibiting relatively low

TABLE 2-2

Diversity Indices as Calculated from 1973 Test and Control Areas Data

Mo	Diversity Index	Test Area						Control Area					
		Station						Station					
		A	B	C	D	E	F	M	N	O	P	Q	R
Apr	SW	0.67	0.61	0.53	0.73	0.42	0.73	-	-	-	-	-	-
	H	2.80	1.93	1.22	3.69	0.67	3.89	-	-	-	-	-	-
	J	0.60	0.53	0.49	0.67	0.34	0.66	-	-	-	-	-	-
May	SW	0.60	0.64	0.75	0.80	0.45	0.69	-	-	-	-	-	-
	H	2.23	2.29	4.37	4.59	0.92	2.89	-	-	-	-	-	-
	J	0.63	0.61	0.72	0.77	0.42	0.69	-	-	-	-	-	-
Jun	SW	0.73	0.42	0.71	0.65	0.60	0.71	0.46	0.14	0.10	0.27	0.26	0.24
	H	3.65	0.71	3.34	2.89	2.15	3.31	0.96	0.14	0.09	0.39	0.35	0.33
	J	0.77	0.37	0.64	0.68	0.63	0.71	0.44	0.14	0.11	0.27	0.26	0.28
Jul	SW	0.50	0.26	0.32	0.68	0.68	0.66	0.38	0.33	0.15	0.47	0.46	0.32
	H	1.60	0.34	0.46	2.95	3.05	2.47	0.79	0.46	0.15	0.94	0.97	0.59
	J	0.53	0.27	0.29	0.65	0.61	0.66	0.40	0.33	0.15	0.45	0.42	0.36
Aug	SW	0.26	0.30	0.49	0.29	0.56	0.65	0.57	0.39	0.28	0.37	0.42	0.14
	H	0.35	0.46	1.29	0.44	1.98	3.19	3.37	0.73	0.44	1.12	1.04	0.18
	J	0.25	0.30	0.51	0.30	0.52	0.60	0.81	0.44	0.34	0.53	0.50	0.15
Sep	SW	0.59	0.67	0.67	0.58	0.47	0.58	0.51	0.57	0.12	0.57	0.48	0.10
	H	2.24	2.55	2.94	1.88	1.56	1.94	1.62	1.88	0.13	1.91	1.34	0.10
	J	0.57	0.62	0.62	0.58	0.60	0.51	0.57	0.53	0.13	0.55	0.42	[illegible]
Oct	SW	0.73	0.10	0.85	0.83	0.42	0.84	0.42	0.47	0.31	0.44	0.42	0.52
	H	2.62	0.12	4.35	4.24	0.95	4.30	0.79	1.35	0.53	0.70	[illegible]	[illegible]
	J	0.63	0.12	0.72	0.67	0.39	0.66	0.39	0.43	0.30	0.39	[illegible]	0.43
Nov	SW	0.81	0.70	0.65	0.93	0.77	0.96	0.88	0.61	0.30	1.01	0.64	0.75
	H	4.12	2.01	1.45	5.31	2.93	5.45	4.50	1.35	0.38	7.22	1.95	2.35
	J	0.66	0.58	0.54	0.75	0.59	0.72	0.69	0.49	0.25	0.73	0.49	0.57
Dec	SW	0.71	0.58	0.71	0.89	0.92	0.35	0.37	0.56	0.48	0.43	0.41	0.33
	H	2.28	1.17	2.05	4.12	4.88	0.47	1.30	1.06	1.13	0.77	0.57	0.47
	J	0.60	0.45	0.58	0.71	0.70	0.30	0.34	0.44	0.37	0.37	0.31	0.27

SW = Shannon-Weaver
H = Hulbert
J = Pielou

Source: Texas Instruments Hudson River Ecological Study 1973 Annual Report July 1974

TABLE 2-3

Monthly Diversity Indices at Indian Point Test and Control Region Stations during 1974

Month	Index	Test Area Stations A	B	C	D	E	F	Control Area Stations M	N	O	P	Q	R
Apr	SW	0.85	0.79	0.80	0.42	0.66	0.32	0.50	0.43	0.32	0.45	0.66	0.54
	H	4.31	3.76	3.67	0.76	2.28	0.67	1.49	1.33	0.57	0.92	3.25	1.74
	J	0.63	0.60	0.6	0.33	0.49	0.25	0.45	0.41	0.29	0.38	0.66	0.47
May	SW	0.66	0.47	0.47	0.38	0.40	0.49	0.65	0.43	0.46	0.55	0.51	0.41
	H	2.21	1.43	1.35	1.08	0.97	1.29	2.14	0.99	1.45	1.70	1.55	1.24
	J	0.55	0.44	0.36	0.37	0.37	0.38	0.62	0.38	0.46	0.42	0.49	0.36
Jun	SW	0.61	0.60	0.61	0.48	0.71	0.53	0.61	0.63	0.62	0.66	0.49	0.41
	H	1.78	1.99	2.14	1.40	3.03	1.65	2.12	2.21	2.21	2.42	1.45	1.23
	J	0.49	0.50	0.47	0.39	0.54	0.41	0.51	0.51	0.53	0.64	0.37	0.35
Jul	SW	0.51	0.61	0.65	0.71	0.75	0.62	0.46	0.55	0.56	0.63	0.38	0.50
	H	0.96	1.95	2.39	2.63	3.25	2.06	1.02	1.57	1.27	1.73	0.61	1.56
	J	0.41	0.44	0.49	0.52	0.56	0.46	0.38	0.46	0.45	0.49	0.32	0.43
Aug	SW	0.58	0.80	0.75	0.65	0.34	0.36	0.67	0.74	0.49	0.48	0.62	0.25
	H	2.09	3.36	3.03	2.06	0.63	0.89	2.87	3.02	1.39	1.42	2.44	0.47
	J	0.52	0.56	0.55	0.47	0.27	0.27	0.53	0.58	0.39	0.35	0.48	0.20
Sep	SW	0.57	0.71	0.68	0.65	0.50	0.46	0.67	0.67	0.60	0.55	0.54	0.39
	H	1.91	3.15	2.52	2.23	1.23	1.19	2.55	1.94	2.39	1.20	1.36	1.09
	J	0.49	0.59	0.52	0.50	0.42	0.39	0.51	0.53	0.49	0.45	0.40	0.33
Oct	SW	0.79	0.83	0.77	0.32	0.36	0.58	0.81	0.63	0.72	0.65	0.47	0.46
	H	3.44	3.84	3.09	0.40	0.52	1.35	3.37	1.37	2.29	2.22	1.11	1.29
	J	0.63	0.60	0.58	0.25	0.27	0.44	0.61	0.46	0.56	0.50	0.38	0.38
Nov	SW	0.75	0.39	0.84	0.58	0.59	0.68	0.65	0.51	0.62	0.65	0.72	0.59
	H	2.92	0.86	4.38	1.25	1.34	1.99	2.27	1.42	2.26	2.77	3.49	1.77
	J	0.56	0.30	0.66	0.44	0.44	0152	0.50	0.44	0.51	0.53	0.59	0.46
Dec	SW	0.73	0.55	0.71	0.53	0.66	0.36	0.60	0.76	0.67	0.60	0.58	0.42
	H	2.39	1.71	2.23	0.92	1.57	0.59	2.08	3.00	2.66	1.88	1.80	1.23
	J	0.56	0.41	0.54	0.40	0.51	0.28	0.51	0.58	0.54	0.50	0.51	0.35

*SW = Shannon-Weaver log 10
H = Hurlbert
J = Pielou

Source: Texas Instruments - 1974 Annual Report
Hudson River Ecological Study

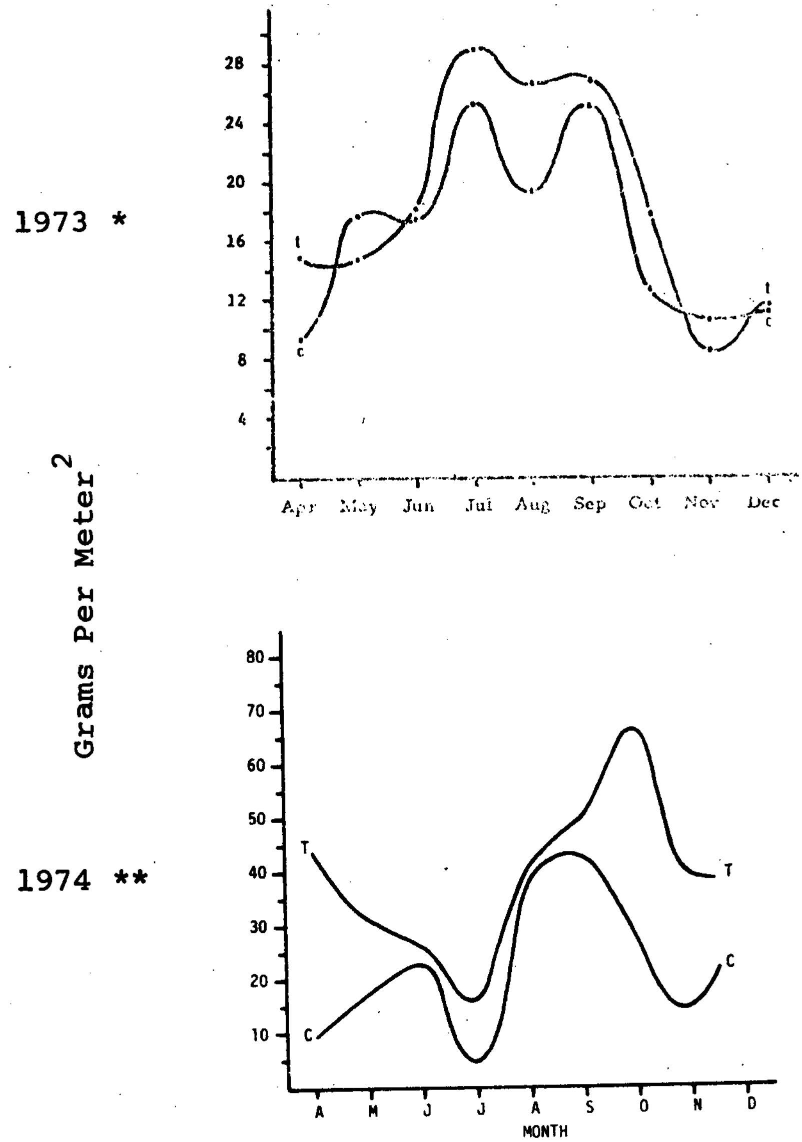

FIGURE 2-2

MONTHLY MEAN WET WEIGHT BIOMASS/M^2 AT INDIAN POINT TEST AND CONTROL REGIONS

Source: * Texas Instruments 1973 Annual Report Hudson River Ecological Study

** Texas Instruments 1974 Annual Report Hudson River Ecological Study numbers during the early months of the year, high reproduction and corresponding increases in numbers in May through September and a general decline in abundance through the fall and winter. This pattern is consistent with the pattern of seasonal changes during 1972 and 1973. See Figure 2-3.

Temperature measurements made in the test area and in the control area indicate the thermal plume has no influence on the temperature of the sediments, the water layer within 2.5 cm of the bottom, or the water at 30 cm above the bottom. See Table 2-4.

The depth of the bottom at the test area ranges from 11.5 to 22 meters (36-72 feet). The ports of the discharge structure are located between minus 10 feet and 14 feet at mean low water, (Environmental Report-Indian Point Unit No. 3 § 9.2) well above the river bottom.

Based on the results of three years of benthic studies performed by Texas Instruments and reported on in the following Hudson River Ecological study Reports: First Semi-annual Report, Vol I, July 1972, First Annual Report, April 1973, - 1973 Annual Report, July, 1974, and in a letter dated May, 1975, it is concluded that the operation of the Indian Point Station has had no adverse impact on the benthic community in its vicinity. Therefore, it is concluded that the requested extension of the period of operation with once-through cooling will not result in an adverse impact on benthos.

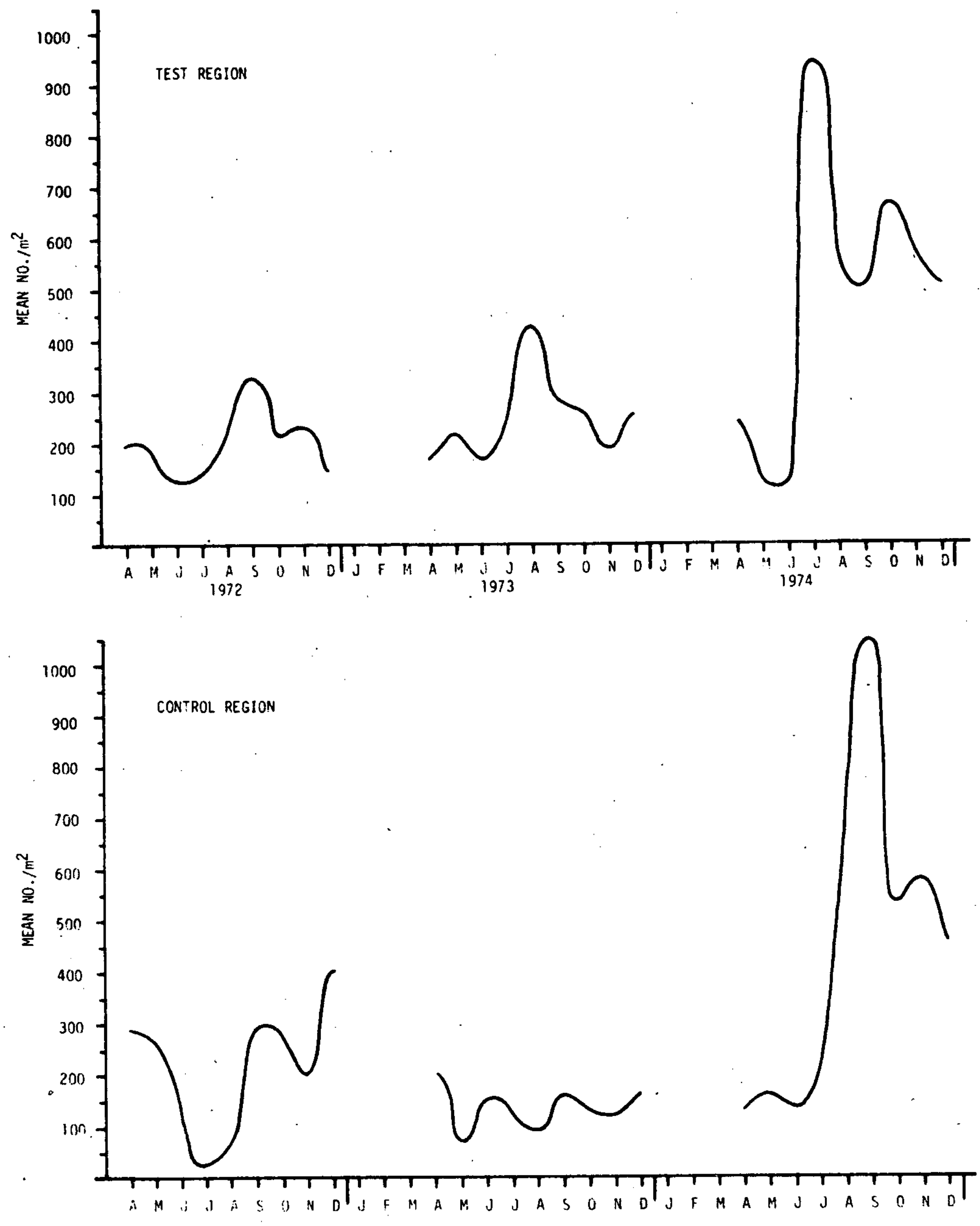

FIGURE 2-3

MEAN MONTHLY DENSITY OF CYATHURA POLITA (STIMPSON) IN INDIAN POINT TEST AND CONTROL REGIONS BETWEEN APRIL 1972 AND DECEMBER 1974

Source: Texas Instruments: 1974 Annual Report Hudson River Ecological Study

TABLE 2-4

Mean *In situ* Water and Sediment Temperature (°C) for Indian Point Test and Control Regions during 1974

		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
Test	Sediment	4.2	12.8	18.8	26.0	25.0	24.0	18.8	11.9	6.8	16.48
	Water										
	2.5 cm	3.5	12.3	17.8	24.0	24.5	24.0	18.7	11.6	6.3	15.86
	30 cm	3.5	12.0	17.8	24.0	24.0	24.0	18.5	11.5	6.3	15.73
Control	Sediment	5.2	12.7	20.0	25.3	24.8	24.5	17.0	14.0	4.8	16.48
	Water										
	2.5 cm	4.2	12.0	19.0	24.3	24.3	24.2	17.1	13.7	4.3	15.90
	30 cm	4.2	12.0	19.0	24.3	24.0	26.0	16.8	13.3	4.3	15.99

Source: Texas Instruments - 1974 Annual Report
Hudson River Ecological Study

2.1.2 Planktonic Organisms (other than fish)

This section of the Environmental Report is concerned with the effects of an extension of the interim period of once-through cooling system operation on planktonic organisms other than fish. These organisms include bacteria, phytoplankton and zooplankton. Planktonic organisms, being in general passive by nature, are moved via the flow of the river, and as such are susceptible to entrainment into both the plant and the thermal plume. Entrained organisms are exposed to stresses such as changes in temperature, pressure, mechanical abrasion, velocity shear forces and chemical additions.

The ecological significance of the entrainment impact resulting from these stresses is dependent on a variety of factors including (1) the number of organisms entrained, (2) the entrainment mortality that arises, (3) the significance of the organism in the biological community, and (4) the reproductive potential of the species.

2.1.2.1 Bacteria

Determination of entrainment effects on bacteria was made through laboratory tolerance studies and intake and discharge canal studies at Indian Point. A comprehensive discussion of the results of these studies is contained in the New York University Progress Report for 1971-1972 on Effect of Entrainment by the Indian Point Plant on Biota in the Hudson River Estuary. Although only Indian Point 1 was operating when the studies were conducted, the results obtained are applicable to the entrainment effects expected during operation of Unit 2.

The NYU program found that only at temperatures in excess of those projected for normal plant operations would Hudson River bacterial populations experience any thermal impacts. It was determined, however, that during chlorination, a significant decrease in adenosine triphosphate (ATP) production would occur in the bacterial populations. The populations showed significant recovery capabilities though, and by the time the discharge water reached the D-1 sampling station, <u>see</u> Figure 2-4, the production of ATP was at 90% of the rate determined for bacteria samples collected from the intake water upstream of the point of chlorination. <u>See</u> Figures 2-5 and 2-6.

It was concluded from these NYU studies that the overall effect of normal plant operation on river populations of bacteria would be negligible. Similarly, it is concluded that the requested extension of operation of the once-through cooling system at Indian Point 2 will not have adverse impacts on Hudson River bacterial populations.

2.1.2.2 Phytoplankton

The impact of entrainment at Indian Point on phytoplankton in the Hudson River was studied by New York University through laboratory thermal tolerance studies and through intake and discharge canal studies performed in 1971, 1972 and 1973. A comprehensive discussion of the methodology and the results of these investigations may be found in the New York University Progress Report for 1971-1972, and a similar NYU Progress report for 1973.

New York University studies found that at various times of the year, it could be expected that phytoplankton productivity (as measured by the Carbon-14 method) could be either inhibited, stimulated, or essentially unaffected upon passage through the plant. See Figures 2-7 and 2-8. During the studies no evidence was found to suggest that the plant operation might be influencing the species composition of the phytoplankton.

Through laboratory experiments NYU found that the productivity of phytoplankton representing each of the populations present during the four seasons could be decreased by exposure to temperatures of 100°F (38°C) for a period of 60 minutes. Populations of phytoplankton collected during the summer and exposed to 87°F (30.5°C) for less than one minute were also adversely affected. However, summer phytoplankton productivity was stimulated by exposure to 91°F (32°C) for one hour. This strongly suggested that the populations had the potential for rapid acclimation to increased temperatures.

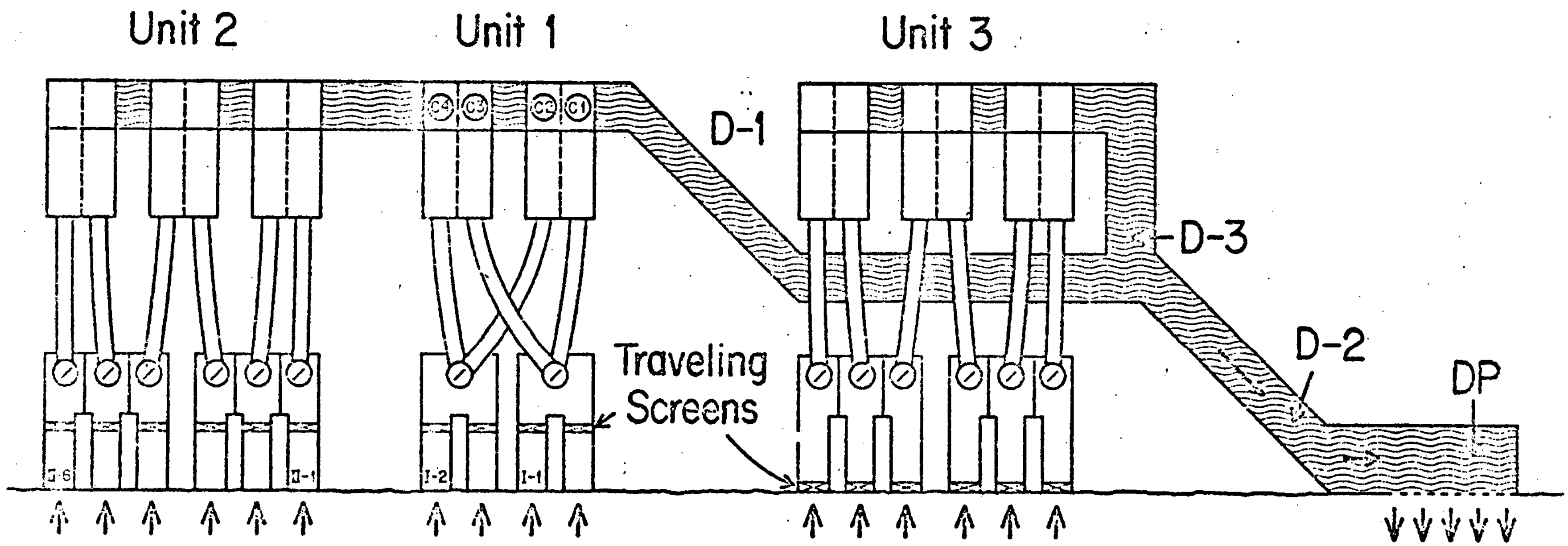

FIGURE 2-4

SCHEMATIC DIAGRAM OF INDIAN POINT COOLING WATER SYSTEM SHOWING LOCATIONS OF SAMPLING STATIONS

Source: New York University Progress Report for 1973

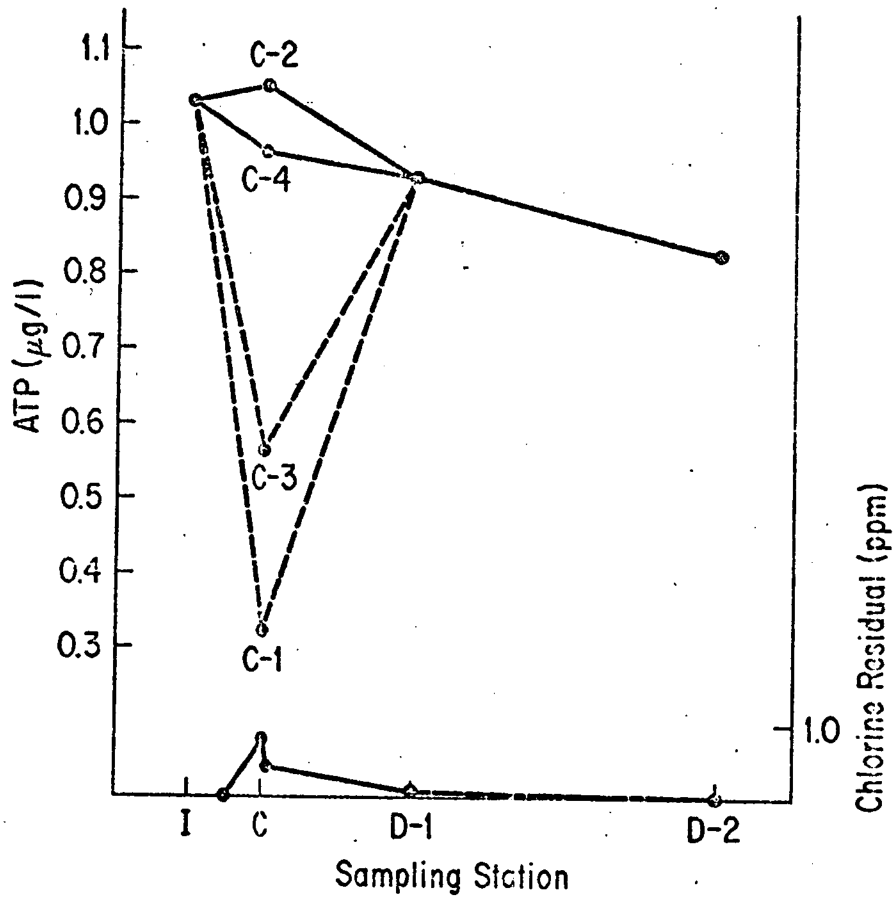

FIGURE 2-5

ATP AND CHLORINE RESIDUAL IN UNIT 1 COOLING WATER SYSTEM ON SEPTEMBER 7, 1971. (AMBIENT WATER TEMPERATURE WAS 77°F; ΔT 11°F. CONDENSERS 1 and 3 WERE CHLORINATED. POINTS SHOWN ARE MEANS OF SAMPLES, 5 REPLICATES PER SAMPLE.)

Source: New York University Progress Report for 1971 and 1972

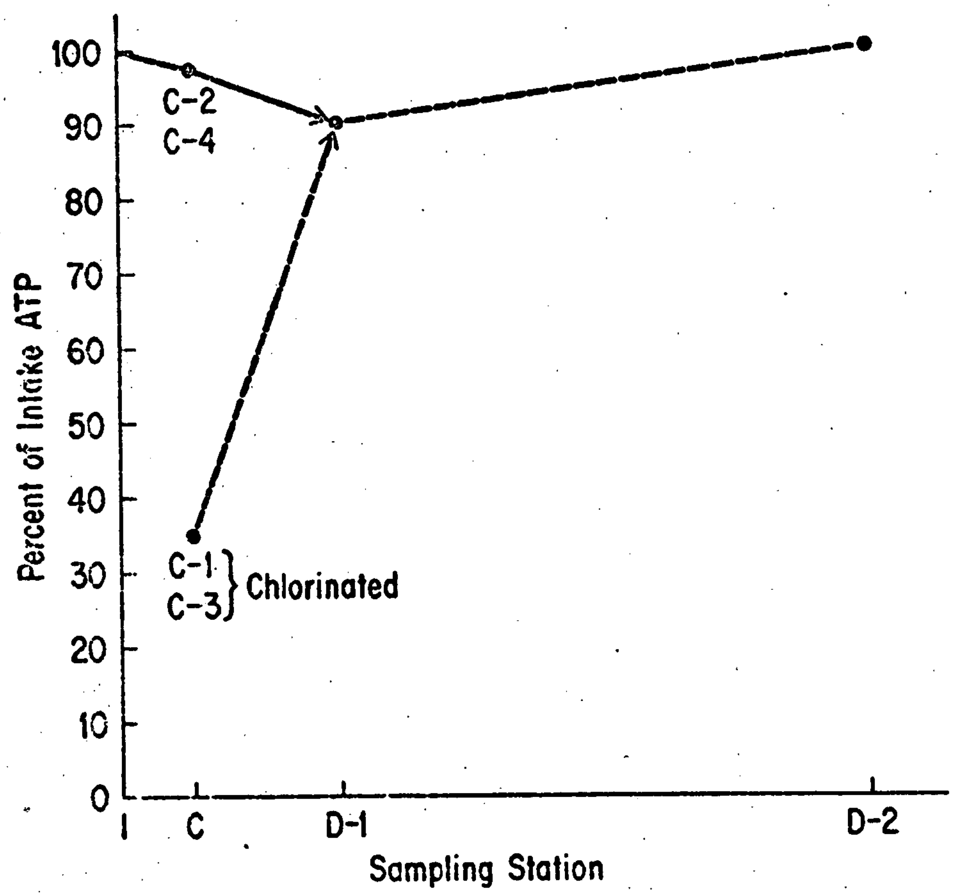

FIGURE 2-6

ATP IN UNIT 1 COOLING WATER SYSTEM AS PERCENTAGE OF INTAKE ATP ON SEPTEMBER 7, 1971
(AMBIENT WATER TEMPERATURE WAS 77°F, ΔT 11°F. CONDENSERS 1 and 3 WERE CHLORINATED. POINTS SHOWN ARE MEANS OF SAMPLES, 5 REPLICATES PER SAMPLE).

Source: New York University Progress Report for 1971 & 1972

NYU concluded from their work that the entrainment exposure to thermal increments resulting from normal plant operation would have no adverse impact on phytoplankton populations, and if anything, would tend to stimulate productivity.

The Regulatory Staff has previously reviewed the NYU study reports, and concluded in the Final Environmental Statement for Indian Point 3 that the entrainment of phytoplankton at Indian Point would not have any adverse impact on the aquatic ecosystem in the vicinity of Indian Point. Indian Point 3 FES at V-76.

Con Edison accordingly concludes that the requested extension for operation of the once-through cooling system at Indian Point 2 will have no adverse impact on the phytoplankton populations of the Hudson River.

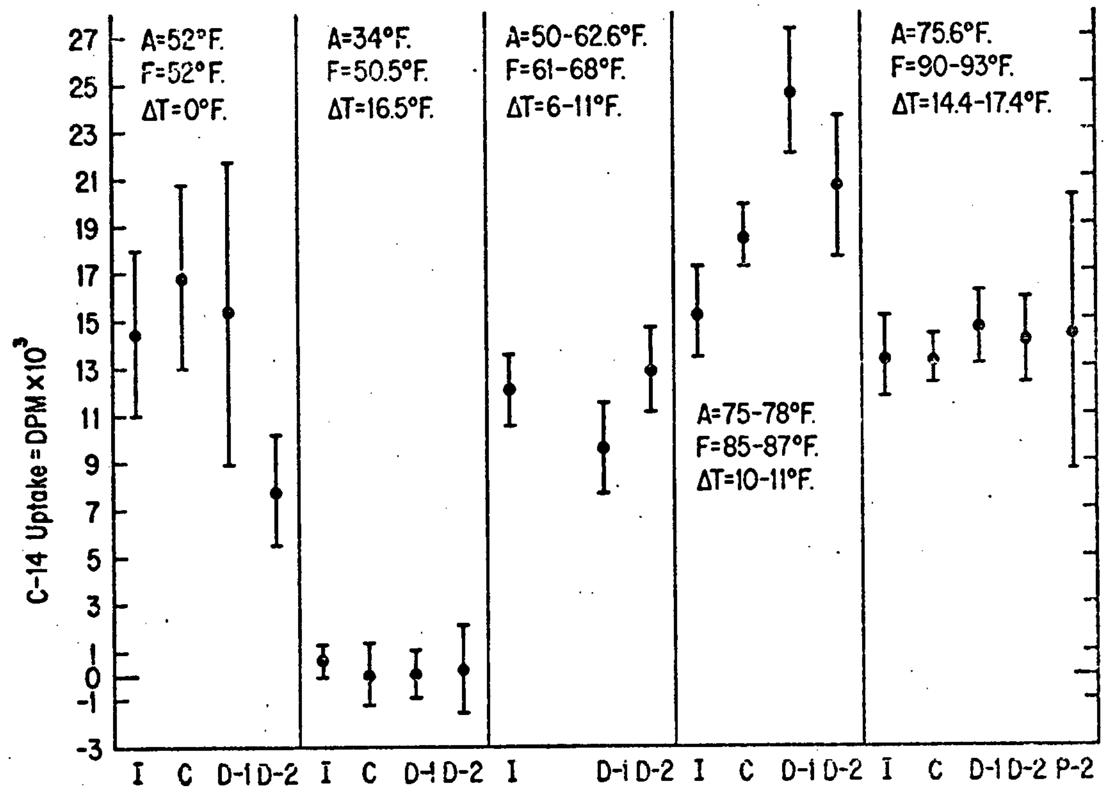

FIGURE 2-7

Thermal effects on relative productivity after passage through condensers. (Samples were incubated at ambient water temperature for 4 hours. Values plotted are mean net ^{14}C uptake rates and 95% C.I.)

A = ambient water temperature
F = final temperature
ΔT = temperature increase
I = intake station
C = condenser station
D-1 = discharge canal station
D-2 = discharge canal station
P-2 = plume station

Source: New York University Progress Report for 1971 and 1972

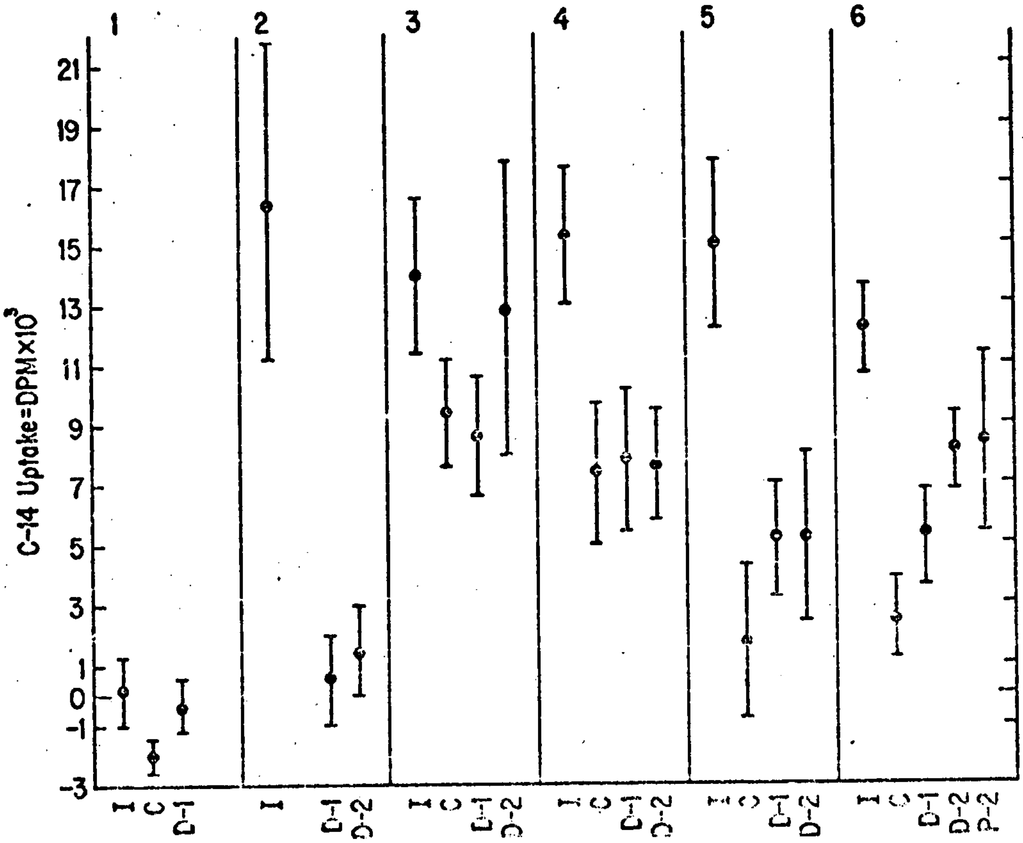

FIGURE 2-8

THERMAL AND CHLORINATION EFFECTS ON RELATIVE PRODUCTIVITY AFTER PASSAGE THROUGH CONDENSERS. (SAMPLES WERE INCUBATED AT AMBIENT WATER TEMPERATURE FOR 4 HOURS. VALUES PLOTTED ARE MEAN NET ^{14}C UPTAKE RATES AND 95% C.I. CONDITIONS ARE AS SHOWN IN TABLE BELOW).

Experiment	Water temperatures (°F) Ambient	Final	Δ T	Total residual chlorine at stations (mg/l) C	D-1	D-2	P-2
1	34	56	22	0.83	0.37	--	--
2	59-62.6	68-69.8	7-11	--	0.08	0.07	--
3	68-71.5	75.2-75.5	4.1-6.8	0.50	0.08	0.07	--
4	68.4	68.4	0	0.23	<0.1	<0.1	--
5	75-78	85-87	7-12	0.30	0.09	0.08	--
6	75-5	90-93	14.4-17.4	0.27	0.08	0.07	0.00

(I = INTAKE STATION, C = CONDENSER STATION, D-1 and D-2 = DISCHARGE CANAL STATIONS, P-2)

Source: New YORK UNIVERSITY PROGRESS REPORT FOR 1971 and 1972

2.1.2.3 Microzooplankton

New York University has also conducted entrainment effects studies on microzooplankton at Indian Point. Major species of microzooplankton include *Acartia* sp., *Halicyclops* sp., *Bosmina* sp., and *Eurytemora affinis*. River population studies were made in 1971 and 1972, and assessments of entrainment-induced impact were made in 1972 and 1973. Comprehensive discussion of the methodology and results of these studies are found in the New York University Progress Reports for 1971-72 and for 1973.

The results of the work suggested that the impact of entrainment was a somewhat reduced population of microzooplankton in the discharge water relative to the intake water. However, the river survey work found no indication that the plant operation was impacting the populations in the river, including the immediate vicinity of the discharge plume.

Laboratory thermal tolerance studies found that during the period of maximum ambient temperature, the more sensitive microzooplankton species might suffer some mortality at the temperature imparted to the cooling water during normal full power operation. *See* Figure 2-9.

In addition, intake and discharge canal studies at Indian Point indicated a slight mortality when the microzooplankton were exposed to a delta T of 8.5°F (4.7°C) over a summer ambient temperature of 80.6°F (27.0°C). *See* Table 2-5. But analysis of these data revealed this not to be a statistically significant difference. Analyses also indicated no

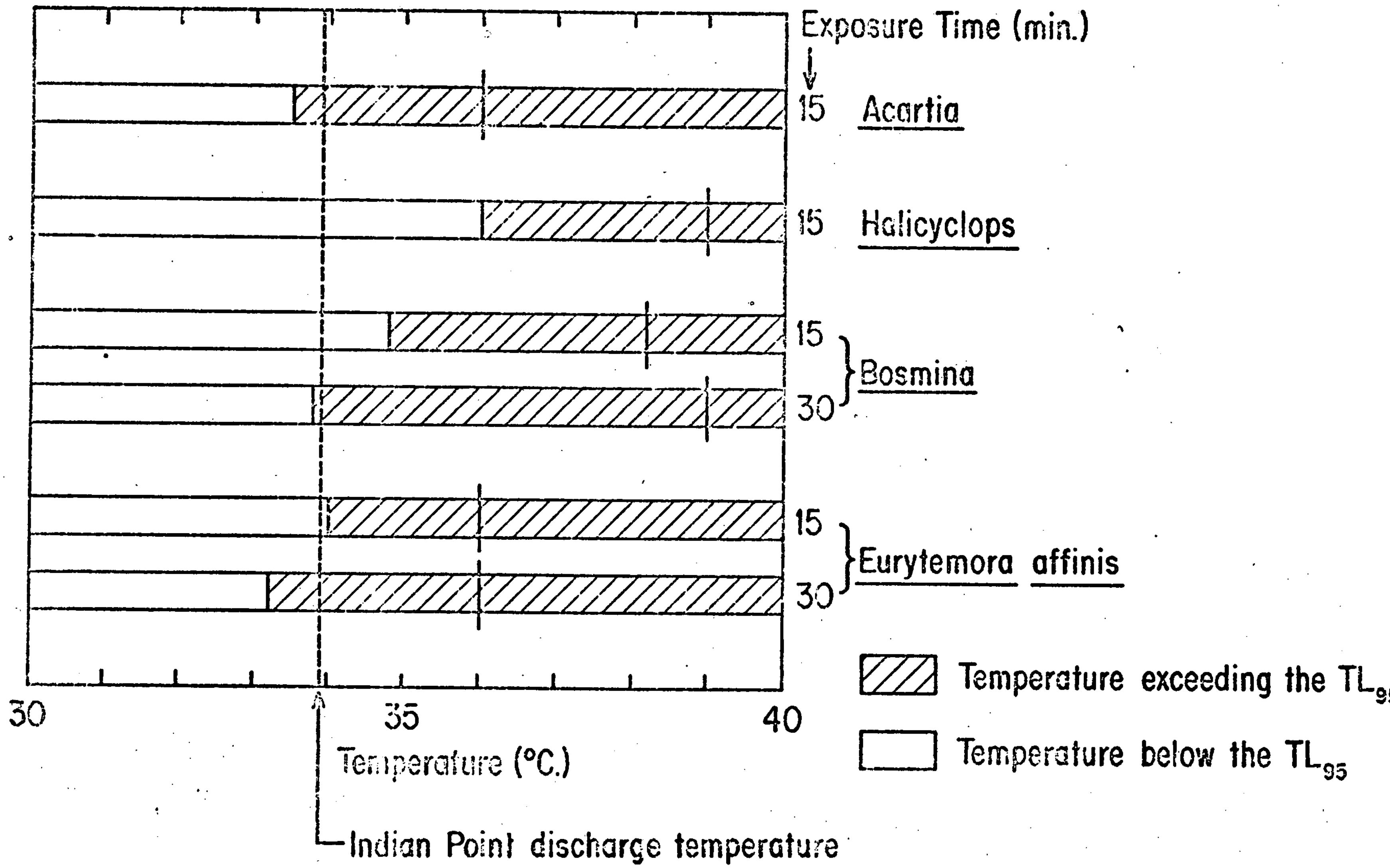

FIGURE 2-9

TEMPERATURE TOLERANCE OF MAJOR HUDSON RIVER MICROINVERTEBRATES DURING SUMMER AMBIENT TEMPERATURES. (THE DISCHARGE TEMPERATURE WAS 33.9°C, WHICH REPRESENTED A ΔT OF 8.3°C OVER AN AMBIENT TEMPERATURE OF 25.6°C).

Source: New York University Progress Report for 1971 and 1972

TABLE 2-5

Percent Survival of Various Species of Microzooplankton In Relation to ΔT at Summer Ambient Temperatures

Species	Number of organisms	ΔT (^oC)	Discharge temp. (^oC)	Percent survival by station: I1	I2	D1	D2	D1-C1	D2-C1
Acartia	114	6.1	30.0	88.0	98.7	84.1	100.0	63.1	100.0
	166	7.2	32.2	96.4		77.2	96.7	67.0	73.0
Halicyclops	181	6.1	30.0	100.0	100.0	100.0	100.0	92.1	97.9
	52	7.2	32.2	100.0		93.3	100.0	100.0	84.6
	407	7.3	32.2	100.0		96.4	87.9	95.6	97.0
	262	7.6	32.3	90.3	94.7		97.0	98.4	91.9
	466	8.3	32.8	100.0		98.6	94.0	98.4	92.7
Bosmina	35	7.3	32.2	87.7		100.0	92.6	100.0	81.9
	35	7.6	32.3	75.0	100.0		93.4	100.0	100.0
	51	8.3	32.8	100.0		100.0	100.0	100.0	85.0
Eurytemora affinis	113	6.1	30.0	100.0	99.5	98.3	100.0	78.2	97.9
	525	7.2	32.2	99.3		97.3	95.5	83.2	84.6
	53	7.3	32.2	89.0		100.0	79.5	100.0	90.0
	25	8.3	32.8	100.0		75.0	75.0	25.0	87.5
Cladocerans & Copepods	683	4.4	28.3		94.5	94.4	97.3	82.8	85.1
	517	5.5	28.9	95.1		91.8	96.3	61.3	66.4
	4,005	4.2	29.8	94.9	97.6	97.5	97.4	97.7	98.6
	668	6.1	30.0	96.7	99.0	96.8	100.0	87.7	95.9
	1,152	5.5	31.1	96.3	98.2	95.8	95.0	88.9	87.4
	1,228	7.2	32.2	97.2		95.2	97.3	87.7	79.2
	533	7.3	32.2	97.1		97.4	85.8	92.0	87.8
	394	7.6	32.3		96.4		95.7		90.3
	718	8.3	32.8	99.4		97.8	93.6	97.6	93.3

$(^oC)(1.8) + 32 = {}^oF$

Source: New York University Progess Report for 1971 and 1972 significant reduction in the survivability of the entrained microzooplankton during periods of chlorination.

The Commission's Regulatory Staff, through detailed analysis of Con Edison's Environmental Report and other work (such as the NYU Entrainment Reports) concluded in the Final Environmental Statement for Indian Point 3 that the entrainment impacts on microzooplankton would not be adverse relative to the aquatic ecosystem near Indian Point. Indian Point 3 FES at V-76.

Con Edison concludes that the requested extension of operation of the once-through cooling system at Indian Point 2 will not cause a significant adverse impact on the microzooplankton populations of the Hudson River ecosystem.

2.1.2.4 Macrozooplankton

Comprehensive investigations of the macrozooplankton populations in the vicinity of Indian Point and of the susceptibility of these organisms to impacts due to plant operations have been conducted by New York University. In addition, assessments of the ecolcgical significance of these organisms in the Hudson River have been studied by Texas Instruments, Incorporated and by Raytheon, Inc. during the past six years. Discussions of the methcdology and results of these studies are contained in the New York University Progress Reports for 1971-1972 and for 1973, in the Texas Instruments Indian Point First Annual Report (July 1973) and in the Raytheon Company Final Report - Consolidated Edison Indian Point Ecological Survey, June 1969-October, 1971.

These studies have found that on an annual basis the macrozooplankton community in the vicinity of Indian Point is dominated by the species _Gammarus spp._, _Monoculodes edwardsi_, and _Neomysis americana_. These three species comprised 97% of the total numbers of macrozooplankton in 1972, and 87% of the total in 1971. NYU Progress Report (1973), at 122, 125. Seasonally, _Gammarus spp_. is most abundant from April through mid-August. _N. americana_ is most abundant from mid-August through October, and then both _M. edwardsi_ and _Gammarus spp_. are predominant during November and December. _See_ Figure 2-10.

The occurrence of _Gammarus_ and _Neomysis_ at Indian Point is closely related to the position of the salt front (defined as approximately 0.1 parts per thousand, Texas

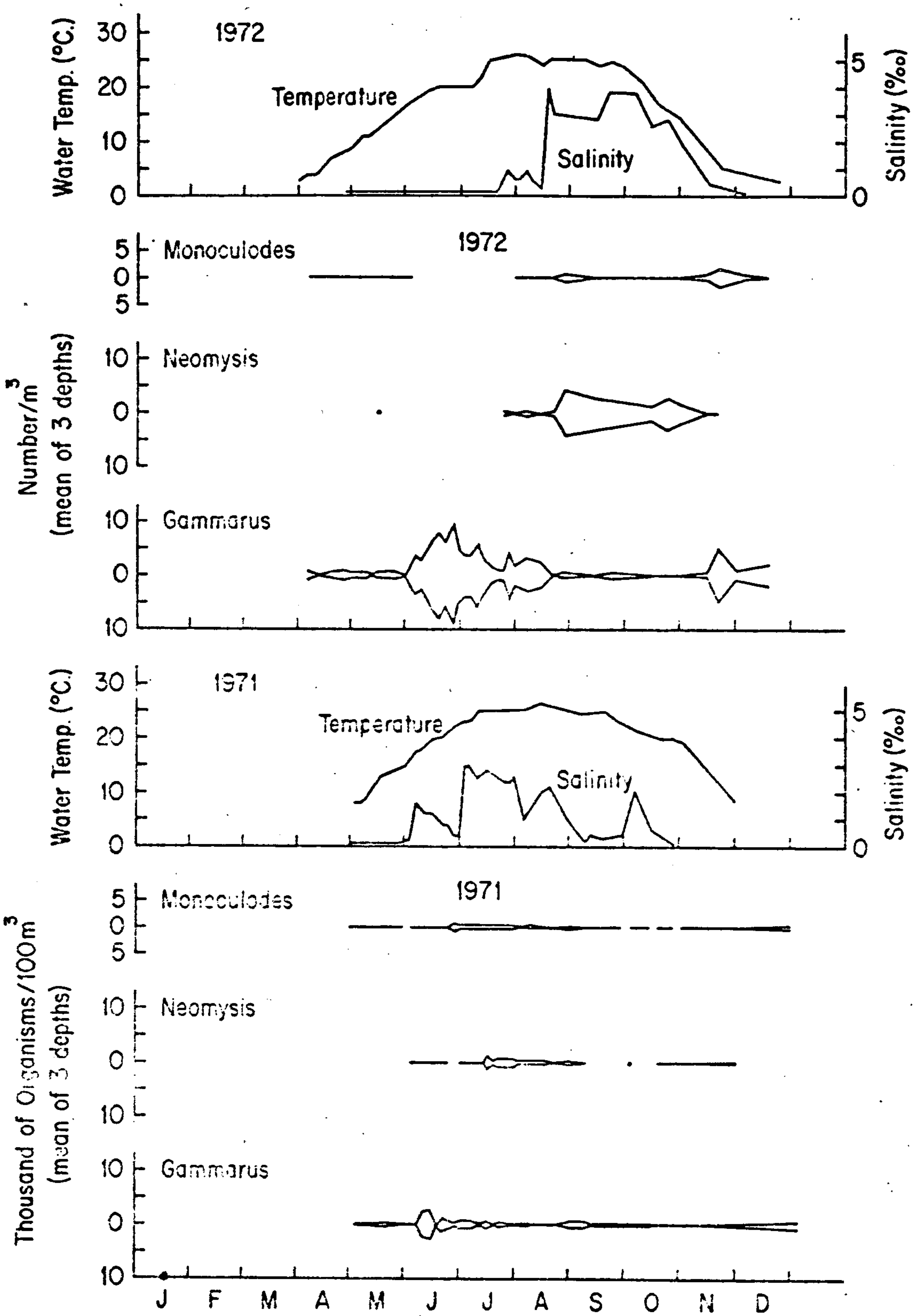

Figure 2-10

SEASONAL ABUNDANCE OF MONOCULODES EDWARDSI, NEOMYSIS AMERICANA and GAMMARUS sp. IN THE HUDSON RIVER AT INDIAN POINT IN RELATION TO WATER TEMPERATURE AND SALINITY IN 1971 and 1972

Source: New York University Progress Report for 1973 (September 1974)

Instruments First Annual Report for the Multiplant Impact Study of the Hudson River Estuary. During periods when the fresh water flow in the Hudson River exceeds 20,000 cfs, the salt front is located downriver of Indian Point, and Gammarus spp. predominate in the Indian Point region. When the salt front passes Indian Point an increase in Neomysis generally occurs, but again declines as the front moves further upstream.

Collections of macrozooplankton made at standard stations over an extended time period showed that substantial variablity in abundances between stations commonly occurs. Since there was no pattern to this variability it was concluded that the changes were indicative of natural patterns of distribution and were unrelated to the presence and operation of the Indian Point Station. See NYU Progress Report (1971-72) Appendix 6A.

The standard station sampling program produced results that showed considerable variability in the vertical distribution of macrozooplankton between day and night. In general, the abundance of these organisms increases significantly with depth during the day, but during the night the populations tend to move upward into the mid-depth and surface strata of the River. See Figure 2-11.

During 1972, the total mean abundance of organisms in daytime collections from near the bottom was about 300 times higher than at the surface and about 14 times higher than at mid-depth. See NYU Progress Report (1973), at 136.

In night collections the mean abundance at the bottom was 16 times higher than the surface collections and 1.04 times higher than mid-depth collections. An analysis of variance of

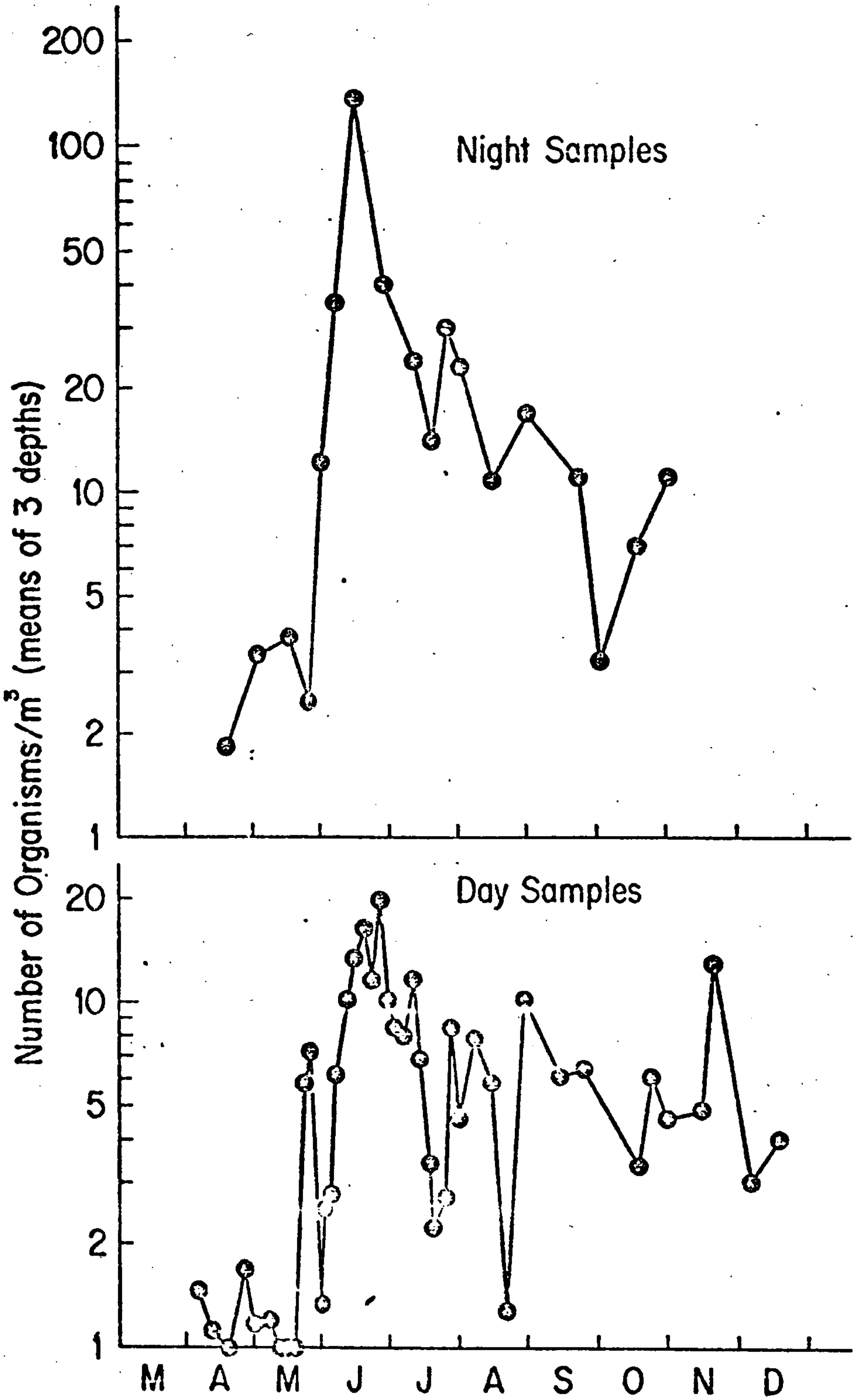

Figure 2-11

SEASONAL CHANGES IN ABUNDANCE OF MACROZOOPLANKTON IN THE HUDSON RIVER AT INDIAN POINT IN 1972. (DATA ARE MEANS OF ALL THREE DEPTHS AT ALL STATIONS FOR EACH DATE SHOWN).

Source: New York University Progress Report for 1973 (September 1974)

day and night collections indicated significant differences among depths for all species combined and for Gammarus sp., M. edwardsi and N. americana individually. NYU Progress Report (1973), at 136, 141.

The diurnal vertical migration of the macrozooplankton in the Hudson profoundly affects their susceptibility to entrainment. The intakes at Indian Point extend from the surface to a depth of 26 feet, while the depth of the river within one thousand feet of the Indian Point plant site averages about 65 feet. Environmental Report Indian Point Unit No. 3, § 4.2. Therefore, during the daylight hours when macrozooplankton are concentrated near the bottom, they are less susceptible to entrainment than during hours of darkness when they are more abundant toward the surface. Sampling at the plant intakes confirms that relatively few macrozooplankters are entrained during the day. See Figure 2-12.

