FINAL

HUDSON RIVER ECOLOGICAL STUDY IN THE AREA OF INDIAN POINT 1988 ANNUAL REPORT

Prepared for

Consolidated Edison Company of New York, Inc.
New York, New York

and

New York Power Authority
White Plains, New York

Jointly Financed by

Central Hudson Gas and Electric Corporation
Consolidated Edison Company of New York, Inc.
New York Power Authority
Niagara Mohawk Power Corporation
Orange and Rockland Utilities, Inc.

Prepared by

EA Engineering, Science, and Technology
Northeast Regional Operations

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CONTENTS

LIST OF FIGURES

LIST OF FIGURES (Cont.)

LIST OF TABLES

LIST OF TABLES (Cont.)

1. SUMMARY

Impingement monitoring of fish and blue crabs was conducted at the Indian Point Generating Station in 1988, continuing sampling efforts that began in 1972. Sampling was performed at Units 2 and 3 following the stratified random design first introduced during the last six months of 1981. The stratified sampling design consisted of 110 sampling days per year, divided into four strata (seasons).

The estimated total number of fish impinged, adjusted for collection efficiency, was 923,533 fish at Unit 2 and 212,043 fish at Unit 3 for a combined total of 1,135,576 fish weighing an estimated 8,966 kg. Impingement abundance in previous years ranged from 850,000 to 6,470,000 (adjusted for collection efficiency). The estimated number of fish impinged per unit volume of water circulated in 1988 totaled $489/10^6m^3$ and was slightly below the range reported from past years ($496\text{-}2,910/10^6m^3$).

Sixty-five species of fish were recorded in impingement collections during 1988, which was within the range from past years (43-79). The three most numerous species impinged at Units 2 and 3 combined in 1988 were, in order of abundance, white perch, striped bass, and hogchoker, which together comprised 86 percent of the total estimated impingement abundance. Seasonal impingement patterns and rates of these and other selected species were generally consistent with past years.

The total impingement count of blue crabs in 1988 was 41,363 crabs at Unit 2 and 15,233 crabs at Unit 3 for a combined total of 56,596 crabs at both units. This value was more than 4.6 times higher than reported for any of the previous study years. The blue crab collection was characterized by a male to female ratio of approximately 2 to 1 and a survival rate of 80.7 percent. Ninety-six percent of the blue crabs collected were between 30-170 mm with most ranging from 80 to 160 mm. Blue crab impingement rates ($no./10^6m^3$) unadjusted for collection efficiency were higher at Unit 2 than Unit 3. Peak blue crab impingement rates occurred during August, October, and November and ranged from $363/10^6m^3$ at Unit 2 to $45/10^6m^3$ at Unit 3.

2. INTRODUCTION

This report is the 17th in a series of annual reports entitled "Hudson River Ecological Study in the Area of Indian Point." Previous annual reports have presented the results of various studies conducted at or in the vicinity of the Indian Point Generating Station, including impingement sampling, fisheries surveys, mitigation studies, and ichthyoplankton entrainment sampling (TI 1973, 1974, 1975, 1976, 1977, 1979, 1980a, 1980b; Con Edison 1982a, 1982b, 1983; NAI 1984a, 1986, 1987; MMES 1985; EA 1988). This report discusses the 1988 impingement data and interprets the latest study results in conjunction with the findings of previous years. Estimates are provided for the total number of fish and blue crabs impinged at each unit and for all individual species. Seasonal impingement trends at Units 2 and 3 are also discussed.

With the implementation of the Settlement Agreement, the Hudson River Utilities (Consolidated Edison Company of New York, Inc.; New York Power Authority; Central Hudson Gas and Electric Corporation; Orange and Rockland Utilities, Inc.; and Niagara Mohawk Power Corporation) re-examined each of the programs they had been conducting to determine whether the effort allocated was sufficient. For the Indian Point impingement program, it became evident after extensive data analysis and literature review that daily collections were unnecessary to maintain acceptable levels of accuracy and precision (TI 1980b; NAI 1984b). Three potential sampling strategies were evaluated in terms of the accuracy and precision afforded by each in estimating total fish impingement at the Indian Point Generating Station. One design randomly allocated the sampling effort throughout the year. The other two designs were both stratified, one on a seasonal basis, and the other based on distinct periods of high and low impingement variation at each unit (TI 1980b). The design that was ultimately selected utilized seasonal stratification and involved sampling on 110 days annually. Simulated sampling at this yearly level of intensity (30 percent) was found to be very accurate, i.e., the 95 percent confidence intervals about the simulated mean of daily impingement counts enclosed the true mean (the mean of all daily impingement counts for each unit in the 1976-1979 period) at Units 2

and 3 more than 92 and 93 percent of the time, respectively (TI 1980b). Increasing the sampling intensity beyond 30 percent resulted in only marginal improvements in accuracy (TI 1980b).

Precision and accuracy of the reduced sampling design (110 days per year) implemented in 1981 was re-evaluated after 1983 by examining the combined impingement database from 1976 to 1983 (NAI 1984b). Species-specific impingement rate changes during 1981, 1982, and 1983 did not affect the precision or accuracy of impingement estimates. Similarly, mandated changes in plant operating flows have not detracted from the validity of the reduced sampling design. The inclusion of post-1979 collections in the evaluation produced a slight revision in the way in which the 110 sampling days were allocated among seasonal strata, and this revised allocation was used beginning in 1985 (NAI 1984a). Impingement monitoring during 1988 at Units 2 and 3 of the Indian Point Generating Station was conducted for the entire year on random, pre-selected days according to the stratified random sampling design.

Chapter 3 of this report (Materials and Methods) presents a description of the Indian Point Generating Station, field and laboratory methods, the 1988 sampling design, and the collection efficiency estimates and regression models used to adjust impingement counts. Chapter 4 (Results and Discussions) provides estimates of the number of fish impinged during 1988, evaluates the effects of collection efficiency adjustments, presents species composition and relative abundances, describes seasonal and yearly impingement patterns, and describes blue crab impingement patterns. Literature citations are presented in Chapter 5. Data calculations procedures are presented in Appendix A. Appendix B provides summary tables for water quality and impingement collection results.

3. MATERIALS AND METHODS

Impingement collections at Indian Point Units 2 and 3 were taken in four seasonal strata according to the stratified random sampling design introduced in Chapter 2. On all days when the plant operated, whether or not sampling was scheduled for impinged fish, the traveling screens were washed to remove fish, crabs, and debris. On all days when the plant operated, samples of impinged blue crabs were collected when present. The field and laboratory procedures used in collecting and processing samples are presented below, and the formulas used in the data calculations are presented in Appendix A.

3.1 THE INDIAN POINT GENERATING STATION

The Indian Point Generating Station is located on the east bank of the Hudson River, about 69 km (43 mi) above the Battery in New York City (Figure 3-1). The Indian Point Generating Station began operating with the completion of Unit 1 in 1962. Unit 2, which is operated by Consolidated Edison Company of New York, Inc. (Con Edison), and Unit 3, which is operated by the New York Power Authority (NYPA), began operation in 1973 and 1976, respectively. Each unit of this nuclear plant utilizes a once-through cooling system that can entrain the early life stages of various fish species into and through the cooling system, and can impinge juvenile and older fishes on screening devices located at the opening of each water intake bay.

The combined pumping capacity of the three units for cooling purposes is 7,790 m^3/min (2,058,000 gal/min). Unit 1, which has two 530 m^3/min (140,000 gal/min) circulator pumps, was retired from commercial operation in October 1974. The two units currently operating each have six 530 m^3/min circulating pumps. Each unit also has service water pumps, which also withdraw river water. Unit 1 has two service pumps with a total pumping rate of 144 m^3/min (38,000 gal/min). Units 2 and 3 each have six service pumps with a total pumping rate of 114 m^3/min (30,000 gal/min) at each unit.

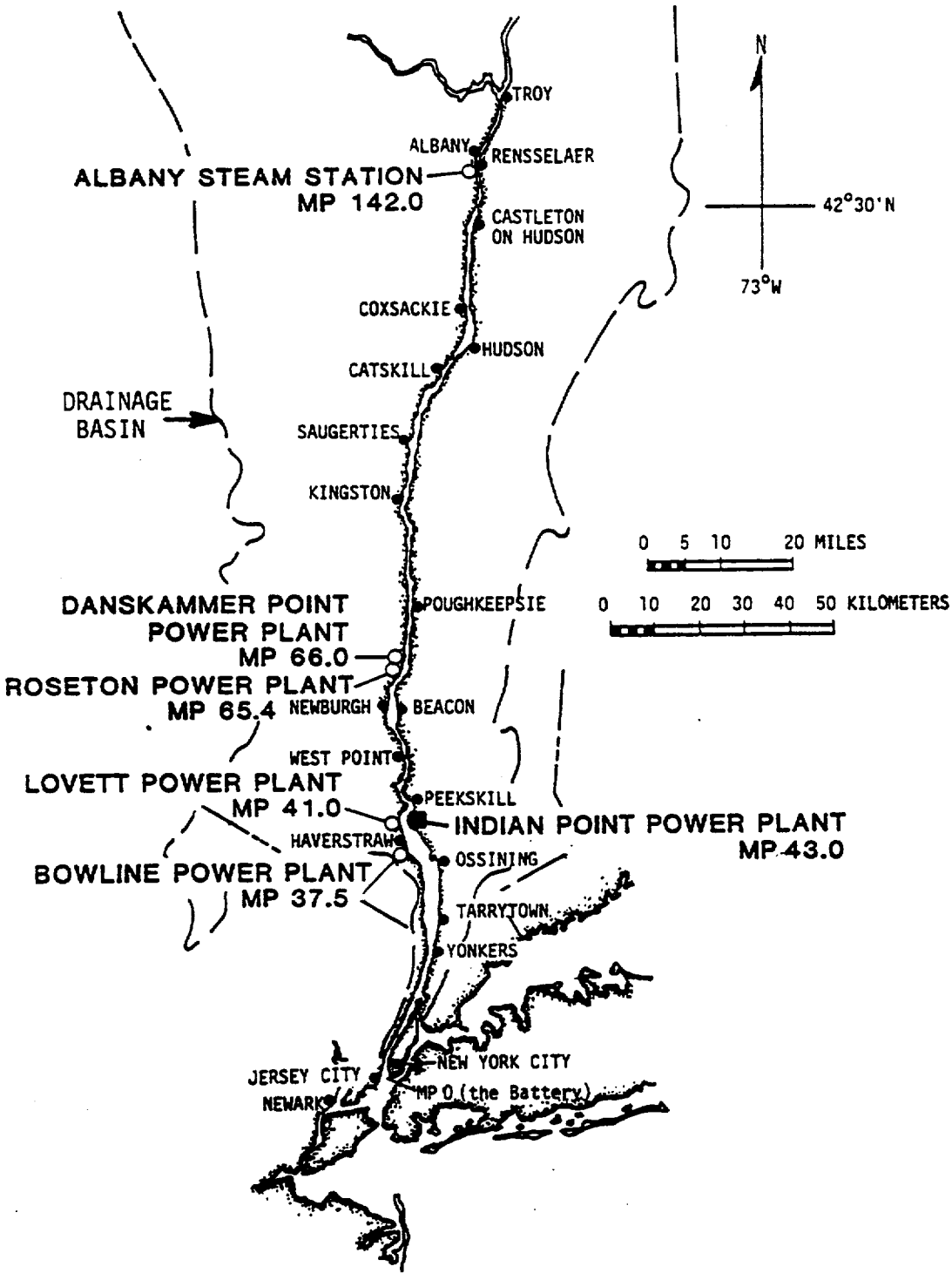

Figure 3-1. Location of Indian Point Generating Station relative to other Hudson River stations.

Unit 1 intakes and Unit 2 Intakes 21-25 have fixed intake screens at the River's edge and conventional vertical traveling screens within each intake bay (Figure 3-2). Unit 2 Intake 26 has a Ristroph-modified vertical traveling screen; the fixed screen was not in place during 1988. Unit 3 has vertical traveling screens at the River's edge, but no fixed screens (Figure 3-3). Details of the plant and associated intake structures have been presented previously (Con Edison 1977; NAI 1986).

In December 1980, Con Edison, NYPA, and other Hudson River Utilities consented to certain restrictions in operating conditions, including the flow rates for the circulating water pumps, as part of an agreement reached with government agencies. To achieve the flow rate schedule specified by the Agreement (Table 3-1), which became effective 14 May 1981, dual speed circulating water pumps were to be installed at both Indian Point Units 2 and 3 by 14 November 1984. During the interim, alternative flow rates (Table 3-2) were required to be met.

These flow rates were specified as a measure to reduce a minimum water withdrawal from the Hudson River to rates necessary for efficient operation of the plants. The operation of Unit 2 with dual speed pumps commenced on 20 September 1984. Variable speed pumps were installed at Unit 3 and were available for service in September 1985.

3.2 FIELD AND LABORATORY METHODS

3.2.1 Sample Design and Schedule

The stratified sampling design for impingement and water quality data collection that was initiated in July 1981 was continued throughout 1988 at Units 2 and 3. Sample days were assigned to randomly selected dates within four seasonal strata, in contrast to the daily sampling which was conducted before July 1981.

Fish and blue crab impingement samples were collected on the randomly selected sample days and analyzed. On days not selected for sample collection (non-sample days), only blue crabs were collected and analyzed; fish and debris were

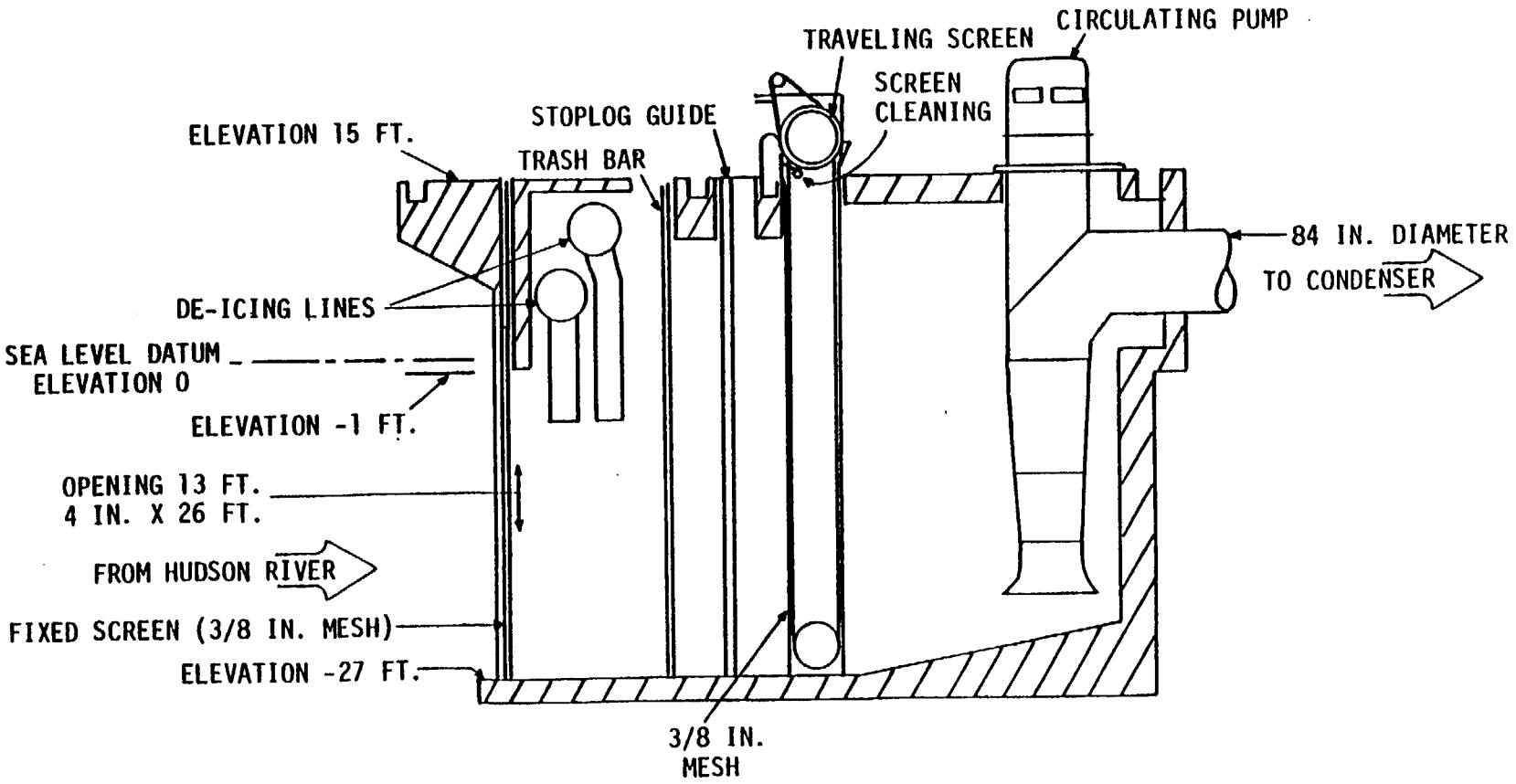

Figure 3-2. Schematic intake bay cross-section of Indian Point Unit 2.

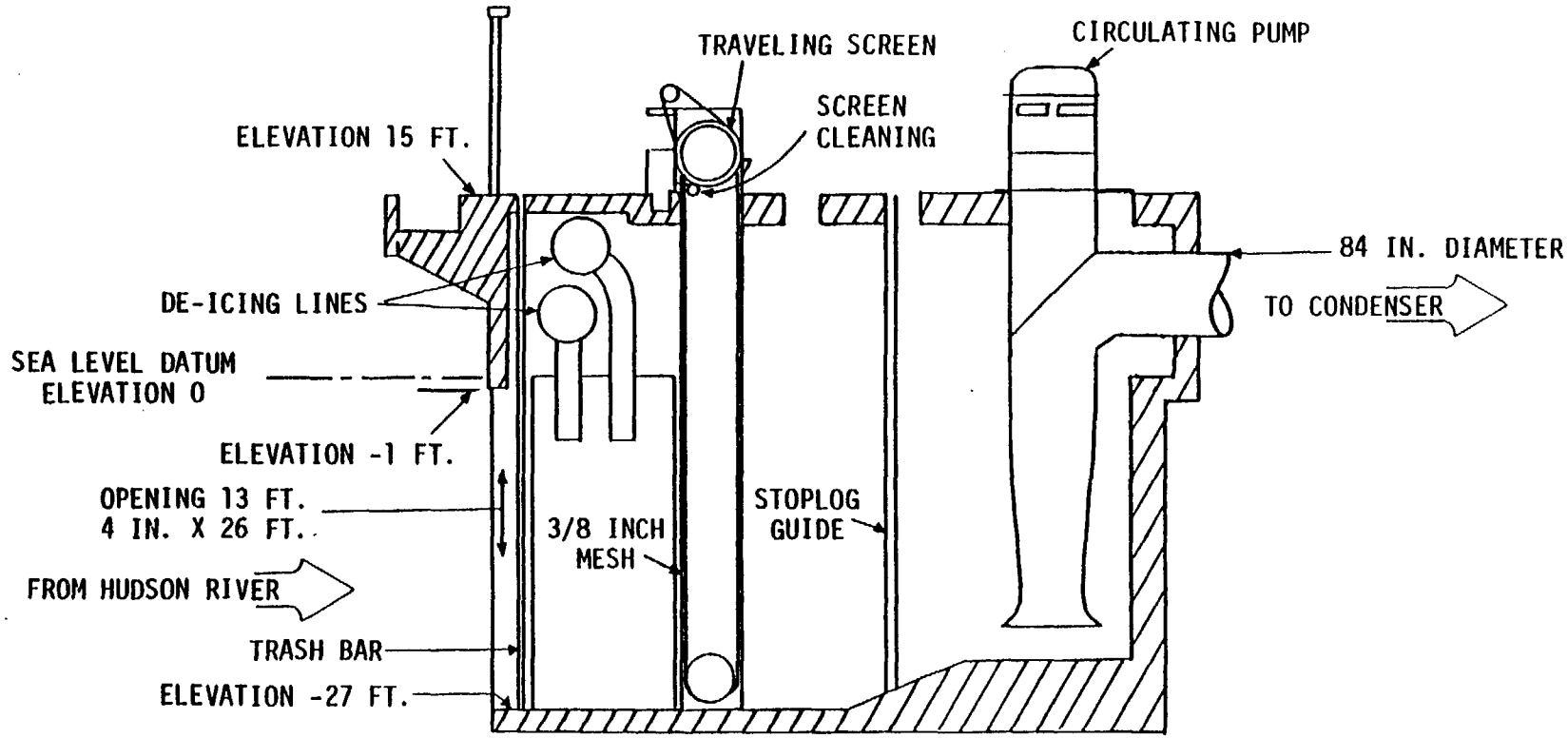

Figure 3-3. Schematic intake bay cross-section of Indian Point Unit 3.

TABLE 3-1 FLOW RATE SCHEDULE FOR DUAL SPEED/VARIABLE SPEED CIRCULATING WATER PUMPS AT INDIAN POINT UNITS 2 AND 3 IN EFFECT AFTER 14 NOVEMBER 1984

Approximate Period	Approximate Flow (gpm/Unit)	Approximate Flow $10^6 m^3$/min/Unit
01 JAN - 15 MAY	504,000	1.9
16 MAY - 22 MAY	560,000	2.1
23 MAY - 31 MAY	672,000	2.5
01 JUN - 08 JUN	731,000	2.8
09 JUN - 30 SEP	840,000	3.2
01 OCT - 31 OCT	731,000	2.8
01 NOV - 31 DEC	504,000	1.9

TABLE 3-2 INTERIM CIRCULATING WATER FLOW RATE SCHEDULE FOR INDIAN POINT UNITS 2 AND 3 BEWTEEN 14 MAY 1981 AND 14 NOVEMBER 1984

Approximate Period	Approximate Flow (gpm/Unit)
01 JAN - 01 MAY	505,000 gpm (60 percent flow)
01 MAY - 01 JUN	Change: From 505,000 gpm to 840,000 gpm (100 percent flow)
01 JUN - 01 OCT	840,000 gpm
01 OCT - 01 NOV	Change: From 840,000 gpm to 505,000 gpm (60 percent flow)
01 NOV - 31 DEC	505,000 gpm

discarded when the traveling screens were washed. Blue crab impingement counts and biocharacteristics data were collected on all days in 1988 when blue crabs were present in impingement collections. Water quality data were collected at Units 2 and 3 intakes on days when either fish or blue crabs were collected. Allocation quotas of sampling days were met among all seasonal strata except for fall at Unit 2, where only 65 of the allocated 68 samples were available (Table 3-3). Samples collected on 19 October and 5 and 6 November 1988 contained void components (21-25 screens) and were excluded from analysis.

Screens were washed daily, generally between 0800 and 1200 hours. Each sample day began at the time of a scheduled daily wash on one day and concluded at the time of the subsequent scheduled wash. On preselected random sampling days, fish were collected from the screenwash of Unit 2 Intakes 21-25 combined, Unit 2 Intake 26 (Ristroph screen), and Unit 3 Intakes 31-36 combined. On non-sample days, fish and debris were disposed of without enumeration. On occasion when sampling could not be carried out due to outages, abnormal screenwash procedures, or unexpected operating conditions, an additional sampling day was randomly selected from the remaining non-sample days in the stratum (if any remained) to replace the one lost. If unscheduled screenwashes or continuous washing was necessary during a sampling day because of heavy trash loading, screen malfunction, etc., then sampling was also conducted during those unscheduled washes to make the date representative of the full sampling period.

The method used to calculate an estimate of the total number of fish impinged during the year (Appendix A) assumes that the volume of cooling water pumped by the plant on sample days is representative of the volume pumped for all operating days in a stratum, since each operating day is weighted equally in computing the estimate. The validity of this assumption is shown by the close correspondence between sample and operating days in the average daily circulating volumes observed each month at Unit 2 (Table 3-4) and Unit 3 (Table 3-5).

TABLE 3-3 NUMBERS OF IMPINGMENT COLLECTION DAYS AND DAYS OF PLANT OPERATION AT INDIAN POINT UNITS 2 AND 3 DURING 1988

Unit	Seasonal Stratum	Days of Plant Operation*	Days of Impingement Collections	Days Allocated in Stratified Design
2	Winter (JAN-MAR)	82	23	23
	Spring (APR-JUN)	91	9	8
	Summer (JUL-SEP)	92	11	11
	Fall (OCT-DEC)	92	65	68
	Total	357	108	110
3	Winter (JAN-MAR)	91	35	35
	Spring (APR-JUN)	77	20	20
	Summer (JUL-SEP)	92	31	31
	Fall (OCT-DEC)	92	24	24
	Total	352	110	110

* A unit was considered operating on a day if any circulator pump operated for any time on that day.

TABLE 3-4 COMPARISON OF SAMPLING DATES, AVERAGE DAILY SAMPLING VOLUMES, OPERATING DATES, AND AVERAGE DAILY OPERATING VOLUMES AT INDIAN POINT UNIT 2 BY MONTH DURING 1988

Month	Sampling Dates	Average Daily Sampling Volume ($10^6 m^3$)	Standard Deviation	Operating Dates	Average Daily Operating Volume ($10^6 m^3$)*	Standard Deviation
JAN	12-13, 23, 26	1.47	1.39	9-13, 15-31	1.71x31 53	1.16
FEB	2-3, 17-19, 21-23 26-27	2.65	0.15	1-29	2.83x28 79	0.12
MAR	1-2, 7-8, 11, 13-14, 22-23	2.63	0.21	1-31	2.87x31 89	0.01
APR	28	1.97	---	1-30	2.85x30 86	0.06
MAY	3, 6, 16, 23-24 26	2.86	0.62	1-31	3.19x31 99	0.41
JUN	4, 6	3.32	1.33	1-30	3.57x30 107	1.37
JUL	6, 19	3.28	1.87	1-31	3.41x31 105	1.16
AUG	9, 15-16, 20, 22, 24	4.46	0.38	1-31	4.69x31 145	0.11
SEP	11, 18, 27	3.74	1.30	1-30	4.53x30 136	0.36
OCT**	4-7, 10-18, 20-31	3.83	0.25	1-31	4.00x31 124	0.17
NOV	1-2, 8-11, 13-17, 19-20, 22-29	2.71	0.25	1-30	2.85x30 86	0.02
DEC	1-6, 8-14, 17-19, 21-23	2.73	0.20	1-31	2.87x31 89	0.11
					1,198	

* Includes service water, except days when no circulating pump operated.

** The 19 October, 5 November, and 6 November 1988 Ristroph only sample(s) not included in analysis.

TABLE 3-5 COMPARISON OF SAMPLING DATES, AVERAGE DAILY SAMPLING VOLUMES, OPERATING DATES, AND AVERAGE DAILY OPERATING VOLUMES AT INDIAN POINT UNIT 3 BY MONTH DURING 1988

Month	Sampling Dates	Average Daily Sampling Volume ($10^6 m^3$)	Standard Deviation	Operating Dates	Average Daily Operating Volume ($10^6 m^3$)*	Standard Deviation
JAN	7, 9-10, 12-14, 18-19, 21, 23-25, 27-28	2.52	0.32	1-31	2.64 x 31 82	0.20
FEB	1, 4, 6, 9, 14, 19, 21-23, 27	2.59	0.22	1-29	2.78 x 29 81	0.10
MAR	1, 9-12, 15-16, 18, 21, 25, 28	2.59	0.33	1-31	2.85 x 31 90	0.05
APR	28-29	2.17	0.27	1-30	2.80 x 30 84	0.07
MAY	2-3, 5-7, 9, 12, 31	2.52	0.68	1-12, 27-31	2.53 x 31 78	0.89
JUN	1-7, 13, 16, 19	3.79	0.33	1-30	4.31 x 30 129	0.54
JUL	3-6, 9, 19-20, 24-26	4.54	0.31	1-31	4.67 x 31 146	0.07
AUG	2, 4-5, 10, 16-17, 19, 21-23, 28	4.37	0.34	1-31	4.71 x 31 146	0.01
SEP	8, 11, 14-17, 20, 24-25, 27	4.62	0.32	1-30	4.71 x 30 141	0.02
OCT	3-4, 8-10, 12, 24-29, 31	1.91	1.53	1-31	2.52 x 31 78	1.49
NOV	1-5, 7-8, 25-26	1.01	0.92	1-30	1.21 x 30 36	1.01
DEC	1,6	2.52	0.25	1-31	2.67 x 31 83	0.11
						1,174

* Includes service water, except days when no circulating pump operated.

