FINAL

HUDSON RIVER ECOLOGICAL STUDY IN THE AREA OF INDIAN POINT 1990 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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October 1991

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EXECUTIVE SUMMARY

Impingement monitoring of fish and blue crab was conducted at the Indian Point Generating Station in 1990, continuing sampling efforts that began in 1972. From January to October 1990, 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). Beginning in October 1990, a systematic sampling design for fish and blue crab where one day per week was designated as a sample day was implemented.

The estimated total number of fish impinged, adjusted for collection efficiency, was 829,239 fish at Unit 2 and 237,180 fish at Unit 3 for a combined total of 1,066,419 fish weighing an estimated 9,573 kg. Impingement abundance in previous years ranged from 850,000 to 6,480,000 (adjusted for collection efficiency). The estimated number of fish impinged per unit volume of water circulated in 1990 totaled $563/10^6m^3$ and was within the range reported from past years ($491\text{-}3,061/10^6m^3$).

Fifty-three species of fish were recorded in impingement collections during 1990, which was also within the range from past years (43-79). The three most numerous species impinged at Units 2 and 3 combined in 1990 were, in order of abundance, white perch, Atlantic tomcod, and hogchoker, which together comprised 90 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 crab in 1990 was 23,664 crabs at Unit 2 and 27,139 crabs at Unit 3 for a combined total of 50,803 crabs at both units. The blue crab collection was characterized by a male to female ratio of approximately 2 to 1 and a survival rate of 81.6 percent. Most of the blue crab measured were between 50-150 mm with a modal size of 80-89 mm in August that increased to 140-149 mm in October. Blue crab impingement rates ($no./10^6m^3$) unadjusted for collection efficiency were higher at Unit 2 than at Unit 3. Peak blue crab impingement rates occurred during August and September and ranged from $318/10^6m^3$ at Unit 2 to $91/10^6m^3$ at Unit 3.

Annual impingement estimates from 1974 through 1990 were recalculated using collection efficiency equations first developed in 1982. For most study years, impingement was less than 2 million fish per year; but from 1977 through 1981, annual impingement remained between 3.5 and 6.5 million fish. On the average, white perch comprised 57-58 percent of the total catch at each unit; Atlantic tomcod represented 12.7 percent of the catch; blueback herring accounted for 8.5-9.8 percent; and bay anchovy made up 5.9-7.7 percent of the total catch at each unit.

Monitoring of the blue crab impingement at Indian Point began in 1983 and has continued to the present. Annual impingement counts, unadjusted for collection efficiency, for blue crab from 1983 through 1990 ranged from a low of 348 in 1984 to a high of 196,201 in 1989. Strong year classes in 1987, 1988, and 1989 resulted in large increases in abundance during the following years. Biological characteristics and seasonal occurrence of blue crab have been similar for all study years. Estimates of blue crab losses due to impingement at Indian Point ranged from 87 (1984) to 27,180 (1990) and totaled 51,975 for the 8-year study period.

1. INTRODUCTION

This report is the 19th 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 1974, 1975, 1976, 1977, 1979, 1980a, 1980b; Con Edison 1982a, 1982b, 1983; NAI 1984a, 1986, 1987; MMES 1985; EA 1988, 1989; LMS 1990). This report discusses the 1990 impingement data and interprets these latest study results in conjunction with the findings of previous years. Estimates are provided for the total number of fish and blue crab impinged at each unit and for all individual species. Seasonal impingement trends at Units 2 and 3 are also discussed. Additionally, this report summarizes plant operational data and annual impingement estimates for selected species from 1973 through 1990.

With the implementation of the Settlement Agreement, the Hudson River Utilities (Consolidated Edison Company of New York, Inc. [Con Edison]; New York Power Authority [NYPA]; Central Hudson Gas and Electric Corporation [CHG&E]; 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 percent 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 were 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 manner in which the 110 sampling days were allocated among seasonal strata; this revised allocation was used beginning in 1985 (NAI 1984a).

Impingement monitoring during 1990 at Units 2 and 3 of the Indian Point Generating Station was conducted from January through September on random, pre-selected days according to the stratified random sampling design. Beginning on 2 October 1990, a systematic sampling design where one day per week (Tuesday) was designated as a sample day at Unit 2 was implemented. This systematic sampling schedule was adopted to reduce the cost of the impingement sampling program. No sampling was conducted at Unit 3 after 1 October 1990 because of an outage.

An evaluation of levels of precision associated with impingement estimates from a systematic sampling design concluded that only a moderate reduction in precision would result from a weekly sampling schedule (Con Edison 1990). The expected coefficient of variation under the systematic weekly sampling design for total fish impinged would increase to approximately 20 percent from the expected 10 percent under stratified random sampling. However, the regular spacing of sampling may actually increase the precision for species impinged irregularly or species impinged in seasons for which few samples were allocated.

Chapter 2 of this report, Materials and Methods, presents a description of the Indian Point Generating Station, field and laboratory methods for 1990, and compares field and laboratory methods from 1973 through 1990. Chapter 3, Results and Discussions for 1990, provides estimates of the number of fish impinged and levels of precision associated with these estimates during 1990, presents species composition and relative abundances, describes seasonal impingement patterns, and describes blue

crab impingement patterns. Chapter 4, Summary of Plant Flow and Impingement, 1973-1990, summarizes the history of plant operations from 1973 through 1990, presents annual impingement estimates for selected fish species from 1974 through 1990, and also provides annual impingement counts for blue crab from 1983 through 1990. 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 for 1990. Appendix C contains tables of plant operational data from 1973 through 1990. Appendix D presents comparisons of annual impingement estimates (as calculated in this report) with previously reported estimates from 1974 through 1990.

2. MATERIALS AND METHODS

Impingement collections at Indian Point Units 2 and 3 were taken in four seasonal strata according to the stratified random and systematic 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 except during the fall, samples of impinged blue crab were collected when present. In the fall, blue crab and fish were sampled systematically as detailed below. 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.

2.1 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 2-1). The Indian Point Generating Station began operating with the completion of Unit 1 in 1962. Unit 2, which is operated by Con Edison, and Unit 3, which is operated by 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.

Unit 1 intakes and Unit 2 Intakes 21-25 have fixed intake screens at the Hudson River's edge and conventional vertical traveling screens within each intake bay (Figure 2-2). Unit 2 Intake 26 has a Ristroph-modified vertical traveling screen; the fixed screen was not in place during 1990.

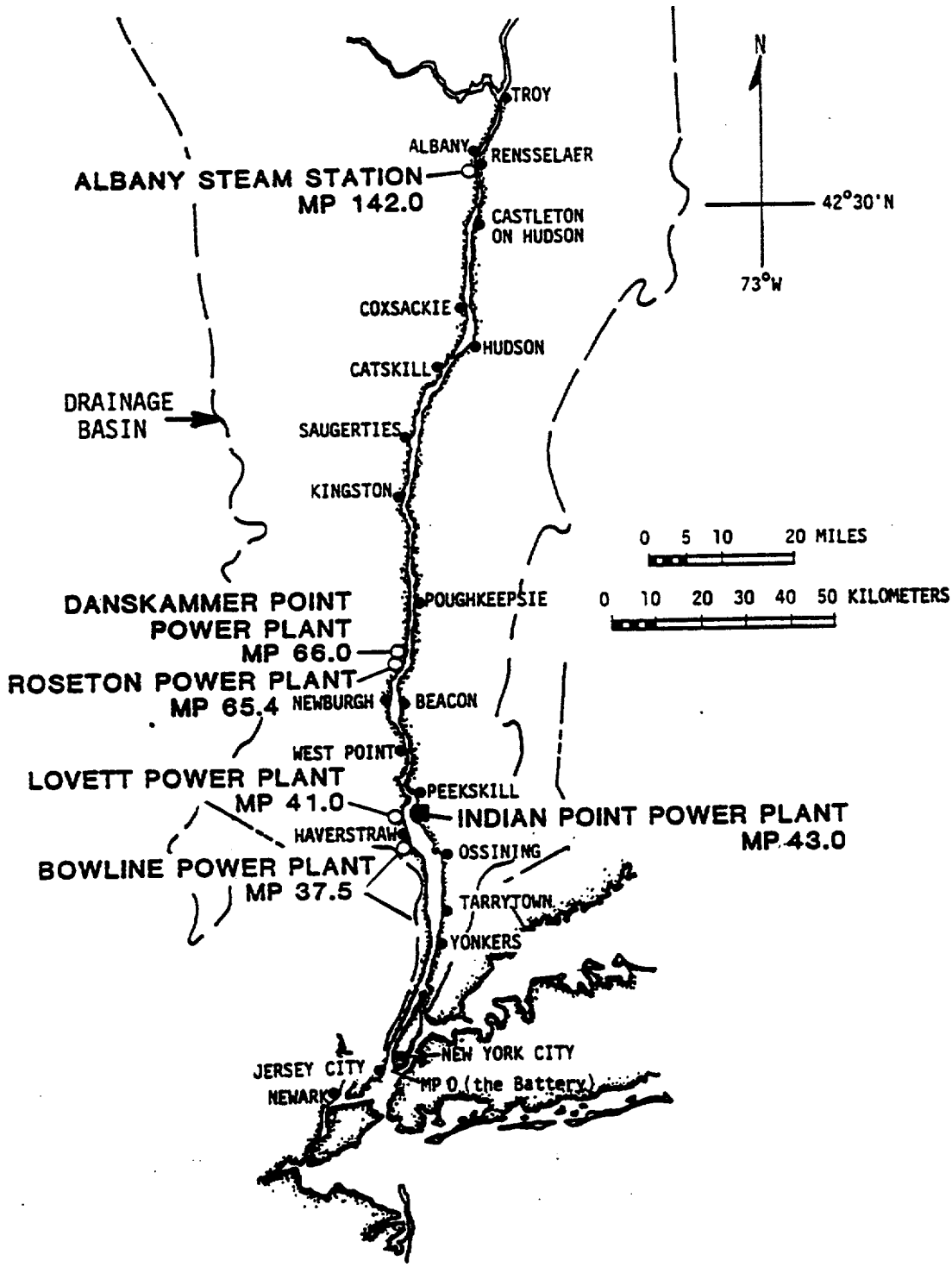


Figure 2-1. Location of Indian Point Generating Station relative to other Hudson River stations.

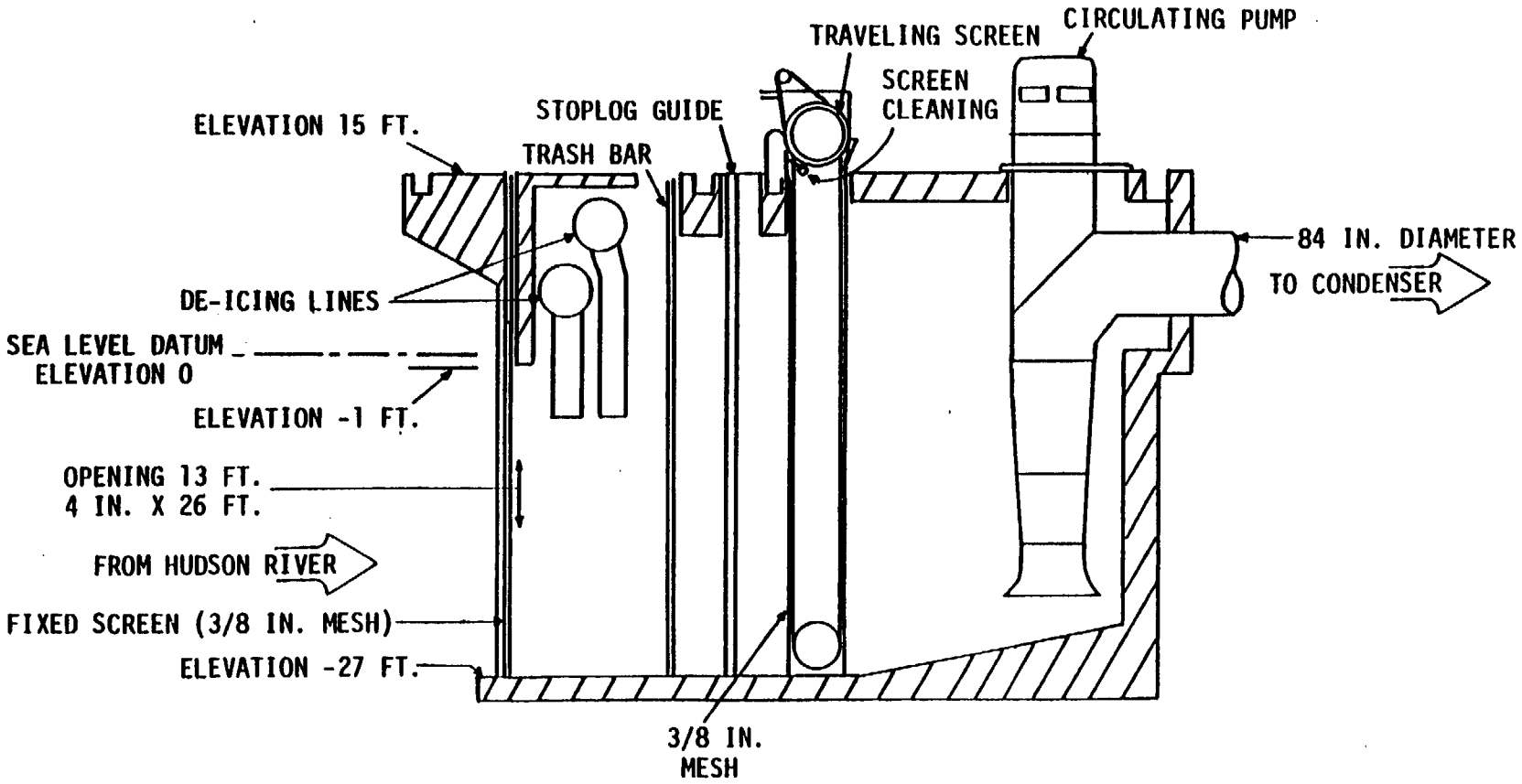


Figure 2-2. Schematic intake bay cross-section of Indian Point Unit 2.

Unit 3 has vertical traveling screens at the Hudson River's edge, but no fixed screens (Figure 2-3). 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 (Table 2-1) specified by the agreement, which became effective 14 May 1981, dual-speed circulating water pumps were to be installed at Indian Point Units 2 and 3 by 14 November 1984. During the interim, alternative flow rates (Table 2-2) were required to be met. These flow rates were specified as a measure to reduce water withdrawal from the Hudson River to minimal 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.

2.2 FIELD AND LABORATORY METHODS FOR 1990

2.2.1 Sample Design and Schedule

The stratified sampling design for impingement and water quality data collection initiated in July 1981 was continued through 1 October 1990 at Units 2 and 3. Sample days were assigned to randomly selected dates within three seasonal strata, in contrast to the daily sampling which was conducted before July 1981. Beginning on 2 October 1990, a systematic sampling design where one day per week (Tuesday) was designated as a sample day at Unit 2 was implemented. No sampling was conducted at Unit 3 after 1 October 1990 because of an outage.

Fish and blue crab impingement samples were collected on the selected sample days and analyzed. Before 2 October 1990; on days not selected for sample collection (non-sample days), only blue crab were collected and analyzed; fish and debris were discarded when the traveling screens were washed. After 1 October 1990, blue crab were collected and analyzed with fish only on sample days designated by the systematic sampling schedule. Water quality data were collected at Units 2 and 3 intakes on scheduled sample days. Allocation quotas of sampling days were generally met among all

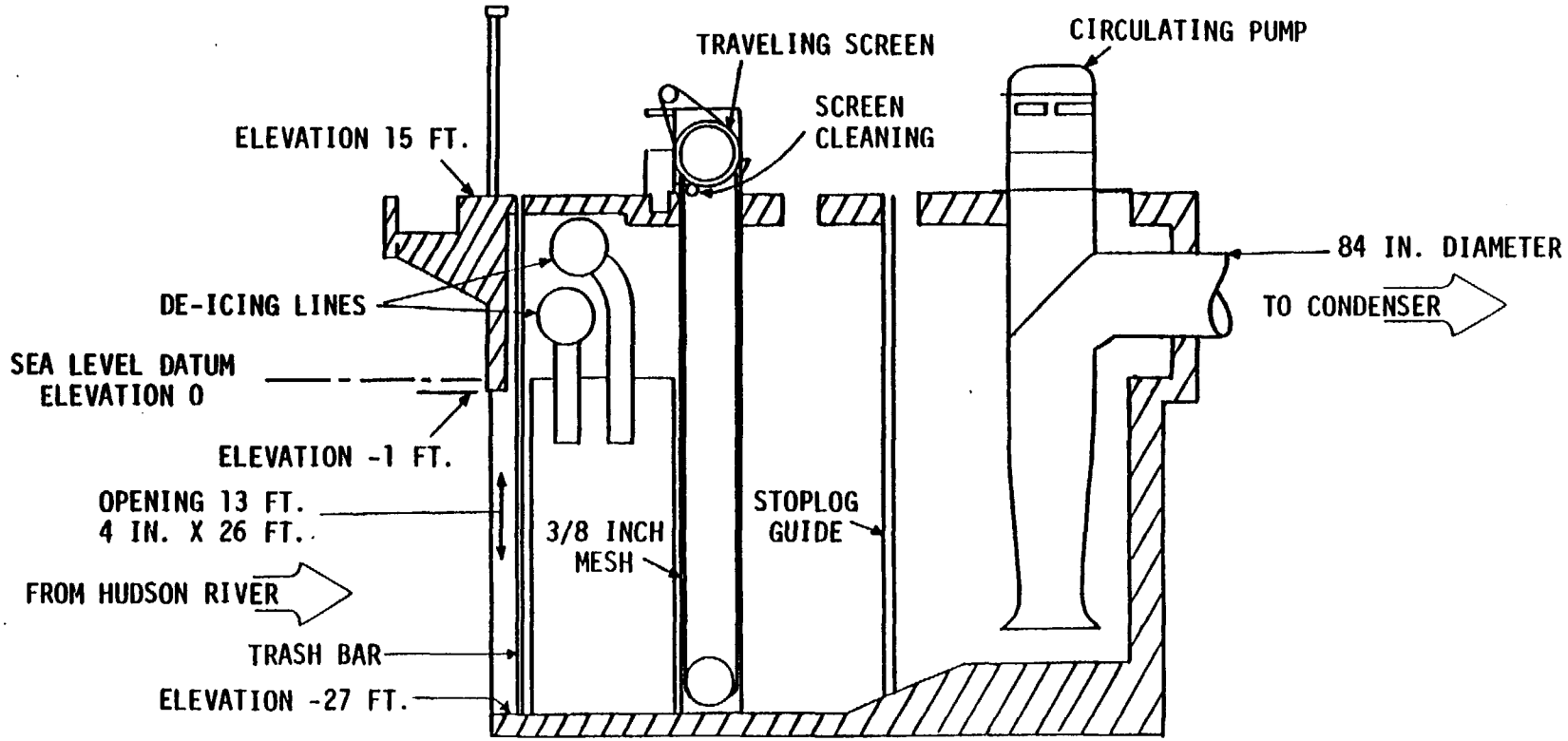


Figure 2-3. Schematic intake bay cross-section of Indian Point Unit 3.

TABLE 2-1 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)	$10^6 m^3$/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 2-2 INTERIM CIRCULATING WATER FLOW RATE SCHEDULE FOR INDIAN POINT UNITS 2 AND 3 BETWEEN 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

seasonal strata except for winter, when only 12 of the 23 allocated samples were collected at Unit 2 and only 28 of the 35 allocated samples were collected at Unit 3 (Table 2-3) due primarily to outages at both units in March.

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 pre-selected 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, a sampling day was rescheduled within the same week. If the sample day could not be rescheduled, no additional sample was taken in that week. 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 ensure that the data was 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 in each month at Unit 2 (Table 2-4) and Unit 3 (Table 2-5).

2.2.2 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 Intake 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

TABLE 2-3 NUMBER OF IMPINGMENT COLLECTION DAYS AND DAYS OF PLANT OPERATION AT INDIAN POINT UNITS 2 AND 3 DURING 1990

Unit	Seasonal Stratum	Days of Plant Operation*	Days of Fish Impingement Collections	Days Allocated in Stratified and Systematic Design
2	Winter (JAN-MAR)	90	12	23
	Spring (APR-JUN)	91	6	8
	Summer (JUL-SEP)	92	12	11
	Fall (OCT-DEC)	92	14	13
	Total	365	44	55
3	Winter (JAN-MAR)	77	28	35
	Spring (APR-JUN)	91	21	20
	Summer (JUL-SEP)	85	29	31
	Fall (OCT-DEC)	19	0	0
	Total	272	78	86

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

TABLE 2-4 COMPARISON OF SAMPLING DATES, AVERAGE DAILY SAMPLING VOLUMES, OPERATING DATES, AND AVERAGE DAILY OPERATING VOLUMES AT INDIAN POINT UNIT 2 BY MONTH DURING 1990

Month	Sampling Dates	Average Daily Sampling Volume ($10^6 m^3$)	Standard Deviation	Operating Dates	Average Daily Operating Volume ($10^6 m^3$)[a]	Standard Deviation
JAN	9, 11, 14, 16, 22, 23, 28	2.78	0.12	1-31	2.83	0.01
FEB	4, 5, 8, 11, 13	2.55	0.33	1-28	2.55	0.68
MAR[b]	---	---	---	1-31	0.84	0.07
APR[b]	---	---	---	1-30	0.94	0.09
MAY	14	0.72	---	1-31	0.84	0.02
JUN	23, 26, 27, 29, 30	3.66	1.73	1-30	2.66	1.71
JUL	2, 14, 16, 24, 25	4.31	0.45	1-31	4.51	0.34
AUG	13, 15	3.36	0.81	1-31	4.38	0.37
SEP	19, 21, 23, 24, 26	4.77	0.55	1-30	4.13	0.78
OCT	2, 9, 16, 23, 30	3.85	0.54	1-31	4.09	0.23
NOV	6, 13, 21, 27	2.61	0.29	1-30	2.85	0.05
DEC	4, 14, 18, 26, 29	2.35	1.14	1-31	2.85	0.03

a. Includes service water, except days when no circulating pump operated.
b. Unit outage, but some circular pumps continued to operate.

NOTE: Dashes (---) = No sampling.

TABLE 2-5 COMPARISON OF SAMPLING DATES, AVERAGE DAILY SAMPLING VOLUMES, OPERATING DATES, AND AVERAGE DAILY OPERATING VOLUMES AT INDIAN POINT UNIT 3 BY MONTH DURING 1990

Month	Sampling Dates	Average Daily Sampling Volume ($10^6 m^3$)	Standard Deviation	Operating Dates	Average Daily Operating Volume ($10^6 m^3$)[a]	Standard Deviation
JAN	8, 9, 10, 13, 14, 18, 20, 22, 24, 27, 28, 31	2.52	0.17	1-31	2.74	0.12
FEB	2, 5, 6, 7, 10, 12, 16, 23, 26, 28	2.49	0.29	1-28	2.78	0.01
MAR	1, 5, 6, 10, 27, 29	1.02	0.48	2-11, 24-31	1.10	0.62
APR	3, 10, 11, 14, 17, 18, 19, 20, 21, 22, 24, 25, 26	2.58	0.49	1-30	2.46	0.59
MAY	5, 7, 10, 25, 27	2.98	0.44	1-31	3.12	0.40
JUN	26, 27, 28	4.52	0.05	1-30	4.43	0.26
JUL	5, 9, 13, 14, 17, 20, 25, 29, 30, 31	4.39	0.15	1-31	4.62	0.08
AUG	1, 18, 20, 21, 22, 24, 27, 28, 29, 31	3.97	1.23	1-31	4.57	0.24
SEP	4, 5, 6, 7, 8, 10, 11, 12, 13	4.47	0.19	1-23	3.14	2.03
OCT[b]	---	---	---	---	---	---
NOV[b]	---	---	---	---	---	---
DEC[b]	---	---	---	13-31	1.93	0.69

a. Includes service water, except days when no circulating pump operated.
b. Unit outage.

NOTE: Dashes (---) = No sampling.

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 1990 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 the sample day.

On sample days, all fish and blue crab washed from the intake screens of the unit(s) being sampled were taken to the laboratory for processing. On non-sample days before 2 October 1990, only blue crab 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 sample days, 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 crab were collected and included time of screenwash, screenwash order, head loss at each screen, and operating condition of each screen.

2.2.3 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 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 total length (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-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 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 sampling locations (i.e., Unit 2 Intakes 21-25, Unit 2 Intake 26, and Unit 3 Intakes 31-36).

Blue crab were examined for total count (Table B-11) and total weight, and the following data were recorded for each specimen: carapace width (nearest millimeter) (Table B-12), weight (nearest 0.1 g), survival (alive or dead), condition (intact or missing body parts), and sex. If more than 50 blue crab were present in a sample, then a subsample of 50 whole blue crab was randomly selected and weighed. The total number of blue crab in the sample was estimated as 50 multiplied by the ratio of

total weight of the blue crab 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 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. Water temperatures 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 bottom of the gangway near the intake structure. 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 the contractor's standards laboratory. Calibrations were performed prior to each collection of conductivity/temperature data.

2.2.4 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 Intakes 21-25 and at Unit 3 to estimate total impingement.

For the Ristroph screen (Intake 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 low

collection efficiency estimates of 18.7 percent for July and August and 29.6 percent for September occurred in months when blue crab were present and may in part be due to crab predation.

For other months, the collection efficiency for Intake 26 was assumed to be the same as for Intakes 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 Intake 26.

2.3 COMPARISON OF FIELD AND LABORATORY METHODS, 1973-1990

The impingement sampling schedule at Indian Point has changed since monitoring began in June 1972 (Table 2-6). Fish samples were collected and analyzed on a daily basis from the beginning of sampling until 1 July 1981 when a reduced sampling program was initiated. This reduced sampling program was based on a stratified random sampling design of 110 sampling days (30 percent sampling intensity) allocated across four seasonal strata for each unit according to a Neyman allocation procedure (Cochran 1977). This procedure assigned the number of sampling days in direct proportion to both the impingement variance and the number of days in each stratum (MMES 1985). In April 1983, monitoring of blue crab impingement was initiated but, unlike fish monitoring, samples were collected and analyzed whenever blue crab were present. On 2 October 1990, a further reduction in fish as well as blue crab impingement monitoring was instituted. A systematic sampling design designated one day per week (Tuesday) as the sample day for both fish and blue crab.

To assess the impact of the systematic sampling schedule on impingement estimates, levels of precision for impingement estimates from a systematic sampling design with successively longer sampling intervals were evaluated (Con Edison 1990). As expected, precision levels increased as the sampling interval decreased. When sampling was conducted at least weekly, the reduction in precision from levels associated with the stratified random sampling design was moderate. For both sampling designs, levels of precision varied between years and species, but increased with higher impingement rates and more days of plant operation.

TABLE 2-6 IMPINGEMENT FIELD METHODS AT INDIAN POINT GENERATING STATION, 1973-1990

Year	Units Sampled	Sampling Schedule	Rescheduled Samples	Blue Crab Sampling	Ristroph Screen	Plant Operating Conditions Recorded	Water Quality Data Recorded	Other
15 JUN 1972 - 1973	1, 2, Occassionally 3	Daily	Not applicable	No	Not installed	Power output, startup and shutdown time for each circulator, daily flow rate for each circulator, discharge water temperature at each unit, rise in temperature across condensors of each unit	Temperature, dissolved oxygen, pH, turbidity, conductivity (intakes only)	
1974	1, 2 Occassionally 3	Daily	Not applicable	No	Not installed	Head loss, current velocity	Dissolved oxygen, temperature, conductivity (intakes and discharge)	In March, horizontal baskets were attached to Unit 2 fixed screens 23 and 26 at 0, 6, 12, and 18 ft above river bottom. Fish were removed by hand.
1975	1, 2	Daily	Not applicable	No	Not installed	Circulator duration, air curtain duration, head loss	Same as above	
1976	Occasionally 1, 2, 3	Daily	Not applicable	No	Not installed	Daily flow rate for each circulator, duration of circulator operation	Same as above	
1977 - 30 JUN 1981	2, 3	Daily	Not applicable	No	Not installed	Circular flow rates, duration of circulator operation, frequency of pump startups and shutdowns	Same as above	
1 JUL 1981 - 1982	2, 3	Stratified randomly selected days in four seasonal strata	Randomly selected from days remaining in the same strata	No	Not installed	Circulator flow rates, duration of circulator operation	Temperature, conductivity (intakes only on sampling days)	
1983-1984	2, 3	Same as above	Same as above	APR-DEC on all days when blue crab were present in 1983; on all days when blue crabs were present in 1984.	Not installed	Time of screenwash, screenwash order, head loss at each screen, operating condition of each screen	Same as above	

TABLE 2-6 (Cont.)

Year	Units Sampled	Sampling Schedule	Rescheduled Samples	Blue Crab Sampling	Ristroph Screen	Plant Operating Conditions Recorded	Water Quality Data Recorded	Other
1985	2, 3	Same as above except as modified for special studies	Same as above	On all days	Installed at Intake 26	Same as above	Same as above	From 1 JAN to 18 APR, special studies included 2 samples/day at Intake 26 and 1 sample/day at each intake 21-25. From 16 JUL to 31 DEC, special studies included 1 sample/day at Intake 26 and 1 sample/day at combined Intakes 21-25.
1986 - 1 OCT 1990	2, 3	Stratified randomly selected days in four seasonal strata	Same as above	Same as above	Same as above	Same as above	Same as above	Samples from Unit 2 Intakes 21-25, Unit 2 Intake 26, and Unit 3 Intakes 31-36 treated separately.
2 OCT - 31 DEC 1990	2, 3	Once a week on Tuesday	Rescheduled within the same week	Only on scheduled or rescheduled sample days	Same as above	Same as above	Same as above	

For individual species, the levels of precision under the systematic weekly sampling design were apparently related to the temporal pattern of impingement. Higher precision was achieved for species that were impinged over a longer time period (Con Edison 1990). The coefficient of variation for white perch and striped bass (impinged in winter, spring, and fall) under a systematic weekly sampling design is expected to be approximately 20 percent. Conversely, for blueback herring and American shad (impinged in fall), the coefficient of variation for a systematic weekly sampling design is expected to vary from 10 to 95 percent. Depending on the total number impinged, coefficients of variation for blue crab ranged from about 20 to 40 percent when precision levels based on historic data were recalculated assuming a systematic weekly sampling design.