The impact of plant operation on entrained macrozooplankton, particularly Gammarus spp. and N. americana has been studied by New York University. In laboratory tolerance studies Gammarus sp. was found to have a pronounced seasonal variation in acute thermal tolerance corresponding to seasonal changes in ambient river temperature. Exposure time was found to be an important factor in the response of Gammarus sp. to thermal shock. The test organisms tolerated considerably higher temperatures during short-term exposures (5 to 60 minutes) than during a 48-hour exposure time. See Figures 2-13 and 2-14. Gammarus sp. showed no increase in mortality after 24 hours when

Day Abundance of Total Macroinvertebrates at Sampling Stations in 1972

Night Abundance of Total Macroinvertebrates Sampled at Indian Point Unit 1 Intake Stations in 1972

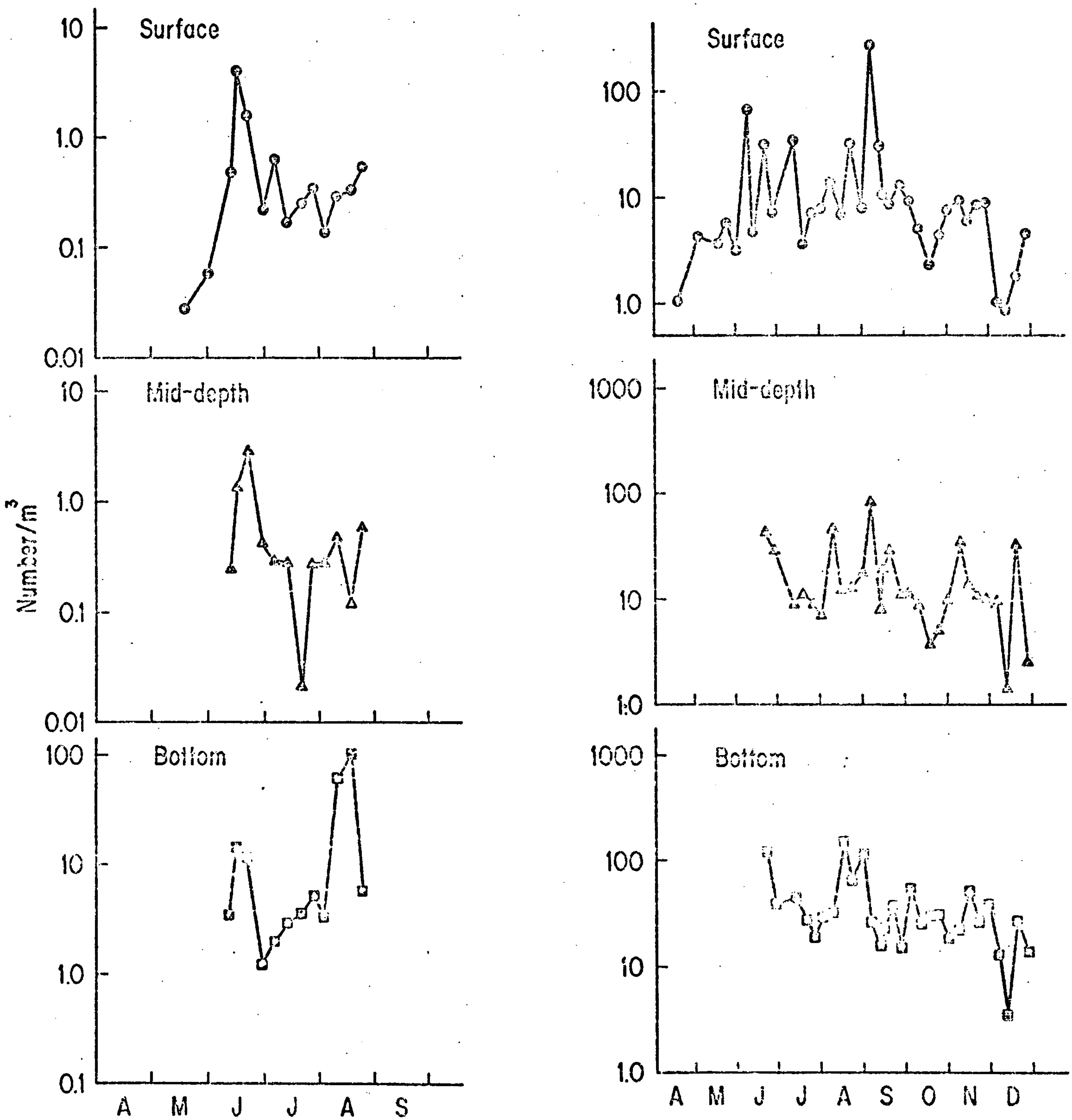

Figure 2-12

Source: New York University Progress Report for 1971 and 1972 (September 1973).

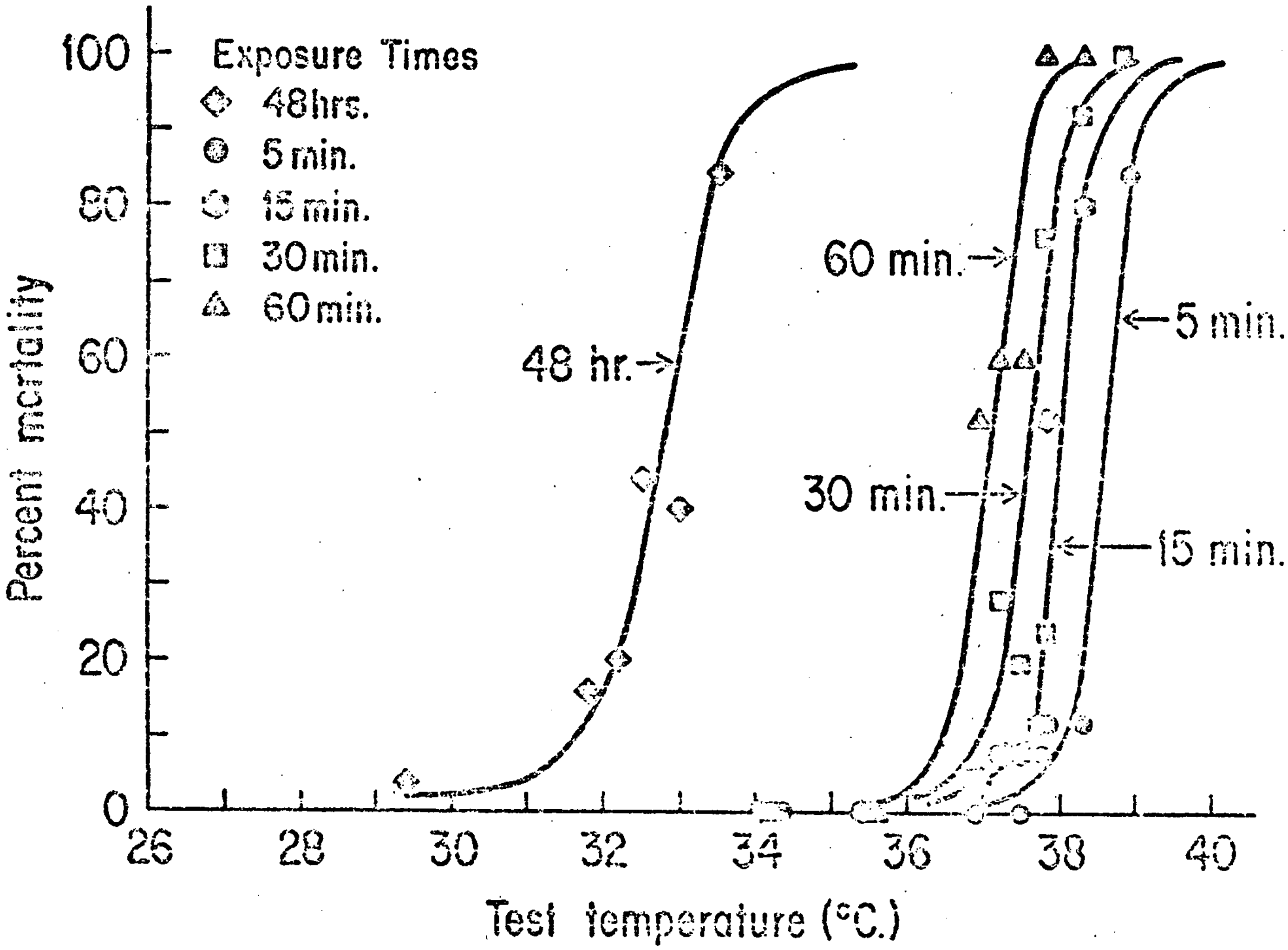

Figure 2-13

TEMPERATURE TOLERANCE OF <u>GAMMARUS</u> sp. AT AN AMBIENT TEMPERATURE OF 24.7 to 25.8°C

Source: New York University Progress Report for 1971 and 1972 (September 1973).

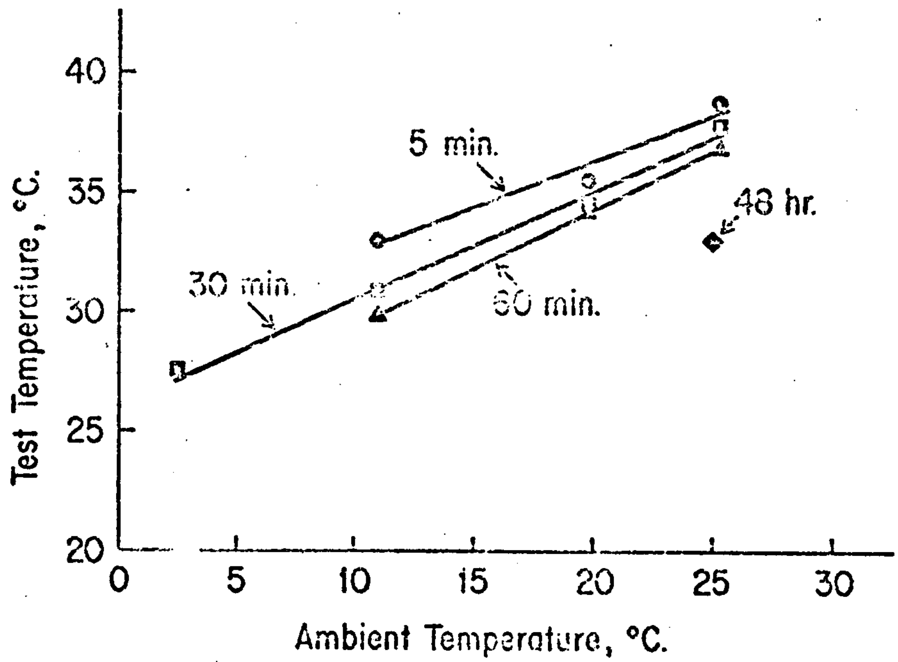

Figure 2-14

UPPER 50% TOLERANCE LIMITS OF GAMMARUS sp.

Source: New York University Progress Report for 1971 and 1972 (September 1973).

exposed to a test temperature of 95°F for 5 to 60 minutes over an ambient of 77°F. NYU Progress Report (1971-72), at 130, 133.

Intake and discharge canal sampling found that it is unlikely there will be significant acute or latent mortality of Gammarus spp. during most of the entrainment period when ambient temperatures are below mid-summer maxima. See NYU Progress Report (1973) at 161, 165, 166. Substantial mortality may occur, however, during the limited periods of chlorination. Since the periods are of short duration (a maximum of 3 hours per week between April and November), this mortality will not affect river populations.

The susceptibility of Neomysis americana to entrainment is dependent upon its occurrence at Indian Point which, in turn, is dependent upon the location of the salt front in relation to the plant intakes. The period of time each year that N. americana is susceptible to entrainment will depend on the freshwater flow in the river which controls the location of the salt front. N. americana was found to be widely distributed in the lower Hudson in the fall of 1972 and to be reproducing over most of this range.

Laboratory experiments and intake and discharge canal sampling indicate that N. americana will suffer increased mortalities when the temperature in the discharge canal exceeds 88°F and during chlorination. At maximum summer ambient temperatures approximately 50% of entrained N. americana will be killed. See Figure 2-15.

The total annual loss of N. americana due to entrainment at Indian Point will vary depending on the location

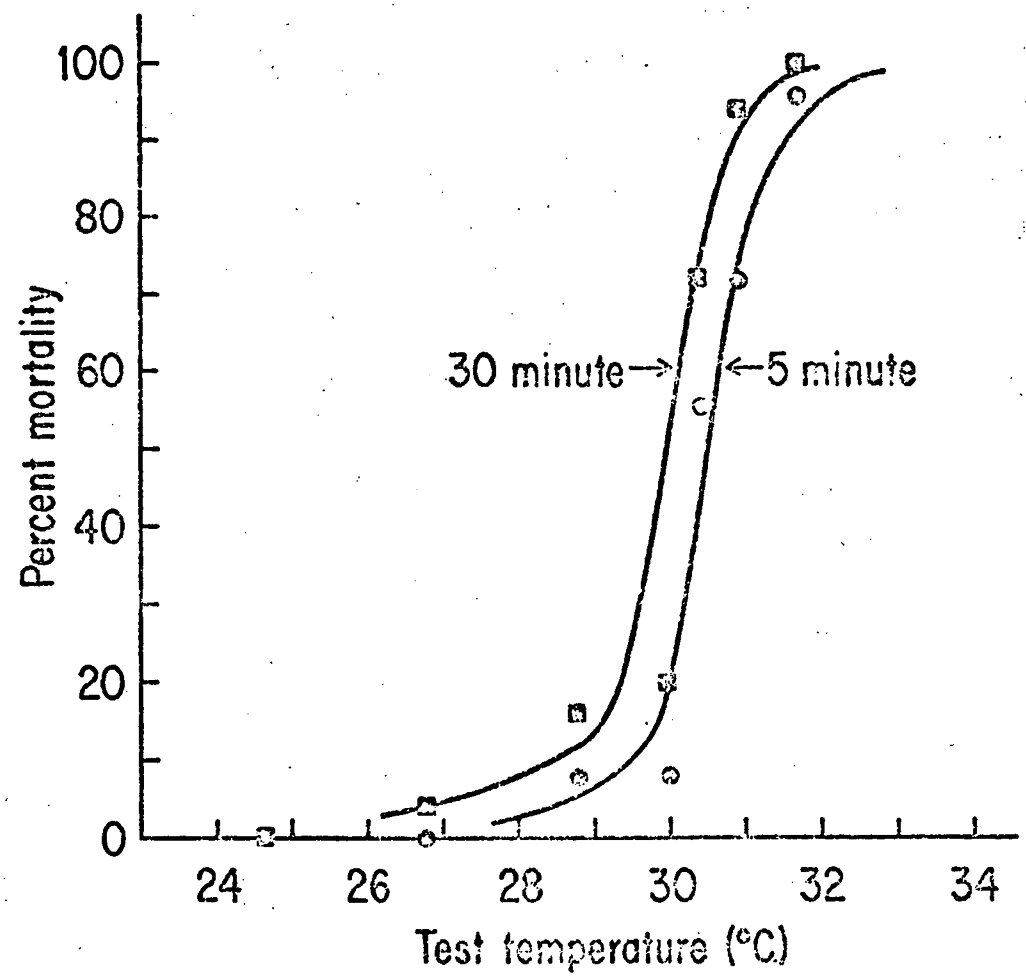

Figure 2-15

MORTALITY OF <u>NEOMYSIS AMERICANA</u> AFTER 5-MINUTE AND 30-MINUTE EXPOSURE TO ELEVATED TEMPERATURES AT AN AMBIENT OF 13.8°C

Source: New York University Progress Report for 1973 (September 1974)

and duration of the salt front in the vicinity of the intakes at Indian Point. Since N. americana are found throughout the brackish water portion of the Hudson Estuary, periodic exposure of that portion in the vicinity of the plant primarily in late summer and early fall will not be critical to the survival of this species in the Hudson.

N. americana is not a major food source for striped bass and white perch except for young striped bass in the brackish portion of the estuary during the fall. Since young striped bass are widely distributed throughout this lower region of the river in the fall, localized reductions in the size of the N. americana population will not adversely affect the striped bass population, particularly since other major food items are available. Texas Instruments, Hudson River Ecological Study, 1973 Annual Report (July, 1974) at IV-44. See also NYU Progress Report (1971-72) at 119, 125, 126 and NYU Progress Report (1973) at 156-157. In addition though members of this population may be killed, they are not lost from the food web, but are still available for consumption.

It is concluded that the requested extension of operation of the once-through cooling system operation at Indian Point will not have an adverse effect on the population of macrozooplankton in the Hudson River, or on the organisms which feed on this species.

2.1.3 Fishes

Fish populations may be influenced by power plants in a variety of ways. Fish may be entrained along with the water passing through the plants' condensers; they may be impinged on the screens that keep fish and other matter from clogging condenser tubing; they may be repelled or attracted to the thermal discharge; or they may be entrained into the discharge plume. In addition, fish may be influenced by chemicals used for a variety of purposes within the plant and thereafter released to the water.

These potential impacts have been thoroughly reviewed elsewhere. See Applicant's Environmental Report for Indian Point Unit 2; Applicant's Environmental Report for Indian Point Unit 3; Proceedings of Atomic Safety and Licensing Board, Indian Point Unit 2, NRC Dkt. No. 50-247. This Report by Con Edison will show, that the requested two year extension of operation of the once-through cooling system at Indian Point 2 will have no irreversible direct or indirect adverse impact on striped bass or other fish species.

Emphasis in this Section is placed on striped bass because it is an important species in the Hudson River, extensive data have been collected specifically for this species during the past ten years, and the species has been assessed to be among the most vulnerable to power plant impacts of all dominant fish species in the Hudson. In addition, attention has been paid to the plant impact on white perch, Atlantic tomcod and American shad.

In addition to the data presented here, it is important to note that during the period of the requested extension, the Environmental Technical Specification Requirements will remain in effect. These requirements currently mandate that Con Edison take "immediate corrective action . . . to reduce the number" of impinged fish when certain levels are reached. Facility Operating License No. DPR-26, App. B, § 4.1.2(a) (2) (VI). Other measures that will remain in effect are the limitation on delta T's accross the condenser at Unit 2, and the chlorination frequency limits. Id. §§ 2.1.1 and 2.3.1.

Each of the species mentioned above will be discussed relative to entrainment and impingement impacts at Indian Point. In addition assessments of the anticipated impact of the requested extension of the once-through cooling system operation on these species will be presented.

The "First Annual Report for the Multiplant Impact Study of the Hudson River, Volumes I and II," which is Appendix D to this Environmental Report, presents an assessment of the impact on striped bass and certain other species of fish of the operation of Indian point Unit 2 during 1974 as well as during 1973. It is important to recognize that the assessment of impact on striped bass as discussed in Appendix D, Section VII, is an evaluation of what actually occurred in 1973 and in 1974. This assessment complements the predictions of impact that are anticipated during the requested two-year extension and which are described in Sections 2.1.3.1.2, 2.1.3.1.3 and Appendix A.

This report contains three approaches which provide insight in estimating the potential level of impact on striped bass of the requested license amendment. The approaches are:

(a) Evaluation of the impact of two-year extension by estimating the effect on adult striped bass populations by examination of the reproductive capacity of adult stock. See Section 2.1.3.1.2 (p. 2-24 et seq.).

(b) The striped bass life cycle model which estimates cropping of the first-year class of striped bass and the impact of such cropping on adult populations in future years. See Section 2.1.3.1.3 and Appendix A.

(c) Texas Instruments First Annual Report for the Multiplant Impact Study of the Hudson River Estuary, which estimates actual impacts incurred in 1973 and 1974, and reports evidence of the existence of compensation. See Appendix D.

These are different approaches which complement each other, and Con Edison believes they all support the requested amendment. The analyses described in (a) and (b) above are predictive and indicate impacts of the requested amendment which are insignificant and clearly not irreversible. The analysis in (a) is a "worst case" presentation as it does not include a compensatory response. (See p. 2-29). The analysis described in (b) provides a "best estimate" of impact and does include compensation. The analysis described in (c) represents an estimate of actual impacts incurred.

The Texas Instruments analysis is not predictive but estimates impacts on the first-year class of striped bass which actually occurred in 1973 and 1974. These impacts are of a low order and are in the same range as that included in the predictive estimates described in (a) and (b). No compensation is included in the numerical estimates of impacts which occurred, but Appendix D includes strong evidence that compensatory mechanisms are operative in the Hudson River striped bass population.

The Texas Instruments analysis is based on the flows through the plants which actually occurred in 1973 and 1974. It is not correct to predict impacts in other years by applying flow ratios of future years to the estimated impacts of 1973 and 1974. This is because the measurement techniques used by Texas Instruments take into account the fact that additional power plants would constitute additional competing sources of mortality on a single population. It is obvious that if a portion of a fish population is cropped at one unit, it cannot be cropped at another, and the impact of the other plant can only be assessed in terms of the population which is subjected to its influence after reduction by other sources of mortality. This obvious and highly important concept must be kept in mind when attempts are made to assess the impacts of additional power plants being brought on line.

2.1.3.1 Striped Bass

2.1.3.1.1 Entrainment Impacts

Intensive studies of entrainment of striped bass eggs, larvae and juveniles at Indian Point have been conducted since 1971, and they are continuing in 1975. These investigations have had two primary objectives: (1) to determine how many organisms are entrained; and (2) to determine the impact of entrainment on these organisms.

To date these studies have demonstrated that significant percentages of the entrained life stages of striped bass survive passage through the plant (NYU Progress Reports at § 7.2, 1971-72, and 1973). Lawler, Matusky, and Skelly Engineers, utilizing the data gathered by NYU in developing specific inputs to their striped bass life cycle model, calculated that the "best estimate" for survival of entrainment of various life stages was as follows:

Life Stage	Survival Rate
Eggs	20%
Larvae (including yolk and post yolk sac larvae)	40%
Juveniles	30%

(*See* Appendix A at page 21)

In an independent analysis of the NYU data, the Holifield National Laboratory concluded that the survival of entrained eggs, larvae and juveniles of striped bass was the same as

Lawler, Matusky and Skelly concluded. However the Staff anticipated potential increased mortality due to latent effects and subsequently reduced tha above-listed survival values by 10 percent. Indian Point 3 FES at V-215.

Key parameters for the assessment of the entrainment impact on striped bass include the size of the populations of the various life stages in the river and the numbers of each stage which are actually entrained. The ecological study program has resulted in the compilation of significant amounts of data on both of these key parameters. Due to the specific sampling methodology utilized in collecting these data in each of the sampling areas (river, intake forebays, and the discharge canal) complex analyses are necessary to integrate all the data. Concerted efforts have been made and are continuing in order to complete this data interpretation in timely manner. It is expected that preliminary impact assessments based on empirical data will be included in the reports to be submitted in the summer of 1975.

At this time the following conclusions on the relative vulnerability of various life stages of striped bass can be drawn from the ecological studies which have been conducted during the past decade.

The significance of the entrainment impact on the egg stage of striped bass depends on two factors. The first factor is the percentage of the total spawn in the river that occurs in water that will be withdrawn by the plant before the end of this life stage. The second factor is the percentage survival of this life stage upon passing through the plant. Spawning occurs throughout a zone of the river reaching from Haverstraw Bay around mile point 30 to the Saugerties-Catskill region near mile point 100. (See Figure 2-16, Table 2-6.) Indian Point is located at river mile 42, near the downstream end of this zone.

Eggs spawned in waters some distance upstream of Indian Point hatch before they are transported into the plant vicinity by the net downstream river flow. In addition the eggs are generally more dense than the water in which they are found and thus settle to the bottom strata of the river. These bottom water strata flow downstream at a slower rate than the upper strata, which thereby reduces the transport of eggs into the vicinity of the plant. (See Texas Instruments - Fisheries Survey of the Hudson River Vol IV at V-9-11.) Another significant factor which reduces the potential egg entrainment at Indian Point is that the plant withdraws water from only a relatively small portion of the river cross sectional area. Those eggs found outside of this zone are not susceptible to entrainment. (See NYU Progress Report 1971-72 Appendix Tables at 296-334.)

The second factor influencing the significance of the impact, the entrainment mortality, has been investigated at Indian Point and has been found to be less than 100%. (See NYU Progress Report, 1973 at 231, 232.) In their plant impact assessments, Lawler, Matusky and Skelly Engineers have considered the survival of the egg stage in passing through the plant to be 20%. (See Appendix A at page 21.) Con Edison concludes, therefore, based on egg abundance and distribution data (see table 2-6) and on the survival of a portion of the entrained eggs, that the impact of Indian Point Unit 2 operating with a

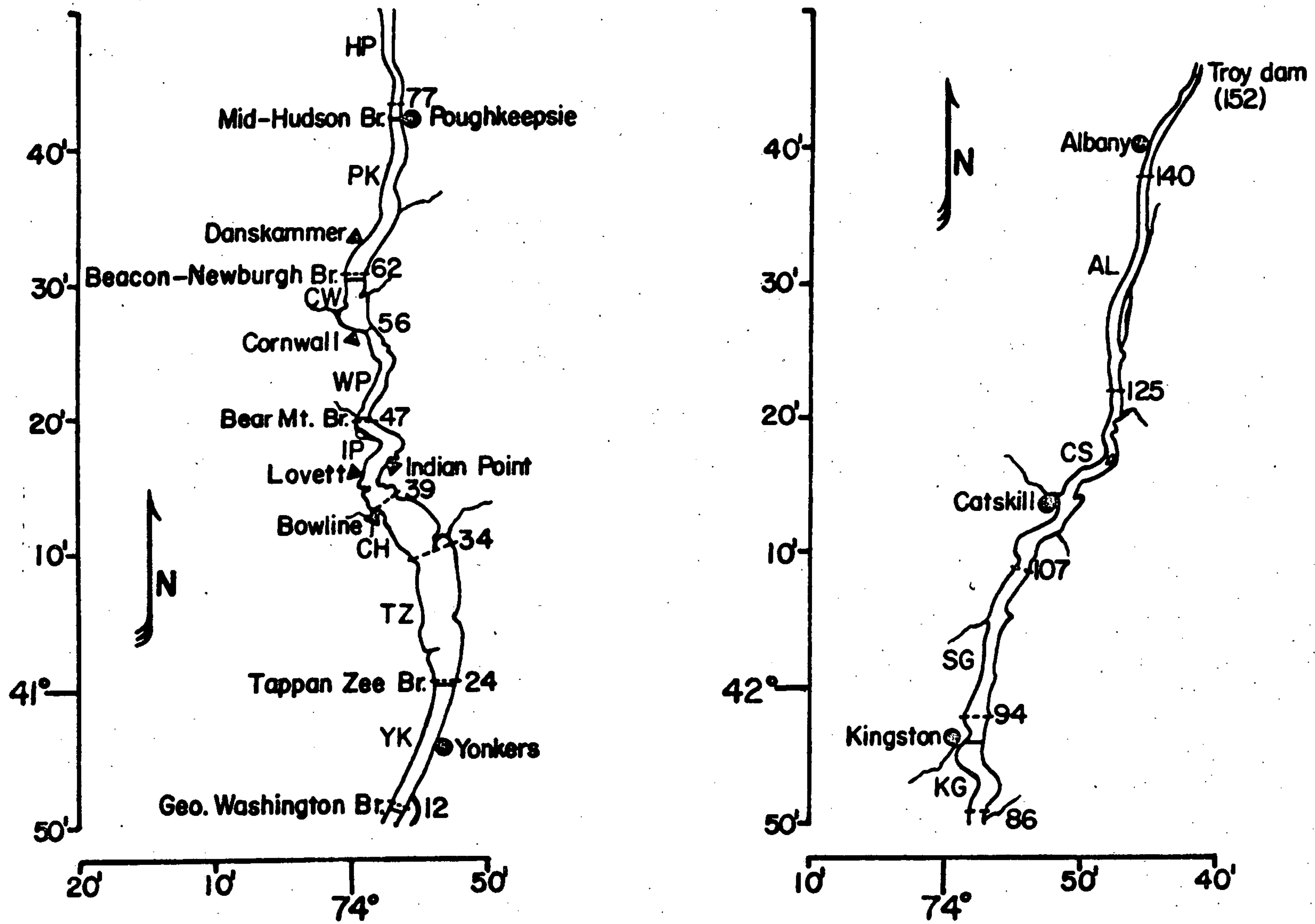

FIGURE 2-16

GEOGRAPHICAL SAMPLING REGIONS AND RIVER LANDMARKS WITHIN THE LOWER HUDSON RIVER ESTUARY

Source: Texas Instruments Fisheries Survey of the Hudson River Volume IV and IV-10

TABLE 2-6

Distribution and Abundance of Striped Bass Eggs in the Hudson River Estuary Collected by Plankton Nets

Number Per 1000 m^3 By Region [c]

	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
1966											
5/8-5/14	*	---	---	*	43.08	---	---	---	---	---	*
5/15-5/21	*	---	---	*	46.26	---	3.88	6.00	6.36	---	*
5/22-5/28	*	16.24	359.50	*	228.83	134.55	54.38	49.79	68.51	38.85	*
5/29-6/4	*	58.27	104.53	*	212.24	262.38	178.69	36.37	105.94	20.84	*
6/5 -6/11	*	39.55	107.35	*	135.25	24.72	240.49	3.53	4.94	3.88	*
1967											
5/7 -5/13	*	---	---	*	0.35	1.41	5.30	1.06	36.02	---	*
5/14-5/20	*	---	2.47	*	2.47	---	10.95	---	3.18	---	*
5/21-5/27	*	---	23.31	*	12.71	---	3.88	9.89	71.69	---	*
5/28-6/3	*	---	16.95	*	37.43	15.89	60.03	24.72	157.15	---	*
6/4 -6/10	*	---	4.94	*	40.26	34.25	94.99	12.36	2.83	---	*
1973											
5/8-5/14	---	---	1.05	101.12	41.08	4.83	50.74	3.75	---	1.19	---
5/15-5/21	23.54	157.48	2431.38	759.74	33.83	253.57	566.89	58.03	2.21	0.95	---
5/22-5/28	---	---	20.52	42.23	---	---	53.05	*	---	*	---
5/29-6/4	0.24	*	0.53	9.14	37.96	5.18	30.84	17.54	---	0.59	5.10
6/5 -6/11	---	---	38.90	5.45	2.23	2.43	48.06	6.86	8.00	1.51	---

* No Sample

--- Zero Catch

Source: Testimony of Dr. James T. McFadden and Mr. Thomas Cannon on Behalf of Consolidated Edison Company of New York, Inc., before the Federal Power Commission October, 1974 Project 2338 (Cornwall) once-through cooling system will not cause a significant reduction in the total number of striped bass eggs spawned in the Hudson River.

Vulnerability to entrainment during the next life stage, the yolk-sac stage is very similar to that of the egg stage as the larvae are generally found in the same river regions and water strata as the eggs (see Table 2-7, see Texas Instruments, 1974, Fisheries Survey of the Hudson River Vol IV at V-13). It is therefore concluded that the operation of the once-through cooling system at Indian Point Unit 2 will result in minimal impact on the yolk-sac stage of the striped bass.

Vulnerability to entrainment increases during the post yolk-sac stage when the larvae become more dispersed throughout the water column than they were during earlier life stages (see Texas Instrument 1974 Fisheries Survey of the Hudson River Vol IV at V-15). The larvae have developed self-deterministic movement by this stage and undertake vertical diurnal migrations which result in greater abundances in surface waters during the night. During the day, however, they tend to move into the middle and lower water strata and become less susceptible to entrainment. Vulnerability to entrainment is also reduced by the migration of the larvae onto the shoals of the river, where they again are less susceptible to plant entrainment.

During the next stage, the early juvenile stage, the young-of-the-year striped bass have well-developed swimming abilities and have moved into the shoal areas. This generally occurs by mid-summer. Concurrently, large numbers of these bass begin to occur in waters downstream of Indian Point (see Texas

TABLE 2-7

Distribution and Abundance of Striped Bass Larvae in the Hudson River Estuary Collected by Plankton Nets

Number per 1000 m^3 By Region [c]

Week	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
					1966						
6/19-6/25	*	6.00	31.43	*	63.92	31.43	30.37	22.60	3.88	—	*
6/26-7/2	*	4.24	26.49	*	19.78	1.41	7.06	2.47	—	—	*
7/3 -7/9	*	7.06	13.42	*	22.95	5.65	23.31	5.30	—	—	*
					1967						
6/18-6/24	*	38.14	53.32	*	76.63	*	2.12	35.67	9.18	—	*
6/25-7/1	*	25.07	1.77	*	15.54	—	5.65	6.36	1.06	—	*
7/2- 7/8	*	6.71	57.56	*	11.65	9.18	15.89	13.07	1.06	—	*
					1973						
6/18-6/24	1.42	76.15	47.52	26.56	*	67.37	2.09	16.87	8.65	13.12	—
6/24-7/1	42.56	55.59	106.26	112.35	232.01	128.31	15.58	71.51	1.94	0.76	0.12
7/2- 7/8	16.39	—	5.57	13.98	3.78	21.6	10.07	16.96	5.96	—	—

* No Sample
— Zero Catch

Source: Testimony of Dr. James T. McFadden and Mr. Thomas Cannon on Behalf of Consolidated Edison Company of New York, Inc., before the Federal Power Commission October, 1974 Project 2338 (Cornwall)

Instruments Fisheries Survey of the Hudson River Vol IV at V-21). Entrainment declines also during this period (see NYU Progress Report 1971-72 at 215). Low numbers in entrainment and impingement samples during the summer and fall indicate that few are exposed to the plant or that they are able to avoid plant intakes. By fall, they are concentrated below Indian Point. See table 2-8.

Though this stage of development of the striped bass does experience a degree of entrainment impacts at Indian Point, Con Edison concludes that these impacts are not substantial and certainly not irreversible in view of the fact that large numbers of bass appear in waters downstream of Indian Point at the time entrainment declines.

Based on entrainment impact estimates of striped bass discussed later (§§ 2.1.3.1.2-.3 and Appendix D, § VII) and the aspect of vulnerability (see also Appendix D, § VI) it is concluded that the impact resulting during the requested extension of the interim operation period will not cause irreparable or irreversible damage to the striped bass population in the Hudson River.

TABLE 2-8

Distribution and Catch Per-Unit-Effort of Striped Bass Juveniles in the Hudson River Estuary Collected by Beach Seines

Catch Per Haul by Region[c]

Month/Year	YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
8-10/66	*	*	19.8	26.22	*	14.44	10.00	2.76	20.78	17.32	5.62	*
8/67	*	*	5.07	2.01	*	4.26	1.18	0.43	5.13	0.26	0.31	*
7/73	33.43	16.60	15.50	9.27	29.88	8.30	9.56	6.50	1.50	1.17	2.27	0.95
8/73	40.79	10.09	28.88	45.11	9.14	35.26	3.09	3.00	3.50	2.05	6.19	3.64
9/73	31.67	16.13	147.08	10.59	76.37	11.47	2.00	0.92	3.00	0.86	4.00	1.93
10/73	15.94	27.33	51.31	7.31	15.61	3.48	0.95	----	----	----	0.45	.08

* no sample

--- zero catch

Source: Testimony of James T. McFadden and Mr. Thomas Cannon on Behalf of Consolidated Edison Company of New York, Inc., before the Federal Power Commission October 1974 Project 2338 (Cornwall)

2.1.3.1.2 Evaluation of Impact of Two-Year Extension

Two approaches to assessing the ecological significances of the proposed two-year delay in cut-over to closed-cycle cooling are presented here. First, as presented in this section, empirical data on age structure of the population and on reproductive patterns are used to trace the effect of the requested extension through the future history of the striped bass stock. Second, the striped bass life cycle model developed by Lawler, Matusky & Skelly, as presented in § 2.1.3.1.3 and Appendix A, is used to make a similar assessment. The two approaches are fundamentally similar. The first uses a relatively simple straight-forward set of ecological information, which is practical to present in detail in this Report; does not involve any assumptions about the operation of compensation; and considers power plant effects to persist in the striped bass population only so long as a year class is present in the spawning stock which had been exposed to the impact of once-through cooling operation of Indian Point 2. The second approach uses a complex set of ecological information embodied in a computer model which is explained in Appendix A. This approach assumes compensation at various levels of effectiveness; and considers power plant effects to persist in the striped bass population until completley damped out by compensation.

<u>Immediate Reduction in Young of Year</u>. It has been established that the size of young-of-the-year populations of striped bass may be reduced by entrainment of eggs, larvae, and early juvenile stages; and by impingement of later juveniles. The actual magnitude of the reduction is at issue presently, and

estimates of absolute numbers and percentage of young fish killed by the power plant, and of possible offsetting compensatory responses by the population, are being developed through Con Edison's research program. <u>See generally</u> § 3.2.

The condenser cooling water pumped at Indian Point 2 during the 1973 entrainment season was less than half the full-flow capacity, consequently having only a marginal impact on the entrainable or impingeable population of organisms. Indian Point 2 operated at substantially full flow in 1974, and is expected to operate at near full flow during 1975-1978. Thus a total of five years (1974-1978) of interim full flow operation with once-through cooling will occur. The effect of the two-year extension of the cut-over date for closed-cycle cooling would be to reduce two additional year classes of striped bass, those spawned in 1979 and 1980 by approximately the same fraction as applied to the preceding year classes.

It is Con Edison's position that the same argument regarding the tolerability of five years of interim full-flow operation can safely be extended to seven years. The reduction in age-group 0 fish, if truly severe, would be readily detected by the research program. The immediate reduction in numbers of young fish has no economic consequence in itself. It is only through subsequent effects of reduction on the fishable population that significant economic consequences may be generated.

<u>Short-Run Impact on Adult Population</u>. Under the "worst case" assumption that the adult portion of the striped bass stock is reduced by the same fraction as the young-of-the-

year are reduced by entrainment and impingement, it is possible to trace the effects of reduction of specific year classes of young through the subsequent adult stock. This exercise very conservatively assumes that no compensating increases in survival or growth rates of striped bass occur as a result of reduction in density of the young. The impact is measured in terms of the reduction in reproductive capacity of the adult stock.

Female striped bass in the Hudson River generally reproduce for the first time at five years of age (Texas Instruments Hudson River Ecology Study 1974 Annual Report). Hence reduction of a year class during the first summer and fall of life will be first reflected in a reduction of the spawning stock five years later, and the reduction will persist for as many additional years as the reduced year class remains a significant component of the spawning stock.

For Hudson River striped bass, the importance of each age group in contributing to reproduction has been estimated by multiplying the relative number of mature females for each reproducing age by the average egg content at that age. <u>See</u> Table 2-9. The number of fish at age IV is arbitrarily set at unity, and adult survival is estimated at 50% per year to obtain the lx values of column 2. The lx values represent the relative numbers of females of each successive age present in the spawning stock on the average. Presently available data (<u>e.g.</u>, Texas Instruments Hudson River Ecological Study 1974 Annual Report) indicate that about 80% of the age V female striped bass are sexually mature, and virtually all females of age VI and older are mature, (Table 2-9, column 3). The product of the proportion

TABLE 2-9

Life table for adult striped bass (l_x) based on 50 percent annual survival; age specific fecundity rate (M_x); and average contribution of each age group to reproduction.

Age in Years X	Proportion Alive l_x	Percent. Mature	Egg Count x 1000	Age Specific Fecundity Rate M_x x 1000	Natality l_x M_x x 1000	Percent. of Egg Production by Age Groups
4	1.00	0	0	0	0	0
5	.50	80	780	624	312	40
6	.25	100	650	650	163	21
7	.13	100	830	830	180	14
8	.07	100	1370	1370	96	12
9	.03	100	1540	1540	46	6
10	.02	100	1810	1810	36	5
11	.01	100	1770	1770	18	2

Source: Dr. James T. McFadden, Personal Communication, April 1975 mature times the average egg count is the age specific fecundity rate, Mx, (Table 2-9, column 5) which is the number of eggs produced, on the average, by a female of age x. Natality (lxMx) is the relative number of eggs produced by each of the age group components of the spawning stock, (Table 2-9, column 6) and is expressed in percentage form in column 7.

Female striped bass first reproduce at age V, and 40% of the spawning is contributed by this age group, on the average. The two youngest spawning age groups together contribute 61% of the spawning; the four youngest age groups contribute 87%; and 98% of the spawning is accomplished by the six youngest age groups (age groups V-X).

It follows that a particular year's spawning in the Hudson River will be more or less influenced by mortality inflicted upon young fish in prior years by entrainment and impingement, depending upon which age groups in that year's spawning stock had been produced in years when Indian Point 2 was in operation with once-through cooling. The total spawning will be more reduced in years when the age V and age VI components of the stock are from year classes which have been reduced by power plant impact; and less reduced when, say, the age VIII and IX components have been so reduced but the younger spawning age groups have not.

The movement through the population of year classes exposed to operation of Indian Point 2 with once-through cooling is traced in Table 2-10. Year classes not exposed to entrainment and impingement at the unit are represented by areas outside of the portion of the table bracketted between the lettered lines.

TABLE 2-10

Movement through the spawning stock of year classes of striped bass affected by operation of Indian Point Unit 2 with once-through cooling. (Area between lines A and C depicts affected year classes; areas outside contain unaffected year classes. Lower boundary of Unit 2 effect represented by line B is for cutover date of 1979 for closed cycle cooling. Lower boundary of Unit #2 effect represented by line C is for requested extension of cutover date to 1981.)

	Age Groups						
Year	V	VI	VII	VIII	IX	X	
1977	'72	'71	'70	'69	'68	'67	
1978	'73	'72	'71	'70	'69	'68	
1979	'74	'73	'72	'71	'70	'69	
1980	'75	'74	'73	'72	'71	'70	
1981	'76	'75	'74	'73	'72	'71	
1982	'77	'76	'75	'74	'73	'72	
1983	'78	'77	'76	'75	'74	'73	
1984	'79	'78	'77	'76	'75	'74	line A
1985	'80	'79	'78	'77	'76	'75	
1986	'81	'80	'79	'78	'77	'76	
1987	'82	'81	'80	'79	'78	'77	
1988	'83	'82	'81	'80	'79	'78	
1989	'84	'83	'82	'81	'80	'79	line B
1990	'85	'84	'83	'82	'81	'80	
1991	'86	'85	'84	'83	'82	'81	line C

Source: Dr. James T. McFadden, Personal Communication , April 1975

The exposed year classes are represented by the area bracketted between the lettered lines. Full-flow operation of Unit 2 began before the 1974 spawning season, hence the 1974 year class, which first spawns at age V in 1979, is the first year class in the spawning stock to be potentially reduced. The table traces contributing age groups through their first six years of spawning, by which time their important contribution to reproduction is completed. The 1974 year class is traced, under this approach, through the spawning seasons, from 1979 to 1984 after which it no longer is an important contributor to reproduction. In 1979 only one age group component of the spawning stock is reduced; in 1980 two are; in 1981 three; and so forth. It is not until 1984 that all six age group components of the spawning stock are reduced although by 1981 the three age groups which contribute 75% of the reproduction have all been exposed to the impact of Unit 2 during their first year of life.

The boundaries, as diagrammed in Table 2-10, to the Indian Point 2 entrainment and impingement effects are represented in Table 2-11; the first boundary (line B) corresponding to the presently established date of 1979 for cutover to closed cycle cooling, and the second (line C) corresponding to the delay for cut-over to closed cycle cooling to 1981 as here requested by Con Edison.

The proposed extension to 1981 would have the effect of increasing from five to seven the number of years during which the most heavily contributing age V component of the spawning stock was reduced; increasing from three to five the number of years during which the three age groups which together contribute

TABLE 2-11

Reduction in Reproduction of Striped Bass Due to Entrainment and Impingement Mortality During the First Year of Life At Indian Point Unit #2, Expressed As A Function of the Reduction - Z - in Survival of Young-of-the-Year Fish

Year of Reproduction	Date of Cutover to Closed Cycle Cooling 1979	1981	Difference
1978	0	0	0
1979	.40 Z	.40 Z	0
1980	.61 Z	.61 Z	0
1981	.75 Z	.75 Z	0
1982	.87 Z	.87 Z	0
1983	.93 Z	.93 Z	0
1984	.98 Z	.98 Z	0
1985	.58 Z	.98 Z	.40 Z
1986	.37 Z	.98 Z	.61 Z
1987	.23 Z	.58 Z	.35 Z
1988	.11 Z	.37 Z	.26 Z
1989	.05 Z	.23 Z	.18 Z
1990	0	.11 Z	.11 Z
1991	0	.05 Z	.05 Z
1992	0	0	0

Source: Dr. James McFadden, Personal Communication, April, 1975

75% of the spawning are reduced; and from none to two the number of years during which all six spawning groups represented in Table 2-10 are reduced. It should be noted that the duration of these reductions is within the span of years which commonly elapses between the spawning of large year classes of striped bass. That is to say, naturally occurring reductions of spawning success over five, six and seven years are common occurrences, readily sustained by the population.

The degree to which year classes subject to entrainment and impingement by Indian Point 2 will actually be reduced is a matter of contention at present, and the subject of a substantial research effort being carried on by Con Edison. (See § 3.2.) The worst case, from the standpoint of population reduction, would be that the fraction of young striped bass killed by operation of the power plant would not be offset to any degree by compensating increases in survival during the first year of life, or in subsequent years, and that the eventual reproductive contribution by each affected year class would be reduced by the same fraction as was their survival during the first year of life. Under this assumption, if Indian Point 2 caused, for example, a 10% reduction in the number of young produced in 1974, the amount of spawning contributed in 1979 by age group V fish (the 1974 year class) would be reduced by 10%, although the contribution by all other age groups would be normal.

Because the reduction in survival of young would recur each year under the interim operating conditions, the spawning contribution in 1981, for example, would be reduced by 10% for age groups V, VI and VII but would be normal for all older age groups.

Letting Z represent the fraction by which each year class of young striped bass is reduced by operation of Unit 2, the reduction in total reproduction of each year, under the worst case assumption above, has been calculated from the data of Table 2-9 and Table 2-10. The results are summarized in Table 2-11 for the currently approved cutover date of 1979 and for the requested extension of the deadline for cut-over to closed-cycle cooling to 1981. In column 4 of Table 2-11 the increment in reduction of spawning due to the requested two-year extension is calculated for each year as the difference between columns 2 and 3. For example, in 1985 instead of the reduction in spawning of .58 Z which would occur under a 1979 cut-over date, a reduction of .98 Z would occur as a result of 1981 cut-over date, an increment of .40 Z in the reduction of reproduction for that year.

It is apparent from Table 2-11 that the increments of reduction in spawning which would be caused by the requested extension of cut-over date from 1979 to 1981 are small, and occur only over the seven-year period 1985 through 1991. For example, if the reduction in number of young-of-the-year striped bass caused by entrainment and impingement at Unit 2 represented in Table 2-7 by the symbol Z were 10 percent, the maximum increment in reduction of spawning would be 6.1% in 1986, and only during the three years of 1985-1987 would the increment exceed 3%. Full recovery of reproduction to levels expected in the absence of Unit 2 entrainment and impingement effects would be delayed only two years (1990-1991), during which the reductions would be trivial: for the example of Z=10% reductions of 1.1 and 0.5%.

Long Run Impact on Striped Bass Population. The small additional short-run impact on the fish population caused by the proposed extension of cut-over date for closed-cycle cooling, as described above, would have negligible and undetectible long-run impacts. The incremental reduction in spawning stock would be very much smaller than the variations occurring in the fish stock caused by natural environmental conditions; would be of short duration; and would be damped out by the compensatory response of the population.

2.1.3.1.3 Population Dynamics Model Assessment

This section of the Report applies the Lawler, Matusky and Skelly Engineers transport model to predict the level of cropping of the Hudson River striped bass population from May 1, 1979 to May 1, 1981 that may result from an extension in the once-through cooling operation of Indian Point 2 alone and in conjunction with other power generating stations on the Hudson. See Appendix A. Data collected during 1973 are used to estimate the standing crop of the striped bass in the river. The plants considered in conjunction with Indian Point 2 are Indian Point 3, Bowline Point 1 and 2, and Roseton 1 and 2. Danskammer, Indian Point 1 and Lovett are not considered in the multiplant projections because they have been in operation for a considerable period of time and their impact, if any, has already been reflected in the present striped bass population.

2.1.3.1.3.1 Effect of Indian Pcint 2 Operation

A series of computer runs of the model were made (see Appendix A) to predict the effects of Indian Point 2 operation on the Hudson River striped bass population. The results of the model runs were used to assess the impact on the Hudson River striped bass population due to the requested extension of operation of the once-through cooling water system at Indian Point 2. The impact was evaluated as the difference between the predicted impacts with and without the extension. See generally Appendix A.

Table 2-12 shows the results of model runs for Indian Point 2 operating alone and with the cut over to closed cycle cooling as required by the terms of the current license. The license calls for a change in the once-through cooling system to a closed-cycle system on May 1, 1979. Figure 1-1.

With this plant operating schedule, the Lawler, Matusky & Skelly striped bass model predicts that the operation of Indian Point 2 alone will result in a cropping 0.47 to 1.25% in the young-of-the-year striped bass population in the Hudson River after one year of operation. After the change in the cooling water system from once-through to closed-cycle in 1979, the impact is reduced to about 0.01 to 0.03% cropping in the adult age 1 population. The impact on the young-of-the-year fish population during 1975-1978 is prcpagated into some later years when these fish mature. However, these impacts diminish to nil as the striped bass population returns to the equilibrium level in subsequent years.

TABLE 2-12

EFFECT OF INDIAN POINT UNIT 2 OPERATION ON THE HUDSON RIVER STRIPED BASS POPULATION
UNDER THE CURRENT COMPLIANCE SCHEDULE CONDITIONS

Year Class	Percent Cropping in Striped Bass After Years of Operation							
	1 yr (1975)	5 yrs (1979)	6 yrs (1980)	7 yrs (1981)	10 yrs (1984)	17 yrs (1991)	20 yrs (1994)	47 yrs (2021)
A) Best Estimate Impact (Best estimate f_c factors*; high compensation)								
Adult 1	0.59	0.01	0.04	0.05	0.22	0.07	0.04	0
Total Adults	0.41	0.20	0.09	0.07	0.21	0.07	0.04	0
B) Best Estimate Impact (Best estimate f_c factors*; low compensation)								
Adult 1	0.95	0.02	0.07	0.11	0.56	0.26	0.13	0
Total Adults	0.66	0.31	0.15	0.12	0.51	0.24	0.15	0
C) Minimum Impact (f_c = 0.5; high compensation)								
Adult 1	0.47	0.01	0.03	0.04	0.18	0.05	0.03	0
Total Adults	0.33	0.16	0.07	0.05	0.16	0.05	0.03	0
D) Maximum Impact (f_c = 1.0; low compensation)								
Adult 1	1.25	0.03	0.10	0.15	0.74	0.35	0.18	0
Total Adults	0.87	0.42	0.20	0.17	0.68	0.32	0.21	0

* For detailed f factors see Appendix A

Table 2-13 shows the predicted impact of Indian Point 2 operating alone if the proposed extension were granted. In this case, the change in the cooling system at Indian Point 2 from the once-through cooling to closed cycle is extended until May 1, 1981. See Figure 1-2. The net impact of the extension on the Hudson River striped bass population is shown in Table 2-14, and is determined by subtracting the percent cropping in the striped bass population shown in Table 2-12 under the current plant license conditions from those shown in Table 2-13 under the amended license conditions.

As shown in Table 2-14, the largest impacts due to the extension in once-through cooling operation are expected to occur in 1979 and 1980, the years during which the extension is in effect. The predicted cropping in the adult 1 population in 1979 ranges from a minimum of 0.49% (Case C) to a maximum of 1.30% (Case D). For 1980, the predicted minimum and maximum impacts are, respectively, 0.47 and 1.23% cropping in the adult 1 population. In all years, the "best estimate" impacts are between the minimum and maximum, as expected.

Under the assumption of a high level of compensation (Cases A and C), the percentage cropping becomes negligible by 1984 and remains so for all subsequent years.

At a low level of compensation (Cases B and D), a very small residual influence of the extension is observed in the predicted impacts for 1994. This is due to the propagation of impacts on the adult 1 population into the spawning adult age classes. The differences in the results at the high and low levels of compensation are reasonable since the amount of

TABLE 2-13

EFFECT OF INDIAN POINT UNIT 2 OPERATION ON THE HUDSON RIVER STRIPED BASS POPULATION UNDER THE PROPOSED SCHEDULE CONDITION

Year Class	Percent Cropping in Striped Bass After Years of Operation							
	1 yr (1975)	5 yrs (1979)	6 yrs (1980)	7 yrs (1981)	10 yrs (1984)	17 yrs (1991)	20 yrs (1994)	47 yrs (2021)
A) Best Estimate Impact (Best estimate f_c factors*; high compensation)								
Adult 1	0.59	0.63	0.63	0.05	0.22	0.09	0.08	0
Total Adults	0.41	0.62	0.62	0.23	0.21	0.09	0.09	0
B) Best Estimate Impact (Best estimate f_c factors*; low compensation)								
Adult 1	0.95	1.01	1.01	0.11	0.56	0.32	0.32	0
Total Adults	0.66	1.00	1.00	0.38	0.52	0.31	0.33	0
C) Minimum Impact (f_c = 0.5; high compensation)								
Adult 1	0.47	0.50	0.50	0.04	0.18	0.07	0.06	0
Total Adults	0.33	0.50	0.50	0.18	0.17	0.07	0.06	0
D) Maximum Impact (f_c = 1.0; low compensation)								
Adult 1	1.25	1.33	1.33	0.15	0.74	0.43	0.43	0
Total Adults	0.87	1.31	1.32	0.50	0.69	0.42	0.44	0

* For Detailed f factors, see Appendix A.

TABLE 2-14

IMPACT OF THE INDIAN POINT UNIT 2 OPERATION ON THE HUDSON RIVER STRIPED BASS POPULATION

DUE TO A TWO-YEAR EXTENSION OF THE ONCE-THROUGH COOLING SYSTEM

Year Class	Percent Cropping in Striped Bass After Years of Operation							
	1 yr (1975)	5 yrs (1979)	6 yrs (1980)	7 yrs (1981)	10 yrs (1984)	17 yrs (1991)	20 yrs (1994)	47 yrs (2021)
A) Best Estimate Impact (Best estimate f_c factors*; high compensation)								
Adult 1	0	0.62	0.59	0	0	0.02	0.04	0
Total Adults	0	0.42	0.53	0.16	0	0.02	0.05	0
B) Best Estimate Impact (Best estimate f_c factors*; low compensation)								
Adult 1	0	0.99	0.94	0	0	0.06	0.19	0
Total Adults	0	0.69	0.85	0.26	0.01	0.07	0.18	0
C) Minimum Impact (f_c = 0.5; high compensation)								
Adult 1	0	0.49	0.47	0	0	0.02	0.03	0
Total Adults	0	0.34	0.43	0.13	0.01	0.02	0.03	0
D) Maximum Impact (f_c = 1.0; low compensation)								
Adult 1	0	1.30	1.23	0	0	0.08	0.25	0
Total Adults	0	0.89	1.12	0.33	0.01	0.10	0.23	0

* For detailed f factors, see Appendix A.

compensation indicates the population's ability to recover from external impacts through density dependent changes in, e.g., growth rates, fecundity, and mortality rates.

In general, the model predictions involving Indian Point 2 alone suggest that the project delay in the implementation of a closed-cycle cooling system will have only a small impact on the Hudson River striped bass population.

2.1.3.1.3.2 Effects of Multi-Plant Operation

Model predictions of the impacts of the Hudson River striped bass due to multi-plant operation under the present license schedule and under the proposed schedule for tower implementation are shown in Tables 2-15 and 2-16 respectively. The model predictions based on multi-plant conditions indicate that the maximum impact that these multi-plant operations may impose upon the striped bass population is a cropping of about 3% of the adult age(1) and the total adult population in the year 1980. See Table 2-16.

The predictions of impact on the Hudson River striped bass population due to the extension of the Indian Point 2 once-through system operation with other plants operating simultaneously are shown in Table 2-17. These impacts are obtained by subtracting the percent population cropping shown in Table 2-15 from those shown in Table 2-16 under the amended condition. Comparing the impacts shown in Table 2-17 with those in Table 2-14, the additional cropping in the striped bass population due to the requested extension of once-through cooling is found to be less under the multi-plant conditions than under

TABLE 2-15

EFFECT OF INDIAN POINT, BOWLINE & ROSETON PLANT OPERATION ON THE HUDSON RIVER STRIPED BASS POPULATION UNDER COMPLIANCE SCHEDULE CONDITIONS

	Percent Cropping in Striped Bass After Years of Operation							
Year Class	1 yr (1975)	5 yrs (1979)	6 yrs (1980)	7 yrs (1981)	10 yrs (1984)	17 yrs (1991)	20 yrs (1994)	47 yrs (2021)
A) Best Estimate Impact (Best estimate f_c factors*; high compensation)								
Adult 1	1.22**	0.84	0.86	0.69	0.52	0.27	0.25	0.10
Total Adults	0.85**	0.96	0.89	0.75	0.51	0.28	0.25	0.10
B) Best Estimate Impact (Best estimate f_c factors*; low compensation)								
Adult 1	2.18**	1.53	1.56	1.35	1.38	0.93	0.87	0.31
Total Adults	1.52**	1.72	1.61	1.43	1.31	0.92	0.89	0.32
C) Minimum Impact (f_c = 0.5; high compensation)								
Adult 1	1.04**	0.71	0.72	0.59	0.46	0.26	0.23	0.11
Total Adults	0.73**	0.81	0.75	0.64	0.45	0.26	0.24	0.11
D) Maximum Impact (f_c = 1.0; low compensation)								
Adult 1	2.94**	2.13	2.17	1.91	1.94	1.40	1.35	0.70
Total Adults	2.05**	2.36	2.23	2.01	1.84	1.39	1.37	0.70

* For detailed f factors, see Appendix A.

** Inadvertently, an additional flow of 318,000 gpm was included in the 1975 projections. To correct this, the estimates of percent cropping presented for 1975 should be reduced by about 12%.

TABLE 2-16

EFFECT OF INDIAN POINT, BOWLINE & ROSETON PLANT OPERATION ON THE HUDSON RIVER STRIPED BASS POPULATION UNDER THE PROPOSED SCHEDULE CONDITIONS

Year Class	Percent Cropping in Striped Bass After Years of Operation							
	1 yr (1975)	5 yrs (1979)	6 yrs (1980)	7 yrs (1981)	10 yrs (1984)	17 yrs (1991)	20 yrs (1994)	47 yrs (2021)
A) Best Estimate Impact (Best estimate f_c factors*; high compensation)								
Adult 1	1.22**	1.29	1.29	0.69	0.52	0.29	0.28	0.10
Total Adults	0.85**	1.27	1.28	0.87	0.51	0.30	0.28	0.10
B) Best Estimate Impact (Best estimate f_c factors*; low compensation)								
Adult 1	2.18**	2.26	2.26	1.35	1.38	0.97	1.01	0.34
Total Adults	1.52**	2.23	2.25	1.62	1.32	0.98	1.02	0.35
C) Minimum Impact (f_c = 0.5; high compensation)								
Adult 1	1.04**	1.10	1.10	0.59	0.46	0.27	0.26	0.12
Total Adults	0.73**	1.08	1.09	0.74	0.45	0.28	0.27	0.12
D) Maximum Impact (f_c = 1.0; low compensation)								
Adult 1	2.94**	3.02	3.02	1.91	1.94	1.45	1.52	0.73
Total Adults	2.05**	2.98	3.01	2.25	1.85	1.46	1.52	0.73

* For detailed f factors, see Appendix A.

** Inadvertently, an additional flow of 318,000 gpm was included in the 1975 projections. To correct this, the estimates of percent cropping presented for 1975 should be reduced by about 12%.