3.2.2 Sample Collection

Impingement samples were obtained from collection areas at the end of the Unit 2 and Unit 3 sluiceways and at a separate collection area for the Ristroph Screen 26. Each sample effort began with a screenwash and thorough cleaning of the sluiceways and debris pits. The fixed screens at Intakes 21-25 were washed manually with a hose prior to washing each traveling screen. Each fixed screen was raised and washed in 4-ft increments until the entire screen broke water and impinged material passed into the intake forebay to be removed from the condenser cooling water by the conventional vertical traveling screens. Unit 2 Intake 26 (Ristroph modified screen) and all of the Unit 3 intakes were equipped only with traveling screens in 1988 so that there was no fixed screen to be washed before washing each traveling screen. Each sample ended with the start of the next scheduled screenwash, usually on the following day. If unscheduled washes occurred before the end time of the sample day, the fish, crabs, and debris were sorted, retained, and added to the contents of the scheduled wash that completed that sample day.

On sample days, all fish and blue crabs washed from the intake screens of the unit(s) being sampled were taken to the laboratory for processing. On non-sample days, only blue crabs were kept for processing. Temperature (C) and conductivity (micro-siemens/cm) were measured at the intake of Units 2 and 3 at 0.3 m (1 ft) below the water surface on days when fish or blue crabs were collected, as close as was practical to the time of flood or high tide (Appendix Table B-1). Plant operating data were recorded for each day that fish or blue crabs were collected: time of screenwash, screenwash order, head loss at each screen, and operating condition of each screen.

3.2.3 Sample Processing

Fish were identified and enumerated by four general size classes for each species, based on total length in millimeters:

Length Class 1 = up to Division 1
Length Class 2 = Division 1 + 1 mm up to Division 2
Length Class 3 = Division 2 + 1 mm up to 250 mm
Length Class 4 = 251 mm and larger

The Division 1 cutoff used to define Length Class 1 represents the upper length limits of young of the year for all species. The Division 2 cutoff represents the upper length limit for yearling alewife, American shad, blueback herring, striped bass, Atlantic tomcod, and white perch. Consequently, Length Class 2 individuals for these species are all yearlings. For all other species, Division 2 is arbitrarily set to 150 mm TL. Values for the division cutoffs were determined from historical and current data obtained from impingement collections. These values were updated weekly during the period of rapid growth for young-of-the-year Atlantic tomcod, white perch, and striped bass. During the remainder of the year, updates were prepared on a biweekly basis.

Subsamples were taken for any species if the total number of fish in Length Class 1 or Length Class 2 exceeded 100. In those cases, 100 fish were randomly selected within the length class and weighed. The total count for that species in the subsampled length class was estimated as 100 multiplied by the ratio of the total weight of the length class to the subsample weight. Total counts (sum of four length classes) for each species are summarized in Tables B-2 through B-7. For each species, weights were recorded to the nearest gram for Length Class 1, Length Class 2, and the total of all four length classes (Tables B-8 through B-10).

Each week for the following 13 selected species, a maximum of 30 individual specimens from all available length classes were measured for total length (nearest mm):

Alewife	Bluefish	Striped bass
American shad	Hogchoker	Weakfish
Atlantic tomcod	Rainbow smelt	White catfish
Bay anchovy	Spottail shiner	White perch
Blueback herring		

Individual measurements were recorded only from regularly scheduled or rescheduled impingement collections. Length measurement records were compiled by sample number so as to associate individual measurements with the three locations (i.e., Unit 2, 21-25; Unit 2, Ristroph 26; and Unit 3, 31-36).

Blue crabs were examined for total count (Table B-11) and total weight, and the following data were recorded for each specimen: carapace width to the nearest millimeter (Table B-12), weight (nearest 0.1 g), survival (alive or dead), condition (intact or missing body parts), and sex. All blue crabs were also examined for the presence of tags applied during a 1986 mark/recapture study. If more than 50 blue crabs were present in a sample, then a subsample of 50 blue crabs was randomly selected and weighed. The total number of blue crabs in the sample was estimated as 50 multiplied by the ratio of total weight of the blue crabs in the sample to the subsample weight. In case of subsampling, sex, alive/dead status, and condition were determined only for the 50 crabs in the subsample. After processing, all living crabs were returned to the Hudson River away from the intake structure.

Any shortnose or Atlantic sturgeon collected were measured (total length in mm), weighed, and the data entered in a Sturgeon Log. Living sturgeon were returned to the Hudson River. All striped bass collected on both sampling and non-sampling days were checked for hatchery implanted magnetic tags. Any suspected recaptures were preserved by freezing for later verification.

Water quality data were collected on scheduled sample days and days when blue crabs were collected. Water temperature and conductivity were measured in situ with a YSI Model 33 SCT Meter at a depth of 1 ft below the surface. The water quality sample for Unit 2 was taken off the gangway in front of Screen No. 2. The sample for Unit 3 was taken at the south side of the Unit 1 pier. Temperature was measured to the nearest 0.5 C and conductivity to the nearest 10 scale units (2.5 percent).

Quality control (QC) checks were performed on fish identifications, counts, weights, length measurements, crab measurements, and examination of suspected recaptures. The selection of samples for QC checks followed Military Standard 1235 (Single and Multiple Level Continuous Sampling Procedures), which assured that 90 percent or more of the data were within specified tolerance limits. Data were recorded on standard data coding forms developed for this study. Calibration checks on the conductivity and temperature measurement systems were performed using standard KCI solutions and NBS traceable thermometers obtained from EA's regional laboratory. Calibrations were performed prior to each collection of conductivity/temperature data.

3.3 COLLECTION EFFICIENCY

While collections from the intake screens at Indian Point provide an indication of seasonal and yearly impingement patterns, they do not account for 100 percent of the fish impinged. Some impinged fish may be lost prior to collection because of (1) scavenging by crabs, fish, and birds, (2) river currents and wave action, or (3) the screenwash collection procedures. Deterioration and disintegration of impinged fish on the screens can also contribute to these losses.

Extensive collection efficiency studies were performed at Indian Point from 1977 to 1980 and in 1982 (Con Edison 1983). The observed values of collection efficiency in those studies, as summarized by Con Edison (1983), were used to develop the following regression models:

$$E_2 = -0.00871\ T_2 + 0.51858 \qquad \text{(Equation 1)}$$

$$E_3 = -0.00792\ T_3 + 0.71640 \qquad \text{(Equation 2)}$$

where

E_2 and E_3 = collection efficiency at Units 2 and 3, respectively.

T_2 and T_3 = intake water temperature (C) at Units 2 and 3, respectively.

Although individual observations of collection efficiency were highly variable at all temperatures, the above relationships were found to be statistically significant (efficiency decreased significantly with increasing temperature) and, therefore, useful for estimating actual impingement rates from impingement collections (Con Edison 1983). These estimates of collection efficiency were used to adjust impingement collections at Unit 2, Screens 21-25, and at Unit 3 to estimate total impingement.

For the Ristroph screen (Screen 26) at Unit 2, the following screen-specific collection efficiency values were determined based on the results of Ristroph Screen Special Studies (1 January - 19 April 1985) and the Ristroph Screen Survival Studies (16 July - 31 December 1985):

Month	Ristroph Screen Collection Efficiency
JAN	74.4 percent
FEB	74.4 percent
MAR	74.4 percent
JUL	18.7 percent
AUG	18.7 percent
SEP	29.6 percent

These screen-specific collection efficiency estimates were used to adjust impingement collections during months for which estimates were available. The design of the Ristroph screen is such that there is little opportunity for impinged fish to be washed off the screen and not be collected. The collection efficiency estimates of 18.7 percent for July and August and 29.6 percent for September were obtained during 1985, a year of unusually high abundance of blue crabs at Indian Point. During that year, approximately 11,000 blue crabs were collected at Unit 2, a number greater than that observed in previous years. This high blue crab abundance and associated predation in 1985 may explain the relatively low collection efficiency estimates from that year. However, in 1988, more than 41,000 blue crabs were collected at Indian Point Unit 2 and more

than 15,000 at Unit 3. If higher crab abundance resulted in lower collection efficiency, then the actual collection efficiency at the Ristroph screen and all other intake screens at both units would have been lower than used for this analysis and the resulting numbers impinged for the summer and fall strata would have been underestimated.

For other months, the collection efficiency for Screen 26 was assumed to be the same as for Screens 21-25 at Unit 2. Since the Ristroph screen at Unit 2 does not include the use of fixed screens and is operated continuously with the fish being retained in collection buckets, this assumption was most likely conservative resulting in overestimates of impingement for Screen 26.

4. RESULTS AND DISCUSSION

4.1 WATER QUALITY

Daily intake water temperature averaged for both units rose from a seasonal low in mid-January of -1.0 C to a high of 33.4 C in mid-August and subsequently declined to 4 C by December (Figure 4-1, Table B-1). Daily intake conductivity fluctuated during the year in a characteristic seasonal pattern. Lowest conductivity levels were recorded during spring when values less than 1,000 uS/cm were recorded with occasional periods of 1,000-3,000 uS/cm. Conductivity was at its highest during summer and fall with values of 4,000-12,000 uS/cm. During fall, conductivity once again dropped to levels generally below 1,000 uS/cm.

4.2 ESTIMATED NUMBERS OF FISH IMPINGED DURING 1988

A combined total of 199,480 fish were collected at Indian Point Units 2 and 3 in 1988 (Table B-4). When adjusted for collection efficiency and scaled to the number of operational days, the estimated total number impinged was 923,533 fish at Unit 2 and 212,043 at Unit 3 (Tables 4-1 and 4-2) for a combined total of 1,135,576 fish weighing an estimated 8,966 kg (Table B-10). The levels of precision (standard errors) were 8.7 and 8.3 percent of the total estimates for Unit 2 and Unit 3, respectively. These levels of precision are consistent with those projected for Unit 2 (9.5 percent [TI 1980b] and 7.8 percent [NAI 1984b]) and Unit 3 (8.2 percent [TI 1980b] and 7.7 percent [NAI 1984b]).

The total number of fish impinged by Units 2 and 3 combined in 1988, estimated at 1.14 million (Tables 4-1 and 4-2), was within the range of other yearly estimates in the 1976-1987 historical database (range 0.85-6.47 million) (Table 4-3) and slightly lower than last year's estimate of 1.54 million. The volume of water circulated through Indian Point Generating Station during 1988 ($2,322 \times 10^6 m^3$) was the highest reported over the past 13-year period (Table 4-4). The resulting overall impingement rate for all taxa (no./$10^6 m^3$) was the lowest reported for the same period.

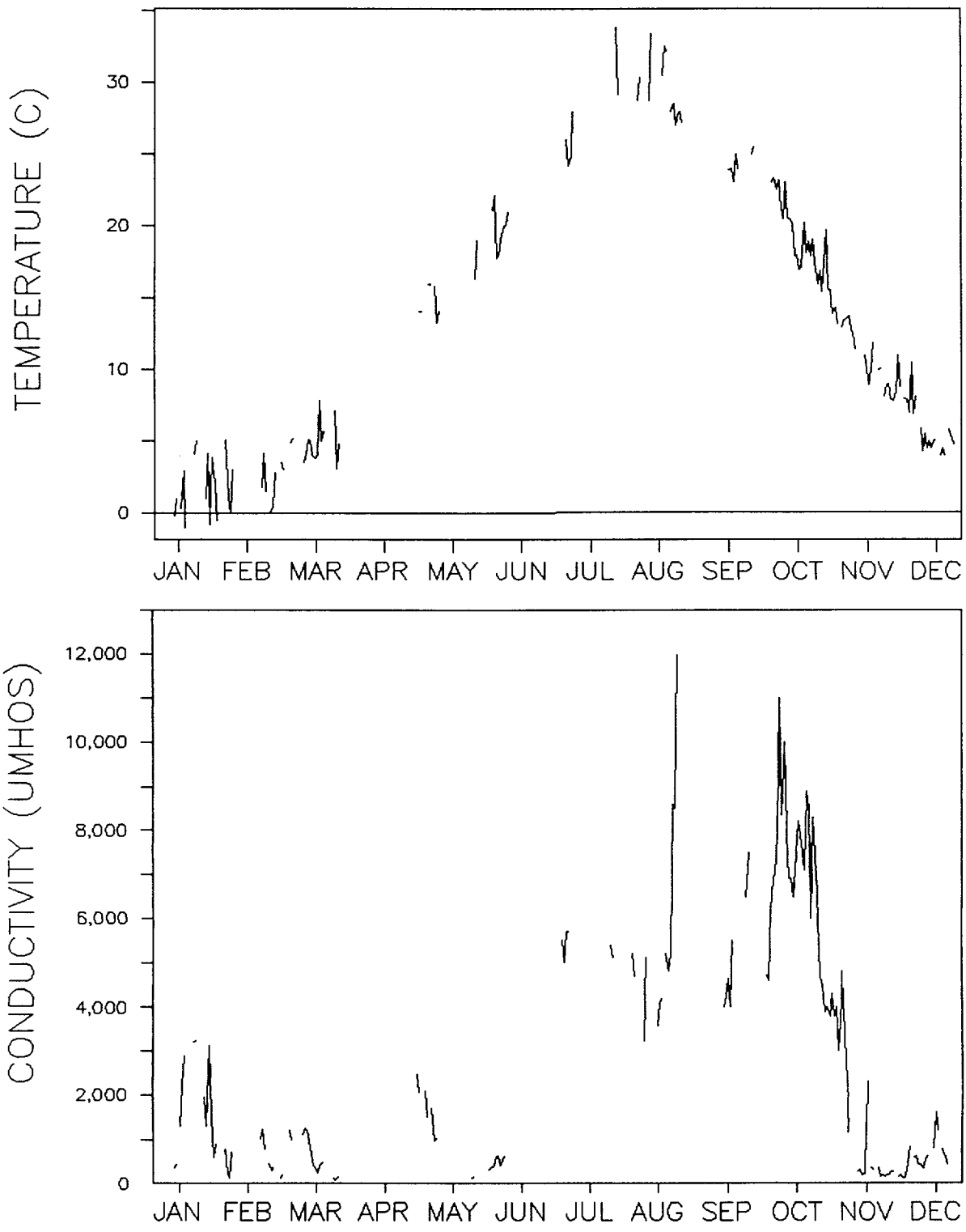

Figure 4-1. Seasonal pattern in water temperature and conductivity during impingement collections at Indian Point, 1988.

TABLE 4-1 ESTIMATED NUMBER OF FISH IMPINGED AT INDIAN POINT UNIT 2 DURING 1988 BY TAXON AND SEASONAL STRATUM (ADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Stratum				1988 Total	Standard Error	Coefficient of Variation
	Winter	Spring	Summer	Fall			
Alewife	78	415	460	392	1,345	208	15.5
Bay anchovy	0	0	18,091	13,133	31,224	12,865	41.2
American shad	0	30	84	242	356	91	25.6
Bluefish	0	0	2,952	204	3,156	1,370	43.4
Bluegill	11	91	59	995	1,156	167	14.4
Brown bullhead	32	30	0	28	90	34	37.8
Pumpkinseed	449	101	42	651	1,243	153	12.3
Black crappie	0	0	0	3	3	1	33.3
American eel	164	536	2,024	157	2,881	779	27.0
Goldfish	39	30	0	17	86	32	37.2
Golden shiner	93	0	0	6	99	23	23.2
Hogchoker	282	19,221	49,429	3,584	72,516	19,633	27.1
Tessellated darter	18	0	0	192	210	24	11.4
Banded killifish	271	30	25	532	858	115	13.4
Largemouth bass	0	0	0	6	6	2	33.3
Mummichog	0	0	0	3	3	1	33.3
Atlantic menhaden	0	0	142	20	162	133	82.1
Blueback herring	96	738	1,556	21,306	23,696	2,660	11.2
White sucker	0	30	0	0	30	29	96.7
Atlantic silverside	0	30	25	215	270	46	17.0
Rainbow smelt	1,341	647	3,529	134	5,651	3,288	58.2
Shortnose sturgeon	0	0	0	0	0	0	0.0
Spottail shiner	941	30	0	304	1,275	228	17.9
Striped bass	41,813	1,213	10,003	17,940	70,969	9,926	14.0
Atlantic tomcod	645	6,714	2,066	375	9,800	4,225	43.1
White catfish	1,219	2,194	109	2,025	5,547	1,238	22.3
White perch	337,116	76,855	84,239	160,588	658,798	58,095	8.8
Yellow perch	135	51	0	48	234	49	20.9
Northern pipefish	0	162	33	539	734	128	17.4
Redbreast sunfish	0	0	0	3	3	1	33.3
Atlantic needlefish	0	0	0	0	0	0	0.0
Crevalle jack	0	0	192	177	369	158	42.8
Weakfish	0	30	18,024	4,222	22,276	9,580	43.0
Lookdown	0	0	0	81	81	13	16.0
Seahorse	0	0	0	4	4	2	50.0
Tautog	0	51	0	0	51	48	94.1
Fourbeard rockling	0	0	0	0	0	0	0.0
Striped cuskeel	0	30	0	0	30	29	96.7
Spot	0	0	284	67	351	267	76.1
Moonfish	0	0	0	8	8	3	37.5
Scup	4	0	0	0	4	3	75.0
Winter flounder	29	30	0	0	59	33	55.9
Inland silverside	4	0	0	34	38	10	26.3
Sea lamprey	4	0	0	3	7	3	42.9
Gizzard shad	3,590	0	0	149	3,739	1,300	34.8
Silver hake	0	0	0	48	48	12	25.0
Threespine stickleback	1,437	0	0	0	1,437	233	16.2
Butterfish	0	0	151	239	390	72	18.5
White crappie	14	0	0	3	17	7	41.2
Red hake	11	81	0	8	100	53	53.0
Grubby	0	30	0	0	30	29	96.7
Eastern mudminnow	4	0	25	0	29	24	82.8
Longear sunfish	0	0	0	0	0	0	0.0
Summer flounder	0	91	84	8	183	72	39.3
Striped searobin	4	0	0	110	114	14	12.3
Northern searobin	0	0	50	0	50	47	94.0
Warmouth	0	0	0	14	14	4	28.6
Naked goby	4	61	25	45	135	46	34.1
Windowpane	0	30	50	137	217	50	23.0
Spotted hake	0	1,183	0	3	1,186	821	69.2
Northern stargazer	0	0	84	4	88	53	60.2
American sandlance	0	0	0	3	3	1	33.3
Fourspot flounder	0	0	0	8	8	3	37.5
Black sea bass	0	0	0	8	8	3	37.5
Cunner	0	30	0	28	58	30	51.7
Total	389,848	110,795	193,837	229,053	923,533	79,907	8.7

TABLE 4-2 ESTIMATED NUMBER OF FISH IMPINGED AT INDIAN POINT UNIT 3 DURING 1988 BY TAXON AND SEASONAL STRATUM (ADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Stratum				1988 Total	Standard Error	Coefficient of Variation
	Winter	Spring	Summer	Fall			
Alewife	36	354	300	8	698	113	16.2
Bay anchovy	8	89	3,846	276	4,219	835	19.8
American shad	0	50	83	15	148	31	20.9
Bluefish	0	50	418	42	510	81	15.9
Bluegill	5	23	12	35	75	24	32.0
Brown bullhead	10	8	6	8	32	12	37.5
Pumpkinseed	153	69	6	0	228	36	15.8
Black crappie	5	0	0	0	5	3	60.0
American eel	57	108	74	8	247	47	19.0
Goldfish	29	8	0	0	37	11	29.7
Golden shiner	34	8	0	0	42	11	26.2
Hogchoker	702	3,708	9,455	104	13,969	3,932	28.1
Tessellated darter	0	0	0	0	0	0	0.0
Banded killifish	29	0	0	15	44	13	29.5
Largemouth bass	18	0	0	8	26	11	42.3
Mummichog	0	0	0	0	0	0	0.0
Atlantic menhaden	3	0	24	0	27	12	44.4
Blueback herring	86	874	1,445	203	2,608	358	13.7
White sucker	0	0	0	0	0	0	0.0
Atlantic silverside	3	0	0	8	11	7	63.6
Rainbow smelt	341	989	383	0	1,713	356	20.8
Shortnose sturgeon	0	0	6	0	6	5	83.3
Spottail shiner	351	8	0	42	401	65	16.2
Striped bass	14,589	470	861	169	16,089	2,681	16.7
Atlantic tomcod	429	4,816	3,535	27	8,807	2,148	24.4
White catfish	861	404	42	38	1,345	142	10.6
White perch	104,395	29,583	4,647	5,930	144,555	13,345	9.2
Yellow perch	18	0	6	0	24	7	29.2
Northern pipefish	0	58	6	15	79	19	24.1
Redbreast sunfish	0	0	0	0	0	0	0.0
Atlantic needlefish	0	0	6	0	6	5	83.3
Crevalle jack	0	0	12	15	27	11	40.7
Weakfish	0	0	3,164	230	3,394	915	27.0
Lookdown	0	0	6	0	6	5	83.3
Seahorse	0	0	0	0	0	0	0.0
Tautog	0	23	0	0	23	11	47.8
Fourbeard rockling	3	0	6	0	9	5	55.6
Striped cuskeel	0	8	0	0	8	7	87.5
Spot	0	0	18	0	18	8	44.4
Moonfish	0	0	0	0	0	0	0.0
Scup	0	0	0	0	0	0	0.0
Winter flounder	3	8	0	0	11	7	63.6
Inland silverside	0	0	0	0	0	0	0.0
Sea lamprey	0	0	0	0	0	0	0.0
Gizzard shad	11,513	0	0	38	11,551	1,995	17.3
Silver hake	0	0	0	0	0	0	0.0
Threespine stickleback	159	31	0	0	190	38	20.0
Butterfish	0	0	223	46	269	83	30.9
White crappie	23	0	0	0	23	9	39.1
Red hake	29	8	0	0	37	13	35.1
Grubby	0	0	0	0	0	0	0.0
Eastern mudminnow	3	0	6	8	17	8	47.1
Longear sunfish	0	0	0	8	8	7	87.5
Summer flounder	0	27	24	0	51	17	33.3
Striped searobin	0	0	0	0	0	0	0.0
Northern searobin	0	0	0	0	0	0	0.0
Warmouth	0	0	0	0	0	0	0.0
Naked goby	0	0	0	0	0	0	0.0
Windowpane	0	0	6	15	21	10	47.6
Spotted hake	3	400	12	0	415	170	41.0
Northern stargazer	0	0	6	0	6	5	83.3
American sandlance	0	0	0	0	0	0	0.0
Fourspot flounder	0	0	0	0	0	0	0.0
Black sea bass	0	0	0	0	0	0	0.0
Cunner	0	8	0	0	8	7	87.5
Total	133,898	42,190	28,644	7,311	212,043	17,612	8.3

TABLE 4-3 ESTIMATED MEAN DAILY NUMBER OF FISH IMPINGED IN EACH SEASONAL STRATUM AT INDIAN POINT UNITS 2 AND 3 DURING 1988

Unit	Seasonal Stratum	Number of Sampling Days	Days Allocated in Stratified Design	Mean Daily Estimate*	Standard Deviation
2	Winter (JAN-MAR)	23	23	4,754.2	3,533.9
	Spring (APR-JUN)	9	8	1,217.6	1,211.9
	Summer (JUL-SEP)	11	11	2,106.9	1,721.1
	Fall (OCT-DEC)	65	68	2,489.8	3,737.1
	Total	108	110	2,586.9**	
3	Winter (JAN-MAR)	35	35	1,471.4	1,235.7
	Spring (APR-JUN)	20	20	547.9	380.5
	Summer (JUL-SEP)	31	31	311.3	486.3
	Fall (OCT-DEC)	24	24	79.5	225.4
	Total	110	110	602.4**	

* Adjusted for collection efficiency.
** Stratified mean daily estimate.

TABLE 4-4 TOTAL VOLUME CIRCULATED AT INDIAN POINT UNITS 2 AND 3 COMBINED, ESTIMATED NUMBER OF FISH IMPINGED, IMPINGEMENT RATE, AND NUMBER OF SPECIES COLLECTED DURING 1976-1988

Year	Volume ($10^6 m^3$)*	Estimated Number Impinged (10^6)**	Impingement Rate (No./$10^6 m^3$)	Number Species Collected
1976	1,329	1.63	1,190	58
1977	2,159	6.47	2,910	72
1978	2,030	3.91	1,870	72
1979	1,935	4.48	2,230	74
1980	1,822	3.21	1,710	76
1981	1,617	4.57	2,830	72
1982	1,273	1.60	1,260	43
1983	1,286	0.85	661	49
1984	1,710	0.85	496	56
1985	1,977	1.08	556	79
1986	1,892	1.09	577	65
1987	1,815	1.54	848	62
1988	2,322	1.14	489	65

* Including service water.
** Adjusted for collection efficiency.

Total estimated impingement abundance at Unit 2 was highest during the winter stratum followed by fall, summer, and spring (Table 4-1). The high estimated impingement during winter at Unit 2 was similar to the pattern observed in many previous years. Estimated mean daily numbers impinged for each seasonal stratum followed a similar seasonal pattern with higher rates during winter and fall (Table 4-3). At Unit 3, total estimated impingement abundance followed a slightly different pattern, being highest during winter, followed by spring, summer, and fall (Table 4-2). Estimated mean daily numbers impinged at Unit 3 were highest during the winter stratum, followed by the spring and summer strata, and lastly the fall stratum (Table 4-3).

The precision of estimated total impingement for individual fish species at Units 2 and 3 varied greatly (9-97 percent). As expected, most species with high coefficients of variation (>80 percent) occurred infrequently in the Indian Point area (striped cuskeel, cunner, lookdown, grubby, northern searobin, shortnose sturgeon, Atlantic needlefish, longear sunfish, northern stargazer, and tautog) or were common in the area but only subject to minimal impingement in 1988 (Atlantic menhaden and white sucker). Conversely, a number of other fish species with a relatively high degree of precision (coefficients of variation <15 percent) for impingement abundance estimates were impinged at Unit 2 largely during the fall stratum, and to a lesser extent, the winter stratum, which had very large allocations of sampling dates (bluegill, pumpkinseed, tessellated darter, banded killifish, blueback herring, striped bass, white perch, and striped searobin). This effect was less evident at Unit 3 where allocation of sampling dates was more uniform among seasonal strata.

The species with the lowest coefficient of variation, white perch (8.8 percent, Unit 2; 9.2 percent, Unit 3), was also by far the single most abundant species collected at either unit. Those results demonstrate the appropriateness of the seasonally stratified collection plan for developing precise estimates of impingement for this species in 1988.