Overall, some loss of precision is expected with sampling reduced from 110 days/year (as allocated by the seasonally stratified random sampling design) to 52 days/year (under the systematic weekly sampling design). The expected coefficient of variation for total fish impinged would increase to approximately 20 percent from the current expectation of 10 percent under stratified random sampling (Con Edison 1990). However, the regular spacing of sampling could actually increase the precision for species impinged irregularly or species impinged in seasons for which few samples are currently allocated.

The actual collection procedures for impingement samples have not changed over the years. A sample was initiated with a thorough cleaning of the fixed and traveling screens, sluiceways, and collection pits usually between 0630 and 1200 hours and ended the next day with the regularly scheduled screenwash during the same time period. If unscheduled washes occurred in the interim, fish and blue crab from those screenwashes were added to the organisms from the regularly scheduled screenwash, whenever possible. Organisms from all screens at a unit were combined and treated as one sample except organisms from the Ristroph screen at Unit 2, after installation, were treated as a separate sample. The fixed screens, where present, were manually washed with a hose in 4-ft increments until the screen broke water and the impinged material passed into the intake forebay to be removed by the traveling screens. The traveling screens were washed individually and the wash water drained through a sluiceway containing a 0.375-in. square mesh collection screen. Fish, blue crab, and debris were removed from the collection screen by hand or scap net. Organisms for processing were separated from the debris, which was bagged and discarded, while the organisms were taken to the laboratory for processing.

In the laboratory, fish were separated by species, enumerated, and the total weight taken. Major changes or additions to the laboratory processing methods over the years include subsampling for determining total count, determination of counts and weights for separate length classes, individual lengths and weights taken for selected species, and the addition of blue crab processing (Table 2-7). Blue crab processing included determining total count and total weight, and individual weight, carapace width, condition, survival status, and sex for all or a subsample of blue crab. The impingement database, at a minimum, contains field collection data, plant operational data, and taxa count and weight data for each year from 1974 to 1990. Other types of data were added to the database as dictated by changes in field and laboratory methods (Table 2-8).

TABLE 2-7 IMPINGEMENT LABORATORY METHODS AT INDIAN POINT GENERATING STATION, 1973-1990

Year	Total Count	Total Weight	Subsampling	Divided into Length Classes	Individual Lengths and Weights	Blue Crab	Sturgeon Log
15 JUN 1972 - 2 DEC 1973	By species	By species	For individual lengths and weights, a random subsample of 30 fish of each species	None	For a subsample of each species	Not collected	Not recorded
3 DEC 1973 - 1974	Same as above	Same as above	For individual lengths and weights, a random subsample of 25 percent of first 100 fish plus 1 percent of fish in excess of 100	SB, WP, AT only for individual lengths and weights	For a subsample of each species and for a subsample of each length class for SB, WP, AT	Not collected	Not recorded
1975	Direct counts for SB, WP and AT except YOY from 1 APR to 15 NOV; subsampling for all other species	Same as above	Total count extrapolated from total weight and weight of 100 randomly selected fish by species	Same as above	Biweekly samples of 25 randomly selected SB, WP, AT in each length class	Not collected	Not recorded
1976-1980	Same as above	Same as above	Same as above	SB, WP, AT, A, BH, AS for total count and total weight in each length class	None	Not collected	Not recorded
1981	By length class for each species; direct counts for SB, WP, AT except YOY from 1 APR to 15 NOV; subsampling for all other species in LC1 and LC2	By LC1, LC2, and all length classes combined for each species	Total count extrapolated from total weight of length class and weight of 100 randomly selected fish from that length class	All species for total count in each length class	None	Not collected	Not recorded
1982	By length class for each species; direct counts for AT (JAN-MAR, DEC); subsampling for all other species in LC1 and LC2	Same as above	Same as above	Same as above	None	Not collected	Not recorded
1983	Same as above	Same as above	Same as above	Same as above	None	Total count, total weight, carapace width, individual weight, condition, survival, sex	Individual length and weight

NOTE: SB = striped bass, WP = white perch, AT = Atlantic tomcod, A = alewife, BH = blueback herring, and AS = American shad; YOY = Young of year; LC1 = Length Class 1; LC2 = Length Class 2.

TABLE 2-7 (Cont.)

Year	Total Count	Total Weight	Subsampling	Divided into Length Classes	Individual Lengths and Weights	Blue Crab	Sturgeon Log
1984	By length class for each species, subsampling for LC1 and LC2	By length class for each species	Same as above	All species for total count and total weight in each length class	None	Same as above	Same as above
1985-1986	By length class for each species; direct counts for AT (JAN-MAR, DEC); subsampling for all other species in LC1 and LC2	By LC1, LC2, and all length classes combined for each species	Same as above for fish and blue crab except only 50 blue crab were subsampled	All species for total count in each length class	None	Same as above except subsampling initiated	Same as above
1987	By length class for each species, subsampling for LC1 and LC2	Same as above	Same as above	Same as above	None	Same as above	Same as above
1988-1990	Same as above	Same as above	Same as above	Same as above	Lengths each week for a maximum of 30 fish from each length class for 13 species	Same as above	Same as above

TABLE 2-8 TYPES OF DATA IN THE IMPINGEMENT DATABASE FOR INDIAN POINT GENERATING STATION, 1974-1990

Year	Field Collection Data	Plant Operational Data	Taxa Count and Weight Data	Separate Datasets for Count and Weight Data for Each Length Class	Individual Length and/or Weight Data	Water Quality Data	Blue Crab Data	Sturgeon Log	Separate Ristroph Screen Data	Collection Efficiency Data
1974	X	X	X	X	X					
1975	X	X	X	X	X	X				
1976	X	X	X	X	X	X				
1977	X	X	X	X	X	X				
1978	X	X	X	X	X	X				
1979	X	X	X	X	X	X				
1980	X	X	X			X				X
1981	X	X	X			X				
1982	X	X	X			X				X
1983	X	X	X			X	X			
1984	X	X	X			X	X			
1985	X	X	X			X	X		X	
1986	X	X	X			X	X			
1987	X	X	X			X	X	X		
1988	X	X	X		X	X	X	X		
1989	X	X	X			X	X	X		
1990	X	X	X		X	X	X			

3. RESULTS AND DISCUSSION FOR 1990

3.1 WATER QUALITY

Daily intake water temperature, averaged for both units, rose from a seasonal low in early February of 2.2 C to a high of 29.8 C in early August and subsequently declined to 4 C by late December (Figure 3-1 and Table B-1). Daily intake salinity fluctuated during 1990 in a characteristic seasonal pattern. Lowest levels were recorded during spring when values generally less than 1 part per thousand (ppt) were recorded. Salinity was at its highest during summer and early fall with values from 4 to 6 ppt, except for a period of low salinity in mid-August. During late fall, salinity once again dropped to levels generally below 1 ppt.

3.2 ESTIMATED NUMBER OF FISH IMPINGED DURING 1990

A combined total of 108,551 fish were collected at Indian Point Units 2 and 3 in 1990 (Tables B-2 through B-4). When adjusted for collection efficiency and scaled to the number of operational days, the estimated total number impinged was 829,239 fish at Unit 2 and 237,180 at Unit 3 (Tables 3-1 and 3-2) for a combined total of 1,066,419 fish weighing an estimated 9,573 kg (Tables B-8 through B-10). The levels of precision (standard errors) were 21.9 and 12.8 percent of the total estimates for Unit 2 and Unit 3, respectively. These levels of precision are lower than 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]), but are within the historic range reported for Unit 2 (7.7-29.2 percent) and Unit 3 (8.3-17.2 percent) (LMS 1990).

The total number of fish impinged by Units 2 and 3 combined in 1990, estimated at 1.07 million (Tables 3-1 and 3-2), was within the range of other yearly estimates in the 1976-1989 historical database (range 0.85-6.48 million) (Table 3-3) and similar to last year's estimate. The volume of water circulated through Indian Point Generating Station during 1990 (1,902 x $10^6 m^3$) was within the range (1,273-2,322 x $10^6 m^3$) reported since 1976 (Table 3-3). The resulting overall impingement rate for all taxa ($563/10^6 m^3$) was also within the range of previously reported values ($491\text{-}3,061/10^6 m^3$).

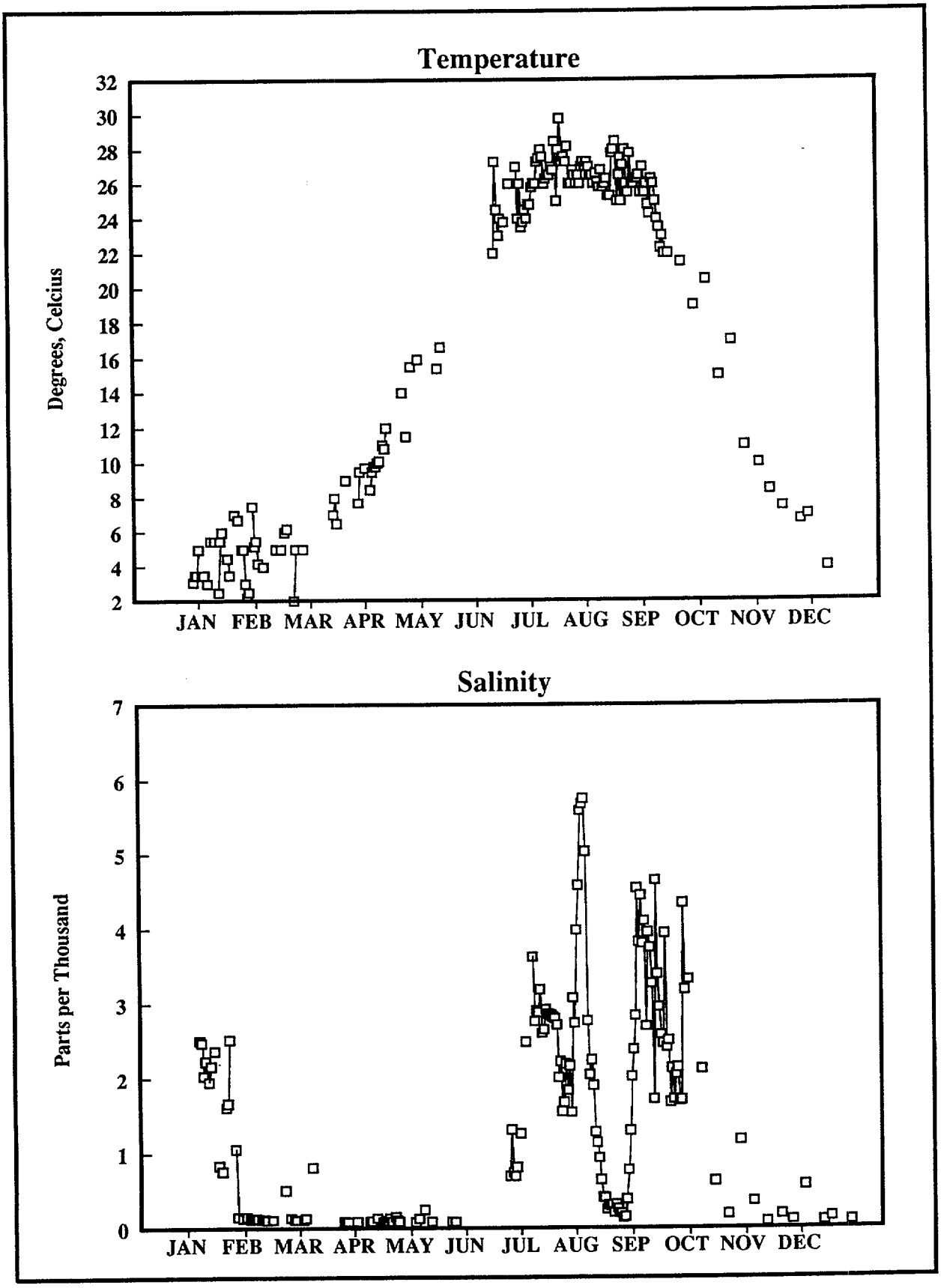


Figure 3-1. Seasonal pattern in water temperature and salinity during impingement collections at Indian Point, 1990.

TABLE 3-1 ESTIMATED NUMBER OF FISH IMPINGED AT INDIAN POINT UNIT 2 DURING 1990 BY TAXON AND SEASONAL STRATUM (ADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Stratum				Total	Standard Error	Coefficient of Variation
	Winter	Spring	Summer	Fall			
Alewife	68	260	414	361	1,103	221	20.0
Bay anchovy	---	78	13,409	1,224	14,711	7,030	47.8
American shad	---	---	1,280	170	1,450	345	23.8
Bluefish	---	4,212	1,572	21	5,805	1,201	20.7
Bluegill	38	---	491	861	1,390	415	29.9
Brown bullhead	30	46	23	39	138	57	41.3
Pumpkinseed	428	91	84	125	728	139	19.1
Black crappie	---	---	---	14	14	13	92.9
Carp	30	---	---	14	44	31	70.5
American eel	330	1,560	169	125	2,184	601	27.5
Goldfish	53	---	---	---	53	28	52.8
Golden shiner	90	---	---	14	104	35	33.7
Hogchoker	5,453	10,205	8,847	3,517	28,022	4,158	14.8
Tessellated darter	15	---	---	85	100	51	51.0
Banded killifish	53	46	38	---	137	62	45.3
Largemouth bass	---	---	84	---	84	79	94.0
Atlantic menhaden	---	288	368	92	748	195	26.1
Chain pickerel	8	---	---	---	8	7	87.5
Blueback herring	---	286	1,066	16,595	17,947	8,734	48.7
Atlantic silverside	---	---	---	21	21	19	90.5
Rainbow smelt	75	195	69	92	431	107	24.8
Spottail shiner	2,213	---	192	262	2,667	446	16.7
Striped bass	6,840	442	5,811	6,277	19,370	5,059	26.1
Atlantic tomcod	2,670	51,168	42,887	149	96,874	40,485	41.8
White catfish	1,905	819	981	594	4,299	683	15.9
White perch	516,210	47,359	13,777	45,409	622,755	166,588	26.8
Yellow perch	683	---	---	99	782	138	17.6
Redbreast sunfish	8	---	---	---	8	7	87.5
Atlantic needlefish	---	---	---	21	21	19	90.5
Crevalle jack	---	---	330	57	387	198	51.2
Weakfish	---	---	2,898	---	2,898	1,711	59.0
Lookdown	---	---	---	21	21	19	90.5
Clupeid unidentified	---	197	130	---	327	167	51.1
Winter flounder	30	---	---	14	44	25	56.8
Sea lamprey	23	---	---	---	23	11	47.8
Gizzard shad	2,235	---	23	657	2,915	1,032	35.4
Threespine stickleback	135	---	---	---	135	62	45.9
Butterfish	---	---	---	21	21	19	90.5
Red hake	8	---	---	---	8	7	87.5
Summer flounder	---	---	115	106	221	76	34.4
Creek chub	8	---	---	---	8	7	87.5
Striped searobin	---	---	23	---	23	21	91.3
Naked goby	---	---	23	14	37	25	67.6
Windowpane	---	---	61	---	61	40	65.6
Syngnathid unidentified	---	---	23	---	23	21	91.3
Gray snapper	---	---	---	14	14	13	92.9
Margined madtom	23	---	---	---	23	15	65.2
Freshwater drum	---	---	38	---	38	36	94.7
Sharptail goby	---	---	---	14	14	13	92.9
Total	539,662	117,252	95,226	77,099	829,239	181,800	21.9

NOTE: Dashes (---) = No catch.

TABLE 3-2 ESTIMATED NUMBER OF FISH IMPINGED AT INDIAN POINT UNIT 3 DURING 1990 BY TAXON AND SEASONAL STRATUM (ADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Stratum			Total	Standard Error	Coefficient of Variation
	Winter	Spring	Summer			
Alewife	74	219	604	897	167	18.6
Bay anchovy	---	50	6,897	6,947	989	14.2
American shad	---	79	1,489	1,568	316	20.2
Bluefish	---	1,489	1,539	3,028	733	24.2
Bluegill	6	25	35	66	18	27.3
Brown bullhead	36	41	---	77	26	33.8
Pumpkinseed	102	25	6	133	35	26.3
Carp	3	---	---	3	2	66.7
American eel	39	199	59	297	57	19.2
Goldfish	30	21	---	51	16	31.4
Golden shiner	41	25	---	66	24	36.4
Hogchoker	853	4,050	7,310	12,213	1,513	12.4
Tessellated darter	---	29	---	29	15	51.7
Banded killifish	19	---	---	19	9	47.4
Largemouth bass	6	8	23	37	14	37.8
Atlantic menhaden	---	41	346	387	64	16.5
Chain pickerel	8	---	---	8	4	50.0
Blueback herring	3	451	2,313	2,767	625	22.6
Atlantic silverside	3	---	---	3	2	66.7
Rainbow smelt	3	132	756	891	345	38.7
Smallmouth bass	3	---	---	3	2	66.7
Spottail shiner	355	83	6	444	65	14.6
Striped bass	1,356	124	1,131	2,611	427	16.4
Atlantic tomcod	396	6,614	18,026	25,036	6,468	25.8
White catfish	327	467	152	946	88	9.3
White perch	142,857	23,722	5,912	172,491	27,565	16.0
Yellow perch	30	8	6	44	15	34.1
Redbreast sunfish	---	---	6	6	5	83.3
Crevalle jack	---	---	94	94	30	31.9
Weakfish	---	---	1,477	1,477	342	23.2
Clupeid unidentified	3	33	243	279	89	31.9
Spot	---	---	18	18	10	55.6
Winter flounder	8	---	6	14	7	50.0
Gizzard shad	3,006	25	---	3,031	799	26.4
Threespine stickleback	50	---	---	50	17	34.0
Butterfish	---	---	686	686	218	31.8
Centrarchidae unidentified	---	---	6	6	5	83.3
Red hake	11	---	---	11	5	45.5
Summer flounder	---	---	141	141	37	26.2
Northern searobin	---	---	6	6	5	83.3
Hickory shad	---	---	6	6	5	83.3
Channel catfish	6	---	---	6	4	66.7
Windowpane	---	8	217	225	86	38.2
Northern stargazer	---	---	6	6	5	83.3
Gobiidae-gobies	---	---	53	53	43	81.1
Margined madtom	3	---	---	3	2	66.7
Total	149,637	37,968	49,575	237,180	30,267	12.8

NOTE: Dashes (---) = No catch.

TABLE 3-3 TOTAL VOLUME CIRCULATED AT INDIAN POINT UNITS 2 AND 3 COMBINED, ESTIMATED NUMBER OF FISH IMPINGED, IMPINGEMENT RATE, AND NUMBER OF SPECIES COLLECTED DURING 1976-1990

Year	Volume ($10^6 m^3$)[a]	Estimated Number Impinged (10^6)[b]	Impingement Rate (No./$10^6 m^3$)	Number of Species Collected
1976	1,329	1.64	1,234	58
1977	2,159	6.48	3,001	72
1978	2,030	3.91	1,926	72
1979	1,935	4.47	2,310	74
1980	1,822	3.36	1,844	76
1981	1,617	4.95	3,061	72
1982	1,273	1.60	1,257	43
1983	1,286	0.85	661	49
1984	1,710	0.85	497	56
1985	1,977	1.08	546	79
1986	1,892	1.09	576	65
1987	1,815	1.54	848	62
1988	2,322	1.14	491	65
1989	1,748	1.07	612	61
1990	1,902	1.07	563	53

a. Including service water.
b. Adjusted for collection efficiency with equations given in Section 2.2.4.

Total estimated impingement abundance at Unit 2 was highest during the winter stratum followed by spring, summer, and fall (Table 3-1). 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 spring (Table 3-4). At Unit 3, total estimated impingement abundance followed a similar pattern being highest during winter, followed by summer and spring (Table 3-2). As with Unit 2, estimated mean daily numbers impinged at Unit 3 were highest during the winter stratum (Table 3-4).

The precision of estimated total impingement for individual fish species at Units 2 and 3 varied greatly (9-95 percent). As expected, most species with high coefficients of variation (> 80 percent) occurred infrequently in the Indian Point area (e.g., creek chub, chain pickerel, lookdown, grubby, northern searobin, Atlantic needlefish, redbreast sunfish, and northern stargazer). Conversely, a number of other fish species with a relatively high degree of precision (coefficients of variation < 15 percent) for impingement abundance estimates (hogchoker, bay anchovy, spottail shiner, and white catfish) are common in the area; and, during periods of their respective seasonal abundance, were probably impinged in relatively uniform numbers.

3.3 SPECIES COMPOSITION AND RELATIVE ABUNDANCE

Fish collected in impingement samples during 1990 totaled 108,551 and were comprised of 53 species for Units 2 and 3 combined (Table 3-5). Among these species, 21 were primarily marine species, tolerant of only minimal freshwater influences; 21 were primarily freshwater inhabitants; and 11 were euryhaline species, tolerant at one time or another of a wide range of salinity conditions. The number of species caught in 1990 (53) was well within the range of the previous 14 years (43-79 species).

The three numerically dominant species impinged at Indian Point Units 2 and 3 in 1990 were white perch, Atlantic tomcod, and hogchoker (Table 3-6). Collectively, these species comprised almost 90 percent of the total estimated impingement abundance at the Indian Point Generating Station in 1990 and were among the top 10 species impinged in previous years. White perch was the most abundant species, accounting for almost 75 percent of the number of fish impinged (Table 3-6). Unit 2 collections accounted for most (78 percent) of the estimated impingement of this species. Atlantic tomcod was considerably less abundant than white perch, accounting for 11.4 percent of the

TABLE 3-4 ESTIMATED MEAN DAILY NUMBER OF FISH IMPINGED IN EACH SEASONAL STRATUM AT INDIAN POINT UNITS 2 AND 3 DURING 1990

Unit	Seasonal Stratum	Number of Sampling Days	Days Allocated in Stratified Design	Mean Daily Estimate[a]	Standard Deviation
2	Winter (JAN-MAR)	12	23	5,996.2	7,050.0
	Spring (APR-JUN)	6	8	1,502.0	1,264.2
	Summer (JUL-SEP)	12	11	1,035.1	1,631.1
	Fall (OCT-DEC)	14	13	814.9	742.7
	Total	44	55	2,271.9[b]	
3	Winter (JAN-MAR)	28	35	1,943.3	2,445.0
	Spring (APR-JUN)	21	20	437.1	407.7
	Summer (JUL-SEP)	29	31	583.2	605.5
	Fall (OCT-DEC)	0	0	---	---
	Total	78	86	872.0[b]	

a. Adjusted for collection efficiency.
b. Stratified mean daily estimate equivalent to the total estimated number of fish divided by the number of operating days at each unit.

NOTE: Dashes (---) = Not sampled.

TABLE 3-5 FISH SPECIES COLLECTED IN IMPINGEMENT SAMPLING AT INDIAN POINT UNITS 2 AND 3 IN 1990

Common Name	Scientific Name	Common Name	Scientific Name
FRESHWATER		**MARINE**	
Banded killifish	*Fundulus diaphanus*	Atlantic menhaden	*Brevoortia tyrannus*
Black crappie	*Pomoxis nigromaculatus*	Atlantic needlefish	*Strongylura marina*
Bluegill	*Lepomis macrochirus*	Atlantic silverside	*Menidia menidia*
Brown bullhead	*Ictalurus nebulosus*	Bay anchovy	*Anchoa mitchilli*
Carp	*Cyprinus carpio*	Bluefish	*Pomatomus saltatrix*
Chain pickerel	*Esox niger*	Butterfish	*Peprilus triacanthus*
Channel catfish	*Ictalurus punctatus*	Crevalle jack	*Caranx hippos*
Creek chub	*Semotilus atromaculatus*	Gray snapper	*Lutjanus griesus*
Freshwater drum	*Aplodinotus grunniens*	Hickory shad	*Alosa mediocris*
Gizzard shad	*Dorosoma cepedianum*	Lookdown	*Selene vomer*
Golden shiner	*Notemigonus crysoleucas*	Naked goby	*Gobiosoma bosci*
Goldfish	*Carassius auratus*	Northern searobin	*Prionotus carolinus*
Largemouth bass	*Micropterus salmoides*	Northern stargazer	*Astroscopus guttatus*
Margined madtom	*Noturus insignis*	Red hake	*Urophycis chuss*
Pumpkinseed	*Lepomis gibbosus*	Sharptail goby	*Gobionellus hastatus*
Redbreast sunfish	*Lepomis auritus*	Spot	*Leiostomus xanthurus*
Smallmouth bass	*Micropterus dolomieu*	Striped searobin	*Prionotus evolans*
Spottail shiner	*Notropis hudsonius*	Summer flounder	*Paralichthys dentatus*
Tessellated darter	*Etheostoma olmstedi*	Weakfish	*Cyanoscion regalis*
White catfish	*Ictalurus catus*	Windowpane	*Scophthalmus aquosus*
Yellow perch	*Perca flavescens*	Winter flounder	*Pseudopleuronectes americanus*
ESTUARINE		**ANADROMOUS**	
Hogchoker	*Trinectes maculata*	Alewife	*Alosa pseudoharengus*
Threespine stickleback	*Gasterosteus aculeatus*	American shad	*Alosa sapidissima*
White perch	*Morone americana*	Atlantic tomcod	*Microgadus tomcod*
		Blueback herring	*Alosa aestivalis*
CATADROMOUS		Rainbow smelt	*Osmerus mordax*
American eel	*Anguilla rostrata*	Striped bass	*Morone saxatilis*

TABLE 3-6 ESTIMATED NUMBER IMPINGED AND PERCENT COMPOSITION OF THE 15 MOST ABUNDANT SPECIES* AND ALL SPECIES COMBINED AT INDIAN POINT IN 1990

Species	Unit 2		Unit 3		Both Units		Cumulative Percent
	Number	Percent	Number	Percent	Number	Percent	
White perch	622,755	75.1	172,491	72.7	795,246	74.6	74.6
Atlantic tomcod	96,874	11.7	25,036	10.6	121,910	11.4	86.0
Hogchoker	28,022	3.4	12,213	5.1	40,235	3.8	89.8
Striped bass	19,370	2.3	2,611	1.1	21,981	2.1	91.9
Bay anchovy	14,711	1.8	6,947	2.9	21,658	2.0	93.9
Blueback herring	17,947	2.2	2,767	1.2	20,714	1.9	95.8
Bluefish	5,805	0.7	3,028	1.3	8,833	0.8	96.6
Gizzard shad	2,915	0.4	3,031	1.3	5,946	0.6	97.2
White catfish	4,299	0.5	946	0.4	5,245	0.5	97.7
Weakfish	2,898	0.3	1,477	0.6	4,375	0.4	98.1
Spottail shiner	2,667	0.3	444	0.2	3,111	0.3	98.4
American shad	1,450	0.2	1,568	0.7	3,018	0.3	98.7
American eel	2,184	0.3	297	0.1	2,481	0.2	98.9
Alewife	1,103	0.1	897	0.4	2,000	0.2	99.1
Bluegill	1,390	0.2	66	0.0	1,456	0.1	99.2
All species combined	829,239		237,180		1,066,419		100.0

* Includes 12 of the 15 species selected for individual analysis.

fish impinged. Unit 2 collections accounted for 79 percent of the estimated Atlantic tomcod impingement. Hogchoker accounted for 3.8 percent of the collections at both units. As with the previous two species, Unit 2 collections accounted for most (70 percent) of the collections of this species.

At Unit 2, an outage in March and April eliminated or greatly reduced cooling water flow (Table 3-7) and the corresponding impingement abundance of spring seasonally abundant fish such as alewife and striped bass. Likewise, at Unit 3, a maintenance outage during October, November, and December eliminated or greatly reduced cooling water flow (Table 3-7) and consequently reduced numbers of impinged species typically abundant in the fall stratum, such as blueback herring and white perch.

3.4 SEASONAL 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 1990 were compared to previous years' (1982-1989) data which were based on the same stratified sampling design used in the 1990 program. The discussion of previous years' data in this section refers to the following references: Con Edison 1983; MMES 1985; NAI 1984a, 1986, 1987; EA 1988, 1989; and LMS 1990.

Impingement patterns in 1990 were generally similar between Unit 2 and Unit 3 (Figure 3-2). Impingement rates at Units 2 and 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 (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

TABLE 3-7 CIRCULATING WATER VOLUME PUMPED (MILLION m^3) IN ASSOCIATION WITH IMPINGEMENT SAMPLING AT INDIAN POINT IN 1990

Month	Unit 2	Unit 3	Units 2 and 3
JAN	19.5	30.2	49.7
FEB	12.8	24.9	37.7
MAR	---	6.1	6.1
APR	---	33.5	33.5
MAY	0.7	14.9	15.6
JUN	18.3	13.6	31.9
JUL	21.5	43.9	65.4
AUG	6.7	39.7	46.4
SEP	23.9	40.3	64.2
OCT	19.3	---	19.3
NOV	10.5	---	10.5
DEC	11.7	---	11.7
Total	144.9	247.1	392.0

NOTE: Dashes (---) = Not sampled.