TABLE 2-17

EFFECT OF INDIAN POINT, BOWLINE & ROSETON PLANT OPERATION ON THE HUDSON RIVER STRIPED BASS POPULATION DUE TO A TWO YEAR EXTENSION OF THE ONCE-THROUGH COOLING SYSTEM AT THE INDIAN POINT UNIT #2

	Percent Cropping in Striped Bass After Years of Operation							
Year Class	1 yr (1975)	5 yrs (1979)	6 yrs (1980)	7 yrs (1981)	10 yrs (1984)	17 yrs (1991)	20 yrs (1994)	47 yrs (2021)
A) Best Estimate Impact (Best estimate f_c factors*; high compensation)								
Adult 1	0	0.45	0.43	0	0	0.02	0.03	0
Total Adults	0	0.31	0.39	0.12	0	0.02	0.03	0
B) Best Estimate Impact (Best estimate f_c factors*; low compensation)								
Adult 1	0	0.73	0.70	0	0	0.04	0.14	0.03
Total Adults	0	0.51	0.64	0.19	0.01	0.06	0.13	0.03
C) Minimum Impact (f_c = 0.5; high compensation)								
Adult 1	0	0.39	0.38	0	0	0.01	0.03	0.01
Total Adults	0	0.27	0.34	0.10	0	0.02	0.03	0.01
D) Maximum Impact (f_c = 1.0; low compensation)								
Adult 1	0	0.89	0.85	0	0	0.05	0.17	0.03
Total Adults	0	0.62	0.78	0.24	0.01	0.07	0.15	0.03

* For detailed f factors, see Appendix A.

conditions with only Indian Point 2 operating. This is expected because, with the multi-plant operations, some of the young fish that may be transported by river flows and/or migrate downstream, are removed by the other plants before they are subject to Indian Point's impact. Thus, the number of fish that may be subject to Indian Point 2 impact are fewer with the multi-plant case than if Indian Point 2 was the only plant on the Hudson.

2.1.3.1.3.3 Discussion

The maximum impact that the extension of use of the Indian Point 2 once-through cooling water system would have upon the Hudson River striped bass population is an additional 0.89% cropping in the adult age 1 year class and 0.78% in the total adult population in 1979. <u>See</u> Table 2-17 (Case D). Although the impact on the young-of-the-year may be diminished to nil in subsequent years as the once-through system is changed to the closed-cycle system, some residual impact upon the offspring of these fish appears in later years when they become sexually mature.

2.1.3.1.4 Compensation in the Striped Bass Population

During the Indian Point 2 licensing hearings Con Edison contended that the impact on the striped bass population due to the once-through cooling operation of the Unit, would not be irreversible and in any event would be largely accommodated by the population itself. (See McFadden, October 1972, Testimony on Impact of Entrainment and Impingement at Indian Point Units #1 and #2 upon Fish Populations, NRC Dkt. 50-247.) The population of striped bass would respond to the conditions which would reduce its total numbers by innate mechanisms which would allow for increased survival of the remaining fish. This fundamental mechanism, generally considered to be functional in all biological populations, is termed compensation. Significant evidence has been found to describe, in part, its operation on the Hudson River striped bass population. This information is provided in the following sections.

2.1.3.1.4.1 Definitions and Explanations

Populations of living organisms typically vary in abundance within at least roughly describable bounds. That is, they do not increase without limit (although they may have the reproductive potential to do so), nor do they commonly dwindle to extinction (although this event does occur under extremely unfavorable conditions). Population size is determined by the interplay among birth rate, death rate, and migration rate. Birth and immigration causes population increase; death and emigration causes population decrease. Over the long run, these two sets of factors tend to balance one another so that the population fluctuates around some average level of abundance, reflecting the capacity of the environment to support the species. The normal confinement of a population within an upper numerical bound is effected by the more intensive operation of the decrease factors (death and emigration) and/or the less intensive operation of the increase factors (birth and immigration) when population density is higher. Conversely, when population density is lower than normal, the rates of death and emigration decline and/or the rates of birth and imigration increase, so that the population begins to increase in size, thus preventing a continuing decline towards dangerously low numbers. This capacity of a population towards "self-adjustment" in numerical size is called compensation. When birth, death, and migration processes operate so as to effect compensation, they are said to be density dependent.

It is recognized that not all birth, death and migration processes are density dependent. Those which operate at rates which are independent of the size of the populations are said to be density independent.

2.1.3.1.4.2 Present Perspective

It is Con Edison's position that the size of the striped bass population in the Hudson River is determined in part by density dependent birth and death processes. These processes are expected to be operative to some degree at all levels of population density, but to be more strongly operative at extremes of density. Many different mechanisms or agents may be the immediate causes of density dependent changes in birth rate or death rate under specific environmental conditions, and the operation of one mechanism may preempt the operation of an alternative mechanism (e.g., a larger than normal year class of striped bass might be reduced by predation before food limitation caused a reduction in growth rate, thus forestalling operation of the density dependent growth process). Different mechanisms may come into play at different thresholds of fish population density or other environmental factors. Several mechanisms may operate simultaneously, either independently or interactively. Both birth and death rates may be affected simultaneously. Thus, what is described as compensation is likely to involve a very complex and pliable set of factors and processes. Con Edison advances the following rationale for considering compensation in relation to predicted impact of the Indian Point power plant on fish populations of the Hudson River:

(1) The reality of compensation in the Hudson River striped bass population may validly be inferred from its general (we argue, universal) occurrence in animal populations; its widely demonstrated operation in fish populations in freshwater, estuaries, and oceans; and empirical evidence of its operation in striped bass populations of the Hudson River and other major water bodies.

(2) It is not necessary to prove the existence of particular compensatory mechanisms within the Hudson River population as a basis for substantiating, in general, point (1) above. However, in order to reasonably infer the operation of compensation during specific stages of the life history, or at certain levels of density, it should be possible to postulate one or more likely mechanisms.

(3) Empirical demonstration of the operation of specific compensatory agents or processes during different life history stages would greatly strengthen inferences of the kind cited in (2) above, and would provide a

basis for partially quantifying the magnitude of the population's potential compensatory response.

(4) The overall capacity of the striped bass population to compensate for reductions in numbers caused by the Indian Point power plant cannot be gauged from the operation of a few empirically demonstrated mechanisms or processes, although these would provide a minimal estimate of compensatory capacity. Overall capacity could be estimated from the numerical performance of the whole population at different levels of density, such as might be reflected in long term records from the commercial fishery, or research observations carried out over a sufficiently long period of time to encompass a wide range of population densities.

(5) It is not necessary to precisely quantify the compensatory capacity of the population before imposing an impact, such as from once-through cooling at nuclear power plants, in order to adequately protect the fish populations. It is feasible to impose new incremental mortalities upon the striped bass population and to simultaneously monitor the compensatory response of the stock, provided that appropriate removal of the incremental mortality or alternative mitigating measures can be implemented if the population begins to decline to undesirably low levels. The advantage of this procedure is that the estuarine environment can be productively utilized while the capacity of the environment to sustain utilization is measured. The applicant's research program has attained a high enough level of precision in measuring fish population parameters to insure detection of serious damage to the striped bass population in time to avoid

> ecologically serious or irreversible damage. The approach described here is the one by which commercial fisheries traditionally are developed, and gradually brought under regulation to optimize yield as the population response to incremental increases in exploitaticn provides a sound empirical basis for the necessary management decisions.

2.1.3.1.4.3 Evidence of Compensation in the Hudson River

As more data on the Hudson River striped bass population have been obtained through Con Edison's research program, and analyses of all available data have proceeded, some significant empirical insights into the phenomenon of compensation have developed. These insights have tended to support the conceptual position taken earlier by Con Edison and currently shared in part by the Staff. Indian Point 3 FES at V-135. The findings presented here are considered tentative because existing data are being further analyzed and new data are becoming available for analysis continuously. Nonetheless, they lend considerable support to Con Edison's request for extension of the date for cessation of operation of the installed once-through cooling system.

The insights developed and presented here are categorized on the basis of the strength of the underlying data as "possibilities," "suggestive relationships," and "empirical demonstrations."

Among the possibilities for compensation presently being examined are a suspected later age of first attainment of sexual maturity in Hudson River striped bass relative to other Atlantic coastal populations; slower growth of Hudson River fish relative to other populations; and predation by tomcod on young striped bass. The first two, if verified, would indicate the possible innate capacity of Hudson River fish to grow faster and to mature at an earlier age under conditions of reduced population density. Both factors would contribute to a compensatory increase in birth rate. Predation, if shown to be significant, might be considered a density-dependent agent of mortality, at least at some densities of young striped bass.

Two potentially important suggestive relationships have emerged in analysis of the research data and are being examined further. The first is evidence of cannibalism by yearling and older striped bass on juvenile striped bass (Texas Instruments First Annual Report for the Multiplant Impact Study of the Hudson River Estuary). Indices of abundance for these two components of the stock were unrelated in 1965-68 when all age group abundance indices were low, but during 1969-1974 there was an inverse correlation between these two components, when yearling and older bass were relatively abundant. Thus, for the latter period, greater abundance of the older fish coincided with lesser abundance in the new juvenile year class. This circumstantial evidence of cannibalism is supported to some degree by food studies, which have demonstrated empirically that some young striped bass are eaten by older members of the population (Texas Instruments 1974 Hudson River Ecological Study, 1973 Annual Report, Table IV-19).

A second suggestive relationship is a negative correlation between indices of abundance of bluefish and juvenile striped bass, which occurs in the data for 1969-74, but not in earlier years (Texas Instruments First Annual Report for the Multiplant Impact Study of the Hudson River Estuary). The correlation might reflect the operation of some environmental factor which oppositely affected bluefish and striped bass abundance, rather than a cause-and-effect predation relationship between the two species. However, the predation interpretaion is a viable one and if substantiated, constitutes yet another ecological process which could operate in a density dependent fashion.

The first empirical demonstration of compensation which we cite here is a statistically significant negative correlation between density of juvenile striped bass in the vicinity of Indian Point and their growth rate. Slower growth at high population densities (and the converse, faster growth at reduced densities) likely would affect in a compensatory manner both birth rate (because growth is related to attainment of sexual maturity and to fecundity), and death rate (because slower growing fish remain for a longer time in smaller size ranges more susceptible to predation).

Densities were estimated for young-of-the-year fish at Indian Point as the mean July-August beach-seine catch per unit surface area (CPUA) during the years between 1965 and 1974, 1971 excluded. Estimates of growth were based on measurements of fish captured in the same beach-seine tows used to estimate densities. In each year, growth was computed as the change in mean total length between July and August, i.e., mean total length in August minus mean total length in July.

For striped bass, the uncorrected correlation coefficient relating young-of-the-year density and growth was $r = -0.719$ (df=6, 2-tail 0.05), indicating a significant negative linear correlation of growth with density. (See figure 2-17) (Texas Instruments First Annual Report for the Multiplant Impact Study in the Hudson River Estuary).

This correlation leads to the conclusion that growth and abundance of young-of-the-year striped bass in the Indian Point area were negatively related; i.e., their growth was density-dependent in the years studied. Although the relationship observed at Indian Point in all probability holds in the striped bass population throughout the Hudson, year-to-year variations in fish distribution make extrapolations from Indian Point to the Hudson as a whole impractical.

A second empirical demonstration of compensation is based upon analysis of the historical records from the commercial fishery. In these records the catch of striped bass per unit of fishing effort (CPUE) can be used as an index of relative abundance of the stock. Furthermore, the stock present in any year are the parents whose reproduction gives rise to a year class or generation of progeny which constitutes part of the stock over a period of years in the future. It is commonly observed in fish populations for which suitable data are available, that the relationship between abundance of parental stock and abundance of the resultant progeny ("recruits" in fishery parlance) is compensatory. That is, the number of

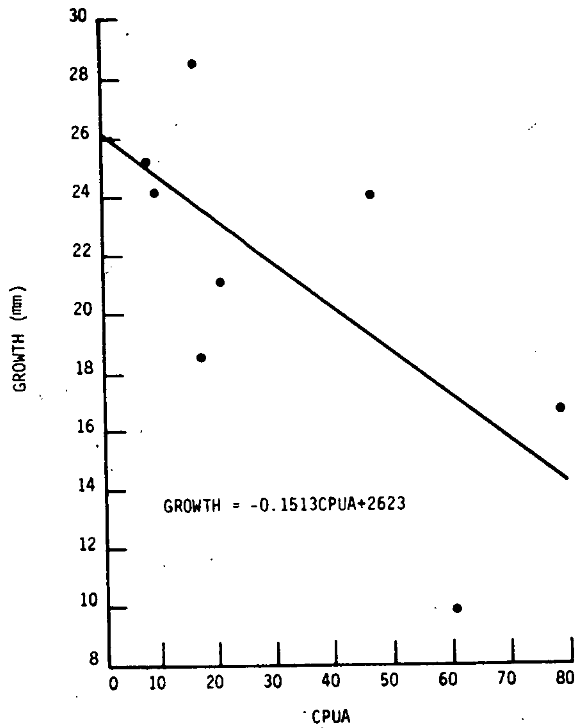

FIGURE 2-17

YOUNG-OF-THE-YEAR STRIPED BASS GROWTH vs. ABUNDANCE

Source: Texas Instruments First Annual Report for the Multiplant Impact Study of the Hudson River Estuary, 1975

adults, for example, captured in a fishery in a given year, can often be correlated with the size of parental stock in some previous year. Figure 2-18 is an example of a stock recruitment curve for striped bass abundance versus abundance five years later. The most vital observations from a management decision point of view are likely to be those near the dome and right hand limb of the curve. Because an intercept at the origin (no parents = no progeny) can be logically inferred, extrapolation of the left limb from the dome of the curve to the origin can often be carried out to an acceptable approximation, even in the absence of empirical observations at relatively low densities of parental stock.

Stock-recruitment relationships in the Hudson River's striped bass population were studied by graphical and linear regression analysis. Historical commercial abundance records for this species (CPUE), covered the period between 1931 and 1972; the CPUE estimates for striped bass were available for all years except 1954. Based on life-history data, several potential intervals between stock and recruitment were scrutinized. Preliminary analysis of 1974 data indicates that in the Hudson River, female striped bass first mature at an age of 5 years. Therefore, in the analysis presented here, CPUE in year X represents parental stock and CPUE in year (X + 5) represents the corresponding recruitment.

During the years 1931-1972, the relationship of striped bass abundance to abundance 5 years later, closely approximates a Ricker (1958) stock-recruitment curve as shown in Figure 2-18. The recruitment curve has two limbs, an ascending

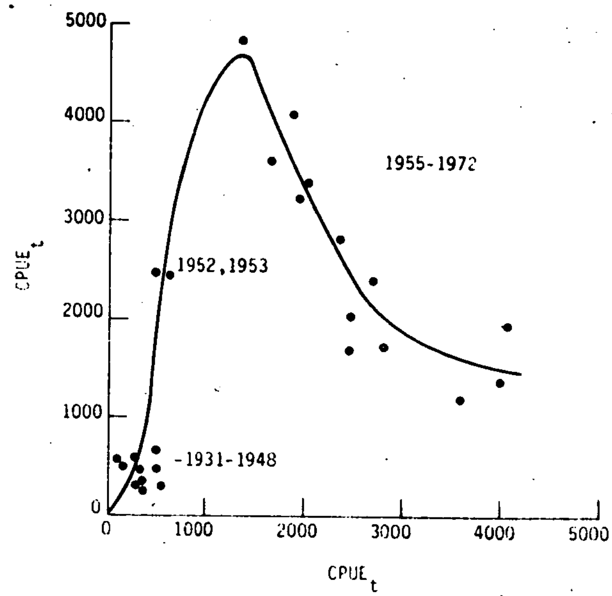

FIGURE 2-18

STRIPED BASS ABUNDANCE vs. ABUNDANCE 5 YEARS LATER FOR ALL AVAILABLE YEARS BETWEEN 1931 and 1972. (THE CURVE IS A FREEHAND APPROXIMATION OF A RICKER STOCK-RECRUITMENT RELATIONSHIP FOR THESE DATA).

Source: Texas Instruments First Annual Report for the Multiplant Impact Study of the Hudson River Estuary, 1975

left limb on which stock and recruitment are positively related and a descending right cne on which they are negatively related. In Figure 2-18 the entire left limb consists of points before 1955. All points representing stock measurements from 1931 through 1948 lie in the extreme lower left corner of the figure. Halfway up the left limb of the recruitment curve are two points produced during the transition to higher density which occurred in the mid-1950's; they represent stocks measured during the period of low abundance and recruitments during the latter years of greater abundance.

Between 1955 and 1972, there was a highly significant negative linear relationship between CPUE and the CPUE 5 years later ($r = -0.811$, $df = 11$, $p = 0.00078$) (Texas Instriments - First Annual Report for the Multiplant Impact Study in the Hudson River Estuary); thus, recruitment in the striped bass population was density-dependent over the abundance range represented by the curve's right limb (See Figure 2-19). Although density-independent factors may have contributed to population shifts since 1955, the magnitude of their contribution is unknown. These data indicate that the Hudson River striped bass population has the capacity to compensate to some extent for increased mortality such as that imposed by power plants. This compensation would seem to occur over a wide range of stock densities (roughly two-thirds of the entire observed range), and the shape of the curve suggests that the compensatory capacity is considerable. Analyses are being continued in an attempt to further substantiate these conclusions and to quantify the striped bass populations compensatcry capability.

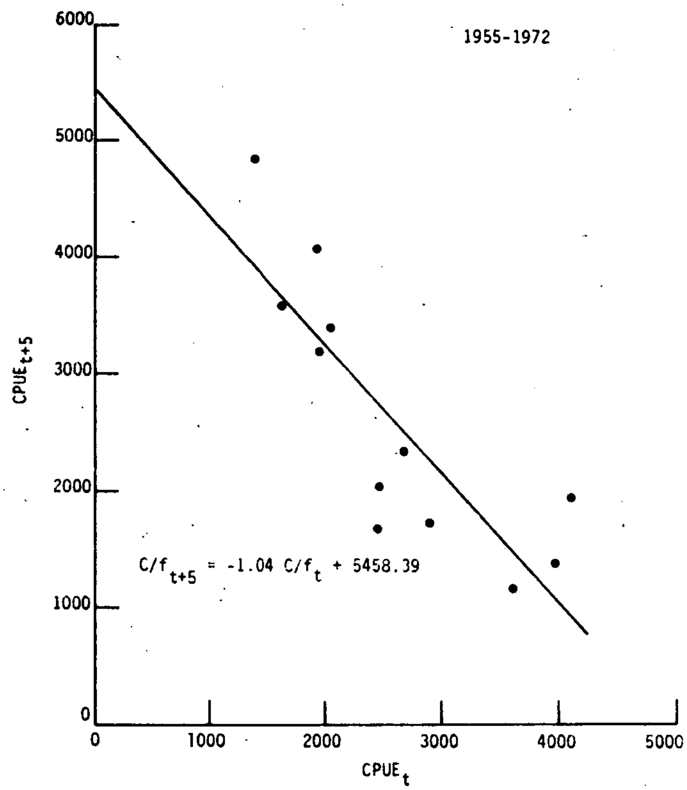

FIGURE 2-19

STRIPED BASS ABUNDANCE vs. ABUNDANCE 5 YEARS LATER DURING 1955- 1972

Source: Texas Instruments First Annual Report For the Multiplant Impact Study of the Hudson River Estuary, 1975

In agreement with current findings, investigators in waters other than the Hudson have reported strong indications of density-dependence in striped bass. Koo (1970) found that commercial landings and catch-per-unit-gear in Maryland fluctuated cyclically with a period of 6 years between successive maxima, which occurred when dominant year classes were fully recruited. Merriman (1941) thought that oscillations in abundance were due to unusually strong year classes which dominated catches for several years. Koo (1970) hypothesized that there was an inverse relationship between striped bass stock and recruitment in Chesapeake Bay, <u>i.e.</u>, that the striped bass population was compensatorially regulated. During the years studied, each dominant year class raised the stock density for two or three years; the population then decreased concurrently with the declining influence of the dominant year class producing lower densities until a new dominant year class was recruited from relatively low stock. Subsequently published data on young-of-the-year densities of striped bass in the Chesapeake (Schaeffer, 1972) showed peaks in the years predicted by Koo's hypothesis. In California waters, Sommani (1972) found by nonlinear multiple regression analysis that physical environment and stock density jointly influenced recruitment variations over a 6-year period; most of the variance was explained by a physical factor, but there was a significant negative relationship at the 1% level between stock and recruitment.

In studies conducted for this report, compensation via density-dependent growth was tentatively confirmed for young-of-the-year striped bass in the Hudson River. Older striped bass in the Hudson were shown to maintain a functional relationship between stock and recruitment. These results reinforce independent studies on Atlantic (Koo, 1970) and Pacific (Sommani, 1972) coastal populations indicating that striped bass normally maintain compensatory stock-recritment relationships.

Although the mechanisms underlying stock-recruitment functions were not determined, prelimianry evidence suggests that striped bass may have two or more compensatory mechanisms at their disposal. In addition, to the density-dependent growth of individuals observed in the Hudson, other potential mechanisms are cannibalism, which has been reported in California (Stevens, 1966), and density-dependent predation.

It is noted that this is one of the few studies designed to determine the existence of compensation in striped bass populations and has been successful in identifying the compensatory effects described above.

2.1.3.1.5 Impingement

Striped bass are impinged in low numbers throughout the year at Indian Point. The size range of impinged bass is about 2-5 inches (see table 2-18). With intermittent operation of circulating water pumps at both Units 1 and 2 in 1972, a total of 1596 striped bass were impinged. In 1973 with Unit 1 operating nearly full time and with Unit 2 circulating pumps operating in 7 months of the year only 1756 bass were collected in the intakes. See Tables 2-19 and 2-20 Texas Instruments 1974 Indian Point Impingement Study Report. In 1974 when Units 1 and

Table 2-18

Average Weights and Lengths of Three Species of Fish
Impinged at Indian Point by Unit and Year

Unit	Year	Average Weight (gm)			Average Length (mm)		
		White Perch	Striped Bass	Tomcod	White Perch	Striped Bass	Tomcod
1	72	13.6	37.1	6.9	82.2	141.1	93.9
2	72	7.2	47.0	6.4	71.1	142.0	89.6
1	73	17.0	9.6	21.0	88.6	93.1	115.5
2	73	11.8	7.4	7.3	81.4	85.2	88.0

Source: Texas Instruments Incorporated
Indian Point Impingement Study Report
For The Period 15 June 1972 - 31 December 1973
(December 1974).

Table 2-19

Total Numbers and Weights of Three Species of Fish
Impinged at Indian Point Units #1 and #2 by Month in 1972

Unit 1	Total Number			Total Weight (gms)		
Month	White Perch	Striped Bass	Tomcod	White Perch	Striped Bass	Tomcod
5	289	0	0	880	0	0
6	1698	8	114	11420	144	324
7	319	58	211	21962	2656	1120
8	1584	480	5983	61247	23846	36567
9	1811	348	24976	40757	17002	168408
10	12691	405	6232	69671	9669	42591
11	5390	133	79	21573	2154	712
12	2613	96	121	19202	2767	1876
Unit 2						
6	139	4	4261	2121	260	14906
9	202	44	4651	1428	1793	29043
10	253	20	2120	1059	1074	13097

Source: Texas Instruments Incorporated
Indian Point Impingement Study Report
For The Period 15 June 1972 - 31 December 1973
(December 1974).

Table 2-20

Total Numbers and Weights of Three Species of Fish Impinged at Indian Point Units #1 and #2 by Month in 1973

Unit 1	Total Number			Total Weight (gms)		
Month	White Perch	Striped Bass	Tomcod	White Perch	Striped Bass	Tomcod
1	1190	131	971	1918	1195	12513
2	9681	136	1153	44677	837	16155
3	30960	501	375	155104	2847	5688
4	24488	414	602	126201	2806	9516
5	3095	9	211	16977	88	529
6	679	25	7918	23511	653	16638
7	381	28	12622	19170	1029	37755
8	2305	223	3424	12690	775	13697
9	219	21	429	1463	567	1635
10	43	14	1	1362	185	11
11	641	113	3	3894	986	48
12	1828	101	43	9481	653	2481
Unit 2						
1	18	0	18	238	0	371
5	2228	9	44	18375	141	64
6	151	8	10	6601	85	19
8	3	0	0	119	0	0
9	0	0	0	0	0	0
11	393	8	1	2502	79	75
12	600	31	385	3067	168	12318

Source: Texas Instruments Incorporated
Indian Point Impingement Study Report
For The Period 15 June 1972 - 31 December 1973
(December 1974) Appendix A.

2 were both operating nearly full time, approximately 6,000 striped bass were impinged.

These impingement numbers are only a fraction of a percent of the standing crop estimates of striped bass population size provided in the 1973 Indian Point Ecological Study Report. Texas Instruments (1974) at III-49. This percentage reduction in population size is insufficient to create any irreversible adverse impacts to this species in the Hudson River. Con Edison concludes, based on the record of striped bass impingement at Indian Point since 1972 and on the preliminary estimates of the size of the bass population in the Hudson River, that the requested extension of operation of the once-through cooling system at Indian Point 2 will have negligible impingement impact on striped bass.

2.1.3.1.6 Contribution of the Hudson River Striped Bass Population to the Mid-Atlantic Coastal Fishery

Prior to the operating license hearing on Indian Point 2, studies of Atlantic Coast striped bass suggested that the Chesapeake Bay had produced the vast majority of fish taken in the coastal fishery northward of Virginia to Maine (Merriman 1941, Koo 1970, Schaeffer 1972).

At the Indian Point 2 operating license hearing, the Regulatory Staff reanalyzed the available striped bass tagging data for Chesapeake Bay and performed other analyses which they felt showed that the Hudson River contributed approximately 80% of the catch of the mid-Atlantic fishery (C.P. Goodyear on origin of the striped bass stock of the Middle Atlantic coast, redirect-rebuttal testimony NRC Docket No. 50-247). This position was contrary to the prevailing opinion on the source of striped bass in the mid-Atlantic fishery. Subsequent review by the Appeal Board rejected the Staff's analysis. ALAB-188, RAI-74-4.

The Regulatory Staff subsequently reevaluated its position on the Hudson's contribution to the Atlantic fishery in the Final Environmental Statement for Indian Point 3. The Staff shifted emphasis in defining the zone of influence of the Hudson River striped bass population from the mid-Atlantic to Northern mid-Atlantic and New England; thus significantly reducing their estimate of the extent to which the Hudson could contribute to the Atlantic commercial fishery while at the same time extending the contribution into the New England zone. An Inner Zone, to which all parties agree the Hudson contributes significantly, retains only a small commercial fishery. The Outer Zone, the northern mid-Atlantic and New England, contribution by the Hudson as reevaluated by the Staff was valued at between 10 and 50% (FES Indian Point Unit No. 3 at V-166-177). Overall, this is a significant reduction from the 80% contribution estimate used by the staff in the Indian Point 2 operating license proceedings.

No new data are available at this time to refute the original hypothesis that the Chesapeake stock is the primary source of striped bass for the coastal fishery. Con Edison is presently sponsoring studies to estimate the respective contribution of the Hudson and the Chesapeake stocks to the coastal fishery. See § 3.2. It is expected that the results of these studies, to be completed in late 1975 and reported on in

1976, will provide substantial evidence with which this point of controversy may be put to rest.

2.1.3.2 White Perch

2.1.3.2.1 Entrainment

White perch spawning occurs in May and June in the Hudson River and appears to be associated with the major tributaries between river miles 80 and 120 (Texas Instruments 1974 Fisheries Survey of the Hudson River Vol IV at V-39). Because the eggs of white perch are adhesive and demersal and usually spawned in shallow water or tributaries and because they are spawned far upriver from Indian Point they are not vulnerable to entrainment at Unit 2. The early larvae are found in the same general river reach as the eggs and, therefore, are not vulnerable in large numbers to entrainment at Unit 2 (See also NYU Progress Report 1971-72 at 215).

Post yolk-sac larvae were initially abundant in the upper end of the estuary in 1973 and later were abundant from the Poughkeepsie-Hyde Park region to the Croton-Haverstraw region (Texas Instruments 1974 Fisheries Survey of the Hudson River Vol IV at V-42). The late larvae of white perch are moderately vulnerable to entrainment at Unit 2 until they move to the shore zone beginning in early July.

White perch early juveniles (15 to 30 mm) were abundant in July 1973 from river mile 50 to 110 while larger juveniles were abundant in the Croton-Haverstraw and Tappan Zee regions after mid-August. Beginning in October the abundance of white perch juveniles in the shore zone decreased until they disappeared almost completely by late November.

2.1.3.2.2 Impingement

White Perch have generally acccunted for the major portion of the total number of fish impinged annually at Indian Point. During the period April 1966 to March 1967, the only continuous 12 month impingement monitoring period pricr to 1970, an estimated 1.3 million white perch were impinged. (See Table 2-21). Mitigating measures including the installaticn of fine fixed screens on the intake forebays and later the implementation of reduced flow operations during winter months at Unit No. 1 significantly reduced white perch impingement below the 1966-1967 levels. With the startup of Unit 2, the total flow rate of the plant has increased by a factor of three and the white perch impingement has increased.

Since 1970 the total number of white perch impinged annually at Indian Point has fluctuated widely. Data collected to date suggest this annual impingement rate of white perch is unrelated to the amount of water pumped, (see Table 2-22), but is closely related to the relative abundance of the species in the river. See Figures 2-20 and 2-21.

The fishery surveys conducted since 1965 do not show a continuing decline in the white perch population, even though the number of generating units on the river has increased. Since the present rate of impingement is roughly equivalent to that occurring prior to the mitigating action initiated in 1967, and since the population tends to be greatly influenced by natural parameters,

TABLE 2-21

Comparison of Estimates of Fish Impingement at Indian Point Unit 1

Month	Mean No. of Fish/Day for 1966 to 1967	Projected Monthly Totals from 1966 to 1967 Data	Mean No. of Fish/ Day for 1971	Projected Monthly Totals From 1971 Data	Actual Monthly Totals for 1972
Jan.	7,200	223,200	453	14,043	19,689
Feb.	4,300	120,400	4,853	135,844	35,865
March	4,400	136,400	333	10,323	27,015
April	500	15,000	497	14,910	6,747
May	700	21,700	181	5,611	933
June	600	18,000	141	4,230	1,990
July	1,600	49,600	51	1,581	694
August	1,000	31,000	814	25,234	16,559
Sept.	900	27,000	1,217	36,510	33,249
Oct.	1,300	40,300	2,190[2]	67,890	24,716
Nov.	1,400	42,000	930	27,900	6,306
Dec.	4,600	142,600	1,127	34,937	3,299
Total		867,200		379,053	177,062
Annual Adjusted Total		1,300,800[1]		473,816[3]	221,328[4]

1. Total adjusted 25% for missed sampling and 25% for undersampling
2. Mean at full flow used because Unit 1 operated at full flow in October 1972 for test purposes
3. Total adjusted 25% for undersampling; representative sample days selected to avoid missed sampling periods
4. Total adjusted 25% for undersampling

Source: Testimony of R. Alevras, The Estimation of Fish Impingement at Indian Point Units 1 and 2, Feb. 5, 1973, NRC Dkt.No. 50-247.

Table 2-22

Total number of white perch impinged per year and total number of pump days per year.

	Total # White Perch			Total # Pump Days*		
Year	Unit 1	Unit 2	Total	Unit 1	Unit 2	Total
1970	522,913	-	522,913	313	-	313
1971	98,890	79,415	178,305	611	113	724
1972	100,046	150,006	250,052	630	163	793
1973	75,510	3,339	78,903	309	1,027	1,336
1974	41,154	319,056	360,210	424	1,377	1,801

* A pump-day is one main circulator pump operating for 1 day.

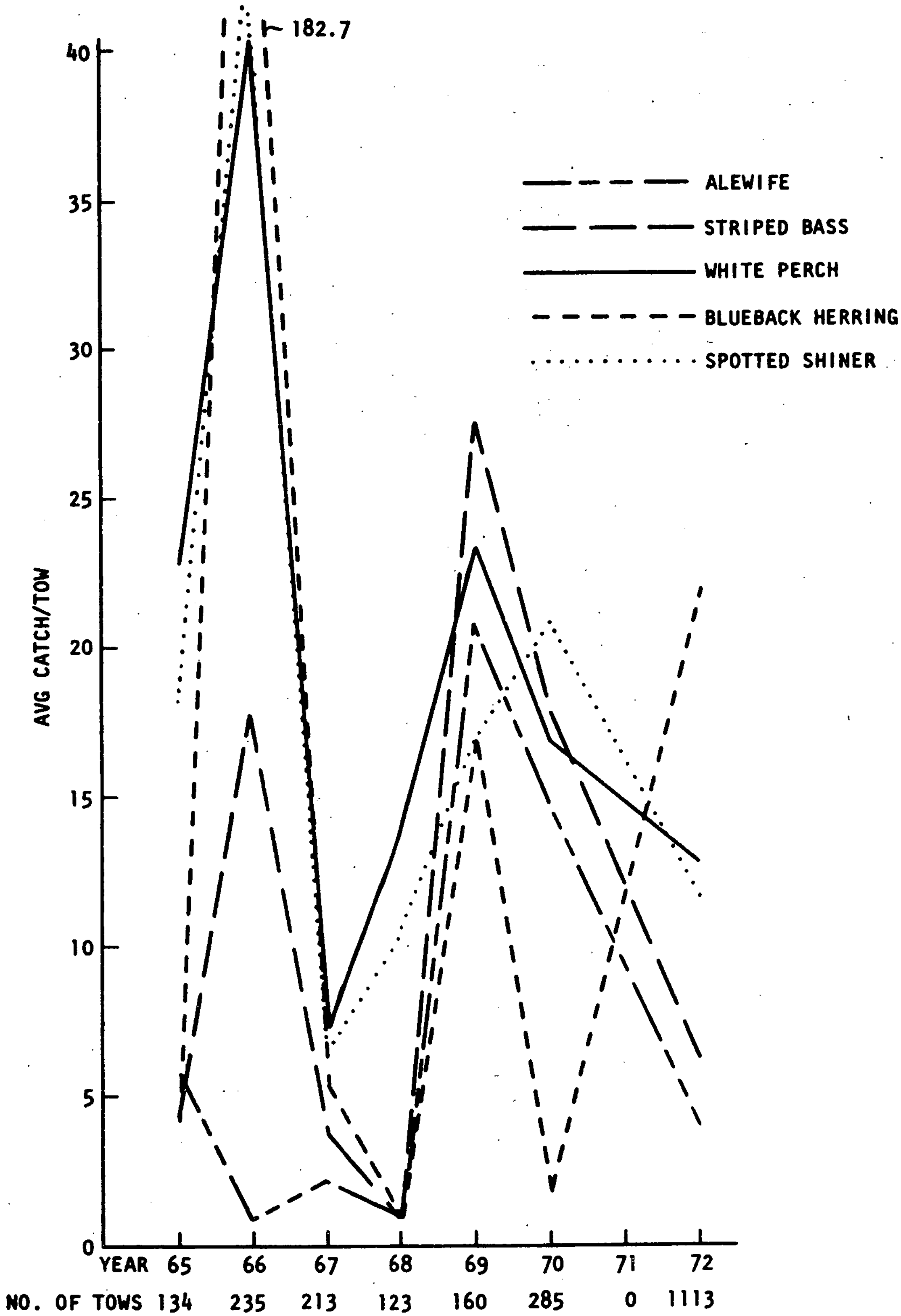

FIGURE 2-20

YEARLY FLUCTUATIONS IN MEAN CATCH PER EFFORT FOR ABUNDANT SPECIES IN BEACH-SEINE HAULS, LOWER HUDSON ESTUARY

Source: Texas Instruments Hudson River Ecological Study First Annual Report April 1973

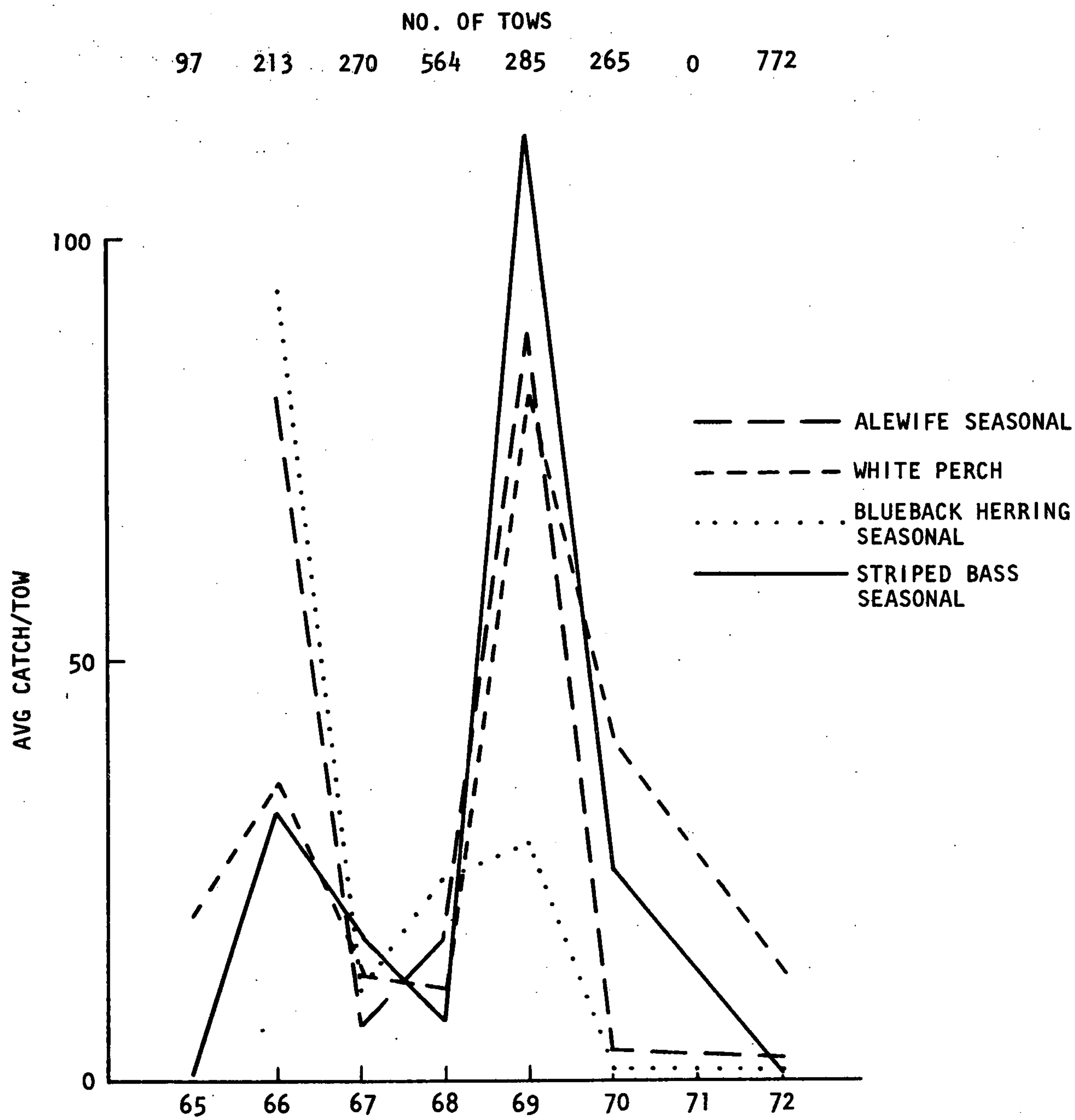

FIGURE 2-21

YEARLY FLUCTUATIONS IN MEAN CATCH PER EFFORT FOR ABUNDANT SPECIES IN BOTTOM TRAWLS, LOWER HUDSON ESTUARY

Source: Texas Instruments Hudson River Ecological Study First Annual Report, April 1973 particularly fresh water flow, it is not anticipated that this impingement rate will result in an irreversible or adverse impact on the white perch population.

2.1.3.3. Atlantic Tomcod

2.1.3.3.1 Entrainment

Tomcod spawn from mid-December to April in the Hudson River in fresh and brackish water. The eggs of tomcod are demersal and adhesive and, therefore, are not planktonic and susceptible to entrainment. Intake and discharge sampling at Indian Point did not collect any tomcod eggs. Intake and discharge canal sampling in 1971 and 1972 collected very few tomcod larvae. Of the larvae collected from the discharge canal (no delta T), 77% survived after a six-day holding period compared to 83% survival for larvae collected at the intake and held for six days. Tomcod Larvae are apparently capable of withstanding pumped entrainment (NYU Progress Report 1971-72 at 227).

In laboratory tolerance tests tomcod larvae 44 hours old and older were able to tolerate at least a 26°F delta T for 60 minutes. This delta T-exposure time exceeds all T-transit time conditions occurring at Indian Point during the occurrence.

Tomcod larvae 26 hours old were able to tolerate a delta T of 16°F for 30 minutes. The temperature tolerance of tomcod larvae of this age would be exceeded during single unit operation at Indian Point (NYU Progress Report 1971-72 at 205,207).

Based on the low abundance of tomcod larvae in entrainment samples and the temperature tolerance of the larvae, entrainment is not a significant mortality for tomcod at Indian Point.

2.1.3.3.2 Impingement

Young-of-the-year tomcod were impinged in relatively large numbers during late spring and early summer at Indian Point Unit 2 during 1974. This is the first year since daily fish counts began in 1970 that tomcod were impinged in such large numbers. It is presently unknown if this was an unusual occurrence or if a similar impingement rate can be expected in future years.

Tomcod are not the object of intensive sport or commercial fisheries, therefore, the increased mortality from power plant operations is not imposed on a heavily fished population.

Tomcod, along with white perch, are among the most abundant resident fish in the estuarine portion of the Hudson River. Although the present impingement rate is high in terms of absolute numbers, the populaticn cf tomcod in the Hudson appears to be large enough to withstand the increased mortality due to impingement. Population estimates of tomcod are presently being attempted in order to assess the impact of impingement.

2.1.3.4 American Shad

Juvenile American shad are impinged in low numbers at Indian Point. In 1974, a total of approximately 1,400 shad were impinged at Units 1 and 2 combined. This low rate of impingement indicates that the requested extension of once-through cooling will have no effect on the Hudson River population of American Shad. Because this species spawns considerably upstream of Indian Point, few if any individuals are entrained.

2.2 Non-Water Quality Environmental Impacts

Postponing termination of operation of the plant with once-through cooling from May 1, 1979 to May 1, 1981 will produce no adverse effects on man's environment, other than the minimal impacts to aquatic biota described in § 2.1 above. On the other hand, termination of operation with once-through cooling and implementation of closed-cycle cooling by means of a wet natural-draft cooling tower will cause non-water quality impacts that will adversely affect the quality of the human environment. Postponement of the implementation date will postpone the start of these impacts. It will also result in a higher probability that the correct decision concerning the necessity for closed-cycle cooling will ultimately be made, because of the better fishery data base that will be available as a consequence of the Con Edison research program. <u>See</u> §§ 3.2, 4.1.1, 6.3.

A complete analysis of the non-water quality environmental impacts from construction and operation of a wet natural draft cooling tower is contained in Con Edison's report on "Economic and Environmental Impacts of Alternative Closed-Cycle Cooling Systems for Indian Point Unit No. 2" (Cooling Tower Report) submitted to the predecessor agency to the Nuclear Regulatory Commission on December 2, 1974. The report was prepared to determine the preferred alternative cooling system to the once-through system should an alternative be required. Con Edison concluded that "a natural draft cooling tower is considered the least objectionable cooling alternative at Indian Point" (Cooling Tower Report at 8-3) and the alternative best able to minimize non-water quality environmental impacts as well as reduce thermal effluents.

Although Con Edison has selected a preferred method of closed-cycle cooling for use in the event such a system is determined to be necessary to protect the fishery, the data on the fishery are not yet sufficient to permit this determination to be made with reasonable precision. A determination based on the limited data base currently available carries with it a large risk that the decision made will ultimately prove to have been incorrect. In particular, a decision to install closed-cycle cooling on the current Nuclear Regulatory Commission license schedule, Figure 1-1, carries with it a substantial risk that the dollar expense and non-water quality environmental impacts incurred would subsequently be proven to have been unnecessary, and that resources will have been irretrievably committed to a project that results in a long-term net detriment to society. Construction and operation of the closed-cycle cooling system is truly necessary only if it is the sole way to protect the Hudson River from very serious damage and only if it would not result in other impacts that would outweigh the benefit to society of such protection. An additional two years of time are required to continue the ecological study program and analyze the data so that a reasonably "correct" decision may be made on the need for, and the net benefit or cost of, closed-cycle cooling. During this period, the onset of irreversible major impacts on man's environment would be delayed.

Impacts which often result from construction and operation of cooling towers, and which were considered in the instant case, include additional atmospheric emissions due to increased fossil fuel-fired electric generation, marked reduction of aesthetic value, botanical damage, uncharacteristic fogging and icing, and excessive noise levels.

Con Edison found in its study of cooling towers that the outage for installation would lead to some additional atmospheric emissions in New York City due to increased combustion of fossil fuel to compensate for decreased nuclear electric generation caused by cooling tower installation and operation. Cooling Tower Report at 8-2. Potential botanical injury could be expected due to saline deposition from drift discharged by a natural draft cooling tower. Id. at 6-26. The visual impact of such a massive structure would be intrusive in the scenic and historic Hudson River Valley and surrounding residential areas. Id. at 8-2.

On the other hand, Con Edison found that "noise emissions from natural draft cooling towers are not expected to cause an adverse impact" (Cooling Tower Report at ii) and the predicted "fogging and icing problems are not considered significant." Id. at 8-1.

2.2.1 Effects on Ambient Air

Extending the period of once-through cooling for two years to collect sufficient biological data would cause virtually no change in ambient air quality. If after this period of collection of sufficient biological data it were determined that closed-cycle cooling would not be needed, the two-year delay would have yielded all the benefits which could be expected by avoiding the adverse impacts of closed-cycle cooling described in the Cooling Tower Report at 6-87. On the other hand, if it were ultimately determined that closed-cycle cooling would indeed be necessary, the onset of these impacts would have been delayed and, for the period of the delay, avoided.

2.2.2 Botanical Effects

Extending the period of once-through cooling for two years to collect sufficient biological data would cause no harm to area plant life. If after this period of collection of sufficient biological data it were determined that closed-cycle cooling would not be needed, then the two-year delay would have yielded all the benefits to area plant life which could be expected by avoiding the adverse impacts of closed-cycle cooling described briefly below and in detail in the Cooling Tower Report beginning at page 6-21. If it were ultimately determined that closed-cycle cooling would indeed be necessary, the onset of these impacts would have been delayed.

Saline drift produced by operation of the natural draft cooling tower could potentially injure three species of trees: (1) hemlock, (Cooling Tower Report at 6-34), (2) white ash, and (3) flowering dogwood. The impact would be concentrated at Montrose and Verplanck in the Town of Cortlandt, in the Village of Buchanan, and to a lesser degree, in the areas north and west of the cooling tower location. Cooling Tower Report at 6-29. Hemlock is found in forested areas and is frequently used as a residential ornamental. Flowering dogwood is on the list of native plants protected under the law of New York "by reason of their rarity, uniqueness, scarcity or endangered status." N.Y. Environmental Conservation Law § 9-1503(2) (McKinney Supp. 1974); 6 N.Y.C.R.R. § 193.3 (eff. Jan. 1, 1975).

2.2.3 Land Use Impacts

Extending the period of once-through cooling for two years to collect sufficient biological data would cause no change in Hudson River Valley land use and aesthetics. If after this period it were determined that closed-cycle cooling would not be needed the two-year delay would have yielded all the benefits to land use which would be expected by avoiding the adverse impacts of closed-cycle cooling, described below. If it were ultimately determined that closed-cycle cooling would indeed be necessary, the onset of these impacts would have been delayed.

A wet natural draft cooling tower at the Indian Point site would have a major visual and aesthetic impact on surrounding areas. Indian Point 3 FES at XI-19; Cooling Tower Report at 6-75 et seq. The certainty and irreversibility of this impact makes unreasonable a decision to proceed on the current NRC schedule with a determination based on incomplete fishery data. The major visual impact of the natural draft cooling tower is its size, which is greater than that of any other structure in the Hudson Valley Region surrounding Indian Point. Indeed, it would be the highest structure along the Hudson River, from New York City to Albany. Visual indicators of its size are that it will rise about 200 feet higher than the existing Indian Point 1 stack, and that the playing area of a football field could be placed on top of the cooling tower. The tower's 565-foot elevation above grade (or 618 feet above sea level) is within approximately 100 feet of the elevation at the summit of many of the mountains in the area which form the slopes of the Hudson Valley.

Another land use category, and one of unique significance in the Indian Point region, is recreational land use. <u>See generally</u> Cooling Tower Report at 6-76. Each year, millions of visitors travel by land and river into and through the region surrounding Indian Point to see historical attractions and to enjoy recreation resources. Vacationing families, school children and clubs visit in increasing numbers every year. Recreational boaters and fishermen on the River will also be exposed to the visual impact of the cooling tower.

Accordingly, a cooling tower, and the visible plume from the tower, would both have a visual impact on the permanent population around Indian Point and on a very large transient population visiting the region, as well.

3. ENVIRONMENTAL RESEARCH AND MONITORING PROGRAMS

3.1 Thermal Surveys

3.1.1 Current Programs

3.1.1.1 Nature of Programs

Con Edison is currently conducting an extensive thermal monitoring program in the vicinity of Indian Point. The objectives of this program are:

(1) To determine the extent of the plume resulting from plant thermal discharges for comparison with applicable thermal discharge criteria; and

(2) To provide data for comparison of the relationship between the thermal discharge to the river and the thermal response of the river as predicted by mathematical and physical models, so as to improve and modify those models as analytical predictive tools for future thermal discharges under anticipated conditions.

The above objectives are being achieved through the employment of two distinct, but complementary efforts:

(1) Routine Thermal Monitoring - geared to satisfy objective (1).

(2) Intensive Thermal Survey - geared to satisfy objective (2).

This aspect of Con Edison's program commenced in May 1974 and is to be conducted during the first year of full power operations of Unit 2, except when ice is on the river. Routine thermal monitoring was conducted in the months of May, June, July, September, and November 1974. A final routine survey took place in April 1975. Intensive thermal surveys were conducted in the months of August and October 1974. An additional intensive survey is envisioned for May 1975.

The thermal surveys currently analyzed and reported indicate that the thermal plume resulting from combined operation of Indian Point 1 and 2 are well within the limits imposed by the New York State Thermal Criteria. A correlation from the intensive survey program should be available that can relate the intensity and extent of the thermal plume to conditions other than those measured. There is, however, no indication that the limited intensities and extent of the thermal plume reported in the surveys conducted to date are not representative of the operation of Units 1 and 2 with once-through cooling. It is concluded therefore, that any extension in the period of once-through cooling for Unit 2 will, as discussed below, neither change this situation nor create an adverse thermal impact.

3.1.1.2 Routine Thermal Monitoring

This program is designed to compare the extent of the thermal plume resulting from operation of Units 1 and 2 with the New York State Thermal Criteria. Each monthly monitoring effort involves the acquisition of data for at least four consecutive major phases of the tidal cycle (high and low slack, maximum ebb and flood). The extent of the plume is quantified for comparison with the constraints of the thermal criteria (maximum surface temperature, surface width, and cross-sectional area). Spatial and temporal mappings of the thermal plume, from discharge temperature down to 2°F excess temperature and with contour intervals of 0.5°F, are constructed.

A significant portion of each monthly program is directed to the delineation of ambient temperature in the affected region, with numerous transects conducted (laterally across the river) outside of the reach of the river affected by the power station. Fixed stations and/or boats are employed, with temperature and salinity measurements being acquired at several stations per transect and at several depths per station.

Plume measurements are divided into those conducted in the near field and those obtained in the far field. Different procedures and instrumentation are being used, since the former plume extends to a greater depth than the latter. Near field measurements are obtained by means of a vertical string of thermistors, attached to a vessel making a criss-cross pattern over the near field. Temperatures are recorded at a series of depths, from the surface to a depth of about 20 feet. The far field is mapped through the use of thermistors, concentrated near the surface at surface, three-, and six-foot depths, with the vessel making many transects accross the river. This pattern is repeated over each phase of the tidal cycle. The temperature data will be acquired over a time period, generally about 3/4 of an hour, such that the positions of the plume will not significantly shift.

Prior to the measurement of the plume at each tidal phase, an ambient transect is conducted either north of the plant (Roa Hook or Bear Mountain Bridge) during ebb current flow (maximum ebb and low water slack), or south of the plant (Haverstraw Bay or Croton Point) during flood current flow (maximum flood or high water slack). This ambient transect is generally a combination of (1) an ambient scan whereby the thermistor string is towed across the width of the river, recording temperatures at the surface and several additional depths, and (2) an ambient profiling transect, wherein several stations are occupied and temperature data are obtained at several depths at each station.

Subsequent to the ambient transect, the near and far field, as described above, are mapped from the discharge down to about 2°F above ambient. Generally two vessels are employed simultaneously for this measurement. The results are presented as near field mapping, covering depths up to about 20 feet, and far field mapping, covering surface and three- and six-foot depths. Because of this buoyant nature of the plume, it is not necessary to extend the data acquisition in the far field beyond the six-foot depth. This procedure is then repeated for the next tidal phase. Intake and discharge temperatures are monitored periodically during the survey.

The results of the May, June, and July 1974 routine thermal surveys have already been submitted to appropriate agencies for review. <u>See</u> Dames & Moore, Indian Point 2 Routine Monthly Thermal Monitoring Reports (May-July 1974). The results, as summarized in Table 3-1, indicate that the plume is well within the surface and cross-secticnal values listed in the New York State Thermal Criteria. As discussed in the survey reports, these results can be considered conservative, <u>i.e.</u>, they overestimate the extent of the plume. This conservatism in the area computations is illustrated by noting that the plume is mapped down to about the 20-foot depth. The plume is assumed to maintain its lateral extent at the 20-foot depth down to the bottom (an average depth of about 40 feet), when in fact the width of the plume decreases with depth.

What is extremely significant in these reports is that they reveal a rather limited cross-sectional plume area. The average value of the maximum cross-sectional areas occupied by a particular excess temperature isotherm can be calculated from the following table:

Tidal Phase	Average Excess Temperature °F	Average Cross-Sectional Area (%)
Flood	3.3	10
HWS	3.4	9
Ebb	3.5	7
LWS	3.3	16
Average	3.4	11

The cross-sectional area occupied by the plume, as given above, reflects the volume of water occupied and is often thought to be the aspect of a discharge most directly related to its ecological impact. The New York State Thermal Criteria are worded in terms of 4°F excess temperature isotherms; that is, the constraint on the cross-sectional area of the plume is such that the 4°F excess temperature isotherm is limited to 50% of the cross-sectional area. Utilizing the criteria as a baseline, the maximum extent of the 3.3°F excess temperature isotherm (which is greater than the 4°F excess isotherm) occurs during LWS and is less than one-third (16/50) of the constraint in the New York Thermal Criteria.

TABLE 3-1

Results of Routine Thermal Survey

(A) River Surface Width

TIDAL PHASE	May, 1974 EXCESS TEMPERATURE (°F)	May, 1974 PERCENT WIDTH (%)	June, 1974 EXCESS TEMPERATURE (°F)	June, 1974 PERCENT WIDTH (%)	July, 1974 EXCESS TEMPERATURE (°F)	July, 1974 PERCENT WIDTH (%)
Flood	3.4*	15	3.4	21	3.1*	17
HWS	3.4	20	3.3*	18	3.2	26
Ebb	3.0	25.	3.8	37	3.8	40
LWS	3.1	46	3.9	48	2.8	30

(B) River Cross-Sectional Area

TIDAL PHASE	May, 1974 EXCESS TEMPERATURE (°F)	May, 1974 PERCENT AREAS (%)	June, 1974 EXCESS TEMPERATURE (°F)	June, 1974 PERCENT AREAS (%)	July, 1974 EXCESS TEMPERATURE (°F)	July, 1974 PERCENT AREAS (%)
Flood	3.5*	2	3.4	14	3.1*	14
HWS	3.4	5	3.5*	10	3.2	13
Ebb	3.2	6	3.6	7	3.8	8
LWS	3.3	19	3.9	16	2.8	13

* Average of two tidal phase measurements.

3.1.1.3 Intensive Thermal Monitoring

This program was designed to acquire sufficient data to evaluate the results predicted by the existing analytical and physical hydrothermal models, and if necessary modify those models. The models have been used to simulate the effect of Indian Point Station on the Hudson River under what have been identified as the most severe or critical river conditions in terms of compliance with the state thermal criteria. Quirk, Lawler & Matusky Engineers, Effect of Submerged Discharge of Indian Point Cooling Water on Hudson River Temperature Distribution (October 1969); Quirk, Lawler & Matusky Engineers, Supplemental Study of Effect of Submerged Discharge of Indian Point Cooling Water on Hudson River Temperature Distribution (May 1972); and Testimony of Dr. John P. Lawler, Quirk, Lawler & Matusky Engineers, The Effect of Indian Point Units 1 and 2 Cooling Water on the Hudson River Temperature Distribution, April 5, 1972, NRC Dkt. No. 50-247. It is desirable, therefore, that any model verification measurements be conducted under similar conditions. A survey of historical, hydrological and meteorological records indicate, that the most adverse conditions are, in order of decreasing severity,

(1) May, with a fresh water flow of about 20,000 cfs; salt front below Indian Point, hence, one layer flow, and

(2) October, with a fresh water flow of about 4,000 cfs; salt front at Indian Point, hence, two-layer flow.

An intensive survey was conducted in October 1974. Another intensive survey is being conducted in May 1975. This effort will provide information towards satisfying objective (2), above, under adverse conditions.

In addition, the Commission's Regulatory Staff has advanced the postulate that the following is the most critical condition:

> (3) August, with a fresh water flow of about 4,000 cfs (salt front above Indian Point); hence, two-layer flow. Indian Point 3 FES at V-19 and V-37.