4.3 SPECIES COMPOSITION AND RELATIVE ABUNDANCE

Fish collected in impingement samples during 1988 totaled 199,480 and comprised 65 species for Units 2 and 3 combined (Table 4-5). Among these species, 26 were primarily marine species tolerant of only minimal freshwater influences, 19 were primarily freshwater inhabitants, and 20 were euryhaline species tolerant at one time or another of a wide range of salinity conditions. The number of species caught in 1988 (65) was well within the range of the previous 11 years (43-79 species).

The three numerically dominant species impinged at Indian Point Units 2 and 3 in 1988 were white perch, striped bass, and hogchoker (Table 4-6). Collectively, these species comprised 86 percent of the total estimated impingement abundance at the Indian Point Generating Station in 1988 and were among the top 10 species impinged in previous monitoring programs. White perch was the most abundant species, accounting for almost 71 percent of the number of fish impinged (Table 4-6). Unit 2 collections accounted for most (92 percent) of the estimated impingement of this species. Striped bass was considerably less abundant than white perch, accounting for 7.7 percent of the fish impinged. Unit 2 collections accounted for 82 percent of the estimated striped bass impingement. The abundance of hogchoker was similar to that of striped bass, accounting for 7.6 percent of the collections at both units. As with the previous two species, Unit 2 collections accounted for most (84 percent) of the collections of this species.

The schedule of plant operation at Unit 2 did not appear to greatly influence estimates of species composition or yearly impingement abundance since the unit operated most of the year. At Unit 3, however, a maintenance outage during late October, November, and December resulted in greatly reduced cooling water flow (Table 4-7) and consequent reduction in the numbers of impinged species typically abundant in the fall stratum, such as blueback herring and white perch (Table 4-7).

TABLE 4-5 FISH SPECIES COLLECTED IN IMPINGEMENT SAMPLING AT INDIAN POINT UNITS 2 AND 3 IN 1988

Common Name	Scientific Name	Salinity Preference
Alewife	*Alosa pseudoharengus*	e
Bay anchovy	*Anchoa mitchilli*	e
American shad	*Alosa sapidissima*	e
Bluefish	*Pomatomus saltatrix*	m
Bluegill	*Lepomis macrochirus*	f
Brown bullhead	*Ictalurus nebulosus*	f
Pumpkinseed	*Lepomis gibbosus*	f
Black crappie	*Pomoxis nigromaculatus*	f
American eel	*Anguilla rostrata*	e
Goldfish	*Carassius auratus*	f
Golden shiner	*Notemigonus crysoleucas*	f
Hogchoker	*Trinectes maculata*	e
Tessellated darter	*Etheostoma olmstedi*	f
Banded killifish	*Fundulus diaphanus*	f
Largemouth bass	*Micropterus salmoides*	f
Mummichog	*Fundulus heteroclitus*	e
Atlantic menhaden	*Brevoortia tyrannus*	m
Blueback herring	*Alosa aestivalis*	e
White sucker	*Castosomus commersoni*	f
Atlantic silverside	*Menidia menidia*	e
Rainbow smelt	*Osmerus mordax*	e
Shortnose sturgeon	*Acipenser brevirostrum*	e
Spottail shiner	*Notropis hudsonius*	f
Striped bass	*Morone saxatilis*	e
Atlantic tomcod	*Microgadus tomcod*	e
White catfish	*Ictalurus catus*	f
White perch	*Morone americana*	e
Yellow perch	*Perca flavescens*	f
Northern pipefish	*Syngnathus fuscus*	e
Redbreast sunfish	*Lepomis auritus*	f
Atlantic needlefish	*Strongylura marina*	m

TABLE 4-5 (Cont.)

Common Name	Scientific Name	Salinity Preference
Crevalle jack	Caranx hippos	e
Weakfish	Cyanoscion regalis	m
Lookdown	Selene vomer	e
Seahorse	Hippocampus erectus	m
Tautog	Tautoga onitis	m
Fourbeard rockling	Enchelyopus cimbrius	m
Striped cuskeel	Ophidion marginatum	m
Spot	Leiostomus xanthurus	m
Moonfish	Selene setapinnis	m
Scup	Stenotomus chrysops	m
Winter flounder	Pseudopleuronectes americanus	m
Inland silverside	Menidia peninsulae	e
Sea lamprey	Petromyzon marinus	e
Gizzard shad	Dorosoma cepedianum	f
Silver hake	Merluccius bilinearis	m
Threespine stickleback	Gasterosteus aculeatus	e
Butterfish	Peprilus triacanthus	m
White crappie	Poxmoxis annularis	f
Red hake	Urophycis chuss	m
Grubby	Myoxocephalus aenaeus	m
Eastern mudminnow	Umbra pygmaea	f
Longear sunfish	Lepomis megalotis	f
Summer flounder	Paralichthys dentatus	m
Striped searobin	Prionotus evolans	m
Northern searobin	Prionotus carolinus	m
Warmouth	Lepomis gulosis	f
Naked goby	Gobiosoma bosci	e
Windowpane	Scophthalmus aquosus	m
Spotted hake	Urophycis regia	m
Northern stargazer	Astroscopus guttatus	m
American sandlance	Ammodytes americanus	m
Fourspot flounder	Paralichthys oblongus	m
Black sea bass	Centropristis striata	m

TABLE 4-6 ESTIMATED NUMBER IMPINGED AT INDIAN POINT IN 1988 AND TOTAL PERCENT COMPOSITION OF THE 15 MOST ABUNDANT SPECIES* AND ALL SPECIES COMBINED

Species	Unit 2		Unit 3		Both Units		
	Number	Percent	Number	Percent	Number	Percent	Cum. Percent
White perch	658,798	71.3	144,555	68.2	803,353	70.7	70.7
Striped bass	70,969	7.7	16,089	7.6	87,089	7.7	78.4
Hogchoker	72,516	7.9	13,969	6.6	86,485	7.6	86.0
Bay anchovy	31,224	3.4	4,219	2.0	35,443	3.1	89.1
Blueback herring	23,696	2.6	2,608	1.2	26,304	2.3	91.4
Weakfish	22,276	2.4	3,394	1.6	25,670	2.3	93.7
Atlantic tomcod	9,800	1.1	8,807	4.2	18,607	1.6	95.3
Gizzard shad	3,739	0.4	11,551	5.4	15,290	1.3	96.6
Rainbow smelt	5,651	0.6	1,713	0.8	7,364	0.6	97.2
White catfish	5,547	0.6	1,345	0.6	6,892	0.6	97.8
Bluefish	3,156	0.3	510	0.2	3,666	0.3	98.1
American eel	2,881	0.3	247	0.1	3,128	0.3	98.4
Alewife	1,345	0.1	698	0.3	2,043	0.2	98.6
Spottail shiner	1,275	0.1	401	0.2	1,676	0.1	98.7
Threespine stickleback	1,437	0.2	190	0.1	1,627	0.1	98.8
All species combined	923,533		212,043		1,135,576		

* Includes 12 of the 15 selected species.

TABLE 4-7 CIRCULATING WATER VOLUME PUMPED (MILLION m^3) IN ASSOCIATION WITH IMPINGEMENT SAMPLING AT INDIAN POINT IN 1988

Month	Unit 2	Unit 3	Units 2 and 3
JAN	5.9	35.3	41.2
FEB	26.5	25.9	52.4
MAR	23.6	28.4	52.0
APR	2.0	4.3	6.3
MAY	17.2	20.2	37.4
JUN	6.6	37.9	44.5
JUL	6.6	45.4	52.0
AUG	26.8	48.1	74.9
SEP	11.2	46.2	57.4
OCT	96.1*	24.8	120.9
NOV	57.8*	9.1	66.9
DEC	51.9	5.0	56.9
	332.2	330.6	662.8

* Includes 19 October, 5 November, and 6 November Ristroph samples.

4.4 SEASONAL AND YEARLY IMPINGEMENT PATTERNS

Seasonal trends were examined using mean monthly impingement rates (daily count of a taxon adjusted for collection efficiency divided by the daily volume pumped, averaged over each month). Seasonal patterns and rates for 1988 were compared to the 1982-1987 data which were based on the same stratified sampling design used in the 1988 program.

Impingement patterns in 1988 were generally similar between Unit 2 and Unit 3 (Figure 4-2). Impingement rates at Unit 3 were highest during winter, principally a result of white perch collections. Overall monthly rates at both units were within the range reported for recent years.

Fifteen species were previously selected for more detailed examination of impingement patterns, based on abundance in impingement collections, designation as representative important species by the U.S. Environmental Protection Agency (U.S. EPA), and current or potential importance to commercial or sport fisheries (TI 1980b):

Alewife	Blueback herring	Spottail shiner
American shad	Bluefish	Striped bass
Atlantic sturgeon	Hogchoker	Weakfish
Atlantic tomcod	Rainbow smelt	White catfish
Bay anchovy	Shortnose sturgeon	White perch

Monthly impingement rates for 13 of the above species were high enough to warrant description of seasonal patterns. Only four shortnose sturgeon and one Atlantic sturgeon were collected during impingement monitoring in 1988. In addition, monthly impingement rates for gizzard shad (a species that was among the top 10 most abundant species collected for the first time) are also discussed.

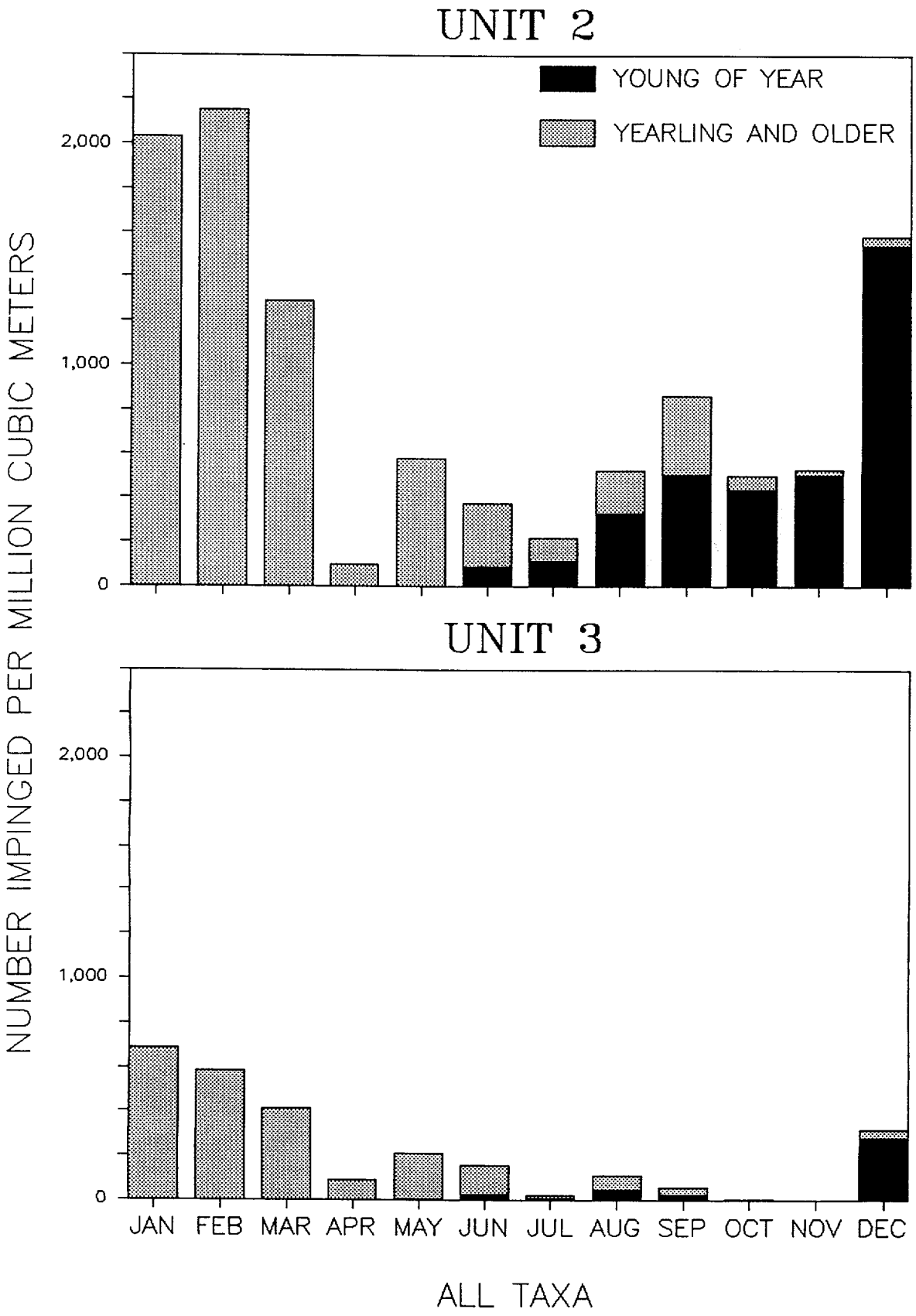

Figure 4-2 Monthly adjusted impingement rates for all taxa combined at Indian Point Units 2 and 3 in 1988, adjusted for collection efficiency.

Atlantic tomcod were collected during all months except April in 1988 (Figure 4-3). Young-of-the-year fish were considerably more abundant in impingement collections than yearling and older and occurred in highest numbers during June. Atlantic tomcod yearling and older fish were impinged during the winter stratum in relatively low numbers. This pattern was similar to patterns of tomcod impingement observed in previous years and is consistent with the described life history of the tomcod in which older fish spawn in shoal areas in the winter and young-of-the-year fish are first large enough to be impinged by late spring and early summer (TI 1980a). Peak monthly impingement rates for 1988 were generally lower than peak rates recorded in previous years (Con Edison 1983; MMES 1985; NAI 1984a, 1986; EA 1988).

White perch were the most numerous fish impinged in 1988 (Table 4-6). Impingement rates were highest during winter and early spring at both Units 2 and 3, when collections consisted mostly of yearling fish (Figure 4-4). Impingement rates decreased in the spring stratum and were low during summer. Impingement rates increased again in fall as young-of-the-year white perch became abundant during December. This seasonal pattern and the magnitude of monthly impingement rates were consistent with patterns and rates presented in previous years' reports (Con Edison 1983; MMES 1985; NAI 1984a, 1986, 1987; EA 1988).

Bay anchovy were impinged from May through November with yearling and older fish most numerous during September and young-of-the-year fish becoming more numerous during September and October (Figure 4-5). Bay anchovy spawn in the high salinity waters of the lower estuary primarily from June through August (NAI 1985). The yearling and older fish that were impinged beginning in May may represent a portion of the bay anchovy population that utilize the Indian Point region as a feeding ground prior to spawning (NAI 1985). The young-of-the-year fish impinged from September and October most likely represent the dispersion of early life stages upstream into the lower salinity waters of the lower and middle estuary that are the bay anchovy's nursery grounds. Peak monthly impingement rates and the seasonal pattern of impingement during 1988 were comparable to most previous years (Con Edison 1983; MMES 1985; NAI 1984a, 1986, 1987; EA 1988).

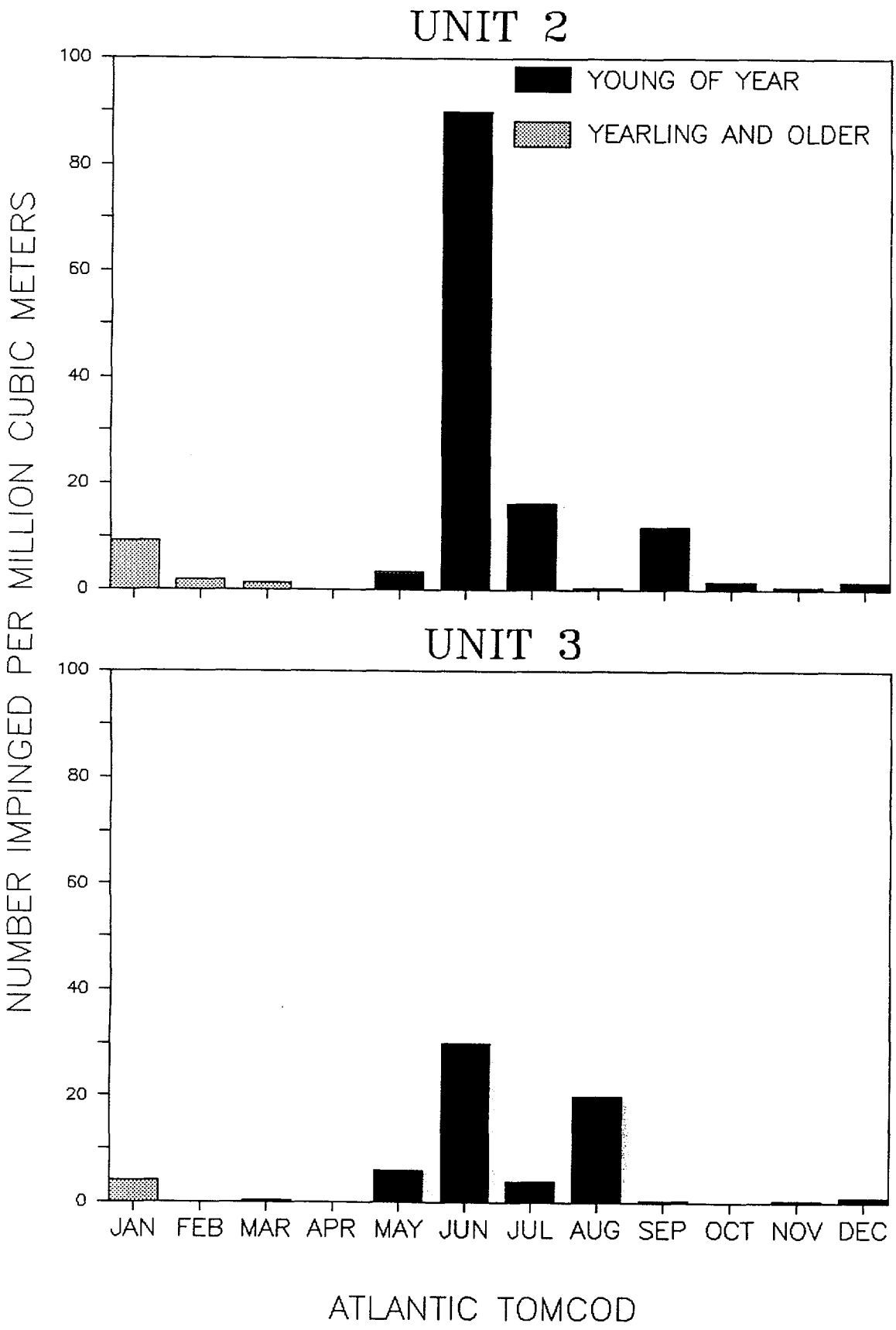

Figure 4-3. Monthly adjusted impingement rates for Atlantic tomcod at Indian Point Units 2 and 3 in 1988, adjusted for collection efficiency.

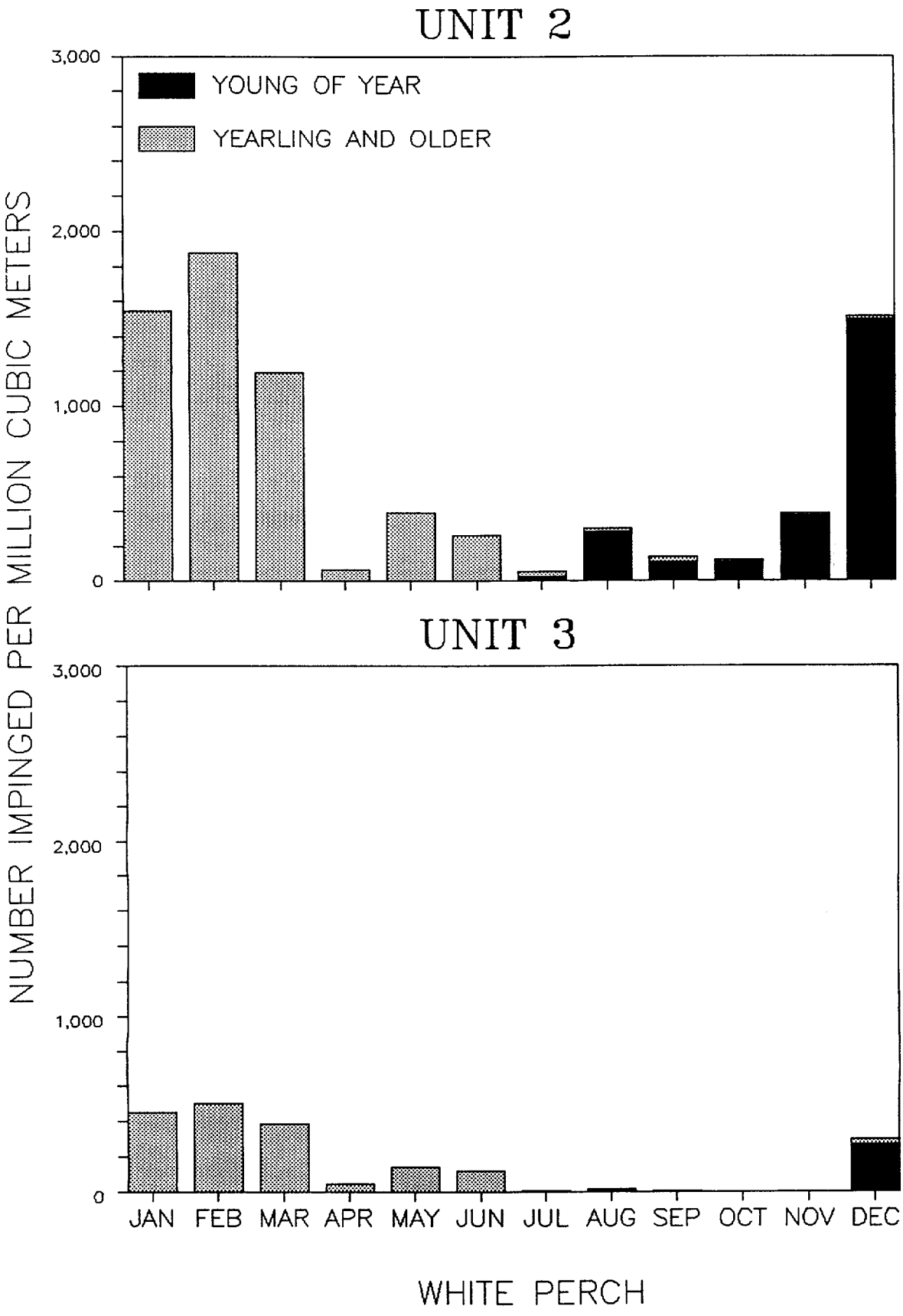

Figure 4-4. Monthly adjusted impingement rates for white perch at Indian Point Units 2 and 3 in 1988, adjusted for collection efficiency.

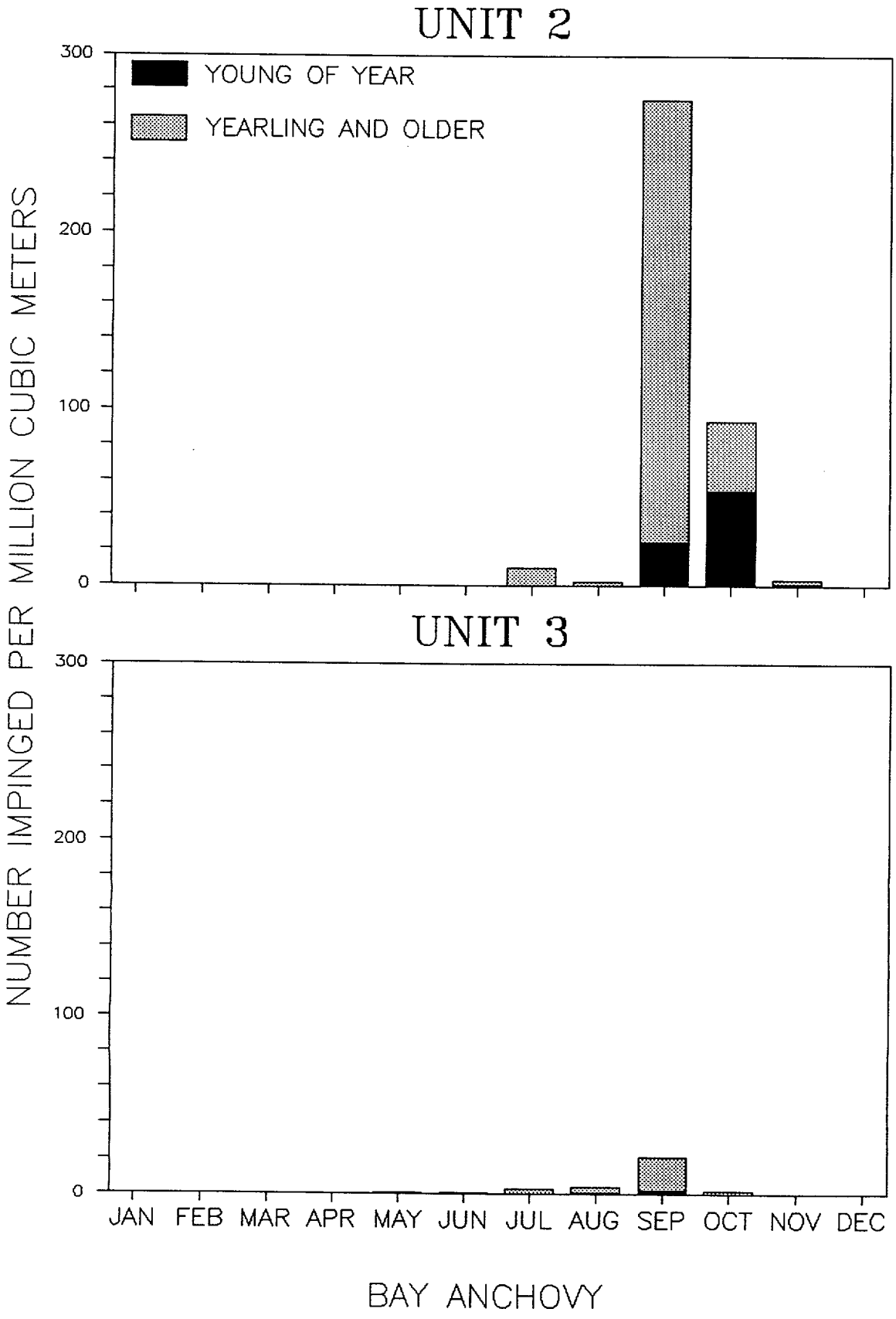

Figure 4-5. Monthly adjusted impingement rates for bay anchovy at Indian Point Units 2 and 3 in 1988, adjusted for collection efficiency.

Hogchoker were impinged during most months in 1988 with peak impingement rates from April through September at Unit 2 and January and February at Unit 3 (Figure 4-6). Yearling and older fish comprised the majority of the total hogchoker impingement abundance with young of the year recorded only from September through November. The seasonal pattern of hogchoker impingement was similar to previous years while overall monthly rates were slightly higher in 1988 (Con Edison 1983; MMES 1985; NAI 1984a, 1986, 1987; EA 1988).

Blueback herring were impinged primarily during October and November (Figure 4-7). This fall peak consisted principally of young of the year, whereas the limited spring impingement was yearling and older fish. This pattern was similar to that observed in most previous years (Con Edison 1983; MMES 1985; NAI 1984a, 1986, 1987; EA 1988). Yearling and older fish migrate upriver during spring to spawn in the freshwater areas of the river above Catskill and are subject to impingement by Indian Point and other cooling water intakes which they pass on route. During fall, as young-of-the-year fish migrate downriver toward high salinity waters, they too become vulnerable to impingement by these same cooling water intakes. Peak monthly impingement rates in 1988 were within the range reported for previous years.