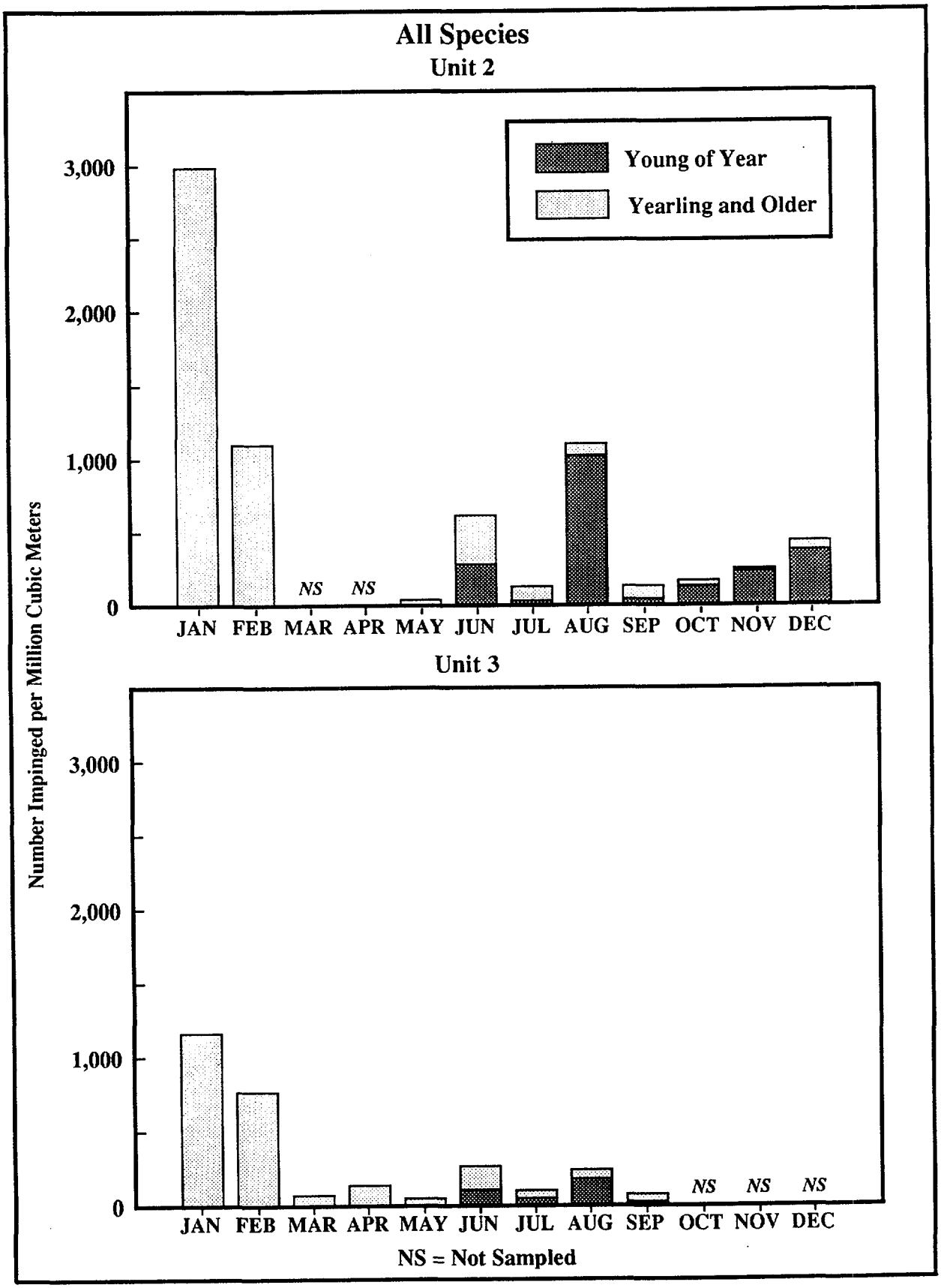


Figure 3-2. Monthly impingement rates, adjusted for collection efficiency, for all species at Indian Point Units 2 and 3 in 1990.

Monthly impingement rates for 13 of the above species were high enough to warrant description of seasonal patterns. Only one shortnose sturgeon and two Atlantic sturgeon were collected during impingement monitoring in 1990.

Atlantic tomcod were collected during all months except November and December in 1990 (Figure 3-3). Young-of-year fish were considerably more abundant in impingement collections than yearling and older fish and occurred in highest numbers during August. Yearling and older Atlantic tomcod were impinged during the winter and late spring stratum in relatively low numbers. This pattern was similar to patterns of tomcod impingement observed in previous years although the summer peak was slightly later than most other years. The pattern is also consistent with the described life history of the tomcod in which older fish spawn in shoal areas in the winter and young-of-year fish are first large enough to be impinged by late spring and early summer (TI 1980a). The peak monthly impingement rate for 1990 ($900/10^6m^3$) was the second highest rate recorded since 1982, but still considerably lower than the highest rate in 1987 ($< 8,000/10^6m^3$).

White perch were the most numerous fish impinged in 1990 (Table 3-6) and were collected in each month. Impingement rates were highest during winter at both Units 2 and 3, when collections consisted mostly of yearling fish (Figure 3-4). Impingement rates decreased in the spring stratum and were low during summer. Impingement rates increased again in fall when young-of-year white perch move down from the upper and middle estuary as the salt front recedes and the temperature in the upper river declines (LMS 1990). This seasonal pattern and the magnitude of monthly impingement rates were consistent with patterns and rates presented in previous years' reports. The peak monthly impingement rate for 1990 was again the second highest rate recorded since 1982, however, peak rates have generally been very consistent in the intervening years of study.

Bay anchovy were impinged from June through November with yearling and older fish most numerous from July through September while young-of-year fish became more numerous during October (Figure 3-5). 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-year fish impinged from September to November most likely represent the dispersion of early life stages upstream into the lower salinity

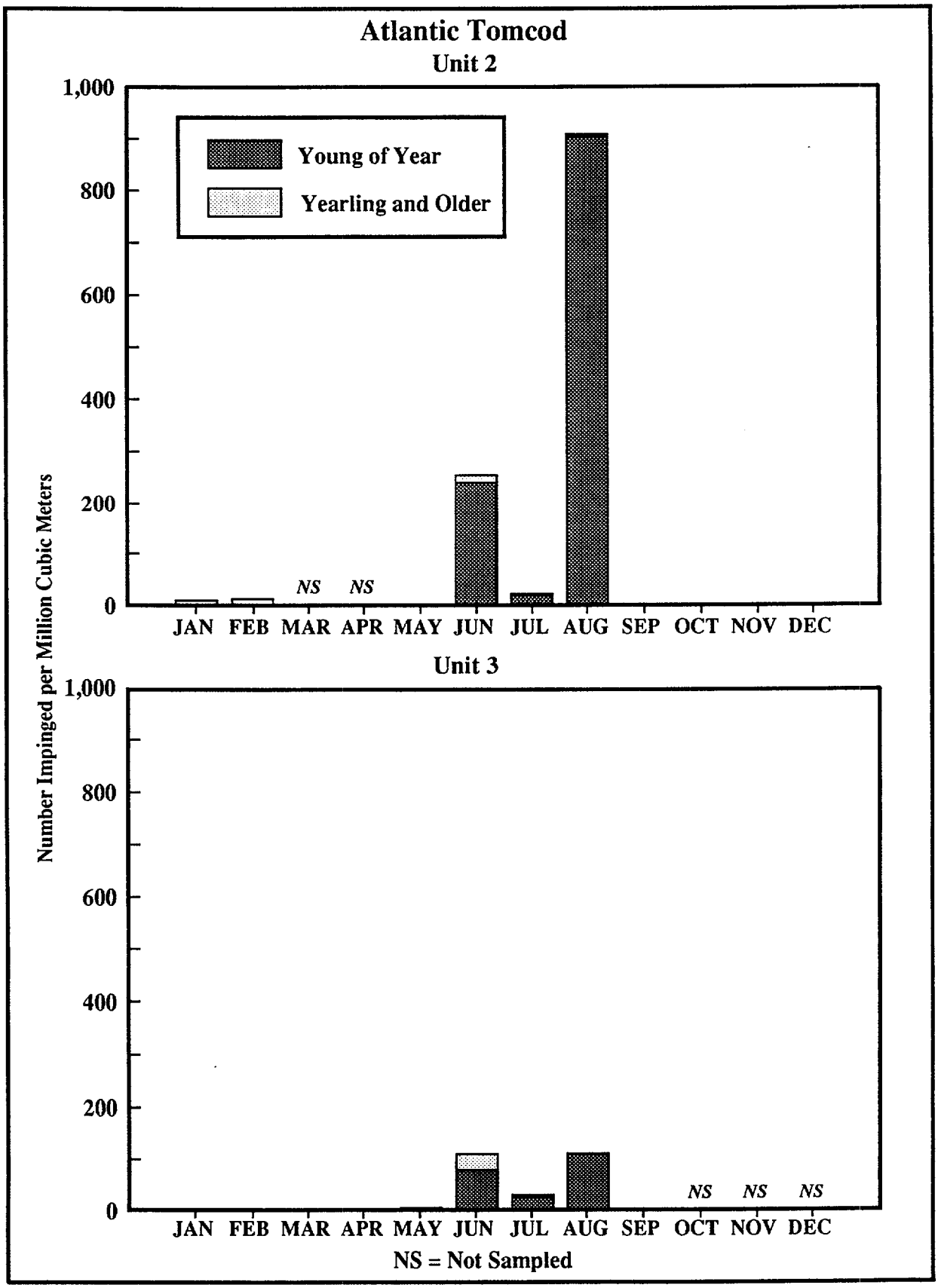


Figure 3-3. Monthly impingement rates, adjusted for collection efficiency, for Atlantic tomcod at Indian Point Units 2 and 3 in 1990.

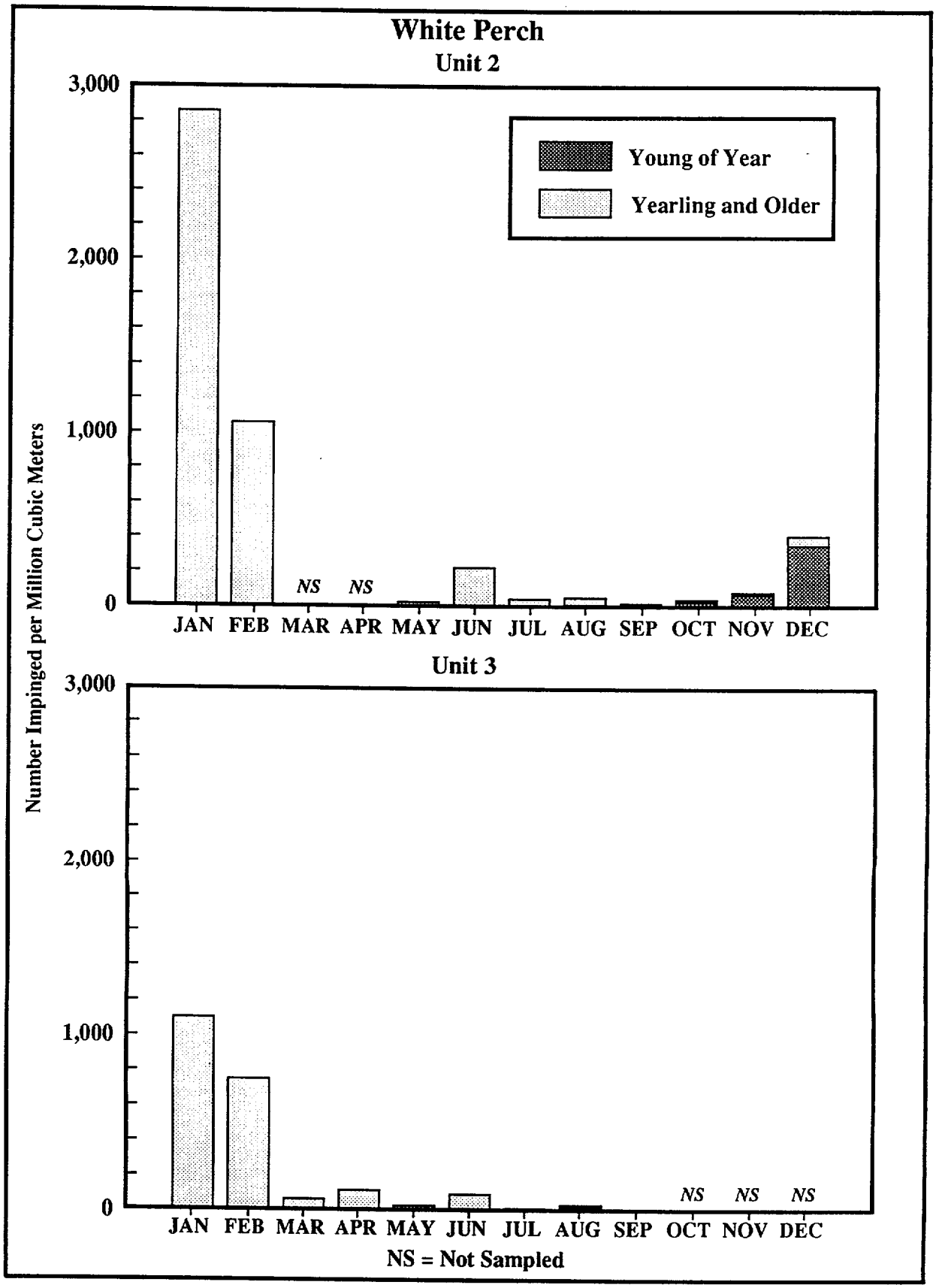


Figure 3-4. Monthly impingement rates, adjusted for collection efficiency, for white perch at Indian Point Units 2 and 3 in 1990.

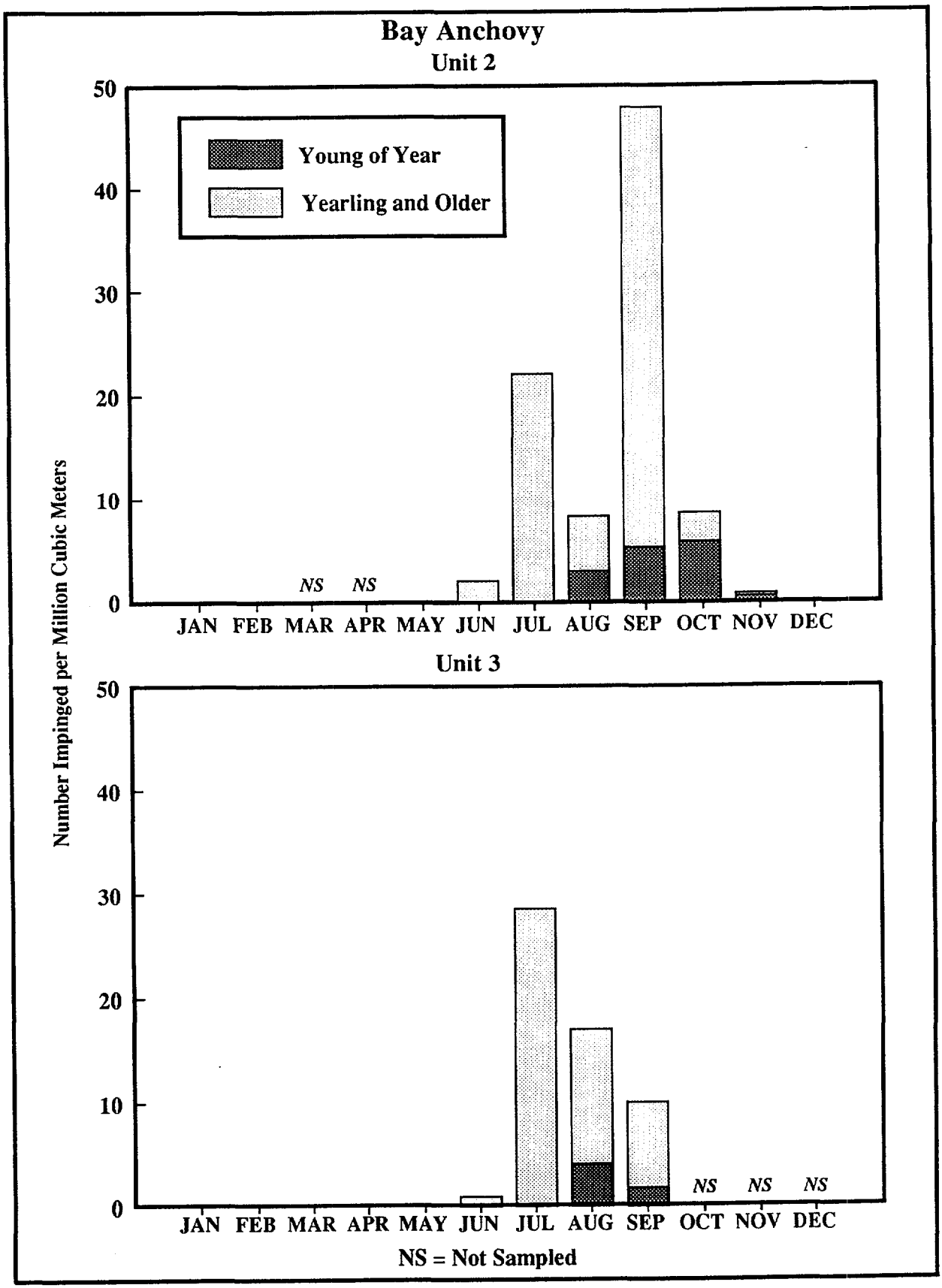


Figure 3-5. Monthly impingement rates, adjusted for collection efficiency, for bay anchovy at Indian Point Units 2 and 3 in 1990.

waters of the lower and middle estuary that are part of the bay anchovy's nursery grounds. Peak monthly impingement rates were low compared to most previous years but the seasonal pattern of impingement during 1990 was comparable to past years.

Hogchoker were impinged in each month in 1990 with peak impingement rates in June at Unit 2 and August and September at Unit 3 (Figure 3-6). Yearling and older fish comprised the majority of the total hogchoker impingement abundance with young-of-year fish recorded from July through November. The seasonal pattern of hogchoker impingement was similar to previous years while the peak monthly rates in 1990 were lower than most previous years.

Blueback herring were impinged primarily during October and November (Figure 3-7). This fall peak consisted principally of young-of-year fish, whereas the limited spring impingement was composed of yearling and older fish. This pattern was similar to that observed in most previous years. 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-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 1990 were within the range reported for previous years.

Rainbow smelt were impinged in almost all months in 1990, but impingement rates were greatest from June through August at Indian Point (Figure 3-8). Yearling and older fish were impinged through August while young-of-year fish were first impinged in June and continued to be collected through December with peak impingement rates in August. Impingement patterns have been variable for this species in previous years (LMS 1990) with maximum impingement rates composed of yearling and older fish during the winter and early spring months or composed of young-of-year fish during the summer months. Peak monthly impingement rates in 1990 were lower than most peak monthly rates observed in past years.

American shad impingement collections were composed mainly of young-of-year fish and were collected from July through November with peak impingement rates in July and August (Figure 3-9). Limited collections of yearling and older American shad were made from April to August. The

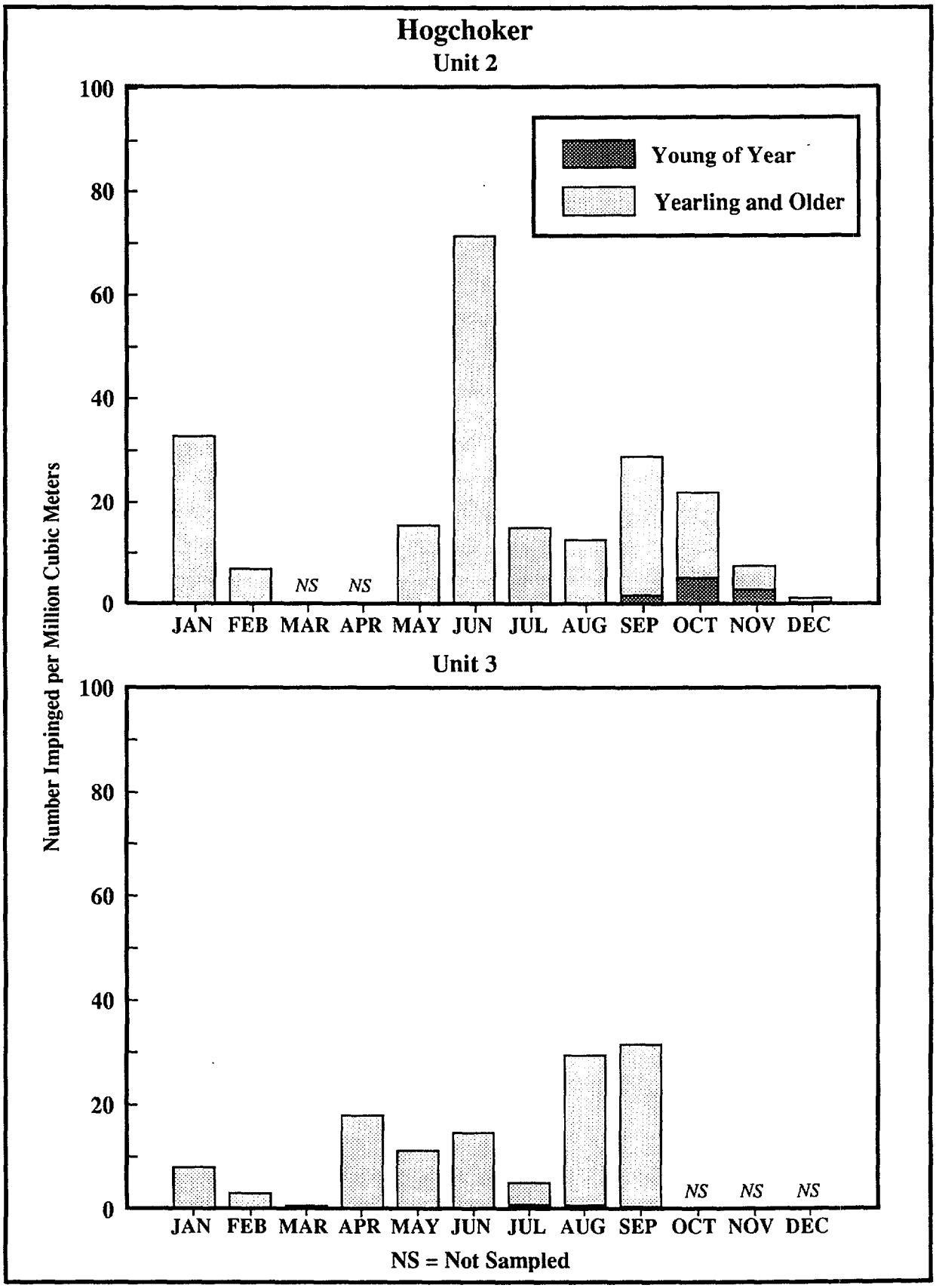


Figure 3-6. Monthly impingement rates, adjusted for collection efficiency, for hogchoker at Indian Point Units 2 and 3 in 1990.

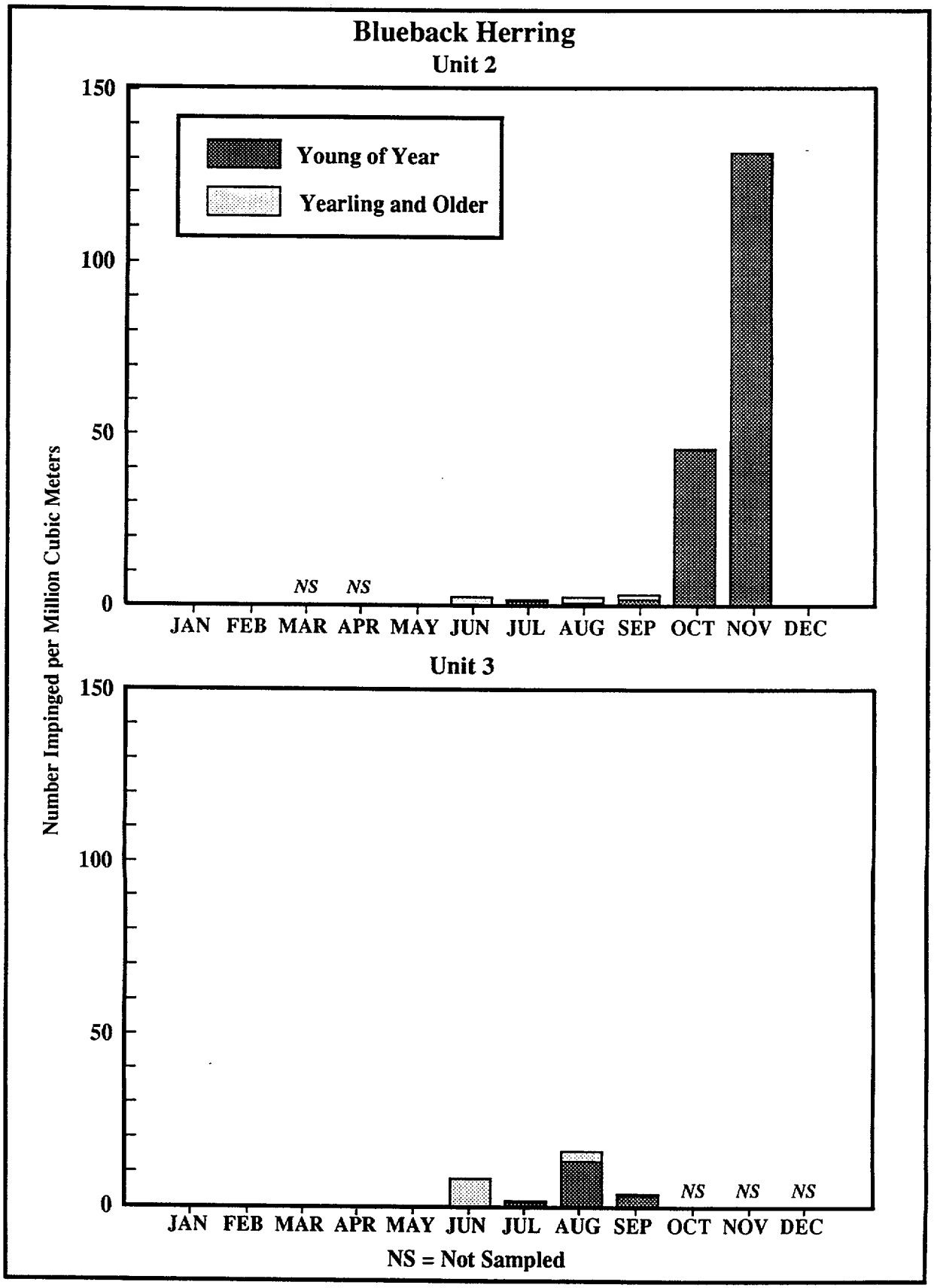


Figure 3-7. Monthly impingement rates, adjusted for collection efficiency, for blueback herring at Indian Point Units 2 and 3 in 1990.

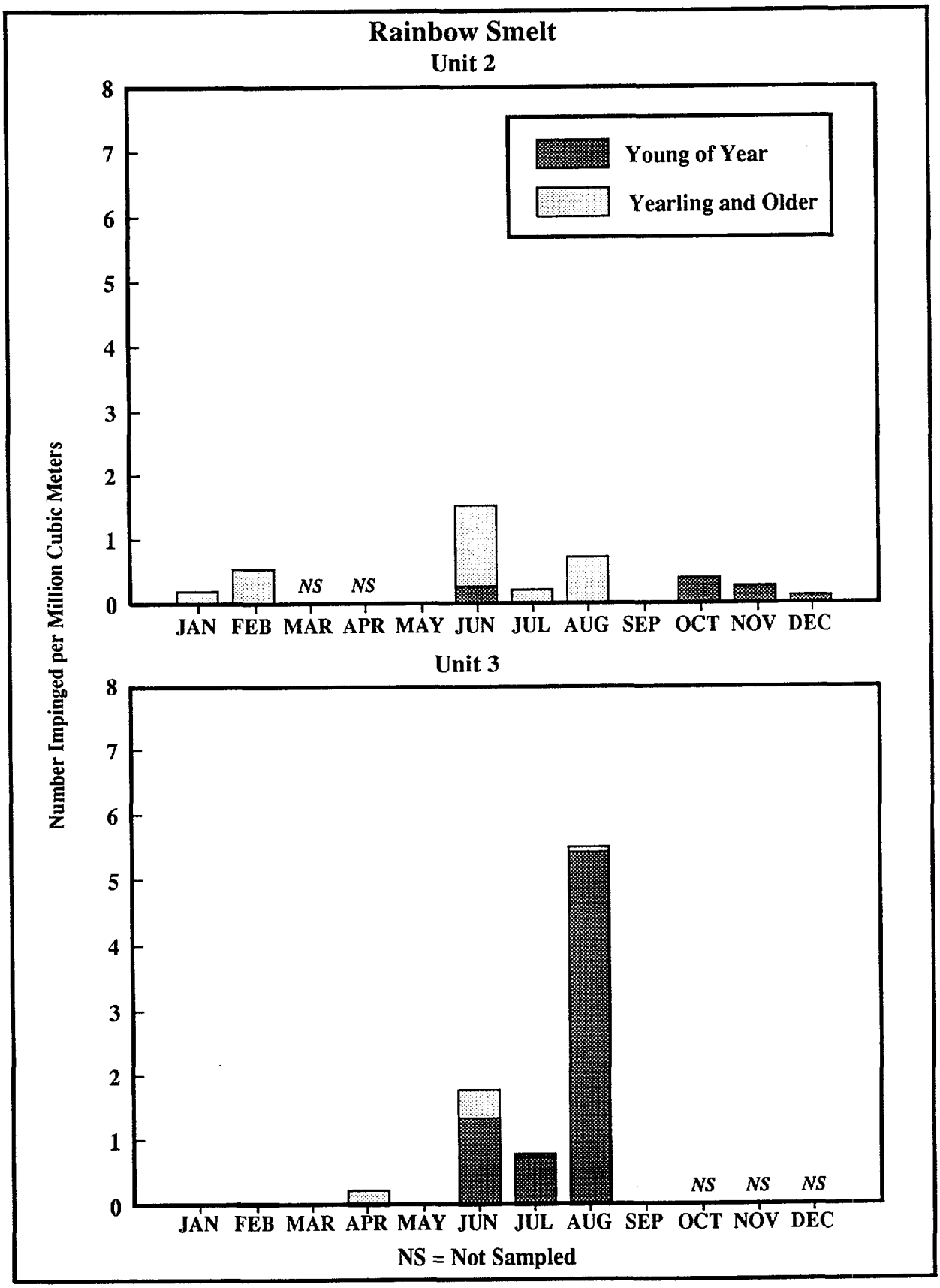


Figure 3-8. Monthly impingement rates, adjusted for collection efficiency, for rainbow smelt at Indian Point Units 2 and 3 in 1990.