While Con Edison does not subscribe to the foregoing, it has expanded its program to include an intensive survey in August. Such a survey was conducted in August 1974. The scope of the intensive survey program is indicated below, and described in detail in a report prepared for Con Edison. See Dames & Moore, Phase I Progress Report, Indian Point No. 2, Temperature Survey for Model Prototype Comparison (April 1974).

An introductory analysis was initially employed, utilizing both the mathematical and physical models along with existing thermal data for the site to select the location for possible surface and subsurface transects. Interactions between the thermal plume of Indian Point and other power plants was evaluated. The information realized from the routine thermal surveys (May-July 1974) guided the August 1974 intensive survey.

The experimental data acquisition portion of each intensive survey encompassed approximately 10 days. This should provide reasonable reproducibility over several tidal cycles, and minimize uncertainty attributable to perturbations in experimental conditions. The data acquisition procedure (i.e., methodology for far field and near field plume mappings) described under routine monitoring was employed here. However, as indicated below, the level of effort was much greater.

Measurement of River Parameters. This aspect determines the salient river and atmospheric parameters, such as salinity, net non-tidal flow, fresh water runoff, river velocities, heat exchange or heat transfer coefficient, thermal stratification factor, dispersion coefficient, and the local meteorology.

Near Field Measurements. The near field is defined as the region within which effluent momentum is detectable as compared to natural dispersive processes and tidal momentum. The discharge velocity and direction through the submerged ports in the discharge structure are measured to determine the proper functional relationship between head differential across the discharge structure and discharge velocity. Detailed measurements of the near field patterns were taken.

Far Field Measurements. The far field program included aerial temperature surveys along with triaxial measurements through the detectable Indian Point plume. The results were time-dependent three-dimensional temperature profiles over the tidal cycle and over a number of cycles.

The near field measurements are being compared with the results of the undistorted hydraulic model and the submerged discharge mathematical model. The far field measurements are being compared with the distorted physical model and the far field mathematical model. The results of both the far field and near field measurements are being integrated to present the spatial and temporal temperature distribution in the river, and necessary modifications will be made in either the physical models or the mathematical models.

The updated models can be run, if the need arises, with conditions other than those occurring during the survey, and it will be possible to evaluate the response of the river with respect to the thermal criteria under any conditions. The analysis of the data from the August and October 1974 intensive surveys is currently underway and should be available in the near future. An enormous amount of field data was acquired during the intensive surveys. A total of 64 separate tidal phases were mapped for both surveys, resulting in over 200 plume mappings that must be reduced and analyzed. This must be compared with the predictive models, which cannot be run until certain field data (such as heat transfer coefficient and fresh water flow) have been analyzed. The dependence of several portions of this study upon information from the analysis of a previous segment does not permit many aspects of the program to be run concurrently, but rather sequentially. This wealth of information, of necessity, results in a considerable time span between the data-gathering effort and availability of the final report.

3.1.2 Future Thermal Monitoring

Con Edison will initiate another thermal survey program commencing with full power operation of Indian Point 3. This program will draw upon the knowledge acquired in the Unit 2 Thermal Surveys, and will be employed to identify the combined thermal impact of the once-through cooling of both Units 2 and 3.

The proposed thermal plume survey will tentatively consist of routine thermal surveys, conducted on a monthly basis, of the intensity and extent of the plume. This program is envisioned to be identical to the Unit 2 routine thermal survey effort (near and far field).

Upon completion of the yearly Unit 3 survey program, an analysis of the results, along with the employment of the predictive models will determine the need for and intensity of any future thermal programs. The Unit 3 thermal plume survey program will provide additional information on the potential impact of three-unit operation resulting from the requested additional period of operation of Unit 2 with once-through cooling.

3.2 Hudson River Ecological Study

The Hudson River Ecological Study is probably the most thorough study of its type ever undertaken in this country. A comprehensive study of the life history of striped bass has been conducted for the entire stretch of the tidal portion of the river, and an intensive investigation of the life history of white perch throughout the major portion of the estuary has been undertaken. Atlantic tomcod and American shad have also been studied in considerable detail. Results of these studies, conducted and refined over a 10-year period, will serve as baseline data and in part as operational data for estimating power plant impacts on the river populations due to (1) impingement at the intakes, (2) entrainment through the plant, and (3) the thermal plume. Data obtained in 1974 and later will serve as operational data which is necessary for comparison with data from previous years to verify impact predictions and for decisions as to the necessity for installation of closed-cycle cooling systems. Also being studied is the feasibility of artificially rearing striped bass for subsequent stocking in the River to mitigate possible losses to the population from power plant operations. <u>See</u> § 3.4.1.

Results of these studies to date are contained in numerous technical reports, and an estimated 15 additional reports will be prepared before the completion of the work. This represents the broadest acquisition of data on the environmental impact of an industrial activity in the United States. The reports completed and furnished to the Commission to date are listed in § 8.1. Other pertinent reports are Appendices to this Environmental Report.

These studies have been and are continuing to be performed under the guidance of the Hudson River Fish and Wildlife Management Cooperative (formerly the Hudson River Policy Committee) and the Hudson River Technical Committee. The Technical Committee had previously designed and managed the 1965-1968 Hudson River Fisheries Investigations and oversaw the Raytheon Ecological Study of 1969-1971. With the inception of the Hudson River Ecological Study in 1972, Con Edison has designed and managed, as well as continued the financial support of the various studies. The Policy and Technical Committees review study design and progress by means of the various contractor study reports which are sent to them in addition to following daily progress through an on-site representative of the U.S. Fish and Wildlife Service. (The latter position is presently vacant, though it was to have been filled by January 1975.) The Policy and Technical Committees are comprised of representatives of the directors or commissioners of the U.S. Fish and Wildlife Service, National Marine Fisheries Service, New Jersey Department of Environmental Protection, and the New York State Department of Environmental Conservation.

These investigations have been the subject of unusually exhaustive regulatory review. The Indian Point 2 operating license hearings before the Atomic Safety and Licensing Board amassed about 10,000 pages of transcript. The remanded Cornwall Pumped-Storage Project hearings before the Federal Power Commission in the fall of 1974 totalled almost 5,000 pages of transcript, and those hearings are expected to reconvene in late 1976.

The materials presented by Con Edison during the Indian Point 2 licensing hearings were accepted in large measure by the Atomic Safety and Licensing Appeal Board in its April 4, 1974 decision with respect to Indian Point 2. There the Appeal Board supported Con Edison's position regarding many of the areas of contention, including the contribution of the Hudson River striped bass to the mid-Atlantic fishery and the notion that compensation in natural populations including striped bass does occur and can offset the effect of adverse conditions on the size of fish populations. The Appeal Board further stated that "the record does not support the HRFA (Hudson River Fisherman's Association) and staff position on the percentage of striped bass eggs, larvae, and juveniles I which it is reasonable to expect will be entrained in Units Nos. 1 and 2 during the spawning season." ALAB-188, RAI-74-4, at 406. This, in effect, discarded the finding of a model developed at the then Oak Ridge National Laboratory in favor of one developed for Con Edison by Lawler, Matusky and Skelly Engineers (formerly Quirk, Lawler and Matusky Engineers).

In a hearing on the FPC-licensed Cornwall Pumped-Storage Project conducted by a subcommittee of the House Committee on Merchant Marine and Fisheries on February 19, 1974, Assistant Secretary of the Interior Nathaniel Reed endorsed Con Edison's study program, stating that "Consolidated Edison is currently funding on the lower Hudson River probably the most concentrated fishery research investigations in the world." Tr.

19. He went on to say that ". . . I felt after visiting the site last summer that the study team was honest and had been given a green light by Consolidated Edison to do, in fact, the most detailed fishery study ever completed in the country." Id. at 49.

The major objectives of the Hudson River Ecological Study were described in detail during the operating license hearing for Indian Point 2. See Testimony of Dr. James McFadden and Harry G. Woodbury, NRC Dkt. No. 50-247, Tr. at 9405. These objectives are as follows:

> (1) To determine the ecological significance of exploiting screenable fishes on the intake screens of Indian Point 1,2 and 3.
>
> (2) To determine the ecological significance of passing non-screenable organisms through the three units.
>
> (3) To determine the ecological significance of thermal and chemical effluents on aquatic biota.

Subsidiary objectives necessary in accomplishing the major study objectives include the following:

> (4) Population dynamics of key species (striped bass, white perch, Atlantic tomcod and representative benthic organisms).
>
> (5) Water quality studies and their relation to biotic distribution, behavior and abundance.
>
> (6) Relative abundance of fishes and benthos.
>
> (7) Spatial distribution of fishes and benthos.
>
> (8) Physiological/behavioral and bioassay studies of fishes and benthos.

(9) Biological characteristics investigations including age and growth, fecundity and food habits.

(10) Monitoring of fishes collected at the Indian Point Plant and relating plan operating and river conditions tc impingement.

(11) Evaluation of the effectiveness of various fish protective devices at Indian Point such as air bubblers and fish pumps.

(12) Determine abundance and temporal-spatial distribution of entrainable organisms.

(13) Determine mortality estimates based on entrainment.

(14) Evaluate effects of entrainment mortality on Hudson River populations.

(15) Develop a mathematical model to describe the distribution of striped bass in the Hudson River and the impact of power plants on striped bass populations.

The Hudson River Ecological Study objectives as outlined above have subsequently received meaningful and necessary input from other efforts deemed necessary to evaluate the impact of once-through cooling for power plants on the Hudson River. Additional programs are currently underway to:

(1) Determine the population densities, movements and distribution of ichthyoplankton by sampling longitudinally, vertically, laterally and temporally from river mile 10 to river mile 150.

(2) Determine the relative abundance and movements of late fish larvae and juveniles by shoal sampling from river mile 10 to river mile 150.

(3) Conduct mark-recapture effort along the whcle river for population dynamics of key species.

(4) Create an historical data base for analysis from present and past surveys including sport and commercial fisheries of important fishes.

(5) Determine the contribution of the Hudson River striped bass to the coastal Atlantic fishery by examining fishes caught in that fishery for innate characteristics known to be peculiar to fishes spawned in the Hudson.

Thus, in addition to the initial studies which were described in the Indian Point 2 operating license hearing and which are continuing on schedule, additional studies have been added to the program. These new investigations are primarily far-field surveys designed to determine the spatial and temporal distribution of ichthycplankton and older fish.

With respect to the special study to evaluate the contribution of Hudson River striped bass to the coastal Atlantic fishery, feasibility studies conducted in 1974 indicated that a serum protein analysis method coupled with morphometric and meristic character assessments could allow discrimination of the origin of striped bass collected in coastal waters with 80-85 percent certainty. This work is continuing in 1975 and should provide within approximately one year the most realistic estimate of the contribution of striped bass from each of the major spawning grounds to the coastal fishery that has been made to date.

As in all research programs, flexibility must be retained so that improvements in the data and its acquisition can be made during the course of a study. In the Hudson River Ecological Study changes have been made in the sampling program, the locations where samples are collected, the gear used to collect the samples, the frequency and time of day of collections, and in the number of samples collected. Details of the major changes made in the river survey work are provided in the comparisons of 1973 and 1974 research methods presented in Tables 3-2 to 3-5. These changes have resulted from the review of past procedures and are considered to have significantly improved the quality and usefulness of the data.

Significant progress has been made in elucidating information on nearly all the study objectives as outlined in the testimony of Dr. James McFadden and Mr. Harry G. Woodbury during the Indian Point 2 operating license proceedings. Upon completion of the analysis and interpretation of the data collected on the 1974 year class of striped bass (which were continued into 1975 in order to obtain estimates of over-winter survival and hence of year-class strength), it will be possible to assess the impacts on this species during the first year of power operation of Indian Point 2. The 1974 assessments will be discussed in the reports to be available in the summer of 1975.

The results of the 1975 studies are expected to be available during mid-summer 1976, following which a more considered judgment can be made on the need for closed-cycle cooling. This approach has been dictated by the necessity for analyzing data from two years of plant operations. Since the

TABLE 3-2

Comparison of 1973 and 1974 Ichthyoplankton Sampling Program

Area of Change	Sampling Season 1973	1974
Sample design	Sampling occurred every 8 km until *Morone* eggs or larvae were collected. Sampling then was concentrated in immediate area to define limits of *Morone* abundance.	Sampling occurred on a stratified random basis. Sites were selected within a region and stratum from a random number table. Numbers of samples per region and stratum were determined by relative river volume within each region and stratum.
Sampling time period	Around the clock	Each individual river survey was conducted during daylight or nighttime hours.
Sampling gear	1-m^2 epibenthic sled 1-m^2 Tucker trawl 2-m^2 Tucker trawl	1-m^2 epibenthic sled 1-m^2 Tucker trawl
Plankton nets	Each gear was equipped with three nets. Samples were collected consecutively. Mesh sizes increased throughout the sampling season from 500 through 505, 1000, 1800 and 3000 μ consecutively.	Each gear was equipped with a single 505-μ mesh net. Mesh size was not changed during the season.

Source: Texas Instruments First Annual Report for the Multiplant Impact Study of the Hudson River Estuary, 1975

TABLE 3-3

Comparison of the 1973 and 1974 Interregional Trawl Survey Sampling Programs

Area of Change	Sampling Season 1973	Sampling Season 1974
Sample design	32 stations between Tappan Zee Bridge [RM 27 (km 43)] and Newburgh-Beacon Bridge [RM 62 (km 99)]	32 stations between the Tappan Zee Bridge [RM 27 (km 43)] and Newburgh-Beacon Bridge [RM 62 (km 99)] and 7 additional stations between the George Washington Bridge [RM 12 (m 19)] and the Tappan Zee Bridge
Sampling gear	Otter-type bottom trawl constructed of knotted nylon mesh	Otter-type bottom trawl constructed of knotted nylon mesh used from April through June; knotless nylon mesh trawl used from July through December
	Cod-end cover not used	Cod-end cover used from April through December
Sampling procedure	Stern-trawl from April through December	Side-trawl from April to mid-May; stern trawl from June through December
Field and laboratory procedures	Examined striped bass and white perch for fin clips or tags	Examined striped bass, white perch and Atlantic tomcod for fin clips or tags
	Did not differentiate yearling striped bass, white perch, American shad, alewife, and blueback herring from Age II and older specimens	Differentiated yearling striped bass, white perch, American shad, alewife and blueback herring from Age II and older specimens
	Identified and counted all individuals; mean total lengths and length/frequency distributions for each species determined by randomly selecting and measuring approximately 20 individuals from within the size classes 0-100 mm, 101-150 mm, 151-250 mm and 251+ mm	Identified and counted all yearling and older individuals; identified and counted all juveniles and recorded total length measurements on up to 25 randomly-selected juveniles of each species
	Record water temperature at each sampling site	Determine oxygen, temperature, pH and conductivity in surface and bottom waters and turbidity in surface water at each sampling site

Source: Texas Instruments First Annual Report for the Multiplant Impact Study of the Hudson River Estuary, 1975

TABLE 3-4

Comparison of 1973 and 1974 Beach-Seine Survey Sampling Programs

Area of Change	Sampling Season	
	1973	1974
Night-time sampling location	George Washington Bridge [RM 12 (19 km)] to Marlboro [RM 69 (110 km)]	Indian Point region [RM 39-46 (63-75 km)] and Cornwall [RM 56-62 (90-99 km)]
Night-time sampling season	Irregular intervals, August through December	Weekly August through December
Gear	50-ft (15.2-m) beach seine 100-ft (30.5-m) beach seine	100-ft (30.5-m) beach seine
Field Procedures	Did not differentiate yearling striped bass, white perch, American shad, alewife, and blueback herring from Age II and older specimens	Differentiated yearling striped bass, white perch, American shad, alewife, and blueback herring from Age II and older specimens
	Water-quality samples collected at most but not all sample sites	Water-quality samples collected at all sample sites
	Examined striped bass and white perch for fin clips or tags	Examined striped bass, white perch, and Atlantic tomcod for fin clips or tags
Laboratory procedures	Alewife and blueback herring identified to species	Alewife and blueback herring < 30 mm in total length identified as *Alosa* sp.

Source: Texas Instruments First Annual Report for the Multiplant Impact Study of the Hudson River Estuary, 1975

TABLE 3-5

Comparison of 1973 and 1974 Standard-Station Sampling Programs

Area of Change	Sampling Season 1973	1974
Beach seines		
(1) Sample design [RM 52-60 (km 83-96)]	Six sites sampled weekly during day from mid-March to mid-December and biweekly at night in April, May, August, and October	Six sites sampled weekly during day from mid-March to late April; no night sampling
(2) Sample design [RM 39-43 (km 62-69)]	Five sites sampled weekly during day in January and from March through December and monthly over 24-hr interval from March through December	Five sites sampled weekly during day from March through December; two additional sites sampled from May through December; no samples collected over a 24-hr interval
Bottom trawls		
(1) Sample design [RM 56-57 (km 90-91)]	Five sites sampled biweekly during day from April to mid-December	Five sites sampled during mid-April
(2) Sample design [RM 39-43 (km 62-69)]	Seven sites sampled biweekly during day in January and February and April through December	Seven sites sampled biweekly during day from April through December
(3) Sampling gear	Otter-type bottom trawl constructed of knotted nylon mesh; trawl liner not used	Otter-type bottom trawl constructed of knotted nylon mesh used from April through June; knotless nylon mesh trawl used from July through December; replicate set of trawl samples taken with liner from late July through December
Surface trawls [RM 39-43 (km 62-69)]	Seven sites sampled biweekly during day in January and May through December	Seven sites sampled biweekly during day from mid-July through December
Field and laboratory procedures		
(1) Water chemistry	Water samples not always taken concurrently with trawl catches	Water samples taken concurrently with trawl catches
(2) Length categories	0-100 mm, 101-150 mm, 151-250 mm and 251+ mm from January to mid-July; 0-X mm, X-150 mm, 151-250 mm and 251 mm from mid-July through December; used primarily to separate juvenile striped bass and white perch from older individuals	0-X mm, X-150 mm, 151-250 mm, and 251+ mm from April through December where X equaled 100 mm until juveniles occurred in catches; then particular X values for each species were used as division points
(3) Length/weight measurements	Adults weighed to nearest gram; juvenile striped bass and white perch weighed to nearest 0.1 gm; juveniles of other species weighed to nearest 0.5 gm	From April through mid-July, adults weighed to nearest gram and juveniles other than striped bass and white perch weighed to nearest 0.5 gm; juvenile striped bass and white perch weighed to nearest 0.1 gm; from mid-July through December, fish ≤100 gm weighed to nearest 0.1 gm and fish > 100 gm weighed to nearest gm

Source: Texas Instruments First Annual Report for the Multiplant Impact Study of the Hudson River Estuary, 1975

plant did not operate at sufficient power levels during 1973, the two principal operational years for study are 1974 and 1975.

3.3 Striped Bass Life-Cycle Modeling

Following enactment of the National Environmental Policy Act of 1969 (NEPA), and the decision in Calvert Cliffs' Coordinating Comm. v. Atomic Energy Comm'n, 449 F.2d 1109 (DC Cir. 1971), it was determined that the AEC should review the environmental impact of all nuclear power generating stations licensed after January 1, 1970. The licensing proceedings of Indian Point 2 became one of the first such investigations.

A substantial fishery biology data base had been developed at Con Edison's expense and was available for utilization in the Indian Point proceedings. However, the data base represented conditions in the Hudson River during a period when no additional power plants were brought on line, and hence provided no basis for assessment of the incremental impact on the Hudson River of new power generation units operating with a once-through cooling system. Therefore, it became necessary to make estimates of what that impact might be. The striped bass, a species that is both recreationally important and relatively sensitive to the types of impacts most apt to result from power plant operation with a once-through cooling system, and for which a significant amount of data existed at that time, was selected to be the species by which the plant impacts would be predicted.

Predictions of impact were developed by use of mathematical models which simulated the primary physical components of the Hudson River ecosystem: the tidal flow, the freshwater flow, and the withdrawal of water for condenser cooling power plants. During the course of the Indian Point 2 licensing proceedings there was a continuous evolution of the predictive models. The purpose of the major changes which occurred was to more precisely represent: (1) the actual hydraulic conditions in the river, and (2) the actual behavior of the various life history stages of the striped bass. To date, three mathematical models have been developed for this purpose. The first of these considered the river as a completely mixed volume of water and did not account for the transport of the organisms by water movement. The predictions by this model are conservative since it forced every organism in the river to be equally subject to entrainment, whereas in reality, only a portion of those organisms in front of the plants are entrained.

The second model, in addition to mortality, incorporated a transport mechanism for consideration of freshwater inflow and associated dispersion processes in the movement of striped bass eggs and larvae. The estuary was divided into a number of longitudinal segments and the simulation moved the organisms from one segment to the next on a tidally averaged time scale basis. In this case, the portion of the striped bass population that was subject to entrainment and/or impingement was a function of plant flow, natural mortality, convection, dispersion and behavioral characteristics of the young striped bass. Results from this transport model were presented at Indian Point 2 operating license hearings on April 5, 1973 and before the Federal Power Commission in the reopened Cornwall Pumped Storage Project hearing in October 1974.

The third model, briefly described in Appendix A at page 2, combines real-time tidal flow information with a twolayered, age and time-dependent transport model to predict the impact of power plants on the Hudson River striped bass population. This model includes the simulation of inter-tidal movement of organisms between the upper and lower layers of the river (predicted on the freshwater inflow), and refinement of the biological input data to reflect both real-time behavior, and space and age distribution. In addition to generating real-time predictions of early-life stages, the present model separates the mortality rate of adult fish into several components (e.g., natural, fishing) including a non-linear fishing stress similar to that included in a recent version of the Holifield National Laboratory model. This will permit comparison of the impacts of fishing and power plant operation on the striped bass population of the Hudson River. The real-time model formulation includes continuous age-grouping from spawn through the first-year-of-life and permits the possible daily variation of parameters related to the fish life cycle such as the spawning, hatching, growth and survival rates.

The model, being a two-dimensional approach, accounts for the vertical migration patterns of the organisms and uses real-time flow information specified as a function of the longitudinal and vertical dimensions. Flow information in the vertical direction is averaged to give the flow in the upper and lower layers of the river. A dispersion term accounts for mixing above the tidal action and the mixing effects lost due to the averaging in the vertical direction. Vertical migration of larvae and longitudinal migration of juveniles are simulated by forming a migration rate as the difference between the observed field data and calculated distributions. Real-time flow information was obtained from a sinusoidal function representing flow patterns in the upper and lower layers at a given location along the longitudinal axis of the river segment.

Empirical data obtained during the ecological studies will be used as input to this model to develop single and multiple plant impact predictions on striped bass. It is anticipated at this time that data collected in 1974 and 1975 will be incorporated, and model-developed impact assessments will be available about January, 1977, in accordance with the study schedule set out in the Environmental Technical Specification Requirements. Facility Operating License No. DPR-26, App. B, Figure 4-1.

3.4 Mitigating Measures

Mitigating measures can be placed in two categories: (1) those which may be implemented on short notice and are utilized for relatively short periods of time, and (2) those which are implemented through major modifications or additions to existing structures and are utilized for either short- or long-term periods. The shutdown of a circulating water pump or the switchover to reduced flow operations are typical short-term measures which have proven to be effective in reducing impingement, without unreasonable added costs or losses of revenue. The construction of closed-cycle cooling systems, or major alternations to existing intake structures and construction and operation of fish hatcheries conversely are long-term actions which can only be attained with significant economic commitments.

3.4.1 Fish Hatchery and Stocking Program

One mitigating measure that was described in detail during the Indian Point 2 operating license hearing was the use of a hatchery rearing and stocking program to replace fish which were lost due to plant impacts, primarily entrainment. Con Edison has conducted two years of research into the feasibility of this measure relative to obtaining brood fish, spawning and hatching the eggs, rearing the fry to stockable size and assessing the survivability of the stocked fish in the Hudson River. Work is continuing in this program in two major areas: (1) determining the contribution of the stocked fish to the reproductive population in the Hudson River, and (2) determining the best methodology for large-scale rearing of striped bass.

During 1973, a total of 28,674 striped bass were stocked, and in 1974 approximately 103,000 were stocked. By the end of each of the two years, a total of 0.16 percent of the stocked fish have been recaptured. These fish were larger than their wild counterparts, generally because they had achieved a greater growth rate during their early development under the hatchery conditions.

Stocking will continue in 1975, at a rate of approximately 200,000 fish per year. Beginning in 1976 and continuing for several years thereafter it will be possible to evaluate the contribution of the stocking program to the commercial and sport fishery because the fish carry a permanent magnetized wire nose tag. More importantly, however, it will be possible to determine whether or not the hatchery fish are contributing to the spawning populations in the river.

The research into the best methodology for culturing striped bass is continuing in 1975. Intensive culture procedures were investigated in 1974 and many of the potential problems associated with this method were identified and are to be rectified during the 1975 season. In addition, a potential intensive culture hatchery has been designed and several potential sites for the facility have been investigated and reported on for Con Edison's review. UMA Engineering Pacific, Inc., Feasibility Study and Design Development, Striped Bass Fish Hatchery, Hudson River, New York (Dec. 15, 1974).

Intensive and extensive culture methods will be reviewed for their reliability and feasibility for use in a large-scale mitigation program for the Hudson River. A hatchery facility can be located at considerable distance from the Hudson River, as detailed procedures for transporting bass fingerlings have been developed.

3.4.2 Other Mitigating Measures

Con Edison has studied and found it useful to operate Indian Point 1 and 2 under reduced circulating water flow in the period when intake water temperatures are below 40°F. In addition, it has found that unusual incidents such as high impingement numbers can be controlled by shutting down circulating water pumps, provided that such shutdowns do not create a significant loss of power production.

The use of an air bubble curtain has been tested under a variety of environmental conditions, and the results of these tests have suggested that this concept is not successful on all occasions. It has been found, too, that some fish have been lost from the intake screens during the daily screen washing program. The air curtain, however, may have had significant but unquantified benefits in reducing impingement in an indirect manner. It has been found that the air curtain is quite effective in reducing debris build up and subsequent head loss across the fixed screens. With increased head loss, intake approach velocity can increase which can result in a greater rate of impingement. In addition, screens have not been damaged as freqently or needed to be washed as frequently, an operation during which fish can enter the forebays and become trapped.

Presently, tests on long-term mitigating measures are in progress. An experimental flume has been constructed for the purpose of evaluating specific fish protection systems, and to ascertain their efficiency and applicability to power plants on the Hudson River. The flume is a rectangular channel within which various fish diversion or collection systems can be placed. Water flows through these systems and fish of the species and sizes commonly collected on the intake screens are tested relative to their behavior and direction of movement when they approach the system. Specific devices being tested include: louvers which direct the fish to side-channel collecting devices; inclined planes which direct the fish to surface water or bottom water bypasses; and lift basket systems which can be used either with the bypasses for the louvers or planes or with baffle walls which create large eddies of calm water in which fish seek shelter from the water current.

The results of these tests, expected in early 1976, could lead to prototype studies at an intake at Indian Point or another power plant, and then to full scale implementation of these types of systems as a long-term impingement mitigation program. It will probably be two to three years before a prototype of these systems can be tested.

Another concept to be tested both in the flume and at Indian Point 1 is a submerged wall. The ecological studies have shown that significant numbers of organisms, fish eggs and larvae, are often concentrated near the bottom of the river. If the cooling water can be withdrawn from surface waters, then these bottom-oriented organisms may not be impinged or entrained at the rate presently being experienced.

An ideal situation exists at Unit 1 to test this mitigating measure. A wall can be fastened to the pilings on the existing wharf which extends outward over the intakes. The wall will rise from the river bottom to a depth of -6 feet mean low water. Side walls at the edge of the intakes will extend above the water line to prevent excessive lateral withdrawal of water. As Unit 1 is currently out of service and is expected to remain so for some time, the circulating water pumps can be operated in 100% testing mode, an ideal condition for impingement and entrainment monitoring. It is expected that results of this study will be available by mid-summer or fall of 1976.

4. BENEFIT-COST ANALYSIS OF THE PROPOSED ACTION

4.1 Benefits

4.1.1 Improvements in Biological Data Base for Decision-Making

The chief benefit to be derived from the proposed action is the achievement of a substantial improvement in the biological data base available to the Commission through completion of the Con Edison research program. The nature of the principal improvements to be expected in the period until January 1, 1977 is as follows:

(1) Further refinement will be made of the striped bass life-cycle models developed both by Con Edison's consultants and by the Holifield National Laboratory personnel at Oak Ridge, Tennessee for the Regulatory Staff.

(2) Empirical data from two years of operation of the plant (1974-1975) will be made possible, including effects of operation of Indian Point 3, which is scheduled to load fuel and commence testing shortly. From these data an assessment will be made of the significance of entrainment and impingement on the populations of striped bass and other important fish species.

(3) Further analysis of the movements of Hudson River striped bass, and their contribution to sports and commercial fisheries can be made.

(4) Work on the effects of entrainment and the proportion of total organisms actually entrained will continue, leading to a better appreciation of the impact of the

plant on entrained organisms and on river populations generally.

(5) Research and experiments in the area of stocking of hatchery-reared fish in the Hudson River will be able to continue and to be meaningfully evaluated. Other possible mitigating measures can also receive further attention as merited.

(6) The critical concept of compensation in the striped bass and other fish populations of the Hudson River ecosystem can be further explored. At present, both Con Edison and the Staff agree that the phenomenon occurs, but the extent of compensation remains controversial.

In all of these areas, substantial progress has already been made. See generally § 2 above. The Appeal Board itself has formally rejected a contention that the Con Edison research program "would not produce useful base data on the entrainment and impingement impacts of Indian Point Units Nos. 1 and 2 on the Hudson River fishery." ALAB-188, RAI-74-4, at 406, Para. IV.2.a(4). The Staff has acknowledged the value of the research program by incorporating it in the Environmental Technical Specification Requirements for Indian Point 2, See also Indian Point 3 FES at XI-112, and has given indication that it views our contribution study affirmatively. Id. at V-177. Hence, Con Edison is not asking the Commission to adopt uncritically its request for an extension based on puffed-up claims for an untested and unknown program. The Commission is familiar with the scope and rigor of the work already undertaken, and it should be apparent that the program is capable of generating data of crucial importance to a decision on the ultimate question of cooling systems for Indian Point 2.

It has been said with justification that the National Environmental Policy Act of 1969 is, at the very least, an environmental "full disclosure" law. See, e.g., Environmental Defense Fund v. Corps of Engineers, 325 F. Supp. 749, 759 (E.D. Ark. 1971). This request will serve that purpose by providing the Commission with substantial empirical and analytical data concerning the environmental consequences of utilizing a once-through cooling system. Where, as here, the costs associated with the present terms of the license condition --economically, aesthetically, and otherwise--are so severe, it is appropriate that the Commission take reasonable, available measures to ensure that the quality of the data on which it bases its judgment is in every sense commensurate with the irretrievable investment and other costs of the condition. In this section of the Report, we will describe the various benefits to be achieved during and as a result of the period of extended interim operation. In addition, § 4.1.4 provides a discussion of the benefit that is achieved simply by preserving the possibility of an ultimate finding that closed-cycle cooling is not warranted.

During the Indian Point 2 operating license hearings, Con Edison described its ecological study program as one designed to provide both pre-operational and operational data with which to assess the impact of Indian Point 2 operating with a once-through cooling system. The Atomic Safety and Licensing Appeal Board, in recognition of the significance of the operational studies, made provision for Con Edison to seek an amendment to the operating license, in order to extend the date for cessation of operation with the once-through cooling system. The basis for the application was to be new data relevant to the impact assessment.

The Appeal Board extended the interim period during which the plant could operate with the once-through cooling system from May 1, 1978 to May 1, 1979. This deadline, reviewed in light of the most realistic construction schedule for a closed-cycle cooling system and the necessity for administrative reviews of any request for an extension of the interim operation period, allowed at best only one year of operational data to be gathered with which to assess the plant impact on Hudson River aquatic life. This period was and is insufficient. During the licensing hearings, Con Edison maintained that a minimum of two years of operational data for Indian Point 2 (i.e., 1974 and 1975) were necessary to most realistically assess its impact. The chief basis for the two years of operational data was that it provided for the measurement of year-to-year variability in actual plant impacts, and an assessment of the significance of those impacts on the populations of organisms, primarily striped bass, found in the Hudson River.

The present Report will provide preliminary operational evidence that Indian Pcint 2 will not have an irreversible impact on the aquatic biota in the River if once-through cooling continues until May 1, 1981. Additional evidence in support of this conclusion will be presented in the summer of 1975 by a Supplement to this Report. This section of the Report describes how improvements in the biological data base will result from the completion of the proposed two years of operational data collection.

4.1.1.1 Assessment of Operational Data Variability

The development of an adequate pre-operational data base with which to assess an impact on a population of organisms is dependent on the acquisition of sufficient data with which to estimate natural variations through time. Often two or more years of data are strongly recommended, and it is clear that one year of pre-operational data would not be adequate as the base line data for the Indian Point 2 impact assessment. The same holds true for the actual measurement period. It is necessary to obtain an estimate of the variability from year-to-year of the impact in order to evaluate its significance in terms of the homeostasis of the population of organisms.

The data collected in 1974 represent an "instant in time" relative to the impact of Indian Point 2, and provide some indication of the dynamics of the populations of fish and invertebrates relative to the effects of the plant operation. The current studies, however, are acquiring the necessary additional information to allow an empirical evaluation of the population changes and the significance of those changes. The information on entrainment and impingement being collected in 1975 will, together with the 1974 data, provide the necessary operational information for comparison with pre-operational data, and from which an informed, responsible decision on the real need for a closed-cycle cooling system at Indian Point 2 can be made.

4.1.1.2 The Multiplant Impact Assessment

The most appropriate approach to the management of the Hudson River and its aquatic life is one accomplished through analysis of impacts on the system as a whole. Important advances have been made in assessing the significance of one form of impact, that of power plants. Recent information has been analyzed to determine the impact of added generating units on the Hudson. At present, the results are not conclusive, basically because there is no estimate of the year-to-year impact variability. Current studies will provide that information shortly.

Until that information is obtained, a reasoned decision on the significance of the actual multiplant impacts cannot be made. In addition the impacts of other encroachments, such as sewage disposal and water diversion, have not been evaluated sufficiently by the governing agencies to provide for responsible system-wide decisions on the total resource management.

4.1.1.3 Measurement of Compensatory Response in Striped Bass Populations

Compensation, as has been discussed in § 2.1.3.1.3 above and in earlier Indian Point 2 licensing proceedings, is a mechanism by which a population of organisms responds to changes in its environment. The compensatory response of a population can be assessed in part, prior to an environmental perturbation, by a study of the life history of a species in its specific habitat. However, the proper way to assess accurately the capacity of a population to respond to an environmental change, is to implement the change under controllable conditions and then measure the response. This is the method by which the compensatory reserve of striped bass can be measured relative to the power plant impacts on this species. This methodology is a well known procedure utilized in the management of many high intensity commercial fisheries. Field investigations of this compensatory process are in progress and only through additional time can this valuable information be factored into the decision on the need for a closed-cycle cooling system at Indian Point 2.

4.1.1.4 Contribution of Hudson River Striped Bass to the Mid-Atlantic Fishery

Research efforts into the feasibility of two methods for assessing the contribution of the Hudson River striped bass to the mid-Atlantic fishery were completed in 1974. <u>See</u> §§ 2.1.3.1.6, 3.3. Preliminary conclusions drawn from these efforts are that through a combined assessment of biochemical characteristics, and differences in scale morphology, it will be possible to determine with significant reliability and confidence the origin of striped bass taken in the mid-Atlantic fishery. During 1975 the Mid-Atlantic striped bass fishery will be sampled for Con Edison and the origins of these fish will be determined. It is firmly believed that through this research effort a definitive assessment of the contribution of the Hudson River to the inner zone and to the outer zone as defined by the Regulatory Staff in its Final Environmental Statement for Indian Point Unit 3 will be possible. See Indian Point 3 FES at V-166 to -178. This knowledge, when combined with appropriate economic assessments of the value of the sport and commercial fisheries for striped bass, will provide significant inputs for the benefit-cost assessment of a closed-cycle cooling system at Indian Point 2.

4.1.1.5 Real-Time Striped Bass Life-Cycle Model

The striped bass life-cycle model which was presented during the Indian Point 2 operating license hearings has been revised to more realistically treat the hydrodynamic aspects of the Hudson River. Previously, the transport of eggs and larvae was approximated by tidal-averaged hydrodynamics. Whereas this model was recognized by the Appeal Board to approximate more realistically Hudson River conditions and the susceptibility of striped bass to power plant impacts than was the Staff's model, it was recognized that the model could be further improved.

The model as it exists now uses hydrodynamic information at two-hour intervals to provide an improved estimate of the tidal action in the river. This has resulted in more realistic appraisals both of the distribution of early life stages of striped bass and of power plant impacts on the species. See generally § 3.3.

4.1.1.6 Further Analysis of Feasibility of Various Mitigating Measures

Presently continuing efforts of mitigation measures include, among others, studies on the effects of louver systems for guiding fish away from intake structures. <u>See</u> § 3.4.2. This work is scheduled for completion in late 1975, and it can be factored into impact mitigation alternatives prior to a final determination on the need for a closed-cycle cooling system as provided for by the April 4, 1974 Appeal Board decision. An extension of time from the May 1, 1979 date will permit consideration to be given to this significant work.

The initial results of the long-term survival assessment of hatchery-reared and stocked fish will be forthcoming in 1975 and early 1976. <u>See</u> § 3.4.1. Hatchery fish were tagged with magnetized wire nose tags and then released with the intention that the commercial fishery catches of striped bass three years later would be sampled to locate these fish. This effort cannot be completed ealrier as the fish will not enter the fishery until their third year of life. Since the tagging program was initiated in 1973, it is necessary to conduct the recapture program in 1976. A complete assessment of the feasibility of the stocking program would be available in preliminary form with a granting cf the requested extension.

4.1.2 Savings if Wet Natural Draft Cooling Tower Installation is Delayed Two Years

4.1.2.1 Incremental Generating Cost Analysis

The current license for Indian Point 2 sets a tentative date of May 1, 1979 for termination of operation with the installed once-through cooling system. The Application for Amendment requests that the date be delayed by two years to May 1, 1981. Under the schedule dictated by the present license condition (Case I), the Unit would be shut down for cut-in of the closed-cycle cooling system between May 1, 1979 and December 1, 1979. For the purpose of this analysis, it has been assumed that with the requested delay (Case II), the Unit would be shut down October 1, 1980 and would resume operation on May 1, 1981 in the closed-cycle cooling mode. While operation in the once-through cooling mode would be permissible until May 1, 1981 under the amended schedule, it has been assumed that cut-in activity would be planned to occur in the interval prior to May 1, so as to avoid a summer outage of the Unit with its related impact on system reliability. A similar advancement to a winter outage cannot be accomplished for Case I, the present license schedule, since sufficient time is not available under that schedule.

4.1.2.1.1 Refueling Schedules

Table 4-1 shows the refueling schedules which would govern the Unit's operation under either schedule. These refueling outages are keyed to avoiding summer outages. In both cases, this results in one short cycle (January 1, 1979 to May 1, 1979 in Case I, and April 1, 1980 to October 1, 1980 in Case II)

TABLE 4-1

INDIAN POINT NO. 2 REFUELING SCHEDULE

YEAR	CASE I		CASE II	
	STARTING DATE	OUTAGE PERIOD	STARTING DATE	OUTAGE PERIOD
1977	Oct. 1	7 Weeks	Oct. 1	7 Weeks
1978				
1979	Jan. 1	3 Weeks		
	May. 1	7 Months	Jan. 1	7 Weeks
1980			Apr. 1	3 Weeks
			Oct. 1	7 Months
1981	Apr. 1	7 Weeks		
1982	Oct. 1	7 Weeks	Oct. 1	7 Weeks
1983				
1984	Jan. 1	7 Weeks	Jan. 1	7 Weeks

after a partial refueling which will be accomplished during a three week outage. All other outages are assumed to last seven weeks. The cycle duraticns are respectively, fifteen months, fifteen months and eighteen months between shutdowns in a repeating pattern.

4.1.2.1.2 Uprating

Indian Point 2 is presently licensed to operate at 2758 MW (thermal). It is expected that the license will be amended to allow operation at the design level of 3216 MW (thermal). For purposes of this Report, Con Edison has assumed that this uprating would not take place prior to the transition to the closed-cycle cooling mode of operation, as this requires separate licensing action and sufficient lead time must be allocated to account for possible delays.

4.1.2.1.3 Cost Data for the Cooling Tower

Tables 4-2 and 4-3 indicate a capital cost for the cooling tower of $91,000,000 and $100,000,000, respectively, for Case I (May 1979 outage) and Case II (October 1980 outage). The increase in cost corresponds primarily to the escalation which is expected to occur during the interval of the requested delay.

4.1.2.1.4 Methodology of Incremental Generating Cost Calculation

TABLE 4.2
CAPITAL COST ESTIMATE SUMMARY OF CLOSED CYCLE NATURAL
DRAFT WET COOLING TOWER FOR CASE I SCHEDULE

DESCRIPTION	INSTALLATION		MATERIAL	TOTAL
	COMPANY	CONTRACTOR		
Install cooling tower		10,372,000		$10,372,000
Amertap clean system		3,112,000		3,112,000
Furn. install piping (mech sys)	$17,600	2,652,400	4,973,400	7,643,400
Struct., excavation, tunnels, tower, etc.	20,700	13,778,500		13,799,200
Struct., excav., roads, sump pits, etc.		1,020,000		1,020,000
Struct., excav., for elect work & assoc.		86,100		86,100
Elect. work assoc. w/tower		620,500	370,300	990,800
Elec. work assoc. w/substa.		362,200	815,900	1,178,100
Elec. work lighting power		23,600	140,000	163,600
Real estate tax during constr.			3,382,300	3,382,300
PROJECT MANAGEMENT & INSPECTION	1,136,800			1,136,800
OTHER DIRECT COST	82,100		110,100	192,200
TOTAL DIRECT COST	$1,257,200	$32,027,300	$9,792,000	$43,076,500
ENGINEERING & SUPERVISION				5,160,300
ADMINISTRATION & SUPERVISION				1,345,600
PAYROLL TAXES & PENSIONS				1,861,100
INTEREST DURING CONSTRUCTION				8,760,800
TOTAL PROJECT COST				$60,204,300
ESCALATION				16,182,500
CONTINGENCY				14,613,200
TOTAL ESTIMATED COST				$91,000,000

Based on Construction Period 6/1/76 to 12/1/79

TABLE 4.3

CAPITAL COST ESTIMATE SUMMARY OF CLOSED CYCLE NATURAL DRAFT WET COOLING TOWER FOR CASE II SCHEDULE

DESCRIPTION	INSTALLATION		MATERIAL	TOTAL
	COMPANY	CONTRACTOR		
Install cooling tower		10,372,000		$10,372,000
Amert ap clean system		3,112,000		3,112,000
Furmish install piping (mech) systems)	$ 17,600	2,652,400	$4,973,400	7,643,400
Struct,, excavation, tunnels, tower, etc.	20,700	13,778,500		13,799,200
Struct., excav., roads, sump pits, etc.		1,020,000		1,020,000
Struct ., excav., for elect. work & assoc.		86,100		86,000
Elec. work assoc. w/tower		620,500	370,300	990,800
Elec. work assoc. w/substa.		362,200	815,900	1,178,000
Elec. work lighting power		23,600	140,000	163,600
Real estate taxes during constr.			4,148,500	4,148,500
PROJECT MANAGEMENT & INSPECTION	1,136,800			1,136,800
OTHER DIRECT COST	82,100		110,100	192,200
TOTAL DIRECT COST	$1,257,200	32,027,300	10,558,200	43,842,700
ENGINEERING & SUPERVISION				5,160,300
ADMINISTRATION & SUPERVISION				1,345,600
PAYROLL TAXES & PENSIONS				1,861,100
INTEREST DURING CONSTRUCTION				9,376,900
TOTAL PROJECT COST				$61,586,600
ESCALATION				22,142,400
CONTINGENCY				$16,271,000
TOTAL ESTIMATED COST				$100,000,000

Based on Construction Period 9/1/77 to 5/1 81

In order to determine the economic impact of either schedule, the over-all revenue requirements over the lifetime of a cooling tower have been evaluated for Case I and Case II according to the methodology described in this section. To allow comparison between Case I and II, the revenue requirements have been present-worthed to a common date (January 1, 1975). Furthermore, in order to allow comparison of these results with the economic impact on society of the consequences to the Hudson River fisheries of the proposed change in cooling tower cut-in schedule as calculated in $ 4.2, the revenue requirements have been present-worthed using a discount factor of 6.5% per year. The selection of this value for the "private discount factor" is discussed in greater detail in Appendix B to this Report. The economic life of the cooling tower utilized herein is measured from the time it becomes operational to the end of the total economic serivce life of the plant, a period taken to be thirty years. Hence, although Indian Point 2 went into service in 1973, the incremental generating costs are considered to run from the beginning of the economic impact of the cooling tower in 1979 to the end of 2003.

The estimated incremental generating costs for the natural draft wet cooling tower systems are presented in Tables 4-4 and 4-5, respectively, in the following two modes:

(1) The present worth in 1975 of the total revenue requirements (column 1).

(2) The corresponding annual levelized revenue requirements from 1979 to 2003 (column 2).

TABLE 4-4

INCREMENTAL GENERATING COSTS FOR A NATURAL DRAFT WET COOLING TOWER ON INDIAN POINT NO. 2 CUT-IN BETWEEN MAY 1, 1979 AND DECEMBER 1, 1979

(CASE I)

DESCRIPTION OF EXPENSES	PRESENT WORTH REVENUE REQUIREMENTS 1979-2003*	ANNUAL LEVELIZED REVENUE REQUIREMENTS 1979-2003
A) Maintenance and Other Operating Expenses	2,854,000	301,000
B) Carrying Cost of Capital for Cooling Tower	168,859,000	17,809,000
C) Cost of Replacing Deficient Energy (Average Derating)	66,789,000	7,044,000
D) Carrying Cost of Capital for Replacement Capacity	35,499,000	3,744,000
E) Incremental Electric System** Production Cost	45,285,000	4,776,000
F) Sub-Total	319,286,000	33,674,000
G) Carrying Cost of Capital for Replacement Capacity for Plant Downtime to Cut-in Cooling Tower	248,581,000	26,217,000
H) Total	567,867,000	59,891,000

*Base Year 1975
**For 1979-1984 Period (See Text)

TABLE 4-5

INCREMENTAL GENERATING COSTS FOR A NATURAL DRAFT WET COOLING TOWER ON INDIAN POINT NO. 2 CUT-IN BETWEEN OCTOBER 1, 1980 AND MAY 1, 1981

(CASE II)

DESCRIPTION OF EXPENSES		PRESENT WORTH REVENUE REQUIREMENTS 1979-2003*	ANNUAL LEVELIZED REVENUE REQUIREMENTS 1979-2003
A)	Maintenance and Other Operating Expenses	2,731,000	288,000
B)	Carrying Cost of Capital for Cooling Tower	172,406,000	18,183,000
C)	Cost of Replacing Deficient Energy (Average Derating)	63,717,000	6,720,000
D)	Carrying Cost of Capital for Replacement Capacity	32,266,000	3,403,000
E)	Incremental Electric System** Production Costs	50,604,000	5,337,000
F)	Sub-Total	321,724,000	33,931,000
G)	Carrying Cost of Capital for Replacement Capacity for Plant Downtime to Cut-in Cooling Tower		
H)	Total	321,724,000	33,931,000

*Base Year 1975
**For 1979-1984 Period (See Text)

The present worth of the "Revenue Requirements" (column 1) is the sum of the annual additional costs due to the cooling tower "present-worthed" to January 1, 1975. The present worth of a revenue requirement in any given year is the amount of money which, if invested at the specified rate of return in 1975, would meet this revenue requirement in the later year. The "Annual Levelized Revenue Requirements" (column 2) is a constant annual revenue requirement, from 1979 through 2003, which is equivalent to the actual stream of revenue requirements such that the sum of the present worth of these equivalent annual revenue requirements equals the sum of the present worth of the actual annual revenues required from 1979 through 2003. The present worth and the annual levelized revenue requirements are computed using the private discount factor, as per Appendix B. Table 4-6 illustrates the difference between the incremental generating costs of Case I and Case II.

These costs reflect the actual increments which, if incurred, would show in Con Edison's customers bills. If the Gross Revenue Tax, Federal Income Tax and local Property Tax were to be deducted as transfer payments, as suggested by the Indian Point 2 Atomic Safety and Licensing Board, LBP-73-33, RAI-73-9, 751, 775 (Sept. 25, 1973), aff'd as to this point, ALAB-188, RAI-74-4, 323, 403 (Apr. 4, 1974), the sub-total annual levelized revenue requirements (line F in either Table 4-4 or 4-5) would be reduced by $7,241,000 and $7, 247,000 in Case I and Case II, respectively. The total annual levelized revenue requirements (line H in Tables 4-4 and 4-5) would be reduced by $15,197,000 and $7,247,000 in Case I and Case II, respectively.

TABLE 4-6

DIFFERENTIAL INCREMENTAL GENERATING COSTS FOR A NATURAL DRAFT WET COOLING TOWER ON INDIAN POINT NO. 2 CUT-IN BETWEEN CASE I AND CASE II

(CASE I - CASE II)

DESCRIPTION OF EXPENSES		PRESENT WORTH REVENUE REQUIREMENTS 1979-2003*	ANNUAL LEVELIZED REVENUE REQUIREMENTS 1979-2003
A)	Maintenance and Other Operating Expenses	123,000	13,000
B)	Carrying Cost of Capital for Cooling Tower	-3,547,000	-374,000
C)	Cost of Replacing Deficient Energy (Average Derating)	3,072,000	324,000
D)	Carrying Cost of Capital for Replacement Capacity	3,233,000	341,000
E)	Incremental Electric System** Production Costs	-5,319,000	-561,000
F)	Sub-Total	-2,438,000	-257,000
G)	Carrying Cost of Capacity for Replacement Capacity for Plant Downtime to Cut-in Cooling Tower	248,581,000	26,217,000
H)	Total	246,143,000	25,960,000

*Base Year 1975
**For 1979-1984 Period (See Text)

Line H on Tables 4-4 and 4-5 shows the increase in revenue requirements that Con Edison customers will pay based on the assumption that gas turbines would be installed in order to maintain system reliability during the cut-in outage. An economic credit is given when the gas turbines are required at a later date in the electric system expansion. A more economical means of obtaining the needed capacity would be to seek a purchase that would enable the Company to meet the customers' needs throughout the summer. Con Edison has negotiated and will continue to negotiate purchases which can supply needed power at the least cost, however, there is no certainty that such a purchase would be available. For the license schedule (Case I), total annual levelized revenue requirements would be reduced by $21,896,000 to $37,995,000/year (equivalent to $360,256,000 sum present worth in 1975), under the most optimistic assumptions that it would both (1) prove possible to purchase the capacity required to replace the unit during the cut-in period and (2) the purchase would be from efficient oil-fired generating units. If a purchase were made from gas turbines, the total annual levelized revenue requirements would exceed $37,995,000 per year.

4.1.2.1.5 Maintenance and Other Operating Expenses

Cooling tower operating and maintenance costs are estimated based on industry experience. The estimates are escalated by 5% per year compounded to reflect anticipated increases in the cost of labor and materials.

4.1.2.1.6 Carrying Charges on Additional Capital for the Cooling Tower Systems

An annual carrying charge is computed as the sum of the following factors: depreciation, return on invested capital, Federal Income Tax, allowance for replacements, insurance, property taxes and gross revenue tax. See Tables 4-7 and 4-8.

The total capital costs of the cooling tower system are depreciated using the straight line depreciation method over the appropriate life, which results in a depreciation for evaluating book value. An annual rate of return is computed based on Con Edison's capital structure which consists of approximately 53% debt, 13% preferred stock and 34% common stock. The 15-3/8% cost of capital, reflecting the Company's current incremental cost of capital, see Table 4-9, yields the levelized rates of return over the recovery period for the cooling tower or for gas turbines shown in the Tables.

In calculating revenue requirements, it is necessary to include a component for Federal Income Tax in the determination of a carrying charge rate. This calculation also takes into consideration the fact that interest on debt is deductible for Federal Income Tax purposes while earnings earmarked for preferred and common stock are not. For Federal Income Tax purposes, equipment is depreciated using the sum of years digits technique. A job-development credit tax write-off, equivalent to 4% of book cost of the installed equipment, is also taken into account.

TABLE 4-7

ANNUAL LEVELIZED CARRYING CHARGES
OF A COOLING TOWER AND GAS TURBINES AT INDIAN POINT
(AS A PERCENT OF CAPITAL COST)

CASE I (5/1/79 - 12/1/79)

	COOLING TOWER (1)	GAS TURBINE (2)
Return	9.861	9.921
Depreciation	4.167	4.000
Federal Income Tax	2.884	2.855
Allowance for Replacements	0.500	0.500
Insurance	0.300	0.100
Property Taxes	2.200	2.200
Sub-Total	19.912	19.576
Gross Revenue Taxes	1.294	1.272
Total Fixed Charges	21.206	20.848
Total Fixed Charges Rounded	21.21	20.85

NOTES:

(1) 24 Year Recovery Period to allow recovery coincident with 30 Year Economic Service Life of Indian Point No. 2

(2) 25 Year Recovery Period to allow recovery coincident with 30 Year Economic Service Life of Indian Point No. 2.

TABLE 4-8

ANNUAL LEVELIZED CARRYING CHARGES
OF A COOLING TOWER AND GAS TURBINES AT INDIAN POINT
(AS A PERCENT OF CAPITAL COST)

CASE II (10/1/80 - 5/1/81)

	COOLING TOWER (1)	GAS TURBINE (1)
Return	9.803	9.803
Depreciation	4.348	4.348
Federal Income Tax	2.917	2.917
Allowance for Replacements	0.500	0.500
Insurance	0.300	0.100
Property Taxes	2.200	2.200
Sub-total	20.068	19.868
Gross Revenue Taxes	1.304	1.291
Total Fixed Charges	21.372	21.159
Total Fixed Charges Rounded	21.37	21.16

NOTES:

(1) 23 Year Recovery Period to allow recovery coincident with 30 Year Economic Service Life of Indian Point No. 2.

TABLE 4-9

CONSOLIDATED EDISON COMPANY OF NEW YORK
ESTIMATED COST OF CAPITAL
AS OF APRIL 1, 1975

	CAPITALIZATION RATIO %	NOMINAL COST %	EFFECTIVE COST %
Debt	53	14.0	7.42
Preferred Stock	13	14.0	1.82
Common Stock	34	18.0	6.12
TOTAL	100		15.36
Rounded Off To			15 3/8

Allowance for replacement is an annual average figure, not included in the annual depreciation rate, to cover periodic replacement of components to maintain an asset in good working condition. Experience indicates that an allowance of 0.50% of capital costs per year would be a reasonable figure for this item.

Provision must be made for the increased premium for property insurance which will be paid on the increased value represented by the equipment. This has been estimated by dividing the total present insurance charged by the present book cost of the plant. Nuclear property insurance rates are 0.30%, which can be applied to the cooling tower, while the conventional property insurance rate of 0.10% is applied to the gas turbines.

The carrying charges should also include a factor for property taxes allocable to this addition. This has been computed on the basis of the annualized rate of property taxes Con Edison has paid for Indian Point 1 to the Town of Cortlandt and the Village of Buchanan, divided by the average book cost of the plant. This results in a factor of 2.20% for facilities located at Indian Point.

The Gross Revenue Tax is a 6.1% tax on the revenues received by Con Edison. It is composed of state and local gross receipts taxes and a state public utility excise tax. Since the tax is levied on all revenues received by Con Edison, an allocation for the tax is included in all components of the revenue requirement necessitated by installation of a closed-cycle cooling system.

4.1.2.1.7 Cost of Replacing Deficient Energy

The computation of incremental annual charges includes the cost of additional energy required because of the derating imposed upon Indian Point 2 by the cooling tower. Two types of derating are involved.

One type of derating is an average annual energy derating as a consequence of (1) additional energy required to operate circulating pumps and other auxiliary equipment, and (2) high turbine backpressures associated with heat transfer characteristics of the cooling tower as compared to once-through cooling.

The cost of the derating is the cost of obtaining electric energy to compensate for the derating. In this analysis, the alternative source of energy is assumed to be from within the Con Edison system, at incremental system cost. This cost estimate is based upon the cost of fuel for the energy necessary to replace the energy that was anticipated from Indian Point 2. This energy is supplied through additional operation of a combination of oil-fired steam generators and gas turbines within the Con Edison system, resulting in an incremental operating cost of approximately 29 mills per kilowatt hour for fuel in 1979.

4.1.2.1.8 Cost of Replacement Capacity

A second type of derating is the loss of peak generating capacity which otherwise would have been available to meet Con Edison's peak loads. Peak system demands and the maximum loss of generating capacity due to the cooling tower normally occur during the summer's hottest, most humid weather making it necessary to install new capacity to cover this derating in order to maintain system reliability. The cheapest source for this replacement generating capacity, from the point of view of overall system cost, would be the installation of gas turbines at a capital cost of approximately $285 per Kw, if installed in 1979, or $300 per MW, if installed in 1980.

The cost of this replacement capacity is the carrying charge on the capital cost of the gas turbines. The carrying charge for the gas turbines is 20.86% if the gas turbines are installed in 1979, _see_ Table 4-7 or 21.17% if the gas turbines are installed in 1980, _see_ Table 4-8. The cost of any operation of the gas turbines is not included under this item because the cost of energy to offset the derating of Indian Point 2 is included under Cost of Replacing Deficient Energy, § 4.1.2.1.7 above, and is to be supplied from within the Con Edison system by a combination of base load oil-fired generation and gas turbines.