Rainbow smelt were impinged primarily during January through July at Indian Point (Figure 4-8). Yearling and older fish were impinged almost exclusively during January through June. Young-of-the-year fish were impinged from July through December with peak impingement rates during July. Impingement patterns have been variable for this species in previous years with maximum impingement rates occurring in several different months (NAI 1984a). Peak monthly impingement rates in 1988 (up to $45/10^6 m^3$) were higher than peak monthly rates observed in past years.

American shad yearling and older fish were impinged in low numbers during many months of the year with the peak in September. Young-of-the-year fish were impinged from August through November with peak numbers in September and October (Figure 4-9). This seasonal occurrence pattern was within the range reported

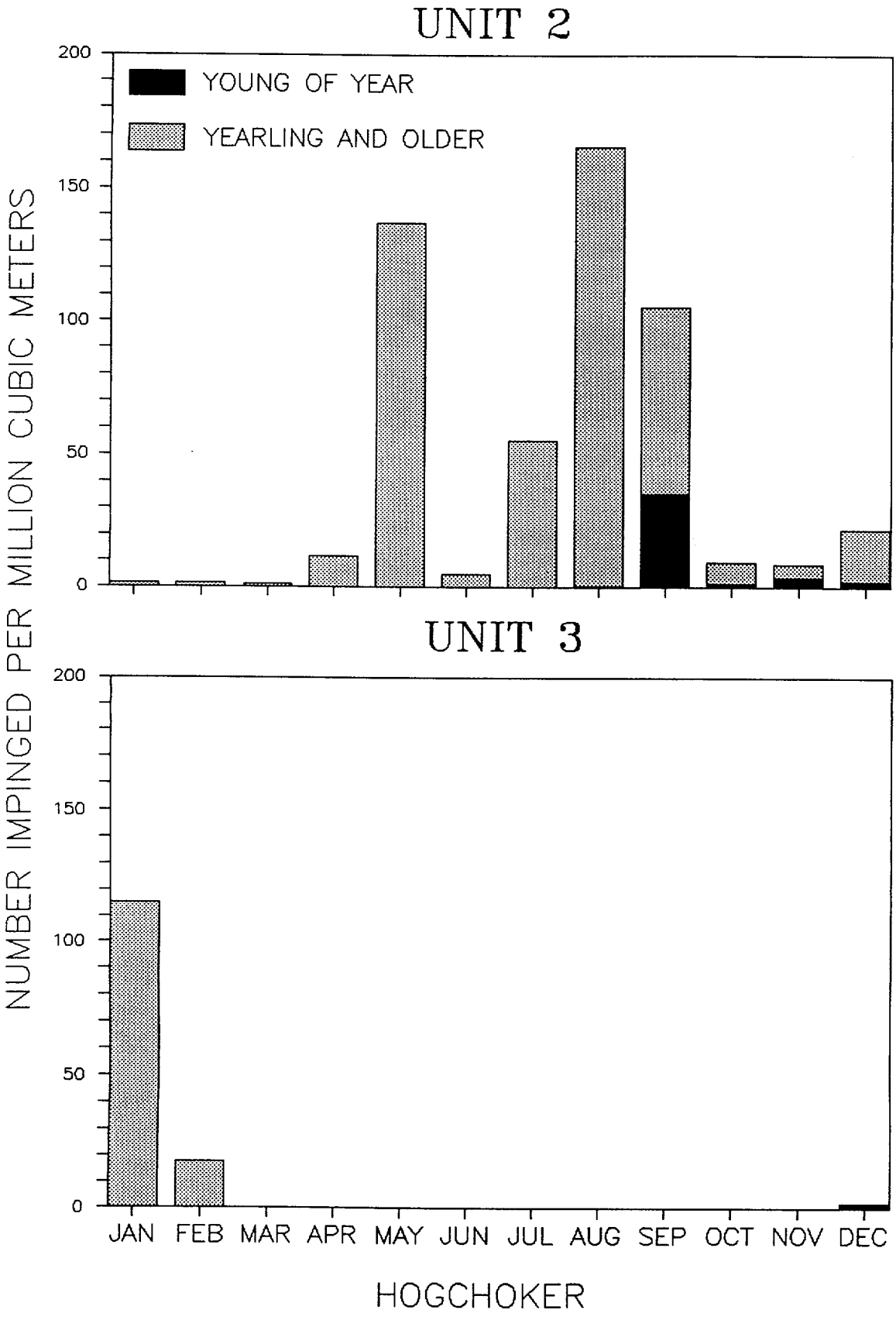

Figure 4-6. Monthly adjusted impingement rates for hogchoker at Indian Point Units 2 and 3 in 1988, adjusted for collection efficiency.

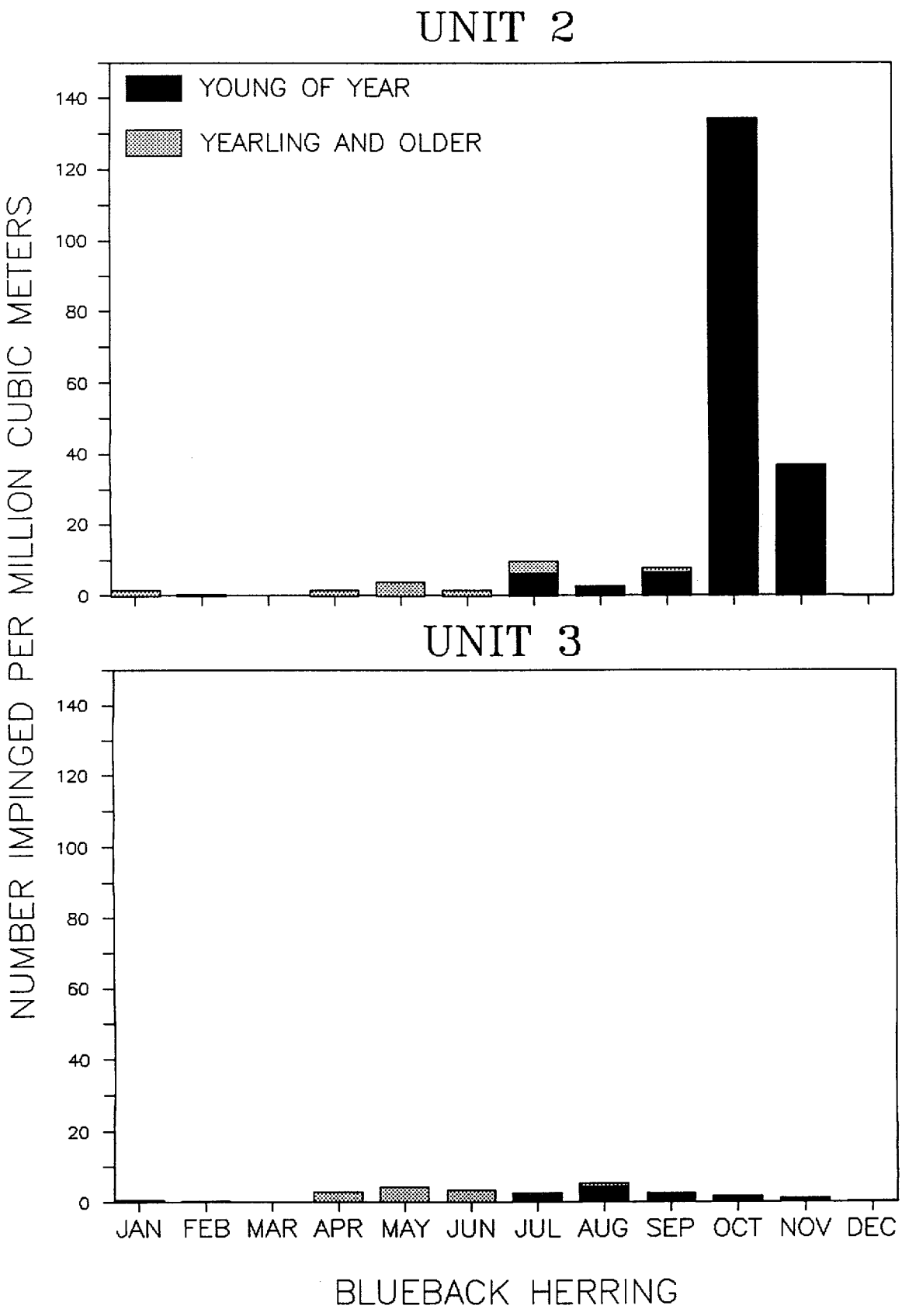

Figure 4-7. Monthly adjsuted impingement rates for blueback herring at Indian Point Units 2 and 3 in 1988, adjusted for collection efficiency.

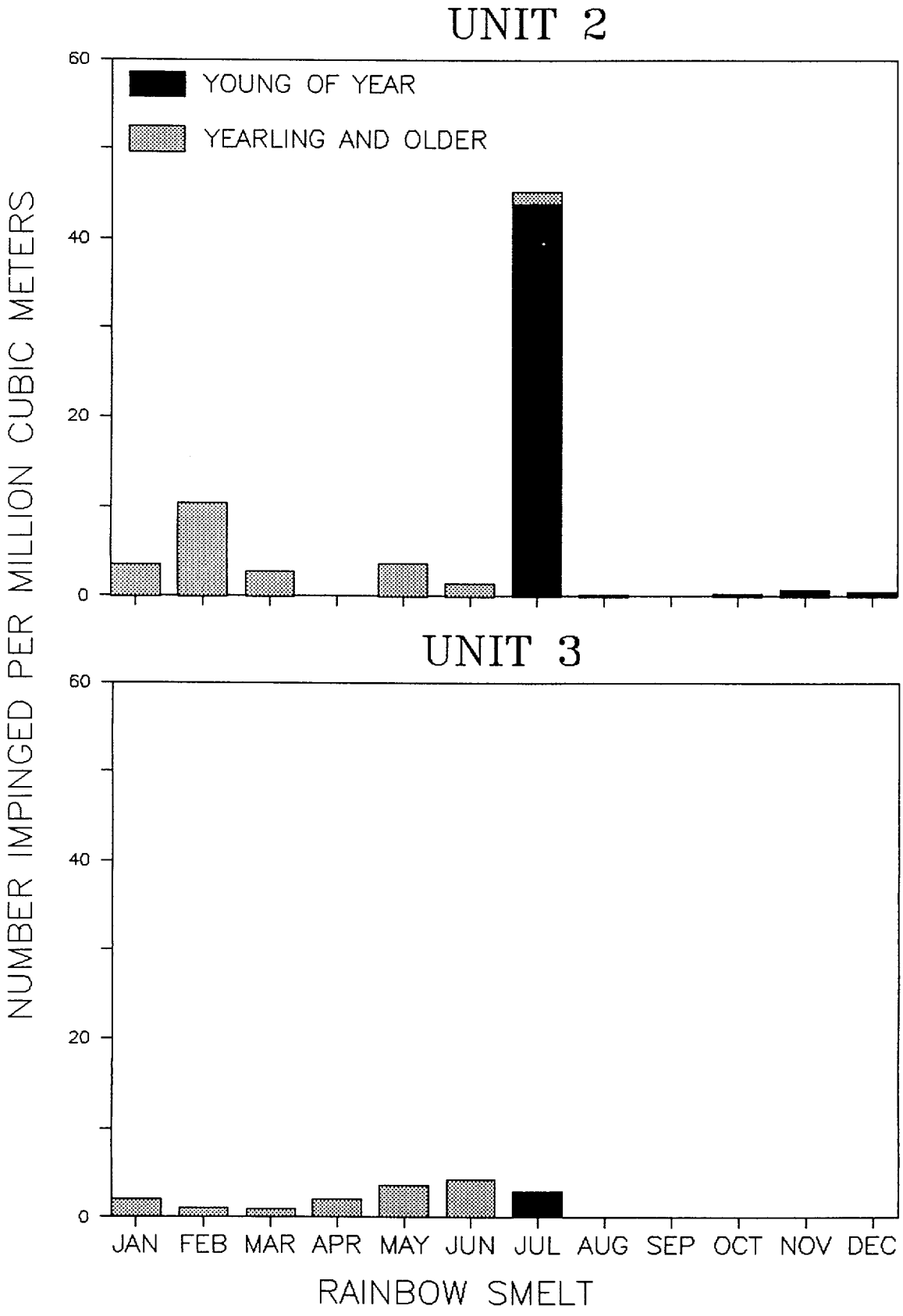

Figure 4-8. Monthly adjusted impingement rates for rainbow smelt at Indian Point Units 2 and 3 in 1988, adjusted for collection efficiency.

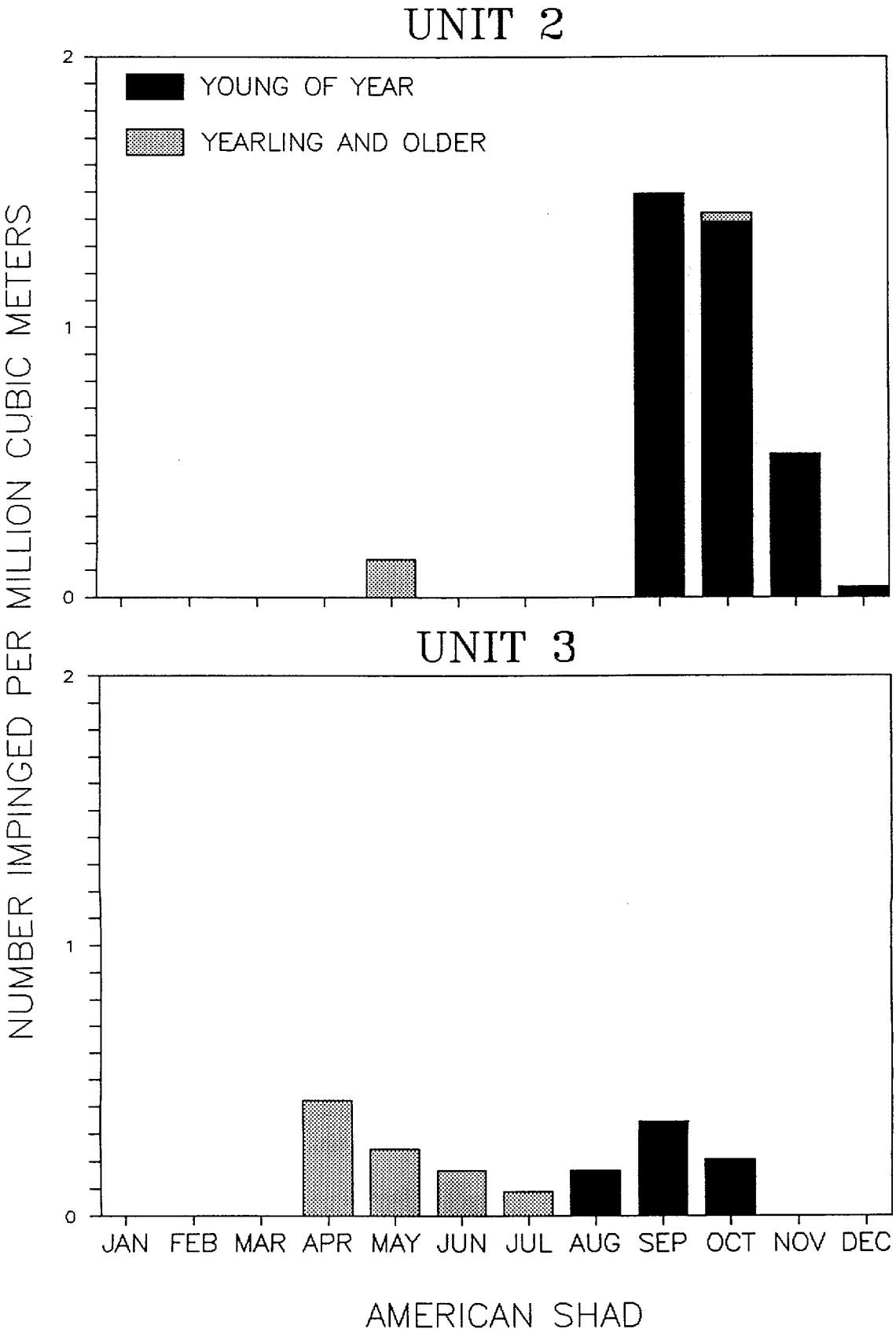

Figure 4-9. Monthly adjusted impingement rates for American shad at Indian Point Units 2 and 3 in 1988, adjusted for collection efficiency.

for previous years (Con Edison 1983; MMES 1985; NAI 1984a, 1986, 1988). American shad spawn in the fresh water of the upper estuary, and shad eggs and larvae are concentrated in this region (NAI 1985). Transformation of the American shad post yolk-sac larvae to the juvenile stage begins around late June at about 25 C and juveniles subsequently become much more dispersed throughout the estuary. During fall, as water temperatures drop, young-of-the-year shad actively emigrate from the estuary. Variability in the timing of peak impingement of American shad at Indian Point reflects differences in growth and emigration. Peak monthly impingement rates in 1988 were generally lower than peak monthly rates presented in previous reports (Con Edison 1983; MMES 1985; NAI 1984a, 1986, 1987; EA 1988).

Striped bass exhibited a bimodal seasonal impingement pattern (Figure 4-10) similar to that of previous years. Peak impingement occurred during January and February when most collected were yearlings. Impingement during winter and early spring was due to the overwintering of yearling and older striped bass in the deep waters of the lower estuary such as that in the Indian Point area (TI 1980b). Impingement rates for both young-of-the-year and yearling and older striped bass were within the range reported for previous years (Con Edison 1983; MMES 1985; NAI 1984a, 1986, 1987; EA 1988).

Weakfish were impinged at Units 2 and 3 in 1988 only as young-of-the-year fish (Figure 4-11). Impingement occurred from August through December with the peak impingement rate during September. Weakfish spawn at the mouths of estuaries and the juveniles subsequently move upstream to utilize the low salinity water of the estuary as a nursery area (NAI 1985). Peak monthly impingement rates in 1988 (up to $213/10^6 m^3$) were considerably higher than impingement rates reported for other years (Con Edison 1983; MMES 1985; NAI 1984a, 1986, 1987; EA 1988).

Bluefish were impinged at Indian Point from June through October only as young of the year (Figure 4-12). Peak impingement occurred during September. Monthly impingement rates at Indian Point in 1988 were generally within the range presented in previous reports (Con Edison 1983; MMES 1985; NAI 1984a, 1986, 1987; EA 1988).

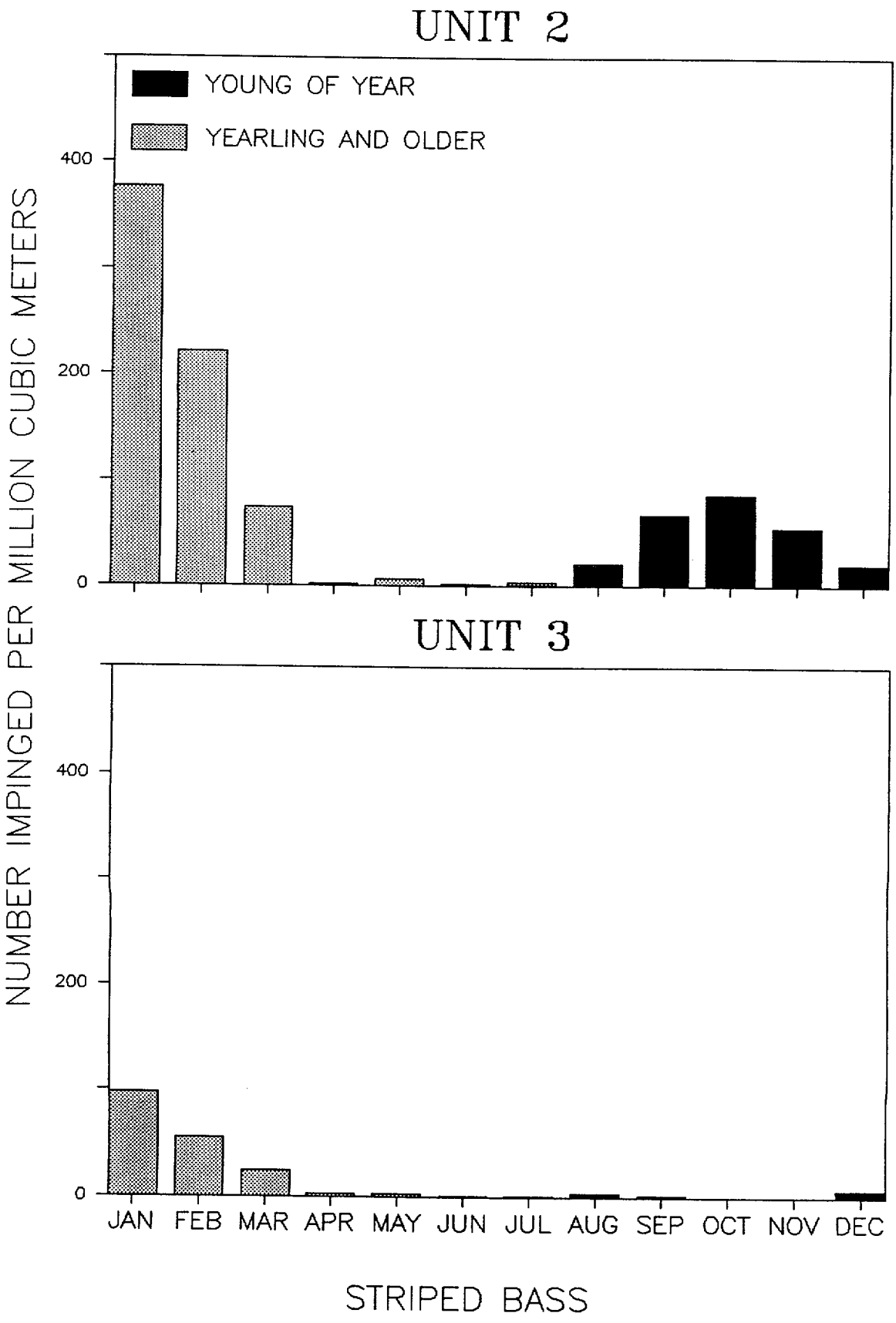

Figure 4-10. Monthly adjusted impingement rates for striped bass at Indian Point Units 2 and 3 in 1988, adjusted for collection efficiency.

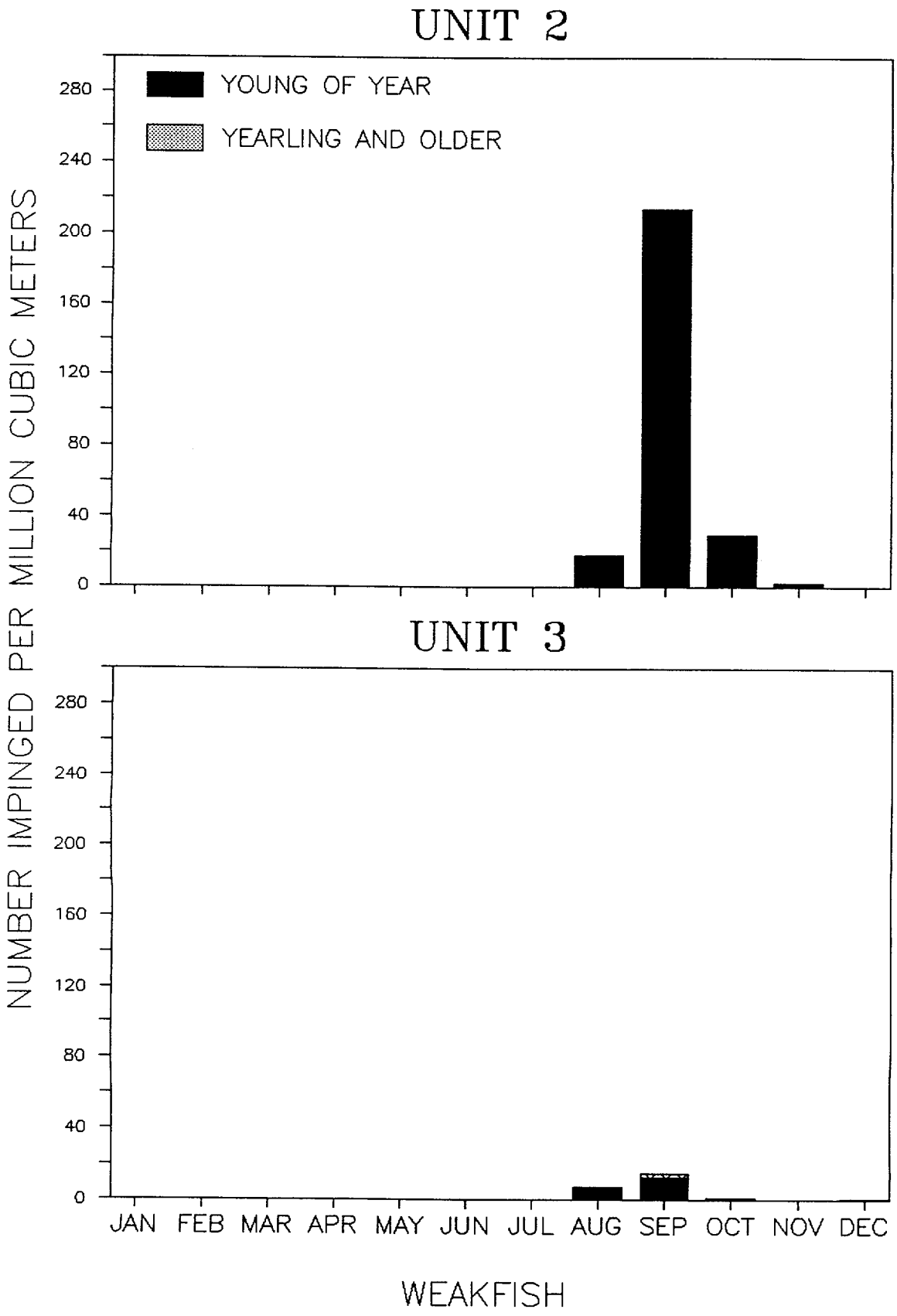

Figure 4-11. Monthly adjusted impingement rates for weakfish at Indian Point Units 2 and 3 in 1988, adjusted for collection efficiency.