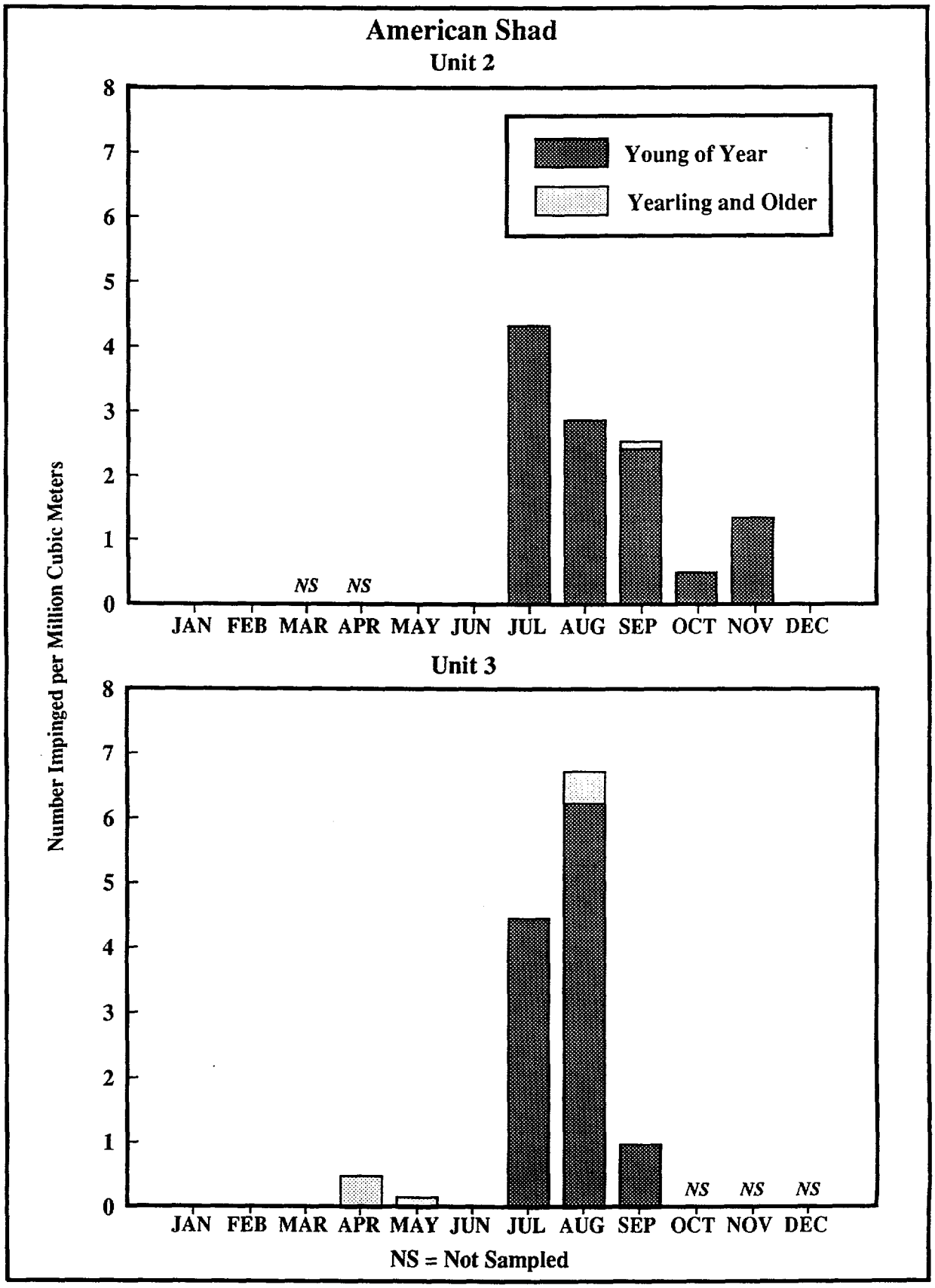


Figure 3-9. Monthly impingement rates, adjusted for collection efficiency, for American shad at Indian Point Units 2 and 3 in 1990.

seasonal occurrence pattern in 1990 was similar to that reported for previous years, but peak abundance occurred earlier than most years. Variability in the timing of peak impingement of American shad at Indian Point reflects differences in growth and emigration of young-of-year shad from the estuary. Peak monthly impingement rates in 1990 were within the range but lower than peak monthly rates for most previous years.

Striped bass exhibited a bimodal seasonal impingement pattern (Figure 3-10) similar to that of previous years. A secondary impingement peak composed of yearling and older striped bass in January was due to the overwintering of yearling and older striped bass in deep waters of the lower estuary such as that in the Indian Point area (TI 1980b). The major impingement peak in August was composed chiefly of young-of-year fish as were subsequent collections through December. Peak impingement rates for both young-of-year and yearling and older striped bass were within the range reported for previous years, but 1990 was only the second year in the past 9 years that the summer/fall peak was greater than the winter peak.

Weakfish were impinged at Units 2 and 3 in 1990 only as young-of-year fish (Figure 3-11). Impingement occurred from July through September with the peak impingement rate in 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). The peak monthly impingement rate in 1990 was among the lowest peak impingement rates reported for other years of the study.

Bluefish were impinged at Indian Point from June through September and collections were composed almost exclusively of young of year (Figure 3-12). Bluefish use the estuary as a nursery area in the summer months (TI 1980b). Peak impingement occurred during June. Monthly impingement rates at Indian Point in 1990 were generally within the range presented in previous reports, but the peak monthly impingement rate was the second highest recorded since 1982.

White catfish impingement was greatest in January with lesser rates occurring from June through August and in November and December (Figure 3-13). Yearling and older white catfish predominated during winter and summer while young-of-year white 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). Young-of-the-year fish are first present beginning

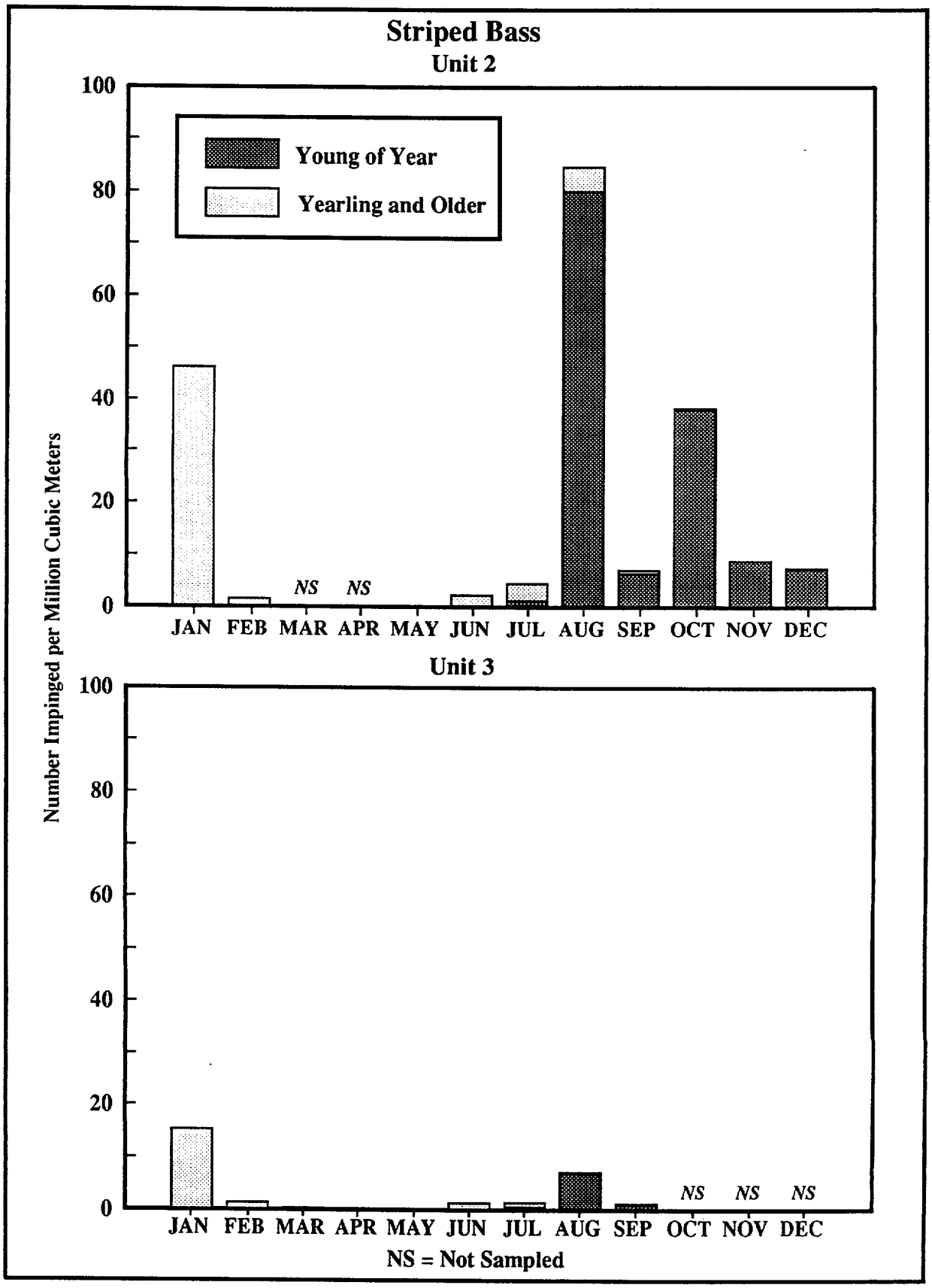


Figure 3-10. Monthly impingement rates, adjusted for collection efficiency, for striped bass at Indian Point Units 2 and 3 in 1990.

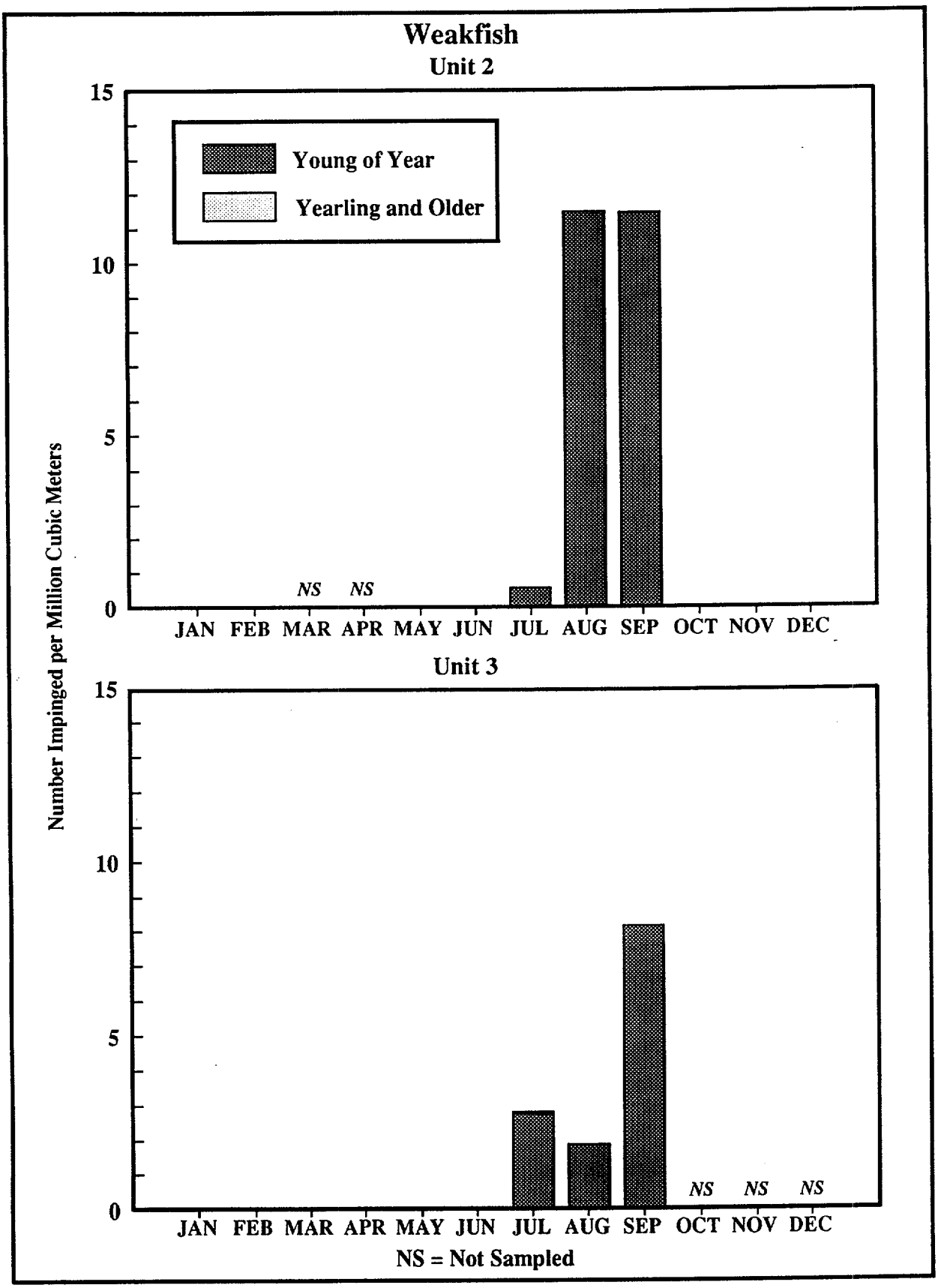


Figure 3-11. Monthly impingement rates, adjusted for collection efficiency, for weakfish at Indian Point Units 2 and 3 in 1990.

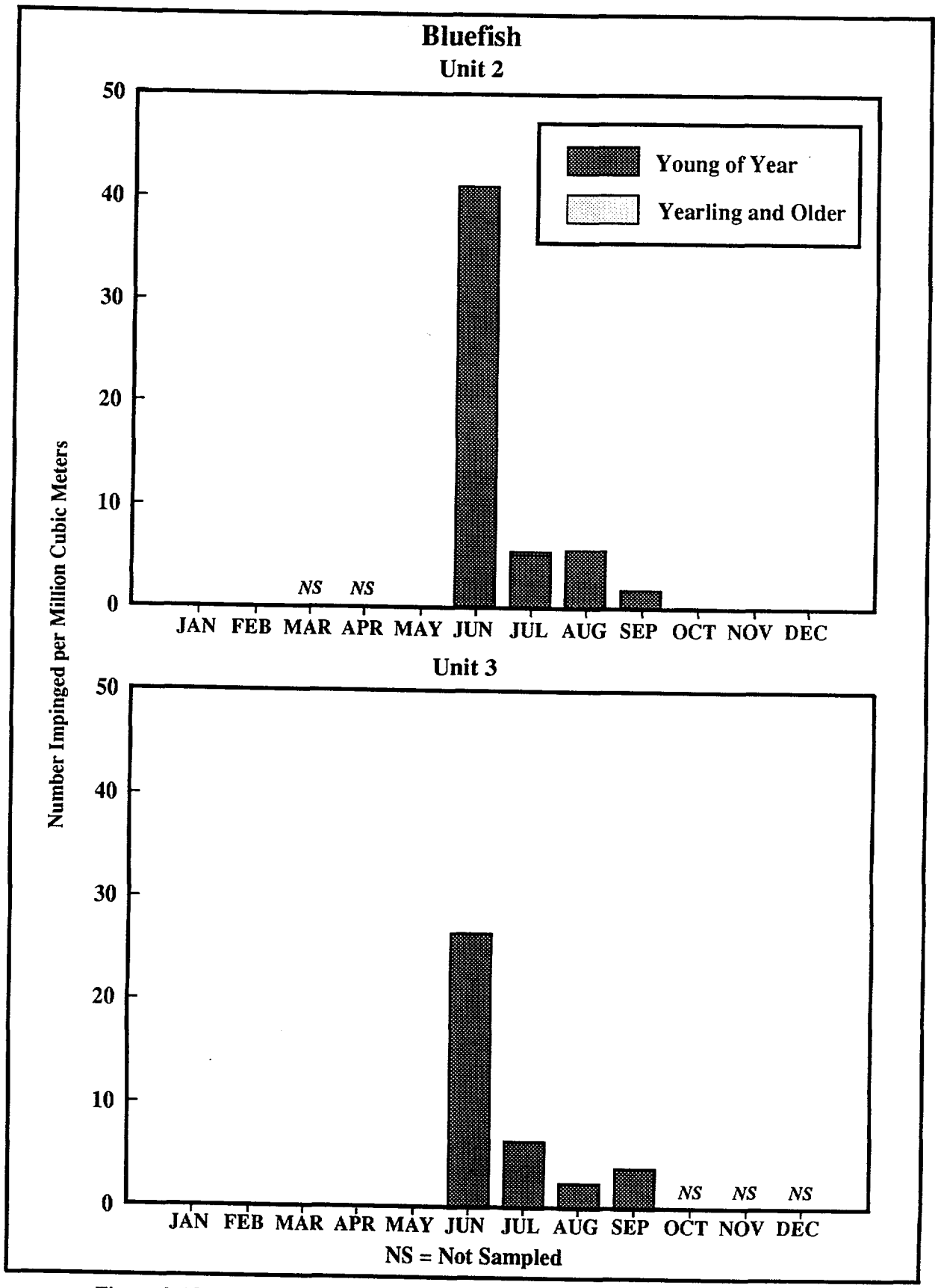


Figure 3-12. Monthly impingement rates, adjusted for collection efficiency, for bluefish at Indian Point Units 2 and 3 in 1990.

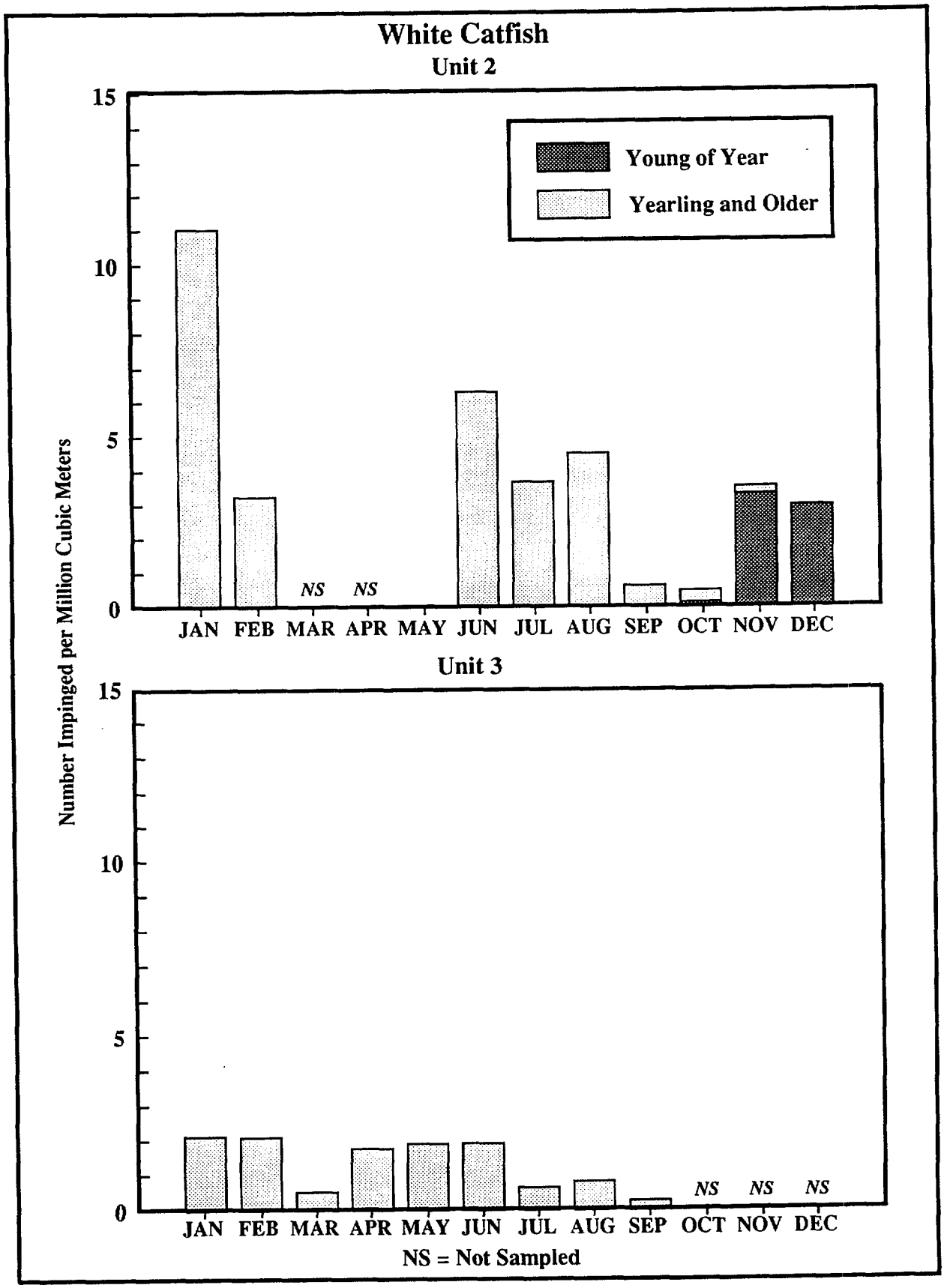


Figure 3-13. Monthly impingement rates, adjusted for collection efficiency, for white catfish at Indian Point Units 2 and 3 in 1990.

around July and continuing through December with peak densities upstream of Indian Point (NAI 1985). Monthly adjusted impingement rates in 1990 were within the range observed in previous years.

Alewife were impinged from January through November (Figure 3-14). Yearling and older fish were recorded primarily from January through June and young-of-year fish from June through November. This was similar to previous years and corresponded with the general 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-year fish migrate downriver past Indian Point to the ocean in the fall (NAI 1985). Peak monthly impingement rates in 1990, as well as 1989, were the lowest observed in the past 9 years.

Spottail shiner were impinged principally during the winter and late fall (Figure 3-15). The majority of spottail shiner impinged in the winter were yearling and older fish that were probably overwintering in deeper water areas such as Indian Point (NAI 1985). The young-of-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 magnitude of monthly impingement rates in 1990 were consistent with previous years.

Two *Atlantic sturgeon* were impinged at Unit 3 and one *shortnose sturgeon* was impinged at Unit 2 during 1990 as detailed below. The three sturgeon ranged in total length from 271 to 575 mm and in weight from 83 to 750 gm. All sturgeon were found dead at the time of collection.

Species	Date	Unit	Length (mm TL)	Weight (grams)	Condition
Atlantic	26 FEB	3	271	83	Dead
Atlantic	27 APR	3	575	750	Dead
Shortnose	18 SEP	2	443	687	Dead

3.5 BLUE CRAB IMPINGEMENT

Blue crab were impinged at Indian Point in January and in May through November 1990 (Table 3-8). A total of 50,803 crabs were collected, with a total weight of 3,128 kg. The number of crabs

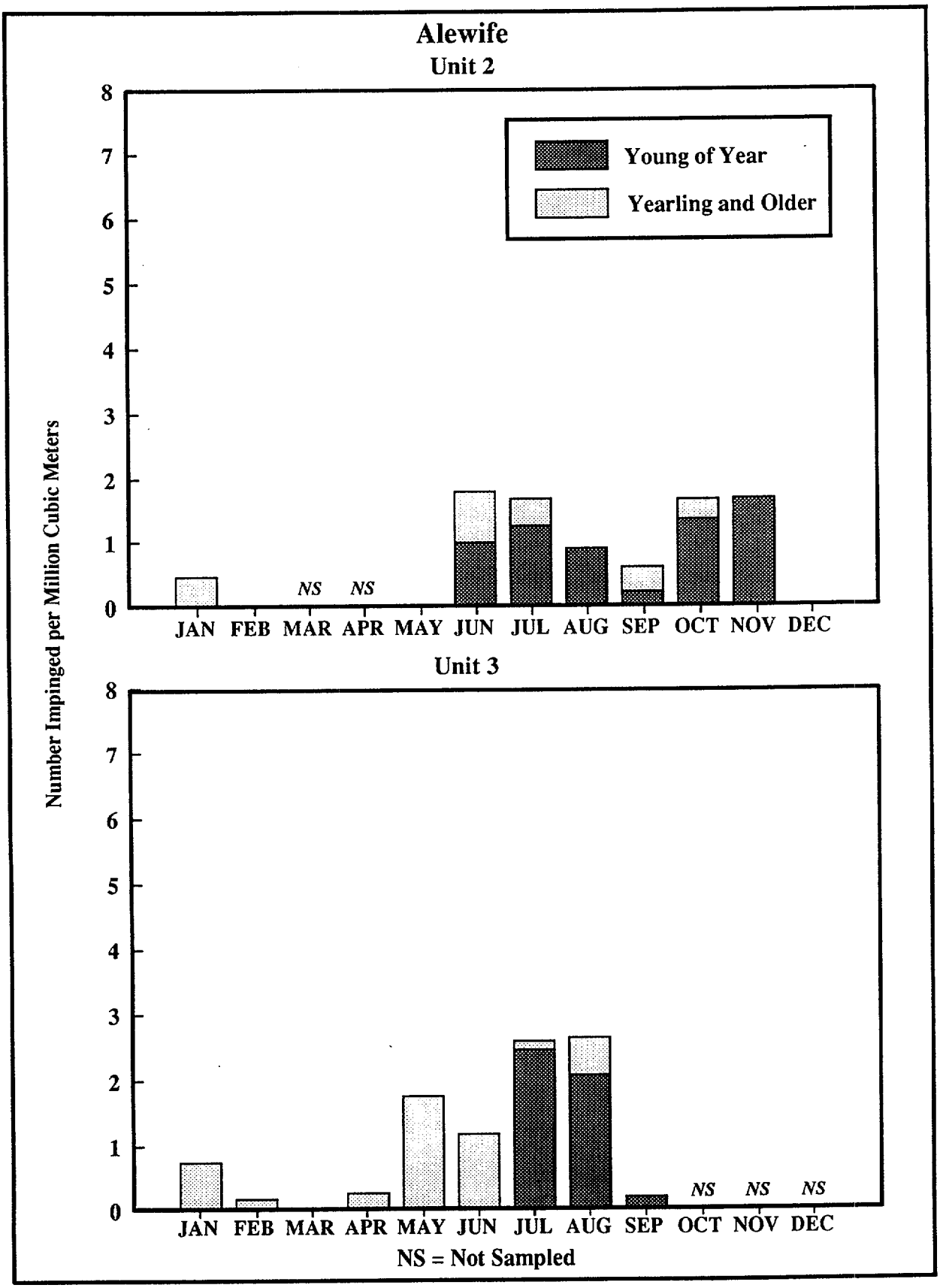


Figure 3-14. Monthly impingement rates, adjusted for collection efficiency, for alewife at Indian Point Units 2 and 3 in 1990.

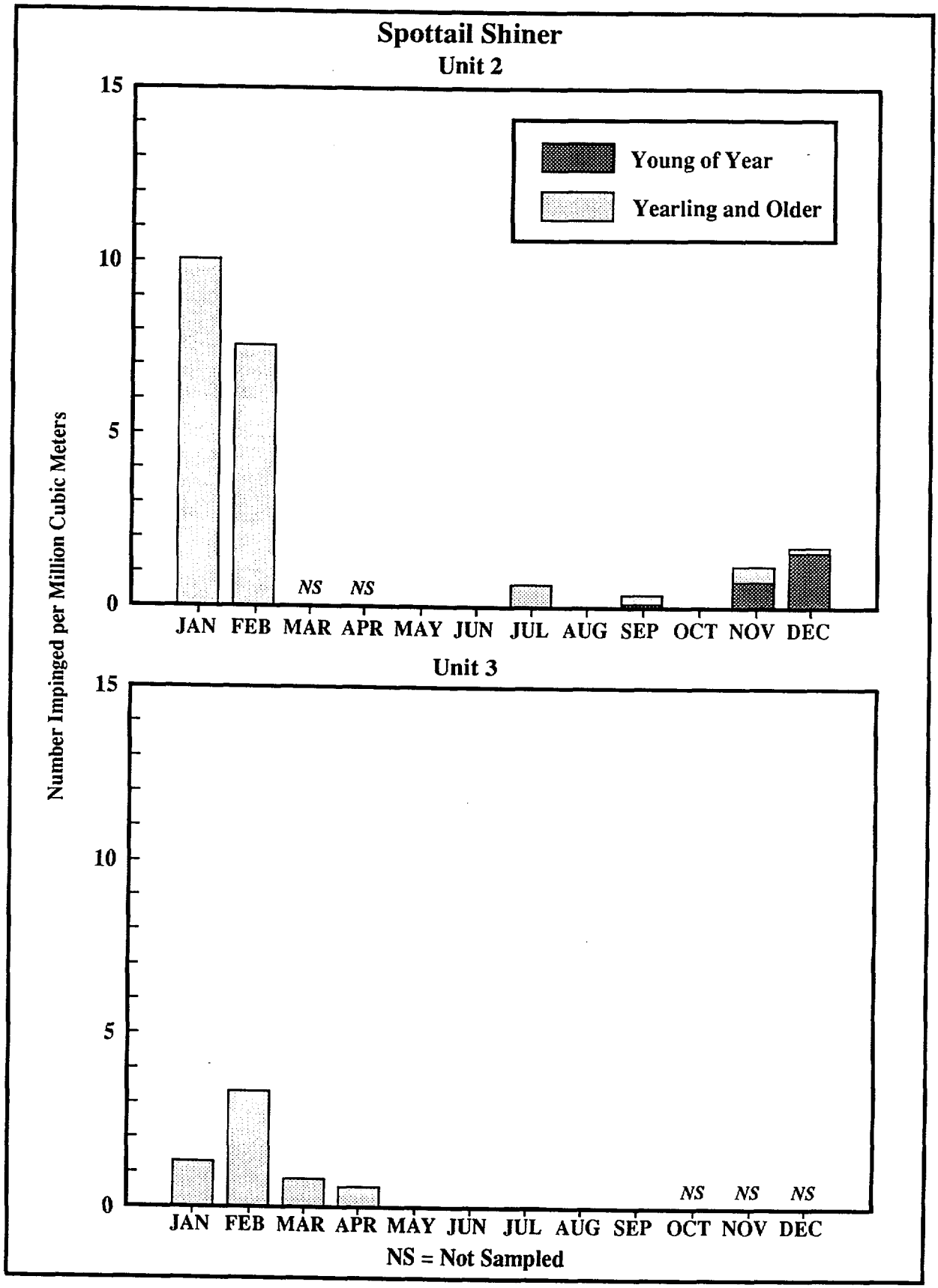


Figure 3-15. Monthly impingement rates, adjusted for collection efficiency, for spottail shiner at Indian Point Units 2 and 3 in 1990.