4.1.2.1.9 Replacing Energy for Plant Downtime

Indian Point 2 would not operate during the seven-month period required for the cut-in of the closed-cycle cooling system. As illustrated in Table 4-1, a change in the cooling tower cut-in scheulde will affect the refueling schedule for the Unit in later years which will induce a change in the maintenance schedules for the other units on the Con Edison system. To account for this, an analysis of system operation for the six year period from 1979 to 1984, inclusive, was performed to estimate the total cost of operating the electric system in both Case I and Case II. The analysis assumed that the energy not generated by Indian Point 2 and other units on the system, because of the cut-in and its after-effects would be replaced by additional operation of other plants on the Con Edison system together with some increase in the dispatch of capacity already under firm purchase contract from other utilities. The decrease in fuel expenditures resulting at Indian Point 2 during this period was also taken into account. After 1984, the residual impact on the operation of the system is insignificant.

4.1.2.1.10 Summary of Incremental Generating Costs

The granting of the requested amendment will defer the start of cooling tower cut-in from May 1979 to approximately October 1980. The annual levelized revenue requirement savings over the 25-year period from 1979 to 2003, as summarized in Table 4-6, will be $25,960,000. These savings, which are equivalent to

$246,143,000 expressed as a sum present worth in 1975, will be passed directly through to Con Edison's electric customers.

The $246,143,000 saving is derived from tables 4-4 and 4-5. In Table 4-4 for the present license-imposed construction schedule, the total of the revenue requirements, "present worthed" to 1975, including the reliability impact, would be $567,867,000, which also includes the $248,581,000 carrying cost for gas turbines to meet system requirements during the outage. See § 4.1.2.2.2.

A less costly potential alternative source for the necessary replacement capacity would be a firm purchase of power. Con Edison is constantly seeking purchases that could be used to reduce overall costs, but there is not way to determine with certainty whether a firm pruchases could be arranged. Under the optimistic assumption that a frim purchase from an efficient oil-fired base-load generating unit could be arranged, the total revenue requirements to replace the capacity would be $40,970,000 for the license-imposed construction schedule. See § 4.1.2.2.3. The total of the revenue requirements (sum present worth in 1975) would thus be reduced from the $567,867,000 mentioned above to $360,256,000 if firm purchases from base-load units can be effected.

Table 4-5 shows the same information for the construction schedule that would obtain under the requested extension, with the result that revenue requirements of $321,724,000 (sum present worth in 1975) will exist. The principal savings over the present license schedule stem from the avoidance of the additional capacity required for the summer outage. The net result of delaying the cooling tower installation from May 1, 1979 to May 1, 1981, then, is a savings of $246,143,000 if gas turbines must be resorted to (see Table 4-6), or $38,532,000 if firm purchases from base-load generating units can be negotiated.

4.1.2.2. Reliability Impact

The Con Edison request for a two year delay of operation with an alternate cooling system would allow additional flexibility in scheduling the actual construction of such a system. The licensing schedule (Case I) has a summer reliability impact and the amended schedule (Case II) can avoid that impact. For purposes of this analysis, it has been assumed that the outage for Indian Point 2 can be advanced to the period October 1980 to April 1981, in order tc avoid impacts on system reliability in the summer of 1981.

4.1.2.2.1 Reliability Impact of Indian Point 2 Outage in the Summer of 1979

For the summer of 1979 Con Edison plans to have an installed reserve of 2836 MW or 29.2% of the estimated peak load. This will be provided by 12,536 MW of capacity resources, including firm purchases and Indian Point 2 to meet an estimated peak load of 9700 MW. This load reflects the impacts of energy conservation as a result of the present energy crisis.

Without Indian Point 2, Con Edison's summer 1979 installed reserve would drop to 1963 MW or 20.2% of the estimated peak load. This reserve is essentially the same as the megawatt reserve planned for the summer of 1975 and reflects the recent delay of firm commercial service for Indian Point 3 to the winter of 1975-1976, the long-term outage of Indian Point 1 until the summer of 1978, and approximately 500 MW of firm purchase. The reserve in the summer of 1975 does not meet the Con Edison planning criterion, which is an expectation of one day per summer inability to meet load with Con Edison's own capacity plus firm purchases. The summer 1979 reserve, without Indian Point 2, is significantly below the planned reserve for each of the intervening years, 1976, 1977 and 1978. When expressed as a percentage of peak load, the summer 1979 reserve, without Indian Point 2, is approximately 2.5% below the reserve for the summer of 1975.

While a reserve of 20% has generally been regarded as adequate for individual utility systems and regions, such a reserve level is less than the desired objective for the Con Edison system. For the summer of 1974, for example, the average "unscheduled unavailable capacity" on the Con Edison system as reported in weekly reports of capacity and load at peak hour submitted to the New York Public Service Commission was approximately 2,050 MW or 20.7% of total installed capacity. The maximum and minimum unscheduled unavailable capacity were 2,889 MW (28.6%) and 1,299 MW (13.1%), respectively, and prudence requires that similar performance be provided for in future years. Unscheduled unavailable capacity is the total of forced outages and miscellaneous unavailable capacity, short-term deratings primarily due to equipment and auxiliary outages, and long-term deratings due to causes such as equipment deterioration. Unscheduled unavailable capacity does not include deratings to supply the steam system, planned outages, or maintenance outages. Planned outages frequently intrude into the summer due to inability to complete the October-to-May overhaul program on schedule.

For the summer of 1981, Con Edison plans to have an installed reserve of 2448 MW or 23.4% of the estimated peak load. This will be provided by 12898 MW of capacity resources including firm purchases and Indian Point 2, to meet an estimated peak load of 10450 MW.

In analyzing the summer 1981 reserve, it has been assumed that the outage of Indian Point 2 has been advanced to the previous winter (October 1, 1980 to May 1, 1981). As a result, the outage would have no significant impact on reliability in that summer. There is only a small reduction in the reserve capacity due to the cooling tower derating (from 2448 MW to 2385 MW), and this has been included in the incremental generating cost analysis. See § 4.1.2.1.

4.1.2.2.2. Cost of Providing Capacity to Offset Reliability Impact

The time span to the summer of 1979 and even 1981 is too short to provide new base load capacity, fossil or nuclear, to offset the reliability deficiencies caused by the outage of

Indian Point 2. A discussion of reliability alternatives to the summer outage is included in § 4.1.2.2.3. The only certain way to compensate for the reserve deficiencies is to install gas turbines. The least expensive available type of gas turbine is the simple cycle turbine.

In the summer of 1979, without Indian Point 2, the negative reserve expectation is 2.7 days per summer. The negative reserve expectation cculd be restored to the same level that would apply if the Unit were in service by the installation of approximatley 845 MW of simple cycle gas turbines. The revenue requirements of the capital expenditures (levelized from 1979 to the end of the remaining economic life of Indian Point 2) would be approximately $26,438,000 per year based on Con Edison's incremental costs of capital. There would be no requirement for replacement capacity in 1981 due to the assumed advancement of the Indian Point 2 outage to the winter of 1980-1981.

Thus, from a reliability viewpoint the 1979 outage has a significantly larger impact on the adequacy of customer service as a result of the inability to advance the 1979 outage to the previous winter period and the assumption that such an advancement will be possible for the 1981 outage.

4.1.2.2.3. Alternatives to Summer Outage of Indian Point 2

Since no planned additional base load capacity can be advanced to the 1979-1981 period and no new unit can be scheduled now for operation by that time, the only capacity that can be installed as a replacement for Indian Point 2 during the seven-month outage of the Unit necessary to connect the closed-cycle cooling system would be gas turbines, either simple cycle or combined cycle. While these gas turbines would be the only certain way to provide such capacity, the installation of new capacity for a single, relatively brief capacity period is certainly a very expensive solution.

Firm purchase capacity ranging from 800 MW up to 900 MW cannot be relied upon as being available so far in advance. Even if several other utilities were willing to consider a long-range firm sale to Con Edison for a single capacity period, a slippage in the schedules of generating units currently under construction would jeopardize their ability to complete the transaction. The availability of additional firm purchases of the required magnitude in this time frame is uncertain.

A firm purchase for a single capacity period, if available, would be much less costly than the installation of simple cycle gas turbines. Nevertheless, replacement with a purchase from an efficient base load generating unit for the summer period would result in an annual levelized revenue requirement of about $4,300,000, which is equivalent to $40,970,000 (sum present worth in 1975). A purchase from gas turbines, which is more likely to be the source of purchased power, if indeed any firm purchase can be arranged, would result in a greater annual levelized revenue requirement.

The optimum solution is to avoid summer reliability problems by rescheduling the outage to a winter period. The current license schedule, however, cannot be advanced due to construction time restraints. The amendment requests a delay of the 1979 license schedule to 1981, allowing sufficient flexibility to advance the outage to the previous winter (1980-1981) as necessary, to alleviate the reliability impact in summer of 1981.

4.1.3 Savings from Prevention of Non-Water Quality Environmental Impacts

The construction and operation of a cooling tower causes adverse environmental impacts as an offset to the expected benefits to the aquatic environment. The only opportunity to prevent the non-water quality environmental impacts described in § 2.2 from occurring over the life of Indian Point 2 is to defer closed-cycle cooling for two years for the purpose of improving the biological data base and preserving the potential societal benefits of once-through cooling. Granted a deferral of the requirement for installation of a wet natural draft cooling tower, the onset of adverse effects would be delayed, thus providing a benefit to the environment. These benefits or environmental savings would accrue to regional, area and local land use and aesthetic values. In addition, increased emissions of the bi-products of fossil fuel combustion would be delayed, as would the potential botanical damage.

Upon completion of an additional two years of study of the impact of once-through cooling on the fishery, it may be decided that a wet natural draft cooling tower is necessary. In that case the benefit of the two-year delay would be the delay in the onset of these effects. If, however, it is determined after the study period that the cooling tower is not truly necessary and does not result in an actual net benefit to society, the substantial benefit of the two-year delay would be the permanent avoidance of irreversible land use damage and potential damage to trees.

From the standpoint of botanical effects, operation of a wet natural draft cooling tower could irreversibly damage aesthetically valuable trees found in the principally residential and rural area east and south of Indian Point. A damaged treescape, for area residents, would be a negative environmental impact and certainly not desirable. It could only be justified if it is proven, on balance, that the botanical sacrifice must be made to protect the fishery and provide a net benefit to society.

Looking to the broader question of land use, preservation of the beauty of the Hudson River Valley has, for some years, been not only a matter of regional concern but one of national concern as well. Evidence is found in the persistent scrutiny other major industrial and transportation projects have received when proposed for the Hudson Valley. The unique aesthetic value of the Hudson Valley has had a major influence on project design in some cases. See, e.g., A. Talbot, Power Along the Hudson 160 et seq. (1972). A good illustration of this concern is the action of the Hudson River Valley Commission in 1968, disapproving plans for a power plant with cooling towers at a site upstream of Indian Point, because of the aesthetic impact on both the River and a nearby historical park. See Exhibit 4-1. Similar considerations apply at the Indian Point site, and the Staff has itself indicated that "Cooling tower appearance and effluents may have direct impacts on Bear Mountain State Park and the Hudson Highlands." Indian Point 3 FES at XI-19; see also Cooling Tower Report at 6-77.

Concern for the aesthetic impact of cooling towers is not, of course, confined to the Hudson River Valley. Cooling tower design locations were required to be changed by Public Service Electric and Gas Company at the Newbold Island site on the Delaware River to comply with requests by the Advisory Council on Historic Preservation and the Pennsylvania Historical and Museum Commission. See Exhibit 4-2.

In the cases cited above, cooling towers were found to be aesthetically objectionable and the preservation of aesthetic values held to be paramount. In the same vein, the Director of the New York State Historic Trust has expressed his hope to the NRC that there be "no additional damaging effects" on the Indian Point surroundings. See Letter from Mark Lawton, Dir., N.Y. State Historic Trust to Lester Rogers, Dir., Div. of Radiological and Environmental Protection, AEC, May 12, 1972, quoted in Indian Point 3 FES at V-4.

Monetization of local, area and regional land use and aesthetic costs is at this time still an ill-defined process. Alteration of land uses as described would definitely result in long-term external costs irreversible for at least the life of the tower, a generation long. Categorical costs identified by the Regulatory Staff begin with deterioration of aesthetic and scenic values and degradation of areas having natural value. See NRC Regulatory Guide 4.2 at 38 (rev. 1, 1975). Additionally, in all probability, there would be lost income from recreation and tourism that would be disturbed by this environmental intrusion. Finally, it is likely that there would be a decrease in residential real estate values in areas adjacent to or within sight of the wet natural draft cooling tower. The fact that such costs cannot be readily quantified does not make them less substantial, or permit them to be discounted.

4.1.4. Potential Finding that Cooling Tower is Not Required

The object of the requested extension of the interim operation period is to allow Con Edison to continue and complete its ecological study program of the effects of plant operation on the aquatic biota of the Hudson River before making a large, irretrievable commitment of resources to the construction of a cooling tower. If the studies show that the impact of once-through cooling operation is acceptable, and hence that closed-cycle cooling is not required, the Company's customers will avoid a significant economic penalty. The avoided annual levelized revenue requirements - those which would be incurred if a cooling tower were installed - would be about $33,931,000/yr, levelized from 1979 to 2003. See Table 4-5. These savings reflect the differences between the costs to be incurred if Con Edison constructs and operates a closed-cycle cooling system by 1981, and the costs to be incurred if the Company continues to operate the facility with once-through cooling.

For Con Edison's customers to obtain this possible savings, the requested delay would involve certain costs to fisheries. These costs are minuscule in comparison with the ultimate costs associated with construction and operation of a closed-cycle cooling system and have been estimated to be $29,900/yr levelized from 1979-2003. Table 4.10 and § 4.2. In an ultimate sense, this latter figure is the price of preserving society's option to render a reascned decision on the far larger expenditures for closed-cycle cooling.

On this basis, the expected benefit to society (including Con Edison's customers) from granting the requested amendment can be quanitified. If the amendment is granted, two eventual outcomes are possible, depending upon the results of the research program: Con Edison (1) may be allowed to continue operation with once-through cooling or (2) may be directed to build the cooling tower as a condition of future operation. Let p be the probability that operation with once-through cooling will be allowed to continue, and let (1-p) be the probability that a tower will be required. The expected societal benefit can be expressed as follows:

$$\underline{B} = pb1 + (1-p)b2$$

where

$\underline{B}$ = net societal benefit with a positive value or net societal cost with a negative value

b1 = net benefit if cooling tower is not required.

b1 = R + W - TC

$\underline{R}$ = Con Edison revenue requirements avoided if no tower is built

W = non-fishery environmental benefits if no tower is built.

T$\underline{C}$ = Total cost to the fishery if no tower is built

b2 = net benefit of delay in cooling tower installation

b2 = RI + WI - IC

RI = Con Edison revnue requirements avoided if delay is granted (summarized in S 6.4).

WI = Non-fishery interim environmental benefits if delay is granted.

$\underline{IC}$ = Cost to the fishery for interim operation until tower is built on proposed deferred schedule

The minimum fishery cost that will result in a net societal benefit is that for which B=0 (Benefit/Cost ratio = 1).

Substituting (with all costs in dcllars per year levelized from 1979 to 2003):

p = .01 - arbitrarily assumed 1% probability

$\underline{R}$ = $33,931,000/year levelized (Table 4.5)

W = 0 - conservative assumption for not easily quantified value.

RI=0 - neglected for conservatism in calculation

WI = 0 - conservative assumption for not easily quantified value.

$\underline{IC}$ = $29,900/year levelized (See generally § 4.2.1.1.2)

Yields:

0 = .01 (33,931,000 - TC) - .99 (29,900)

Solving for TC:

TC = $30,970,000

Thus, assuming arbitrarily a low probability of only 1% that a cooling tower will not eventually be required on the basis of the studies to be completed during this extension, if the total cost to the fishery were less than $30,970,000/yr, levelized from 1979 to 2003, a net benefit would be expected from a decision not to grant the requested extension.

In other words, if the total cost to the fishery of continued once-through cooling operation (for the life of the plant) were as high as $30,970,000/yr (levelized 1979-2003), granting the extension would lead to an expected net loss to society only if there were more than a 99% assurance that the results of the research program would be such as to require cessation of operation with once-through cooling by May 1981. To the extent that (1) the real societal value of the damage to the fisheries is anticipated to be markedly below $30,970,000/yr, and (2) the probability that a cooling tower would not be required is greater than 1%, the benefit to society of granting the amendment would be greater than that calculated above. While it is not feasible to express with precision the likelihood that the present license condition requiring closed-cycle cooling will eventually be deleted, the evidence available to date indicates that the likelihood is considerably in excess of the 1% level assumed in the above calculation. On this basis, approval of Con Edison's request to allow the completion of the study program is clearly the prudent course.

4.2 Costs

4.2.1 Cost to the Fisheries

4.2.1.1 Striped Bass

To complete the assessment required in a benefit-cost analysis, the benefits of the requested license amendment presented in § 4.1 must be compared with the costs of the proposed action. This section discusses the impact on the fisheries of a two-year delay in implementing closed-cycle cooling, and expresses that impact as a monetized present worth value for comparison with the monetized benefits described in § 4.1.

4.2.1.1.1. Impact of Delay on Fishery

The impact on the striped bass fishery of the proposed amendment was computed utilizing a model developed by Lawler, Matusky and Skelly Engineers, as described in Appendix A.

Data collected during 1973 by several of Con Edison's contractors have been used to estimate the standing crop of striped bass in the river. The plants considered in conjunction with Indian Point 2 were Indian Pcint 3, Bowline Point 1 and 2, and Roseton 1 and 2. The Indian Point 1, Danskammer and Lovett plants were not considered in the multiplant projections herein because they have been in operation for a sufficient period of time and this impact has already been reflected in the present striped bass population.

Flow rates used in the computer simulation for the various units at Indian Point, Bowline Point and Roseton reflect statistically derived forced outage rates. Thus in the case of Indian Point 2, an intake flow rate of 730,000 gpm was used for summer operation in 1975 and 1976, and an increased flow rate of 786,000 gpm was used in 1977 and 1978. Other parameters used in developing the impact of the two year delay are discussed in § 2.1.3.1.3 and Appendix A.

Tables 2-15, 2-16 and 2-17 summarize the results of the computer simulation of plant effects due to entrainment and impingement of striped bass. These tables include the impact of the generating units at Bowline Pcint, Indian Point and Roseton, and show that impact in terms of percent reduction in Adult 1 and total Adults in the Hudson River.

Table 2-15 is a prediction of the reduction in striped bass populations over a period of 50 years under the current license condition (i.e., implementation of closed-cycle cooling at Units 2 and 3 according to the present Unit 2 license conditicn and the Unit 3 stipulation). Table 2-16 indicates the effect on the Hudson River populaticns of plant operation if the proposed amendment were granted. The difference between these two cases is the net impact of the two-year delay in constructing cooling towers on river striped bass stock. For purposes of deriving the cost component of the final benefit-cost ratios the "Best Estimate Impact" with low compensatory response has been utilized. <u>See</u> Table 2-17. This "Best Estimate Impact" shows a maximum percentage reduction in total Hudson River striped bass adults of 0.64% in 1980.

The actual cost estimate is derived from the monetized value of the reduction in commercial and sport fishing due to the "Best Estimate" reduction in Hudson River total adult striped bass populations. In actuality, use of impact on total adults is conservative since stripers enter the fishery at about age 3-4 and not after the first or second year of life. Hudson River contribution to the mid-Atlantic striped bass fishery is assumed to be at the 25% level for purposes of this analysis even though the final estimate for such a contribution is expected to be below this level.

4.2.1.1.2. Monetized Value of Fishery Impact

The approach utilized in placing a monetary value on a reduction in the striped bass fishery resulting from the requested amendment is one of computing the benefits foregone because of the reduction. The analysis includes an estimate of the consumer surplus per recreation day. Consumer surplus per day represents the difference between the price that a consumer pays for a day of recreation and the amount he would be willing to pay rather than do without the recreation. Using the estimated value of consumer surplus for striped bass fishing and a determination of the number of fishing recreation days lost as a result of this amendment, the cost component of the benefit-cost ratio can be developed.

While the consumer surplus per recreation day can be derived in several ways, the approach used by the Water Resources Council was taken to be representative. See U.S. Water Resources Council, Principles and Standards for Planning Water and Related Land Resources, 38 Fed. Reg. 24779 (1973). The guidelines suggest a value of $3.00 to $9.00 for a specialized recreation day and these values have been used as guidance in selecting a range of $4.00 to $10.00 as representing the amount consumers would be willing to pay not to be deprived of a day of striped bass fishing. See Appendix C.

Once the value of a fishing day is determined it is necessary to evaluate the relationship between the demand for striper fishing days and the stock of striped bass. Basic factors comprising the relationship include the unit cost of a fishing day, the individual's level of income, the stock of striped bass and the availability of alternatives to striped bass fishing. For example, research in sport fishing has demonstrated that individuals tend to increase their fishing effort as their income rises. This can be factored into the analysis of number of striped bass fishing days in any year (qt) demanded by the typical consumer as follows:

$$qt = b \times \%\text{ growth in average income}$$

$$b = \text{elasticity of } qt \text{ with respect to income}$$

The other determinants of the demand for fishing days can be treated similarly, see Appendix C, with the result that the total demand for striped bass fishing days is obtained (after multiplying qt by the relevant population Pt).

VtPtqt (License Schedule) - VtPtqt (Proposed Schedule) is the measure of impact of the proposed amendment in year "t". The difference can be computed each year using the impact level in Table 2-17 and the methodology described above and in Appendix C for deriving the consumer surplus. As in § 4.1, a present value of the dollar stream for all years is determined (See Appendix B) and compared with the present value of the revenue requirements saved by the two-year extension.

Table 4-10 shows the results obtained as a result of the analysis contained in Appendix C utilizing a low cost elasticity and a high income elasticity for computing Ptqt. The impact of the proposed amendment in 1975 dollars, the pleasure foregone expressed as the present value of the difference between the compliance schedule and the proposed schedule, is calculated to be $283,200. The equivalent annual levelized cost is $29,900 for the years 1979-2003.

The impact is brought to a present value using the discount rate and techniques described in Appendix B. The consumer surplus value (Vt) utilized in computing the $283,200 sum present worth is $10 as provided in Appendix C. Finally, the Hudson contribution to the mid-Atlantic striped bass fishery is assumed to be 25% in Table 4-10. It is expected that the actual contribution will be determined to be lower than this value by the ongoing ecological study program.

4.2.1.2 Other Species

TABLE 4-10

CONSUMER SURPLUS CALCULATION:
TWO YEAR EXTENSION OF
ONCE-THROUGH COOLING

Value Per Day	Consumer Surplus**
$4.00	$113,280
$10.00	$283,200

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* Incorporates Lawler, Matusky & Skelly "best estimate" of fc factors, with low compensation (Appendix A); assumes 25% contribution

** Incorporates low cost elasticity and high income elasticity (Appendix C); expressed as sum present worth in 1975.

The impact of Indian Point 2 operation with a once-through cooling system on species of fish other than striped bass is considered to be monetarily negligible. Only limited sport and commercial fishing effort in the Hudson River is expended on species such as white perch and tomcod. In addition, as with striped bass, there is presently nc evidence that these limited fishing efforts have been impaired to any measurable degree by the operation of the Indian Point facilities. American shad in the Hudson River is a sport and commercial fish of significant stature, but that species is not entrained or impinged at Indian Point to any significant degree.

Con edison therefore concludes that the requested extension of the once-through cooling system operation will result in no measurable economic impact on other species of fish.

5. ALTERNATIVES TO THE PROPOSED ACTION

5.1 Retention of Present License Condition

An obvious alternative to the proposed license amendment would be retention of the present license condition requiring termination of operations with once-through cooling by May 1, 1979. In Con Edison's view, this alternative is feasible, but only at extreme expense to the Company and its consumers, with no countervailing benefit to society.

Briefly stated, retention of the present license condition would permit completion of the Con Edison ecological study program, but would render useless all the results of that program. Under the present license condition and construction schedule, as outlined in §§ 1.1 and 1.3 and Figure 1-1 above, the initial commitment of resources to construction of an alternative cooling system would have to commence no later than June 1, 1976, whereas the results of the ecological study program will not be available until approximately January 1, 1977. Con Edison could, of course, commence excavation or construction without the results of the research program, but would then either have to abandon all such expenditures (if the program demonstrated the lack of need for closed-cycle cooling) or, worse yet, would be compelled to expend additional funds to restore the site, to the extent possible, to its condition prior to the commencement of construction, thus adding even more to the purposeless expenditures. Such a course has nothing to recommend it, and in view of the substantial possibility that the expenditure of funds would serve no purpose, Con Edison is compelled to seek relief from this feature of the present license.

Moreover, retention of the present license condition would be based on an inflexible reading of the license, in direct contravention of the spirit of flexibility announced by the Appeal Board in its decision of April 4, 1974. Thus, the Appeal Board noted, on review of the proceedings leading to the issuance of the full-term, full-power operating license:

> [T]he record establishes no compelling reason for the selection of the May 1, 1978 date, but suggests <u>some flexibility is needed in the selection of the termination date for operation with once-through cooling in order to permit consideration of additional environmental impact data</u> which will be relevant to reaching an informed decision on the permanent cooling system . . . ALAB-188, RAI-74-4, 323 406 (Apr. 4, 1974) (emphasis added).

Since the chief premise of the Appeal Board's selection of the provisional May 1, 1979 date for termination of operation in the once-through cooling system--the meaningful consideration of environmental impact data--would be subverted in the absence of a change in the license, the alternative of retention of that date would not be justified. The expenditure of funds that would follow from retention of the present text of the condition would not provide any substantial environmental benefit, and, indeed, the costs of the research program itself will have been wasted.

Furthermore, removal of the unit from service during the summer of 1979 would have a serious impact on the reliability of service. The Cornwall Pumped Storage Project has encountered extensive delays, and the additional removal of Indian Point 2 would require equivalent replacement capacity by whatever means feasible and considerable additional expense to Con Edison's customers who would pay the full cost of replacement capacity and energy. The section dealing with reliability impact (§ 4.1.2.2) details the load and capacity information for the summer of 1979 and discusses the impact of summer outage of Indian Point 2.

Delaying the commencement of excavation work to conform with the schedule for obtaining results from the study program would lead to a corresponding delay of closed-cycle cooling operation. Scheduling the Indian Point 2 shutdown as per the license (May 1, 1979) would then result in an outage correspondingly longer than the May 1 to December 1, 1979 outage analyzed in § 4.1.2.1. The costs of such an outage would be greater than those specified for the license schedule (see Table 4-4) due essentially to the "Incremental System Production Costs" (Line E), which would increase to reflect the longer outage.

5.2 Operation With Once-Through Cooling System Beyond May 1, 1981

Yet another alternative to the proposed action would be to modify the operating license to permit operation with the once-through cooling system for some period extending beyond May 1, 1981 including possibly the entire remainder of the life of the license. In Con Edison's view, such action would be premature because although the financial, aesthetic and other advantages of such action are known--and are enormous--the impact on the fishery is still obscure.

It is not our contention here that the data presently available justify a complete release from the present license condition requiring installation of closed-cycle cooling, or even a deferral of the date for installation of such a system to some date later than May 1, 1981. Rather, our contention is that the Con Edison research program should be permitted to run its course and be reviewed by the Commission prior to the initiation of the massive irretrievable commitment of resources associated with construction of a cooling tower. At the conclusion of the study program, if the data indicate that the impact of plant operation, feasibility of mitigating measures, and the dynamics of the aquatic biota in the River will be such that closed-cycle cooling is not warranted, then Con Edison will indeed seek permanent relief from the closed-cycle cooling license condition, consonant with the provisional character of that condition. <u>See</u> ALAB-188, RAI-74-4, 406-09, at IV. 3-4.

5.3 Derating and Reduced Flow Operations

A third alternative to the proposed action is to allow operation through the requested period while reducing the amount of water withdrawn from the river from that at full flow to some smaller amount either by operating the circulating water system at 60% flow or by operating fewer than six (6) circulating water pumps.

In accordance with the facility operating license Con Edison submitted on January 1, 1974 to the then Atomic Energy Commission a Plan of Action of operating procedures of the existing once-through cooling system designed to minimize detrimental effects on aquatic biota in the Hudson River during the interim period prior to installation of a closed-cycle cooling system. <u>See</u> A Plan of Action for Operating Procedures and Design of the Once-Through Cooling System for Indian Point Unit No. 2, submitted in accordance with Section E. (3) of the Facility Operating License No. DPR-26, as amended by Amendment No. 4 dated September 28, 1973, January 1, 1974, NRC Dkt. No. 50-247.

Reduced flow operation is one of the mitigating measures recommended by Con Edison at that time. Con Edison's method of reduced flow operation consists of operating all circulating water pumps at approximately 60% of full flow during the period from October 1 to March 31. <u>See</u> Plan of Action § 2.3.

Operation at 60% of full flow during the winter months has little effect on plant operation because the intake water temperature is sufficiently low that heat transfer can take place at approximately the normal rate. As the river temperature rises, however, two effects come into play when flow is reduced. These are (1) that heat transfer efficiency is reduced with increasing river temperature (resulting in reduced electrical output and higher heat load to the river), and (2) that higher delta T's can result in violation of the maximum allowable discharge temperatures. Compliance with these limits can be achieved by derating (reducing output) of the plant. These deratings range from zero at full flow and river temperatures below about 65 F to losses of hundreds of megawatts when the plant operates with three pumps at 60% flow and river temperature are at their maximum.

The deratings involve large economic costs because nuclear generation would have to be replaced by higher cost oil-fired plants. While the actual cost of deratings and reduced flow operation would vary depending on the amount of derating and periods during which such operation occurred, a typical value for 1979 would be approximately $560/MW/day. Such replacement power would also require increased consumption of imported oil and increased emissions of air pollutants, probably in New York City. See Cooling Tower Report at 6-87. It should also be pointed out that maximum deratings would coincide with the summer peak demand for electricity.

For these reasons reduced flow operation during the summer months is not considered to be a viable alternative to the proposed action.

6. SUMMARY BENEFIT-COST ANALYSIS

6.1 Introduction

In reviewing this application, the Commission must balance the environmental, economic and other costs and benefits associated with granting or denying the requested license amendment. In this case, the Commission is working against a background of unusual environmental studies. Although these studies have not yet been completed, the mass of data presently available is prodigious. The sheer bulk and complexity of these data, however, and the long history of interest in the River, must not be permitted to obscure the issues before the Commission. In the ensuing paragraphs we will summarize these issues and attempt to set them in a comprehensible matrix.

6.2 Effects of Closed-Cycle Cooling

The ultimate issue that runs through the instant amendment application, as well as the present license, is the need for installation of a closed-cycle cooling system to protect aquatic biota of the Hudson River. If, as Con Edison proposed on December 2, 1974, a natural draft cooling tower is to be the cooling method adopted, then the costs to Con Edison (and through it, to the consumers of electric power in New York City and Westchester County) will be enormous. Capital costs will be approximately $91,000,000 under the schedule mandated by the present license condition. In addition, there will be losses due to the necessary derating of Indian Point 2 to accomodate the tower, which will cost approximately $66,789,000 sum present worth in 1975. Other quantifiable costs due to construction of a cooling tower include the incremental energy cost during the seven-month outage for construction, the economic impact of which is estimated to be $45,285,000 sum present worth in 1975. See generally Table 4-4 (enumerating costs). The total of all these costs is $567,867,000 sum present worth in 1975.

Other costs associated with closed-cycle cooling are not readily quantifiable. These include, first and foremost, the colossal environmental insult to the aesthetics of the Hudson River Valley at the site. The charms of the River have been apparent to observers almost since the first European settlement. Hence, the imposition of a cooling tower on its banks, and soaring to 565 feet above grade, is a step that should not be lightly undertaken. As the Staff has previously recognized, "the esthetic effect is a major impact of [cooling towers], even though it cannot be quantified." Indian Point 3 FES at XI-19.

Other adverse effects of construction and operation of a closed-cycle cooling system are described in the Cooling Tower Report at § 6.

6.3 The Research Program and the Data Base for Decision-Making

Con Edison's research program, scheduled for completion by January 1, 1977, will provide answers to the crucial questions that bear on whether the irretrievable commitments described in § 6.2 above are rational. To date, all parties to the Indian Point 2 licensing proceeding have acknowledged that there are important gaps in man's understanding of the Hudson River ecosystem and the influence of the plant on that system. Con Edison is working to reduce these gaps. The research program begun in 1972 has already produced important results. These results have established that there is not 100% mortality of organisms entrained in the plant and that the proper fI factor is considerably less than unity. Moreover, the research program has provided additional information on (1) the migratory range of the Hudson River striped bass and the contribution of the Hudson stock to the mid-Atlantic striped bass fishery; (2) the existence of compensation in the Hudson River striped bass population; and (3) the lack of vulnerability of young striped bass to the plant. That the research program has provided this information is demonstrated not only by Con Edison's conclusions but by the conclusions of the Regulatory Staff in the Indian Point 3 Final Environmental Statement. <u>See</u> Indian Point 3 FES at V-177, XI-110.

With another two years of operational data, an informed judgment on the need for closed-cycle cooling will be rendered possible. Matters previously deemed obscure or at least controversial--such as compensation in the striped bass population, the contribution of the Hudson River to the mid-Atlantic striped bass fishery, or the effect of the plant on entrained organisms--will be better understood, and the data base for decision-making will more nearly approach in depth the magnitude of the irretrievable commitment Con Edison has been directed to make by constructing a closed-cycle cooling system. Plainly, the confidence level associated with the determination on closed-cycle cooling should reflect the magnitude of the commitment of resources that is involved.

Under the present license condition, however, contrary to the Staff's conclusion in the Indian Point 3 case, see Indian Point 3 FES at XI-112, there is not adequate time to complete our research program--i.e., to analyze the results of the plant's operation on the 1975 year class of striped bass. Such analysis would seem to be required in light of the Staff's prior insistence on the availability of data on power plant operation during two spawning seasons. Id. at XI-115. For Con Edison to complete the program and allow adequate time for agency review and possible hearings would force the Company either to make substantial irretrievable commitments to construction activities or to run the risk of having to keep the plant shut down for an unacceptably long period after May 1, 1979. Such alternatives cannot be justified, as indicated in § 5 above. In light of the progress the research program has already made, as well as the likelihood of further new information, the Commission should allow this program to be completed and evaluated prior to starting construction of a closed-cycle cooling system, consonant with the flexibility implicit in the Appeal Board's April 4, 1974 decision and the "fresh look" there ordered. ALAB-188, RAI-74-4, at 407.

When completed, the Con Edison research program will provide a much better basis than previously existed or now exists for estimating (1) the impact of power plants on the important fish species of the Hudson, and (2) the best means of mitigating that impact. See §§ 1.3, 3. Although it is not certain either that our research program will succeed in producing these results or that the results will dictate a decision other than the one set forth in the present license, there is a sufficient probability of both of these outcomes that, from society's point of view, Con Edison should be allowed to proceed with the research program before substantial irretrievable commitments of resources are made toward the construction of a closed-cycle cooling system. See § 4.1.4. This conclusion is dictated both by logic and by the fundamental principles of the National Environmental Policy Act of 1969.

6.4 The Period of the Extension

The considerations noted in the preceding section, though in some respects unquantifiable, involve stakes that are both higher financially and of greater permanence than the considerations pertinent to the NEPA balance limited strictly to the period of the requested extension of operation with once-through cooling. Here, too, however, the benefit-cost analysis favors the extension request. As shown by the analyses set forth in this Report, the deferral will have only the smallest adverse effect on the Hudson River striped bass fishery, and that effect will not be irreversible. According to our estimate, <u>see</u> § 2.1.2 above, any reduction in the striped bass population would be completely corrected through natural population dynamics by 1994, only 13 years after installation of closed-cycle cooling (assuming that the requirement for such a system is not, in the end, deleted from the license). In this connection, it is important to recall that the Staff has conceded the sufficiency of the Con Edison research program "for determining short-term effects of the once-through cooling system and for assuring that the short-term impacts will be kept to an acceptable limit." Indian Point 3 FES at XI-112. Moreover, during the period of the extension, the present Environmental Technical Specification Requirements will remain in effect, and will provide substantial operational protection against interim adverse effects on the fisheries. <u>See</u> § 2.1.3.

The reduction in the numbers of fish during the added two years and during the period leading to total recovery of the fishery is of modest value. As described in §§ 2.1 and 4.2 and Appendix C, the monetary cost to the striped bass sport fishery will be approximately $283,200 (sum present worth in 1975), which is equivalent to an annual levelized cost (1979-2003) of $29,900 per year. Lost commercial striped bass fishing will be only a small fraction of the value of the lost sport fishing, and costs to other less significant species will also be low.

Balanced against the impact on the fishery are some important benefits derived from the deferral of the transition to closed-cycle cooling. Aside from the improvement in the data base for decision-making attributable to completion of the research program, §§ 4.1.1 and 6.3 above, important savings will be achieved by the avoidance of large incremental generating costs as well as the reliability losses that would result from the summer cut-in outage required by the construction schedule (Figure 1-1) required under the present license condition. § 4.1.2. Yet other societal savings will be realized through the prevention of certain unquantified non-water quality environmental impacts. See § 4.1.3. These combined elements of savings far outweigh the modest environmental costs of the requested extension of the interim operation period.

On the basis of the monetized consequences of the proposed extension the relevant benefit-cost ratios can be computed. The numerator of the benefit-cost ratio for the requested two-year extension is the saving in incremental generating costs, $246,143,000 as developed in Tables 4-4 through 4-6. The denominator of the benefit-cost ratio is the fishery cost of $283,200 developed in § 4.2 and Table 4-10. Under the optimistic assumption that a firm purchase from an efficient oil-fired base-load generating unit could be arranged for the cooling tower cut-in period, the numerator of the benefit-cost ratio becomes $38,532,000 in place of the $246,143,000. See §§4.1.2.1.10 and 4.1.2.2.3.

Comparing economic benefits and costs results in the following benefit-cost ratios for the proposed two year extension:

$$\frac{\text{Incremental Benefit of Delay}}{\text{Incremental Cost of Delay}} :$$

If gas turbines are required:

$$\frac{\$246{,}143{,}000}{\$\quad 283{,}200} = \frac{869}{1}$$

If firm purchases from base-load generating units are available:

$$\frac{\$\ 38{,}532{,}000}{\$\quad 283{,}200} = \frac{136}{1}$$

Accordingly, it is manifest that whether the lost capacity is made up by purchase or by installation of gas turbines, the quantifiable benefits associated with the requested extension of the interim operation period are far in excess of the environmental costs attributable to such an extension. If, moreover, consideration is given--as the law requires--to the unquantified elements in the equation (improvement in the data base for decision-making, and effects of a cooling tower on the site vicinity), then the benefit-cost ratio becomes even greater.

7. ENVIRONMENTAL APPROVALS

Since this request consists of an extension of present operating conditions, the number of agencies to be contacted is at a minimum.

The Commission, in granting this request, would amend the operating license to allow continuing operation under present conditions for an additional two years.

At this time, it is not anticipated that the approval of any other governmental agencies will have to be obtained with regard to this action, except that any permits or certificates which may now expire during the extension period would require renewal.

The discharge permit issued by the Environmental Protection Agency pursuant to § 402 of the Federal Water Pollution Control Act (FWPCA) expires on March 31, 1980 and will have to be renewed at that time, but several conditions in that permit, including the requirements for closed-cycle cooling, have been objected to in a request for an adjudicatory hearing submitted to the EPA. If responsibilities for administration of the National Pollutant Discharge Elimination System (NPDES) have been transferred to New York State prior to expiration of the NPDES permit, New York State will issue a State Pollution Discharge Elimination System (SPDES) permit.

8. SOURCES

8.1 Reports Previously Furnished

For the convenience of the Commission, the following is a list of reports and studies furnished to the Regulatory Staff by Con Edison which bear on the disposition of the present application:

Consolidated Edison Company of New York, Inc., Contribution of the Hudson River Striped Bass to the Mid-Atlantic Fishery (March 1974).

* A Plan of Action for Operating Procedures and Design of the Once-Through Cooling System for Indian Point Unit No. 2, Submitted in Accordance with Section E.(3) of Facility Operating License No. DPR-26, as Amended by Amendment No. 4 dated September 28, 1973 (January 1, 1974).

* Economic and Environmental Impacts of Alternative Closed-Cycle Cooling Systems for Indian Point Unit No. 2 (December 1, 1974).

* Environmental Report, Indian Point Unit No. 2, NRC Dkt. No. 50-247 (Sept. 1971).

* Environmental Report, Indian Point Unit No. 3, NRC Dkt. No. 50-286 (June 14, 1971).

Dames & Moore, Comparison, Indian Point 2 Phase I Progress Report (April 1974).

Dames & Moore and Consolidated Edison Company of New York, Inc. Indian Point No. 2, Routine Monthly Thermal Monitoring, Report No. 1, May 1974 (September, 1974)

* Indian Point No. 2, Routine Monthly Thermal Monitoring, Report No. 2, June 1974 (December, 1974).

* Indian Point No. 2, Routine Monthly Thermal Monitoring, Report No. 3, July 1974 (March, 1975).

Lawler, Matusky & Skelly Engineers, Compensation (March 15, 1974).

* F Factor Report (1974).

* F Factor Glossary of Abbreviations (1974).

* Reduction of 1973 Data from Texas Instruments Longitudinal River Trawl Survey and Seining Survey (August 20, 1974).

* Computational Procedures for f Factors and an Example Model Run of the Hudson River Striped Bass Life Cycle Model (December 1974).

<u>New York University, Institute of Environmental Medicine</u>, Effects of Entrainment by the Indian Point Power Plant on Biota in the Hudson River Estuary, Progress Report for 1971-1972 with Appendix Tables (September 1973).

* Effects of Entrainment by the Indian Point Power Plant on Biota in the Hudson River Estuary, Progress Report for 1973 (September 1974).

* Larval Striped Bass (Morone Saxatilis) Length Frequency Analysis (October 1974) (draft).

* A Preliminary Analysis of the Abundance of Four Life History States of Striped Bass (Morone Saxatilis) Collected in the Intakes of Indian Point Unit 1 and in the Hudson River in front of Indian Point (August 1974) (draft).

* Hudson River Ecosystem Studies, Semiannual Progress Report, 1 January to 30 June 1974.

<u>Texas Instruments, Inc.</u>, Hudson River Ecological Study in the Area of Indian Point, First Semiannual Report, Vol. I (Biological Sampling), Vol. II (Procedures) (July 1972).

* Hudson River Ecological Study in the Area of Indian Point, First Annual Report (April 1973).

* 1973 Hudson River Program, Fisheries Data Summary, Vol. I (May-July) (October 1973).

* 1973 Hudson River Program, Fisheries Data Summary, Vol. II (July-November) (December 31, 1973).

* Fisheries Survey of the Hudson River, Vol. III (March-July) (November 1973).

* Fisheries Survey of the Hudson River, Vol. IV (March-December 1973) (September 1974).

* Hudson River Ecological Study in the Area of Indian Point for the Period January 1 to June 30, 1973: Second Annual Report (November 1973).

* Hudson River Ecological Study in the Area of Indian Point, 1973 Annual Report (July 1974).

* Evaluation of High Frequency Sonar for Fish Counting and Relative Biomass Estimation in the Lower Hudson Estuary (1974).

* Acute and Chronic Effects of Evaporative Cooling Tower Blowdown and Power Plant Chemical Discharges on White Perch and Striped Bass (November 1974).

* Feasibility of Culturing and Stocking Hudson River Striped Bass (July 1974).

* Indian Point Impingement Study Report for the Period June 15, 1972 through December 31, 1973 (December 1974).

* Semi-Annual Progress Report for the Multiplant Impact Study of the Hudson River Estuary (February 1975).

* Second Semi-Annual Report Related to the Feasibility Study for Spawning, Hatching and Stocking Striped Bass in the Hudson River (November 1974).

* Hudson River Ecological Study in the Area of Indian Point - 1974 Annual Report(July 1975).

8.2 References

Calvert Cliffs' Coordinating Comittee v. AEC, 449 Fed. 2d 1109 (D.C. Cir. 1971)

Con Edison, Economic and Environmental Impacts of Alternative Closed-Cycle Cooling System for Indian Point Unit No. 2, December 1, 1974.

Environmental Defense Fund v. Corps of Engineers, (E.D. Ark. 1971)

Koo, T.S.Y. 1970. The Striped bass fishery in the Atlantic states. Ches. Sci., 11(2): 73-93.

Merriman, D. 1941. Studies on the striped bass (Roccus saxatilis) of the Atlantic Coast. U.S. Fish and Wildl. Serv. Fish. Bull. 35: 1,77.

NRC, Environmental Technical Specification Requirements for Once-Through Cooling, Indian Point Units 1 and 2, Appendix B to Facility Operating License DPR-26.

NRC, Final Environmental Statement, Indian Point Unit No. 3, Docket No. 50-286, February 1975.

NRC, Regulatory Guide 4.2, Revision 1, 1975.

Schaeffer, R.H. 1972. A short-range forecast function for predicting the relative abundance of striped bass in Long Island waters. N.Y. Fish and Game J. 19(2): 178-181.

Sommani, P. 1972. A sutdy on the population dynamics of striped bass (Morone saxatilis, Walbaum) in the San Francisco Bay esturary. Doctoral dissertation, Univ. of Wash.

Stevens, D.E. 1966. Food habits of striped bass, Roccus Saxatilis in the Sacramento-San Joaquin Delta. Calif. Fish and Game Fish. Bull, 52:68-97.

Talbot, A., Power Along the Hudson, 1972.

Texas Instruments Incorporated. 1972a. Hudson River ecological study in the area of Indian Point. First semiannual rpt. v. I-Biological sampling for Consolidated Edison Company of New York, Inc.

Texas Instruments Incorporated. 1973c. Hudson River ecological study in the area of Indian Point. First annual report for Consolidated Edison Co. of New York, Inc.

Texas Instruments Incorporated. 1974a. Indian Point impingement study report for the period June 18, 1972 through Dec. 31, 1973 for Consolidated Edison Co. of New York, Inc.

Texas Instruments Incorporated. 1974b. Hudson River ecological study in the area of Indian Point 1973 annual report. For Consolidated Edison Co. of New York, Inc.

Texas Instruments Incorporated. 1974c. Fisheries Survey of the Hudson River, March-December, 1973. V. IV. (unpublished). For Consolidated Edison Company of New York, Inc.

Texas Instruments Incorporated. 1975. First Annual Report for the Multiplant Impact Study of the Hudson River Estuary.

Texas Instruments Incorporated. 1975. Hudson River Ecological Study in the Area of Indian Point 1974 Annual Report.

Water Resources Council, Principles and Standards for Planning Water and Related Land Resources, 38 Fed. Req. 24779, 1973.

8.3 Exhibits

4-1 Excerpt, Findings, State of New York, Hudson River Valley Commission of New York, Review of Proposed 766 Megawatt Nuclear Power Generating Facility of Niagra Mohawk Power Corporation, Albany, N.Y., March 22, 1968.

4-2 Management Information Bulletin, Public Service Electric and Gas Company, General Bulletin 3-70, March 2, 1970.

STATE OF NEW YORK
HUDSON RIVER VALLEY COMMISSION OF NEW YORK
- -X

In the Matter of

Review of Proposed 766 Megawatt Nuclear Power Generating Facility

of

NIAGARA MOHAWK POWER CORPORATION,

Sponsor

- -X

FINDINGS

On February 7, 1968, under the project review authority granted by Chapter 345 of the Laws of 1966, the Hudson River Valley Commission reviewed a proposal by the Niagara Mohawk Power Corporation to construct a nuclear power generating facility in the Town of Easton in the County of Washington. The Commission found that the project might have an unreasonably adverse effect on the recreational, scenic, natural and historic resources of the Hudson River Valley. As provided by law, the Commission then issued an Order directing the company not to undertake the project for a 30-day period, commencing February 21, and followed this action with a public hearing on February 28 at 8 P.M. at Chancellor's Hall in the City of Albany. Alexander Aldrich, Executive Director of the Commission, presided as hearing officer. At the public hearing, 33 persons offered testimony and prior to and subsequent to the hearing, an additional 20 statements were received by the Commission with the request that these statements be made part of the hearing record. During the period following February 7, the Commission further reviewed the project.

of the State Health Department.

E. Cooling Towers. The sponsor has indicated that the proposed project will not require additional mechanical cooling devices, and reliance is being placed solely upon the ability of River water to serve cooling requirements. However, should it be necessary to maintain a safe thermal load on the River or should the capacity of the Easton station be expanded at some future date, as it is logical to assume in order to meet increasing future power demands, it might become necessary to use towers or other devices.

The Commission finds that the addition of such devices at any time would seriously affect the area's visual values, further aggravating the scenic impairment already evident at the site, and it also might have adverse effects on the climatic conditions of the immediate area.

F. Relation to the Saratoga National Historical Park. The plant as proposed lies directly across the River and less than one half mile from the Bemis Heights area of the Saratoga National Historical Park. Bemis Heights commands a magnificient view across the Hudson, which the construction of the plant would substantially impair. The New York State Historic Trust took a very strong position in opposition to the project and expressed its concern that the building of such a plant would be highly destructive of the historic significance and scenic aspects of the Saratoga National Historical Park. The Commission notes that the 200th Anniversary of the American Revolution is approaching and that particular public concern will develop in the near future for all of the Revolutionary War sites in the Hudson River Valley.

preparation at the area where the proposed Easton plant might be located. It notes that this preparation has proceeded in spite of the fact that no application has been submitted to the New York State Health Department for a permit to build there, and no permission has been received from the U. S. Atomic Energy Commission.

RECOMMENDATIONS

The Commission staff has been working with the other power companies within its jurisdiction to seek suitable sites along the River for nuclear power generating plants. The Commission recommends that Niagara Mohawk join the Commerce Department, the Atomic and Space Development Authority and Commission staff to locate the best sites for the atomic generation of power within its jurisdiction. The Commission further recommends that all activities at the Easton site cease forthwith until the questions raised in the public hearing and in these findings are adequately answered.

DATED: Albany, New York
March 22, 1968

HUDSON RIVER VALLEY COMMISSION
OF NEW YORK

BY: Alexander Aldrich
Alexander Aldrich,
Executive Director

TO: Mr. Rex H. Stratton, Vice President
Niagara Mohawk Power Corporation
126 State Street
Albany, New York 12201

Management Information

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
TAXPAYING SERVANT OF A GREAT STATE

General Bulletin 3-70 March 2, 1970

COMPANY FILES APPLICATION

TO BUILD NEWBOLD ISLAND NUCLEAR GENERATING STATION

Public Service Electric and Gas Company applied to the Atomic Energy Commission on February 27 for a construction license to build Newbold Island Nuclear Generating Station in Bordentown Township. The island is about six miles south of Trenton in the Delaware River.

Two nuclear units are planned for the site, each with a capacity of 1,100,000 kilowatts. If construction and operating licenses are granted by the Atomic Energy Commission, the first unit will go into operation in 1975, the second in 1977.

Cost of the project had originally been set at $450 million, but at a meeting with the Delaware Valley Regional Plan Association on Wednesday in Philadelphia, the Company announced that it would accede to the wishes of objectors and relocate cooling towers on the site at an additional cost of $4.2 million.

The tower locations will be changed to comply with the requests of the President's Advisory Council on Historic Preservation and the Pennsylvania Historical and Museum Commission. The towers will be relocated along the eastern property line of the proposed site or in an area which would be acceptable to all parties concerned.

In its original announcement about the project, the Company indicated that it intended to build four cooling towers on the site to avoid any thermal effects on the Delaware River and to comply with the wishes of the Delaware River Basin Commission.

The Pennsylvania Historical and Museum Commission had voiced objections to the towers in recent months because they were in full view of visitors to Pennsbury Manor, once the home of William Penn, directly across the river from the Newbold site. At a February 5th hearing before the Advisory Council on Historic Preservation in Washington, D.C., the Company was asked by council members to relocate or redesign the 400-foot towers. The Council voiced no objections to construction of a nuclear plant on the island.

Copies of the application, which is more than a foot high, were filed on February 27th with the Governor's office, the State Attorney General's office, the Department of Conservation and Economic Development, the State Health Department, the Public Utility Commission, the New Jersey Atomic Energy Council, the Delaware River Basin Commission, the Board of Freeholders of Burlington County, and the Office of the Mayor of Bordentown Township.

Preliminary work on the site will begin in June. Processing of the application by the Atomic Energy Commission is expected to take about 18 months. Near the end of this period, a public hearing will be held in the Bordentown Township area, after which a decision will be made by the Atomic Energy Commission. Actual construction on the site cannot begin until a license is granted.

8.4 Appendices

A Lawler, Matusky & Skelly Engineers, Impact on the Hudson River Striped Bass Population due to Two Year Extension of Once-Through Cooling Operation at Indian Point Unit #2 (April 1975).

B Mathematica, Inc., Alternative Procedures for Discounting Costs and Benefits of Privately Financed Pollution Control Projects (April 15, 1975).

C Kenneth E. McConnell, An Economic Evaluation of Postponing Closed Cycle Cooling Construction on Indian Point (April 28, 1975).

D Texas Instruments Incorporated Ecological Services, First Annual Report for the Multiplant Impact Study of the Hudson River Estuary, (two volumes, July 1975).

APPENDIX A

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

IMPACT ON THE HUDSON RIVER STRIPED BASS POPULATION DUE TO TWO YEAR EXTENSION OF ONCE-THROUGH COOLING OPERATION AT INDIAN POINT UNIT #2

Project No. 115-53

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TABLE OF CONTENTS

continue -

TABLE OF CONTENTS
(continued)

IMPACT ON THE HUDSON RIVER STRIPED BASS POPULATION DUE TO TWO YEAR EXTENSION OF ONCE-THROUGH COOLING OPERATION AT INDIAN POINT UNIT #2

INTRODUCTION

Due to increasing concern about the possible impact of power plants located on the Hudson River on the indigenous striped bass population, a number of field programs and modeling studies have been funded by Consolidated Edison Company of New York, Inc. and other utilities in order to provide estimates of these impacts. From 1971 to the present, Lawler, Matusky & Skelly Engineers (LMS) has been retained by Con Edison and other New York State utilities having generating stations located on the Hudson River to develop and apply computer models to predict the effects of entrainment and of impingement of young-of-the-year striped bass at generating stations on the Hudson River striped bass population.

To date, three generations of models have been developed for this purpose. The first of these (1) modeled the river as a completely mixed volume of water and did not account for the transport of the organisms in the river by the fresh-water flow and tidal action in the estuary. The second generation is a tidal-averaged model which accounts for the transport mechanisms in the estuary by dividing the river into a number of longitudinal segments and simulating the movement of organisms from one segment to the next. Results from this transport model were presented at Indian Point Unit 2 Licensing Hearings (2). On April 4, 1974 the Atomic Safety Licensing and Appeal Board issued a decision concerning Indian Point Unit 2 in which it stated that the transport model "more nearly conforms to reality and is superior to the Staff's (AEC) model." (6)

The second generation (transport) model has been used in the study to be described herein to predict the impact on the Hudson River striped bass population due to an extension in the operation of Indian Point Unit 2 with once-through cooling from May, 1979 to May, 1981. Since June 1974, LMS has been developing a third generation striped bass model which uses hydrodynamic information from a real-time, two dimensional model of the Hudson. The new model includes the simulation of movement of organisms between the upper and lower layers of the river, inter-tidal movement predicated on freshwater flow, and refinement of the biological input data to reflect both real-time behavior, and space and age distribution. In addition to generating real-time predictions of early life-stages, the third generation model separates the mortality rate of adult fish into several components (natural, fishing, etc.), including a non-linear fishing stress. The new model accounts directly for tidal movements and freshwater flow rather than using daily averages. Appendix A presents a comparison of results from the real-time model and the transport model.

SCOPE OF THE STUDY

The present study applies the transport model to predict the level of cropping of the Hudson River striped bass population which may result from an extension in the once-through cooling operation of Indian Point Unit 2 alone and in conjunction with various new or planned power generating stations on the Hudson. Data collected during 1973 are used to estimate the "standing crop" or equilibrium population of the striped bass in the river. Consequently, the only plants considered in conjunction with Indian Point Unit 2 are Indian Point Unit 3, Bowline Units 1 & 2, and Roseton Units 1 & 2. The Danskammer, Lovett and Indian Point Unit 1 plants are not considered in the multiplant projections because they have been in operation for a sufficient period of time and their impact, if any, has already been reflected in the present striped bass population.

THE MODEL

LMS's transport model is described in detail in Dr. John P. Lawler's October 1972 testimony (2). This model is a generalized computer program which has been used for predicting the impact of the operation of generating stations on the Hudson River striped bass population (3). The model, with appropriate modifications, could also be applied to other estuaries as well as to other species of fish.

Figure 1 shows the location of the existing and proposed generating stations on the Hudson River.