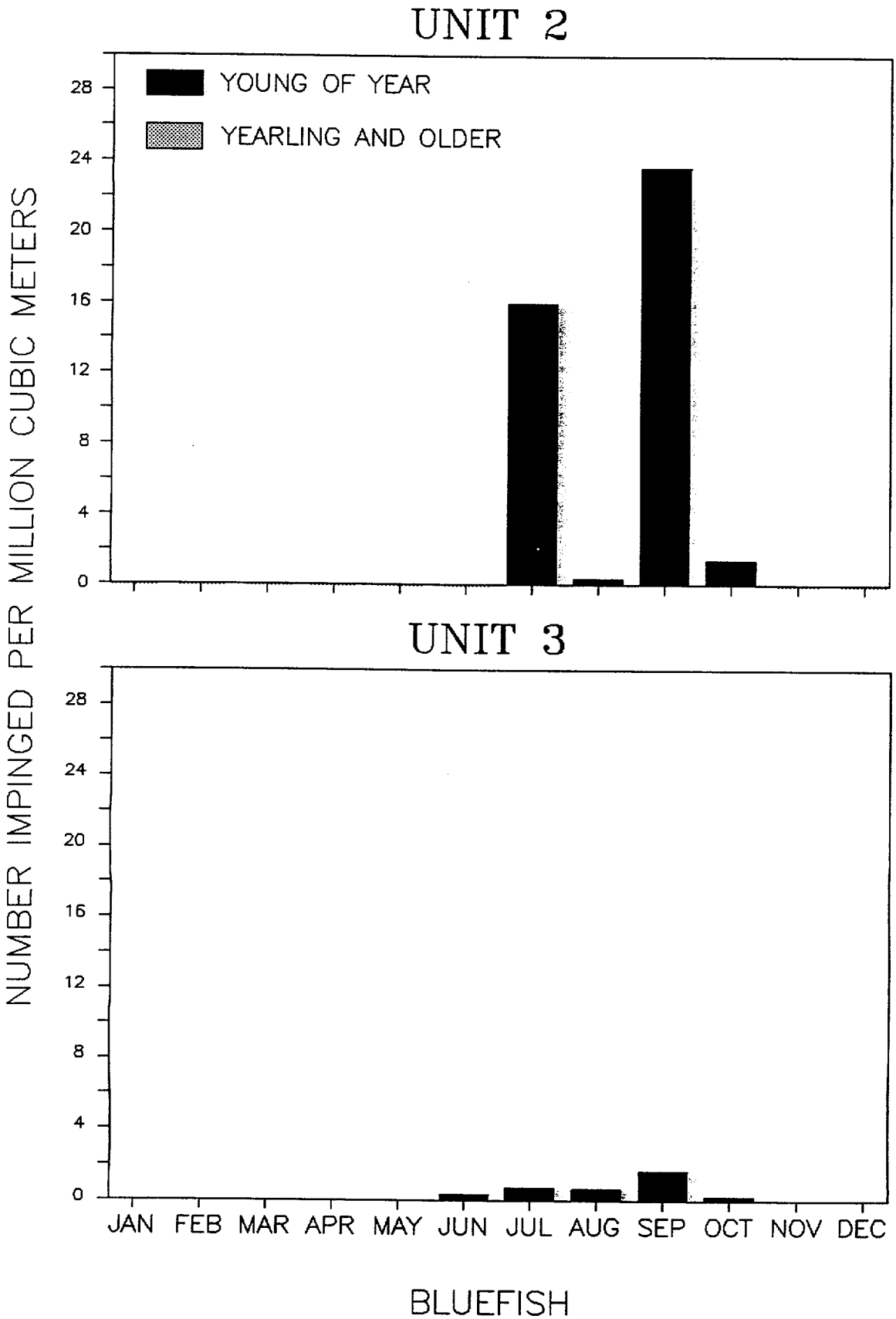

Figure 4-12. Monthly adjusted impingement rates for bluefish at Indian Point Units 2 and 3 in 1988, adjusted for collection efficiency.

White catfish impingement was greatest from November through May (Figure 4-13). Yearling and older white catfish predominated during winter and early spring while young-of-the-year catfish were most abundant during fall. Adult white catfish overwinter in deep water areas of the lower Hudson River such as Indian Point and during spring move upstream into the low salinity and shallow water regions of the middle and upper estuary to spawn (TI 1981). Spawning occurs during spring in waters with salinities below 2 ppt and young-of-the-year fish are first present beginning around July and continuing through December with peak densities upstream of Indian Point (NAI 1985). Monthly adjusted impingement rates in 1988 were within the range observed in previous years (Con Edison 1983; MMES 1985; NAI 1984a, 1986, 1987; EA 1988).

Alewife were impinged from January through November (Figure 4-14). Yearling and older fish were recorded primarily during May and June and young of the year from August through November. This was similar to previous years and corresponded with the generalized life history of the alewife in which spawning adults migrate upriver in the spring past Indian Point to spawn in fresh water, and both adults and young-of-the-year fish migrate downriver past Indian Point to the ocean in the fall (NAI 1985). Peak monthly impingement rates in 1988 were within the range observed in past years (Con Edison 1983; MMES 1985; NAI 1984a, 1986, 1987; EA 1988).

Spottail shiner were impinged principally during the winter and early spring (Figure 4-15). The majority of the spottail shiners impinged were yearling and older fish that were probably overwintering in deeper water areas such as Indian Point (NAI 1985). The young-of-the-year fish impinged during late fall were presumably the product of the spring and early summer spawning in the upper estuary. The seasonal pattern and magnitudes of monthly impingement rates in 1988 were consistent with previous years (Con Edison 1983; MMES 1985; NAI 1984a, 1986, 1987; EA 1988).

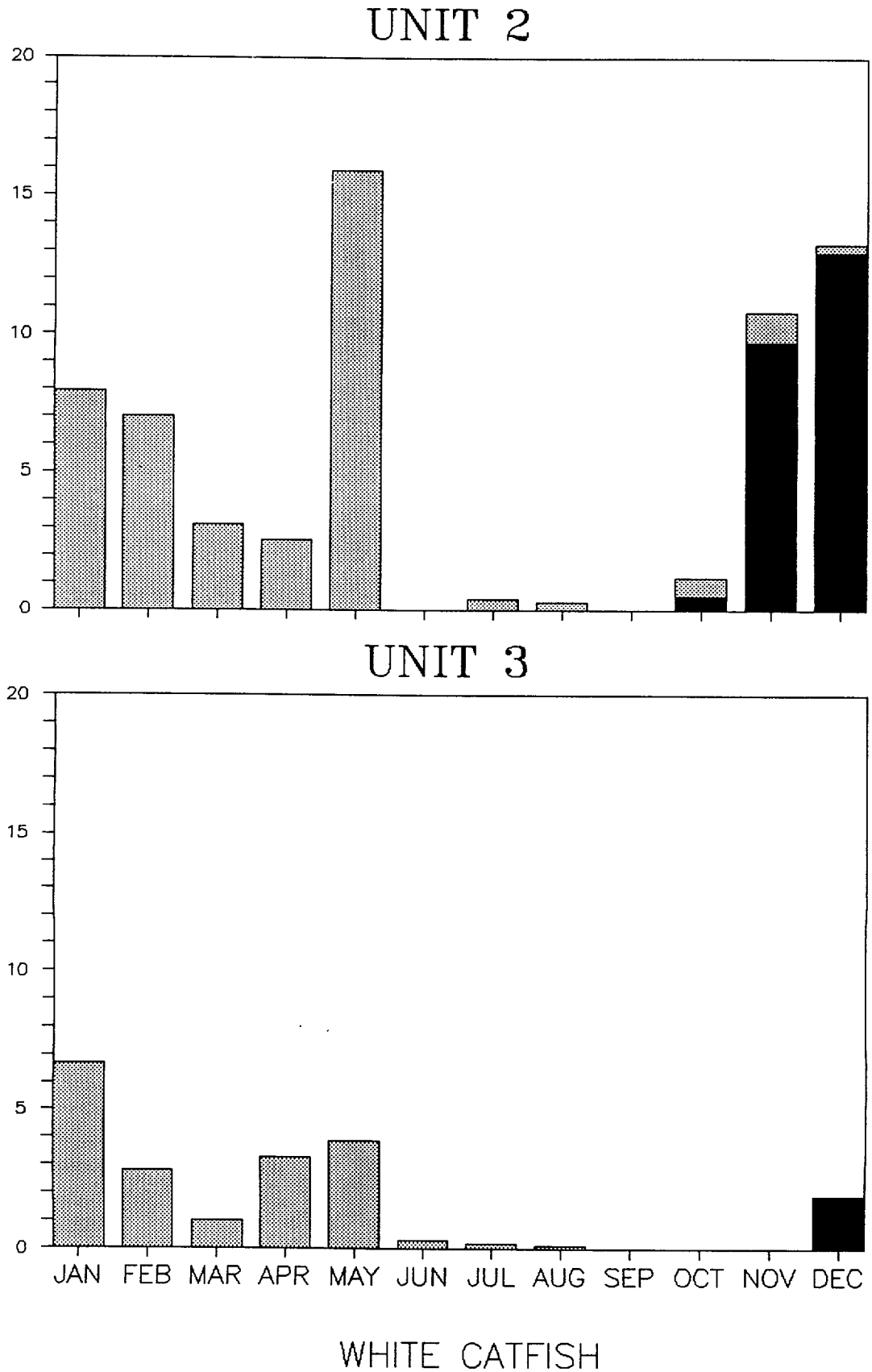

Figure 4-13. Monthly adjusted impingement rates for white catfish at Indian Point Units 2 and 3 in 1988, adjusted for collection efficiency.

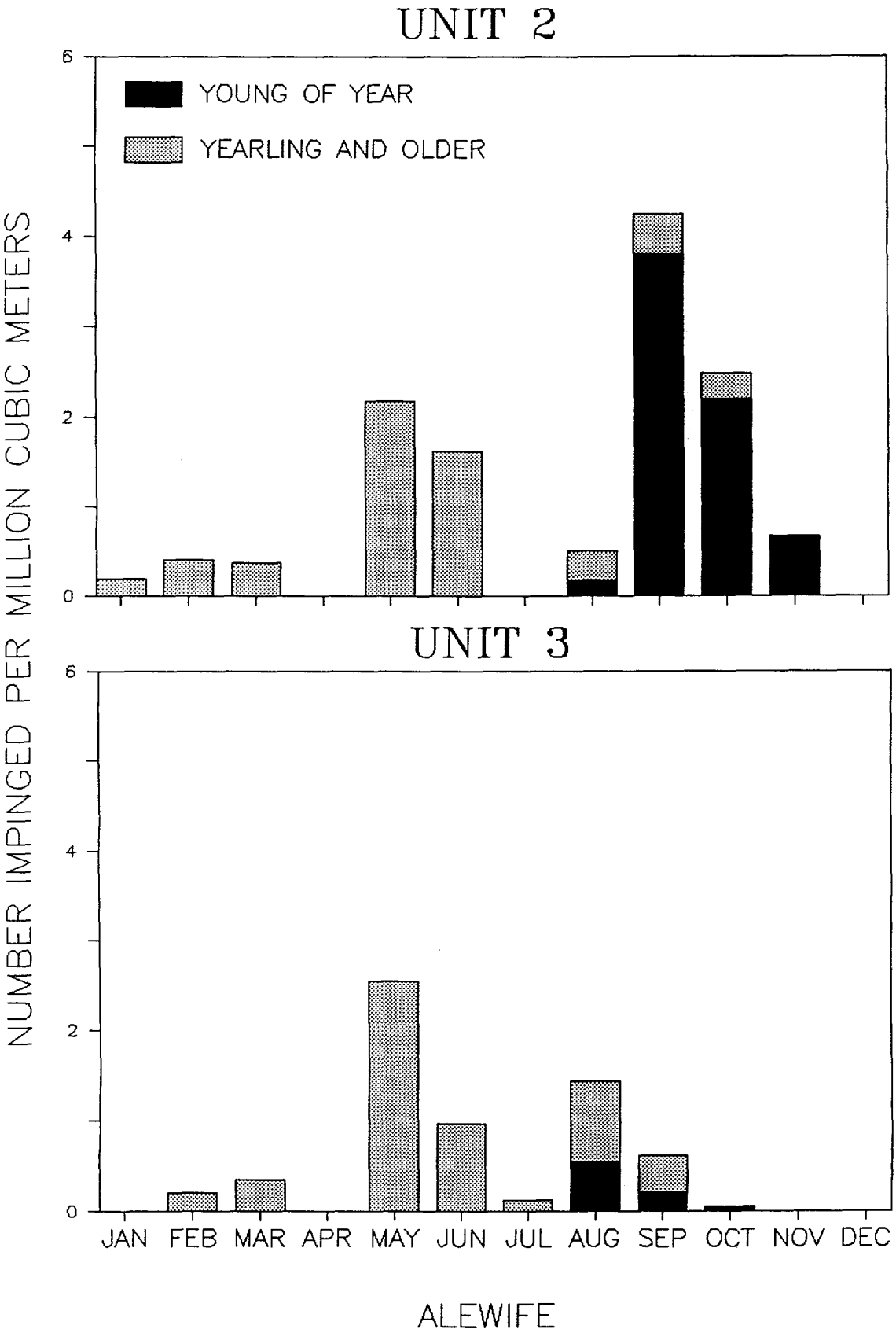

Figure 4-14. Monthly adjusted impingement rates for alewife at Indian Point Units 2 and 3 in 1988, adjusted for collection efficiency.

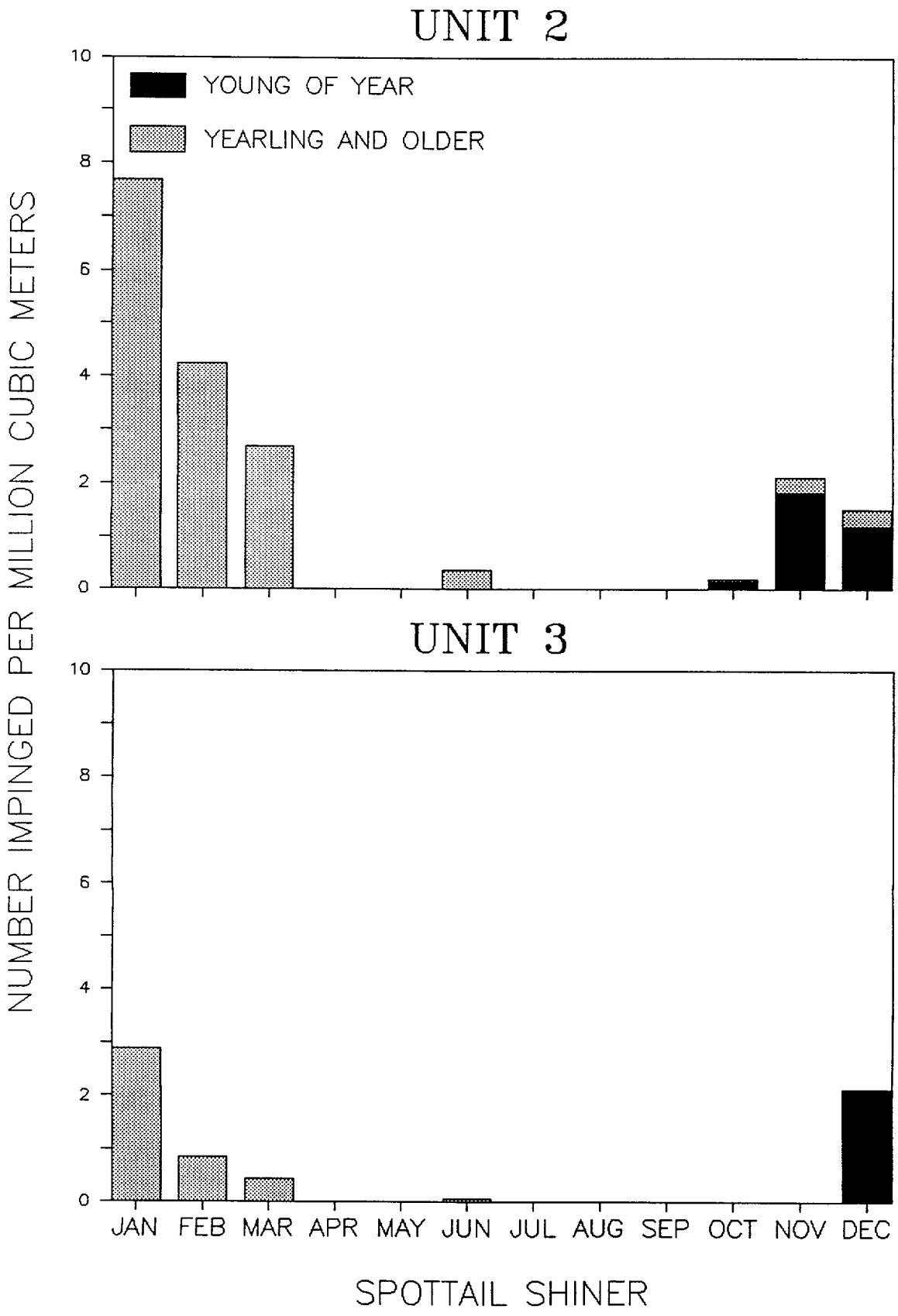

Figure 4-15. Monthly adjusted impingement rates for spottail shiner at Indian Point Units 2 and 3 in 1988, adjusted for collection efficiency.

Gizzard shad were the eighth most abundant species collected at Indian Point in 1988 (Table 4-6). Collections were almost exclusively yearling and older individuals impinged during January and February (Figure 4-16). A relatively small number of young of the year was also collected in December. The total number of gizzard shad estimated to have been impinged in 1988 (15,290) was considerably higher than reported in previous years (peak of 9,508 in 1986). Whether the increased catch at Indian Point reflects an overall increase in abundance of the species in the Hudson River or just a temporary increase in vulnerability to Indian Point impingement is not known.

One Atlantic sturgeon was impinged and collected alive and was returned to the Hudson River away from the plant intakes. Four shortnose sturgeon were also impinged at Indian Point during 1988 (Table 4-8). The five sturgeon ranged in total length from 434 to 672 mm and in weight from 325 to 1,785 gm.

4.5 SENSITIVITY OF UNIT 2 IMPINGEMENT ESTIMATES TO CHANGES IN THE COLLECTION EFFICIENCY ESTIMATES USED FOR THE RISTROPH SCREEN

Estimates of the number of fish impinged at Indian Point Unit 2 were developed from impingement collection data adjusted for the collection efficiency of the two screen types; fixed screens (Screens 21-25) and the Ristroph screen (Screen 26) (Appendix A). Collection efficiency estimates for the fixed screens were based on extensive collection efficiency studies conducted in previous years. Study results produced a significant regression model relating Unit 2 collection efficiency and water temperature (Con Edison 1983).

Collection efficiency estimates for the Ristroph screen during the winter and summer strata were based on studies conducted during 1985 (Con Edison 1985). For the spring and fall strata, collection efficiency estimates for the Ristroph screen were not available and the collection efficiency was conservatively assumed to be the same as the fixed screens during the same interval (Section 3.3). It is reasonable to assume, however, that the collection efficiency of the Ristroph screen is at least as high or possibly much higher than the fixed screens due to the collection baskets which would minimize fish loss off the screens panels. In order to evaluate the effects of this assumption on

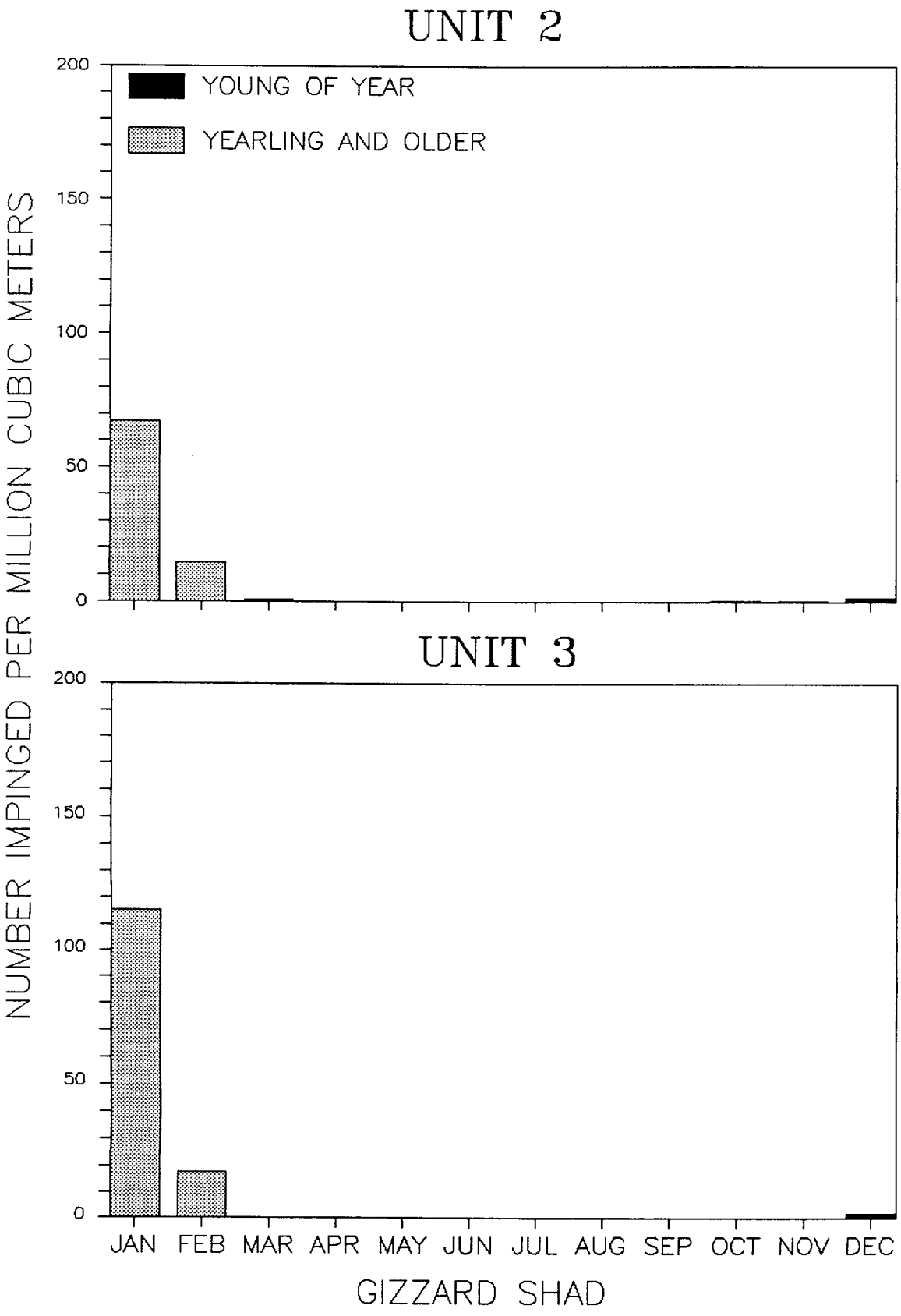

Figure 4-16. Monthly adjusted impingement rates for gizzard shad at Indian Point Units 2 and 3 in 1988, unadjusted for collection efficiency.

TABLE 4-8 STURGEON IMPINGED AT INDIAN POINT UNITS 2 AND 3 DURING 1988

Species	Date	Unit	Length (mm TL)	Weight (grams)	Condition
Shortnose	01 FEB	2	580	637	Dead
Atlantic	04 MAR	2	462	325	Alive*
Shortnose	27 APR	2	605	1,160	Dead
Shortnose	19 AUG	3	434	479	Dead
Shortnose	04 NOV	2	672	1,785	Dead

* Alive fish were released to the river away from the intake screens.

impingement estimates, estimates of numbers impinged at Indian Point Unit 2 were calculated for each species using assigned collection efficiency values for the Ristroph screen for the spring and fall strata ranging from 30 to 90 percent.

Annual impingement estimates for Unit 2 as previously calculated were generally equivalent to estimates based on a collection efficiency of approximately 40 percent for the Ristroph screen (Table 4-9). For the most part, estimates of fish impinged at Unit 2 were not drastically affected by varying collection efficiency values in the spring and fall for the Ristroph screen. At the extreme, using 90 percent collection efficiency, the estimate of total fish impinged was only 11 percent lower than the estimate previously developed in this report. For individual species, using the same range of collection efficiencies, the reduction in annual impingement estimates at Unit 2 ranged from zero for several species to 63 percent for white sucker, redbreast sunfish, and American sandlance, all species with relatively low impingement at Indian Point. The variability among species is a function of the time of the year when they were collected, with those collected principally in the spring and fall being most sensitive to the changes in assumed collection efficiency.

This sensitivity analysis demonstrates that impingement of fish at Indian Point Unit 2 may have been overestimated as a result of assumptions made concerning the collection efficiency of the Ristroph screen for the spring and fall strata. However, the magnitude of this overestimation appears to be relatively small for most species.

4.6 BLUE CRAB IMPINGEMENT

Blue crabs were impinged at Indian Point in January and May through December 1988 (Table 4-10). A total of 56,596 crabs were collected, with a total weight of 3,789 kg. This number of crabs was considerably higher than numbers observed at Indian Point since blue crab impingement monitoring began in 1983 (previous high at 12,316 in 1985). Impingement rates were notably higher at Unit 2 than at Unit 3 with peak rates occurring during August and November. Peak values ranged from $363/10^6m^3$ at Unit 2 to $45/10^6m^3$ at Unit 3 (Figure 4-17).

TABLE 4-9 ESTIMATED TOTAL NUMBER OF FISH IMPINGED IN 1988 AT INDIAN POINT UNIT 2 BY TAXON AND SEASONAL STRATA USING VARIOUS COLLECTION EFFICIENCY ESTIMATES FOR THE RISTROPH SCREEN (SCREEN 26) DURING THE SPRING AND FALL STRATA

Taxon	Current Estimate	Ristroph Screen Collection Efficiency						
		30%	40%	50%	60%	70%	80%	90%
Alewife	1,345	1,446	1,322	1,247	1,197	1,162	1,135	1,115
Bay anchovy	31,224	31,578	31,113	30,834	30,648	30,515	30,416	30,338
American shad	356	381	348	328	315	305	298	292
Bluefish	3,156	3,163	3,138	3,122	3,112	3,104	3,099	3,094
Bluegill	1,156	1,333	1,168	1,069	1,003	956	921	893
Brown bullhead	90	99	85	76	70	66	63	61
Pumpkinseed	1,243	1,351	1,229	1,155	1,106	1,071	1,045	1,024
Black crappie	3	3	3	3	3	3	3	3
American eel	2,881	3,000	2,865	2,783	2,729	2,690	2,661	2,638
Goldfish	86	96	89	85	82	80	79	78
Golden shiner	99	99	99	98	98	97	97	97
Hogchoker	72,516	77,633	71,988	68,600	66,342	64,729	63,519	62,578
Tessellated darter	210	283	228	194	172	156	144	134
Banded killifish	858	1,024	890	809	755	717	688	666
Largemouth bass	6	6	6	5	5	4	4	4
Mummichog	3	3	3	3	3	3	3	3
Atlantic menhaden	162	165	163	161	160	159	159	158
Blueback herring	23,696	24,991	23,417	22,472	21,842	21,393	21,055	20,793
White sucker	30	33	25	20	17	14	13	11
Atlantic silverside	270	276	264	257	252	249	247	245
Rainbow smelt	5,651	5,793	5,648	5,560	5,502	5,460	5,429	5,404
Shortnose sturgeon	0	0	0	0	0	0	0	0
Spottail shiner	1,275	1,342	1,294	1,265	1,246	1,232	1,222	1,213
Striped bass	70,969	74,226	70,839	68,806	67,451	66,483	65,757	65,193
Atlantic tomcod	9,800	10,062	8,930	8,250	7,797	7,473	7,231	7,042
White catfish	5,547	6,747	5,652	4,994	4,556	4,243	4,008	3,825
White perch	658,798	727,987	672,497	639,202	617,006	601,151	589,260	580,012
Yellow perch	234	276	243	223	210	200	193	187
Northern pipefish	734	743	731	724	719	716	714	712
Redbreast sunfish	3	3	3	2	2	1	1	1
Atlantic needlefish	0	0	0	0	0	0	0	0
Crevalle jack	369	384	361	347	338	331	326	322

TABLE 4-9 (Cont.)