TABLE 3-8 TOTAL COUNT AND WEIGHT OF BLUE CRAB IMPINGED MONTHLY AT INDIAN POINT UNITS 2 AND 3 IN 1990

Unit	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT*	NOV*	DEC*	Total
COUNT													
2	0	0	NS	NS	0	446	4,659	9,957	5,140	2,660	803	0	23,664
3	1	0	0	0	18	328	8,050	9,606	9,136	NS	NS	NS	27,139
Total	1	0	0	0	18	774	12,709	19,563	14,276	2,660	803	0	50,803
WEIGHT (G)													
2	0	0	NS	NS	0	22,609	231,303	636,184	574,341	183,638	20,468	0	1,668,542
3	98	0	0	0	367	18,143	374,855	537,112	529,315	NS	NS	NS	1,459,890
Total	98	0	0	0	367	40,752	606,158	1,173,296	1,103,656	183,638	20,468	0	3,128,432

* Total count and weight were estimated using data calculation procedures developed for the stratified-random sampling design.

NOTE: NS = Not sampled.

collected was within the range observed since blue crab impingement monitoring began at Indian Point in 1983 (see Section 4.3 of this report). Impingement rates were notably higher at Unit 2 than at Unit 3 in 1990 with peak rates ranging from $318/10^6m^3$ in August at Unit 2 to $91/10^6m^3$ in September at Unit 3 (Figure 3-16). One blue crab was collected in January and no blue crab were collected during the next three months of 1990 (Table 3-8). Impingement abundance increased through summer, peaked during August, and subsequently declined to zero by December. Total weight also peaked in August due to the large number of crabs at this time.

Blue crab 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. After mating, females move downriver to the higher salinity waters (20-32 ppt) to spawn (Van Den Avyle 1984), while males remain upriver in the low salinity waters throughout the summer (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 69 percent of blue crab impinged at Indian Point in 1990 (Tables 3-9, 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. Males were more abundant than females during every month but the proportion of males to females remained fairly consistent throughout the year (Table 3-9).

The carapace width distribution of subsampled blue crab collected in impingement samples was similar for both units throughout the year (Figure 3-17). Most of the crabs measured were between 50 and 150 mm with a modal size of 80-89 mm in August that increased to 140-149 mm in October (Table B-12). This pattern reflects utilization of the Indian Point region by adult crabs with the increases in modal size resulting from the rapid growth and molting which occurs in estuaries during

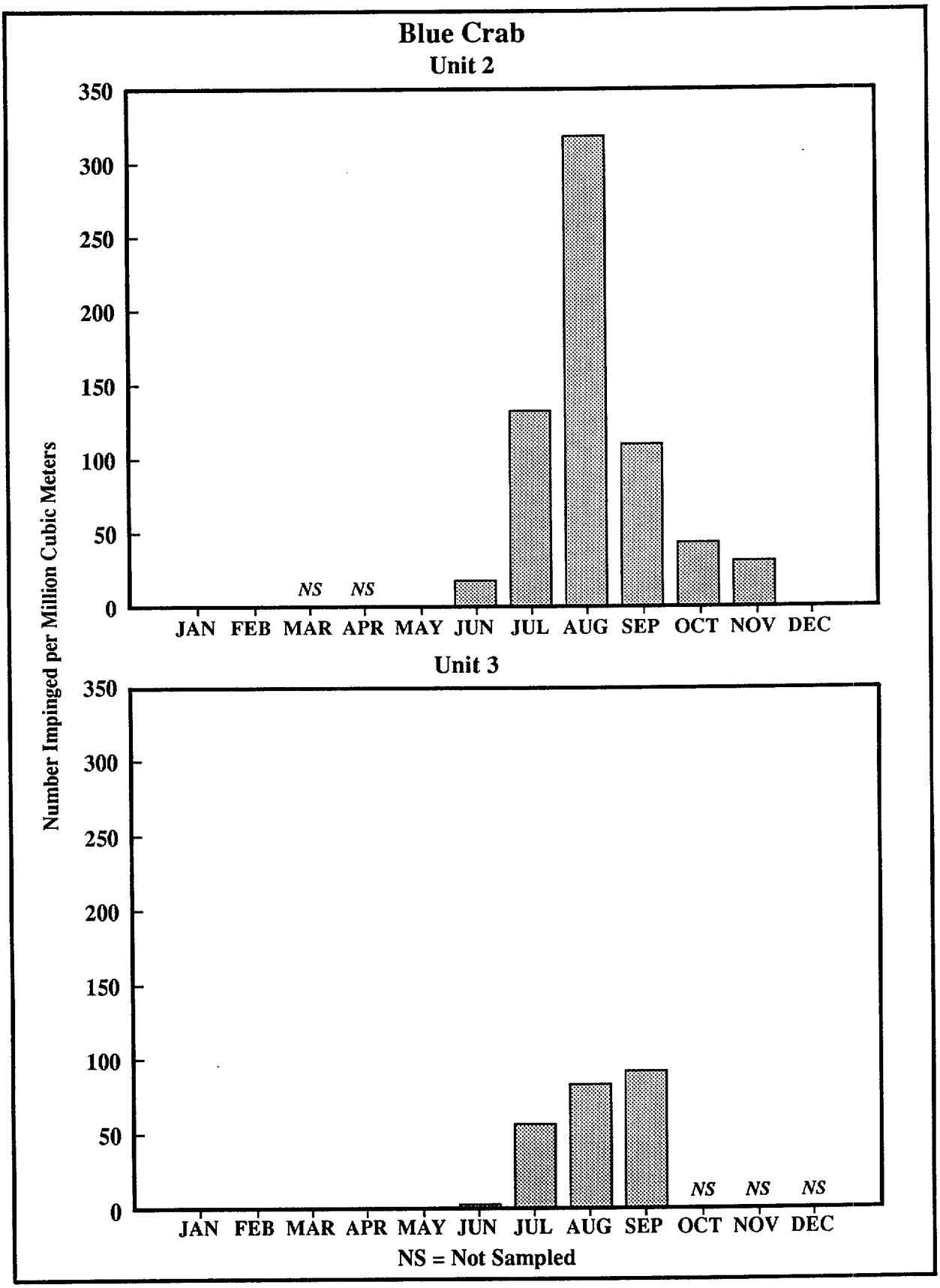


Figure 3-16. Monthly impingement rates, unadjusted for collection efficiency, for blue crab at Indian Point Units 2 and 3 in 1990.

TABLE 3-9 MONTHLY COUNTS BY SEX, SURVIVAL, AND CONDITION OF BLUE CRAB SUBSAMPLED AT INDIAN POINT UNITS 2 AND 3 COMBINED IN 1990

Sex	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Male	1	0	0	0	12	362	1,793	3,136	2,049	230	73	0	7,656
Female	0	0	0	0	6	91	980	1,331	984	87	33	0	3,512
Undetermined	0	0	0	0	0	0	0	2	3	0	0	0	5
Total	1	0	0	0	18	453	2,773	4,469	3,036	317	106	0	11,173

Survival	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Alive	1	0	0	0	17	333	2,187	3,625	2,575	283	101	0	9,122
Dead	0	0	0	0	1	120	586	844	461	34	5	0	2,051
Total	1	0	0	0	18	453	2,773	4,469	3,036	317	106	0	11,173

Condition*	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Intact	1	0	0	0	12	188	1,071	1,701	1,418	154	61	0	4,606
Missing parts	0	0	0	0	6	264	1,701	2,766	1,616	163	45	0	6,561
Total	1	0	0	0	18	452	2,772	4,467	3,034	317	106	0	11,167

* Condition was not recorded for six blue crabs.

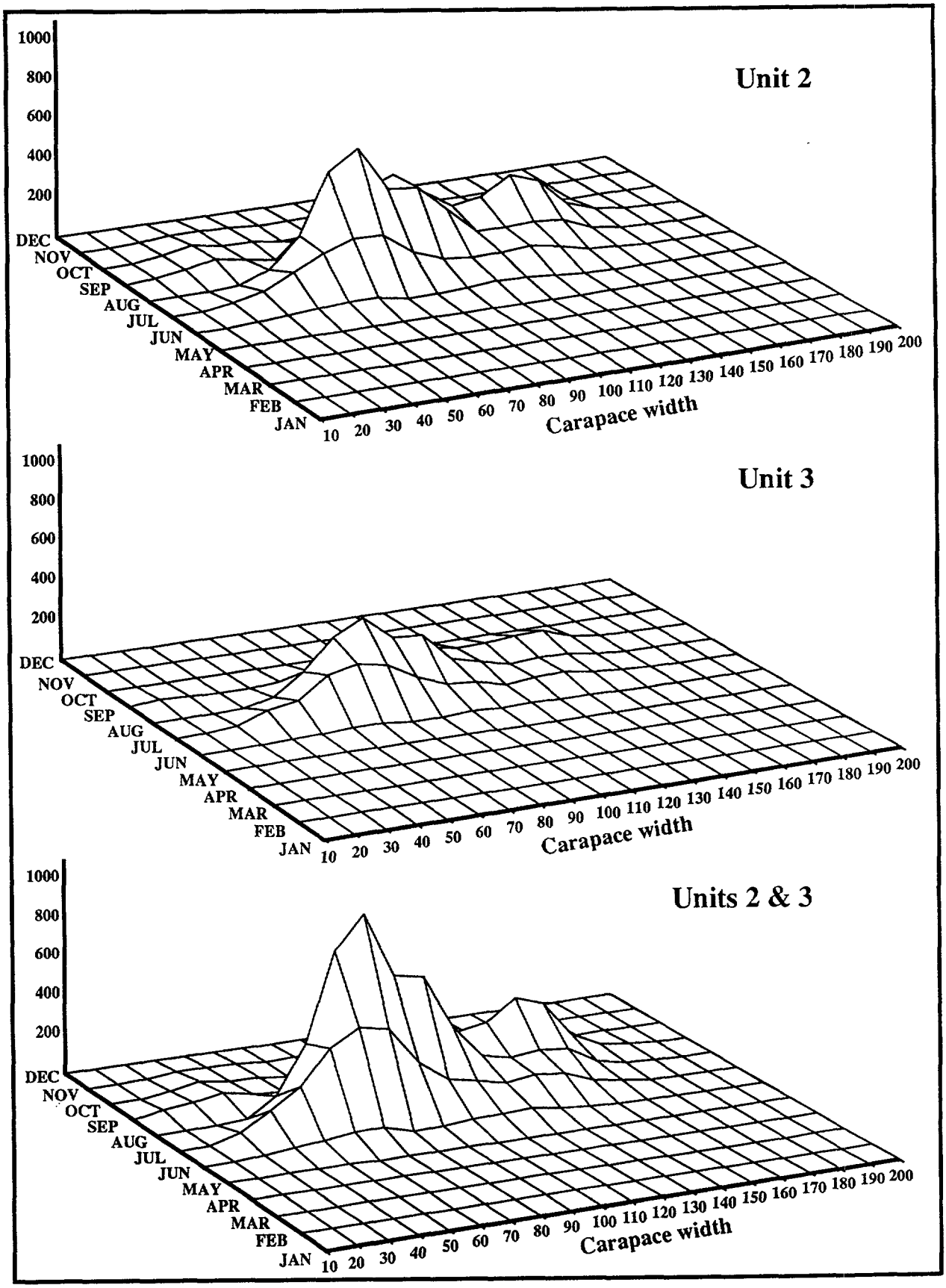


Figure 3-17. Frequency distribution of blue crab carapace width (mm) at Indian Point Units 2 and 3 in 1990.

summer. A secondary mode of smaller carapace width observed in the fall of previous years was only slightly represented in September 1990 in the 40-49 mm range. This mode has been attributed to young-of-year blue crab utilizing the estuary as a late summer nursery area.

Survival averaged 81.6 percent for crabs subsampled for survival (Table 3-9). This was within the range of monthly rates observed in previous years (47-100 percent) (Table 3-10). Survival increased from a low of approximately 74 percent in June to 95 percent in November. The higher survival rates during fall was similar to the pattern observed in all previous years except 1986. The highest proportion of intact crabs occurred in November (57.5 percent) and the lowest proportion in August (38.1 percent) (Table 3-10). Like survival rates, more crabs were collected intact during November than other months in all previous years except 1986 and 1989. Overall, the proportion of intact crabs at Units 2 and 3 in 1990 averaged 41.2 percent.

TABLE 3-10 SUMMARY OF PROPORTIONS OF BLUE CRAB RECOVERED ALIVE AND INTACT IN IMPINGEMENT COLLECTIONS AT INDIAN POINT, 1983-1990

Year	Condition	JUN	JUL	AUG	SEP	OCT	NOV
1983	% Alive	91.1	68.9	66.4	81.9	75.0	100.0
	% Intact	71.1	34.4	49.3	58.6	45.8	80.0
1984	% Alive	100.0	47.1	71.6	75.7	73.7	88.9
	% Intact	33.3	17.6	44.8	33.9	34.3	77.8
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
1989	% Alive	NS	79.5	82.8	87.4	88.0	92.0
	% Intact	NS	62.4	42.0	50.1	40.0	44.5
1990	% Alive	73.5	78.9	81.1	84.8	89.3	95.3
	% Intact	41.6	38.6	38.1	46.7	48.6	57.5

NOTE: NS = Not sampled.

4. SUMMARY OF PLANT FLOW AND IMPINGEMENT, 1973-1990

4.1 HISTORY OF PLANT COOLING WATER FLOW RATES, 1973-1990

Weekly average cooling water flow rates at the Indian Point Generating Station from 1973 through 1990 were compiled from station operational records (Figure 4-1). Tables that summarize monthly plant operations are presented in Appendix C.

4.2 ANNUAL IMPINGEMENT ESTIMATES FOR SELECTED FISH SPECIES, 1974-1990

Annual impingement estimates for selected fish species and all species combined from 1974 through 1990 were calculated and adjusted for temperature-dependent collection efficiency for Unit 2 (Table 4-1), Unit 3 (Table 4-2), and for both units combined (Table 4-3). Calculation methods for these estimates are presented in more detail in Appendix D, which also contains comparisons of the recalculated annual impingement estimates to estimates previously reported in annual impingement reports for Indian Point Generating Station (TI 1975, 1976, 1977, 1979, 1980a, 1980b; Con Edison 1982a, 1982b, 1983; NAI 1984a, 1986, 1987; EA 1988, 1989; LMS 1990).

Recalculated annual impingement estimates for all species at both units ranged from a low of 850,000 in 1983 and 1984 to a high of 6.5 million in 1977 (Table 4-3). For most study years, impingement was less than 2 million fish per year; but from 1977 through 1981, annual impingement remained between 3.5 and 6.5 million fish (Figure 4-2). Most of the high impingement estimates can be attributed to relatively large collections of white perch (Figure 4-2) together with smaller contributions by Atlantic tomcod, blueback herring, and bay anchovy. In percent of total annual catch, these four species ranked in the four topmost positions (Figure 4-2). For the 17-year period from 1974 through 1990, white perch comprised 58.1 percent and 57.2 percent of the total catch at Units 2 and 3, respectively. Catches of Atlantic tomcod contributed 12.7 percent to the total catch at both units for the 17-year study period, while blueback herring accounted for 8.5 and 9.8 percent and bay anchovy made up 7.7 and 5.9 percent of the total catch at Units 2 and 3, respectively.

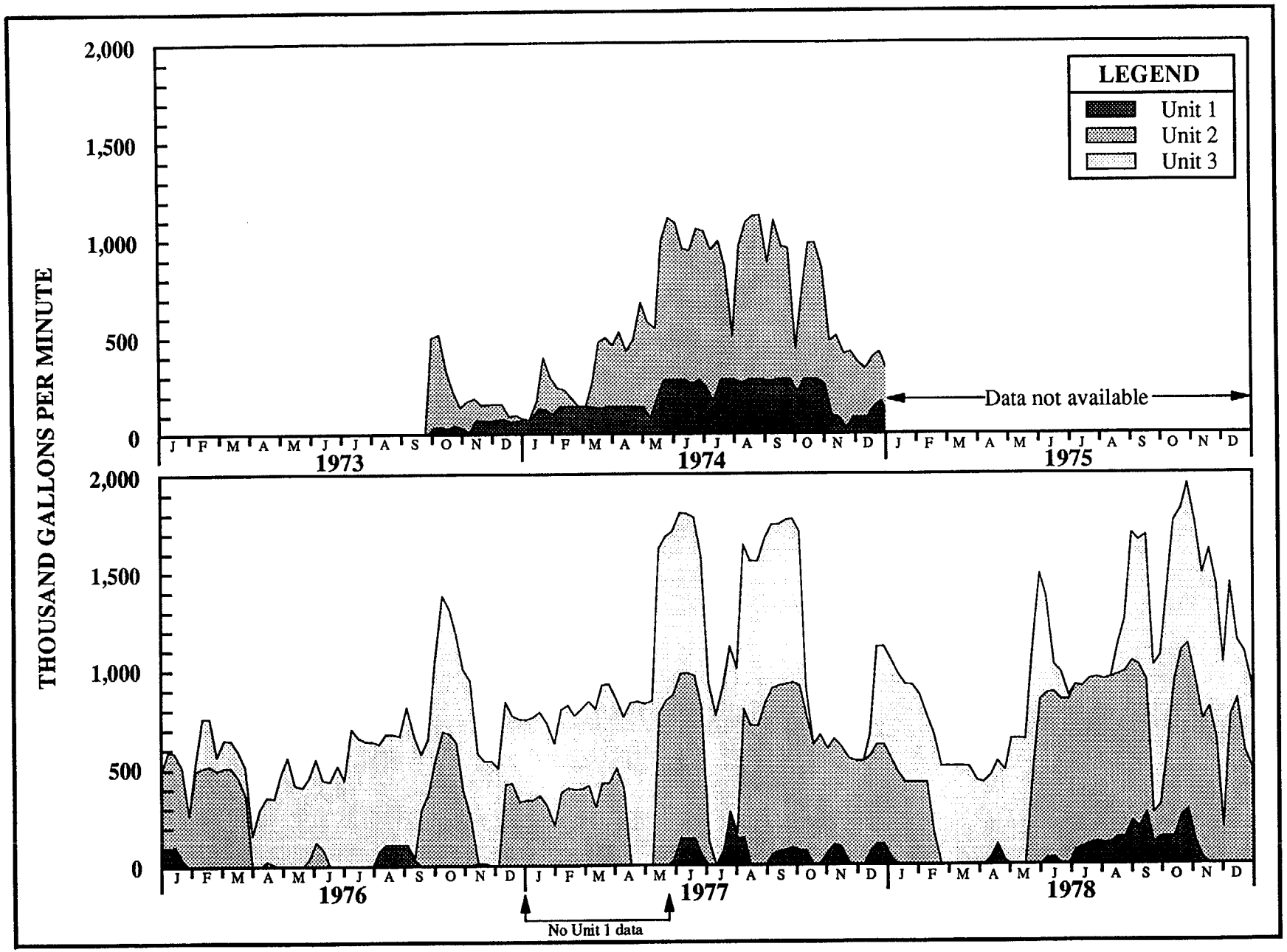


Figure 4-1. Weekly average cooling water flow rate at the Indian Point Generating Station.

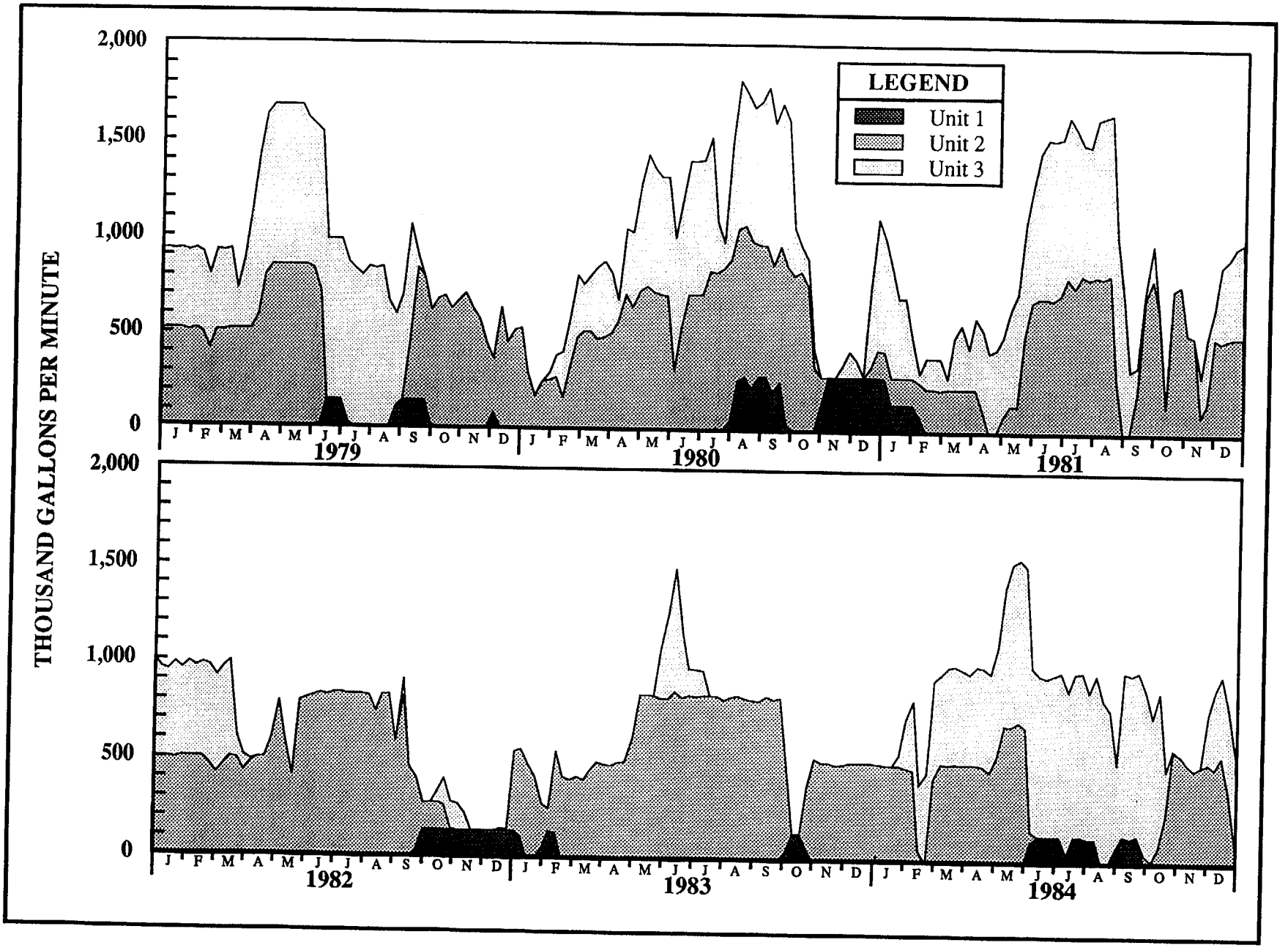


Figure 4-1 (Cont.)

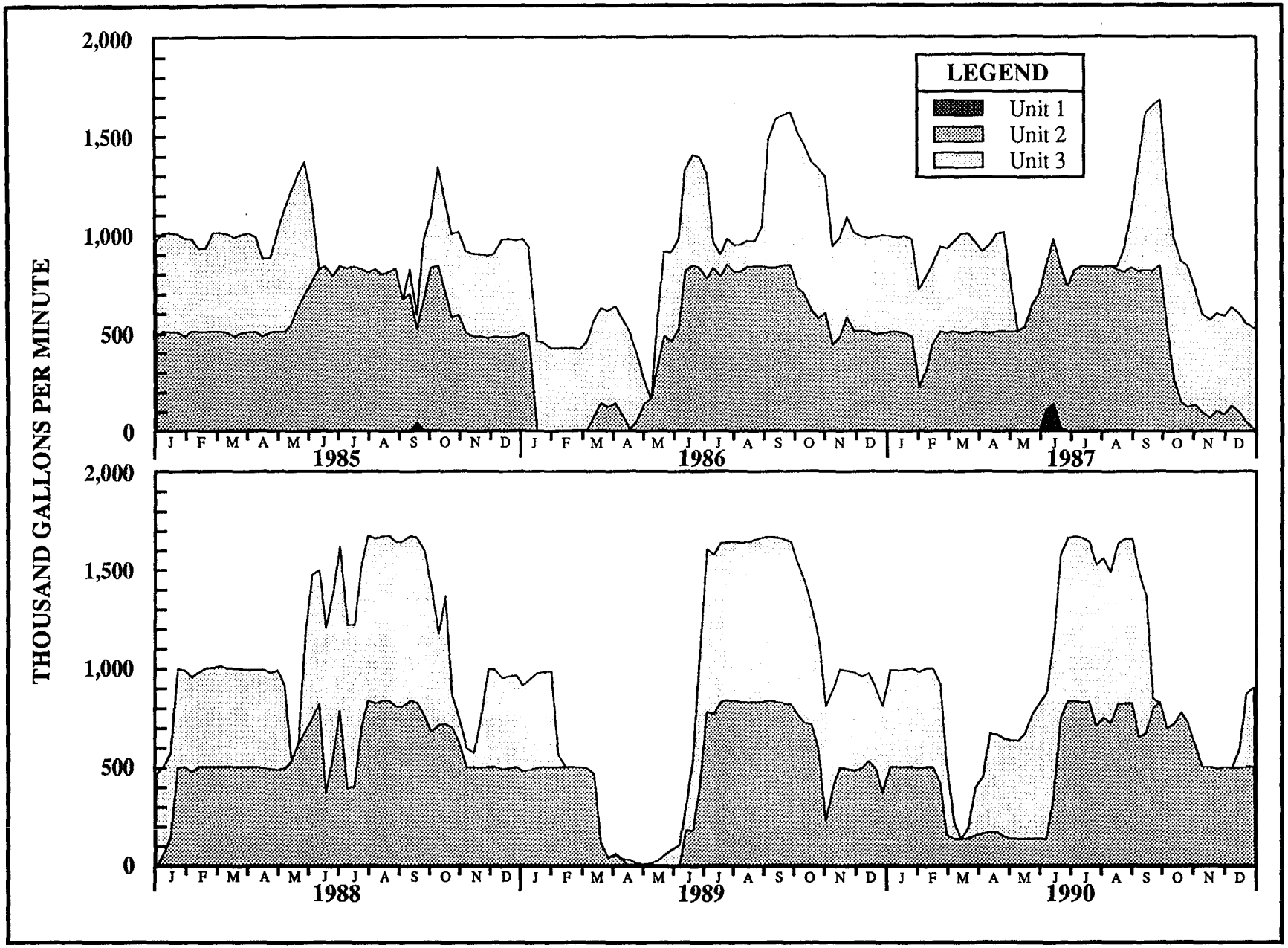


Figure 4-1 (Cont.)