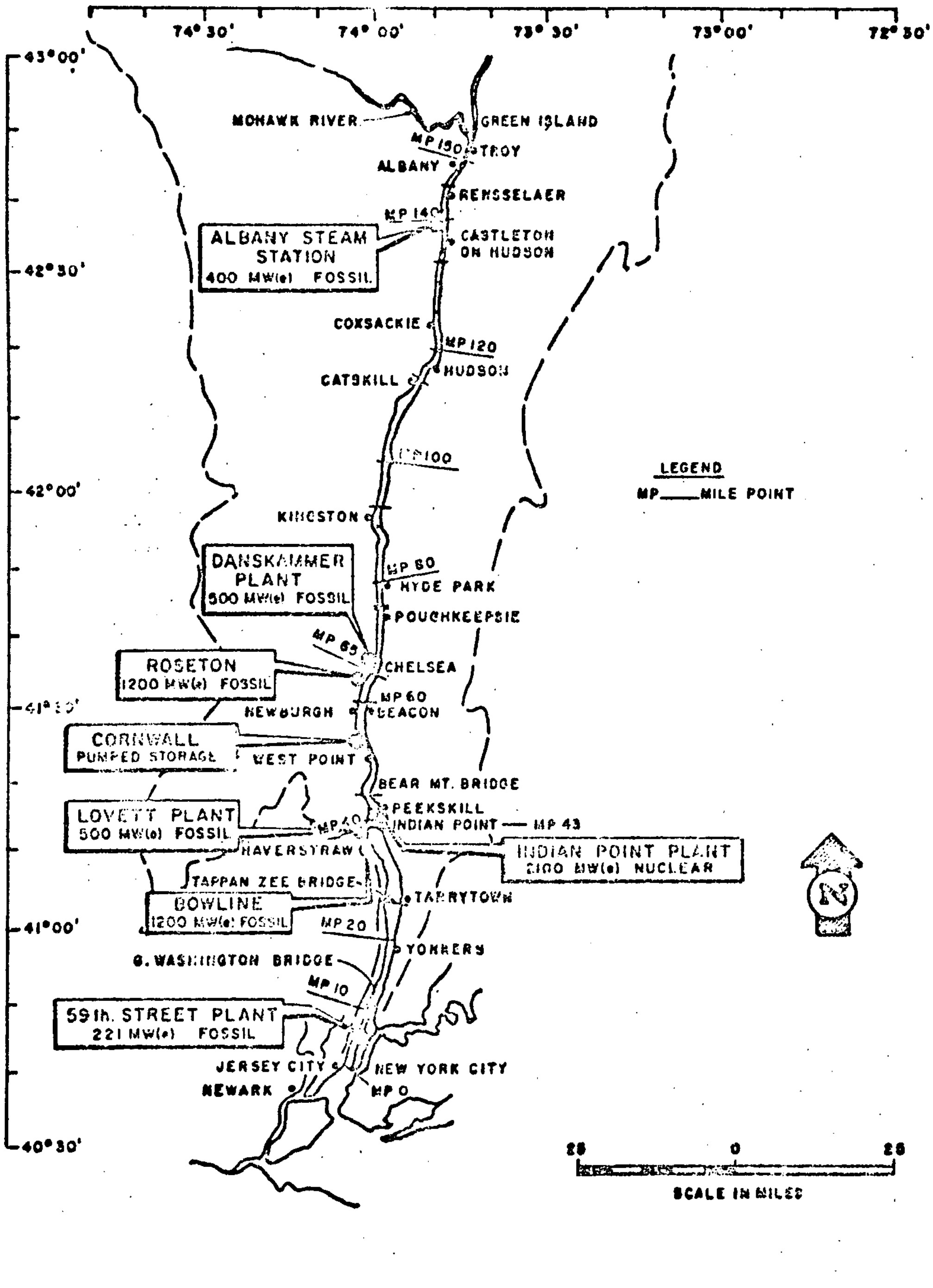
Model Modifications Since Previous Testimony

Since the presentation of Lawler's 1972 and 1973 testimony before the AEC (3), LMS's model has been modified as follows:

1. An avoidance factor in the egg and larval stages has been added to the transport terms in the model equations. This factor permits a fraction of the organisms (e.g., those very near the bottom and those resident in the shoals) to avoid the transport mechanism of the estuary.

2. The computer solution techniques have been changed to improve the efficiency of the program which solves the model equations.

3. The output facilities of the program have been expanded to allow more detailed analysis of the model's predictions.



The Hudson River showing major existing and planned power generating plants.

Item 1 above affects the model predictions in varying degrees depending on the particular configuration of plant impacts simulated. Detailed discussions of this mechanism and results of sensitivity runs for the "transport avoidance factor" can be seen in Dr. Lawler's October 1974 testimony before the Federal Power Commission (5).

Items 2 and 3 above have no effect on the predictions produced by the model. Test runs of the model using data files from runs presented in previous testimony (4) gave the same results before and after items 2 and 3 were implemented. (see Appendix B)

INPUT PARAMETERS

The input parameters required by the Hudson River striped bass transport model are shown in Figure 2. The three principal categories of data required are:

- Mass transport parameters
- Fish life cycle parameters
- Plant and impact parameters

The data sources and computational methods used in evaluating the parameters in the above categories are discussed in detail in Lawler's October 1974 testimony before the Federal Power Commission (5). In essence, data collected by Texas Instruments, Inc. (9), New York University and QLM Laboratories during 1973 were used for this purpose. Consequently, whenever possible, data used to evaluate input parameters such as freshwater flow and dispersion were also 1973 measurements.

Most of the parameters required by the transport model are functions of space (location or position on river) and time. The submission of these parameters

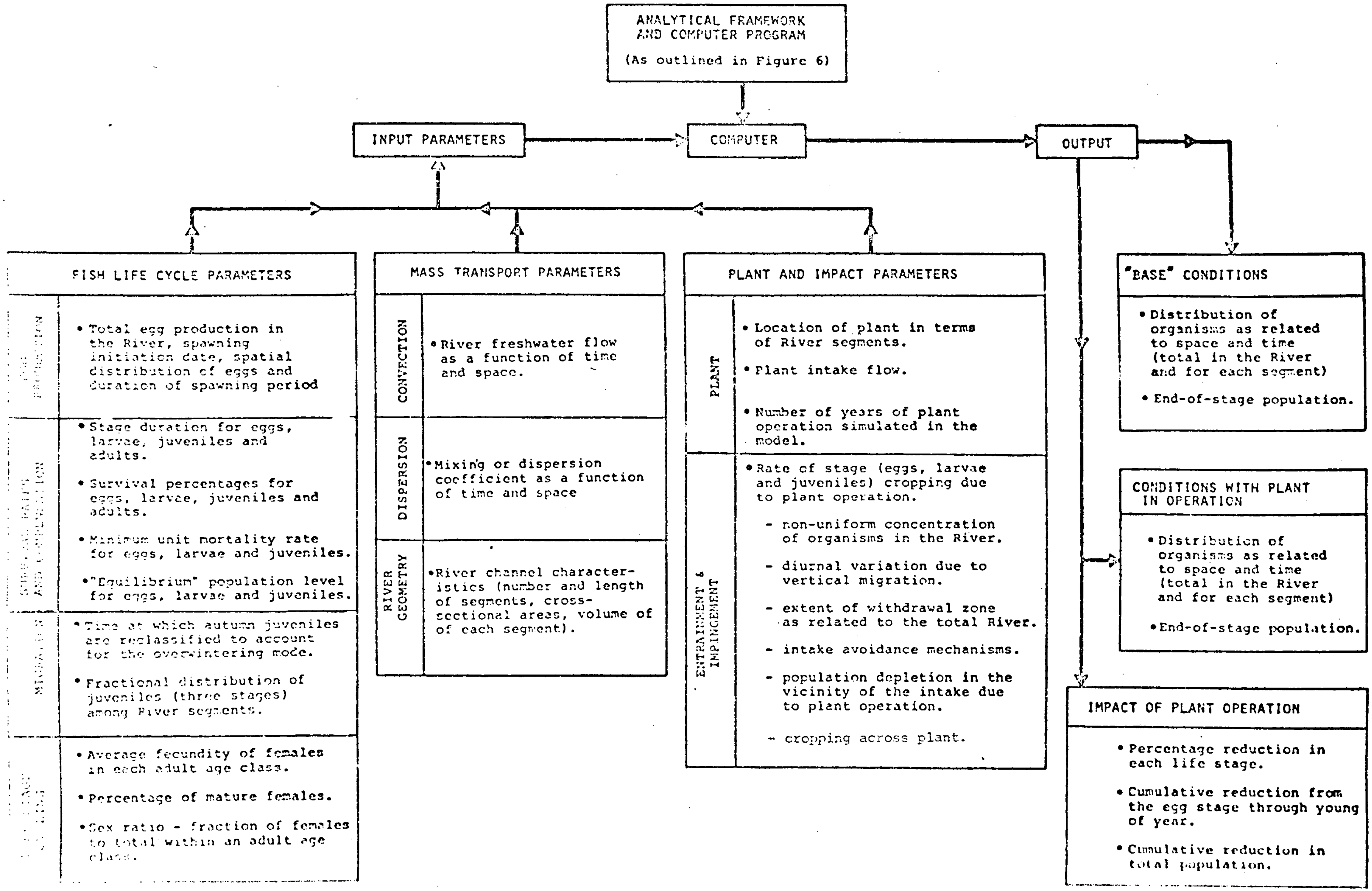

ANALYTICAL FRAMEWORK AND COMPUTER PROGRAM
(As outlined in Figure 6)
INPUT PARAMETERS
COMPUTER
OUTPUT
FISH LIFE CYCLE PARAMETERS
• Total egg production in the River, spawning initiation date, spatial distribution of eggs and duration of spawning period
• Stage duration for eggs, larvae, juveniles and adults.
• Survival percentages for eggs, larvae, juveniles and adults.
• Minimum unit mortality rate for eggs, larvae and juveniles.
• "Equilibrium" population level for eggs, larvae and juveniles.
• Time at which autumn juveniles are reclassified to account for the overwintering mode.
• Fractional distribution of juveniles (three stages) among River segments.
• Average fecundity of females in each adult age class.
• Percentage of mature females.
• Sex ratio - fraction of females to total within an adult age class.
MASS TRANSPORT PARAMETERS
CONVECTION
• River freshwater flow as a function of time and space.
DISPERSION
• Mixing or dispersion coefficient as a function of time and space
RIVER GEOMETRY
• River channel characteristics (number and length of segments, cross-sectional areas, volume of of each segment).
PLANT AND IMPACT PARAMETERS
PLANT
• Location of plant in terms of River segments.
• Plant intake flow.
• Number of years of plant operation simulated in the model.
ENTRAINMENT & IMPINGEMENT
• Rate of stage (eggs, larvae and juveniles) cropping due to plant operation.
- non-uniform concentration of organisms in the River.
- diurnal variation due to vertical migration.
- extent of withdrawal zone as related to the total River.
- intake avoidance mechanisms.
- population depletion in the vicinity of the intake due to plant operation.
- cropping across plant.
"BASE" CONDITIONS
• Distribution of organisms as related to space and time (total in the River and for each segment)
• End-of-stage population.
CONDITIONS WITH PLANT IN OPERATION
• Distribution of organisms as related to space and time (total in the River and for each segment)
• End-of-stage population.
IMPACT OF PLANT OPERATION
• Percentage reduction in each life stage.
• Cumulative reduction from the egg stage through young of year.
• Cumulative reduction in total population.

FIGURE 2

to the model is accomplished by dividing the river into twelve ten mile segments (see Table 1) and evaluating parameters on a time scale of one week.

Mass Transport Parameters

During the egg and early larval stages of the striped bass life cycle, the organisms are generally presumed to be relatively strongly susceptible to hydrodynamic transport. Those not close to the river bottom are, therefore, presumed to be transported by the tidal action and freshwater flow in the Hudson. When the striped bass mature into the juvenile stage they appear to have sufficient swimming ability to avoid the river's motion. Consequently, values for the mass transport parameters of flow and dispersion are required only for the period when eggs and larval are present in the river. Migration factors, obtained from observed behavior of the juveniles, are employed to characterize juvenile activity.

River freshwater flow, as a function of river segment and variable periods over the months May through July, was taken from data provided by the USGS (10). Values used are shown in Table 2. Mixing or dispersion coefficients for the same period were calculated as a function of space and time using the freshwater flow information and a freshwater flow dispersion coefficient relationship developed for the Hudson River (7). Dispersion coefficients used are shown in Table 3.

The segment numbers, milepoint ranges, and volumes are shown in Table 4. Also shown are the volumes of the upper and lower (bottom four feet) layers of the segments. The volume of the bottom layer of each segment was determined by calculating the volumes of two slabs each four feet deep and five miles long

TABLE 1

HUDSON RIVER SEGMENTS
USED IN TRANSPORT MODEL
FOR EVALUATION OF
INDIAN POINT AND OTHER PLANTS OPERATION

Number of Segment	River Mile Point Range	Plants Within Segment
1	120-130	
2	110-120	
3	100-110	
4	90-100	
5	80-90	
6	70-80	
7	60-70	Danskammer Roseton
8	50-60	Cornwall
9	40-50	Indian Point Lovett
10	30-40	Bowline
11	20-30	
12	10-20	

TABLE 2

1973 HUDSON RIVER FRESH WATER FLOW RATES USED IN THE MODEL*
(CUBIC MILES/DAY)

	Seg. No. / Mile Point / Week	1 120-130	2 110-120	3 100-110	4 90-100	5 80-90	6 70-80	7 60-70	8 50-60	9 40-50	10 30-40	11 20-30	12 10-20
1.	4/29-5/12	.0110	.0114	.0117	.0123	.0127	.0130	.0130	.0130	.0130	.0130	.0130	.0130
2.	5/13-5/26	.0252	.0257	.0274	.0282	.0292	.0303	.0303	.0303	.0303	.0303	.0303	.0303
3.	5/27-6/2	.0167	.0173	0.0178	.0185	.0191	.0197	.0197	.0197	.0197	.0197	.0197	.0197
4.	6/3-6/9	.0100	.0102	.0105	.0107	.0110	.0112	.0112	.0112	.0112	.0112	.0112	.0112
5.	6/10-6/16	.0076	.0078	.0082	.0083	.0086	.0087	.0087	.0087	.0087	.0087	.0087	.0087
6.	6/17-6/23	.0058	.0058	.0060	.0061	.0063	.0064	.0064	.0064	.0064	.0064	.0064	.0064
7.	6/24-6/30	.0083	.0086	.0090	.0093	.0096	.0099	.0099	.0099	.0099	.0099	.0099	.0099
8.	7/1-7/7	.0146	.0148	.0152	.0154	.0159	.0162	.0162	.0162	.0162	.0162	.0162	.0162
9.	7/8-7/14	.0052	.0053	.0053	.0054	.0055	.0057	.0057	.0057	.0057	.0057	.0057	.0057
10.	7/15-8/4	.0038	.0039	.0039	.0040	.0041	.0043	.0043	.0043	.0043	.0043	.0043	.0043

*Based on USGS gaging station readings at Green Island, N.Y. (10) and LMS's analysis of long-term hydrological data for the lower Hudson River.

TABLE 3

1973 DISPERSION COEFFICIENTS USED IN THE MODEL*
[(MILE)^2/DAY]

	Seg. No. Mile Point Week	1 120-130	2 110-120	3 100-110	4 90-100	5 80-90	6 70-80	7 60-70	8 50-60	9 40-50	10 30-40	11 20-30	12 10-20
1.	4/29-5/12	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.20	2.30	4.20	9.00	13.30
2.	5/13-5/26	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.15	2.40	3.80	8.50
3.	5/27-6/2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.50	3.00	6.20	10.50
4.	6/3 -6/9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.50	3.00	4.40	9.30	14.00
5.	6/10-6/16	1.0	1.0	1.0	1.0	1.0	1.1	1.30	1.80	3.50	5.50	10.40	16.00
6.	6/17-6/23	1.0	1.0	1.0	1.0	1.10	1.30	1.80	3.60	5.70	8.50	12.30	18.20
7.	6/24-6/30	1.0	1.0	1.0	1.0	1.0	1.0	1.20	1.60	3.10	4.70	9.60	14.90
8.	7/1- 7/7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.20	1.90	4.00	8.00	12.00
9.	7/8- 7/14	1.0	1.0	1.0	1.0	1.0	1.2	2.20	4.10	6.70	9.60	13.00	18.90
10.	7/15-8/4	1.0	1.0	1.0	1.1	1.3	1.80	3.60	5.90	8.90	11.63	14.40	20.37

*Reference 10 and 7

TABLE 4

HUDSON RIVER VOLUMES OF 10-MILE SEGMENT, UPPER, BOTTOM (BOTTOM 4 ft.) LAYERS AND SHALLOWS

SEGMENT NO.	MILE POINT RANGE	AVERAGE CROSS-SECTION AREA (10^5 FT^2)	SEGMENT VOLUME (10^4 TCM)	UPPER LAYER VOLUME (10^4 TCM)	LOWER LAYER VOLUME (10^4 TCM)	VOLUMES OF SHALLOWS (10^4 TCM)
1	120-130	0.2983	5.2438	3.9629	1.2809	0.716
2	110-120	0.4461	7.6925	5.8337	1.8588	0.985
3	100-110	0.8336	11.0743	8.7171	2.3572	0.440
4	90-100	1.0900	15.7354	13.1588	2.5766	0.954
5	80-90	1.1151	17.6251	15.6315	1.9936	0.597
6	70-80	1.2350	19.3707	17.9255	1.4452	0.297
7	60-70	1.5389	21.3640	18.8522	2.5118	0.985
8	50-60	1.7257	22.4262	20.1138	2.3124	1.044
9	40-50	1.4943	23.9786	22.2766	1.7020	2.152
10	30-40	1.9459	30.0881	23.4796	6.6085	10.794
11	20-30	2.0463	29.1856	24.1970	4.9886	5.082
12	10-20	1.3744	20.8653	18.0084	2.8569	1.345

TCM = thousand cubic meters

*Volume of lower layer represents the volume of the bottom 4 feet. It was computed by multiplying 4 ft. by the average width of a 5-mile segment and summing two 5-mile segment volumes to obtain the 10-mile segment volume.

with widths equal to the average width over the first and second five mile intervals in the segment. The volumes of the two slabs were summed to give the volume of the bottom layer of the segment. Subtracting the volume of the bottom layer from the segment volume gave the volume of the upper layer of the segment. The volumes of the upper and lower layers of the segments were used to estimate the fraction of each life stage found in the bottom four feet of the river. The details of the procedure used to determine this fraction are discussed below under "Egg Production Parameters."

It has been assumed that the portion of the organisms near the bottom of the estuary can be used to estimate what fraction of the organisms will not be significantly affected by the macro-scale transport mechanism in the river.

There are a number of justifications for this assumption. First, velocity measurements by a number of investigators (13) in the Hudson indicate that velocity near the river bottom is much smaller than that in the upper layers. Among the results presented are measurements which indicate that flows two feet from the bottom may be only 20% of the flows at mid-depth. This is to be expected due to the effect of friction at the river bottom. In fact, the friction drag causes the water velocities to go to zero directly at the river bottom. Deep holes in the river bed cause "dead zones" near the river bottom. In these holes, mixing and turbulence cause dispersive activity but there is very little net movement of water upstream or downstream.

A number of biological measurements give further evidence of reduced transport of the organism. In the egg stage, the density of the eggs is an important consideration. Nicholson and Lewis (11) state that striped bass eggs are slightly more dense than water. This causes the eggs to concentrate near the river bottom and also reduces the influence of the river's transport mechanisms on these organisms, since particles more dense than water will be transported at rates less than the movement of the water molecules.

The early larval stage is found near the bottom of the river like the eggs. Using the computational procedure described below, the fraction of the yolk sac found in the bottom four feet of the river was estimated to be .38. As the larvae mature into the post yolk sac stage they are able to avoid the river's transport mechanisms due to their increased swimming ability. Texas Instruments' (9) 1973 data also indicate that the later larvae move to the shoal and shore areas. The capability of the larvae to move to these areas and the expected reduced flow conditions in the shoals vis à vis the channel lead to reduced transport of the organisms. All of the above factors contribute to the transport avoidance factor for the larval stage.

Evidence that all the organisms in the egg and larvae stages are not transported by the hydrodynamics in the estuary can be found in the beach seine data collected by Texas Instruments (9). These data show some juveniles between milepoints 120 and 130 in early July. Further, the average total lengths of the young striped bass captured in the beach seines above milepoint 100 show a steady growth from 15 mm at the beginning of July to 50 mm at the end of July. Since there is no indication of significant spawning above milepoint 130, this suggests that some of the young striped bass are maturing in the area which they are spawned and are not being influenced by the transport mechanisms in the estuary.

As mentioned earlier, LMS's transport model has been modified to include an avoidance factor in the mass transport terms of the model equations. In the present study, the avoidance factor was assumed to be equivalent to the fraction of organisms found in the bottom four feet of the river. Movement to shoals and swimming ability of later larvae also contribute to the transport avoidance factor (TAF) but numerical evaluation of these effects has not been attempted here.

Using the data analysis techniques described below, transport avoidance factors (the fraction of organisms in the bottom four feet of the river) for eggs and larvae were calculated to be .58 and .20, respectively. For each stage, the convection and dispersion terms in the transport model were multiplied by (1 - TAF). A sensitivity analysis of the effects of this parameter on model predictions is presented with the results of model runs shown in Lawler's Cornwall testimony (5).

Fish Life Cycle Parameters

LMS's model of the Hudson River striped bass population requires a variety of life cycle parameters which quantify the biological aspects of the model. For convenience, the fish life cycle parameters are discussed below under the categories shown in Figure 2.

Egg Production Parameters

The computational procedure described in Lawler's October 1972 testimony (2) was used to calculate the egg production rate from egg data collected by Texas Instruments in 1973. In computing numbers of eggs from the data supplied by Texas Instruments, the samples collected by the two types of gear used were weighted by depth. The computational procedure as outlined below is based on the assumption that the concentration of eggs collected by the epibenthic sled represents the concentrations of eggs in the bottom four feet of the river.

1. Average concentrations of eggs collected in the epibenthic sled and the Tucker trawl samples were calculated for each week over each ten mile segment.

2. The average concentration in the sled samples was multiplied by the volume of the lower layer (bottom four feet) of the river. This gave the number of eggs in the bottom layer, N_L.

3. The number of eggs in the upper layer, N_u, was determined from the product of the average concentration in the Tucker trawl and the volume of the upper layer.

4. The sum of N_L and N_u gave the total number of eggs in the segment, N_T.

A graphical integration procedure was used to find the egg production rate from the N_T values. Using an egg gestation period of 1.5 days, and an egg survival of 10%, the total egg production in the river during the 1973 spawning season was calculated to be about 2.8 billion eggs. This is nearly one billion more eggs than the 1.9 billion estimate given in Lawler's October 30, 1972 testimony (2) in which the 1967 HRFI (8) data were used. (The same computational procedure and same assumptions on egg gestation and survival were used for each estimate.) The 2.8 billion figure is almost certainly an underestimate of the actual number of eggs spawned in the river, largely due to the inability to sample at the bottom and to gear efficiency.

Tables 5 and 6 give the fractional time and space distribution of the egg production for each segment and each week of spawning between April 30 and June 17. These fractional values are multiplied as shown at the bottom of

TABLE 5

FRACTIONAL DISTRIBUTION OF EGG PRODUCTION

(Texas Instruments 1973 Data, Reference 9)

TIME DISTRIBUTION OF TOTAL ESTUARY EGG PRODUCTION

Week Number	Calendar Time	Egg Production, Fe*	Starting Time, ts (Days)	Ending Time, te (Days)
1	April 30 - May 6	.0016	0	7
2	May 7 - May 13	.1826	7	14
3	May 14 - May 20	.5108	14	21
4	May 21 - May 27	.0594	21	28
5	May 28 - June 3	.2148	28	35
6	June 4 - June 10	.0191	35	42
7	June 11 - June 17	.0117	42	49
	Total	1.0000		

*See Lawler's October 30, 1972 testimony (2) for computational procedure.

TABLE 6

FRACTIONAL DISTRIBUTION OF EGG PRODUCTION
(Texas Instruments 1973 Data, Reference 9)

WEEKLY SPATIAL DISTRIBUTION (BY RIVER SEGMENT)

Fraction (fsi) of Each Week's Production Assigned to Each 10-Mile River Segment

Week Number	Segment: Mile Pt.:	1 120-130	2 110-120	3 100-110	4 90-100	5 80-90	6 70-80	7 60-70	8 50-60	9 40-50	10 30-40	11 20-30	12 10-20	Total
1		.000	.000	.101	.000	.899	.000	.000	.000	.000	.000	.000	.000	1.000
2		.003	.001	.000	.000	.099	.000	.116	.772	.009	.000	.000	.000	1.000
3		.000	.001	.005	.006	.222	.015	.085	.146	.286	.213	.021	.000	1.000
4		.000	.000	.000	.000	.024	.000	.000	.652	.214	.000	.000	.000	1.000
5		.005	.001	.001	.002	.177	.077	.041	.680	.011	.005	.000	.000	1.000
6		.005	.026	.114	.021	.215	.038	.194	.174	.213	.000	.000	.000	1.000
7		.005	.000	.000	.000	.000	.026	.000	.018	.744	.207	.000	.000	1.000

Daily Egg Production Rate Introduced to Transport Model Segment i $= 2.8 \times 10^9 \times \left(\frac{F_E*}{t_e - t_s}\right) \times fsi,$

See Lawler's October 30, 1972 testimony (2)

* From Table 5.

Table 6 to obtain the egg production rate in eggs/segment/day. These results are input to the egg stage of the transport model to initiate the calculations for each segment.

Age Distribution

Within the transport model, the population of each stage is broken into a sequence of ages to permit the proper tracking of the movement of different age fish along the river as they mature. The procedure used in the present study was identical to that described in previous testimony (2).

Survival Rates and Stage Duration

The stage length and survival percentages used were nearly identical to those presented in Lawler's October 1972 testimony (2). For convenience, these parameter values are shown in Table 7.

Compensation Parameters

The compensation mechanism presented in Lawler's October 1972 testimony (2) was employed as discussed in that document. The level of compensation is indicated by the value of the ratio of the minimum mortality rate to the first order rate, KO/KE. The two values of this ratio used were 0.5 and 0.8 which are indicative of high and moderate compensation levels, respectively. More detailed discussion of compensation appears in the section entitled "Interpretation of Results," toward the end of this study.

Migration Parameters

When the young striped bass reach approximately one inch in length they pass from the larval stage into the juvenile stage. Beginning with the post yolk

TABLE 7

COMPARISON OF PRIMARY STAGE LENGTH AND SURVIVAL PERCENTAGES EMPLOYED IN OCTOBER 30, 1972 TESTIMONY [(2)] AND THE PRESENT STUDY

Parameter	October 30, 1972 Testimony [(2)]	Present Study
Stage Length (days)		
Egg	1.5	1.5
Larval	28	28
Juvenile I	30	30
Juvenile II	123 (average)*	123
Juvenile III	158	158
Survival Rates (%)		
Egg	10	10
Larval	15 to 50	15
Juvenile I	20	20
Juvenile II	50	53
Juvenile III	18.98	18.6
Start of Spawn	May 7, 1967	April 30, 1973
Spawn Time (days)	49	49
Eggs Produced**	2 Billion±***	3 Billion±***
Begin over Wintering Period	December 1	December 1

* Minimum = 98.5 days, maximum = 147.5 days

** Based on relative abundances obtained by sampling standing crop

*** For indentification purposes, the precise numbers used were 2,157,750,000 in October 1972 testimony (2) and 2,812,750,000 in the present analysis sac larval stage, the young fish become increasingly less planktonic, their swimming ability improves and results in a non-passive response to river hydrodynamics.

Nicholson and Lewis (11) as well as others have indicated that striped bass begin to migrate to the shoal areas of the river when they are about one half inch in length. Analysis of the beach seine data collected by Texas Instruments, Inc. during 1973 (9) confirms this notion. Therefore, to simulate the longitudinal distribution of these juveniles in the model, migration preferences, which are indicative of the distribution of juveniles, were calculated as described below using the 1973 Texas Instruments beach seine data and input to the model.

1. Estimate the volume of water sampled by the beach seine. The sample volume was approximated by the product of the width of the net and the area of a semicircle with a perimeter equal to the length of the net (50 or 100 feet, depending on the gear used).

2. Divide the number of striped bass in a given seine by the estimated sample volume to yield the relative concentration of stripers in the shoal area.

3. Multiply the average shoal area concentration for a given week and a given ten mile segment by the volume of the shoals in the segment to give the number of fish per segment.

The migration preferences for the juvenile I and II stages shown in Table 8 were determined by calculating the ratio of the number of fish in a given segment to the total number of fish in the river. Migration preferences for juvenile III were assumed equal to those for juvenile II since data could not be obtained for the winter months due to ice cover.

TABLE 8

MIGRATION PREFERENCES
(1973 Texas Instruments Beach Seine Data, Reference 9)

Segment Number	River Mile Point Range	Migration Preferences J I	J II	J III
1	120-130	.0028	.0030	.0030
2	110-120	.0026	.0025	.0025
3	100-110	.0012	.0003	.0003
4	90-100	.0066	.0008	.0008
5	80-90	.0064	.0024	.0024
6	70-80	.0069	.0011	.0011
7	60-70	.0253	.0047	.0047
8	50-60	.1382	.0331	.0331
9	40-50	.0698	.0486	.0486
10	30-40	.4000	.7034	.7034
11	20-30	.2386	.1755	.1755
12	10-20	.1016	.0246	.0246

The computational procedure used to simulate the migration phenonenon in the model was identical to that described in Lawler's October 1972 testimony (2).

Life Stage Cycling Parameters

Estimates of sex ratios, maturity indices, and fecundities for adult striped bass are shown in Table 9. Maturity indices and fecundity information are taken from Texas Instruments' 1973 data (12). The sex ratios are the same as those used in Lawler's October 1972 testimony (2).

Plant and Impact Parameters

To predict the cropping of fish populations by power plants on the Hudson River, the transport model requires data concerning the location of the plants, the plant flow rates and the rate at which various life stages of the fish will be drawn into the plant. The location of the plants considered in the study are shown in Figure 1. The other parameters are discussed below.

Plant Flow Rates

The flow rates of the various units at Indian Point, Bowline and Roseton and their operating schedules are shown in Table 10, as supplied by Con Edison. The detailed operating schedules call for periodic down times and/or reduced flows at each of the various units for maintenance purposes. Since these maintenance schedules are of relatively short durations (about one month per year for complete shut-off or one or two months per year for reduced flow), they are not included in the plant flow input to the model. In other words, the plants are assumed to be operating continuously without interruptions. This approach should give conservative estimates of plant impact.

TABLE 9

SELECTED FERTILITY FACTORS

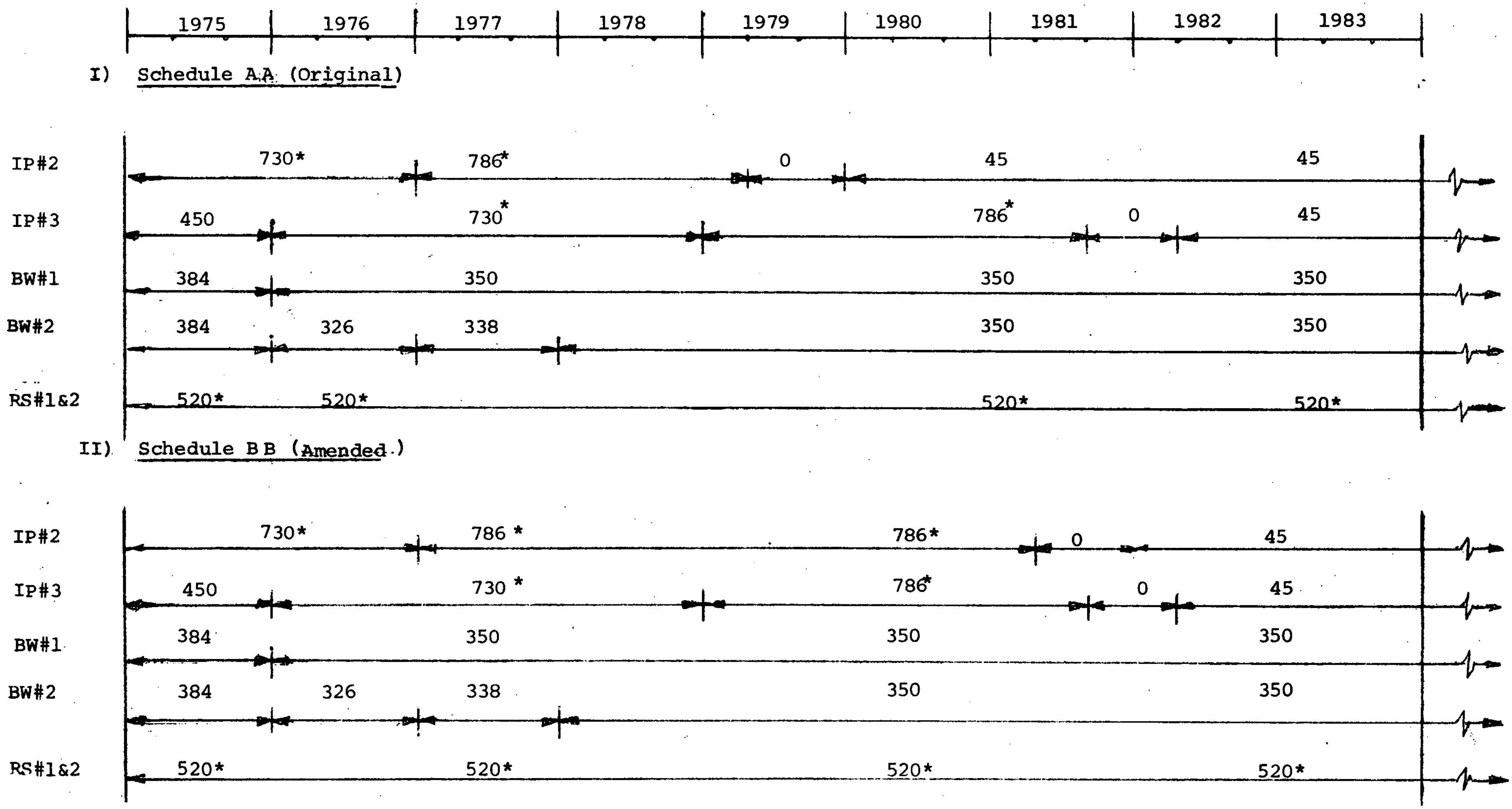
Age Group	Female Fraction*	Female Maturity	Fecundity (Eggs/Fertile Female)
1	.50	0	0
2	.52	0	0
3	.54	0	0
4	.56	0	0
5	.58	0	0
6	.60	.67	451,000
7	.62	1.0	780,000
8	.64	1.0	1,543,000
9	.66	1.0	1,563,000
10	.68	1.0	1,841,000
11	.70	1.0	2,095,000**
12	.70	1.0	2,350,000
13	.70	1.0	2,269,000**
14	.70	1.0	2,189,000

*Values between age group 1 and 11 were linearly interpolated from estimates of age group 1 and 11 female fractions.

**Computed by interpolation using data for years 10, 12 and 14.

TABLE 10

INDIAN POINT, BOWLINE AND ROSETON PLANT FLOW RATES (in 1000 gpm) AND OPERATING SCHEDULES
(Supplied by Consolidated Edison Co. of New York, Inc.)



Note: IP = Indian Point; BW=Bowline; RS = Roseton
* 534,000 gpm for each of IP#2 & #3 during Oct.-Mar. and 730,000 or 786,000 gpm during Apr.-Sept.
336,000 gpm for both RS #1 & #2 during Dec.-Apr. and 520,000 gpm during May-Nov.

The plant flow rates input to the transport model are shown in Table 11.

Entrainment Impact Factors

The transport equations in the LMS model of the Hudson River striped bass population predict the concentration of the various striped bass life stages at a given time and location in the river. In order to predict the cropping effects of the entrainment of organisms by plant withdrawal of river water, it is necessary to evaluate the ratio:

$$\frac{\text{(concentration of live organisms in plant intake water)}}{\text{(cross-sectional average concentration of live organisms in the river)}}$$

The methodology developed to evaluate this ratio is described in detail in Lawler's October 30, 1972 testimony (2), under the heading "f factors." This terminology was coined to reflect the variety of phenomena which lead to a value of the foregoing ratio of less than unity, including larval vertical diurnal motion, plant intake withdrawal zone, long term drawdown, and juvenile avoidance mechanisms.

Evaluation of the above ratio from data measurements permits an estimation of the number of organisms withdrawn by the plant. Field and laboratory data also suggest that many of the organisms drawn into the plants will be returned to the river alive. The f factors described below allow the model to account for the heterogeneous distribution of the organisms and the expected fractional mortality.

The basic approach used in determining the f factors is described in Lawler's October 1972 testimony (2). Modifications of that previous strategy are discussed below.

TABLE 11

PLANT FLOW RATES USED IN THE MODEL

NO.	YEAR	Schedule AA (Original) IP#2	Schedule AA IP#2&3	Schedule AA BW#1&2	Schedule AA RS#1&2	Schedule BB (Amended) IP#2	Schedule BB IP#2&3	Schedule BB BW#1&2	Schedule BB RS#1&2
I) Flow Rates in 1000 GPM									
1	1975	730*	1498*Δ	768	520*	730*	1498*Δ	768	520*
2	1976	730*	1180*	676	520*	730*	1180*	676	520*
3	1977	786*	1516*	688	520*	786*	1516*	688	520*
4	1978	786*	1516*	700	520*	786*	1516*	700	520*
5	1979	15	801*	700	520*	786*	1572*	700	520*
6	1980	45	831*	700	520*	786*	1572*	700	520*
7	1981	45	569	700	520*	45	569	700	520*
8	1982	45	90	700	520*	45	90	700	520*
9	1983-2025	45	90	700	520*	45	90	700	520*
II) Flow Rates in 10^{-3} Cubic Mile/Day									
1	1975	0.9548	1.9593	1.0045	0.6801	0.9548	1.9593	1.0045	0.6801
2	1976	0.9548	1.5434	0.8842	0.6801	0.9548	1.5434	0.8842	0.6801
3	1977	1.0280	1.9828	0.8999	0.6801	1.0280	1.9828	0.8999	0.6801
4	1978	1.0280	1.9828	0.9156	0.6801	1.0280	1.9828	0.9156	0.6801
5	1979	0.0196	1.0477	0.9156	0.6801	1.0280	2.0561	0.9156	0.6801
6	1980	0.0589	1.0869	0.9156	0.6801	1.0280	2.0561	0.9156	0.6801
7	1981	0.0589	0.7442	0.9156	0.6801	0.0589	0.7442	0.9156	0.6801
8	1982	0.0589	0.1177	0.9156	0.6801	0.0589	0.1177	0.9156	0.6801
9	1983-2025	0.0589	0.1177	0.9156	0.6801	0.0589	0.1177	0.9156	0.6801

Note: 1000 GPM= 1.30793×10^{-6} Cubic Mile/Day
IP = Indian Point; BW=Bowline; RS=Roseton
*534,000 GPM for both IP #2 & #3 during Oct.-Mar.; 730,000 or 786,000 GPM during Apr.-Sept.
336,000 GPM for both Roseton #1&2 during Dec.-Apr.; 520,000 GPM during May-Nov.
ΔInadvertently, an additional flow of 318,000 gpm was included.

The Composite f factor and its Components

In Lawler's April 1972 testimony (1), the composite f factor for a given life stage is given as:

$$f_1 \cdot f_2 \cdot f_3 \cdot f_c$$

in which:

- f_1 = ratio of the daily average river concentration of organisms in the near vicinity of the intake to $\bar{\bar{N}}_i$, the overall cross-sectional average concentration.
- f_2 = ratio of the actual intake concentration to $f_1 \cdot \bar{\bar{N}}_i$, under existing conditions of operation.
- f_3 = a factor which recognizes that population depletion in the immediate vicinity of the intake may not be immediately replenished.
- f_c = fraction of organisms destroyed by passage through the plant.

The revised procedure for calculating the composite f factors is:

$$(f)_{Day} = (f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c)_{Day}$$

$$(f)_{Night} = (f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c)_{Night}$$

$$\text{Composite } f = (f)_{Day} + (f)_{Night}$$

where:

- f'_D, f'_N = ratio of daytime and nighttime cross-sectional river concentration to 24 hour average concentration.
- F_{wD}, f_{wN} = weighting factor based on hours of daytime and nighttime plant operation during the entrainment period.

$$f_{wD} = 15/24 = .625$$

$$f_{wN} = 9/24 = .375$$

The f' factor represents a modification in the computational procedure which has been introduced to account for day-night differences in the river area-averaged concentrations computed from field data. For the early life stages, the transport model generates average river concentrations of organisms over a 24 hour period. Designate such concentrations as $\bar{C}_R$. The f_1, f_2 and f_3 factors were originally defined so that their product gave:

$$\frac{\text{Intake Concentration}}{\text{River Cross Section Concentration}} = \frac{\bar{C}_I}{\bar{C}_R}$$

In the above, $\bar{C}_I$ is the average plant intake concentration. The 24-hour plant entrainment rate is $Q_p \bar{C}_I$, in which Q_p is plant flow, assumed to be consistent over the 24 hour period. Since $\bar{C}_I = f_1 \cdot f_2 \cdot \bar{C}_R$, plant entrainment rate could then be written in terms of the model generated concentration parameter, $\bar{C}_R$, i.e.,

$$\text{entrainment rate} = Q_p\, C_I = f_1 \cdot f_2 \cdot Q_p \quad \bar{C}_R$$

On the hypothesis that extensive longitudinal movements of the organisms would not occur on so short a time scale, theoretically one would expect $\bar{C}_{R,Night}$ = $\bar{C}_{R,Day}$; i.e., the overall tidal-smoothed, area-averaged river concentration should be consistent, regardless of the vertical movement taking place.

Field measurements, however, sometimes result in rather wide variations between the nighttime and daytime river average concentrations. This may be partially due to longitudinal transport, but factors such as relatively inefficient bottom sampling and increased gear avoidance during daylight hours may also account for the divergence.

To treat the situation as observed, the following modification in the f factor analysis was developed.

Average 24 hour entrainment rate is written:

$$f_{wD} \quad [Q_p \; \bar{C}_I]_{Day} \; + \; f_{wN} \quad [Q_p \; \bar{C}_I]_{Night}$$

in which:

$$f_{wD} = \text{weight factor for daylight operation} = \frac{\text{hours of daylight operation}}{24}$$

$$f_{wN} = \text{weight factor for nighttime operation} = \frac{\text{hours of operation in darkness}}{24}$$

$\bar{C}_{I_{Day}}$ = average daytime intake concentration

$\bar{C}_{I_{Night}}$ = average nighttime intake concentration

In terms of f factors, the foregoing can be written as:

$$f_{wD} \quad [Q_p \cdot f_1 \cdot f_2 \cdot \bar{C}_R]_D \; + \; f_{wN} \; [Q_p \cdot f_1 \cdot f_2 \cdot \bar{C}_R]_N$$

This expression can be written in terms of the average 24 hour river concentration $\bar{C}_R$ as follows:

$$C_R \; [\, f_{wD} \cdot Q_{p_D} \cdot f_{1_D} \cdot f_{2_D} \cdot \frac{\bar{C}_{R_D}}{\bar{C}_R} + f_{wN} \cdot Q_{p_N} \cdot f_{1_N} \cdot f_{2_N} \cdot \frac{\bar{C}_{R_N}}{\bar{C}_R} \,]$$

Similarly, to recognize the possibility of flow variation between day and night, the expression can be written:

$$Q_p \;\; C_R \; [\, f_{wD} \cdot f_{1_D} \cdot f_{2_D} \cdot \frac{Q_{p_D}}{Q_p} \cdot \frac{\bar{C}_{R_D}}{\bar{C}_R} + f_{wN} \cdot f_{1_N} \cdot f_{2_N} \cdot \frac{Q_{p_N}}{Q_p} \cdot \frac{\bar{C}_{R_N}}{\bar{C}_R} \,]$$

Now let $f'_D = \frac{\bar{C}_{R_D}}{\bar{C}_R}$, $f'_N = \frac{\bar{C}_{R_N}}{\bar{C}_R}$

and $f''_D = \frac{Q_{P_N}}{Q_P}$, $f''_D = \frac{Q_{P_N}}{Q_P}$

The average 24 hour entrainment rate then becomes:

$$Q_p \bar{C}_R \; [f_w \cdot f' \cdot f'' \cdot f_1 \cdot f_2)_D \quad + \quad f_w \cdot f' \cdot f'' \cdot f_1 \cdot f_2)_N]$$

in which the f' and f" are simply the ratios of the daytime and nighttime river concentrations and plant flows to the 24 hour average river concentration and plant flow, respectively. Since plant flows generally do not vary over the 24 hour day, the f" are generally set to unity and the above reduces to the simpler expression given at the beginning of this section.

Notice in the above that, when there is no divergence between the river daytime and nighttime area-average concentrations, $\bar{C}_{R_D} = \bar{C}_{R_N} = \bar{C}_R$ and therefore $f'_D = f'_N = 1.0$. For this case, the expression presented above reduces to the original expression given in Lawler's October 1972 testimony (2).

CALCULATION OF f FACTORS FROM FIELD DATA

Detailed computational procedures used to evaluate the individual f factors from field data can be found in Lawler's October 1974 testimony before the Federal Power Commission (5). For convenience, brief descriptions of the f factor calculations are discussed below.

The f_1 factor - Both Method A (assigning double weight to mid-channel values) and Method B (assigning uniform lateral weight) were used in calculating the f_1 factors at all plants. When transect data were available for several sample dates, the f_1 factors for day and night were calculated as:

$$f_1 = \frac{\dfrac{\sum_{i=1}^{n} (\text{Upper East or West Quadrant Concentration})_i}{n}}{\dfrac{\sum_{i=1}^{n} (\text{Cross-sectional Concentration})_i}{n}}$$

where n = number of sample dates.

For the larval stage, the f_1 factor was computed by adding the average quadrant concentrations for the yolk sac and post yolk sac stages and dividing by the sum of the average cross-sectional concentrations for the two stages.

The sample dates included in the calculation of the average quadrant cross-sectional concentrations began with the first appearance of a given life stage in either the plant or river samples and ran through to the last day on which the life stage was captured.

The f_2 factor - The average concentration of organisms in the intake and/or discharge samples was determined by finding the total number of organisms captured for a given life stage and dividing by the total of all sample volumes. In equation form this is:

$$C_{AVG} = \frac{\sum_{i=1}^{m} N_i}{\sum_{i=1}^{m} V_i}$$

where:

m = number of samples

V_i = sample volume for i^{th} sample

N_i = number of organisms of a given life stage captured in the i^{th} sample.

When all the V_i are equal, this approach is identical to:

$$C_{AVG} = \frac{\sum_{i=1}^{m} C_i}{m}$$

where:

$$C_i = \frac{N_i}{V_i}$$

For the larval stage, the yolk sac and post yolk sac organisms captured were both included in the summation to determine the total number of organisms captured.

In some cases, the field data were collected at both the intake and discharge of a plant. When these data were applicable, the C_{AVG} values calculated from the intake and discharge samples were averaged with equal weighting to give the final estimate of the concentration of organisms entering the plant. In any case, the goal was an estimate of the numerator of the f_2 factor.

The denominator of the f_2 factor was set equal to the numerator of the f_1 factor. The net result of the product of f_1 and f_2 is simply the ratio of intake concentration to river concentration.

Averaging of data from several sample dates was performed over the same period of abundance used in computing the f_1 factor.

The f_3 factor - No information is available concerning the rate at which organisms withdrawn by the plant will be replenished in the water immediately in front of the plant. Consequently, although it is believed that it must be less than 1.0, particularly beyond the larval stage, a value of 1.0 has been selected for this parameter for all three early stages.

The f' factor - The f' factor was evaluated directly from the field measurements at the river transects in front of the plant, using the procedures described on pages 14 through 17.

The f_w factor - The day and night weight factors were evaluated on the basis of the expected hours of day and night plant operation.

The f_c factor - When data were available, the f_c factor was evaluated by the following defining formula:

$$f_c = \frac{(\%\text{ Alive in Plant Intake} - \%\text{ Alive in Plant Discharge})}{\%\text{ Alive in Plant Intake}}$$

The composite f factor - The composite f factor was evaluated by Methods A and B described above and the results from the two methods were averaged to give the final value.

Indian Point Entrainment Factors

The f factors at Indian Point were evaluated from data collected by New York University (NYU) during 1973. The data used in the present analysis were in preliminary form and may have to be revised when NYU has completed their statistical analysis of the data. The f factors calculated from the river transect data and the data collected at plant intakes and discharges are shown in Tables 12 through 14. In evaluating the f_2 factor for the larval stage, the data collected at the plant discharge were used. The intake data were not in usable form for the present study. For the egg and juvenile I stages, the f_2 factor was assigned the value 1.0 because no data were available to evaluate it.

The f_w factor was evaluated on the basis of 15 hours of daylight and 9 hours of darkness for the months May through July and on the basis of 24-hour plant operation.

The f_c factors at Indian Point were calculated from data collected by NYU during 1973 while Indian Point Unit 2 was operating without any thermal load. Using the formula defined above, the f_c factors calculated for the egg, larval and juvenile I stages are 0.8, 0.6 and 0.7, respectively. These values are assumed to be the present "best estimate" of f_c at all thermal plants because laboratory tests by NYU during 1972 indicate that the added mortality due to thermal effects will not be significant unless the river temperature is abnormally high (10).

Bowline Entrainment Factors

The f factors for the Bowline plant were calculated from data collected in the Bowline pond, the plant intake and discharge, and in the river in front of the

TABLE 12

INDIAN POINT 1973 STRIPED BASS EGG STAGE COMPOSITE f * FACTOR
(3 Sampling Dates Between May 29 and June 13)

	DAY		NIGHT	
	Method A	Method B	Method A	Method B
River Cross-sectional Concentration (#/TCM)	24.155	23.850	21.466	20.428
Weighted River Cross-sectional Concentration (#/TCM)	15.097	14.906	8.050	7.661
River 24-hour Average Concentration (#T/TCM)	23.147	22.567	23.147	22.567
River Concentration near Intake (#/TCM)	17.295	14.930	5.452	8.416
Intake: No. of eggs				
Volume strained (TCM)				
Concentration (#/TCM)	---	---	---	---
Discharge:				
No. of eggs				
Volume strained (TCM)				
Concentration (#/TCM)	---	---	---	---
Plant Concentration (Average of Intake and Discharge) (#/TCM)	---	---	---	---
f'	1.044	1.057	0.927	0.905
f_w	0.625	0.625	0.375	0.375
f_1	0.716	0.626	0.254	0.412
f_2**	1.000	1.000	1.000	1.000
f_3**	1.000	1.000	1.000	1.000
f_c***	0.800	0.800	0.800	0.800
$f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c$	0.374	0.331	0.071	0.112
Composite f	Method A = 0.445;		Method B = 0.443	

* Composite f $= (f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c)$ Day + $(f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c)$ Night

#/TCM = number of organisms per thousand cubic meters

** 1.0 is assumed for lack of data.

*** Conservative estimate, based on NYU studies.

TABLE 13

INDIAN POINT 1973 STRIPED BASS LARVAL STAGE COMPOSITE f * FACTOR
(3 Sampling Dates between May 29 and June 13)

	DAY		NIGHT	
	Method A	Method B	Method A	Method B
River Cross-sectional Concentration (#/TCM)	269.47	260.50	331.12	289.89
Weighted River Cross-sectional Concentration (#/TCM)	168.419	162.813	124.170	108.709
River 24-hour Average Concentration (#T/TCM)	292.589	271.522	292.589	271.522
River Concentration near Intake (#/TCM)	239.91	178.74	297.58	175.44
Intake: No. of larvae (ys + pys)				
Volume strained (TCM)				
Concentration (#/TCM)	-	-	-	-
Discharge:				
No. of larvae (ys + pys)				
Volume strained (TCM)				
Concentration (#/TCM)	74.346	74.346	31.420	31.420
Plant Concentration (Average of Intake and Discharge) (#/TCM)	74.346	74.346	31.420	31.420
f'	0.921	0.959	1.132	1.068
f_w	0.625	0.625	0.375	0.375
f_1	0.890	0.686	0.899	0.605
f_2	0.310	0.416	0.106	0.179
f_3**	1.000	1.000	1.000	1.000
f_c***	0.600	0.600	0.600	0.600
$f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c$	0.095	0.103	0.024	0.026
Composite f	Method A = 0.119;		Method B = 0.129	

* Composite f $= (f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c)$ Day + $(f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c)$ Night

#/TCM = number of organisms per thousand cubic meters

ys = yolk-sac larvae; pys = post yolk-sac larvae

** 1.0 is assumed for lack of data.

*** Conservative estimate, based on NYU studies.

TABLE 14

INDIAN POINT 1973 STRIPED BASS JUVENILE I STAGE COMPOSITE f * FACTOR
(4 sampling dates between June 26 and July 18)

	DAY		NIGHT	
	Method A	Method B	Method A	Method B
River Cross-sectional Concentration (#/TCM)	1.327	1.269	1.348	1.350
Weighted River Cross-sectional Concentration (#/TCM)	0.829	0.793	0.506	0.506
River 24-hour Average Concentration (#T/TCM)	1.335	1.299	1.335	1.299
River Concentration near Intake (#/TCM)	0.831	0.600	1.306	2.025
Intake: No. of Juvenile 1 Volume strained (TCM) Concentration (#/TCM)	---	---	---	---
Discharge: No. of Juvenile 1 Volume strained (TCM Concentration (#/TCM)	---	---	---	---
Plant Concentration (Average of Intake and Discharge) (#/TCM)	---	---	---	---
f'	0.994	0.977	1.010	1.039
f_w	0.625	0.625	0.375	0.375
f_1	0.626	0.473	0.969	1.500
f_2**	1.000	1.000	1.000	1.000
f_3**	1.000	1.000	1.000	1.000
f_c***	0.700	0.700	0.700	0.700
$f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c$	0.272	0.202	0.257	0.409
Composite f	Method A = 0.529;		Method B = 0.611	

* Composite f = $(f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c)$ Day + $(f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c)$ Night

#/TCM = number of organisms per thousand cubic meters

** 1.0 is assumed for lack of data.

*** Conservative estimate, based on NYU studies.

pond. These data were all collected by QLM Laboratories during 1973 under contract to Orange and Rockland Utilities, Inc.

Since all the water entering the Bowline plant comes from the Bowline pond, average concentrations over the entire depth of the pond were used in evaluating the numerator of the f_1 factor.

At Bowline the f_2 factor was calculated from the average of the intake and discharge concentrations for the larval stage. The f_2 factor for juvenile I stage was calculated from the intake concentration only. The discharge sample was not used here because the sampling efficiency at the discharge for the juvenile I stage is expected to be much greater than in the intake or river sampling. Velocities in the Bowline discharge pipe are up to 10 ft./sec. which results in extremely good mixing. Consequently, nets placed in the discharge exhibit a very high efficiency in sampling organisms as large as the juvenile I's. The f factors have to be evaluated using data collected with methods which have comparable efficiency in the plant and the river.

The f_w and f_c factors were computed as described under "Indian Point Entrainment Factors." The calculations of composite f factors for larval and junveile I stages at Bowline are shown in Tables 15 and 16.

Roseton Entrainment Factors

Entrainment f factors at the Roseton plant were calculated from data collected during 1973 by QLM Laboratories in the intake and discharge of the plant and at river transects in front of the plant. The data collection was done under contract to Central Hudson Gas & Electric Corporation.

TABLE 15

BOWLINE 1973 STRIPED BASS LARVAL STAGE COMPOSITE f * FACTOR
(6 yolk-sac larvae - May 23 and July 5)
sampling dates between
(8 post yolk-sac larvae May 23 and July 18)

	DAY		NIGHT	
	Method A	Method B	Method A	Method B
River Cross-sectional Concentration (#/TCM)	169.49	165.22	143.02	166.39
Weighted River Cross-sectional Concentration (#/TCM)	105.93	103.26	53.63	62.40
River 24-hour Average Concentration (#T/TCM)	159.56	165.66	159.56	165.66
River Concentration near Intake -Pond (#/TCM)	26.327	26.327	98.512	98.512
Intake: No. of larvae (ys + pys)	14		38	
Volume strained (TCM)	1.899		2.004	
Concentration (#/TCM)	7.372		18.962	
Discharge:				
No. of larvae (ys + pys)	29		318	
Volume strained (TCM)	10.027		7.977	
Concentration (#/TCM)	2.892		39.865	
Plant Concentration (Average of Intake and Discharge) (#/TCM)	5.132		29.413	
f'	1.062	0.997	0.896	1.004
f_w	0.625	0.625	0.375	0.375
f_1	0.155	0.159	0.689	0.592
f_2**	0.218	0.218	0.308	0.308
f_3**	1.000	1.000	1.000	1.000
f_c***	0.600	0.600	0.600	0.600
$f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c$	0.013	0.013	0.043	0.041
Composite f	Method A = 0.056;		Method B = 0.054	

* Composite f = $(f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c)$ Day + $(f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c)$ Night

#/TCM = number of organisms per thousand cubic meters

ys = yolk-sac larvae; pys = post yolk-sac larvae

** 1.0 is assumed for lack of data.

*** Conservative estimate, based on NYU studies.

TABLE 16

BOWLINE 1973 STRIPED BASS JUVENILE I STAGE COMPOSITE f FACTOR
(5 Sampling Dates Between June 20 and July 18)

	DAY		NIGHT	
	Method A	Method B	Method A	Method B
River Cross-sectional Concentration (#/TCM)	2.862	2.112	6.485	7.322
Weighted River Cross-sectional Concentration (#/TCM)	1.789	1.320	2.432	2.746
River 24-hour Average Concentration (#T/TCM)	4.221	4.066	4.221	4.066
River Concentration near Intake - Pond (#/TCM)	0.055	0.055	17.314	17.314
Intake: No. of Juvenile I	0		3	
Volume strained (TCM)	0.622		0.466	
Concentration (#/TCM)	0.01		6.438	
Discharge:				
No. of Juvenile I	-		-	
Volume strained (TCM)				
Concentration (#/TCM)				
Plant Concentration (Average of Intake and Discharge) (#/TCM)	0.01		6.438	
f'	0.678	0.519	1.536	1.801
f_w	0.625	0.625	0.375	0.375
f_1	0.019	0.026	2.670	2.365
f_2	0.182	0.182	0.372	0.372
f_3**	1.000	1.000	1.000	1.000
f_c***	0.700	0.700	0.700	0.700
$f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c$	0.001	0.001	0.400	0.416
Composite f	Method A = 0.401		Method B = 0.417	

* Composite $f = (f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c)$Day + $(f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c)$ Night

#/TCM = number of organisms per thousand cubic meters

** 1.0 is assumed for lack of data.

*** Conservative estimate, based on NYU studies.

At Roseton, the f_2 factor was calculated from the average of the intake and discharge concentrations for the larval stage. Data were not available for the juvenile I stage f_2 factor so it was assigned a value of 1.0.

The f_W and f_C factors were computed as described under "Indian Point Entrainment Factors." The calculations of composite f factors for larval and juvenile I stages at Roseton are shown in Tables 17 and 18.