Taxon	Current Estimate	Ristroph Screen Collection Efficiency						
		30%	40%	50%	60%	70%	80%	90%
Weakfish	22,276	22,444	22,149	21,971	21,853	21,768	21,705	21,655
Lookdown	81	82	80	78	77	76	76	75
Seahorse	4	4	4	4	4	4	4	4
Tautog	51	67	50	40	33	29	25	22
Fourbeard rockling	0	0	0	0	0	0	0	0
Striped cuskeel	30	30	30	30	30	30	30	30
Spot	351	355	348	344	341	339	338	337
Moonfish	8	8	8	8	8	8	8	8
Scup	4	4	4	4	4	4	4	4
Winter flounder	59	61	53	48	45	42	41	39
Inland silverside	38	39	37	35	34	33	33	32
Sea lamprey	7	7	7	6	6	5	5	5
Gizzard shad	3,739	3,784	3,756	3,739	3,728	3,720	3,714	3,709
Silver hake	48	58	50	45	42	39	38	36
Threespine stickleback	1,437	1,437	1,437	1,437	1,437	1,437	1,437	1,437
Butterfish	390	404	379	363	353	345	340	335
White crappie	17	17	17	17	17	17	17	17
Red hake	100	115	98	87	80	75	71	68
Grubby	30	30	30	30	30	30	30	30
Eastern mudminnow	29	29	29	29	29	29	29	29
Longear sunfish	0	0	0	0	0	0	0	0
Summer flounder	183	186	177	171	167	165	163	161
Striped searobin	114	117	110	106	103	101	100	99
Northern searobin	50	50	50	50	50	50	50	50
Warmouth	14	17	15	13	12	11	11	10
Naked goby	135	158	135	121	112	105	100	96
Windowpane	217	225	208	197	190	185	181	178
Spotted hake	1,186	1,429	1,151	984	873	793	734	687
Northern stargazer	88	88	88	88	88	88	88	88
American sandlance	3	3	3	2	2	1	1	1
Fourspot flounder	8	8	8	8	8	8	8	8
Black sea bass	8	7	7	6	6	5	5	5
Cunner	58	59	56	54	53	52	51	50
Total	923,533	1,005,853	935,201	892,809	864,548	844,362	829,222	817,446

TABLE 4-10 TOTAL NUMBERS AND WEIGHTS OF BLUE CRABS IMPINGED EACH MONTH AT INDIAN POINT DURING JANUARY-DECEMBER 1988

COUNT

Unit	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
2	1	0	0	0	16	1,288	2,814	10,054	3,352	12,480	11,274	84	41,363
3	0	0	0	0	3	1,204	3,307	6,199	2,744	1,500	273	3	15,233
Total	1	0	0	0	19	2,492	6,121	16,253	6,096	13,980	11,547	87	56,596

WEIGHT (G)

Unit	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
2	14	0	0	0	75	46,864	203,084	1,228,005	527,193	149,857	78,555	651	2,234,298
3	0	0	0	0	19	44,183	230,477	820,602	417,432	39,878	1,759	25	1,554,375
Total	14	0	0	0	94	91,047	433,561	2,048,607	944,625	189,735	80,314	676	3,788,673

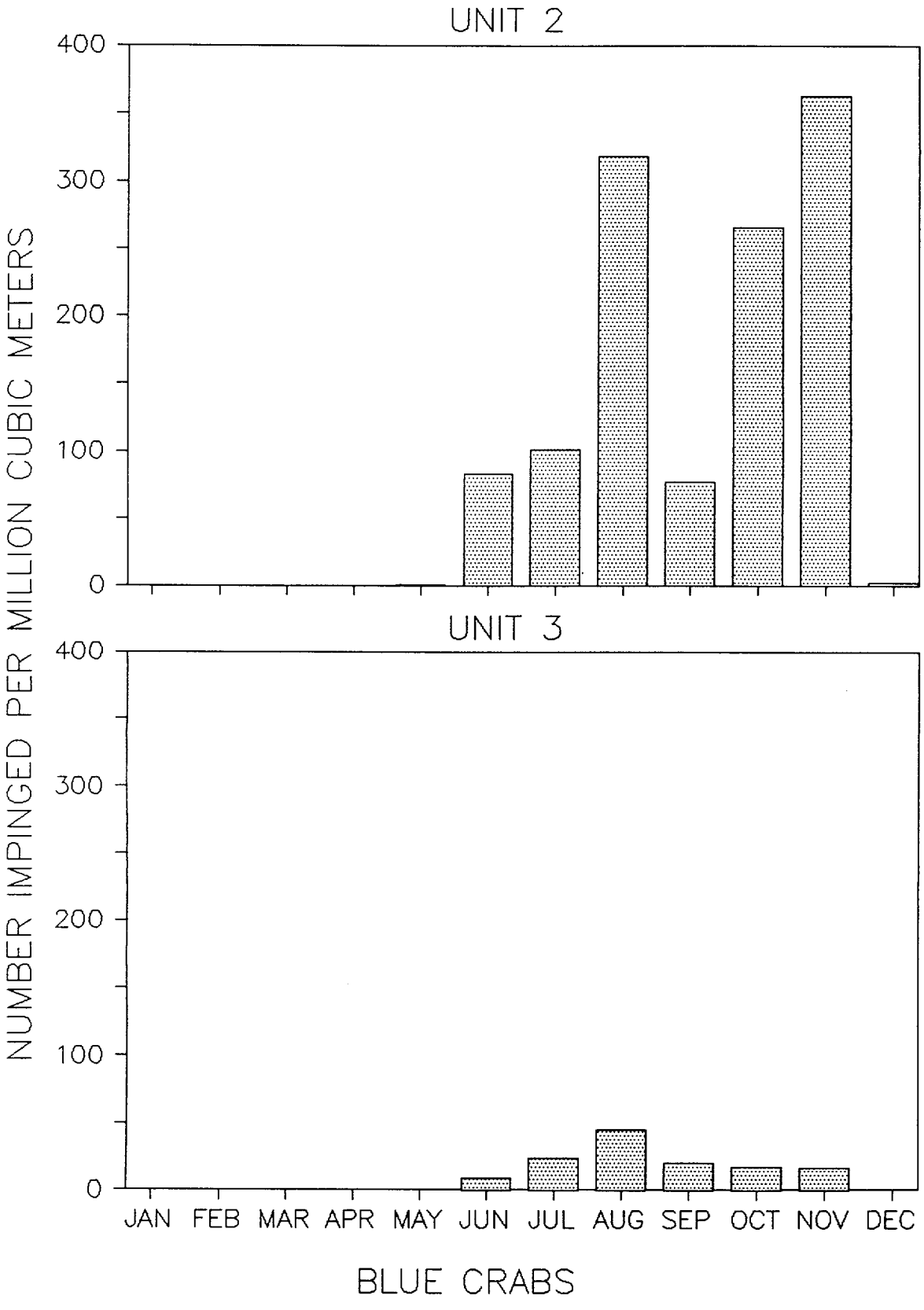

Figure 4-17. Monthly adjusted impingement rates for blue crab at Indian Point Units 2 and 3 in 1988, unadjusted for collection efficiency.

A small number of blue crabs were collected in early January, however, no blue crabs were impinged during the next three months of 1988 (Table 4-10). Impingement abundance increased through summer, peaked during October, and subsequently declined to near zero by December. Total weight, on the other hand, peaked in August due to the prevalence of larger crabs at this time. Blue crabs undergo extensive seasonal migrations related to mating and spawning (Lippson et al. 1980; Williams 1965) and the pattern of impingement abundance at Indian Point probably reflects this migration. Mature male and female crabs migrate into shallow and low salinity water during spring and early summer months to mate. Juvenile crabs hatched during the previous years' spawning also move upstream and into the shallows. During fall, as temperatures cool, females move downriver to the higher salinity waters (20-32 ppt) to spawn (Lippson et al. 1980), while males remain upriver in the low salinity waters throughout the year (Williams 1965). Females can spawn 2-9 months after mating but most often wait until the following spring. By late fall and winter, the male and juvenile crabs in the upriver regions move offshore into deeper waters where they burrow into the bottom and become inactive.

Blue crab males accounted for approximately 63 percent of blue crabs impinged at the Indian Point Generating Station in 1988 (Tables 4-11, B-11, and B-13). A greater number of males than females is fairly typical of blue crab populations in low salinity areas like Indian Point (Williams 1965), since mature females enter these areas only to mate and subsequently return to high salinity waters in the lower estuary to spawn, while males remain in the low salinity waters after mating for the remainder of their lives. Males were more abundant than females during every month collected with the exception of January and August (Table 4-11). The increased number and proportion of female crabs in August may reflect the period during which mating occurs.

The blue crabs collected in impingement samples exhibited a bimodal distribution in carapace width (Figure 4-18). The higher mode, first evident in June samples at 60- to 89-mm carapace width, increased through late summer and fall such that by October, the mode was at 140-169 mm (Table B-12). This mode undoubtedly

TABLE 4-11 MONTHLY COUNTS BY SEX, SURVIVAL, AND CONDITION OF BLUE CRABS IMPINGED AT INDIAN POINT, JANUARY-DECEMBER 1988

Sex	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Male	0	0	0	0	13	1,006	1,663	1,612	2,175	1,852	1,043	51	9,415
Female	1	0	0	0	6	202	792	1,714	745	1,104	937	36	5,537
Undetermined	0	0	0	0	0	0	0	6	1	2	0	0	9
Total	1	0	0	0	19	1,208	2,455	3,332	2,921	2,958	1,980*	87	14,961

Survival	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Alive	1	0	0	0	17	1,044	1,988	2,275	2,156	2,728	1,803	62	12,074
Dead	0	0	0	0	2	164	467	1,057	765	230	177	25	2,887
Total	1	0	0	0	19	1,208	2,455	3,332	2,921	2,958	1,980*	87	14,961

Condition	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Intact	1	0	0	0	11	625	1,059	1,724	1,263	2,281	1,541	43	8,548
Missing parts	0	0	0	0	8	583	1,396	1,608	1,658	677	439	44	6,413
Total	1	0	0	0	19	1,208	2,455	3,332	2,921	2,958	1,980*	87	14,961

* Data for this category not recorded for all crabs caught during this month.

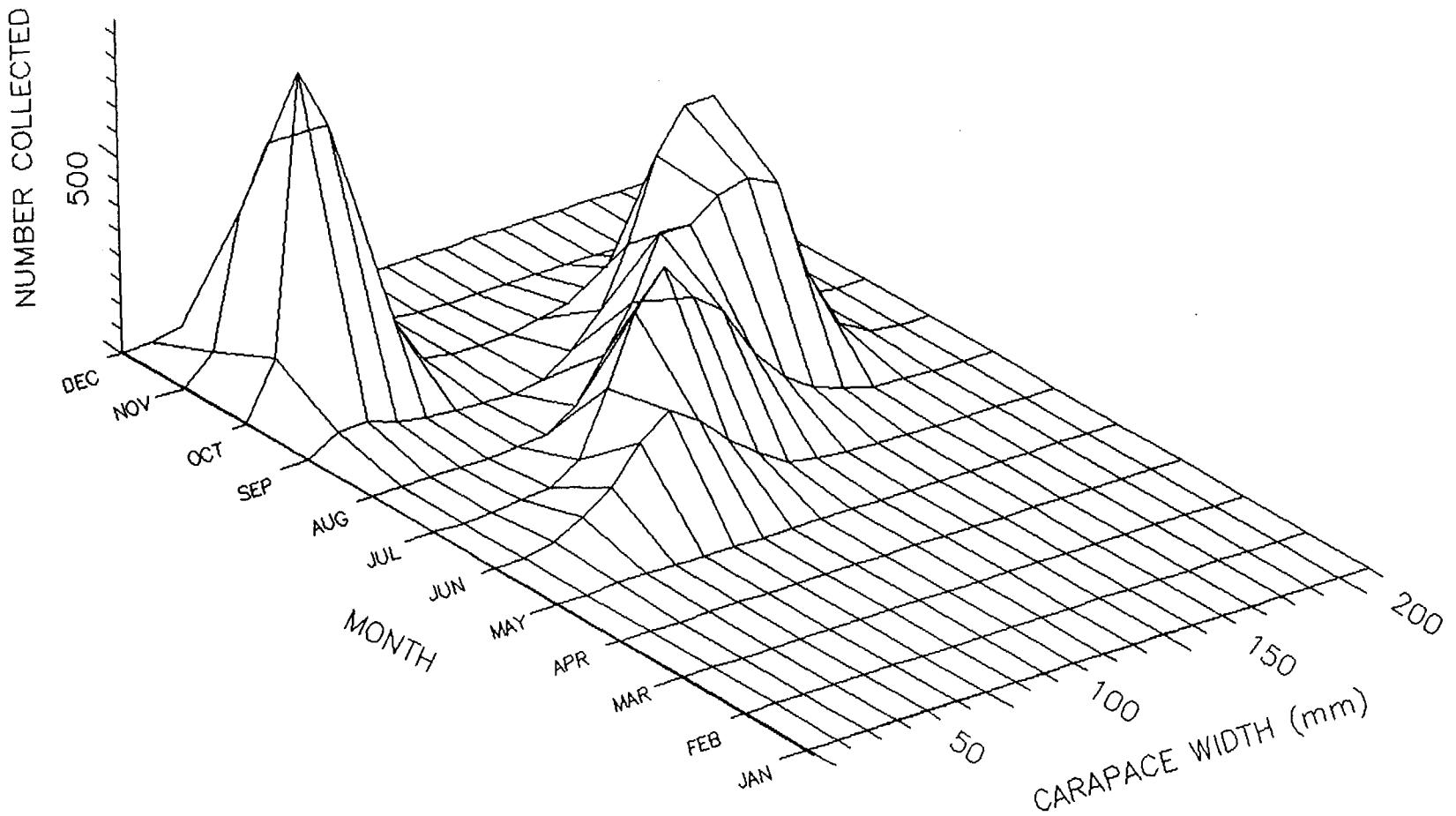

Figure 4-18. Frequency distribution of carapace width (mm) for blue crab collected at Indian Point Units 2 and 3 in 1988.

reflects utilization of the Indian Point region by adult crabs with the increases in modal size resulting in the rapid growth and molting which occurs in estuaries during summer. The second and smaller mode was first evident in impingement collections in September at 20- to 39-mm carapace width. These individuals continued to be abundant in impingement collections through October. This mode is clearly a result of young-of-the-year blue crabs utilizing the estuary as a late summer nursery area.

Survival averaged 80.7 percent for crabs subsampled for survival (Table 4-11). This was within the range of monthly rates observed in previous years (47-100 percent) (NAI 1984a, 1986, 1987; MMES 1985; EA 1988) (Table 4-11). Survival increased from a low of approximately 68 percent in August to 92 percent in October. The higher survival rates during fall was similar to the pattern observed in 1983-1985 and 1987. During the November peak of blue crab impingement, survival was more than 90 percent.

The highest proportion of intact crabs occurred in November (78.8 percent) and the lowest proportion in July (43.1 percent) (Table 4-12). Overall, the proportion of intact crabs at Units 2 and 3 averaged 57.1 percent.

In general, intact crabs were collected alive more frequently than damaged crabs (Table 4-12). Also, the frequency of intact crabs showed a decrease with increasing carapace width (Figure 4-19), probably as a result of the greater susceptibility of larger, heavier individuals to the mechanical stresses inherent in the impingement collection process. The impact of appendage loss on long-term survival in blue crabs is uncertain. Juvenile blue crabs do regenerate lost chelipeds, but show a reduction in carapace width increase with the next molt when compared to intact controls (Ary et al. 1987).

None of the 2,280 blue crabs tagged and released during 1986 (NAI 1987) were recaptured during impingement collections at Indian Point during 1988, the same as observed in 1987 (EA 1988). Several factors in the life history of the blue crab could explain the failure to recover any tagged individuals after their first season of release. First, typical of highly fecund opportunistic species,

TABLE 4-12 SUMMARY OF PROPORTIONS OF BLUE CRABS RECOVERED ALIVE AND INTACT IN IMPINGEMENT COLLECTIONS AT INDIAN POINT, 1985-1988

Year		JUN	JUL	AUG	SEP	OCT	NOV
1985	% Alive	89.9	66.4	61.6	76.2	88.1	86.9
	% Intact	36.5	24.7	36.4	54.3	48.0	59.4
1986	% Alive	64.4	84.9	72.8	65.5	75.1	75.0
	% Intact	45.2	58.4	45.0	28.2	39.3	40.0
1987	% Alive	85.7	96.2	79.4	75.5	90.7	96.7
	% Intact	57.1	35.4	51.0	53.5	77.4	96.1
1988	% Alive	86.4	81.0	68.3	73.8	92.2	91.1
	% Intact	51.7	43.1	51.7	43.2	77.1	77.8

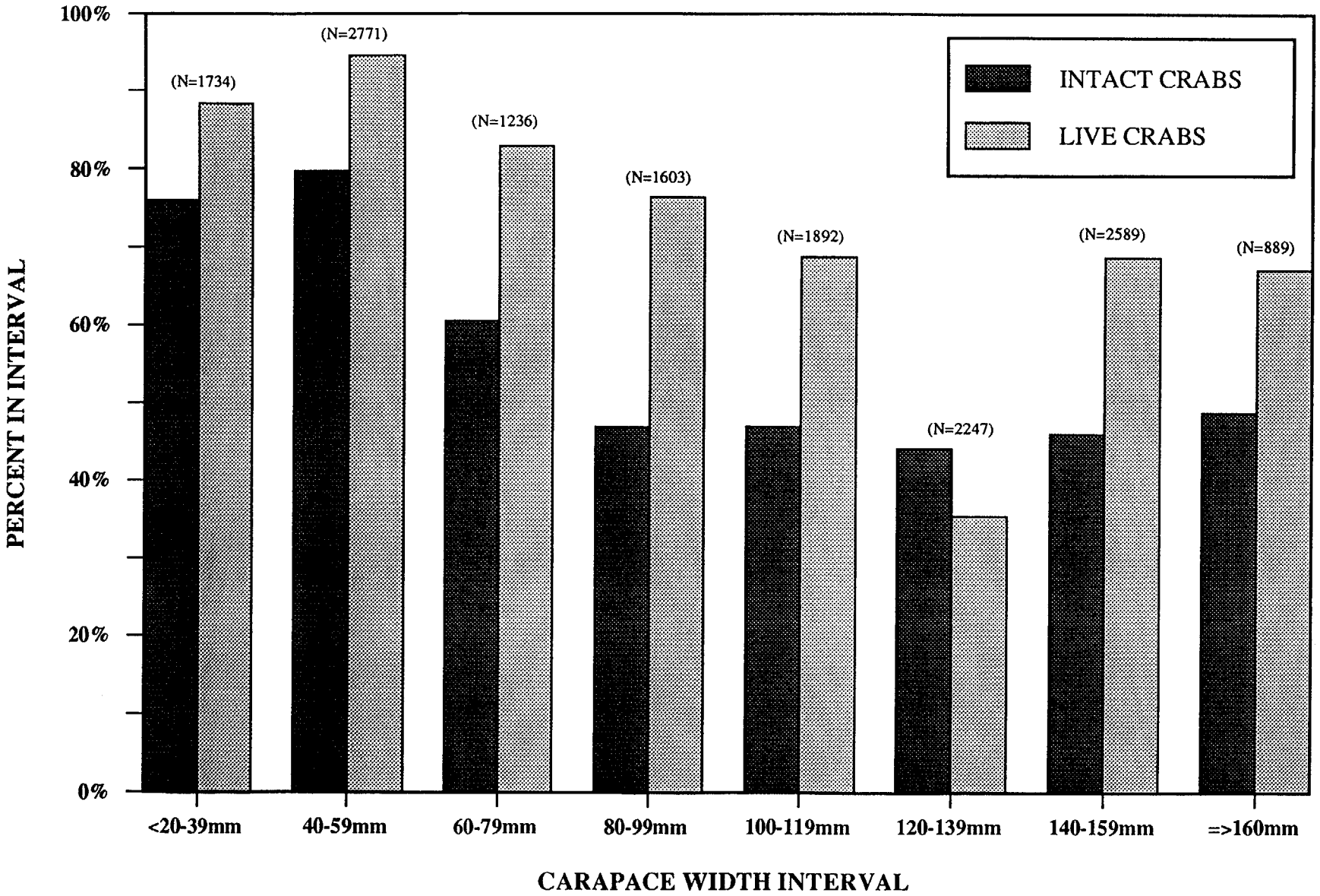

Figure 4-19. Proportion of live and intact crabs in impingement collections at the Indian Point Generating Station, 1988.

blue crabs experience high annual mortality rates, with life expectancy of rarely more than 3 years (Van Den Avyle 1984). Natural mortality, without any consideration of any incremental mortality caused by the tagging process, could remove a significant number of individuals from the tagged population within one year. Second, female blue crabs move into less saline regions after their first winter. After mating, they migrate to high salinity areas in the lower estuary and never return to the upper reaches (Williams 1965). If the sex ratio in the tagged pool were the same as that observed in the general population during the 1986 tagging study (about 23 percent female [NAI 1987]), then post-mating out-migration of females would result in the loss of that proportion from the tagged crabs available for recapture at Indian Point. Third, male blue crabs, unlike females, continue to grow and molt throughout their lives. Although the tag retention study conducted as part of the 1986 tagging effort was of sufficient duration to encompass one molt (NAI 1987), it did not address the long-term effect of repeated molting. It is possible that the 1+ year tag loss rate could be considerably higher than the 13.8 percent reported at 25 days.

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APPENDIX A

DATA CALCULATION PROCEDURES

APPENDIX A

DATA CALCULATION PROCEDURES

Impingement data were collected separately at intake Screens 21-25, 26, and 31-36. In order to provide standard, unit-wide sample data for Unit 2, impingement data from Screens 21-25 and 26 were combined within each sample day. The impingement statistics calculated from Units 2 and 3 1988 data are:

- Number of fish impinged on each sampling day at each unit (Equation 1).
- Total number of fish impinged over the whole year (Equation 2).
- Standard error of the total estimated number of fish impinged (Equation 3) and the coefficient of variation (Equation 4).
- Total estimated weight of fish impinged in each stratum and at each unit (Equation 5).
- Mean daily fish impingement rates standardized to the volume of water sampled (Equation 6).
- Mean daily blue crab impingement rates standardized to the volume of water sampled (Equation 7).

Calculations

To estimate the number of fish actually impinged on a sampling day, the count from the day's impingement collection was divided by the corresponding collection efficiency (Equation 1):

$$Y_{im} = \sum_{L=1}^{4} \left(C_{Lim} / E_{im} \right) \qquad \text{(Equation 1)}$$

where

Y_{im} = Estimated number of fish impinged on day i at Unit m.

C_{Lim} = Count for length class L on day i at Unit m.

E_{im} = Collection efficiency estimate for day i at Unit m (calculated as shown in Section 3.2).

At Unit 2, the non-Ristroph (Screens 21-25) and the Ristroph screens were treated separately through Equation 1. The adjusted daily estimates (Y_{im}) for each screen type were then summed to produce the overall adjusted daily estimate for Unit 2.

Within each seasonal stratum (h), a mean (Y_{hm}) and a variance (S^2_{hm}) were calculated for the n_{hm} values of the daily estimate Y_{im} (where n_{hm} = the number of sampling days in stratum h at Unit m). The total number of fish impinged over the whole year was estimated by Equation 2:

$$T_m = \sum_{h=1}^{4} \left(N_{hm} \times Y_{hm} \right) \qquad \text{(Equation 2)}$$

where

T_m = Total estimated number of fish impinged at Unit m.

N_{hm} = Number of days in stratum h that Unit m operated (a unit was considered to be operating if any circulating water was being pumped).

Y_{hm} = Mean daily estimate for stratum h at Unit m.

This estimate of the total number of fish impinged (T_m) is equivalent to the number which would result from generating an annual estimate from each of the daily estimates and then averaging them using the appropriate stratified sampling formula. Therefore, its standard error can be calculated from the within-stratum variances as a measure of the estimate's precision (Equation 3);

$$S.E._m = \sqrt{\sum_{h=1}^{4} \left(\left(N_{hm} \quad (N_{hm} - n_{hm})/n_{hm} \right) S^2_{hm} \right)} \qquad \text{(Equation 3)}$$

where

$S.E._m$ = Standard error of the total estimated number of fish impinged at Unit m.

N_{hm}, n_{hm}, S^2_{hm} = as defined on the previous page.

The stratified mean daily impingement estimate and standard error of the stratified mean can be calculated by dividing T_m or $S.E._m$ by the total number of operating days at Unit m. The coefficient of variation was calculated to relate the precision to the total estimate (Equation 4):

$$C.V. = \frac{S.E._m}{T_{hm}} \times 100\% \qquad \text{(Equation 4)}$$

where

C.V. = Coefficient of variation.

$S.E._m$ = As defined above.

T_{hm} = Estimated number of fish impinged in stratum h at Unit m.

The total weight of fish impinged for each stratum was estimated using Equation 5:

$$W_{hm} = \left(w_{hm} / \sum_{L=1}^{4} C_{Lhm} \right) Y_{hm} N_{hm} \qquad \text{(Equation 5)}$$

where

W_{hm} = Total estimated weight of fish impinged in stratum h at Unit m.

w_{hm} = Total weight of fish actually impinged in stratum h at Unit m.

C_{Lhm} = Total count of fish actually collected in length class L in stratum h at Unit m.

N_{hm}, Y_{hm} = As defined above.

Mean daily impingement rates were calculated by standardizing the daily impingement estimates (adjusted for collection efficiency) by dividing by each sample day's circulating water volume:

$$A_{km} = 1/n_{km} \sum_{i=1}^{n_{km}} \left[\left(\sum_{L=1}^{4} C_{Likm}/E_{ikm} \right) /V_{ikm} \right] \qquad \text{(Equation 6)}$$

Mean daily impingement rates standardized to the volume of water sampled were calculated by summing within each month the quotient of the adjusted daily impingement estimate divided by the corresponding volume of circulating water sampled and dividing this sum by the total number of sample days.

where

A_{km} = Mean daily adjusted impingement rate for month k at Unit m.

n_{km} = Number of sampling days in month k at Unit m.

C_{Likm} = Count for length class L on day i of month k at Unit m.

V_{ikm} = Volume of circulating water sampled on day i of month k at Unit m.

E_{ikm} = Collection efficiency on day i of month k at Unit m.

Mean daily impingement rates unadjusted for collection efficiency were calculated for blue crabs by summing within each month the quotient of the daily count divided by the daily sampling volume and dividing this sum by the number of plant operating days:

$$A_{km} = 1/n_{km} \sum_{i=1}^{n_{km}} (C_{ikm}/V_{ikm}) \qquad \text{(Equation 7)}$$

where

A_{km} = Mean daily adjusted impingement rate for month k at Unit m.

n_{km} = Number of plant operating days in month k at Unit m.

C_{ikm} = Count of blue crabs on day i of month k at Unit m.

V_{ikm} = Volume of circulating water sampled on day i of month k at Unit m.

The number of operating days was used rather than the number of sample days since a blue crab sample day was defined as any day that the plant operated. Collection efficiency data were not available for blue crabs impinged at the Indian Point Generating Station. Consequently, blue crab impingement rates were not adjusted.