TABLE 4-1 ANNUAL IMPINGEMENT ESTIMATES, ADJUSTED FOR COLLECTION EFFICIENCY, FOR SELECTED SPECIES AT INDIAN POINT UNIT 2, 1974-1990

Taxon	1974	1975	1976	1977	1978	1979	1980	1981	1982
Alewife	10,377	12,920	1,751	43,333	34,479	2,493	10,322	58,346	2,223
American shad	2,532	3,462	3,015	10,674	45,763	12,420	44,285	227,867	1,492
Atlantic tomcod	929,266	244,024	28,783	815,623	356,881	79,980	672,329	382,531	118,015
Bay anchovy	250,547	318,261	9,851	191,016	290,090	91,512	347,559	1,327,578	113,550
Blueback herring	55,678	380,795	344,739	1,494,065	712,363	305,261	29,346	255,782	1,081
Bluefish	7,009	5,021	33	12,425	2,541	129	10,603	10,874	1,453
Gizzard shad	136	1,959	3,214	11,944	1,556	1,273	132	719	335
Hogchoker	37,134	59,089	8,270	33,839	65,287	34,304	42,244	25,591	56,240
Rainbow smelt	1,901	15,368	4,965	36,262	55,393	37,002	21,458	725	1,212
Striped bass	11,738	14,543	8,491	42,472	59,838	77,756	30,206	60,601	8,258
Weakfish	3,577	30,000	485	14,363	37,003	7,059	46,530	55,112	17,413
White perch	644,585	591,107	596,746	1,829,955	912,198	2,621,218	1,172,364	1,463,046	577,872
All species	1,978,263	1,713,038	1,048,022	4,654,398	2,645,048	3,331,060	2,461,564	3,914,962	906,729

Taxon	1983	1984	1985	1986	1987	1988	1989	1990
Alewife	4,549	3,310	2,343	2,026	3,562	1,345	584	1,103
American shad	8,504	242	1,340	6,423	2,639	356	3,438	1,450
Atlantic tomcod	117,234	2,709	39,558	117,378	684,568	9,800	6,082	96,874
Bay anchovy	128,626	3,684	8,686	85,495	24,786	31,224	1,496	14,711
Blueback herring	46,854	3,251	8,337	7,219	35,259	23,696	23,233	17,947
Bluefish	7,269	30	582	4,044	6,028	3,156	627	5,805
Gizzard shad	1,817	1,474	1,646	1,773	280	3,739	13,140	2,915
Hogchoker	22,176	1,985	26,314	50,452	34,818	72,516	86,877	28,022
Rainbow smelt	2,196	844	3,552	10,879	7,280	5,651	306	431
Striped bass	19,023	4,551	53,451	8,417	24,879	70,969	21,047	19,370
Weakfish	174,991	1,358	8,399	6,592	2,688	22,276	6,127	2,898
White perch	274,899	310,336	543,274	409,605	432,422	658,798	601,345	622,755
All species	820,624	339,859	716,805	736,821	1,276,856	923,533	787,767	829,239

TABLE 4-2 ANNUAL IMPINGEMENT ESTIMATES, ADJUSTED FOR COLLECTION EFFICIENCY, FOR SELECTED SPECIES AT INDIAN POINT UNIT 3, 1976-1990

Taxon	1976	1977	1978	1979	1980	1981	1982	1983
Alewife	4,928	82,827	32,862	15,054	6,493	9,101	0	212
American shad	5,361	17,037	29,010	39,500	13,885	22,421	5	10
Atlantic tomcod	40,814	912,514	15,764	255,695	162,343	78,202	976	12,361
Bay anchovy	16,468	170,809	32,664	189,302	77,129	117,433	72	404
Blueback herring	216,651	106,905	429,699	12,140	11,418	15,788	111	2,878
Bluefish	2,908	32,590	216	7,550	10,094	8,297	0	550
Gizzard shad	1,736	1,737	1,376	542	2,508	2,593	1,961	0
Hogchoker	21,837	24,119	41,738	17,638	17,477	23,289	449	817
Rainbow smelt	1,544	21,821	28,594	26,833	6,164	961	68	132
Striped bass	4,009	18,386	25,950	18,480	18,320	26,911	49,365	67
Weakfish	715	6,201	3,450	11,342	12,887	12,104	0	0
White perch	242,100	368,598	590,108	525,397	539,459	698,867	639,491	11,633
All species	588,245	1,825,618	1,263,954	1,139,314	895,259	1,031,126	696,161	29,453

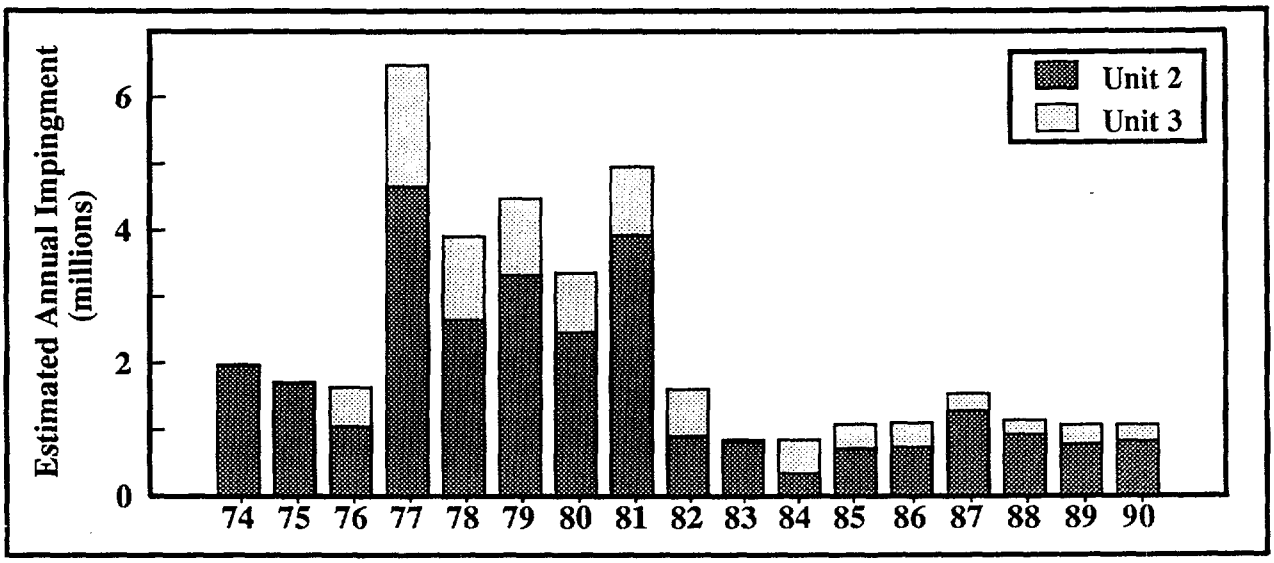
Taxon	1984	1985	1986	1987	1988	1989	1990
Alewife	4,704	2,824	1,416	1,166	698	860	897
American shad	458	1,656	4,904	1,730	148	5,868	1,568
Atlantic tomcod	95,855	9,723	13,602	1,097	8,807	2,422	25,036
Bay anchovy	109,086	4,743	16,665	6,082	4,219	4,572	6,947
Blueback herring	10,216	47,551	10,640	62,467	2,608	32,735	2,767
Bluefish	6,464	27	1,515	745	510	605	3,028
Gizzard shad	81	3,993	7,735	1,056	11,551	7,485	3,031
Hogchoker	9,477	13,145	22,875	9,585	13,969	34,401	12,213
Rainbow smelt	733	1,806	2,776	1,782	1,713	84	891
Striped bass	6,414	27,011	2,305	3,794	16,089	3,747	2,611
Weakfish	10,193	510	1,802	310	3,394	31,902	1,477
White perch	234,299	239,912	259,986	168,015	144,555	147,712	172,491
All species	508,759	361,372	355,145	262,306	212,043	277,403	237,180

TABLE 4-3 ANNUAL IMPINGEMENT ESTIMATES, ADJUSTED FOR COLLECTION EFFICIENCY, FOR SELECTED SPECIES AT INDIAN POINT UNITS 2 AND 3 COMBINED, 1974-1990

Taxon	1974*	1975*	1976	1977	1978	1979	1980	1981	1982
Alewife	10,377	12,920	6,679	126,160	67,341	17,547	16,815	67,447	2,223
American shad	2,532	3,462	8,376	27,711	74,773	51,920	58,170	250,288	1,497
Atlantic tomcod	929,266	244,024	69,597	1,728,137	372,645	335,675	834,672	460,733	118,991
Bay anchovy	250,547	318,261	26,319	361,825	322,754	280,814	424,688	1,445,011	113,622
Blueback herring	55,678	380,795	561,390	1,600,970	1,142,062	317,401	40,764	271,570	1,192
Bluefish	7,009	5,021	2,941	45,015	2,757	7,679	20,697	19,171	1,453
Gizzard shad	136	1,959	4,950	13,681	2,932	1,815	2,640	3,312	2,296
Hogchoker	37,134	59,089	30,107	57,958	107,025	51,942	59,721	48,880	56,689
Rainbow smelt	1,901	15,368	6,509	58,083	83,987	63,835	27,622	1,686	1,280
Striped bass	11,738	14,543	12,500	60,858	85,788	96,236	48,526	87,512	57,623
Weakfish	3,577	30,000	1,200	20,564	40,453	18,401	59,417	67,216	17,413
White perch	644,585	591,107	838,846	2,198,553	1,502,306	3,146,615	1,711,823	2,161,913	1,217,363
All species	1,978,263	1,713,038	1,636,267	6,480,016	3,909,002	4,470,374	3,356,823	4,946,088	1,602,890

* Unit 2 only.

Taxon	1983	1984	1985	1986	1987	1988	1989	1990
Alewife	4,761	8,014	5,167	3,442	4,728	2,043	1,444	2,000
American shad	8,514	700	2,996	11,327	4,369	504	9,306	3,018
Atlantic tomcod	129,595	98,564	49,281	130,980	685,665	18,607	8,504	121,910
Bay anchovy	129,030	112,770	13,429	102,160	30,868	35,443	6,068	21,658
Blueback herring	49,732	13,467	55,888	17,859	97,726	26,304	55,968	20,714
Bluefish	7,819	6,494	609	5,559	6,773	3,666	1,232	8,833
Gizzard shad	1,817	1,555	5,639	9,508	1,336	15,290	20,625	5,946
Hogchoker	22,993	11,462	39,459	73,327	44,403	86,485	121,278	40,235
Rainbow smelt	2,328	1,577	5,358	13,655	9,062	7,364	390	1,322
Striped bass	19,090	10,965	80,462	10,722	28,673	87,058	24,794	21,981
Weakfish	174,991	11,551	8,909	8,394	2,998	25,670	38,029	4,375
White perch	286,532	544,635	783,186	669,591	600,437	803,353	749,057	795,246
All species	850,077	848,618	1,078,177	1,091,966	1,539,162	1,135,576	1,065,170	1,066,419



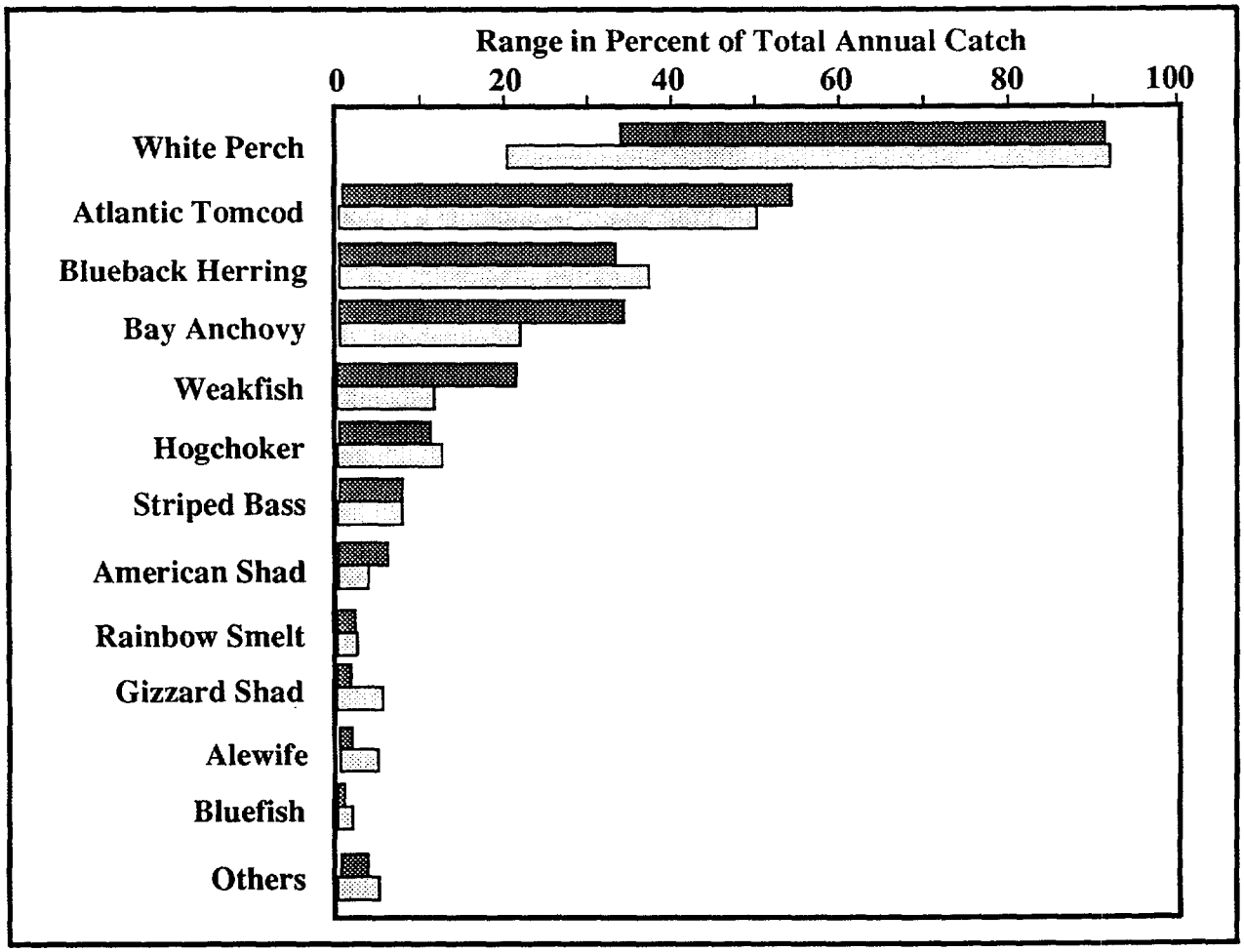


Figure 4-2. Estimated annual impingement for all species and percent of total annual catch for selected species at Indian Point Generating Station, 1974-1990.

White perch was the most abundant fish impinged at Indian Point from 1974 through 1990. Collections of white perch ranged from 20 to 90 percent of the total catch. Annual impingement estimates for most years remained between 600,000-800,000 except from 1977 to 1982 when annual estimates totaled between 1 and 3 million fish (Figure 4-3).

The second most abundant fish collected in impingement at Indian Point across the 17-year study period was ***Atlantic tomcod***. Overall, this species represented 12.7 percent of the total catch at each unit from 1974 to 1990, however, individual annual impingement estimates have varied considerably in magnitude from a high of 1.7 million in 1977 to 8,500 in 1989 (Figure 4-3). Atlantic tomcod abundance in impingement declined in the 1980s following elevated levels in the late 1970s.

Impingement of ***blueback herring*** also declined in the 1980s following peak abundance levels in the late 1970s (Figure 4-3). In 1977, over 1.6 million blueback herring were impinged, mainly at Unit 2; however, since 1980, impingement abundance rarely exceeded 50,000 per year.

Bay anchovy were impinged in fairly uniform abundance from 1974 through 1980 at approximately 300,000 fish per year (Figure 4-3). In 1981, impingement increased three-fold with over 1.4 million bay anchovy collected, mostly at Unit 2. For the following 5 years, annual impingement estimates for bay anchovy remained near 100,000 and, subsequently, declined again in 1987 to 35,000 fish or less per year in impingement samples and remained at that level through 1990.

American shad, although impinged in much less abundance than the aforementioned species, were impinged in a similar temporal pattern; annual impingement estimates for 1977 through 1981 were higher than all other study years (Figure 4-3). Abundance peaked in 1981 at 250,000 fish, mostly at Unit 2, and has subsequently ranged from 500 to 11,000 American shad impinged each year.

Impingement of ***weakfish*** was variable from 1974 to 1990 but, as with most other species, impingement abundance was greatest from 1978 to 1981 (Figure 4-3). Peak abundance, however, occurred in 1983 when 175,000 weakfish were impinged at Unit 2 alone. Annual impingement estimates from the other study years ranged from 1,200 to 67,000 weakfish.

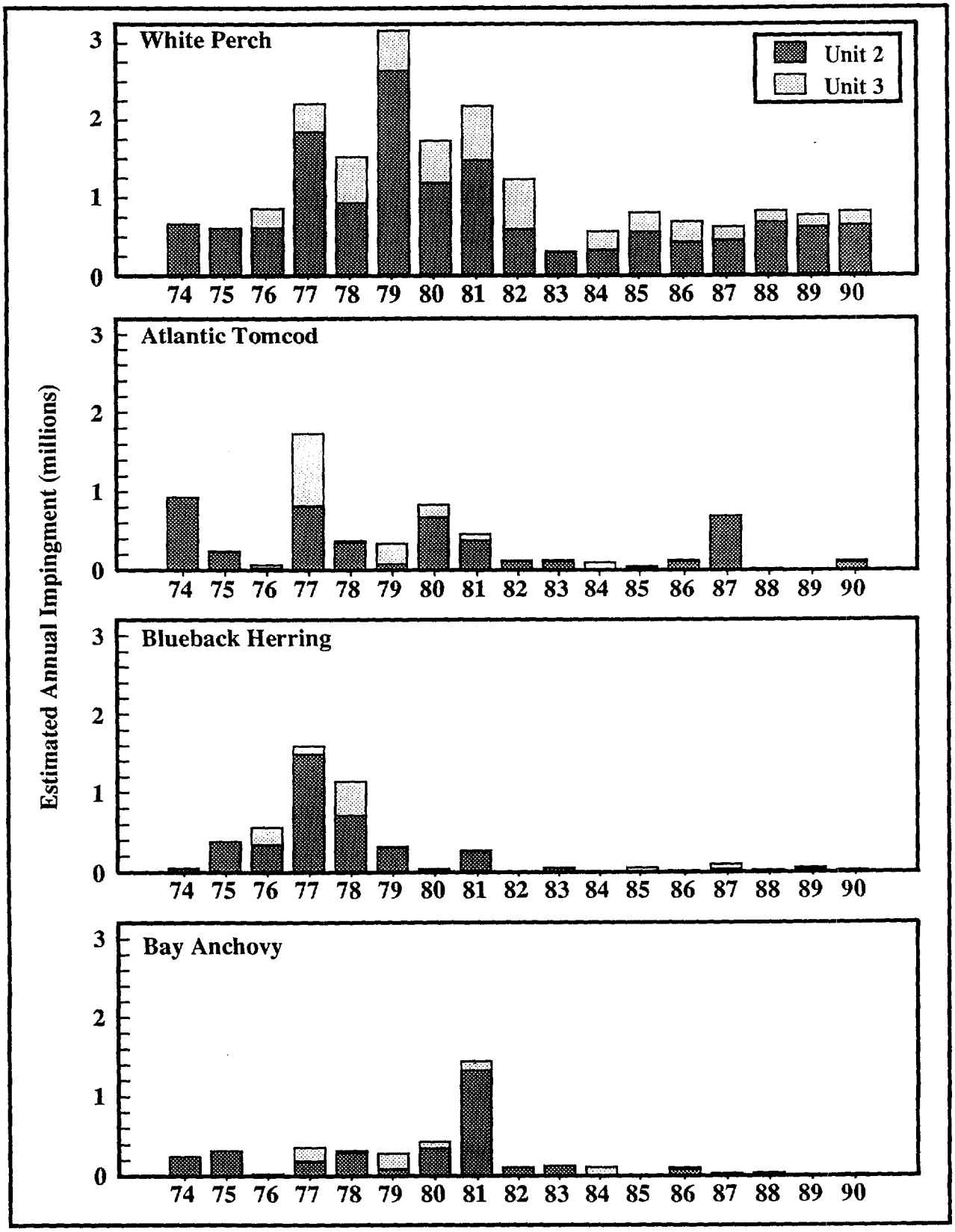


Figure 4-3. Estimated annual impingement for selected species at Indian Point Generating Station, 1974-1990.

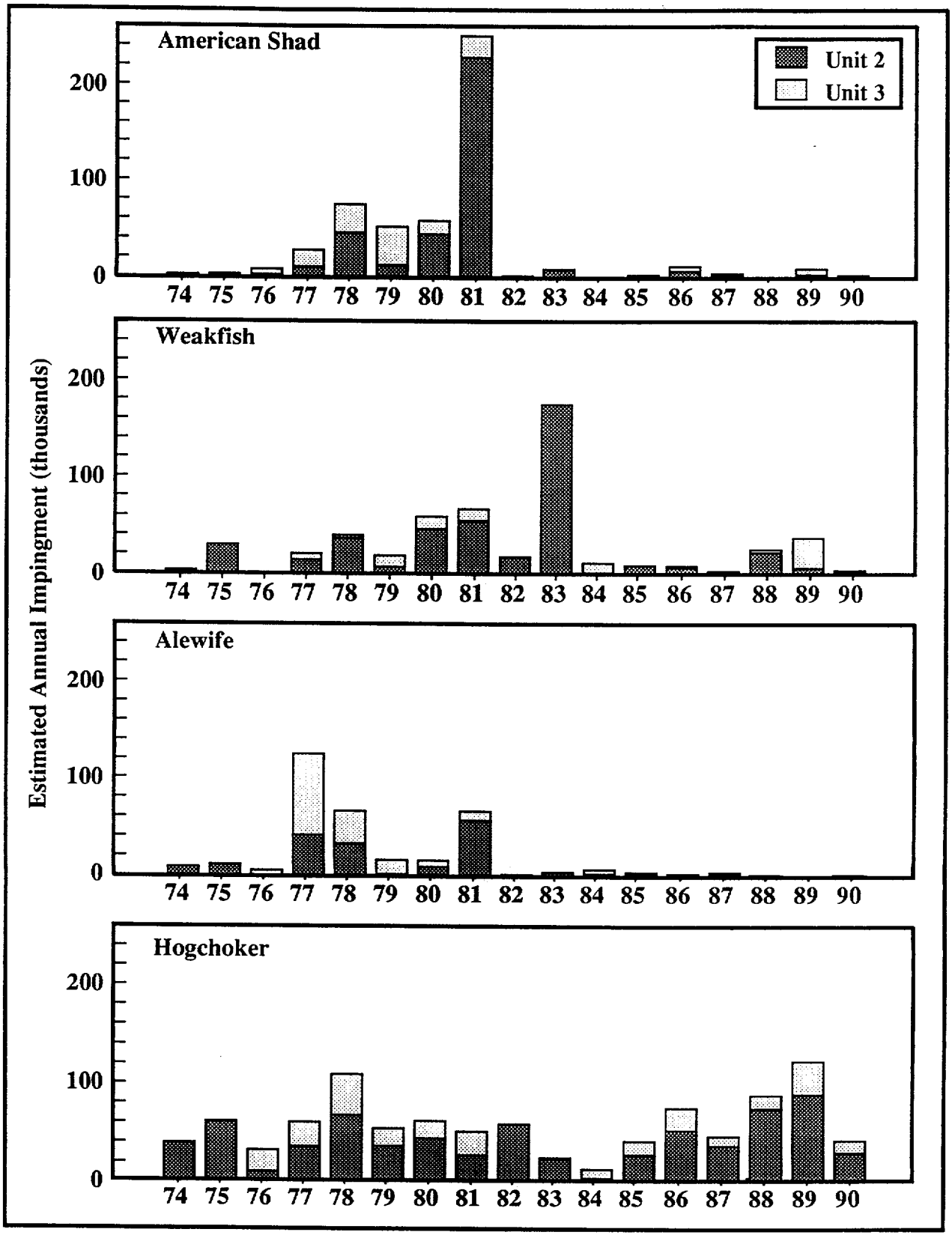


Figure 4-3 (Cont.)

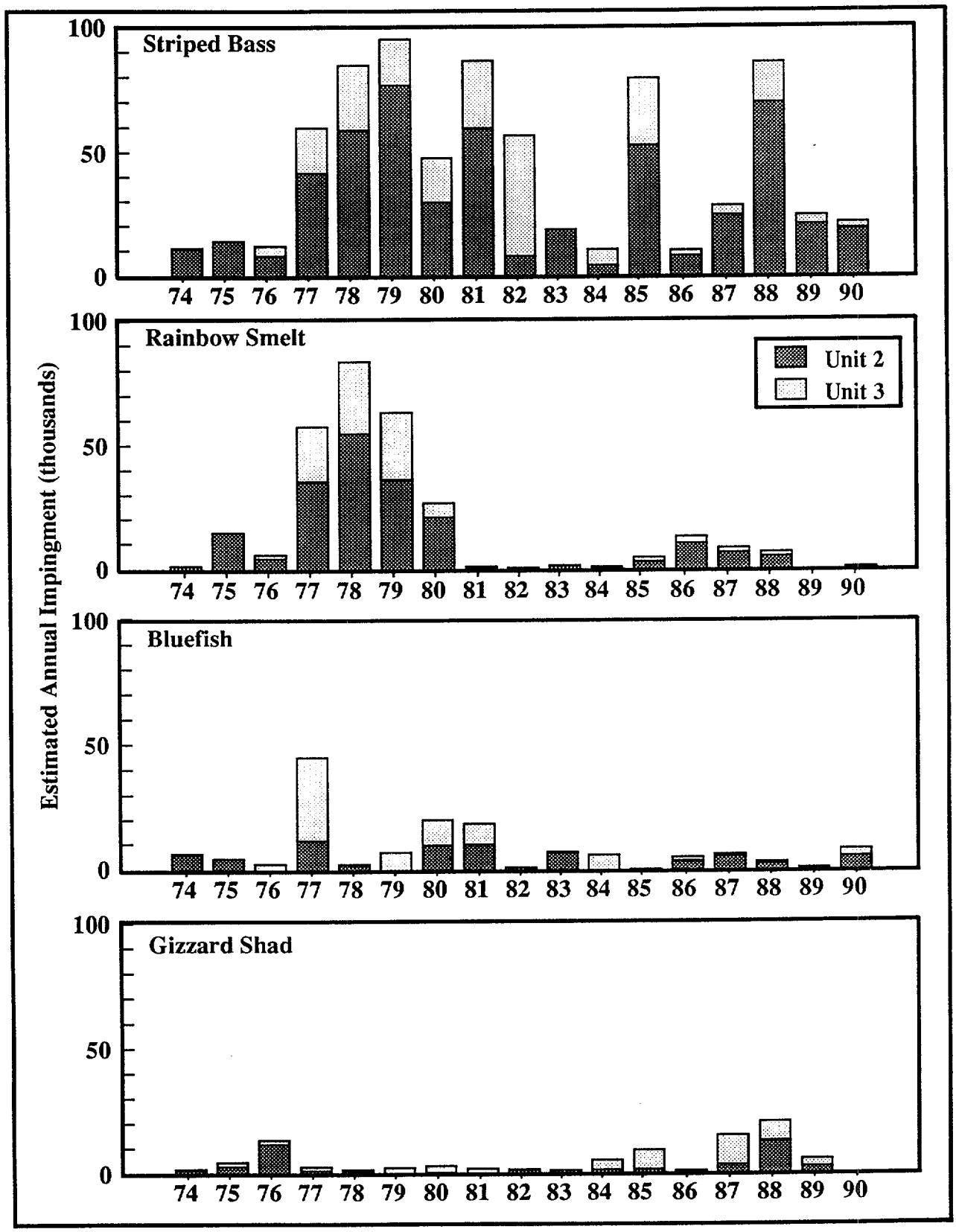


Figure 4-3 (Cont.)

Alewife is another species for which impingement abundance was greatest from 1977 to 1981 with annual estimates for this period between 17,000 and 126,000 (Figure 4-3). For all other study years, annual estimates for alewife were generally less than 10,000 and often 4,000 or less.

Impingement of ***hogchoker*** at Indian Point exhibited a relatively consistent pattern during the study years (Figure 4-3). Impingement increased to a peak in 1978 (over 100,000 fish), declined to a minimum in 1984 (11,000 fish), and then increased again to a peak over 100,000 in 1989.

Annual impingement abundance estimates for ***striped bass*** were highest from 1977 through 1981 and again in 1985 and 1988 (Figure 4-3). Peak abundance reached 80,000-90,000 fish per year while estimates in years of lower impingement ranged from 10,000 to 20,000 striped bass per year.

Rainbow smelt, like many other species, were impinged in greatest numbers from 1977 to 1980 with peak annual impingement estimates from 60,000 to 80,000 (Figure 4-3). A secondary period of abundance was recorded from 1985 to 1988 when annual estimates were 5,000-14,000 rainbow smelt per year. In the intervening years and after 1988, usually less than 2,000 rainbow smelt were impinged in a year.

For most of the study years from 1974 to 1990, ***bluefish*** were consistently impinged at a rate of about 4,000-8,000 fish per year (Figure 4-3). A primary peak in abundance, however, occurred in 1977 with the majority of the 45,000 fish impinged at Unit 3. In 1980 and 1981, a secondary peak in abundance at 20,000 fish per year was recorded.

Gizzard shad impingement was relatively low (<2,000 fish per year) during most of the study period (Figure 4-3). Two peaks in abundance were noted, one in 1977 (14,000) and one in 1989 (21,000).

4.3 ANNUAL IMPINGEMENT COUNTS FOR BLUE CRAB, 1983-1990

Monitoring of blue crab impingement began in April 1983. From that point until October 1990, blue crab were collected and processed daily (as described in Section 2.3). Annual impingement counts, therefore, are the sum of the daily blue crab collections. Beginning in October 1990, blue crab were sampled only when fish samples were collected, which occurred every Tuesday. The impingement

estimate from October through December 1990 was calculated by multiplying the mean count for the sampling days by the number of operating days. This estimate was added to the daily counts from the remainder of 1990 to arrive at the annual impingement count.

Annual impingement counts, unadjusted for collection efficiency, for blue crab from 1983 through 1990 ranged from a low of 348 in 1984 to a high of 196,201 in 1989 (Table 4-4). Annual counts before 1988 were less than 15,000 but increased dramatically in 1988 to over 50,000 and nearly quadrupled in 1989 to almost 200,000 before returning to 50,000 in 1990 (Figure 4-4). Total counts were nearly equivalent at Unit 2 and Unit 3 when each unit was in operation. Outages or reduced operating volumes expectedly decreased blue crab impingement. In 1988, although both units were in operation, blue crab impingement at Unit 2 was almost three times greater than at Unit 3 due to a large catch of young-of-year blue crab in October and November.