Summary of Entrainment Factors

Table 19 summarizes the entrainment impact factors for the early life history stages at various generating stations. These f factors represent the average composite f factors evaluated from Method A and Method B as described above. The "best estimate" refers to the use of "best estimate" cropping factors, f_C, while the minimum and maximum impact are based on an f_C of 0.5 and 1.0, respectively, for all early life history stages.

Impingement Factors

Estimates of the striped bass impingement rates under the projected plant flow rate conditions were multiplied by a 0.1 gear efficiency factor (3) and then input to the model. The impingement estimates used were based on the 1973 monthly average impingement collections at the plant intakes.

Using the 1973 data and the assumption that impingement is directly proportional to plant flow rate, estimates of impingement under the projected 1975 plant flows shown in Table 10 were derived. Since 1975 was the first year of the simulation study, the estimates of impingement rates for 1975 were input to the model as the base conditions. Within the model, the impingement rates were

TABLE 17

ROSETON 1973 STRIPED BASS LARVAL STAGE COMPOSITE f * FACTOR
(7 Sampling Dates between May 10 and August 1)

	DAY Method A	DAY Method B	NIGHT Method A	NIGHT Method B
River Cross-sectional Concentration (#/TCM)	12.765	10.979	188.737	174.039
Weighted River Cross-sectional Concentration (#/TCM)	7.978	6.862	70.776	65.265
River 24-hour Average Concentration (#T/TCM)	78.754	72.127	78.754	72.127
River Concentration near Intake (#/TCM)	12.716	5.439	343.385	247.310
Intake: No. of larvae (ys + pys)	17		14	
Volume strained (TCM)	2.59		1.10	
Concentration (#/TCM)	6.564		12.727	
Discharge:				
No. of larvae (ys + pys)	41		21	
Volume strained (TCM	1.6		1.35	
Concentration (#/TCM)	25.625		15.556	
Plant Concentration (Average of Intake and Discharge) (#/TCM)	16.095		14.141	
f'	0.162	0.152	2.397	2.413
f_w	0.625	0.625	0.375	0.375
f_1	0.996	0.495	1.819	1.421
f_2**	1.265	2.956	0.041	0.057
f_3**	1.000	1.000	1.000	1.000
f_c***	0.600	0.600	0.600	0.600
$f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c$	0.076	0.083	0.040	0.044
Composite f	Method A = 0.116;		Method B = 0.127	

* Composite f $= (f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c)$ Day + $(f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c)$ Night

#/TCM = number of organisms per thousand cubic meters

ys = yolk-sac larvae; pys = post yolk-sac larvae

** 1.0 is assumed for lack of data.

*** Conservative estimate, based on NYU studies.

TABLE 18

ROSETON 1973 STRIPED BASS JUVENILE I STAGE COMPOSITE 'f * FACTOR
(4 Sampling Dates between July 2 and August 15)

	DAY		NIGHT	
	Method A	Method B	Method A	Method B
River Cross-sectional Concentration (#/TCM)	1.025	0.890	2.304	2.760
Weighted River Cross-sectional Concentration (#/TCM)	0.641	0.556	0.864	1.035
River 24-hour Average Concentration (#T/TCM)	1.505	1.591	1.505	1.591
River Concentration near Intake (#/TCM)	0.578	0.660	0.491	0.028
Intake: No. of Juvenile I				
Volume strained (TCM)				
Concentration (#/TCM)	-	-	-	-
Discharge:				
No. of juvenile I				
Volume strained (TCM)				
Concentration (#/TCM)	-	-	-	-
Plant Concentration (Average of Intake and Discharge) (#/TCM)	-	-	-	-
f'	0.681	0.559	1.531	1.735
f_w	0.625	0.625	0.375	0.375
f_1	0.564	0.742	0.213	0.010
f_2**	1.000	1.000	1.000	1.000
f_3**	1.000	1.000	1.000	1.000
f_c***	0.700	0.700	0.700	0.700
$f'\cdot f_w\cdot f_1\cdot f_2\cdot f_3\cdot f_c$	0.168	0.181	0.086	0.005
Composite f	Method A =	0.254;	Method B =	0.186

* Composite f $= (f'\cdot f_w\cdot f_1\cdot f_2\cdot f_3\cdot f_c)$ Day + $(f'\cdot f_w\cdot f_1\cdot f_2\cdot f_3\cdot f_c)$ Night

#/TCM = number of organisms per thousand cubic meters

** 1.0 is assumed for lack of data.

*** Conservative estimate, based on NYU studies.

TABLE 19

Summary of Composite f* Factors
Used in Model Runs

Generating Plant	Egg Stage	Larval Stage	Juvenile I Stage
A) "Best Estimate"			
Roseton	0.16	0.10	0.22
Indian Point	0.44	0.13	0.57
Bowline	0.16	0.05	0.41
B) "Minimum Impact" (fc=0.5)			
Roseton	0.10	0.10	0.16
Indian Point	0.28	0.10	0.41
Bowline	0.10	0.05	0.29
C) "Maximum Impact" (fc=1.0)			
Roseton	0.20**	0.20	0.31
Indian Point	0.56	0.21	0.81
Bowline	0.20**	0.09	0.58

*Composite f $= (f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_c)_{Day} + (f' \cdot f_w \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_c)_{Night}$

**Striped bass egg data are not available at this time at Roseton and Bowline. The value of 0.20 is based on river average observation of striped bass egg behavior surveyed by Texas Instruments in 1973 and Indian Point egg mortality data (1973 NYU results). Since the duration of the egg stage is approximately 1 to 3 days, the exposure of eggs to entrainment is much smaller than the larval stage. Consequently the f factors for the egg stage are relatively unimportant and application of overall river behavior is appropriate.

automatically increased or decreased in direct proportion to projected changes in plant flow rates during subsequent years in the simulation.

At all plants except Bowline Units 1 and 2, the impingement rates used in the model were based on reduced plant flow conditions during the fall and winter months. This is consistent with the operating schedules supplied by Consolidated Edison (see Table 10).

In some cases, it was not possible to simulate the reduced flow conditions exactly so conservative approximations were made. At Indian Point Unit 2, for example, the October through March flow was always taken as 73% of the April through September flow rate. Consequently, when the April through September flow at Indian Point Unit 2 is increased to 786,000 gpm, the rate used in the model for the remainder of the year is 575,000 gpm (.73 x 786,000 gpm) instead of the scheduled rate of 534,000 gpm.

Although this application of a slightly higher flow rate is conservative, it is not expected to have a significant effect on the predictions of impact. The impingment estimates and factors used in the model for Indian Point Unit 2 and other plants are shown in Table 20.

EFFECT OF INDIAN POINT UNIT 2 OPERATION

Using the entrainment and impingement factors shown in Tables 19 and 20 for Indian Point Unit 2, a series of computer runs of the model were made to predict the effects of Indian Point Unit 2 operation on the Hudson River striped bass population. The results of the model runs were used to assess the impact on the Hudson River striped bass population due to the extension of the once-through cooling water system at Indian Point Unit 2 from May 1, 1979 to May 1, 1981.

TABLE 20

Impingement Rates (No./year) of Striped Bass
Juveniles II & III*

Generating Station	Estimated Impingement Rates Under Projected 1975 Plant Flow Rate**		Impingement Rates Input To the Model***	
	Juvenile II	Juvenile III	Juvenile II	Juvenile III
Indian Point Unit 2 (730,000 gpm Apr.-Sept. 534,000 gpm Oct.-Mar.)	1,034	9,102	129	1,138
Indian Point Unit 3 (450,000 gpm Apr.-Sept. 329,000 gpm Oct.-Mar.)	637	5,611	80	702
Indian Point Units 2 & 3	1,671	14,713	209	1,840
Roseton Units 1 & 2 (520,000 gpm May-Nov. 336,000 gpm Dec.-Apr.)	8,124	4,354	812	435
Bowline Units 1 & 2 (768,000 gpm Jan.-Dec.)	1,713	21,843	171	2,184

*Juvenile II - Juveniles impinged between May 8 (77% of May) and Nov. 30th.
Juvenile III - Juveniles impinged between Dec. 1 and May 7 (23% of May).
**See Table 11 for flow rates and text for impingement estimates.
***A factor of 0.1 is applied to account for the 10% gear efficiency. For Indian Point, an additional 25% upward adjustment is also applied to account for specimen losses during impingement collections.

The impact due to the extension in once-through cooling operation was evaluated as the difference between the predicted impacts with and without the extension.

Table 21 shows the results of model runs for Indian Point Unit 2 alone with the plant flow rates set according to the original operating schedule (Schedule AA) shown in Tables 10 and 11. This original schedule calls for a change in the once-through cooling water system to a closed-cycle system on May 1, 1979.

With this plant operating schedule, the LMS striped bass model predicts that the operation of Indian Point Unit 2 alone will result in a cropping of 0.47 to 1.25% in the young-of-the-year striped bass population in the Hudson River after one year of operation. After the change in the cooling water system from once-through to closed-cycle in the year 1979, the impact is reduced to about 0.01 to 0.03% cropping in the adult age 1 population. The impact on the young-of-the-year fish population during 1975 through 1978 is propagated into some later years when these fish mature. However, these impacts diminish to nil as the striped bass population returns to the equilibrium level in subsequent years.

Table 22 shows the predicted impact of Indian Point Unit 2 with the plant flow rates set forth in the amended plant operating schedule (Schedule BB). In this amended schedule, the change of the cooling water system at Indian Point Unit 2 from the once-through cooling to closed-cycle is delayed until May 1, 1981. The impact of this extension on the Hudson River striped bass population is shown in Table 23. The impact is determined by subtracting the percent cropping in the striped bass population shown in Table 21 under the original plant operating conditions from those shown in Table 22 under the amended operating conditions.

TABLE 21

EFFECT OF INDIAN POINT UNIT 2 OPERATION ON THE HUDSON RIVER STRIPED BASS POPULATION

Under the Original Plant Operating Schedule (AA) Conditions

Year Class	Percent Cropping in Striped Bass After Years of Operation 1 yr (1975)	5 yrs (1979)	6 yrs (1980)	7 yrs (1981)	10 yrs (1984)	17 yrs (1991)	20 yrs (1994)	47 yrs (2021)	50 yrs (2024)
A) Best Estimate Impact (Best estimate f_c factors*; high compensation) (Files: IP2731 & IPF8A1)									
Adult 1	0.59	0.01	0.04	0.05	0.22	0.07	0.04	0	0
Total Adults	0.41	0.20	0.09	0.07	0.21	0.07	0.04	0	0
B) Best Estimate Impact (Best estimate f_c factors*; low compensation) (Files: IP2732 & IPF8A2)									
Adult 1	0.95	0.02	0.07	0.11	0.56	0.26	0.13	0	0
Total Adults	0.66	0.31	0.15	0.12	0.51	0.24	0.15	0	0
C) Minimum Impact (f_c = 0.5; high compensation) (Files: PI2731 & IPF5A1)									
Adult 1	0.47	0.01	0.03	0.04	0.18	0.05	0.03	0	0
Total Adults	0.33	0.16	0.07	0.05	0.16	0.05	0.03	0	0
D) Maximum Impact (f_c = 1.0; low compensation) (Files: PI2732 & IPF1A2)									
Adult 1	1.25	0.03	0.10	0.15	0.74	0.35	0.18	0	0
Total Adults	0.87	0.42	0.20	0.17	0.68	0.32	0.21	0	0

*f_c = 0.8 Egg stage
= 0.6 Larval stage
= 0.7 Juvenile I stage

For detailed f factors, see Table 19.

TABLE 22

EFFECT OF INDIAN POINT UNIT 2 OPERATION ON THE HUDSON RIVER STRIPED BASS POPULATION

Under the Amended Plant Operating Schedule (BB) Condition

Year Class	Percent Cropping in Striped Bass After Years of Operation 1 yr (1975)	5 yrs (1979)	6 yrs (1980)	7 yrs (1981)	10 yrs (1984)	17 yrs (1991)	20 yrs (1994)	47 yrs (2021)	50 yrs (2024)
A) Best Estimate Impact (Best estimate f_c factors*; high compensation) (Files: IP2733 & IPF8B1)									
Adult 1	0.59	0.63	0.63	0.05	0.22	0.09	0.08	0	0
Total Adults	0.41	0.62	0.62	0.23	0.21	0.09	0.09	0	0
B) Best Estimate Impact (Best estimate f_c factors*; low compensation) (Files: IP2734 & IPF8B2)									
Adult 1	0.95	1.01	1.01	0.11	0.56	0.32	0.32	0	0
Total Adults	0.66	1.00	1.00	0.38	0.52	0.31	0.33	0	0
C) Minimum Impact (f_c = 0.5; high compensation) (Files: PI2733 & IPF5B1)									
Adult 1	0.47	0.50	0.50	0.04	0.18	0.07	0.06	0	0
Total Adults	0.33	0.50	0.50	0.18	0.17	0.07	0.06	0	0
D) Maximum Impact (f_c = 1.0; low compensation) (Files: PI2734 & IPF1B2)									
Adult 1	1.25	1.33	1.33	0.15	0.74	0.43	0.43	0	0
Total Adults	0.87	1.31	1.32	0.50	0.69	0.42	0.44	0	0

*f_c = 0.8 Egg stage
= 0.6 Larval stage
= 0.7 Juvenile I stage

For detailed f factors, see Table 19.

TABLE 23

IMPACT OF THE INDIAN POINT UNIT 2 OPERATION ON THE HUDSON RIVER STRIPED BASS POPULATION

DUE TO A TWO-YEAR EXTENSION OF THE ONCE-THROUGH COOLING SYSTEM

Year Class	Percent Cropping in Striped Bass After Years of Operation								
	1 yr (1975)	5 yrs (1979)	6 yrs (1980)	7 yrs (1981)	10 yrs (1984)	17 yrs (1991)	20 yrs (1994)	47 yrs (2021)	50 yrs (2024)
A) Best Estimate Impact (Best estimate f_c factors*; high compensation)									
Adult 1	0	0.62	0.59	0	0	0.02	0.04	0	0
Total Adults	0	0.42	0.53	0.16	0	0.02	0.05	0	0
B) Best Estimate Impact (Best estimate f_c factors*; low compensation)									
Adult 1	0	0.99	0.94	0	0	0.06	0.19	0	0
Total Adults	0	0.69	0.85	0.26	0.01	0.07	0.18	0	0
C) Minimum Impact (f_c = 0.5; high compensation)									
Adult 1	0	0.49	0.47	0	0	0.02	0.03	0	0
Total Adults	0	0.34	0.43	0.13	0.01	0.02	0.03	0	0
D) Maximum Impact (f_c = 1.0; low compensation)									
Adult 1	0	1.30	1.23	0	0	0.08	0.25	0	0
Total Adults	0	0.89	1.12	0.33	0.01	0.10	0.23	0	0

*f_c = 0.8 Egg stage
= 0.6 Larval stage
= 0.7 Juvenile I stage

For detailed f factors, see Table 19.

As shown in Table 23, the largest impacts due to the extension in once-through cooling operation are expected to occur in 1979 and 1980, the years during which the extension is in effect. The predicted cropping in the adult 1 population in 1979 ranges from a minimum of 0.49% (Case C) to a maximum of 1.30% (Case D). For 1980, the predicted minimum and maximum impacts are, respectively, 0.47 and 1.23% cropping in the adult 1 population. In all years, the "best estimate" impacts are between the minimum and maximum, as expected.

Under the assumption of a high level of compensation (Cases A and C), the percentage cropping becomes negligible by 1984 and remains so for all subsequent years.

At a low level of compensation (Cases B and D), a very small residual influence of the extension is observed in the predicted impacts for 1994. This is due to the propagation of impacts on the adult 1 population into the spawning adult age classes. The differences in the results at the high and low levels of compensation are reasonable since the amount of compensation indicates the populations ability to recover from external impacts through density dependent changes in growth rates, fecundity, mortality rates, etc.

In general, the model predictions involving Indian Point 2 alone suggest that the projected delay in the implementation of a closed-cycle cooling system may have a small, reversible impact on the Hudson River striped bass population.

EFFECTS UNDER MULTI-PLANT OPERATION

Model predictions of the impacts on the Hudson striped bass due to multi-plant operation under the original and amended plant flow conditions are shown in Tables 24 and 25, respectively. The plants included in the multi-plant runs are

TABLE 24

EFFECT OF INDIAN POINT, BOWLINE & ROSETON PLANT OPERATION ON THE HUDSON RIVER STRIPED BASS POPULATION

Under the Original Plant Operating Schedule (AA) Conditions

Year Class	1 yr (1975)	5 yrs (1979)	6 yrs (1980)	7 yrs (1981)	10 yrs (1984)	17 yrs (1991)	20 yrs (1994)	47 yrs (2021)	50 yrs (2024)
	Percent Cropping in Striped Bass After Years of Operation								
A) Best Estimate Impact (Best estimate f_c factors*; high compensation) (Files: RIB731 & MPF8A1)									
Adult 1	1.22**	0.84	0.86	0.69	0.52	0.27	0.25	0.10	0.10
Total Adults	0.85**	0.96	0.89	0.75	0.51	0.28	0.25	0.10	0.10
B) Best Estimate Impact (Best estimate f_c factors*; low compensation) (Files: RIB732 & MPF8A2)									
Adult 1	2.18**	1.53	1.56	1.35	1.38	0.93	0.87	0.31	0.29
Total Adults	1.52**	1.72	1.61	1.43	1.31	0.92	0.89	0.32	0.29
C) Minimum Impact (f_c = 0.5; high compensation) (Files: IBR731 & MPF5A1)									
Adult 1	1.04**	0.71	0.72	0.59	0.46	0.26	0.23	0.11	0.11
Total Adults	0.73**	0.81	0.75	0.64	0.45	0.26	0.24	0.11	0.11
D) Maximum Impact (f_c = 1.0; low compensation) (Files: IBR732 & MPF1A2)									
Adult 1	2.94**	2.13	2.17	1.91	1.94	1.40	1.35	0.70	0.67
Total Adults	2.05**	2.36	2.23	2.01	1.84	1.39	1.37	0.70	0.67

*f_c = 0.8, 0.6, and 0.7 for egg, larval, and juvenile I stages, respectively. (For detailed f factors, see Table 19).

** Inadvertently, an additional flow of 318,000 gpm was included in the 1975 projections. To correct for this, the estimates of percent cropping presented for 1975 should be reduced by about 12%.

TABLE 25

EFFECT OF INDIAN POINT, BOWLINE & ROSETON PLANT OPERATION ON THE HUDSON RIVER STRIPED BASS POPULATION

Under the Amended Plant Operating Schedule (BB) Conditions

Year Class	Percent Cropping in Striped Bass After Years of Operation 1 yr (1975)	5 yrs (1979)	6 yrs (1980)	7 yrs (1981)	10 yrs (1984)	17 yrs (1991)	20 yrs (1994)	47 yrs (2021)	50 yrs (2024)
A) Best Estimate Impact (Best estimate f_c factors*; high compensation) (Files: RIB733 & MPF8B1)									
Adult 1	1.22**	1.29	1.29	0.69	0.52	0.29	0.28	0.10	0.10
Total Adults	0.85**	1.27	1.28	0.87	0.51	0.30	0.28	0.10	0.10
B) Best Estimate Impact (Best estimate f_c factors*; low compensation) (Files: RIB734 & MPF8B2)									
Adult 1	2.18**	2.26	2.26	1.35	1.38	0.97	1.01	0.34	0.31
Total Adults	1.52**	2.23	2.25	1.62	1.32	0.98	1.02	0.35	0.32
C) Minimum Impact (f_c = 0.5; high compensation) (Files: IBR733 & MPF5B1)									
Adult 1	1.04**	1.10	1.10	0.59	0.46	0.27	0.26	0.12	0.11
Total Adults	0.73**	1.08	1.09	0.74	0.45	0.28	0.27	0.12	0.11
D) Maximum Impact (f_c = 1.0; low compensation) (Files: IBR734 & MPF1B2)									
Adult 1	2.94**	3.02	3.02	1.91	1.94	1.45	1.52	0.73	0.70
Total Adults	2.05**	2.98	3.01	2.25	1.85	1.46	1.52	0.73	0.70

* f_c = 0.8, 0.6, and 0.7 for egg, larval, and juvenile I stages, respectively (For detailed f factors, see Table 19).

** Inadvertently, an additional flow of 318,000 gpm was included in the 1975 projections. To correct for this, the estimates of percent cropping presented for 1975 should be reduced by about 12%.

Indian Point Units 2 and 3, Bowline Units 1 and 2 and Roseton Units 1 and 2. The model predictions indicate that the maximum impact that these multi-plant operations may impose upon the striped bass popoulation is a cropping of about 3% in either the adult age 1 or the total adults population in the year 1980 (see Table 25). This is based on the assumption that these plants will be operating continuously with flow rates prescribed in Tables 10 and 11. In fact, some of the plants will be shut down for maintenance during certain times of the year while other units may be off-line at other times.

The predictions of impact on the Hudson River striped bass population due to the extension of the Indian Point Unit 2 once-through cooling water system with other plants operating simultaneously are shown in Table 26. These impacts are obtained by subtracting the percent population cropping shown in Table 24 from those shown in Table 25 under the amended conditions. Comparing the impacts shown in Table 26 with those in Table 23, the additional cropping in the striped bass population due to the extension of the once-through cooling water system is found to be less under the multi-plant conditions than under conditions with Indian Point Unit 2 alone operating.

This is expected because, with the multi-plant operations, some of the young fish that may be transported by river flows and/or migrate downstream, are killed by the Roseton plant before they are subject to Indian Point's impact. Thus, the number of fish that may be subject to Indian Point Unit 2 impact are less with the multi-plant case than if Indian Point Unit 2 was the only plant on the Hudson. Another factor that may contribute to the smaller impact of the extension in the multi-plant case is an increased compensatory reaction due to the slightly lower population levels resulting from the higher impacts in the multiplant case.

TABLE 26

EFFECT OF INDIAN POINT, BOWLINE & ROSETON PLANT OPERATION ON THE HUDSON RIVER STRIPED BASS POPULATION DUE TO A TWO YEAR EXTENSION OF THE ONCE-THROUGH COOLING SYSTEM AT THE INDIAN POINT UNIT #2

	Percent Cropping in Striped Bass After Years of Operation								
Year Class	1 yr (1975)	5 yrs (1979)	6 yrs (1980)	7 yrs (1981)	10 yrs (1984)	17 yrs (1991)	20 yrs (1994)	47 yrs (2021)	50 yrs (2024)
A) Best Estimate Impact (Best estimate f_c factors*; high compensation)									
Adult 1	0	0.45	0.43	0	0	0.02	0.03	0	0
Total Adults	0	0.31	0.39	0.12	0	0.02	0.03	0	0
B) Best Estimate Impact (Best estimate f_c factors*; low compensation)									
Adult 1	0	0.73	0.70	0	0	0.04	0.14	0.03	0.02
Total Adults	0	0.51	0.64	0.19	0.01	0.06	0.13	0.03	0.03
C) Minimum Impact (f_c = 0.5; high compensation)									
Adult 1	0	0.39	0.38	0	0	0.01	0.03	0.01	0
Total Adults	0	0.27	0.34	0.10	0	0.02	0.03	0.01	0
D) Maximum Impact (f_c = 1.0; low compensation)									
Adult 1	0	0.89	0.85	0	0	0.05	0.17	0.03	0.03
Total Adults	0	0.62	0.78	0.24	0.01	0.07	0.15	0.03	0.03

*f_c = 0.8 Egg stage
= 0.6 Larval stage
= 0.7 Juvenile I stage

For detailed f factors, see Table 19.

DISCUSSION

As demonstrated in preceding sections, the impact due to the extension of the Indian Point Unit 2 once-through cooling operation on the Hudson River striped bass population as predicted through computer runs is greater with Indian Point Unit 2 operation alone than under multi-plant conditions. However, the impacts predicted in the multi-plant model runs are probably more meaningful because they represent the actual plant operating conditions planned for the simulation period. Consequently, the maximum impact that the extension of the Indian Point Unit 2 once-through cooling water system would have upon the Hudson River striped bass population is an additional 0.89% cropping in the adult age 1 class and 0.78% in the total adult population as shown in Table 26.

The maximum impact of the extension of the once-through cooling water system occurs in the year before the system is changed to the closed-cycle system. Although the impact on the young-of-the-year may be diminished to nil in subsequent years as the once-through system is changed to the closed-cycle system, some residual impact upon the offspring of these fish appears in later years when they become sexually mature. These residual impacts result, in part, from the assumption that no compensatory mechanisms are operative within the adult populations in the current striped bass model. However, recent studies by Texas Instruments, Inc. on the possible compensatory mechanisms operative within the Hudson River striped bass population indicate that at least two compensatory mechanisms are available to this fish population.

The first mechanism involves a density-dependent growth rate of the early life history stages. In addition to this, Texas Instruments demonstrated that since 1955 there has been a negative correlation between the catch-per-unit-effort of the current adult population with those five years earlier. That is, there is a strong stock-recruit relationship extant within the Hudson River striped bass population, such that large spawning classes produce smaller classes of offspring.

These recent indications of compensation mechanisms operative in the Hudson River striped bass population merit further study to attempt to determine if there are compensatory mechanisms operative in the adult striped bass.

APPENDIX A

COMPARISON OF COMPUTER RUNS OF THE REAL-TIME MODEL WITH THE TRANSPORT MODEL

(With High Level Compensation: $K_O/K_E = 0.5$)

Descriptions (Number of Organisms in Estuary)	Transport Model*	Real-Time Model
A) Total number of eggs impulsed	2.8×10^9	3.1×10^9**
B) Equilibrium Population		
Juvenile II population at		
Day 109.5	7,769,392	8,303,113
Day 149.5	5,823,796	5,989,766
Day 199.5	4,119,355	4,247,786
Juvenile III population at		
Day 209	3,840,481	3,978,776
Day 226	2,968,336	2,737,970
Day 256	2,045,555	1,985,059
Day 296	1,345,523	1,322,353
Day 356	730,317	739,934
Adult age 1 class	670,324	676,959
Total adults (ages 1-14)	964,409	974,674
C) Population after 1-year Plant Operation (Indian Point Units 1, 2 & 3 alone)		
Adult age 1 class	659,307	668,449
Total adults (ages 1-14)	953,391	966,165
D) Percent Cropping in Population		
Adult age 1 class	1.64%	1.26%
Total adults (ages 1-14)	1.14%	0.87

*Transport model used for the Cornwall testimony, October 1974.
**Based on a hatching period of 1.5 days and 29 segments in the river.

APPENDIX B

COMPARISONS OF COMPUTER OUTPUTS FROM THE PRESENT VERSION WITH THE PREVIOUS VERSION

File Name: KE75

Descriptions (Total Number of Organisms in Estuary)	Previous Version*	Present Version
A) Equilibrium Population		
Number of eggs impulsed	216×10^7	216×10^7
Larvae	216×10^6	216×10^6
Juvenile I	262×10^5	261×10^5
Juvenile II	705×10^4	712×10^4
Juvenile III	378×10^4	383×10^4
Adult age 1 class	870×10^3	871×10^3
Total adults	124×10^4	124×10^4
B) Population after 1 year Operation		
Larvae	216×10^6	216×10^6
Juvenile I	253×10^5	253×10^5
Juvenile II	682×10^4	689×10^4
Juvenile III	366×10^4	370×10^4
Adult age 1 class	838×10^3	840×10^3
Total adults	121×10^4	121×10^4
Cropping of adult age 1	3.7%	3.6%
Cropping of total adults	2.4%	2.4%

*Dr. Lawler's October 30, 1972 testimony (2)

REFERENCES

1. Testimony by John P. Lawler, Ph.D. for Consolidated Edison Company of New York, Inc. Hearings before Atomic Energy Commission Licensing Board on Indian Point Unit 2: Docket No. 50-247 "Effect of Entrainment at Indian Point on the Population of the Hudson River Striped Bass," April 5, 1972.

2. ______________________, "Effect of Entrainment and Impingement at Indian Point on the Population of the Hudson River Striped Bass," October 30, 1972.

3. ______________________, "Cumulative Effects of Bowline, Roseton and Indian Point Generating Stations on the Hudson River," March 30, 1973.

4. ______________________, "Sensitivity of the Model Presented in the Testimony of October 30, 1972," February 5, 1973 and "Sensitivity of the Model Presented in the Testimony of October 30, 1972 on the Effect of Entrainment and Impingement at Indian Point on the Population of Hudson River Striped Bass," February 20, 1973.

5. Testimony by John P. Lawler, Ph.D. for Consolidated Edison Company of New York, Inc. Hearings before the Federal Power Commission in the matter of Project No. 2338 (Cornwall) "Effect of Entrainment and Impingement at Cornwall on the Hudson River Striped Bass Population," October 1974.

6. United States of America Atomic Energy Commission's Atomic Safety and Licensing Appeal Board Decision, dated April 4, 1974, (ALAB-188) in the matter of Consolidated Edison Company of New York, Inc. (Indian Point Station, Unit No. 2) (Docket No. 50-247.

7. Quirk, Lawler & Matusky Engineers, "Hudson River Water Quality and Waste Assimilative Capacity Study," Report to State of New York Department of Environmental Conservation, December 1970

8. Hudson River Policy Committee, "Hudson River Fisheries Investigations 1965-1968 - Evaluation of a Proposed Pumped Storage Project at Cornwall, New York in Relation to Fish in the Hudson River," A report prepared by Frank T. Carlson and James A. McCann and presented to Consolidated Edison Company of New York, Inc.

9. Texas Instruments, "1973 Hudson River Program Fisheries Data Summary"
Vol. I - "1973 Hudson River Program Fisheries Data Summary, May - July,"(October 1973)
Vol. II - "1973 Hudson River Program Fisheries Data Summary, July - November," (December 1973)
Vol. III - "Fisheries Survey of the Hudson River, March - July 1973," (November 1973)
Reports prepared for Consolidated Edison Company of New York, Inc.

10. U.S. Department of Interior, Geological Survey, "1973 Water Resources Data for New Jersey, Part 1 Surface Water Records."

11. Nicholson, William R. and Robert M. Lewis, "Briefing Paper on the Status of Striped Bass", Atlantic Estuarine Fisheries Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, May 1973

12. Texas Instruments Incorporated, "Hudson River Ecological Study in the area of Indian Point for the Period January 1 to June 30, 1973 - Second Semiannual Report," prepared for Consolidated Edison Company of New York, November 1973.

13. Abood, Karim A., "Circulation in the Hudson Estuary," Quirk, Lawler & Matusky Engineers, published in Annals of the New York Academy of Sciences, Volume 250, Pages 39-111, May 24, 1974.

APPENDIX B

ALTERNATIVE PROCEDURES FOR DISCOUNTING COSTS AND BENEFITS OF PRIVATELY FINANCED POLLUTION CONTROL PROJECTS

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ALTERNATIVE PROCEDURES FOR DISCOUNTING COSTS AND BENEFITS OF PRIVATELY FINANCED POLLUTION CONTROL PROJECTS

A. Introduction

This report describes alternative procedures for discounting costs and benefits of privately financed pollution control projects. In so doing, it addresses three fundamental questions:

(i) What is the "social rate of discount", and how does it relate to the "private rate of discount" and to the "firm's cost of capital"?

(ii) Which rate concept or concepts should be used in discounting costs and benefits of privately financed but publicly regulated pollution control projects?

(iii) What numerical values are to be used for these rates?

These questions are the subject of substantial professional controversy. The various positions that have been taken on them are outlined below. The implications of these positions for calculation of costs and benefits of project construction delays are also presented, along with our recommendations concerning what procedure should be adopted and what rates should be used.

B. What are the various discounting concepts and how do they relate to one another?

Three discounting concepts arise in most discussions of evaluation criteria for "public" investment projects. These are the "social rate of discount", the "private rate of discount", and the firm's "opportunity cost of capital".

Of the three concepts, the third is perhaps the most widely understood and used and least controversial.[1] The firm's cost of capital is that rate of return below which the firm cannot invest without lowering its market value.[2] It can be shown that this "hurdle rate" is approximately equal to a weighted average of the costs of funds from the various sources (e.g., stocks, bonds) of finance used by the firm. The rate at which the firm can obtain funds is obviously conditioned by investors' appraisals of the riskiness of the enterprise. It is generally agreed that the opportunity cost of capital (taking into account the tax advantage of debt finance) is the discount rate that should be used by firms in making their private investment decisions.

The "private rate of discount" in contrast to the much used cost of capital, is largely a theoretical concept. Technically, it is the rate of interest of a riskless security. It is equivalent to the rate at which individual consumers are willing to give up present consumption for certain future consumption.[3]

The "social rate of discount" is purportedly the rate at which society is willing to give up present consumption for future consumption. Three reasons for believing that there is a social discount rate that is different from the private rate have been advanced.[4]

The first is "The Authoritarian Reason" generally associated with Pigou (1960). The individual consumer is seen as "myopic" compared to society when evaluating the benefits of consumption by future generations. Therefore private decision-makers will underinvest according to this view. The second is the "Schizophrenic Reason". This reason is attributed to Gerhard Colm, who emphasizes the different frames of reference that an individual is in when making private versus political decisions.

The third reason, developed by Marglin and extended in d'Arge and Wilen (1972) is the "Interdependence Reason".

Thus, Marglin (1963a, p. 99):

> "The third argument for taking different views of collective and individual savings versus consumption decisions starts from the premise that each individual's satisfaction may depend directly on the consumption of other individuals, present and future, as well as on his own consumption. But having no power over others' market actions, an individual cannot secure adherence to his preferences for the consumption pattern over time of the rest of the community through the market. In a state in which political decisions are reached through majority voting, however, he can employ the coercive machinery of government to secure adherence to his preferences for others if only he can find a sufficient number of like-minded individuals. The frame of reference is, as in the schizophrenia argument, all important. But here, unlike the previous case, the key is not that a change in the frame of reference occasions a change in individual preferences. Rather it is the difference between the machinery offered by the political process and the machinery offered by the market process for implementing one's preferences."

Whichever argument is used, the implication is that the social rate of discount should be less than the private rate since the use of the private rate will result in underinvestment from society's viewpoint.

It should be noted that this view is by no means held unanimously by economists. In a comment on Marglin, Tullock (as summarized in Baumol (1968, p. 800)) attacks the idea that an increase in investment is necessarily desirable for society in the present.

> "Tullock points out that an increase in investment, aside from its allocative consequences, constitutes a redistribution of income from present to future generations. That being so, he reminds us, it is incumbent on us to ask ourselves whether we really want to undertake such a redistribution of income -- as in any such redivision of the pie the answer depends heavily on who the recipients are to be, and on their economic circumstances. In particular, in our economy if past trends and current developments are any guide, a redistribution to provide more for the future may be described as a Robin Hood activity stood on its head -- it takes from the poor to give to the rich. Average real per capita income a century hence is likely to be a sizeable multiple of its present value. Why should I give up part of my income to help support someone else with an income several times my own?"

Whether or not there exists a conceptually meaningful and operational social rate of discount in the context of most projects is thus a very real point of dispute. However, Federal standards for water resources project evaluation including "Atomic Energy Commission's licenses that involve or affect water use"[5] specify the application of a social rate of discount.

> "The discount rate used in plan or project evaluation will reflect the value placed by society on benefits and costs in the future as compared with present benefits and costs. The rate shall reflect the public aspects of the discounting process (social time preference).
>
> In plan formulation and evaluation the benefits and costs that accrue at varying times may be made comparable by adjusting them to a uniform time basis. This problem is much more complex when environmental, social well-being, and regional development objectives are considered in plan formulation, since many of the values toward these objectives are not reflected in market transactions.

The social rate of time preference reflects the weights of decision-makers regarding the value of consumption in different time periods. One approach would determine such a rate as an average of the individual rates of time preference. It is likely, however, that society as a whole is more concerned than individuals about the welfare of future generations and the quality of the environment and would therefore accord a greater weight to the future. Thus, the rate to be used for plan formulation should reflect the public aspects of the discounting process.[6]

C. What rate concept or concepts are to be used?

Non-equivalence between alternative discount rates (due to taxes, risk differentials, etc.) raises the problem of which rate is to be used for evaluation of privately financed pollution control projects. There are two approaches for calculating discount rates that are generally accepted today. Both require a judgment about the opportunity cost of the investment for which the cost-benefit analysis is being conducted -- and hence a judgment about where (what use investors would make of their available funds) the inputs to the project are to come from.

1. The Weighted Average Approach[7]

Suppose project inputs come from two firms, one offering a gross percentage rate of return of r_1 and the other a gross percentage rate of r_2 and that the proportion f of project inputs would come from the first of these firms and the proportion $(1 - f)$ would come from the second. Then the average gross rate of return that these resources would earn if left in their alternative uses is $fr_1 + (1 - f)r_2$. The basic weighted average approach argues for use of a discount rate computed in this manner for project evaluation.

Since, at the margin, resource use alternatives yield returns equal to the opportunity costs of capital of the firms involved, the weighted average approach employs an opportunity cost of capital discounting concept.

Recently, Arrow and Lind (1970) have suggested a reasonable modification to the basic weighted average approach that would discount benefits and costs accruing to the public at large by the private rate of discount. These benefits and costs are, since they are spread across the public, not subject to risk it is argued. Where costs and benefits accrue to identifiable private groups, proponents of this approach believe that these groups' discount rates should apply.[8]

2. The Cost Adjustment Approach[9]

The cost adjustment approach takes opportunity cost into account by adjusting the value of the cost of project inputs rather than through the discount rate. Suppose that a project under consideration draws x dollars from a sector in which each dollar's input returns $1 + r$ dollars in revenues. Then the cost of the project is calculated as $x(1 + r)$. Costs and benefits, under this approach, are discounted in general at the private rate of discount. Only if there is reason to believe that there is in fact a divergence between private and social rates would a social rate be applied.

3. Recommended Approach

Certain examples have been formulated that suggest that the weighted average approach can give incorrect evaluations. Moreover, a compelling formal rationale can be given for the cost adjustment approach. The cost adjustment approach is therefore recommended. This section presents formulae for calculating the net present value of the benefits associated with a delay in the construction of a cooling tower facility financed by Consolidated Edison. The formulae presented here are based on the cost adjustment approach for the reasons cited above.

It will be noted that the formulae presented here specify use of the private discount rate for time discounting.

For weighting benefits and costs accruing to society at different points in time, we recommend the application of the private rate of discount. The reasons for this recommendation are as follows:

(a) Federal Water Policy Standards accept the concept of a social rate of discount and require its use. For efficiency in public decisions, societal rates of time performance must be applied to weighting benefits and costs even though such costs and benefits are not incurred by society at large.

(b) An operational procedure for calculating the social rate of discount has not been devised.

(c) It is agreed among most economists that the private rate of discount will be equal to the social rate of discount under certain circumstances or exceed the social rate of discount. Therefore, if the computed societal benefit-cost ratio exceeds one for any rate greater than zero and lower than the private rate of discount, it can be concluded that this ratio will be greater than one for the social rate as well.

(d) Applying the private rate of discount is consistent with the "Cost of Adjustment" Approach since this rate reflects how all individual consumers are willing to give up present consumption for a certain future consumption. Thus, it reflects the cost currently of individuals in society forgoing current consumption.

In developing the formula for the methodology the following steps are followed.

(1) adjust all costs financed privately by Consolidated Edison's cost of capital

(2) discount all costs to the present by the private rate of discount

(3) discount all benefits using the private rate of discount.

The following notation will be used. Let

$K(t)$	=	capital investment at time t
$r(t)$	=	opportunity cost of capital to Consolidated Edison
$\rho(t)$	=	the private rate of discount
$D(t, N)$	=	net damages in year t as a result of an N year delay in construction

$V(t)$ = operating costs in year t

t_0 = 1975

i_0 = originally scheduled start date.

The formula is composed of three terms representing capital cost savings, operating cost savings, and additional net damages.

For first expository purposes, assume investment occurs in one year, operating costs, damages, and rates are constant.

The savings in capital costs, then, are calculated by taking the stream of capital cost outlays over the delay period and discounting to the present. Thus, if NPV(K) is the net present value of the savings in capital costs,[10]

$$NPV(K) = \sum_{t=i_0}^{N-1} \frac{r \cdot K}{(1+\rho)^{t-t_0}}$$

If, in addition to debt servicing, the annual costs from the capital investment includes other costs (e.g., taxes, etc.) then a "capital recovery factor" can be used to denote the annual payments resulting from an investment. If, for example, the capital recovery factor for an investment of K is $R(t)$ in year t, then the net present value of the savings from delay is

$$NPV(K) = \sum_{t=i_0}^{N-1} \frac{R(t)}{(1+\rho)^{t-t_0}}$$

Operating costs are calculated similarly. An additional complication arises since, rather than being a one-time outlay, operating costs are a stream. Thus, total operating cost savings are represented by the difference in total outlays. Let n be the number of years of outlays. Then, similarly,

$$NPV(V) = \sum_{t=i}^{N} \frac{V}{(1+\rho)^{t-t_0}}$$

The damages calculation is similar to the cost calculation. Let m be the number of years after construction in which damages occur. Then,

$$NPV(D) = \sum_{t=i_0+m}^{m+N-1} \frac{D}{(1+\rho)^{t-t_0}}$$

where D is considered negative.

The total net present value of the benefits associated with delay is thus

$$NPV = NPV(K) + NPV(V) + NPV(D)$$

D. <u>What numerical values are to be used for these rates?</u>

1. <u>Opportunity Cost of Capital, r(t)</u>

Nuclear Regulatory Commission practices specify that a discount rate of 10 percent shall be used for evaluation of private utility environmental project evaluations.[11] This rate evidently is intended to be an approximation to utility costs of capital.[12]

"It is the staff's policy to use a discount rate of 8.75% for environmental statements for investor-owned utilities, based on an average rate of return on new investments. About 65% of such investments consist of bonds and preferred stock with a rate of return taken as 7% per year. The other 35% of the investments consist of common equity (common stock and retained earnings) with a rate of return taken as 12% per year. The weighted average is then (0.65 x 7%) + (0.35 x 12%), or 8.75% per year. These figures vary from time to time and from utility to utility but are believed to provide a reasonable basis for calculations of present worth."

If Consolidated Edison's estimated cost of capital differs substantially from this 10 percent figure, a case may well be made in terms of the theory summarized in the preceding section and NRC procedural rationale quoted above and NRC guidelines[13] for use of the Consolidated Edison figure.

2. Private Rate of Discount, p(t)

Most economists would accept long-term bond yields as an approximation to the private rate of discount. As an example of this methodology, the "official" rate, as established under procedures set forth in Senate Document No. 97 (87th Congress, May, (1962)) can be described as[14]:

"The interest rate to be used in plan formulation and evaluation for discounting future benefits and computing costs, or otherwise converting benefits and costs to a common time basis shall be based upon the average rate of interest payable by the Treasury on interest-bearing marketable securities of the United States outstanding at the end of the fiscal year preceding such computation which, upon original issue, had terms to maturity of 15 years or more. Where the average rate so calculated is not a multiple of one-eighth of 1 percent, the rate of interest shall be the multiple of one-eighth of 1 percent next lower than such average rate.

A more realistic method, and the one we recommend to estimate the private rate of discount would be to average yields on bonds with maturities greater than 15 years issued in the past year. Another possible rate could be obtained by using the rate for long-term savings accounts. Table 1 provides three possible rates of discount.

TABLE 1

Long-term ($\geq$ 15 year) government bond yields	6.5%
Long-term (4 year) savings rate	7.25%
Water Resource Council (After July 1, 1975)	5.875% 6.125%

Source: Long-term government bond yield quote from Smith-Barney, Philadelphia.

It should be noted that these rate estimates are nominal rates. That is, they include a premium demanded by investors based upon their expectations of inflation. Accordingly, costs and benefits should be estimated in current dollars (as opposed to constant dollars).

FOOTNOTES

1. How the cost of capital is to be measured is controversial, but the concept is not.

2. A very concise discussion of the cost of capital concept is available in Modigliani and Miller (1967).

3. A full discussion of this rate concept is available in Hirshleifer (1970).

4. See Marglin (1963a).

5. Special Task Force of the United States Water Resources Council, Procedures for Evaluation of Water and Related Task Resource Projects, Findings and recommendations of the Special Task Force of the United States Water Resources Council, Serial No. 92-20, USGPO (1971) p. I-3.

6. Special Task Force, *op. cit.*, p. IV-7.

7. This approach, or varient theory, is generally consistent with the recommendation of Hirshleifer (1965), (1966), Baumol (1968).

8. Arrow and Lind (1970).

9. This approach is summarized in Marglin (1963b).

10. To see the cost adjustment explicitly and to prove its equivalence with the more common method of obtaining net present values of differences, consider a public investment of magnitude K which is funded totally by Consolidated Edison. In any year t, the undiscounted opportunity cost of that investment is rK. If the investment were funded publically, its opportunity cost in any year t would be ρK. A public investment K^* equivalent to an investment of K funded by Consolidated Edision would be determined by

$$K^* = \frac{r}{\rho} K$$

since the opportunity cost of K^* is $\rho(\frac{r}{\rho} K) = rK$. Therefore, the investment is "adjusted" by $\frac{r}{\rho}$.

The present value of an investment K in terms of time streams is

$$(1) \qquad NPV_0 = \sum_{t=0}^{\infty} \frac{\rho K^*}{(1+\rho)^t} = \sum_{t=0}^{\infty} \frac{\rho\left(\frac{r}{\rho} K\right)}{(1+\rho)^t} = \sum_{t=0}^{\infty} \frac{rK}{(1+\rho)^t} = \frac{rK}{\rho}$$

For an N year delay, the net present value is

$$(2) \qquad NPV_N = \frac{1}{(1+\rho)^N} \sum_{t=N}^{\infty} \frac{rK}{(1+\rho)^t} = \frac{1}{(1+\rho)^N} \cdot \frac{rK}{\rho}$$

The net present value of the savings from delay is

$$(3) \qquad NPV = \frac{rK}{\rho} - \frac{1}{(1+\rho)^N} \frac{rK}{\rho} = \frac{r}{\rho} \left[K - \frac{K}{(1+\rho)^N} \right]$$

But the right-hand side of the above equality is just the difference in the net present values adjusted by $\frac{r}{\rho}$.

To see that the formulation in this appendix is equivalent to that in the text, consider equations (1) and (2). Thus

$$(1') \qquad NPV_0 = \sum_{t=0}^{\infty} \frac{rK}{(1+\rho)^t}$$

$$(2') \qquad NPV_N = \frac{1}{(1+\rho)^N} \sum_{t=N}^{\infty} \frac{rK}{(1+\rho)^t}$$

The difference is

$$\begin{aligned} NPV_0 - NPV_N &= \sum_{t=0}^{\infty} \frac{rK}{(1+\rho)^t} - \frac{1}{(1+\rho)^N} \sum_{t=N}^{\infty} \frac{rK}{(1+\rho)^t} \\ &= \sum_{t=0}^{N-1} \frac{rK}{(1+\rho)^t} + \frac{1}{(1+\rho)^N} \sum_{t=N}^{\infty} \frac{rK}{(1+\rho)^t} - \\ &\quad - \frac{1}{(1+\rho)^N} \sum_{t=N}^{\infty} \frac{rK}{(1+\rho)^t} \\ &= \sum_{t=0}^{N-1} \frac{rK}{(1+\rho)^t} \end{aligned}$$

This is equivalent to the formulation in the text with the discounting from i_0 to t_0 being omitted.

11. Nuclear Regulatory Commission practices as indicated by Paul Fine, February 19, 1975.

12. U.S.A.E.C. draft Environmental Statement by the Directorate of Licensing related to operation of Indian Point Nuclear Generating Plant Unit No. 3, October, 1973. The 8.75 percent has since been changed to 10 percent.

13. Regulatory Guide 4.2, Revision 1, Preparation of Environmental Reports for Nuclear Power Stations, January 1975, U.S. Nuclear Regulatory Commission, Table 3, page 4.2-51.

14. Senate Document No. 97, "Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plants for Use and Development of Water and Related Land Resources", 87th Congress, May, 1962.

BIBLIOGRAPHY

Arrow, K. J. and R. C. Lind, "Uncertainty and the Evaluation of Public Investment Decisions", American Economic Review, LX, pp. 364-378 (June, 1970)

Baumol, W. J., "On the Social Rate of Discount", American Economic Review, LVIII, pp. 788-802 (September, 1968)

d'Arge, R. C. and J. Wilen, "On the Social Rate of Discount and Preservation Versus Development Controversy", proceedings of the 14th Annual Western Resources Conference, Ft. Collins, Colorado, 1972.

Hirshleifer, J., "Investment Decision Under Uncertainty: Choice-Theoretic Approaches", Quarterly Journal of Economics, Nov. 1965, 79, pp. 509-36.

————————, "Investment Decision Under Uncertainty: Applications of the State-Preference Approach", Quarterly Journal of Economics, 80, pp. 252-77

————————, Investment, Interests, and Capital, 1970, Englewood Cliffs, New Jersey, Prentice Hall

Marglin, S. (1963a), "The Social Rate of Discount and the Optimal Rate of Investment Quarterly Journal of Economics, February, 1963, 77, pp. 95-111

————————, (1963b), "The Opportunity Costs of Public Investment", Quarterly Journal of Economics, 1963, 77, pp. 274-289.

Modigliani, F. and Miller, M. H., "Some Estimates of the Cost of Capital to the Electric Utility Industry, 1954-1957", American Economic Review, June, 1966

Pigou, A. C., Economics and Welfare, 4th Edition 1960, London, Macmillan and Company

Musgrave, R. A., The Theory of Public Finance, 1959, New York, McGraw-Hill Book Company

U.S. Senate Document No. 97, "Policies, Standards, and Review of Plans For Use and Development of Water and Related Land Resources", 87th Congress, Second Session

APPENDIX

The purpose of this appendix is to extend the methodology developed in the main body of the paper by the relaxation of the assumptions about investment and changes over time. Specifically, let,

$D(t, w)$	=	net damages in year t as a result of a w-year delay in construction.
$s(w)$	=	number of years after construction delayed by w years in which damages are incurred (i.e., $D(t, w) = 0$ $t \geq s(w)$).
$K(t, w)$	=	investment in year t for a project delayed w years.
$u(w)$	=	number of investment outlays for a project delayed w years.
$r(t)$	=	Consolidated Edison's cost of capital in year t.
$\rho(t)$	=	the private discount rate in year t.
$V(t, w)$	=	operating costs in year t as the result of a w-year delay in investment.
t_0	=	1975.
i_0	=	orignally scheduled start date.

Because of the increased generality, the formula is not quite so straightforward. Consider, first, costs with no delay in the continuous case. Then

$$NPV(C, 0) = \frac{1}{\prod_{t=1}^{i_0} (1 - \rho(t))} \int_{i_0}^{\infty} \left[r(t) \int_{i_0}^{\min(t, u(0))} K(z, 0)dz + V(t, 0) \right] e^{-\rho(t)t} dt$$

The discrete formulation is

$$(1) \qquad NPV(C,0) = \frac{1}{\prod_{t=1}^{i_0}(1+\rho(t))} \sum_{t=i_0+1}^{\infty} \left[r(t) \sum_{z=i_0}^{\min(t,u(0))} K(z,0) + V(t,0) \right] \frac{1}{1+\rho(t))^t}$$

The continuous case for damages is

$$NPV(D,0) = \int_0^{s(0)} D(t,0)e^{-\rho(t)t}dt$$

or, in the discrete case,

$$(2) \qquad NPV(D,0) = \sum_{t=1}^{s(0)} \frac{D(t,0)}{(1+\rho(t))^t}$$

The formulae are similar for the case of N-year delay. The net present value of the benefits of an N year delay is then

$$(3) \qquad NPV = NPV(C,0) + NPV(D,0) - NPV(C,N) - NPV(D,N)$$

(recalling that the D's are negative)

While (1) is an infinite sum and convergence cannot be guaranteed, "reasonable" assumptions about the future and the difference in investment outlays will cause the differences in the later years to be negligible.

APPENDIX C

AN ECONOMIC EVALUATION OF POSTPONING CLOSED CYCLE COOLING CONSTRUCTION ON INDIAN POINT 2

for

Consolidated Edison

and

Lawler, Matusky, Skelly Engineers

April 28, 1975

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University of Rhode Island

I. INTRODUCTION

This paper reports on an analysis of the economic benefit of striped bass fishing. The research attempts to compute the foregone net benefits of striped bass fishing induced by a reduction in the striped bass fishing stock on the Hudson River. To achieve this end, the work of fishery biologists and statisticians is relied upon for data pertaining to changes in the striped bass fishing stock and the number of striped bass fishing days, while techniques of economists will be used to estimate the economic value of changes in the stock.

The reduction in the stock of striped bass is caused by postponing the installation of closed cycle cooling on Indian Point 2 from May 1979 to May 1981. This postponement implies that impingement and entrainment will continue for two years and because of the dynamics of fisheries populations, the effect, though quite small in magnitude, theoretically could last for several years.

Reductions in the stock of striped bass cause the economic benefits of fishing for striped bass to be reduced. The striped bass is a sport fish pursued avidly by fishermen on the East Coast from Maine to the middle Atlantic. The fishing is principally by charter or private boat or by surf casting. Fishing is an activity for which people are willing to pay, as is evidenced by licenses, charter prices, and private fishing areas. Hence, if the change in the stock of striped bass is large enough to affect the level of sports effort, as measured by fishing days, there will be an associated loss in economic value to the fishermen. This paper will present some estimates of the loss of economic value from a reduction in the striped bass stock.[1]

II. MEASURING THE ECONOMIC VALUE OF RESOURCES

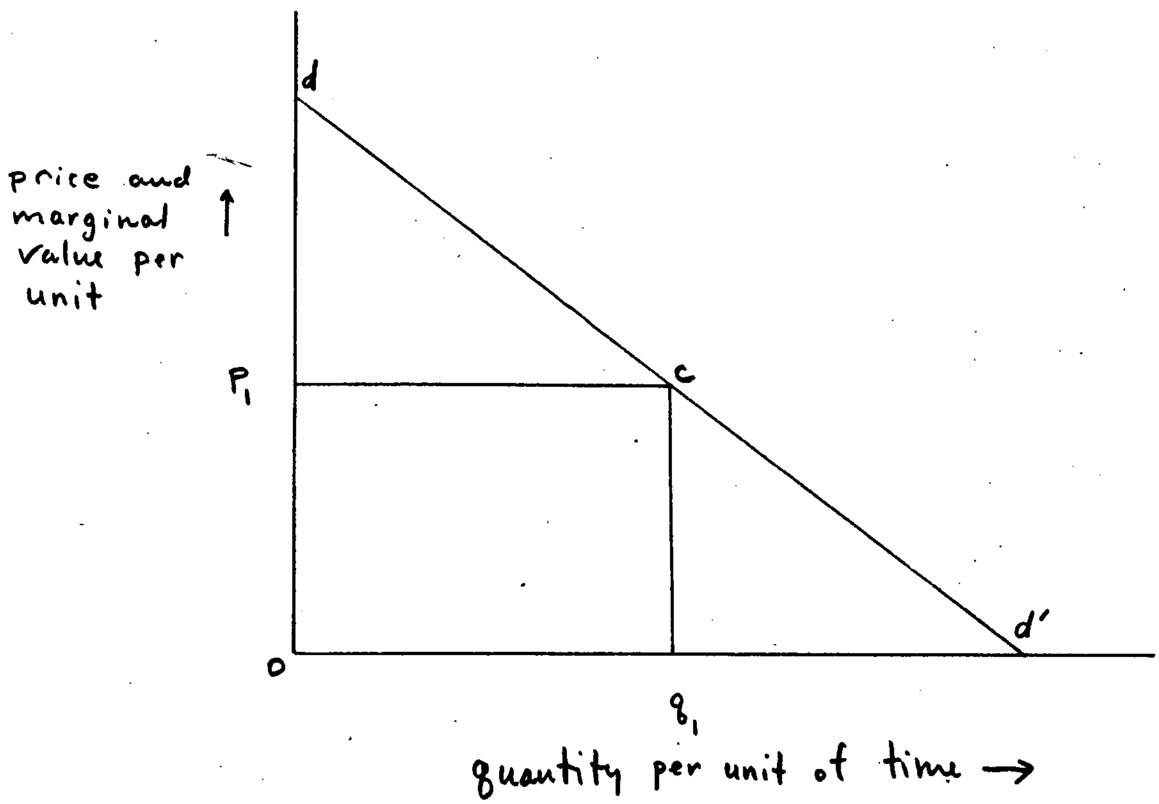
The approach of economists is to establish the value of a resource by determining the amount of money consumers are willing to pay for the resource. To estimate how much consumers are willing to pay for a resource, economists have used the relationship between the price and quantity of a resource demanded by the consumer. This relationship, known as the demand curve, gives the prices the consumer is willing to pay for different quantities of the resource per period of time.

On the market, the consumer chooses the quantity of a resource, paying a known price. If we ask the consumer why he did not purchase one more unit than he actually purchased, he will likely tell us that the extra unit was not worth the price. If we ask the consumer why he did not purchase fewer units, he will likely tell us that, with fewer units, the extra unit was worth more than the price.

Thus, for any given price, the value of the extra or marginal unit of the resource is just equal to the price. Hence we draw the demand curve (as in Figure 1) with price as the dependent variable and quantity as the independent. Because the consumer adjusts his quantity consumed so that the value of

FIGURE 1

A Single Individual's Hypothetical Demand Schedule



the marginal unit is equal to the price, we can view the price axis as the marginal value of the resource.

For example, in Figure 1 the demand curve is drawn as dd'. If the price is given by p_1, q_1 is the quantity demanded. Hence if the consumer chooses q_1 units of the resource, p_1 represents the marginal value of a unit of the resource. If the consumer were made to pay for each unit of the resource at its marginal value, he would pay out the total area under the demand curve, given by $odcq_1$. However, the consumer pays the same price for all units, so that he receives a surplus on some. The consumer surplus is the net total value of the resource to the consumer. It equals the amount the consumer would be willing to pay minus what the consumer must pay. In this example, consumer's surplus is the area p_1dc. It is found by subtracting the rectangle op_1cq_1, the amount the consumer must pay out, from the total value, $odcq_1$. The net loss to the consumer if he could no longer consume the resource is equivalent to the consumer's surplus.