APPENDIX B

SUMMARY TABLES FOR WATER QUALITY AND IMPINGEMENT COLLECTION RESULTS

APPENDIX B
LIST OF TABLES

TABLE B-1 DAILY INTAKE WATER QUALITY RECORDED AT THE INDIAN POINT GENERATING STATION DURING 1988

Date	Unit 2	Unit 3	Mean	Unit 2	Unit 3	Mean
01/07/88		2.2	2.2		151	151
01/09/88		-0.2	-0.2		359	359
01/10/88		1.0	1.0		435	435
01/12/88	1.8	-1.2	0.3	1890	700	1295
01/13/88	3.8	2.0	2.9	2100	2300	2200
01/14/88		-1.0	-1.0		2900	2900
01/18/88		4.1	4.1		3220	3220
01/19/88		5.0	5.0		3250	3250
01/21/88		2.6	2.6		3000	3000
01/23/88	2.0	0.0	1.0	2300	1600	1950
01/24/88		4.2	4.2		1300	1300
01/25/88		-0.8	-0.8		3110	3110
01/26/88	3.9		3.9	1520		1520
01/27/88		2.1	2.1		600	600
01/28/88		-0.5	-0.5		900	900
02/01/88		5.1	5.1		790	790
02/02/88	1.1		1.1	240		240
02/03/88	0.0		0.0	119		119
02/04/88		3.0	3.0		720	720
02/06/88		0.9	0.9		100	100
02/09/88		-0.1	-0.1		100	100
02/14/88		2.0	2.0		580	580
02/17/88	1.8		1.8	1010		1010
02/18/88	4.2		4.2	1220		1220
02/19/88	0.0	2.9	1.5	470	1100	785
02/21/88	0.0	0.0	0.0	470	420	445
02/22/88	0.0	0.9	0.5	340	240	290
02/23/88	2.9	2.8	2.8	490	235	363
02/26/88	3.5		3.5	125		125
02/27/88	3.0	3.0	3.0	190	220	205
03/01/88	5.1	4.8	4.9	1050	1370	1210
03/02/88	5.2		5.2	1000		1000
03/07/88	3.5		3.5	1100		1100
03/08/88	4.1		4.1	1250		1250
03/09/88		5.1	5.1		1210	1210
03/10/88		5.0	5.0		970	970
03/11/88	5.2	2.9	4.0	780	610	695
03/12/88		3.8	3.8		410	410
03/13/88	4.0		4.0	360		360
03/14/88	7.8		7.8	250		250
03/15/88		5.0	5.0		445	445
03/16/88		5.7	5.7		490	490
03/18/88		6.1	6.1		700	700
03/21/88		7.1	7.1		120	120
03/22/88	3.1		3.1	89		89
03/23/88	4.8		4.8	148		148
03/25/88		6.9	6.9		155	155
03/28/88		8.9	8.9		145	145

TABLE B-1 (Cont.)

Date	Unit 2	Unit 3	Mean	Unit 2	Unit 3	Mean
04/28/88	14.1	14.0	14.1	2870	2070	2470
04/29/88		14.1	14.1		2061	2061
05/02/88		16.0	16.0		2100	2100
05/03/88	16.1	15.8	16.0	1340	1700	1520
05/05/88		15.8	15.8		1700	1700
05/06/88	13.8	12.8	13.3	680	1280	980
05/07/88		14.1	14.1		1010	1010
05/09/88		15.0	15.0		690	690
05/12/88		14.1	14.1		400	400
05/16/88	14.9		14.9	185		185
05/23/88	16.3		16.3	142		142
05/24/88	19.0		19.0	151		151
05/26/88	17.2		17.2	220		220
05/31/88		21.1	21.1		321	321
06/01/88		22.1	22.1		360	360
06/02/88		17.8	17.8		418	418
06/03/88		18.0	18.0		610	610
06/04/88	19.1	19.0	19.1	600	650	625
06/05/88		20.0	20.0		400	400
06/06/88	20.1	20.1	20.1	555	510	533
06/07/88		20.9	20.9		630	630
06/13/88		20.9	20.9		940	940
06/16/88		21.9	21.9		2400	2400
06/19/88		22.8	22.8		1880	1880
07/03/88		26.0	26.0		5500	5500
07/04/88		24.2	24.2		5000	5000
07/05/88		24.8	24.8		5700	5700
07/06/88	24.9	31.0	28.0	4900	6500	5700
07/09/88		25.9	25.9		5900	5900
07/19/88						
07/20/88		28.1	28.1		5300	5300
07/24/88						
07/25/88		33.8	33.8		5400	5400
07/26/88		29.2	29.2		5100	5100
08/02/88		30.8	30.8		5300	5300
08/04/88		28.8	28.8		5200	5200
08/05/88		30.4	30.4		4680	4680
08/09/88	28.8		28.8	3240		3240
08/10/88		33.4	33.4		5100	5100
08/15/88	30.5		30.5	3600		3600
08/16/88	31.0	34.0	32.5	3300	4900	4100
08/17/88		32.2	32.2		4200	4200
08/19/88		28.0	28.0		5200	5200
08/20/88	28.6		28.6	4800		4800
08/21/88		27.0	27.0		5200	5200
08/22/88	27.9	27.6	27.8	9100	8100	8600
08/23/88		28.0	28.0		8500	8500
08/24/88	27.2		27.2	12000		12000
08/28/88		26.8	26.8		12500	12500

TABLE B-1 (Cont.)

Date	Unit 2	Unit 3	Mean	Unit 2	Unit 3	Mean
09/08/88		25.1	25.1		5900	5900
09/11/88	24.5	25.5	25.0	4600	6000	5300
09/14/88		23.9	23.9		4020	4020
09/15/88		24.0	24.0		4240	4240
09/16/88		23.0	23.0		4650	4650
09/17/88		25.0	25.0		4000	4000
09/18/88	24.0		24.0	5500		5500
09/20/88		24.1	24.1		5000	5000
09/24/88		25.0	25.0		6500	6500
09/25/88		25.5	25.5		7500	7500
09/27/88	22.9	23.8	23.4	4700	5800	5250
10/03/88		23.0	23.0		4700	4700
10/04/88	23.1	23.5	23.3	4500	4700	4600
10/05/88	22.5		22.5	6200		6200
10/06/88	23.2		23.2	6900		6900
10/07/88	21.2		21.2	7000		7000
10/08/88		20.5	20.5		7900	7900
10/09/88		23.0	23.0		11000	11000
10/10/88	20.9	20.3	20.6	7200	9500	8350
10/11/88	20.4		20.4	10000		10000
10/12/88	20.1	20.0	20.1	7900	8000	7950
10/13/88	17.9		17.9	6900		6900
10/14/88	18.0		18.0	6900		6900
10/15/88	17.0		17.0	6500		6500
10/16/88	17.1		17.1	7100		7100
10/17/88	20.2		20.2	8200		8200
10/18/88	18.1		18.1	7900		7900
10/19/88	18.9		18.9	7500		7500
10/20/88	17.9		17.9	7100		7100
10/21/88	19.1		19.1	8900		8900
10/22/88	17.5		17.5	8500		8500
10/23/88	16.0		16.0	6000		6000
10/24/88	16.8	16.9	16.9	8200	8400	8300
10/25/88	15.0	15.9	15.5	5500	8500	7000
10/26/88	17.5	17.5	17.5	6000	6000	6000
10/27/88	21.7	17.7	19.7	4320	5000	4660
10/28/88	14.1	17.2	15.6	4130	4900	4515
10/29/88	14.0	17.1	15.6	3800	3995	3898
10/30/88	14.0		14.0	4000		4000
10/31/88	13.9	14.8	14.4	4110	3500	3805
11/01/88	13.2		13.2	4230	4390	4310
11/02/88				3790		3790
11/03/88		13.0	13.0		4000	4000
11/04/88		13.5	13.5		3000	3000
11/05/88	14.0	13.2	13.6	3850	3500	3675
11/06/88	13.8		13.8	4800		4800
11/07/88		12.9	12.9		3300	3300
11/08/88	12.7	12.3	12.5	1870	1750	1810
11/09/88	11.4		11.4	1150		1150

TABLE B-1 (Cont.)

Date	Unit 2	Unit 3	Mean	Unit 2	Unit 3	Mean
11/10/88						
11/11/88	11.1		11.1	272		272
11/13/88	11.0		11.0	280		280
11/14/88	9.9		9.9	308		308
11/15/88	8.9		8.9	199		199
11/16/88	10.0		10.0	221		221
11/17/88	11.9		11.9	2290		2290
11/19/88	10.0		10.0	370		370
11/20/88	10.1		10.1	304		304
11/22/88	8.1		8.1	361		361
11/23/88	8.9		8.9	160		160
11/24/88	9.0		9.0	200		200
11/25/88	7.3	8.5	7.9	178	149	164
11/26/88	6.8	8.8	7.8	200	200	200
11/27/88	8.5		8.5	190		190
11/28/88	11.0		11.0	270		270
11/29/88	8.8		8.8	271		271
12/01/88	8.1	7.9	8.0	138	170	154
12/02/88	7.9		7.9	190		190
12/03/88	7.0		7.0	135		135
12/04/88	10.5		10.5	140		140
12/05/88	6.9		6.9	298		298
12/06/88	8.2	8.0	8.1	690	950	820
12/08/88	5.9		5.9	600		600
12/09/88	4.3		4.3	610		610
12/10/88	5.5		5.5	440		440
12/11/88	4.5		4.5	440		440
12/12/88	5.0		5.0	350		350
12/13/88	4.5		4.5	550		550
12/14/88	5.1		5.1	620		620
12/17/88	4.0		4.0	800		800
12/18/88	4.5		4.5	1600		1600
12/19/88	4.0		4.0	1200		1200
12/21/88	5.8		5.8	780		780
12/22/88	5.2		5.2	600		600
12/23/88	4.8		4.8	420		420

TABLE B-2 TOTAL NUMBERS ACTUALLY COLLECTED BY TAXON AND MONTH AT INDIAN POINT UNIT 2 DURING 1988 (UNADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Month												Total
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Alewife	2	7	6	--	12	3	--	3	13	87	21	--	154
Bay anchovy	--	--	--	--	--	--	21	14	613	3,287	88	1	4,024
American shad	--	--	--	--	1	--	--	--	3	51	13	1	69
Bluefish	--	--	--	--	--	--	33	2	59	46	1	--	141
Bluegill	--	1	2	--	1	2	--	--	2	69	196	37	310
Brown bullhead	1	3	3	--	--	1	--	--	--	4	2	2	16
Pumpkinseed	13	41	30	--	4	--	--	1	--	136	21	19	265
Black crappie	--	--	--	--	--	--	--	--	--	--	1	--	1
American eel	8	12	10	1	15	3	3	43	--	17	18	13	143
Goldfish	2	4	2	--	1	--	--	--	--	--	--	6	15
Golden shiner	4	6	6	--	--	--	--	--	--	--	--	2	18
Hogchoker	10	25	17	9	706	13	125	889	229	336	227	533	3,119
Tessellated darter	--	--	4	--	--	--	--	--	--	3	27	32	66
Banded killifish	15	18	19	--	1	--	--	--	1	12	118	38	222
Largemouth bass	--	--	--	--	--	--	--	--	--	--	--	2	2
Mummichog	--	--	--	--	--	--	--	--	--	--	1	--	1
Atlantic menhaden	--	--	--	--	--	--	--	--	5	2	3	1	11
Blueback herring	11	9	--	1	22	4	14	17	18	4,816	919	2	5,833
White sucker	--	--	--	--	--	1	--	--	--	--	--	--	1
Atlantic silverside	--	--	--	--	--	1	--	--	1	54	3	--	59
Rainbow smelt	25	172	46	--	20	4	118	1	--	11	17	13	427
Spottail shiner	64	77	42	--	--	1	--	--	--	7	53	39	283
Striped bass	2,786	3,735	1,158	2	37	6	9	117	165	3,134	1,483	522	13,154
Atlantic tomcod	67	32	17	--	22	210	34	3	25	54	17	40	521
White catfish	54	115	49	2	82	--	1	2	--	43	272	330	950
White perch	11,103	32,219	18,040	52	2,170	633	96	1,588	367	4,483	9,970	37,767	118,488
Yellow perch	11	9	8	--	2	--	--	--	--	--	4	13	47
Northern pipefish	--	--	--	3	1	2	--	1	--	98	53	--	158
Redbreast sunfish	--	--	--	--	--	--	--	--	--	--	--	1	1
Crevalle jack	--	--	--	--	--	--	--	--	7	36	12	--	55
Weakfish	--	--	--	--	1	--	--	97	494	1,049	52	--	1,693
Lookdown	--	--	--	--	--	--	--	--	--	19	1	--	20
Seahorse	--	--	--	--	--	--	--	--	--	1	--	--	1
Tautog	--	--	--	--	2	--	--	--	--	--	--	--	2

TABLE B-2 (Cont.)

Taxon	Month												Total
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Striped cuskeel	--	--	--	1	--	--	--	--	--	--	--	--	1
Spot	--	--	--	--	--	--	--	--	10	13	1	4	28
Moonfish	--	--	--	--	--	--	--	--	--	2	--	--	2
Scup	1	--	--	--	--	--	--	--	--	--	--	--	1
Winter flounder	--	2	3	--	--	1	--	--	--	--	--	--	6
Inland silverside	--	--	1	--	--	--	--	--	--	7	--	2	10
Sea lamprey	--	1	--	--	--	--	--	--	--	--	--	1	2
Gizzard shad	415	234	10	--	--	--	--	--	--	5	11	34	709
Silver hake	--	--	--	--	--	--	--	--	--	7	1	6	14
Threespine stickleback	1	132	117	--	--	--	--	--	--	--	--	--	250
Butterfish	--	--	--	--	--	--	--	3	1	58	1	--	63
White crappie	1	2	--	--	--	--	--	--	--	--	--	1	4
Red hake	--	1	1	1	2	--	--	--	--	2	--	--	7
Grubby	--	--	--	--	1	--	--	--	--	--	--	--	1
Eastern mudminnow	--	1	--	--	--	--	--	--	1	--	--	--	2
Summer flounder	--	--	--	1	1	1	2	--	1	2	--	--	8
Striped searobin	1	--	--	--	--	--	--	--	--	27	1	--	29
Northern searobin	--	--	--	--	--	--	--	--	2	--	--	--	2
Warmouth	--	--	--	--	--	--	--	--	--	2	1	1	4
Naked goby	--	1	--	--	1	1	--	--	1	3	2	10	19
Windowpane	--	--	--	--	1	--	--	--	2	33	3	--	39
Spotted hake	--	--	--	5	40	--	--	--	--	--	--	1	46
Northern stargazer	--	--	--	--	--	--	--	2	--	1	--	--	3
American sandlance	--	--	--	--	--	--	--	--	--	--	--	1	1
Fourspot flounder	--	--	--	--	--	--	--	--	--	2	--	--	2
Black sea bass	--	--	--	--	--	--	--	--	--	2	--	--	2
Gobiid unid.	--	--	--	--	--	--	--	--	--	--	1	--	1
Cunner	--	--	--	--	1	--	--	--	--	7	--	--	8
Total	14,595	36,859	19,591	78	3,147	887	456	2,783	2,020	18,028	13,615	39,475	151,534

TABLE B-3 TOTAL NUMBERS ACTUALLY COLLECTED BY TAXON AND MONTH AT INDIAN POINT UNIT 3 DURING 1988 (UNADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Month												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Alewife	--	4	7	--	33	20	3	32	14	1	--	--	114
Bay anchovy	2	--	--	--	3	9	59	94	522	38	--	--	727
American shad	--	--	--	1	3	3	2	4	8	2	--	--	23
Bluefish	--	--	--	--	--	7	16	16	40	6	--	--	85
Bluegill	2	--	--	--	1	2	--	1	1	--	1	4	12
Brown bullhead	3	--	--	--	1	--	--	--	1	--	--	1	6
Pumpkinseed	29	13	1	--	7	3	1	--	--	--	--	--	54
Black crappie	1	1	--	--	--	--	--	--	--	--	--	--	2
American eel	11	1	4	1	4	10	1	11	--	--	--	1	44
Goldfish	6	2	1	--	--	1	--	--	--	--	--	--	10
Golden shiner	4	4	3	--	1	--	--	--	--	--	--	--	12
Hogchoker	168	14	10	64	459	46	79	1,255	253	8	--	7	2,363
Banded killifish	6	2	1	--	--	--	--	--	--	1	--	1	11
Largemouth bass	5	1	--	--	--	--	--	--	--	--	--	1	7
Atlantic menhaden	--	1	--	--	--	--	1	1	2	--	--	--	5
Blueback herring	16	6	1	7	49	72	53	129	61	25	3	1	423
Atlantic silverside	--	1	--	--	--	--	--	--	--	1	--	--	2
Rainbow smelt	56	19	18	5	49	88	66	1	--	--	--	--	302
Shortnose sturgeon	--	--	--	--	--	--	--	1	--	--	--	--	1
Spottail shiner	71	16	8	--	--	1	--	--	--	--	--	7	103
Striped bass	2,482	965	441	7	31	32	22	85	39	3	1	23	4,131
Atlantic tomcod	108	2	8	--	86	600	92	481	7	--	1	3	1,388
White catfish	164	48	18	8	48	6	4	3	--	--	--	6	305
White perch	11,760	8,961	7,037	119	1,820	2,425	185	425	178	23	3	977	33,913
Yellow perch	3	2	1	--	--	--	--	1	--	--	--	--	7
Northern pipefish	--	--	--	2	6	--	1	--	--	1	1	--	11
Atlantic needlefish	--	--	--	--	--	--	--	--	1	--	--	--	1
Crevalle jack	--	--	--	--	--	--	1	--	1	1	1	--	4
Weakfish	--	--	--	--	--	--	--	188	365	31	--	1	585
Lookdown	--	--	--	--	--	--	--	1	--	--	--	--	1
Tautog	--	--	--	1	2	--	--	--	--	--	--	--	3
Fourbeard rockling	1	--	--	--	--	--	1	--	--	--	--	--	2
Striped cuskeel	--	--	--	1	--	--	--	--	--	--	--	--	1
Spot	--	--	--	--	--	--	--	--	3	--	--	--	3
Winter flounder	1	--	--	1	--	--	--	--	--	--	--	--	2
Gizzard shad	2,758	324	4	--	--	--	--	--	--	--	--	6	3,092
Threespine stickleback	2	22	20	2	2	--	--	--	--	--	--	--	48
Butterfish	--	--	--	--	--	--	--	14	24	6	--	--	44
White crappie	7	--	--	--	--	--	--	--	--	--	--	--	7
Red hake	9	--	--	--	1	--	--	--	--	--	--	--	10
Eastern mudminnow	1	--	--	--	--	--	--	1	--	--	--	1	3
Longear sunfish	--	--	--	--	--	--	--	--	--	--	--	1	1
Summer flounder	--	--	--	1	3	--	4	--	--	--	--	--	8
Windowpane	--	--	--	--	--	--	--	--	1	1	--	1	3
Spotted hake	--	--	1	5	56	1	2	--	--	--	--	--	65
Northern stargazer	--	--	--	--	--	--	--	--	1	--	--	--	1
Cunner	--	--	--	--	1	--	--	--	--	--	--	--	1
Total	17,676	10,409	7,584	225	2,666	3,326	593	2,744	1,522	148	11	1,042	47,946

TABLE B-4 TOTAL NUMBERS ACTUALLY COLLECTED BY TAXON AND MONTH AT INDIAN POINT UNITS 2 AND 3 COMBINED DURING 1988 (UNADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Month												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Alewife	2	11	13	--	45	23	3	35	27	88	21	--	268
Bay anchovy	2	--	--	--	3	9	80	108	1,135	3,325	88	1	4,751
American shad	--	--	--	1	4	3	2	4	11	53	13	1	92
Bluefish	--	--	--	--	--	7	49	18	99	52	1	--	226
Bluegill	2	1	2	--	2	4	--	1	3	69	197	41	322
Brown bullhead	4	3	3	--	1	1	--	--	1	4	2	3	22
Pumpkinseed	42	54	31	--	11	3	1	1	--	136	21	19	319
Black crappie	1	1	--	--	--	--	--	--	--	--	1	--	3
American eel	19	13	14	2	19	13	4	54	--	17	18	14	187
Goldfish	8	6	3	--	1	1	--	--	--	--	--	6	25
Golden shiner	8	10	9	--	1	--	--	--	--	--	--	2	30
Hogchoker	178	39	27	73	1,165	59	204	2,144	482	344	227	540	5,482
Tessellated darter	--	--	4	--	--	--	--	--	--	3	27	32	66
Banded killifish	21	20	20	--	1	--	--	--	1	13	118	39	233
Largemouth bass	5	1	--	--	--	--	--	--	--	--	--	3	9
Mummichog	--	--	--	--	--	--	--	--	--	--	1	--	1
Atlantic menhaden	--	1	--	--	--	--	1	1	7	2	3	1	16
Blueback herring	27	15	1	8	71	76	67	146	79	4841	922	3	6,256
White sucker	--	--	--	--	--	1	--	--	--	--	--	--	1
Atlantic silverside	--	1	--	--	--	1	--	--	1	55	3	--	61
Rainbow smelt	81	191	64	5	69	92	184	2	--	11	17	13	729
Shortnose sturgeon	--	--	--	--	--	--	--	1	--	--	--	--	1
Spottail shiner	135	93	50	--	--	2	--	--	--	7	53	46	386
Striped bass	5,268	4,700	1,599	9	68	38	31	202	204	3137	1484	545	17,285
Atlantic tomcod	175	34	25	--	108	810	126	484	32	54	18	43	1,909
White catfish	218	163	67	10	130	6	5	5	--	43	272	336	1,255
White perch	22,863	41,180	25,077	171	3,990	3,058	281	2,013	545	4506	9973	38744	152,401
Yellow perch	14	11	9	--	2	--	--	1	--	--	4	13	54
Northern pipefish	--	--	--	5	7	2	1	1	--	99	54	--	169
Redbreast sunfish	--	--	--	--	--	--	--	--	--	--	--	1	1
Atlantic needlefish	--	--	--	--	--	--	--	--	1	--	--	--	1
Crevalle jack	--	--	--	--	--	--	1	--	8	37	13	--	59
Weakfish	--	--	--	--	1	--	--	285	859	1080	52	1	2,278
Lookdown	--	--	--	--	--	--	--	1	--	19	1	--	21
Seahorse	--	--	--	--	--	--	--	--	--	1	--	--	1
Tautog	--	--	--	1	4	--	--	--	--	--	--	--	5
Fourbeard rockling	1	--	--	--	--	--	1	--	--	--	--	--	2
Striped cuskeel	--	--	--	2	--	--	--	--	--	--	--	--	2
Spot	--	--	--	--	--	--	--	--	13	13	1	4	31
Moonfish	--	--	--	--	--	--	--	--	--	2	--	--	2
Scup	1	--	--	--	--	--	--	--	--	--	--	--	1
Winter flounder	1	2	3	1	--	1	--	--	--	--	--	--	8
Inland silverside	--	--	1	--	--	--	--	--	--	7	--	2	10
Sea lamprey	--	1	--	--	--	--	--	--	--	--	--	1	2
Gizzard shad	3,173	558	14	--	--	--	--	--	--	5	11	40	3,801
Silver hake	--	--	--	--	--	--	--	--	--	7	1	6	14
Threespine stickleback	3	154	137	2	2	--	--	--	--	--	--	--	298
Butterfish	--	--	--	--	--	--	--	17	25	64	1	--	107
White crappie	8	2	--	--	--	--	--	--	--	--	--	1	11
Red hake	9	1	1	1	3	--	--	--	--	2	--	--	17
Grubby	--	--	--	--	1	--	--	--	--	--	--	--	1
Eastern mudminnow	1	1	--	--	--	--	--	1	1	--	--	1	5
Longear sunfish	--	--	--	--	--	--	--	--	--	--	--	1	1
Summer flounder	--	--	--	2	4	1	6	--	1	2	--	--	16
Striped searobin	1	--	--	--	--	--	--	--	--	27	1	--	29
Northern searobin	--	--	--	--	--	--	--	--	2	--	--	--	2
Warmouth	--	--	--	--	--	--	--	--	--	2	1	1	4
Naked goby	--	1	--	--	1	1	--	--	1	3	2	10	19
Windowpane	--	--	--	--	1	--	--	--	3	34	3	1	42
Spotted hake	--	--	1	10	96	1	2	--	--	--	--	1	111
Northern stargazer	--	--	--	--	--	--	--	2	1	1	--	--	4
American sandlance	--	--	--	--	--	--	--	--	--	--	--	1	1
Fourspot flounder	--	--	--	--	--	--	--	--	--	2	--	--	2
Black sea bass	--	--	--	--	--	--	--	--	--	2	--	--	2
Gobiid unid.	--	--	--	--	--	--	--	--	--	--	1	--	1
Cunner	--	--	--	--	2	--	--	--	--	7	--	--	9
Total	32,271	47,268	27,175	303	5,813	4,213	1,049	5,527	3,542	18,176	13,626	40,517	199,480

TABLE B-5 TOTAL NUMBERS ACTUALLY COLLECTED BY TAXON AND SEASONAL SAMPLING STRATUM AT INDIAN POINT UNIT 2 DURING 1988 (UNADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Stratum				Total
	Winter	Spring	Summer	Fall	
Alewife	15	15	16	108	154
Bay anchovy	--	--	648	3,376	4,024
American shad	--	1	3	65	69
Bluefish	--	--	94	47	141
Bluegill	3	3	2	302	310
Brown bullhead	7	1	--	8	16
Pumpkinseed	84	4	1	176	265
Black crappie	--	--	--	1	1
American eel	30	19	46	48	143
Goldfish	8	1	--	6	15
Golden shiner	16	--	--	2	18
Hogchoker	52	728	1,243	1,096	3,119
Tessellated darter	4	--	--	62	66
Banded killifish	52	1	1	168	222
Largemouth bass	--	--	--	2	2
Mummichog	--	--	--	1	1
Atlantic menhaden	--	--	5	6	11
Blueback herring	20	27	49	5,737	5,833
White sucker	--	1	--	--	1
Atlantic silverside	--	1	1	57	59
Rainbow smelt	243	24	119	41	427
Spottail shiner	183	1	--	99	283
Striped bass	7,679	45	291	5,139	13,154
Atlantic tomcod	116	232	62	111	521
White catfish	218	84	3	645	950
White perch	61,362	2,855	2,051	52,220	118,488
Yellow perch	28	2	--	17	47
Northern pipefish	--	6	1	151	158
Redbreast sunfish	--	--	--	1	1
Crevalle jack	--	--	7	48	55

TABLE B-5 (Cont.)