Fluctuations in annual abundance of blue crab have been reported in previous studies. A thermal effluent study at Calvert Cliffs Nuclear Power Plant on Chesapeake Bay, Maryland from 1968 to 1981 reported that total numbers of blue crab collected with commercial crab pots varied from 239 to 15,106 (Abbe 1983). A large decrease in otter trawl catch of blue crab from 1976 to 1977 as well as a concomitant 78.2 percent decline in commercial landings in Barnegat Bay, New Jersey may have reflected a reduction in population size (Kennish et al. 1982).

The primary factors affecting growth, survival, distribution, and ultimately, abundance of blue crab are temperature, salinity, substrate, and food (Van Engel 1987). Parasitism, pesticides, and predation have also been suggested as causes of population fluctuations (Van Den Avyle 1984). Although the exact mechanisms through which these environmental factors affect year class strength are only partially known, Van Engel (1987) believes that they occur at critical times early in the life cycle of blue crab. Climatological factors immediately preceding spawning and in the first eight months of blue crab life were major factors in establishing the ultimate population size, as measured by the Chesapeake Bay commercial catch (Van Engel and Harris 1980). Kennish et al. (1982) suggested that a 37.5 percent reduction in recruitment size blue crab ($\leq$59 mm) in Barnegat Bay subsequent to the severe winter of 1976-1977 may have resulted in a considerable decrease in the overall size of the population. Pearson (1948) also felt that variable survival rates during the first year of life accounted for large variations in blue crab abundance.

TABLE 4-4 ANNUAL IMPINGEMENT COUNTS, UNADJUSTED FOR COLLECTION EFFICIENCY, FOR BLUE CRAB AT INDIAN POINT UNITS 2 AND 3, 1983-1990

	1983*	1984	1985	1986	1987	1988	1989	1990
Unit 2	790	20	11,805	4,430	971	41,363	93,432	23,664
Unit 3	31	328	511	775	987	15,233	102,769	27,139
Combined	821	348	12,316	5,205	1,958	56,596	196,201	50,803

* Collections were made only from April through December.

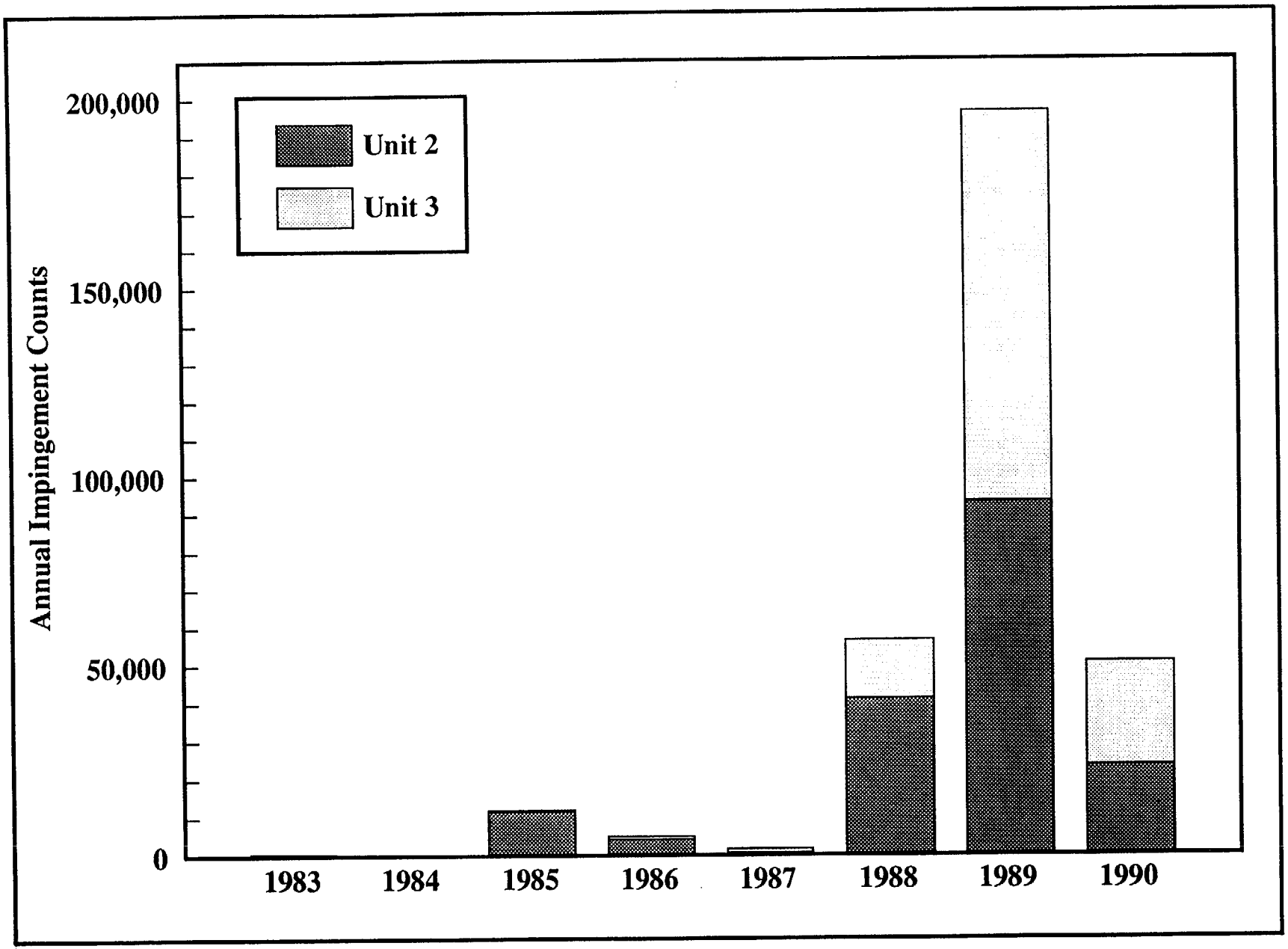


Figure 4-4. Annual impingement counts for blue crab at Indian Point Generating Station, 1983-1990.

The influence of year class strength on the subsequent year's blue crab abundance at Indian Point can be assessed through the carapace width frequency distribution plots (Figure 4-5). A small peak in young-of-year blue crab (50-70 mm) in October 1984 probably contributed to the increase in observed in 1985. Similarly, strong year classes in 1987, 1988, and 1989 resulted in large increases in abundance during the following years.

Although changes in blue crab abundance at Indian Point have been substantial from 1983 through 1990, the biological characteristics and seasonal occurrence of blue crab have been relatively uniform. To compare seasonal patterns during the study years, a temporal abundance index expressing each month's impingement catch as a percentage of the total catch for that year was used. Blue crab first appeared in impingement collections in May and June corresponding with the migration to lower salinity, shallow waters for spawning (Figure 4-6). Abundance increased until maximum abundance was achieved, usually in August, when water temperatures in the Indian Point area were also maximal. Occasionally, maximum abundance occurred in October and can be attributed to large catches of young-of-year blue crab. Impingement abundance declined during the fall as male and young-of-year blue crab emigrated to warmer, deeper waters to overwinter. Few blue crab were collected during the winter season at Indian Point. Carapace width increased from spring through fall during each study year reflecting blue crab growth (Figure 4-5). The percentage of male blue crab in impingement collections was relatively uniform from 1983 through 1990, ranging from 63 percent in 1988 to 81 percent in 1984 (Figure 4-7).

In 1986, a mark and recapture study of blue crab impingement was conducted (NAI 1987). A total of 2,280 blue crab impinged at Units 2 and 3 were tagged and released at the Unit 1 pier located between Units 2 and 3 from June through November 1986. Including 11 double and 2 triple recaptures, the number of unique recaptures (i.e., each crab that was impinged one or more times) from June through November 1986 totaled 44 at Unit 2 and 150 at Unit 3. No tagged blue crab were recaptured after November 1986.

To obtain an estimate of the percent reimpingement of blue crab released and recaptured, it was necessary to have an estimate of tag loss. A laboratory study estimated that the tag loss after 6 days was 2.2 percent (NAI 1987). The 6-day tag loss estimate was chosen over other time intervals because most blue crab tagged and released were recaptured within the first 6 days after release

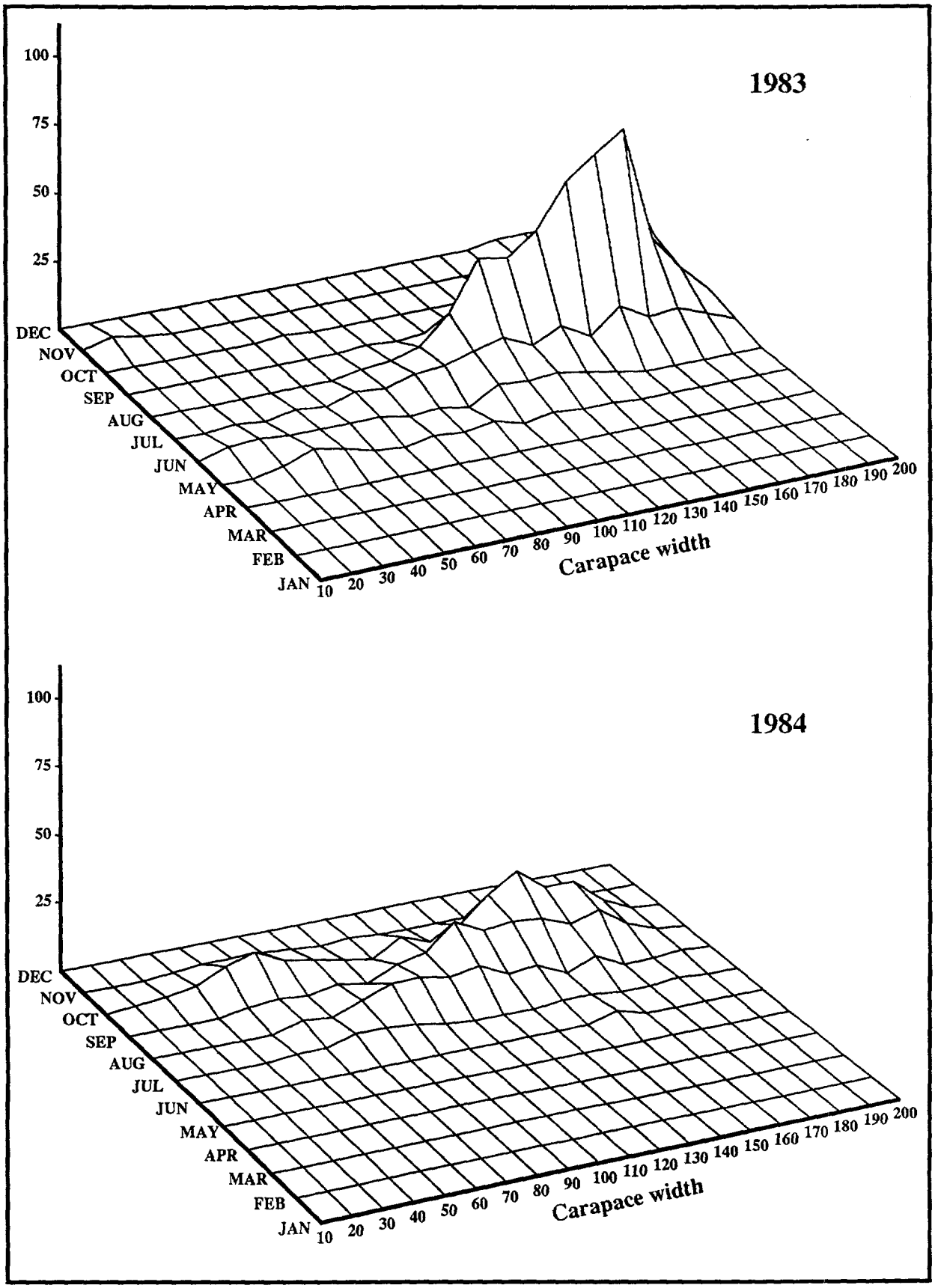


Figure 4-5. Frequency distribution of blue crab carapace width (mm) at Indian Point Generating Station, 1983-1990.

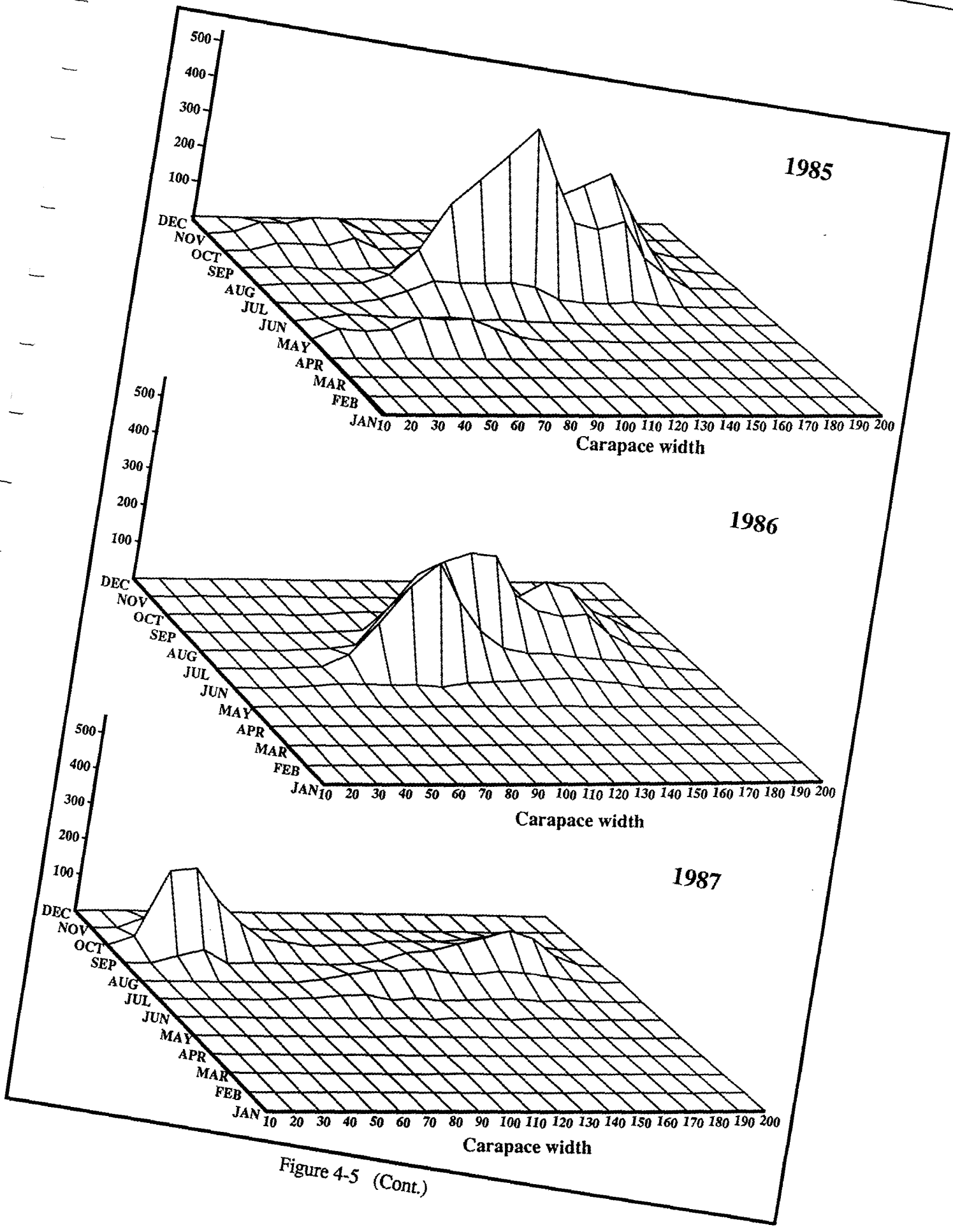


Figure 4-5 (Cont.)

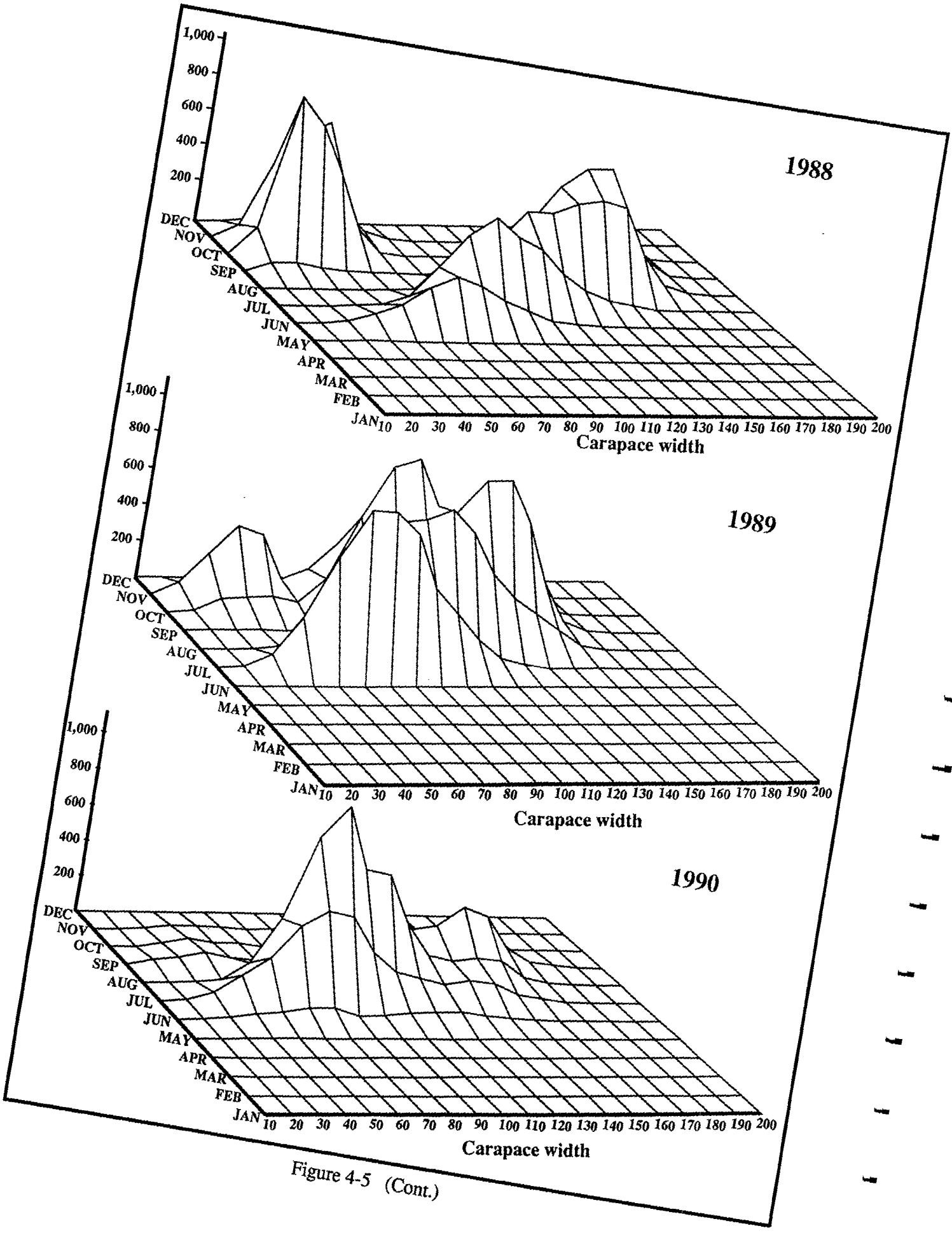


Figure 4-5 (Cont.)

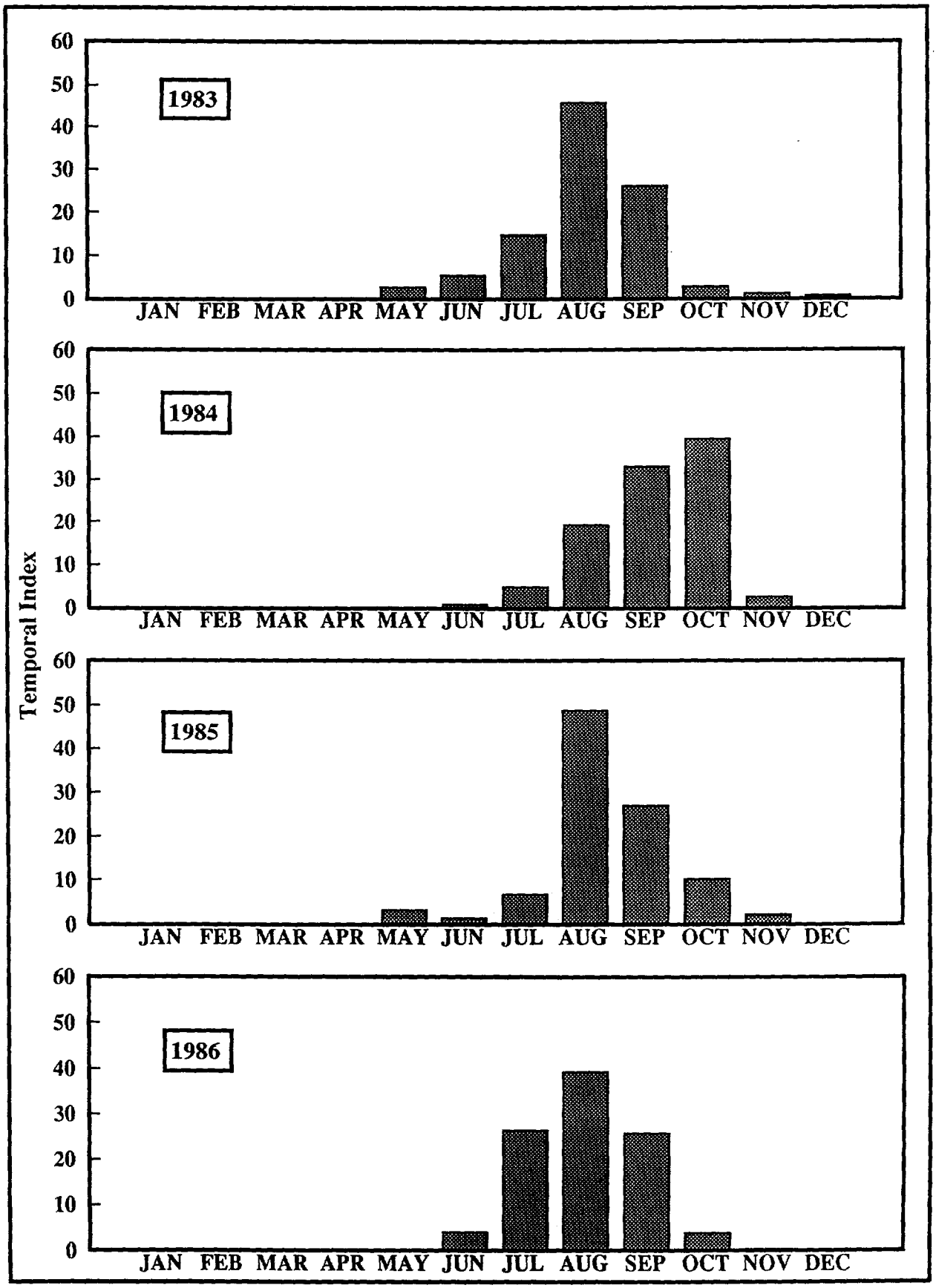


Figure 4-6. Temporal abundance index for impinged blue crab at Indian Point Generating Station, 1983-1990.

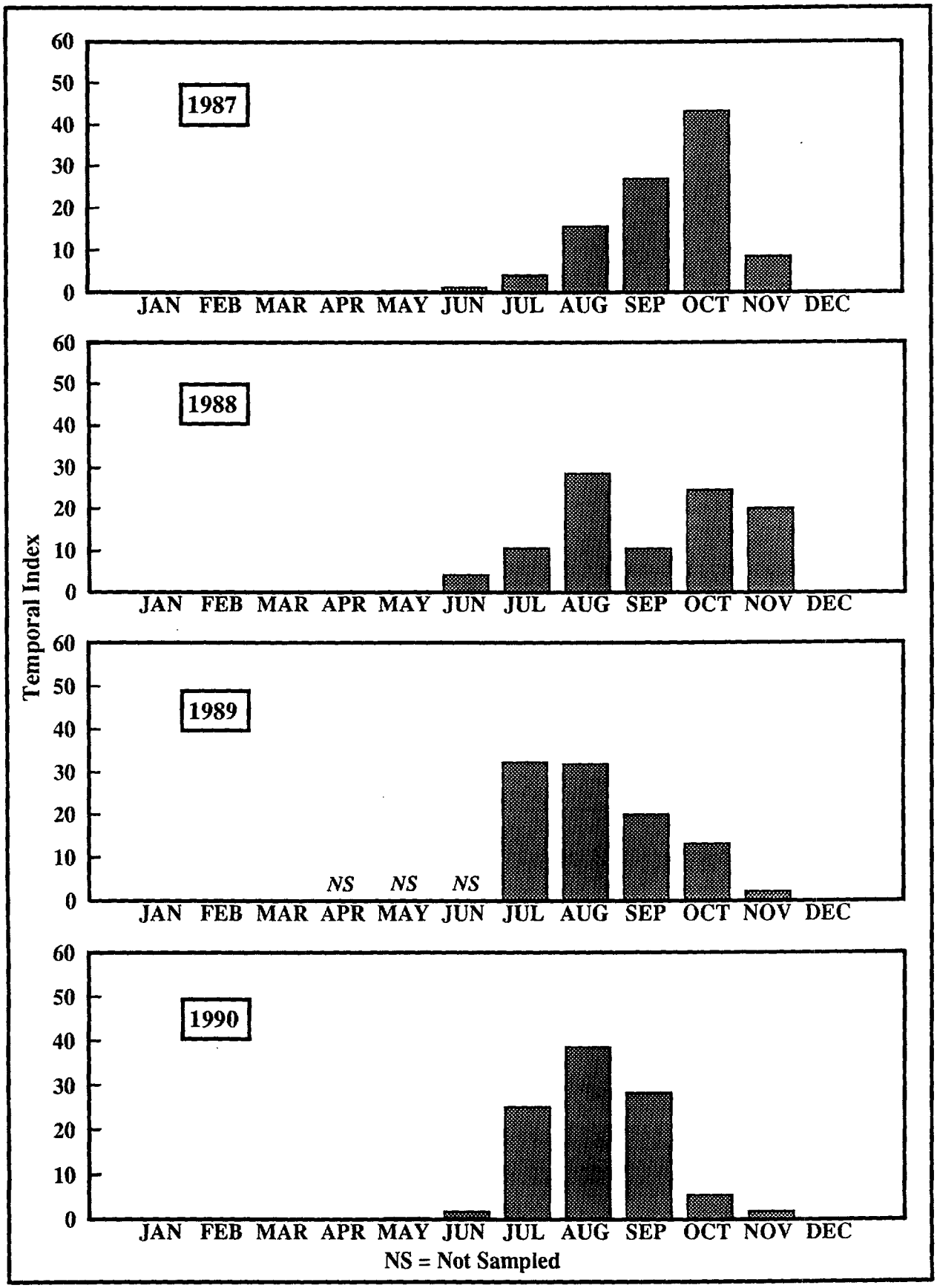


Figure 4-6. (Cont.)

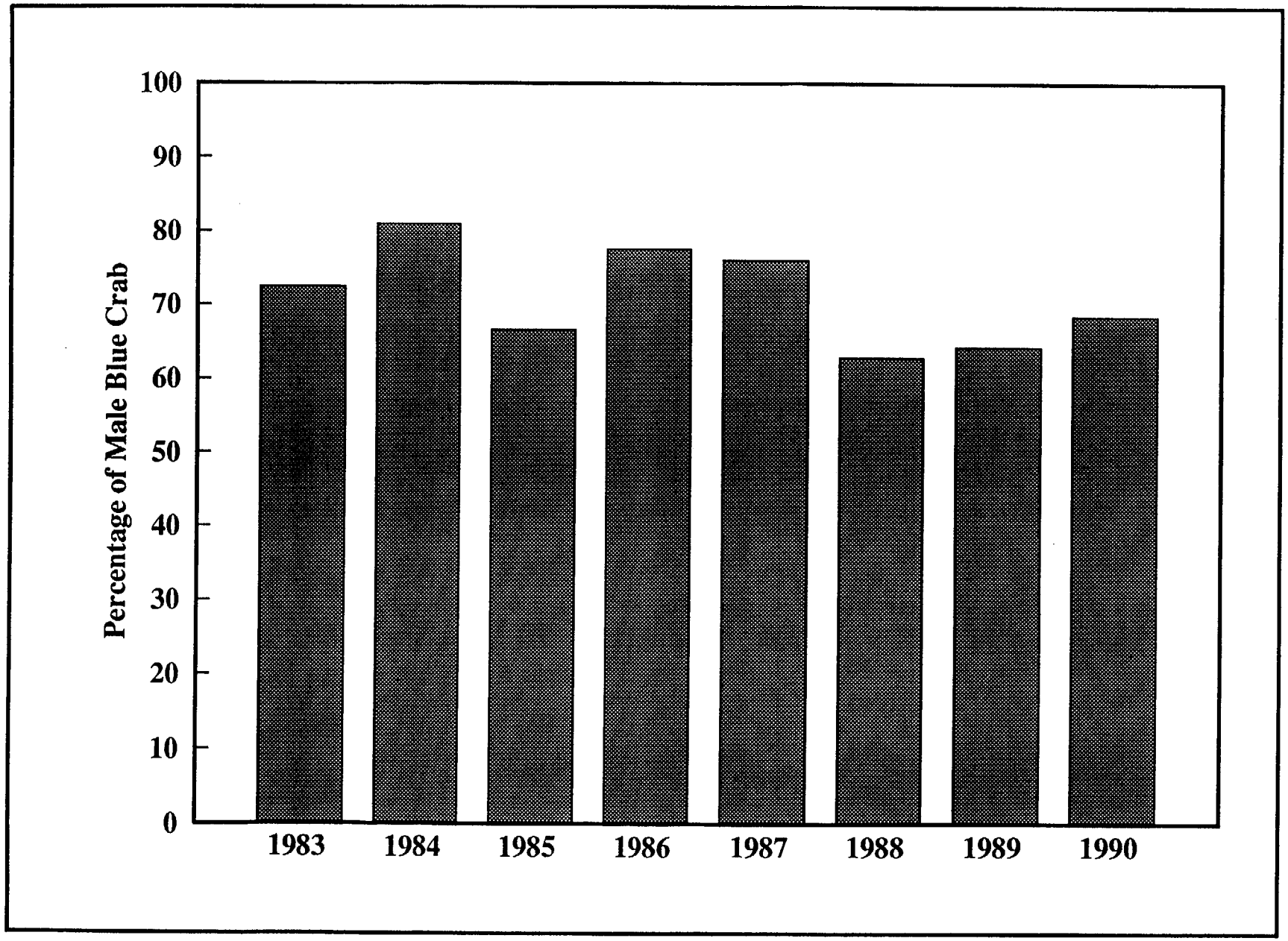


Figure 4-7. Percentage of male blue crab in impingement collections at Indian Point Generating Station, 1983-1990.