The value of consumer's surplus in Figure 1 is for a single individual. To derive the total consumers' surplus for the resource, we must use an aggregate demand schedule, which is computed by adding up the individual demand schedules for all individuals who value the resource. The consumer surplus from the aggregate demand curve is equal to the total area under the demand curve, minus what the consumers pay out, exactly as in the individual case. It is a measure of the total value of the resource to all users.

Estimates of consumer surplus could be used to approximate the value of striped bass recreational fishing if we knew the relationship between the price of striped bass fishing and the quantity demanded (where quantity is measured in some meaningful magnitude, such as fishing-days or fishing-hours). The consumer surplus would tell us the value of the loss to consumers if they were unable to fish. Striped bass fishing is generally available at a zero or nominal fee, as are many other recreational activities based on open-access natural resources. Hence we have no direct knowledge of different price-quantity combinations from which we can statistically estimate the demand curve for striped bass fishing. The absence of price-quantity observations is characteristic of most recreation activities and it has led economists and government officials to devise alternate approaches for evaluating such resource-based activities.

III. MEASURING THE ECONOMIC VALUE OF RECREATION

Two different approaches have been developed to measure the economic value of recreation. On the one hand, economists have devised methods to ascertain consumers' willingness to pay for outdoor recreation: the methods are designed to be applied to specific resource sites, with the clear understanding that the value of outdoor recreation will vary from site to site. On the other hand, the Water Resources Council (WRC) has devised broad measures of the economic value of general types of outdoor recreation.

Economists have devised two techniques for measuring the willingness to pay for recreational resources: the direct interview method and the travel costs method. Both methods are designed to ascertain recreationists' willingness to pay for the outdoor recreation opportunity.

The direct interview approach entails asking the recreationists about their monetary valuation of the activity. This approach can be reliable if well-trained interviewers deliver carefully prepared bidding questions.[2] However, the direct approach has several drawbacks. Recreationists may respond with unrealistically high answers because they are not constrained by income. Or respondents may adjust their answers downward if they think an admissions fee may be based on their responses. In general, the hypothetical nature of the questions makes this approach very difficult to apply in practice.

The most common and widely accepted approach to measuring the value of recreation days at a particular site involves estimating the travel cost demand curve.[4] With the travel cost method of estimating a demand curve, the costs of using a particular site, travel costs and time costs, are a proxy for price. The quantity demanded is in terms of trips to the site. Recreationists from different distance sites have different costs of using the resource. Using data on travel and time costs and the number of trips from different distance zones, economists estimate a demand curve. Then, for each distance zone, consumer surplus is computed. The total consumer surplus of the site is the sum of consumer surplus from each distance zone.

For the travel cost method of estimating value to be valid, a number of assumptions must hold. First, it must be assumed that fishermen get no satisfaction or dissatisfaction from the travel, i.e., they are neutral toward the travel. Second, it must be assumed that fishermen would react to a higher entrance price in the same way that they would react to higher travel costs (i.e., greater distances). Third, it must be assumed that the population in different distance zones has similar tastes and faces similar recreational alternatives. Fourth, the trip must be taken for purposes of the recreation activity only (in the present case, striped bass fishing) and not in conjunction with other activities. Even if these assumptions fail to hold, this method can still be used with more sophisticated statistical analysis.

Both the travel cost method and the direct interview method require surveys at the particular site. If surveys have not been taken, or if the site has not been developed yet, these two approaches are not generally applicable.

As a substitute approach, the WRC has proposed guidelines for the measurement of the economic value of outdoor recreation. The guidelines suggest the following values for general and specialized recreation days:[5]

	Range of values per day
General	$ .75 - $2.25
Specialized	$3.00 - $9.00

To be conceptually correct, these values should represent consumer's surplus per recreation day. The WRC felt that, in the absence of market prices for outdoor recreation, these uniform standards would ensure that recreation would be accounted for in benefit-cost analysis.

How the standards are to be used is not made clear by the WRC. In the first place, the exact meaning of general and specialized is not easy to determine. A general day is defined as ". . .involving primarily those activities attractive to the majority of outdoor recreationists and which generally require the development and maintenance of convenient access and adequate facilities," while a specialized day involves ". . .primarily those activities for which opportunities, in general, are limited, intensity of use low, and often may involve a large personal expense by the user."[6] There is no additional guidance concerning the classification system. What the guidelines seem to imply is that those activities which have a high value (low intensity of use) are specialized while those activities having low value (high intensity of use) are general recreation days. The standards do indicate that activities such as salmon fishing and big game hunting are specialized recreation activities.

Economists have debated extensively the WRC in general and the WRC's recreational values in particular.[7] There are a number of criticisms to be made against the WRC recreational day values:

1) The consumer surplus of a particular activity varies negatively with the availability of alternative

facilities. For example, fishing on a particular lake may have no consumer surplus if there are similar accessible lakes nearby.

2) The value of a particular activity varies with many different features of the recreation site. Recreation research has demonstrated that willingness to pay for a recreational experience depends upon site cleanliness, naturalness of the environment, and many other site-specific variables. Hence, even if one could agree on a value for a recreation day in the abstract, in reality the value would change from site to site.

3) The consumer surplus of a recreation day is negatively correlated with the congestion of a recreation site. A recreationist's willingness to pay at two sites, identical but for crowding, may vary because of the crowding.

4) The consumer surplus of a recreation day varies with the accessibility of the site. A recreationist would be willing to pay less, the further away the site.

To a certain extent, these criticisms apply also to the travel cost method. For example, if there is congestion, the travel cost method may yield incorrect results. Similarly, if the availability of alternative sites is not accounted for, the travel cost method will not yield accurate results. The basic difference between the travel cost method and other methods and the guidelines set forth by the WRC is that a good deal of work has been devoted to determining exactly how the travel cost method works, and what it measures, while no one is quite sure when or how the guidelines are applicable. Nevertheless, the schedule of monetary values is useful on an interim basis, as the WRC suggests.

In sum, no matter what method used, the value of a recreation day should represent the least amount the consumer would accept to forego the recreation day. It is this value, which economists call consumer surplus, which will be approximated in the next section.

IV. VALUING STRIPED BASS FISHING

The specific task here is to impute economic value to striped bass fishing days which are foregone over the next several decades because of the postponement of the cooling tower construction. Since the absence of cooling towers implies a reduction in the striper population, essentially we are interested in the relationship between reduction in the striper population and loss of consumer surplus. To measure this relationship, we must first establish the conceptual relationship between the demand for striper fishing days and the stock of striped bass fishing.

The determinants of the demand for fishing for striped bass are many and varied, but it is useful and meaningful to isolate a small number of factors whose behavior we can predict and whose influence is important. In the discussion below four important factors will be discussed. They are (1) the costs per day of fishing, (2) the level of income of fishermen, (3) the stock of striped bass, and (4) the set of substitutes for striped bass fishing.

1. Costs Per Day of Striped Bass Fishing

The first factor to be included as a determinant of striped bass fishing days is the cost of a fishing trip. The cost per day includes such items as the travel cost, net expenditures on meals and lodgings, and the opportunity cost of the fisherman's time. In a sense, the cost of the fishing trip is the price that a fisherman must pay per day or per trip to enjoy the sport.

Because there have been no studies specifically dealing with striped bass fishing, we know little of the effect of the costs per day on the quantity demanded of striper fishing days. The impact depends upon how far fishermen live from the Atlantic Coast fishing grounds, because travel costs are an important element of the costs of fishing. It depends upon how fishermen value their spare time, because time costs are another important element in the cost of fishing.

An important factor influencing the relationship between costs per day and the quantity demanded of striper days is the price at which substitutes are available. For example, if bluefish were regarded by fishermen as an inexpensive substitute for stripers, then increases in the cost per day of striper fishing would cause immediate shifts to bluefishing. In general, if there are no close substitutes available at low prices, increases in the cost per day of striped bass fishing may have little impact on the quantity demanded of striper fishing days.

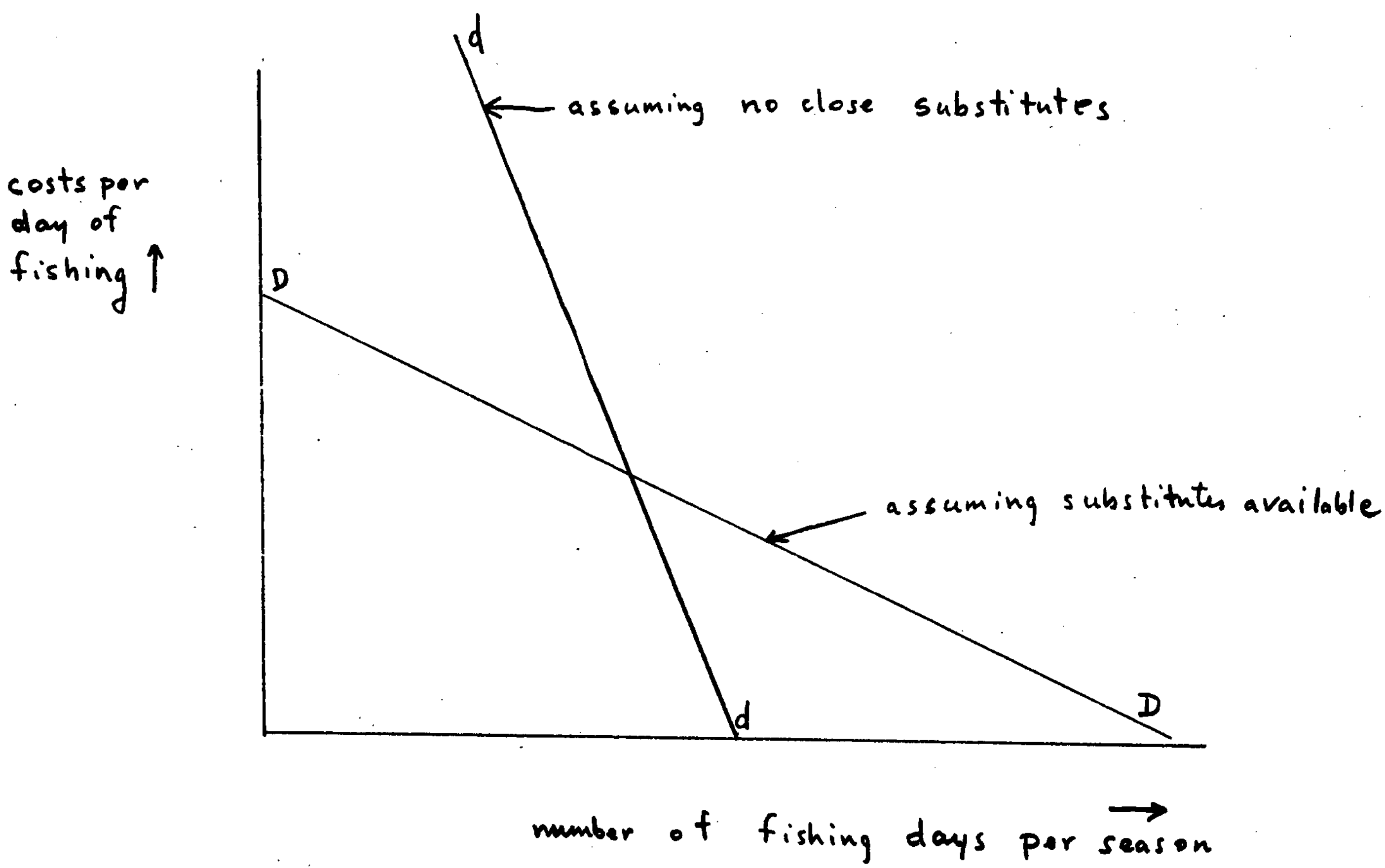
In Figure 2, two demand curves are drawn. The curve DD shows the reaction to cost changes assuming that there are close substitutes, while the curve dd assumes that there are no close substitutes. Of the many demand curves that have been estimated in outdoor recreation in general and sportsfishing in particular, most show that increases in the per unit cost of recreation induce a proportionately smaller percentage change in the quantity of demanded of recreation.[8] For purposes of analysis below, we assume several different values for the elasticity of striped bass fishing days with respect to per unit costs. By permitting this elasticity to vary parametrically, we can show how the results change under alternative assumptions.

2. The Income of Sports Fishermen

A second important determinant is the level of income of an individual. Past research in recreational sports fishing has demonstrated that, for certain types of game fishing, individuals tend to increase their fishing effort as their incomes rise. Although there is no study devoted to the relationship between income and striped bass fishing, we can infer from studies of the income elasticity of similar fisheries that the

FIGURE 2

Demand for Fishing with and without Close Substitutes



income elasticity of striped bass fishing would be less than unity.[9] As with the cost elasticity, the income elasticity will be varied parametrically to demonstrate the sensitivity of the final results to changes in income levels.

3. The Stock of Striped Bass

A third important determinant of the number of striped bass fishing days is the likelihood of catching stripers. Though catching a striper depends upon many factors, including luck, skill, tackle, weather, and tide, it is reasonable to assume that the catch per trip depends upon the stock of stripers. With a larger stock, fishermen are more likely to land a striper. Knowing that their chances of catching a striper have increased, fishermen devote more of their time to fishing. Hence we can state simply that fishermen increase their time devoted to striper fishing as the stock of stripers increases.

As long as the change in the population of striped bass is small, we state that the quantity demanded of striper fishing days changes in the same direction as the fish stock. However, if changes in the fish stock are quite large, the nature of fishing experience may change so much that we are no longer analyzing the demand for the same type of fishing day. For example, large increases in the stock of striped bass may increase fishing days and hence fishing congestion so much that the value of the experience is considerably lessened. On the other hand, a reduction in the stock of stripers, by reducing the total number of fishing days, and hence fishing congestion, may enhance the value per day of fishing. In general, ignoring the impact on congestion of changes in the stock of stripers is likely to overstate the changes in benefits induced by changes in the fish stock.[10] Although we are dealing with very small percentage changes in the stock of striped bass, we must keep in mind that larger percentage changes might drastically alter the quality of the fishing experience.

Hence, when dealing with small changes in the stock, we assert that there is a positive relationship between the demand for striped bass fishing days and the stock of striped bass. While there have been no studies of the relationship between striper fishing days and the striper stock, Castle et al. estimated that salmon fishing trips in the Pacific Northwest increased proportionately with fishing success.[11] In the absence of more data, we can assume that striper fishermen react the same on the East Coast, that each one percent reduction in the stock of striped bass will reduce the quantity of striped bass fishing days by the one percent. This assumption will probably over-state the response of fishermen to changes in the stock, and hence overestimate the economic value of any measure designed to prevent a reduction in the striped bass stock.

It should be observed that because of the dynamics of fisheries populations, there are substantial random changes in the adult year classes of stripers. The random changes quite likely are substantially greater than the rather small changes given in Tables 2 and 3. Because of the large random changes, it is unlikely that fishermen will notice changes of less than one percent.

4. The Substitutes for Striped Bass Fishing

A fourth determinant of the number of striped bass fishing days per person is the availability of substitutes. If other fish, such as blues, become more abundant and easier to catch, we might expect that people would switch from stripers to blues, if all other factors remained constant. The availability of substitutes is of more than passing interest because of the attempts to reestablish the Atlantic salmon.[12] If the salmon were established as a viable sports fishery, we might expect a reduction in the demand for striped bass fishing days.

The preceding discussion has led us to hypothesize that, for a typical individual fisherman, four important forces determine the quantity of striped bass fishing days he enjoys for any period of time:

1) the per unit cost of a fishing day;
2) the individual's level of income;
3) the stock of striped bass; and
4) the set of available alternatives.

For purposes of analysis, we state that

(1) $q_t = f(c_t, y_t, s_t, a_t)$ where

q_t = number of striped bass fishing days in any year t demanded by the typical consumer

c_t = costs per day of striped bass fishing in year t

y_t = average income level in year t

s_t = stock of striped bass in year t

a_t = set of alternatives in year t

f = the mathematical function relating q to the variables which determine q.

If sufficient data were available, then the relationships among striped bass fishing, costs per day of striped bass fishing, income levels, the stock of striped bass, and alternatives could be estimated. If the function f could be estimated, then it would be possible to compute the change in consumers surplus for each change in the stock of striped bass fishing. However, the quantitative relationship between the quantity of striped bass fishing days and the variables determining it is unknown (though based on other research, we can make educated guesses about its rough magnitude).

We do know enough of striped bass fishing to take the following approach: let q_t be the average number of striped bass fishing days per person and p_t be population of the Northeast; then $p_t\ q_t$ is the total number of striped bass fishing days per year in the Northeast. If we can agree upon an average value for consumer surplus per fishing day, then the total value of striped bass fishing is the number of days $(p_t q_t)$ times the average consumer surplus per day (v_t). Let us represent the annual rate at which future benefits are discounted to the present as r. Thus, if the decision making period is from 1975 to 2021, the present discounted value of striped bass fishing with the cooling towers is

$$(2) \quad \sum_{t=1}^{46} v_t p_t q_t (1+r)^{-t} = \sum_{t=1}^{46} v_t p_t f(c_t, y_t, \bar{s}_t, a_t)\ (1+r)^{-t}$$

where $\bar{s}_t$ is the stock of striped bass in year t assuming that the tower is constructed in May 1979. If the tower is constructed in May 1981, the present discounted value of striped bass fishing is

$$(3) \quad \sum_{t=1}^{46} v_t p_t f(c_t, y_t, s_t, a_t) \, (1+r)^{-t}$$

The difference is that with the postponing of the cooling tower construction, the stock of stripers in year t (s_t in (3)) is lessened. In general, we would expect $\bar{s}_t \geq s_t$.

The benefits of constructing the cooling towers are found by subtracting (3) from (2). We compute the present discounted value of recreational striped bass fishing with and without the construction. The benefits of the cooling towers can be attributed to the difference between (2) and (3). It should be noted that the stock of stripers changes by the same amount in the period 1975-1979 whether or not the tower is constructed in 1979 or 1981.

As stated above, we must assume some values for consumer surplus per fishing day. Clearly the present discounted value of striper fishing is sensitive to the values assumed for v_t, consumer surplus per fishing day.. This sensitivity can be tested by letting v_t vary over a reasonable range. It will be argued by examples from empirical work on other sports fisheries that the range of values over which consumer surplus per day may vary is fairly small.

If we assume that consumer surplus per day (v_t) is constant, then we can concentrate on the magnitude of $p_t q_t$, total striped bass fishing days, over time. It can be shown that, for any point in time,

(4) % growth (p_tq_t) = % growth (p_t) + % growth (q_t).

Also, using the demand function described in (1), it can be shown that

(5) % growth (q_t) = b_1 % growth (c_t) + b_2 % growth (y_t)
+ b_3 % growth (s_t) + b_4 % growth (a_t),

where

b_1 = elasticity of q_t with respect to c_t

b_2 = elasticity of q_t with respect to y_t

b_3 = elasticity of q_t with respect to s_t

b_4 = elasticity of q_t with respect to a_t.

By elasticity we mean the percent change in the quantity demanded of striper fishing days caused by a one percent change in one of the determinants.

To predict the percentage growth in fishing days using (4) and (5) we will assume that there is no change in the set of alternatives (a_t), so that we need not be concerned with b_4, because the % growth of a_t is zero. Thus we need estimates of four growth rates (population, daily cost of striped bass fishing, income, and the stock of striped bass) and three elasticities, b_1, b_2 and b_3. If we can predict the percentage growth rate in total striped bass fishing days (p_tq_t) then we can predict the absolute growth also, because we have reasonable estimates of the magnitude of striped bass fishing days in 1970.

Our knowledge of the annual growth rates in expressions (4) and (5) is considerably better than our knowledge of the elasticities. The annual growth rates in per capita income and population for the Northeastern states (Maryland to Maine) have been computed from sources published by the U.S. Government. Table 1 summarizes the annual growth rates of the three significant variables.

Table 2 gives the annual percentage change in the Hudson River adult striper stock by year from 1975 to 2021 for the 1979 cooling tower construction. Table 3 gives the percentage change of Hudson River adults assuming a 1981 construction date. Table 4 explains each of the eight cases considered.

Because we are less certain of the elasticities in expression (6), we take the following approach. First, with respect to the percent response of fishing days to percent changes in the striper stock (b_3), we assume a value of one.[13] For analysis dealing with the economic value changes in the stock of stripers, we must assume that fishermen are keenly aware of changes in the fishing conditions. Other research in recreation economics gives us good a priori information about the range of values over which the income elasticities and price elasticities can vary. From published work, one can reasonably assert that the percent change of striper fishing days due to percent increases in daily costs is likely to be less than one-half. Similarly, the percent change in striper fishing days due to per capita income increases is likely to be less than one. To test the sensitivity of the final results to different values in cost and income elasticities, we used the different values given in Table 5.

TABLE 1

Annual Rates of Increase of Population, Per Capita Income, and Per Unit Costs of Striped Bass Fishing

Years	Population (p_t)	Per Capita Income (y_t)	Per Unit Trip Costs (c_t)
1970-1975	.24%	2%	.96%
1976-2021	.5%	2.5%	.96%

Source: The population figures for 1970-1975 are computed from data given in Current Population Reports, Series P-20, No. 279, issued March 1975, Table 17. The population rate of increase for 1976-2021 is the implied annual rate of increase from 1969-1990, given by the Commission on Population Growth and the American Future, Volume Five, Population, Distribution, and Policy, p. 278, Series E-IV. The income figures for 1970-1975 are taken from the Economic Report of the President, 1975, p. 269. The rate of increase from 1976 to 2021 is the rate implied by projections in Survey of Current Business, April 1974. The annual rate for costs per trip is derived from the assumption that the costs of recreating 10% more per decade than will the overall price level. All figures are for the Northeast United States.

TABLE 2

Annual Percent Change in the Hudson River
Adult Striped Bass Population
Assuming Cooling Tower Construction
in May 1979

Year	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
1975	-.330	-.410	-.660	-.870	-.730	-.850	-1.52	-2.05
1976	-.090	-.121	-.191	-.262	-.222	-.262	-.447	-.592
1977	-.060	-.070	-.110	-.132	-.081	-.101	-.163	-.226
1978	-.010	-.010	-.030	-.041	-.030	-.030	-.061	-.062
1979	.332	.413	.687	.892	.253	.283	-.051	.566
1980	.090	.110	.160	.221	.061	.071	-.020	.133
1981	.020	.020	.030	.030	.111	.141	.645	.225
1982	-.030	-.040	-.120	-.160	.242	.292	.569	.592
1983	-.050	-.060	-.160	-.210	-.010	0.0	-.101	-.193
1984	-.030	-.040	-.110	-.141	-.040	-.050	-.162	-.224
1985	.010	.020	.040	.060	-.010	-.010	-.122	-.071
1986	.040	.050	.121	.161	.020	.020	-.081	.041
1987	.040	.050	.141	.181	.040	.040	.061	.112
1988	.020	.030	.060	.080	.050	.070	.183	.183
1989	.010	.010	0.0	-.010	.040	.050	.203	.142
1990	0.0	-.010	-.050	-.060	0.010	.040	.101	.071
1991	-.010	-.010	-.040	-.050	0.0	.020	0.0	-.020
1992	0.0	0.0	0.0	-.010	.010	0.0	-.030	-.030
1993	.010	.010	.030	.050	.010	.010	-.010	0.0
1994	.010	.020	.060	.070	.020	.020	0.0	.051
1995	.010	.010	.040	.050	.010	.020	.071	.081

Table 2, continued

Year	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
1996	0.0	0.0	.020	.030	.020	.020	.081	.071
1997	.010	.010	-.010	.010	0.010	.010	.071	.061
1998	0.0	0.0	-.010	-.010	0.0	.010	.040	.020
1999	0.0	0.0	0.0	0.0	.010	.010	.010	.010
2000	0.0	0.0	.010	.001	0.0	.010	0.0	.010
2001	0.0	.010	.020	.030	.010	.010	.010	.020
2002	.010	0.0	.030	.030	0.0	0.0	.030	.040
2003	0.0	0.0	.001	.020	.010	.010	.040	.040
2004	0.0	.010	.001	.001	.001	.001	.040	.030
2005	0.0	0.0	0.0	0.0	0.0	0.0	.030	.030
2006	0.0	0.0	0.0	0.0	0.0	.010	.020	.020
2007	0.0	0.0	.001	.001	.010	0.0	.020	.010
2008	0.0	0.0	.001	.001	0.0	.010	.010	.020
2009	0.0	0.0	.001	.020	0.0	0.0	.020	.020
2010	0.0	0.0	0.0	.001	0.0	0.0	.020	.020
2011	0.0	0.0	0.0	0.0	0.0	0.0	.020	.020
2012	0.0	0.0	0.0	0.0	.010	.010	.020	.020
2013	0.0	0.0	0.0	0.0	0.0	0.0	.020	.020
2014	0.0	0.0	0.0	0.0	0.0	0.0	.010	.010
2015	0.0	0.0	0.0	0.0	0.0	0.0	.020	.021
2016	0.0	0.0	0.0	0.0	0.0	0.0	.010	.010
2017	0.0	0.0	0.0	0.0	0.0	.001	.010	.020
2018	0.0	0.0	0.0	0.0	0.0	0.0	.020	.010
2019	0.0	0.0	0.0	0.0	0.0	0.0	.010	.020
2020	0.0	0.0	0.0	0.0	.010	0.0	.010	.010
2021	0.0	0.0	0.0	0.0	0.0	0.0	.010	.010

Source: Dr. Thomas Englert, Lawler, Matusky, Skelly Engineers, personal communication.

TABLE 3

Annual Percent Change in the Hudson River
Adult Striped Bass Population
Assuming Cooling Tower Construction
in May 1981

Year	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
1975	-.330	-.410	-.660	-.870	-.730	-.850	-1.52	-2.050
1976	-.090	-.121	-.191	-.262	-.222	-.262	-.447	-.592
1977	-.060	-.078	-.111	-.132	-.081	-.101	-.163	-.226
1978	-.010	-.010	-.030	-.041	-.030	-.030	-.061	-.062
1979	-.010	-.010	-.010	-.010	-.020	-.030	-.051	-.072
1980	0.0	0.0	0.0	-.010	-.010	-.010	-.020	-.031
1981	.322	.392	.626	.831	.354	.415	.645	.784
1982	.060	.070	.060	.070	.312	.383	.569	.767
1983	-.020	-.020	-.110	-.141	.010	.020	-.101	-.142
1984	-.030	-.030	-.090	-.121	-.030	-.040	-.162	-.214
1985	-.020	-.030	-.060	-.091	-.040	-.040	-.122	-.173
1986	-.010	-.010	-.040	-.040	-.020	-.030	-.081	-.102
1987	.030	.030	.081	.101	.020	.030	.060	.061
1988	.040	.050	.121	.161	.070	.080	.183	.245
1989	.040	.050	.100	.131	.070	.090	.202	.234
1990	.020	.020	.020	.030	.050	.060	.101	.132
1991	0.0	.010	-.010	-.020	.020	.020	0.0	0.0
1992	0.0	0.0	-.030	-.030	0.0	.010	-.030	-.040
1993	0.0	0.0	-.010	-.020	.010	0.0	-.010	-.040
1994	.010	0.0	.020	.030	0.0	.010	0.0	.020
1995	.010	.020	.050	.060	.020	.020	.070	.071

Table 3, continued

Year	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
1996	.010	.010	.050	.060	.020	.020	.080	.112
1997	.010	.010	.030	.040	.020	.030	.071	.081
1998	0.0	.010	.010	.020	.010	.010	.040	.041
1999	.010	0.0	0.0	0.0	.010	.010	.010	.020
2000	0.0	.010	0.0	0.0	.010	.010	0.0	0.0
2001	0.0	0.0	.010	.010	0.0	0.0	.010	.010
2002	0.0	0.0	.020	.030	.010	.010	.030	.030
2003	.010	.010	.020	.030	0.0	.010	.040	.050
2004	0.0	0.0	.020	.030	.010	.010	.040	.050
2005	0.0	.010	.020	.010	.010	.010	.030	.030
2006	.010	0.0	.010	.010	0.0	0.0	.020	.030
2007	0.0	0.0	0.0	.010	.010	.010	.020	.010
2008	0.0	0.0	.010	.010	0.0	0.0	.010	.020
2009	0.0	.010	.010	.010	0.0	0.0	.020	.020
2010	0.0	0.0	.010	.020	.010	.010	.020	.020
2011	0.0	0.0	.010	.020	0.0	0.0	.020	.030
2012	0.0	0.0	.010	.010	0.0	0.0	.020	.020
2013	0.0	0.0	.010	.010	0.0	.010	.020	.020
2014	0.0	0.0	.010	.010	.010	0.0	.010	.020
2015	0.0	0.0	.010	.010	0.0	0.0	.020	.010
2016	0.0	0.0	0.0	.010	0.0	0.0	.010	.020
2017	0.0	0.0	.011	.010	0.0	0.0	.010	.010
2018	0.0	0.0	.008	.010	0.0	.010	.020	.020
2019	0.0	0.0	.011	0.0	0.0	0.0	.010	.020
2020	0.0	0.0	0.0	0.0	0.0	0.0	.010	.010
2021	0.0	0.0	.010	0.0	0.0	0.0	.010	.020

Source: Dr. Thomas Englert, Lawler, Matusky, Skelly Engineers, personal communication.

TABLE 4

Case 1:	Indian Point 2 alone, minimum
Case 2:	Indian Point 2 alone, best estimate, high compensation
Case 3:	Indian Point 2 alone, best estimate, low compensation
Case 4:	Indian Point 2 alone, maximum
Case 5:	Indian Point 2 with multiplant* impact, minimum
Case 6:	Indian Point 2 with multiplant* impact, best estimate, high compensation
Case 7:	Indian Point 2 with multiplant* impact, best estimate, low compensation
Case 8:	Indian Point 2 with multiplant* impact, maximum

*The multiplant impact considers the impact of Indian Point 2 along with Indian Point 3, Bowline 1, Bowline 2, and Roseton 1 & 2.

TABLE 5

Assumed Value for Percent Responses in Striped Bass Fishing Days to One Percent Changes in Per Capita Income and Daily Costs of Fishing

Costs	Income
b_1	b_2
-.1	.25
-.25	.5
-.5	1

The figures in Table 5 demonstrate, for example, when the value of .25 is assumed for the income elasticity (column two), that a 10 percent increase in per capita income brings a 2.5 percent increase in striped bass fishing days.

V. RESULTS

In this section, the results of the analysis are presented. The results should not be construed as exact. The reader familiar with the problem is well aware of the potential for errors in the data. Nonetheless, the results below give estimates of benefits of cooling towers which take into account as many variables as possible, and hence can be thought of as indicative.

To use the framework established in the previous section, we need to know the relationship between annual percent reductions in the Hudson River striper stock (given in Tables 2 and 3) and annual reductions in the Mid-Atlantic striper stock. Biologists are not in complete agreement about this relationship. Clearly the relationship changes from year to year. For purposes of this analysis, we give results for three different assumptions concerning the Hudson's contribution to the Mid-Atlantic striper stock. We assume the Hudson contributes 10 percent, 25 percent and 40 percent. These figures are the same as presented in Lawler's testimony on Indian Point 2.[14] Hence the annual reduction of the Atlantic striper stock is at 10, 25 and 40 percent of the rates given in Tables 2 and 3.

Because there are so many combinations of cost elasticities, income elasticities, and cases, we will present what are felt to be a low, an average, and a high scenario. These three scenarios will give good insight into the range over which the benefits may vary.

It will be recalled from the previous section that the value to be measured is the benefits of striped bass fishing on the East Coast, with and without the postponement. The difference is attributed as the benefits of cooling towers. In the notation of the previous section, the benefits from constructing a cooling tower are

$$\sum_{t=1}^{46} v_t p_t [f(c_t, y_t, \bar{s}_t, a_t) - f(c_t, y_t, s_t, a_t)](1+r)^{-t}.$$

Since we are assuming that v_t, the consumer surplus or net value of a striper fishing day, is constant, we only need to forecast the total number of fishing days for each year from 1970 to 2021. Using expressions (4) and (5), we write the expression for the number of fishing days in year t as

$$(6)\quad p_t q_t = p_{t-1}\, q_{t-1}\, (1 + \%\ \text{growth}\ (p_t) + b_1\ \%\ \text{growth}\ (c_t) + b_2\ \%\ \text{growth}\ (y_t) + b_3\ \%\ \text{growth}\ (s_t)).$$

The recursive form of (6) permits us to predict the number of striped bass angler days in year t if we know its value in year t-1. We know that in 1970 there were approximately 4.3 million striper fishing days in the Mid-Atlantic.[15]

To determine the impact of the stock reductions as given in Tables 2 and 3, we need to simulate the growth path of striped bass fishing days from 1970 to 1975, because the most recent data is available for 1970. Given the growth of p_t, y_t and c_t in Table 1 and assuming no change in the stock of stripers, striped bass fishing days are simulated from 1970 to 1975 under the nine assumptions given in Table 5. The result is a reasonable set of estimates from which the analysis can start in 1975.

Before we present the estimates of benefits, we need to discuss the problems of assigning a value to v_t, the consumer surplus per striped bass fishing day. It is clear that v_t should measure the amount consumers would be willing to pay not to be deprived of days of striped bass fishing.[16] It is conceptually possible to measure v_t, if the appropriate kinds of data are available (as discussed in Sections II and III). However, we must make benefit estimates without specific data on the consumer surplus, so that the estimates of v_t are fairly arbitrary. We have chosen to present results with v_t = \$10 and v_t = \$4. A value of \$10 is slightly higher than the WRC's upper bound value for a specialized recreation day and a value of \$4 is slightly higher than the lower bound for a specialized recreation day. As long as the percent reduction in number of striper angler days is fairly small, it seems reasonable to assign a value in the range of \$4 - \$10 for consumer surplus per recreation day.

What are the arguments against assigning a higher value to consumer surplus per fishing day? First, the number of angler days per saltwater fisherman is fairly high (a mean of around 12 days per angler in 1970), so that the loss per year of fisherman days is a very small proportion of the average fisherman's total days. For striped bass fishing, the number of days per angling season is probably higher than for the average species. Hence the loss in consumer surplus is likely to be quite small for the marginal fishing day foregone.

There is some indirect evidence of the consumer surplus per day of striped bass fishing from the structure of the market. We know that the current price per day of striped bass fishing aboard a charter boat is only about \$30-\$35. This price includes not only fishing all day, but also the boat ride, free bait, tackle fully rigged, hook baited and fish landed. The price of \$30-\$35 is not consumer surplus but we can infer that those who fish from beaches, piers, and jetties without the extras that come with a day of charter boat fishing value a day of fishing at less than the price of a charter boat day. If a day of fishing were worth more than \$30, then the individuals who fish from the beaches, jetties and piers could pay their \$30 for a day of fishing and get all the extras of a day on a charter boat.

A third cogent reason for a relatively low consumer surplus per day of striped bass fishing is the availability of substitutes. In particular, blue fishing, shark fishing, and bill fishing are all reasonably good substitutes for striper fishing.

Together these arguments lend weight to a value of v_t of \$10 or less. However, without more data, it is not possible to state that \$4 is more reasonable than \$10, or vice versa. Hence both figures are used.

The tables below present estimates of benefits of cooling tower construction for three different combinations of cost and income elasticities and for three different assumptions concerning the Hudson's contribution to the Atlantic striper stock. The benefits are computed by multiplying v_t(v_t = \$4 or v_t = \$10) by the present discounted values of striped bass fishing days over the next twenty years. The days are discounted at the rate .065 (i.e., r = .065) to January 1, 1975.

The cases to be considered in the following tables are given in Table 4.

Table 6 presents the results for a relatively low rate of growth in striper fishing days per fisherman. The high cost of elasticity (b_1 = -.25) and low income elasticity (b_2 = .25) imply that per capita demand for striper fishing days will grow at a fairly low rate. The benefits of the cooling tower reflect this low rate of growth.

Table 7 represents a medium case, probably the most likely for striped bass fishing, with a fairly low cost elasticity (b_1 = -.1) and a fairly high income elasticity (b_2 = .5).

Table 8 presents the results for a high rate of growth of per capita demand for striped bass fishing. This table puts a very high upper bound on the benefits of constructing a cooling tower.

The interested reader can examine the tables in detail to gain some appreciation for the benefits of cooling towers. In

TABLE 6

Economic Benefits Foregone by Postponing
Cooling Tower Construction
Low Scenario (b_1=-.25; b_2=.25)

	Value Per Day = \$4			Value Per Day = \$10		
	k = .1	k = .25	k = .4	k = .1	k = .25	k = .4
Case 1	\$14400	\$ 51008	\$109376	\$ 36000	\$127520	\$273440
Case 2	18368	63936	136768	45920	159840	341920
Case 3	38400	134784	287936	96000	336960	719840
Case 4	51008	177984	380672	127520	444960	951680
Case 5	11648	41344	87616	29120	103360	219040
Case 6	12928	46144	97600	32320	115360	244000
Case 7	28672	100992	215488	71680	252480	538720
Case 8	35584	123840	264640	88960	309600	661600

TABLE 7

Economic Benefits Foregone by Postponing
Cooling Tower Construction
Medium Scenario (b_1=-.1; b_2=.5)

	Value Per Day = $4			Value Per Day = $10		
	k = .1	k = .25	k = .4	k = .1	k = .25	k = .4
Case 1	$ 15872	$ 55040	$119040	$ 39680	$137600	$297600
Case 2	19328	69504	149568	48320	173760	373920
Case 3	42560	150016	322112	106400	375040	805280
Case 4	57280	199488	426304	143200	498720	1065760
Case 5	12928	45440	97408	32320	113600	243520
Case 6	14144	49280	105792	35360	123200	264480
Case 7	32256	113280	242752	80640	283200	606880
Case 8	39680	139136	296960	99200	347840	742400

TABLE 8

Economic Benefits Foregone by Postponing
Cooling Tower Construction
High Scenario (b_1=-.1; b_2=1.0)

	Value Per Day = $4			Value Per Day = $10		
	k = .1	k = .25	k = .4	k = .1	k = .25	k = .4
Case 1	$ 18176	$ 63744	$138048	$45440	$159360	$345120
Case 2	21952	79872	173248	54880	199680	433120
Case 3	51008	180928	388672	127520	452320	971680
Case 4	69248	241728	516992	173120	604320	1292480
Case 5	14720	52352	113216	36800	130880	283040
Case 6	16448	57600	122944	41120	144000	307360
Case 7	39424	138112	295808	98560	345280	739520
Case 8	48256	168960	360448	120640	422400	901120

general, it may be said that the present value of benefits in most cases is less than $1 million. The results seem stable with respect to changes in values of b_1 and b_2. That is, the differences between the low scenario and the high scenario are not great.

Tables 6, 7, and 8 indicate very clearly that the greatest source of variation in the estimates of the benefits is the Hudson River's contribution to the Mid-Atlantic striped bass stock. To make more accurate estimates of the economic impact of impingement and entrainment, future research would be most fruitfully put into determining within a more narrow range the value of k, the proportion representing the Hudson River's contribution to the Mid-Atlantic striper stock.

Clearly there are many factors which would change the results one way or the other. It would be possible to do a sensitivity analysis, attempting to measure the benefits under all possible conditions. Such a sensitivity analysis would create so many different numbers that the results would be impossible to digest. It is to be emphasized that the assumptions made in this study have been extremely conservative in that they tend to increase the value of striped bass fishing. Instead, we present a list of the factors which might change the benefits as given in Tables 6-8, and the direction in which the change would be.

1. The discount rate. A higher discount rate would lower the benefits of cooling towers.

2. A lower estimate of striped bass angling days in 1979. The results in Tables 6-8 are based on an estimate of 4.3 million striper fishing days in 1970. If in fact there were more days in 1970, the estimates in Tables 6-8 are too low.

3. Changing alternatives. If other species, such as bluefish, decreased, we would expect a higher value for v_t and higher benefits for cooling towers. Similarly the successful introduction of salmon on the rivers of New England would lower the value of v_t and the benefits in Tables 6-8.

4. Changing the estimates of the biological parameters. Clearly if the Hudson contributes less than k to the Mid-Atlantic striper stock, the benefits given in Tables 6-8 would be lower.

5. Changing the rates of growth of economic variables. If per capita income or population were to grow slower, or costs per day higher than the rates in Table 1 indicates, the benefits in Tables 6-8 would be lower. It seems likely, however, that costs per day will increase faster than the .96% per year given in Table 1, so that, with respect to the growth rates, the benefits are probably over-estimates.

6. A shift in the population distribution. If people in the East moved closer to the Atlantic Coast, the source of striped bass fishing, the daily cost of fishing would decline because travel costs would be lower. A decrease in the daily costs of striped bass fishing would increase either the number of days or consumer surplus per day, or both. This would imply a high estimate of the benefits of striped bass fishing.

However, secular changes seem to imply a reduction in the population of the North Atlantic.

7. A different time horizon. This analysis carries to the year 2021. If power plants wear out sooner, the period of analysis should be shorter and the benefits foregone correspondingly reduced.

VI. CONCLUSION

This report has computed rough measures of the benefits of cooling towers in terms of striped bass fishing days. There are no sources of primary data from which the demand functions for striped bass fishing days could be estimated. Hence we have simulated the growth of per capita demand functions. The results demonstrate that in most cases the benefits for cooling towers are less than \$0.5 million, and in all cases, benefits are less than \$1.3 million. Because of likely errors in the economic and biological data, it is not meaningful to specify any one particular value as <u>the</u> estimate. The figures as a whole, however, may be interpreted with some confidence. More exact answers would require specific studies designed to measure the consumer surplus of striped bass fishing.

FOOTNOTES

[1]The loss in value which we will be attempting to measure is what consumers would be willing to pay not to forego the recreational experience. Other measures of value sometimes presented in similar situations are secondary effects derived from impact analysis. An estimate of the secondary effects would attempt to show the changes in employment, retail sales, production, and so forth, brought about by the change in striped bass fishing. It is widely accepted by economists that secondary benefits are not an appropriate measure of foregone benefits.

[2]The work by Robert K. Davis [6] is a good example of the direct interview approach to measuring the economic value of recreation.

[3]Dealing with experimental subjects, Peter Bohm [1] demonstrated that as long as the respondents knew they would not have to pay what they said they would be willing to pay, the interview method gave unrealistically high results.

[4]The travel cost method was first expounded by Marion Clawson in [5].

[5][16], p. 24804.

[6][16], p. 24804.

[7]The discussion is carried on in [4], [9], and [10] in particular.

[8]For example, in [14], elasticities of fishing vacations, trips, and outings with respect to costs were estimated at -.24, -.27, and -.04, respectively ([14], Table 3-4, p. 125). Each of these elasticities indicates a rather low percent change in quantity of fishing demanded with respect to percent changes in the cost of fishing.

[9]For example, in [2], an income elasticity for salmon-steelhead fishing of .5 can be computed. In [14], an income elasticity of .16 is estimated for fishing outings.

[10]The impact of congestion on estimates of recreational benefits is explored in [7] and [13].

[11]This elasticity is computed in [3].

[12]There is scheduled a conference in January, 1975 in Boston on the topic of Atlantic salmon restoration.

[13]As mentioned above, when there are large changes in the stock of stripers, an equiproportionate response in the number of fishing days may dramatically alter the nature of the recreational experience. Hence $b_3=1$ is a valid assumption only when the percent reduction in stripers is fairly small.

[14](11), p. II-19

[15]The value of 4,250,480 striped bass fishing days is derived by taking the number of striped bass anglers in the Mid-Atlantic (348,400) presented on page 25 of (12) and multiplying by the average number of fishing days per salt water angler, which is 12.20. The last figure can be computed from Table 33, page 93 of (15).

[16]It is important to recall that an angler "day" is any fishing during the day. Thus 45 minutes of surf-casting for stripers on the way home from work is counted as a recreation day in the same way that fishing from a charter boat is a recreation day.

REFERENCES

[1] Bohm, P. "Estimating the Demand for Public Goods: An Experiment," European Economic Review, 3:111-130, March 1972.

[2] Brown, W. G., A. Singh and E. N. Castle. "An Economic Evaluation of the Oregon Salmon and Steelhead Sport Fishery," Oregon Agricultural Experiment Station Technical Bulletin 78, Corvallis, Oregon, September 1972.

[3] Castle, E. N., et al. "Multi-Disciplinary Study of Water Quality Relationship: A Case Study of Yaquina Bay, Oregon," Oregon State University Sea Grant Special Report 348, February 1972.

[4] Cicchetti, C. J., et al. "Evaluating Federal Water Projects: A Critique of Proposed Standards," Science, Vol. 181, No. 4101, 24 August 1973.

[5] Clawson, Marion. Methods of Measuring the Demand for and Value of Outdoor Recreation. Washington, D.C., Resources for the Future, Inc., February 1959.

[6] Davis, R. K. "The Value of Big Game Hunting in a Private Forest," Transactions of the Twenty-Ninth North American Wildlife and Natural Resources Conference, 1964.

[7] Fisher, Anthony and John V. Krutilla. "Determination of Optimal Capacity of Resource-Based Recreation Facilities," Natural Resources Journal, 12:417-444, July 1972.

[8] Fisher, Anthony, John V. Krutilla and C. J. Cicchetti. "The Economics of Environmental Preservation: Further Discussion," American Economics Review, 64:1030-1039, December 1974.

[9] Kalter, Robert J., et al. "Criteria for Federal Evaluation of Resource Investments," Water Resources and Marine Sciences Center, Cornell University, August 1969.

[10] Knetsch, Jack L., et al. "Federal Natural Resources Development: Basic Issues in Benefit and Cost Measurement," Natural Resources Policy Center, George Washington University, May 1969.

[11] Lawler, J. P., "Cumulative Effects of Bowline, Roseton, and Indian Point Generating Stations on the Hudson River," testimony before the Atomic Energy Commission, Dkt. No. 50-247; March 30, 1973.

[12] Lawler, J. P., "Contribution of the Hudson River to the Middle Atlantic Striped Bass Fishery," testimony before the Atomic Energy Commission, Dkt. No. 50-247, February 5, 1973.

[13] McConnell, K. E. and V. A. Duff. "Estimating Net Benefits of Outdoor Recreation under Conditions of Excess Demand," Working Paper, Department of Resource Economics, University of Rhode Island, August 1974.

[14] United States Department of Interior, Bureau of Outdoor Recreation, Outdoor Recreation, a Legacy for America, Appendix "A": An Economic Analysis, Washington, D.C., December 1973.

[15] United States Department of Interior, Bureau of Sports Fisheries, National Survey of Fishing and Hunting, 1970.

[16] United States National Archives, Federal Register, Volume 38, Number 174, Part III: Water Resource Council: Establishment of Principles and Standards for Planning, September 10, 1973.

9. RESPONSES TO REQUEST FOR ADDITIONAL INFORMATION

SUPPLEMENT NO. 1

This supplement to the Environmental Report for Extension of Once-Through Cooling for Indian Point Unit No. 2 consists of responses by Consolidated Edison Company of New York, Inc. to questions posed by the Division of Reactor Licensing of the Office of Nuclear Reactor Regulation of the Nuclear Regulatory Commission in their letter dated July 7, 1975 to Consolidated Edison Company to the attention of Mr. W. J. Cahill, Jr., Vice President.

Response to NRC Request for Additional Information
Indian Point Unit No. 2
Docket No. 50-247

Q 1. Since the application for the amendment to the FTL DPR-26 requests a two year extension of once-through cooling of Indian Point Unit No. 2 from May 1, 1979, to May 1, 1981, discuss the impact of the extension upon the schedule for termination of once-through cooling of Unit No. 3 agreed to by all parties in the Unit No. 3 stipulation. Your discussion should include the impact of the schedule for excavation and construction of Unit No. 2 cooling tower on that for the Unit No. 3 cooling tower.

A 1. The schedule accompanying the request for the two-year extension of operation of Indian Point 2 with the once-through cooling system (ER Figure I-2) shows site preparation from June 1, 1978 to June 1, 1979 and plant outage from May 1, 1981 to December 1, 1981. Con Edison's Indian Point 3 cooling tower project schedule presently in effect and based on the stipulation shows site preparation from September 1, 1978 to September 1, 1979 and unit outage from September 15, 1981 to April 15, 1982. Thus there is an apparent overlap at this time of 9 months of site preparation and 3 months of plant outage.

Simultaneous excavation and outage of the two units is highly undesirable. However, Con Edison does not believe this is a problem which need be addressed at this time because it is erroneous to consider present schedules as immutable. Experience indicates that schedules of this nature established so far in advance inevitably change with subsequent events. The Indian Point 3 schedule in particular may change both from factors within the terms of the stipulation and from factors outside the stipulation.

A. Schedule Changes Provided for in the Indian Point 3 Stipulation and the Indian Point 2 License

The date for termination of operation of Indian Point 3 with once-through cooling, referred to as "the September 15 date" in the stipulation, is subject to change depending upon the receipt by a specified date of all government approvals required to proceed with the construction of the closed-cycle cooling system. In view of the resistance Con Edison has encountered to the cooling tower project following submission of the Indian Point 2 Cooling Tower Report, an extension under this provision is not improbable.

The stipulation provides that, as in the case of Indian Point 2, Con Edison can file for an extension of the period of interim operation if justified by empirical data. Since the stipulation does not allow sufficient time for completion of the ecological study program originally contemplated for Indian Point 3, an extension under this provision is not improbable. A similar request for an extension is possible after the commencement of construction of the closed-cycle cooling system.

The September 15 date is further subject to extension if the plant does not operate a sufficient period of time during the defined spawning season. This provision has already operated to extend the date from September 15, 1980 to September 15, 1981 and is reflected in the present schedule referred to above. It is possible that another such extension might occur.

The stipulation specifically recognizes the probable necessity for relocating a natural gas pipeline owned by Algonquin Gas Pipeline Company. The stipulation assumed a schedule for obtaining Federal Power Commission approval of the relocation and for completing this work, and provided for an adjustment of the September 15 date for variance from the assumed schedule. Such adjustment is possible.

Some of the provisions referred to above are derived from the Indian Point 2 License and may lead to changes in the Indian Point 2 cooling tower schedule.

B. <u>Changes in Schedule for Other Reasons</u>

It must be kept in mind that the schedules described above for both Indian Point 2 and 3 are optimum schedules with no contingency provisions for the factors that customarily delay all public and private construction projects. No contingency provision was provided because it is impossible to predict the extent of such delays and also to allow the Nuclear Regulatory Commission the opportunity to evaluate the consequences of such delays when they occur.

Construction experience at Indian Point shows that delays customarily arise from labor difficulties, inability to secure material, lack of skilled manpower accidents and other events beyond Con Edison's control. Some construction work at Indian Point is presently in suspense because of labor difficulties.

The foregoing shows that the dates referred to in the first paragraph above are presently assumed dates and it is most probable that they will change with time as the procurement and construction programs proceed. In the unlikely event that the schedules remain as presently indicated in the first paragraph, there is the possibility of accelerating the preconstruction portions of the schedule for the cooling tower for Indian Point 2 so that excavation overlap is eliminated and the outage of Unit 2 would end during May 1981. The economic analysis contained in the Environmental Report assumed such a schedule (see ER, p. I-6).

Q 2. Since the Environmental Protection Agency has published a NPDES, pursuant to Section 402 of the FWPCA of 1972, requiring termination of once-through cooling of Unit No. 2 by May 1, 1979, describe your plans to request a change in the NPDES date to be consistent with the dates in your application for extension of once-through cooling of Unit No. 2. On what basis can an extension be granted until the Section 316a hearing is completed and the EPA Administrator's decision is granted?

A 2. The May 1, 1979 "NPDES date" is not legally effective. It is true that a "final" NPDES permit for Indian Point Units 1 and 2 was issued on February 27, 1975 and that the permit requires operation of Unit 2 with a closed-cycle cooling system after May 1, 1979. However, on April 7, 1975 Con Edison filed a request for an adjudicatory hearing with respect to the aforesaid requirement and others in the permit. In that document Con Edison requested, among other things, that the "NPDES date" be changed to July 1, 1981. EPA, in granting the Company's request for an adjudicatory hearing in a public notice dated May 8, 1975, stated that the effectiveness of all the conditions challenged by Con Edison, including the requirement for closed-cycle cooling for Unit 2, was stayed pending the outcome of the adjudicatory hearing.

The Company plans to advocate before EPA that a final decision be made on a closed-cycle cooling system on the same schedule as that which it advocates before the NRC.

Postponement of action on the Con Edison request to the NRC for extension could be justified only if the Commission considers that its NEPA functions with respect to water quality matters are entirely controlled by EPA action under the Federal Water Pollution Control Act in the circumstances of this proceeding. No such official interpretation has ever been given and counsel for the Company does not believe it would be justified.

The practical effect of postponing action on the extension would mean a delay of two years or more, since the Company has every intention of seeking judicial review of any ultimate EPA determination contrary to the positions taken by the Company in requesting the adjudicatory hearing. Such a long delay would either make it impossible to adhere to the schedules as now set or would deprive the Company of any effective possibility of obtaining an extension consistent with its rights under the license.

Q 3. We note that the Environmental Report submitted with the application refers to the significant data collected in 1974 from your ecological study program. This information has not been received by the staff.

A 3. The comprehensive riverwide fisheries survey data gathered in 1974 as well as in years prior to 1974 is reviewed, analyzed and discussed in "The First Annual Report for the Multiplant Impact Study of the Hudson River Estuary." This report, which is being filed as Appendix D to the "Environmental Report to Accompany Application for Facility License Amendment for Extension of Operation with Once-Through Cooling for Indian Point Unit No. 2", was prepared for Con Edison by Texas Instruments Incorporated. It is now being printed and will be filed shortly.

Q 4. Provide a detailed presentation of the two dimensional striped bass life cycle model discussed in the Environmental Report in support of your application for a license amendment.

A 4. Impact assessments presented in the Environmental Report accompanying the application for extension of once-through cooling at Indian Point 2 from May 1979 to May 1981 were all estimated using the second generation transport model of the Hudson River striped bass population, which is not the two-dimensional model referred to in the question. Con Edison has not relied upon the two-dimensional model in presenting its analysis of data on environmental impacts of the requested license amendment. The two-dimensional model is referred to as one of the research projects which will be completed in the future and which justify Con Edison's belief that important new information will be available if the requested amendment is granted.

Since its inception, the striped bass life cycle model has undergone continuous development. The major changes that have been incorporated into the model reflect a determination to represent more precisely fish behavior and the river hydrology.

To date, three generations of the life cycle model have been developed in an effort to ascertain the potential impact of power plant operations on the Hudson River striped bass. The first generation model described the Hudson River as a completely mixed volume of water, excluding all considerations of the hydrodynamics in the estuary and thereby excluding their influence on the distribution of the early life stages of striped bass. Predictions by the completely mixed model resulted in conservative estimates of percent cropping by power plants. This conservatism was the result of the model's "viewing" all organisms as equally subject to entrainment when in fact only those organisms in front of the power plant were susceptible.

The completely mixed model provided the basis for Dr. John Lawler's April 5, 1972 testimony presented during the Indian Point 2 hearings before the Atomic Safety and Licensing Board (ASLB). This model was used in the preparation of all subsequent testimony by Dr. Lawler to extrapolate impacts on fish populations over long periods of time.

The second generation model, the transport model, is a tidal-averaged hydrodynamic model which accounts for the transport of striped bass eggs and larvae by freshwater flow and by tidal currents between segments of the river. The transport model takes into account the specific locations of power plants on the Hudson River as well as the effects of the lateral and vertical distribution of organisms in the vicinity of the plants. This model is most important in estimating the impact of the power plants on the young-of-the-year fish. The transport model provided the basis for Dr. John Lawler's October 30, 1972 testimony presented before the Indian Point 2 ASLB. This is the model which the Atomic Safety and Licensing Appeal Board described as more nearly conforming to reality and superior to the other models presented. ALAB-188, 74-4 RAI 323, 383 (April 4, 1974).

During late 1973 and early 1974, the transport model was revised to increase its efficienty in terms of computer running time and to make it consistent with the knowledge gained from the 1973 data. A transport avoidance factor was incorporated into the model equations in order to take into account the fact that life stages of striped bass which are found very close to the bottom of the estuary are less subject to water transport than are life stages found in upper water strata. In addition, the number of segments in the longitudinal direction was increased from eight to twelve. These revisions did not substantially alter the estimates of impact derived from model runs. They did, however, serve to create a more accurate picture of actual Hudson River conditions.

Predictions of power plant impact from the revised transport model with a 1973 data base were presented in Dr. John Lawler's October 1974 testimony before the Federal Power Commission during the Cornwall Proceedings. Also, the revised model features were discussed in late July-early August, 1974 with Oak Ridge National Laboratory personnel who were working on a striped bass life cycle model for the AEC. This revised model was the one used to determine the impact assessments set forth in the Environmental Report which accompanied the license amendment application.

The third generation model, the real-time transport model, is briefly described in the Environmental Report as a study currently in progresss. Its new features include real-time hydrodynamic inputs and a two-dimensional (length and depth) analysis. This model uses hydrodynamic information at three hour intervals in order to provide a more realistic simulation of the tidal action in the estuary and the effect of these hydrodynamics on the distribution of the early striped bass life stages. In addition, the real-time model considers two layers in the vertical direction in order to simulate more precisely the well-recognized diurnal migration of striped bass larvae. In addition it more accurately simulates the reduced rate of transport of eggs in the bottom layer of the river. The longitudinal dimension of the real-time model is divided into twenty-nine segments, compared with twelve in the transport model. This makes possible more precise modeling of the life stage distributions. With these new features, the real-time model provides an even more realistic simulation of the striped bass population dynamics than did the previous models.

The first results of the real-time model will be presented in a "Report on the Development of a Real-Time, Two-Dimensional Model of the Hudson River Striped Bass Population" which is expected to be delivered to the NRC and others during 1975 as part of Con Edison's on-going ecological study program. The purpose of the requested license amendment is to allow Con Edison time to complete that program. The two-dimensional real-time model is referred to in the Environmental Report solely to identify it as an element of the study program which can only be completed if the amendment application is granted.