Taxon	Stratum				Total
	Winter	Spring	Summer	Fall	
Weakfish	--	1	591	1,101	1,693
Lookdown	--	--	--	20	20
Seahorse	--	--	--	1	1
Tautog	--	2	--	--	2
Striped cuskeel	--	1	--	--	1
Spot	--	--	10	18	28
Moonfish	--	--	--	2	2
Scup	1	--	--	--	1
Winter flounder	5	1	--	--	6
Inland silverside	1	--	--	9	10
Sea lamprey	1	--	--	1	2
Gizzard shad	659	--	--	50	709
Silver hake	--	--	--	14	14
Threespine stickleback	250	--	--	--	250
Butterfish	--	--	4	59	63
White crappie	3	--	--	1	4
Red hake	2	3	--	2	7
Grubby	--	1	--	--	1
Eastern mudminnow	1	--	1	--	2
Summer flounder	--	3	3	2	8
Striped searobin	1	--	--	28	29
Northern searobin	--	--	2	--	2
Warmouth	--	--	--	4	4
Naked goby	1	2	1	15	19
Windowpane	--	1	2	36	39
Spotted hake	--	45	--	1	46
Northern stargazer	--	--	2	1	3
American sandlance	--	--	--	1	1
Fourspot flounder	--	--	--	2	2
Black sea bass	--	--	--	2	2
Gobiid unid.	--	--	--	1	1
Cunner	--	1	--	7	8
Total	71,045	4,112	5,259	71,118	151,534

TABLE B-6 TOTAL NUMBERS ACTUALLY COLLECTED BY TAXON AND SEASONAL SAMPLING STRATUM AT INDIAN POINT UNIT 3 DURING 1988 (UNADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Stratum				Total
	Winter	Spring	Summer	Fall	
Alewife	11	53	49	1	114
Bay anchovy	2	12	675	38	727
American shad	--	7	14	2	23
Bluefish	--	7	72	6	85
Bluegill	2	3	2	5	12
Brown bullhead	3	1	1	1	6
Pumpkinseed	43	10	1	--	54
Black crappie	2	--	--	--	2
American eel	16	15	12	1	44
Goldfish	9	1	--	--	10
Golden shiner	11	1	--	--	12
Hogchoker	192	569	1,587	15	2,363
Banded killifish	9	--	--	2	11
Largemouth bass	6	--	--	1	7
Atlantic menhaden	1	--	4	--	5
Blueback herring	23	128	243	29	423
Atlantic silverside	1	--	--	1	2
Rainbow smelt	93	142	67	--	302
Shortnose sturgeon	--	--	1	--	1
Spottail shiner	95	1	--	7	103
Striped bass	3,888	70	146	27	4,131
Atlantic tomcod	118	686	580	4	1,388
White catfish	230	62	7	6	305
White perch	27,758	4,364	788	1,003	33,913
Yellow perch	6	--	1	--	7
Northern pipefish	--	8	1	2	11
Atlantic needlefish	--	--	1	--	1
Crevalle jack	--	--	2	2	4
Weakfish	--	--	553	32	585
Lookdown	--	--	1	--	1
Tautog	--	3	--	--	3
Fourbeard rockling	1	--	1	--	2
Striped cuskeel	--	1	--	--	1
Spot	--	--	3	--	3
Winter flounder	1	1	--	--	2
Gizzard shad	3,086	--	--	6	3,092
Threespine stickleback	44	4	--	--	48
Butterfish	--	--	38	6	44
White crappie	7	--	--	--	7
Red hake	9	1	--	--	10
Eastern mudminnow	1	--	1	1	3
Longear sunfish	--	--	--	1	1
Summer flounder	--	4	4	--	8
Windowpane	--	--	1	2	3
Spotted hake	1	62	2	--	65
Northern stargazer	--	--	1	--	1
Cunner	--	1	--	--	1
Total	35,669	6,217	4,859	1,201	47,946

TABLE B-7 TOTAL NUMBERS ACTUALLY COLLECTED BY TAXON AND SEASONAL SAMPLING STRATUM AT INDIAN POINT UNITS 2 AND 3 COMBINED DURING 1988 (UNADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Stratum				Total
	Winter	Spring	Summer	Fall	
Alewife	26	68	65	109	268
Bay anchovy	2	12	1,323	3,414	4,751
American shad	--	8	17	67	92
Bluefish	--	7	166	53	226
Bluegill	5	6	4	307	322
Brown bullhead	10	2	1	9	22
Pumpkinseed	127	14	2	176	319
Black crappie	2	--	--	1	3
American eel	46	34	58	49	187
Goldfish	17	2	--	6	25
Golden shiner	27	1	--	2	30
Hogchoker	244	1,297	2,830	1,111	5,482
Tessellated darter	4	--	--	62	66
Banded killifish	61	1	1	170	233
Largemouth bass	6	--	--	3	9
Mummichog	--	--	--	1	1
Atlantic menhaden	1	--	9	6	16
Blueback herring	43	155	292	5,766	6,256
White sucker	--	1	--	--	1
Atlantic silverside	1	1	1	58	61
Rainbow smelt	336	166	186	41	729
Shortnose sturgeon	--	--	1	--	1
Spottail shiner	278	2	--	106	386
Striped bass	11,567	115	437	5,166	17,285
Atlantic tomcod	234	918	642	115	1,909
White catfish	448	146	10	651	1,255
White perch	89,120	7,219	2,839	53,223	152,401
Yellow perch	34	2	1	17	54
Northern pipefish	--	14	2	153	169
Redbreast sunfish	--	--	--	1	1
Atlantic needlefish	--	--	1	--	1
Crevalle jack	--	--	9	50	59

TABLE B-7 (Cont.)

Taxon	Stratum				Total
	Winter	Spring	Summer	Fall	
Weakfish	--	1	1,144	1,133	2,278
Lookdown	--	--	1	20	21
Seahorse	--	--	--	1	1
Tautog	--	5	--	--	5
Four bearded rockling	1	--	1	--	2
Striped cuskeel	--	2	--	--	2
Spot	--	--	13	18	31
Moonfish	--	--	--	2	2
Scup	1	--	--	--	1
Winter flounder	6	2	--	--	8
Inland silverside	1	--	--	9	10
Sea lamprey	1	--	--	1	2
Gizzard shad	3,745	--	--	56	3,801
Silver hake	--	--	--	14	14
Threespine stickleback	294	4	--	--	298
Butterfish	--	--	42	65	107
White crappie	10	--	--	1	11
Red hake	11	4	--	2	17
Grubby	--	1	--	--	1
Eastern mudminnow	2	--	2	1	5
Longear sunfish	--	--	--	1	1
Summer flounder	--	7	7	2	16
Striped searobin	1	--	--	28	29
Northern searobin	--	--	2	--	2
Warmouth	--	--	--	4	4
Naked goby	1	2	1	15	19
Windowpane	--	1	3	38	42
Spotted hake	1	107	2	1	111
Northern stargazer	--	--	3	1	4
American sandlance	--	--	--	1	1
Fourspot flounder	--	--	--	2	2
Black sea bass	--	--	--	2	2
Gobiid unid.	--	--	--	1	1
Cunner	--	2	--	7	9
Total	106,714	10,329	10,118	72,319	199,480

TABLE B-8 TOTAL ESTIMATED WEIGHT (GRAMS) OF FISH IMPINGED AT INDIAN POINT UNIT 2 DURING 1988, BY TAXON AND SEASONAL STRATUM (ADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Stratum				Total
	Winter	Spring	Summer	Fall	
Alewife	1,148	9,565	16,861	3,105	30,679
Bay anchovy	0	0	62,083	27,369	89,452
American shad	0	233	393	1,173	1,799
Bluefish	0	0	19,103	3,049	22,152
Bluegill	36	1,810	84	6,798	8,728
Brown bullhead	3,883	9,424	0	1,304	14,611
Pumpkinseed	18,621	5,733	92	6,611	31,057
Black crappie	0	0	0	16	16
American eel	22,921	43,498	102,998	23,965	193,382
Goldfish	5,533	8,210	0	617	14,360
Golden shiner	2,895	0	0	266	3,161
Hogchoker	4,806	221,140	572,106	50,594	848,646
Tessellated darter	78	0	0	777	855
Banded killifish	1,968	243	59	2,258	4,528
Largemouth bass	0	0	0	96	96
Mummichog	0	0	0	3	3
Atlantic menhaden	0	0	703	84	787
Blueback herring	271	46,673	22,406	45,321	114,671
White sucker	0	14,277	0	0	14,277
Atlantic silverside	0	172	167	947	1,286
Rainbow smelt	10,838	5,025	2,032	176	18,071
Shortnose sturgeon	0	0	0	0	0
Spottail shiner	9,177	263	0	1,444	10,884
Striped bass	285,902	6,633	48,885	94,076	435,496
Atlantic tomcod	16,539	16,117	16,510	9,728	58,894
White catfish	88,974	23,205	13,934	33,706	159,819
White perch	2,411,153	548,265	433,144	991,774	4,384,336
Yellow perch	7,665	2,386	0	1,608	11,659
Northern pipefish	0	182	33	887	1,102
Redbreast sunfish	0	0	0	11	11
Atlantic needlefish	0	0	0	0	0
Crevalle jack	0	0	5,528	3,686	9,214

TABLE B-8 (Cont.)

Taxon	Stratum				Total
	Winter	Spring	Summer	Fall	
Weakfish	0	667	64,116	26,694	91,477
Lookdown	0	0	0	600	600
Seahorse	0	0	0	25	25
Tautog	0	243	0	0	243
Fourbeard rockling	0	0	0	0	0
Striped cuskeel	0	101	0	0	101
Spot	0	0	8,481	2,457	10,938
Moonfish	0	0	0	34	34
Scup	18	0	0	0	18
Winter flounder	260	384	0	0	644
Inland silverside	14	0	0	127	141
Sea lamprey	25	0	0	14	39
Gizzard shad	116,322	0	0	1,894	118,216
Silver hake	0	0	0	317	317
Threespine stickleback	4,039	0	0	0	4,039
Butterfish	0	0	912	3,323	4,235
White crappie	296	0	0	13	309
Red hake	164	961	0	388	1,513
Grubby	0	475	0	0	475
Eastern mudminnow	153	0	1,781	0	1,934
Longear sunfish	0	0	0	0	0
Summer flounder	0	293	24,497	18	24,808
Striped searobin	71	0	0	971	1,042
Northern searobin	0	0	527	0	527
Warmouth	0	0	0	44	44
Naked goby	4	142	59	64	269
Windowpane	0	81	736	1,129	1,946
Spotted hake	0	17,705	0	33	17,738
Northern stargazer	0	0	84	7	91
American sandlance	0	0	0	6	6
Fourspot flounder	0	0	0	45	45
Black sea bass	0	0	0	31	31
Cunner	0	404	0	130	534
Total	3,013,774	984,510	1,418,314	1,349,813	6,766,411

TABLE B-9 TOTAL ESTIMATED WEIGHT (GRAMS) OF FISH IMPINGED AT INDIAN POINT UNIT 3 DURING 1988, BY TAXON AND SEASONAL STRATUM (ADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Stratum				Total
	Winter	Spring	Summer	Fall	
Alewife	9,495	23,127	8,891	27	41,540
Bay anchovy	8	350	11,904	955	13,217
American shad	0	16,328	3,778	54	20,160
Bluefish	0	81	3,205	824	4,110
Bluegill	317	385	264	648	1,614
Brown bullhead	1,404	785	1,202	77	3,468
Pumpkinseed	7,566	3,854	386	0	11,806
Black crappie	632	0	0	0	632
American eel	13,520	7,858	4,514	207	26,099
Goldfish	6,620	1,190	0	0	7,810
Golden shiner	3,016	89	0	0	3,105
Hogchoker	13,941	60,187	147,013	1,449	222,590
Tessellated darter	0	0	0	0	0
Banded killifish	273	0	0	92	365
Largemouth bass	1,958	0	0	2,450	4,408
Mummichog	0	0	0	0	0
Atlantic menhaden	1,336	0	4,656	0	5,992
Blueback herring	231	94,175	12,850	1,342	108,598
White sucker	0	0	0	0	0
Atlantic silverside	55	0	0	27	82
Rainbow smelt	2,418	8,678	223	0	11,319
Shortnose sturgeon	0	0	2,888	0	2,888
Spottail shiner	3,663	73	0	165	3,901
Striped bass	90,865	6,187	7,108	1,284	105,444
Atlantic tomcod	12,449	14,607	21,353	805	49,214
White catfish	27,713	16,305	13,201	188	57,407
White perch	692,994	292,388	110,059	54,054	1,149,495
Yellow perch	2,226	0	635	0	2,861
Northern pipefish	0	169	6	27	202
Redbreast sunfish	0	0	0	0	0
Atlantic needlefish	0	0	166	0	166
Crevalle jack	0	0	113	475	588
Weakfish	0	0	11,521	1,073	12,594

TABLE B-9 (Cont.)

Taxon	Stratum				Total
	Winter	Spring	Summer	Fall	
Lookdown	0	0	30	0	30
Seahorse	0	0	0	0	0
Tautog	0	2,991	0	0	2,991
Fourbeard rockling	60	0	226	0	286
Striped cuskeel	0	400	0	0	400
Spot	0	0	751	0	751
Moonfish	0	0	0	0	0
Scup	0	0	0	0	0
Winter flounder	57	58	0	0	115
Inland silverside	0	0	0	0	0
Sea lamprey	0	0	0	0	0
Gizzard shad	306,670	0	0	418	307,088
Silver hake	0	0	0	0	0
Threespine stickleback	463	62	0	0	525
Butterfish	0	0	3,630	966	4,596
White crappie	354	0	0	0	354
Red hake	837	150	0	0	987
Grubby	0	0	0	0	0
Eastern mudminnow	31	0	24	253	308
Longear sunfish	0	0	0	621	621
Summer flounder	0	54	359	0	413
Striped searobin	0	0	0	0	0
Northern searobin	0	0	0	0	0
Warmouth	0	0	0	0	0
Naked goby	0	0	0	0	0
Windowpane	0	0	12	77	89
Spotted hake	42	7,361	484	0	7,887
Northern stargazer	0	0	12	0	12
American sandlance	0	0	0	0	0
Fourspot flounder	0	0	0	0	0
Black sea bass	0	0	0	0	0
Cunner	0	96	0	0	96
Total	1,201,214	557,988	371,464	68,558	2,199,224

TABLE B-10 TOTAL ESTIMATED WEIGHT (GRAMS) OF FISH IMPINGED AT INDIAN POINT UNITS 2 AND 3 COMBINED DURING 1988, BY TAXON AND SEASONAL STRATUM (ADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Stratum				Total
	Winter	Spring	Summer	Fall	
Alewife	10,643	32,692	25,752	3,132	72,219
Bay anchovy	8	350	73,987	28,324	102,669
American shad	0	16,561	4,171	1,227	21,959
Bluefish	0	81	22,308	3,873	26,262
Bluegill	353	2,195	348	7,446	10,342
Brown bullhead	5,287	10,209	1,202	1,381	18,079
Pumpkinseed	26,187	9,587	478	6,611	42,863
Black crappie	632	0	0	16	648
American eel	36,441	51,356	107,512	24,172	219,481
Goldfish	12,153	9,400	0	617	22,170
Golden shiner	5,911	89	0	266	6,266
Hogchoker	18,747	281,327	719,119	52,043	1,071,236
Tessellated darter	78	0	0	777	855
Banded killifish	2,241	243	59	2,350	4,893
Largemouth bass	1,958	0	0	2,546	4,504
Mummichog	0	0	0	3	3
Atlantic menhaden	1,336	0	5,359	84	6,779
Blueback herring	502	140,848	35,256	46,663	223,269
White sucker	0	14,277	0	0	14,277
Atlantic silverside	55	172	167	974	1,368
Rainbow smelt	13,256	13,703	2,255	176	29,390
Shortnose sturgeon	0	0	2,888	0	2,888
Spottail shiner	12,840	336	0	1,609	14,785
Striped bass	376,767	12,820	55,993	95,360	540,940
Atlantic tomcod	28,988	30,724	37,863	10,533	108,108
White catfish	116,687	39,510	27,135	33,894	217,226
White perch	3,104,147	840,653	543,203	1,045,828	5,533,831
Yellow perch	9,891	2,386	635	1,608	14,520
Northern pipefish	0	351	39	914	1,304
Redbreast sunfish	0	0	0	11	11
Atlantic needlefish	0	0	166	0	166
Crevalle jack	0	0	5,641	4,161	9,802

TABLE B-10 (Cont.)

Taxon	Stratum				Total
	Winter	Spring	Summer	Fall	
Weakfish	0	667	75,637	27,767	104,071
Lookdown	0	0	30	600	630
Seahorse	0	0	0	25	25
Tautog	0	3,234	0	0	3,234
Fourbeard rockling	60	0	226	0	286
Striped cuskeel	0	501	0	0	501
Spot	0	0	9,232	2,457	11,689
Moonfish	0	0	0	34	34
Scup	18	0	0	0	18
Winter flounder	317	442	0	0	759
Inland silverside	14	0	0	127	141
Sea lamprey	25	0	0	14	39
Gizzard shad	422,992	0	0	2,312	425,304
Silver hake	0	0	0	317	317
Threespine stickleback	4,502	62	0	0	4,564
Butterfish	0	0	4,542	4,289	8,831
White crappie	650	0	0	13	663
Red hake	1,001	1,111	0	388	2,500
Grubby	0	475	0	0	475
Eastern mudminnow	184	0	1,805	253	2,242
Longear sunfish	0	0	0	621	621
Summer flounder	0	347	24,856	18	25,221
Striped searobin	71	0	0	971	1,042
Northern searobin	0	0	527	0	527
Warmouth	0	0	0	44	44
Naked goby	4	142	59	64	269
Windowpane	0	81	748	1,206	2,035
Spotted hake	42	25,066	484	33	25,625
Northern stargazer	0	0	96	7	103
American sandlance	0	0	0	6	6
Fourspot flounder	0	0	0	45	45
Black sea bass	0	0	0	31	31
Cunner	0	500	0	130	630
Total	4,214,988	1,542,498	1,789,778	1,418,371	8,965,635

TABLE B-11 TOTAL NUMBER OF BLUE CRABS COLLECTED EACH MONTH AT INDIAN POINT GENERATING STATION DURING 1988

Unit 2	Month JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Male/Alive													
Intact	0	0	0	0	7	249	366	531	551	1,119	687	20	3,530
Missing parts	0	0	0	0	2	227	282	281	472	242	155	12	1,673
Male/Dead													
Intact	0	0	0	0	0	23	26	102	50	34	20	3	258
Missing parts	0	0	0	0	1	60	125	203	221	82	55	14	761
Female/Alive													
Intact	1	0	0	0	3	45	145	398	119	694	606	16	2,027
Missing parts	0	0	0	0	2	44	119	267	126	135	138	11	842
Female/Dead													
Intact	0	0	0	0	0	1	13	82	26	22	29	2	175
Missing parts	0	0	0	0	1	6	51	222	81	20	63	6	450
Undetermined/Alive													
Intact	0	0	0	0	0	0	0	0	1	0	0	0	1
Missing parts	0	0	0	0	0	0	0	0	0	0	0	0	0
Undetermined/Dead													
Intact	0	0	0	0	0	0	0	0	0	0	0	0	0
Missing parts	0	0	0	0	0	0	0	0	0	0	0	0	0

Unit 3	Month JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Male/Alive													
Intact	0	0	0	0	1	237	297	179	306	234	111	1	1,366
Missing parts	0	0	0	0	2	148	406	150	300	82	11	1	1,100
Male/Dead													
Intact	0	0	0	0	0	18	34	44	48	7	1	0	152
Missing parts	0	0	0	0	0	44	127	122	227	52	3	0	575
Female/Alive													
Intact	0	0	0	0	0	48	165	288	138	165	87	1	892
Missing parts	0	0	0	0	0	46	208	176	143	55	8	0	636
Female/Dead													
Intact	0	0	0	0	0	4	13	97	24	5	0	0	143
Missing parts	0	0	0	0	0	8	78	184	88	8	6	0	372

Unit 2	Month JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Undetermined/Alive													
Intact	0	0	0	0	0	0	0	3	0	1	0	0	4
Missing parts	0	0	0	0	0	0	0	2	0	1	0	0	3
Undetermined/Dead													
Intact	0	0	0	0	0	0	0	0	0	0	0	0	0
Missing parts	0	0	0	0	0	0	0	1	0	0	0	0	1
Male/Alive													
Intact	0	0	0	0	8	486	663	710	857	1,353	798	21	4,896
Missing parts	0	0	0	0	4	375	688	431	772	324	166	13	2,773
Male/Dead													
Intact	0	0	0	0	0	41	60	146	98	41	21	3	410
Missing parts	0	0	0	0	1	104	252	325	448	134	58	14	1,336
Female/Alive													
Intact	1	0	0	0	3	93	310	686	257	859	693	17	2,919
Missing parts	0	0	0	0	2	90	327	443	269	190	146	11	1,478
Female/Dead													
Intact	0	0	0	0	0	5	26	179	50	27	29	2	318
Missing parts	0	0	0	0	1	14	129	406	169	28	69	6	822
Undetermined/Alive													
Intact	0	0	0	0	0	0	0	3	1	1	0	0	5
Missing parts	0	0	0	0	0	0	0	2	0	1	0	0	3
Undetermined/Dead													
Intact	0	0	0	0	0	0	0	0	0	0	0	0	0
Missing parts	0	0	0	0	0	0	0	1	0	0	0	0	1

NOTE: Excludes crabs for which information for all categories was not recorded.

TABLE B-12 CARAPACE WIDTH (MM) DISTRIBUTION OF BLUE CRABS IN IMPINGEMENT COLLECTIONS AT INDIAN POINT DURING 1988, BY MONTH

UNIT 2

Month	10.0-19.0	20.0-29.0	30.0-39.0	40.0-49.0	50.0-59.0	60.0-69.0	70.0-79.0	80.0-89.0	90.0-99.0	100.0-109.0	110.0-119.0
JAN	0	0	0	0	0	1	0	0	0	0	0
FEB	0	0	0	0	0	0	0	0	0	0	0
MAR	0	0	0	0	0	0	0	0	0	0	0
APR	0	0	0	0	0	0	0	0	0	0	0
MAY	0	1	7	4	3	1	0	0	0	0	0
JUN	0	4	15	35	60	117	166	124	68	35	16
JUL	0	0	1	4	10	33	113	171	246	195	156
AUG	0	0	0	0	0	4	7	57	128	200	311
SEP	0	35	33	12	4	3	2	0	6	39	88
OCT	3	95	717	635	408	141	21	8	8	9	18
NOV	1	71	362	527	617	161	52	10	1	0	0
DEC	0	2	17	37	20	7	0	0	0	0	0
Total	4	208	1,152	1,254	1,122	468	361	370	457	478	589

Month	120.0-129.0	130.0-139.0	140.0-149.0	150.0-159.0	160.0-169.0	170.0-179.0	180.0-189.0	190.0-199.0	200.0-209.0+
JAN	0	0	0	0	0	0	0	0	0
FEB	0	0	0	0	0	0	0	0	0
MAR	0	0	0	0	0	0	0	0	0
APR	0	0	0	0	0	0	0	0	0
MAY	0	0	0	0	0	0	0	0	0
JUN	9	2	2	1	1	0	0	0	0
JUL	94	54	30	15	3	2	0	0	0
AUG	308	328	308	275	116	33	11	0	0
SEP	179	297	374	336	180	54	4	1	0
OCT	28	41	61	68	53	22	10	2	0
NOV	0	1	0	0	0	0	0	0	0
DEC	1	0	0	0	0	0	0	0	0
Total	619	723	775	695	353	111	25	3	0

TABLE B-12 (Cont.)

UNIT 3

Month	10.0-19.0	20.0-29.0	30.0-39.0	40.0-49.0	50.0-59.0	60.0-69.0	70.0-79.0	80.0-89.0	90.0-99.0	100.0-109.0	110.0-119.0
JAN	0	0	0	0	0	0	0	0	0	0	0
FEB	0	0	0	0	0	0	0	0	0	0	0
MAR	0	0	0	0	0	0	0	0	0	0	0
APR	0	0	0	0	0	0	0	0	0	0	0
MAY	0	0	0	2	1	0	0	0	0	0	0
JUN	0	0	4	25	55	98	111	100	77	51	15
JUL	0	0	0	9	7	32	123	251	276	216	189
AUG	0	0	0	0	0	0	5	9	52	100	155
SEP	1	15	22	14	8	5	2	0	6	25	64
OCT	0	61	198	112	62	20	4	1	1	0	10
NOV	1	5	66	68	65	14	4	2	1	0	0
DEC	0	0	0	1	2	0	0	0	0	0	0
Total	2	81	290	231	200	169	249	363	413	392	433

Month	120.0-129.0	130.0-139.0	140.0-149.0	150.0-159.0	160.0-169.0	170.0-179.0	180.0-189.0	190.0-199.0	200.0-209.0+
JAN	0	0	0	0	0	0	0	0	0
FEB	0	0	0	0	0	0	0	0	0
MAR	0	0	0	0	0	0	0	0	0
APR	0	0	0	0	0	0	0	0	0
MAY	0	0	0	0	0	0	0	0	0
JUN	8	4	2	1	1	0	1	0	0
JUL	111	60	29	16	3	2	2	2	0
AUG	152	186	230	222	110	22	3	0	0
SEP	128	227	257	299	140	49	9	1	2
OCT	15	13	31	32	33	14	3	0	0
NOV	1	0	0	0	0	0	0	0	0
DEC	0	0	0	0	0	0	0	0	0
Total	415	490	549	570	287	87	18	3	2

TABLE B-12 (Cont.)

UNITS 2 & 3 COMBINED

Month	10.0-19.0	20.0-29.0	30.0-39.0	40.0-49.0	50.0-59.0	60.0-69.0	70.0-79.0	80.0-89.0	90.0-99.0	100.0-109.0	110.0-119.0
JAN	0	0	0	0	0	1	0	0	0	0	0
FEB	0	0	0	0	0	0	0	0	0	0	0
MAR	0	0	0	0	0	0	0	0	0	0	0
APR	0	0	0	0	0	0	0	0	0	0	0
MAY	0	1	7	6	4	1	0	0	0	0	0
JUN	0	4	19	60	115	215	277	224	145	86	31
JUL	0	0	1	13	17	65	236	422	522	411	345
AUG	0	0	0	0	0	4	12	66	180	300	466
SEP	1	50	55	26	12	8	4	0	12	64	152
OCT	3	156	915	747	470	161	25	9	9	9	28
NOV	2	76	428	595	682	175	56	12	2	0	0
DEC	0	2	17	38	22	7	0	0	0	0	0
Total	6	289	1442	1485	1322	637	610	733	870	870	1,022

Month	120.0-129.0	130.0-139.0	140.0-149.0	150.0-159.0	160.0-169.0	170.0-179.0	180.0-189.0	190.0-199.0	200.0-209.0+
JAN	0	0	0	0	0	0	0	0	0
FEB	0	0	0	0	0	0	0	0	0
MAR	0	0	0	0	0	0	0	0	0
APR	0	0	0	0	0	0	0	0	0
MAY	0	0	0	0	0	0	0	0	0
JUN	17	6	4	2	2	0	1	0	0
JUL	205	114	59	31	6	4	2	2	0
AUG	460	514	538	497	226	55	14	0	0
SEP	307	524	631	635	320	103	13	2	2
OCT	43	54	92	100	86	36	13	2	0
NOV	1	1	0	0	0	0	0	0	0
DEC	1	0	0	0	0	0	0	0	0
Total	1,034	1,213	1,324	1,265	640	198	43	6	2

TABLE B-13 THE PROPORTION OF BLUE CRABS IMPINGED IN 1988 BY SEX, SURVIVAL, AND CONDITION AT THE INDIAN POINT GENERATING STATION

Unit	Sex	Survival	Condition	Total	I/M, A/D BY M/F χ^a	I VS M BY A/D χ^b	I VS M A/D χ^c	A VS D BY M/F χ^d	M VS F χ^e
2	Male	Alive	Intact	3,530	56.7	67.9	60.9	83.6	64.0
			Missing Parts	1,673	26.9	32.1			
		Dead	Intact	258	4.2	25.3		16.4	
			Missing Parts	761	12.2	74.7	39.1		
	Female	Alive	Intact	2,027	58.0	70.7	63.0	82.1	36.0
			Missing Parts	842	24.1	29.3			
		Dead	Intact	175	5.0	28.0		17.9	
			Missing Parts	450	12.9	72.0	37.0		
3	Male	Alive	Intact	1,366	42.8	55.4	47.5	77.2	61.0
			Missing Parts	1,100	34.4	44.6			
		Dead	Intact	152	4.8	20.9		22.8	
			Missing Parts	575	18.0	79.1	52.5		
	Female	Alive	Intact	892	43.7	58.4	50.7	74.8	39.0
			Missing Parts	636	31.1	41.6			
		Dead	Intact	143	7.0	27.8		25.2	
			Missing Parts	372	18.2	72.2	49.3		
2 & 3	Male	Alive	Intact	4,896	52.0	63.8	56.4	81.5	63.0
			Missing Parts	2,773	29.5	36.2			
		Dead	Intact	410	4.3	23.5		18.5	
			Missing Parts	1,336	14.2	76.5	43.6		
	Female	Alive	Intact	2,919	52.7	66.4	58.5	79.4	37.0
			Missing Parts	1,478	26.7	33.6			
		Dead	Intact	318	5.7	27.9		20.6	
			Missing Parts	822	14.9	72.1	41.5		

a. Percent of total number by sex and unit.
b. Percent of crabs intact and missing parts by survival status, sex, and unit.
c. Percent of crabs intact and missing parts, summed over survival status, by sex and unit.
d. Percent of alive and dead crabs by sex and unit.
e. Percent of male and female crabs by unit.