(76.1 percent at Unit 2, 90.3 percent at Unit 3). Percent reimpingement, therefore, adjusted for the number of unique recaptures and 6-day tag loss was 2.0 percent at Unit 2 and 6.7 percent at Unit 3.

Overall impingement losses for blue crab due to impingement at Indian Point from 1983 through 1990 was calculated by applying the recapture rates and survival rates to the annual impingement counts (Table 4-5). Total annual impingement counts from each unit were decreased by the recapture rate.

Adjusted counts from both units combined were multiplied by the inverse of the reported survival rates for each year to arrive at an estimate of annual impingement loss. Annual estimates of impingement loss ranged from 87 (1984) to 27,180 (1990) and totaled 51,975 blue crab for the 8-year study period. The average mortality rate for this period was 21.9 percent, but weighing the mortality rate by the numbers of blue crab impinged reduced the rate to 16.7 percent.

TABLE 4-5 ESTIMATED BLUE CRAB IMPINGEMENT MORTALITY AT INDIAN POINT UNITS 2 AND 3, 1983-1990

	1983		1984		1985		1986		1987	
	Unit 2	Unit 3	Unit 2	Unit 3	Unit 2	Unit 3	Unit 2	Unit 3	Unit 2	Unit 3
Annual impingement counts[a]	790	31	20	328	11,805	511	4,430	775	971	987
Counts adjusted for recapture rate[b]	774	29	20	306	11,569	477	4,341	723	952	921
Adjusted counts for Units 2 and 3 combined[c]	803		326		12,046		5,064		1,872	
Estimated impingement mortality[d]	217		87		3,397		1,327		275	
Mortality rates[e]	27%		26.7%		28.2%		26.2%		14.7%	

	1988		1989		1990		TOTAL	
	Unit 2	Unit 3	Unit 2	Unit 3	Unit 2	Unit 3	Unit 2	Unit 3
Annual impingement counts[a]	41,363	15,233	93,432	102,769	23,664	27,139	176,475	147,773
Counts adjusted for recapture rate[b]	40,536	14,212	91,563	95,883	23,191	25,321	172,946	137,872
Adjusted counts for Units 2 and 3 combined[c]	54,748		187,447		48,511		310,818	
Estimated impingement mortality[d]	10,566		27,180		8,926		51,975	
Mortality rates[e]	19.3%		14.5%		18.4%		21.9%[f] 16.7%[g]	

a. Annual impingement counts from annual reports.
b. $b_{Unit\ 2} = a - (a * 2.0\%)$, $b_{Unit\ 3} = a - (a * 6.7\%)$.
c. $b_{Unit\ 2} + b_{Unit\ 3}$.
d. c * e.
e. 1 - survival rates from annual reports.
f. Average mortality rate.
g. Weighted average mortality rate = d_{total} / c_{total}.

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APPENDIX A

DATA CALCULATION PROCEDURES

APPENDIX A

DATA CALCULATION PROCEDURES

Impingement data were collected separately at Intakes 21-25, 26, and 31-36. In order to provide standard, unit-wide sample data for Unit 2, impingement data from Intakes 21-25 and 26 were combined within each sample day. The impingement statistics calculated from 1990 data at Units 2 and 3 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 from January through September standardized to the volume of water sampled (Equation 7).
- Mean daily blue crab impingement rates from October through December standardized to the volume of water sampled (Equation 8).

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 2.2.4).

At Unit 2, the non-Ristroph (Intakes 21-25) and the Ristroph (Intake 26) 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);

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

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 above.

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):

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

where

C.V. = Coefficient of variation
$S.E._m$ = As defined above
T_m = Estimated number of fish impinged at Unit m.

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

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

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 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:

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

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.

Until 2 October 1990, mean daily impingement rates unadjusted for collection efficiency were calculated for blue crab 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:

$$A_{km} = 1/o_{km} \sum_{i=1}^{o_{km}} \left(\frac{C_{ikm}}{V_{ikm}} \right) \quad \text{(Equation 7)}$$

where

A_{km} = Mean daily adjusted impingement rate for month k at Unit m
o_{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 from 1 January to 1 October 1990 was defined as any day that the plant operated.

From 2 October 1990 until the end of the year, blue crab were only sampled when fish were sampled on a systematic sampling schedule (every Tuesday). Mean daily impingement rates for this time period were calculated by summing within each month the quotient of the daily count (unadjusted for

collection efficiency) divided by the daily sampling volume and dividing this sum by the number of sampling days:

$$A_{km} = 1/s_{km} \sum_{i=1}^{s_{km}} \left(\frac{C_{ikm}}{V_{ikm}} \right) \qquad \text{(Equation 8)}$$

where

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

Collection efficiency data were not available for blue crab 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 FOR 1990

APPENDIX B

LIST OF TABLES

TABLE B-1 DAILY INTAKE WATER QUALITY RECORDED AT INDIAN POINT GENERATING STATION DURING 1990

Date	Temperature (C)			Conductivity (μS/cm)		
	Unit 2	Unit 3	Mean	Unit 2	Unit 3	Mean
01/08/90	–	3.1	3.1	–	4,421	4,421
01/09/90	3.0	4.0	3.5	4,518	4,222	4,370
01/10/90	–	3.5	3.5	–	3,610	3,610
01/11/90	5.0	–	5.0	3,944	–	3,944
01/13/90	–	3.5	3.5	–	3,461	3,461
01/14/90	3.5	3.5	3.5	3,873	3,791	3,832
01/16/90	3.0	–	3.0	4,183	–	4,183
01/18/90	–	5.5	5.5	–	1,508	1,508
01/20/90	–	5.5	5.5	–	1,361	1,361
01/22/90	2.5	2.5	2.5	2,804	2,932	2,868
01/23/90	5.5	–	5.5	2,956	–	2,956
01/24/90	–	6.0	6.0	–	4,444	4,444
01/27/90	–	4.5	4.5	–	1,889	1,889
01/28/90	3.5	3.5	3.5	293	288	290
01/31/90	–	7.0	7.0	–	250	250
02/02/90	–	6.7	6.7	–	285	285
02/04/90	5.0	–	5.0	241	–	241
02/05/90	–	5.0	5.0	–	229	229
02/06/90	–	3.0	3.0	–	259	259
02/07/90	–	2.2	2.2	–	262	262
02/08/90	2.5	–	2.5	245	–	245
02/10/90	–	7.5	7.5	–	222	222
02/11/90	5.2	–	5.2	229	–	229
02/12/90	–	5.5	5.5	–	223	223
02/13/90	4.2	–	4.2	211	–	211
02/16/90	–	4.0	4.0	–	217	217
02/23/90	–	5.0	5.0	–	927	927
02/26/90	–	5.0	5.0	–	268	268
02/28/90	–	6.0	6.0	–	217	217
03/01/90	–	6.2	6.2	–	217	217
03/05/90	–	2.0	2.0	–	227	227
03/06/90	–	5.0	5.0	–	260	260
03/10/90	–	5.0	5.0	–	1,467	1,467
03/27/90	–	7.0	7.0	–	178	178
03/28/90	–	8.0	8.0	–	160	160
03/29/90	–	6.5	6.5	–	173	173
04/03/90	–	9.0	9.0	–	180	180
04/10/90	–	7.7	7.7	–	183	183
04/11/90	–	9.5	9.5	–	189	189
04/14/90	–	9.7	9.7	–	257	257
04/17/90	–	8.5	8.5	–	172	172
04/18/90	–	9.5	9.5	–	186	186
04/19/90	–	9.8	9.8	–	182	182
04/20/90	–	9.8	9.8	–	196	196
04/21/90	–	10.0	10.0	–	266	266
04/22/90	–	10.1	10.1	–	180	180
04/24/90	–	11.0	11.0	–	285	285
04/25/90	–	10.8	10.8	–	220	220
04/26/90	–	12.0	12.0	–	181	181
05/05/90	–	14.0	14.0	–	166	166
05/07/90	–	11.5	11.5	–	242	242
05/10/90	–	15.5	15.5	–	460	460
05/14/90	15.9	–	15.9	181	–	181
05/25/90	–	15.4	15.4	–	174	174
05/27/90	–	16.6	16.6	–	170	170

NOTE: Dashes (–) = No data.

TABLE B-1 (Cont.)

Date	Temperature (C)			Conductivity (μS/cm)		
	Unit 2	Unit 3	Mean	Unit 2	Unit 3	Mean
06/26/90	22.0	22.0	22.0	1,145	1,378	1,261
06/27/90	25.0	29.5	27.3	2,590	2,091	2,340
06/28/90	–	24.5	24.5	–	1,331	1,331
06/29/90	23.0	–	23.0	1,251	–	1,251
06/30/90	24.0	–	24.0	1,464	–	1,464
07/02/90	23.8	–	23.8	2,254	–	2,254
07/05/90	–	26.0	26.0	–	4,390	4,390
07/09/90	–	27.0	27.0	–	6,363	6,363
07/10/90	24.0	–	24.0	4,881	–	4,881
07/11/90	28.0	24.0	26.0	4,966	5,287	5,127
07/12/90	23.5	23.5	23.5	5,034	5,137	5,085
07/13/90	23.5	24.0	23.8	5,342	5,897	5,620
07/14/90	24.5	24.5	24.5	4,604	4,579	4,592
07/15/90	24.0	–	24.0	4,677	–	4,677
07/16/90	25.0	24.5	24.8	5,180	5,133	5,156
07/17/90	25.0	24.5	24.8	4,781	5,334	5,058
07/18/90	26.0	25.5	25.8	4,880	5,226	5,053
07/19/90	26.0	26.0	26.0	4,880	5,172	5,026
07/20/90	–	26.0	26.0	–	4,977	4,977
07/21/90	27.5	27.0	27.3	5,017	4,877	4,947
07/22/90	29.0	26.0	27.5	4,591	4,977	4,784
07/23/90	–	28.0	28.0	–	3,561	3,561
07/24/90	28.2	27.0	27.6	4,797	3,079	3,938
07/25/90	26.0	26.0	26.0	2,655	2,889	2,772
07/26/90	26.0	26.5	26.3	2,879	3,082	2,980
07/27/90	26.5	26.5	26.5	2,734	5,014	3,874
07/28/90	26.5	26.5	26.5	3,217	3,304	3,260
07/29/90	27.0	27.0	27.0	3,682	3,978	3,830
07/30/90	26.5	27.0	26.8	2,917	2,582	2,750
07/31/90	29.0	28.0	28.5	5,326	5,528	5,427
08/01/90	25.0	25.0	25.0	5,080	4,582	4,831
08/02/90	28.0	28.0	28.0	7,402	6,559	6,981
08/03/90	31.0	28.5	29.8	8,113	7,884	7,999
08/04/90	27.5	27.0	27.3	9,750	9,658	9,704
08/05/90	27.4	27.9	27.6	9,864	9,859	9,862
08/06/90	27.3	–	27.3	9,980	–	9,980
08/07/90	27.9	28.5	28.2	8,450	9,090	8,770
08/08/90	25.9	26.0	26.0	4,890	4,880	4,885
08/09/90	26.0	26.0	26.0	3,562	3,709	3,635
08/10/90	27.0	26.5	26.8	3,825	4,106	3,965
08/11/90	27.0	26.0	26.5	3,729	3,025	3,377
08/12/90	26.0	26.0	26.0	2,225	2,342	2,284
08/13/90	–	26.5	26.5	–	2,029	2,029
08/14/90	27.0	25.0	26.0	2,175	1,195	1,685
08/15/90	27.0	27.0	27.0	1,052	1,291	1,171
08/16/90	27.5	27.0	27.3	710	813	761
08/17/90	27.0	27.0	27.0	669	813	741
08/18/90	27.0	27.5	27.3	404	549	476
08/19/90	27.0	27.0	27.0	359	798	579
08/20/90	26.0	27.0	26.5	415	693	554
08/21/90	27.0	26.0	26.5	765	371	568
08/22/90	26.0	26.0	26.0	405	390	398
08/23/90	27.0	26.2	26.6	765	408	587
08/24/90	25.8	26.5	26.1	390	580	485
08/25/90	25.5	26.0	25.8	377	376	376
08/26/90	26.5	27.0	26.8	377	368	372
08/27/90	26.0	25.5	25.8	262	266	264
08/28/90	26.0	26.0	26.0	283	288	285

TABLE B-1 (Cont.)

Date	Temperature (C)			Conductivity (μS/cm)		
	Unit 2	Unit 3	Mean	Unit 2	Unit 3	Mean
08/29/90	26.5	26.0	26.3	700	732	716
08/30/90	25.0	25.5	25.3	1,295	1,504	1,399
08/31/90	25.0	25.5	25.3	2,017	2,613	2,315
09/01/90	27.5	28.0	27.8	3,597	3,561	3,579
09/02/90	28.0	28.0	28.0	4,217	4,217	4,217
09/03/90	29.5	27.5	28.5	5,908	4,118	5,013
09/04/90	26.0	24.0	25.0	7,222	8,643	7,932
09/05/90	26.0	27.0	26.5	6,734	6,694	6,714
09/06/90	25.0	25.0	25.0	7,670	7,869	7,770
09/07/90	27.0	27.2	27.1	7,172	6,190	6,681
09/08/90	–	28.0	28.0	–	7,192	7,192
09/09/90	26.0	26.0	26.0	4,782	4,733	4,758
09/10/90	25.0	26.0	25.5	9,363	4,489	6,926
09/11/90	27.5	28.0	27.8	4,354	8,808	6,581
09/12/90	26.0	26.0	26.0	4,880	6,636	5,758
09/13/90	26.0	26.0	26.0	5,075	1,027	3,051
09/14/90	26.0	26.5	26.3	10,247	5,989	8,118
09/15/90	26.0	26.5	26.3	5,856	6,086	5,971
09/16/90	–	26.5	26.5	–	5,217	5,217
09/17/90	25.5	25.5	25.5	4,634	4,486	4,560
09/18/90	27.0	–	27.0	4,351	–	4,351
09/19/90	25.5	–	25.5	6,907	–	6,907
09/20/90	26.0	–	26.0	4,265	–	4,265
09/21/90	24.8	–	24.8	4,420	–	4,420
09/22/90	24.3	–	24.3	2,979	–	2,979
09/23/90	26.3	–	26.3	3,772	–	3,772
09/24/90	26.0	–	26.0	3,050	–	3,050
09/25/90	25.0	–	25.0	3,644	–	3,644
09/26/90	24.0	–	24.0	3,798	–	3,798
09/27/90	23.5	–	23.5	3,018	–	3,018
09/28/90	22.3	–	22.3	3,042	–	3,042
09/29/90	23.0	–	23.0	7,593	–	7,593
09/30/90	22.0	–	22.0	5,617	–	5,617
10/02/90	22.0	–	22.0	5,855	–	5,855
10/09/90	21.5	–	21.5	3,759	–	3,759
10/16/90	19.0	–	19.0	1,129	–	1,129
10/23/90	20.5	–	20.5	345	–	345
10/30/90	15.0	–	15.0	2,094	–	2,094
11/06/90	17.0	–	17.0	660	–	660
11/13/90	11.0	–	11.0	162	–	162
11/21/90	10.0	–	10.0	346	–	346
11/27/90	8.5	–	8.5	201	–	201
12/04/90	7.5	–	7.5	1,032	–	1,032
12/14/90	6.7	–	6.7	189	–	189
12/18/90	7.0	–	7.0	281	–	281
12/29/90	4.0	–	4.0	192	–	192

TABLE B-2 TOTAL NUMBER ACTUALLY COLLECTED BY TAXON AND MONTH AT INDIAN POINT UNIT 2 DURING 1990 (UNADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Alewife	7	–	NS	NS	–	6	9	1	5	11	7	–	46
Bay anchovy	–	–	NS	NS	–	2	119	12	376	59	3	–	571
American shad	–	–	NS	NS	–	–	23	4	20	3	6	–	56
Bluefish	–	–	NS	NS	–	87	28	7	15	1	–	–	138
Bluegill	1	2	NS	NS	–	–	–	3	15	21	28	3	73
Brown bullhead	2	2	NS	NS	–	1	–	–	1	–	–	3	9
Pumpkinseed	14	24	NS	NS	–	1	1	–	2	2	4	2	50
Black crappie	–	–	NS	NS	–	–	–	–	–	–	–	1	1
Carp	2	–	NS	NS	–	–	–	–	–	–	–	1	3
American eel	26	4	NS	NS	–	33	2	–	4	3	2	3	77
Goldfish	4	1	NS	NS	–	–	–	–	–	–	–	–	5
Golden shiner	2	7	NS	NS	–	–	–	–	–	–	–	1	10
Hogchoker	438	55	NS	NS	4	200	73	24	220	138	33	8	1,193
Tessellated darter	1	1	NS	NS	–	–	–	–	–	1	1	4	8
Banded killifish	4	1	NS	NS	–	1	1	–	–	–	–	–	7
Largemouth bass	–	–	NS	NS	–	–	–	2	–	–	–	–	2
Atlantic menhaden	–	–	NS	NS	–	4	1	1	12	5	–	–	23
Chain pickerel	1	–	NS	NS	–	–	–	–	–	–	–	–	1
Blueback herring	–	–	NS	NS	–	7	10	4	26	314	550	–	911
Atlantic silverside	–	–	NS	NS	–	–	–	–	–	1	–	–	1
Rainbow smelt	2	4	NS	NS	–	4	1	1	–	3	1	1	17
Spottail shiner	142	64	NS	NS	–	–	3	–	3	–	6	11	229
Striped bass	621	14	NS	NS	–	10	22	104	102	239	39	48	1,199
Atlantic tomcod	125	116	NS	NS	–	1,015	104	1,097	10	7	–	–	2,474
White catfish	145	26	NS	NS	–	16	17	6	5	4	15	19	253
White perch	37,135	8,169	NS	NS	7	899	239	85	176	278	369	2,415	49,772
Yellow perch	43	21	NS	NS	–	–	–	–	–	–	5	1	70
Redbreast sunfish	1	–	NS	NS	–	–	–	–	–	–	–	–	1
Atlantic needlefish	–	–	NS	NS	–	–	–	–	–	1	–	–	1
Crevalle jack	–	–	NS	NS	–	–	–	–	13	1	2	–	16
Weakfish	–	–	NS	NS	–	–	3	16	90	–	–	–	109
Lookdown	–	–	NS	NS	–	–	–	–	–	1	–	–	1
Clupeid unidentified	–	–	NS	NS	–	4	–	–	5	–	–	–	9
Winter flounder	3	–	NS	NS	–	–	–	–	–	–	–	1	4
Sea lamprey	3	–	NS	NS	–	–	–	–	–	–	–	–	3
Gizzard shad	189	1	NS	NS	–	–	–	–	1	1	10	34	236
Threespine stickleback	1	10	NS	NS	–	–	–	–	–	–	–	–	11
Butterfish	–	–	NS	NS	–	–	–	–	–	1	–	–	1
Red hake	1	–	NS	NS	–	–	–	–	–	–	–	–	1
Summer flounder	–	–	NS	NS	–	–	2	1	1	5	–	–	9
Creek chub	–	1	NS	NS	–	–	–	–	–	–	–	–	1
Striped searobin	–	–	NS	NS	–	–	–	–	1	–	–	–	1
Naked goby	–	–	NS	NS	–	–	–	–	1	–	–	1	2
Windowpane	–	–	NS	NS	–	–	1	–	1	–	–	–	2
Syngnathid unidentified	–	–	NS	NS	–	–	–	–	1	–	–	–	1
Gray snapper	–	–	NS	NS	–	–	–	–	–	–	1	–	1
Margined madtom	1	1	NS	NS	–	–	–	–	–	–	–	–	2
Freshwater drum	–	–	NS	NS	–	–	1	–	–	–	–	–	1
Sharptail goby	–	–	NS	NS	–	–	–	–	–	–	1	–	1
Total	38,914	8,524	NS	NS	11	2,290	660	1,368	1,106	1,100	1,083	2,557	57,613

NOTE: Dashes (–) = No catch; NS = Not sampled.

TABLE B-3 TOTAL NUMBER ACTUALLY COLLECTED BY TAXON AND MONTH AT INDIAN POINT UNIT 3 DURING 1990 (UNADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Alewife	17	3	–	5	16	6	58	43	4	NS	NS	NS	152
Bay anchovy	–	–	–	–	–	4	662	344	208	NS	NS	NS	1,218
American shad	–	–	–	10	1	–	100	139	20	NS	NS	NS	270
Bluefish	–	–	–	–	–	153	154	37	81	NS	NS	NS	425
Bluegill	–	–	1	2	1	–	1	4	1	NS	NS	NS	10
Brown bullhead	4	4	1	6	–	–	–	–	–	NS	NS	NS	15
Pumpkinseed	7	19	1	2	1	–	1	–	–	NS	NS	NS	31
Carp	1	–	–	–	–	–	–	–	–	NS	NS	NS	1
American eel	3	6	1	7	4	13	8	5	–	NS	NS	NS	47
Goldfish	4	5	–	3	–	–	–	–	–	NS	NS	NS	12
Golden shiner	2	8	1	3	–	–	–	–	–	NS	NS	NS	14
Hogchoker	156	51	3	398	95	77	120	522	644	NS	NS	NS	2,066
Tessellated darter	–	–	–	4	–	–	–	–	–	NS	NS	NS	4
Banded killifish	2	3	–	–	–	–	–	–	–	NS	NS	NS	5
Largemouth bass	1	1	–	1	–	–	4	–	–	NS	NS	NS	7
Atlantic menhaden	–	–	–	–	–	4	11	25	26	NS	NS	NS	66
Chain pickerel	2	1	–	–	–	–	–	–	–	NS	NS	NS	3
Blueback herring	–	1	–	–	1	41	38	289	80	NS	NS	NS	450
Atlantic silverside	–	–	1	–	–	–	–	–	–	NS	NS	NS	1
Rainbow smelt	–	1	–	4	–	8	17	114	–	NS	NS	NS	144
Smallmouth bass	1	–	–	–	–	–	–	–	–	NS	NS	NS	1
Spottail shiner	29	55	7	11	–	–	1	–	–	NS	NS	NS	103
Striped bass	312	23	3	6	1	6	33	140	25	NS	NS	NS	549
Atlantic tomcod	25	69	4	7	55	597	688	2,446	33	NS	NS	NS	3,924
White catfish	42	36	4	39	15	10	14	9	5	NS	NS	NS	174
White perch	22,741	12,341	394	2,589	239	534	384	623	93	NS	NS	NS	39,938
Yellow perch	4	4	1	1	–	–	–	1	–	NS	NS	NS	11
Redbreast sunfish	–	–	1	–	–	–	–	–	1	NS	NS	NS	2
Crevalle jack	–	–	–	–	–	–	1	11	5	NS	NS	NS	17
Weakfish	–	–	–	–	–	–	61	28	169	NS	NS	NS	258
Clupeid unidentified	1	–	–	–	–	4	12	26	4	NS	NS	NS	47
Spot	–	–	–	–	–	–	–	3	–	NS	NS	NS	3
Winter flounder	1	1	–	–	–	–	–	–	1	NS	NS	NS	3
Gizzard shad	718	31	2	1	2	–	–	–	–	NS	NS	NS	754
Threespine stickleback	1	12	–	–	–	–	–	–	–	NS	NS	NS	13
Butterfish	–	–	–	–	–	–	1	5	113	NS	NS	NS	119
Centrarchidae uniden.	–	–	–	–	–	–	–	1	–	NS	NS	NS	1
Red hake	3	–	–	–	–	–	–	–	–	NS	NS	NS	3
Summer flounder	–	–	–	–	–	–	10	7	7	NS	NS	NS	24
Northern searobin	–	–	–	–	–	–	1	–	–	NS	NS	NS	1
Hickory shad	–	–	–	–	–	–	–	1	–	NS	NS	NS	1
Channel catfish	–	–	1	–	–	–	–	–	–	NS	NS	NS	1
Windowpane	–	–	–	–	–	1	38	–	–	NS	NS	NS	39
Northern stargazer	–	–	–	–	–	–	–	–	1	NS	NS	NS	1
Gobiidae-gobies	–	–	–	–	–	–	–	9	–	NS	NS	NS	9
Margined madtom	1	–	–	–	–	–	–	–	–	NS	NS	NS	1
Total	24,078	12,675	426	3,099	431	1,458	2,418	4,832	1,521	NS	NS	NS	50,938

NOTE: Dashes (–) = No catch; NS = Not sampled.

TABLE B-4 TOTAL NUMBER ACTUALLY COLLECTED BY TAXON AND MONTH AT INDIAN POINT UNITS 2 AND 3 COMBINED DURING 1990 (UNADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Alewife	24	3	–	5	16	12	67	44	9	11	7	–	198
Bay anchovy	–	–	–	–	–	6	781	356	584	59	3	–	1,789
American shad	–	–	–	10	1	–	123	143	40	3	6	–	326
Bluefish	–	–	–	–	–	240	182	44	96	1	–	–	563
Bluegill	1	2	1	2	1	–	1	7	16	21	28	3	83
Brown bullhead	6	6	1	6	–	1	–	–	1	–	–	3	24
Pumpkinseed	21	43	1	2	1	1	2	–	2	2	4	2	81
Black crappie	–	–	–	–	–	–	–	–	–	–	–	1	1
Carp	3	–	–	–	–	–	–	–	–	–	–	1	4
American eel	29	10	1	7	4	46	10	5	4	3	2	3	124
Goldfish	8	6	–	3	–	–	–	–	–	–	–	–	17
Golden shiner	4	15	1	3	–	–	–	–	–	–	–	1	24
Hogchoker	594	106	3	398	99	277	193	546	864	138	33	8	3,259
Tessellated darter	1	1	–	4	–	–	–	–	–	1	1	4	12
Banded killifish	6	4	–	–	–	1	1	–	–	–	–	–	12
Largemouth bass	1	1	–	1	–	–	4	2	–	–	–	–	9
Atlantic menhaden	–	–	–	–	–	8	12	26	38	5	–	–	89
Chain pickerel	3	1	–	–	–	–	–	–	–	–	–	–	4
Blueback herring	–	1	–	–	1	48	48	293	106	314	550	–	1,361
Atlantic silverside	–	–	1	–	–	–	–	–	–	1	–	–	2
Rainbow smelt	2	5	–	4	–	12	18	115	–	3	1	1	161
Smallmouth bass	1	–	–	–	–	–	–	–	–	–	–	–	1
Spottail shiner	171	119	7	11	–	–	4	–	3	–	6	11	332
Striped bass	933	37	3	6	1	16	55	244	127	239	39	48	1,748
Atlantic tomcod	150	185	4	7	55	1,612	792	3,543	43	7	–	–	6,398
White catfish	187	62	4	39	15	26	31	15	10	4	15	19	427
White perch	59,876	20,510	394	2,589	246	1,433	623	708	269	278	369	2,415	89,710
Yellow perch	47	25	1	1	–	–	–	1	–	–	5	1	81
Redbreast sunfish	1	–	1	–	–	–	–	–	1	–	–	–	3
Atlantic needlefish	–	–	–	–	–	–	–	–	–	1	–	–	1
Crevalle jack	–	–	–	–	–	–	1	11	18	1	2	–	33
Weakfish	–	–	–	–	–	–	64	44	259	–	–	–	367
Lookdown	–	–	–	–	–	–	–	–	–	1	–	–	1
Clupeid unidentified	1	–	–	–	–	8	12	26	9	–	–	–	56
Spot	–	–	–	–	–	–	–	3	–	–	–	–	3
Winter flounder	4	1	–	–	–	–	–	–	1	–	–	1	7
Sea lamprey	3	–	–	–	–	–	–	–	–	–	–	–	3
Gizzard shad	907	32	2	1	2	–	–	–	1	1	10	34	990
Threespine stickleback	2	22	–	–	–	–	–	–	–	–	–	–	24
Butterfish	–	–	–	–	–	–	1	5	113	1	–	–	120
Centrarchidae unid.	–	–	–	–	–	–	–	1	–	–	–	–	1
Red hake	4	–	–	–	–	–	–	–	–	–	–	–	4
Summer flounder	–	–	–	–	–	–	12	8	8	5	–	–	33
Creek chub	–	1	–	–	–	–	–	–	–	–	–	–	1
Striped searobin	–	–	–	–	–	–	–	–	1	–	–	–	1
Northern searobin	–	–	–	–	–	–	1	–	–	–	–	–	1
Hickory shad	–	–	–	–	–	–	–	1	–	–	–	–	1
Channel catfish	–	–	1	–	–	–	–	–	–	–	–	–	1
Naked goby	–	–	–	–	–	–	–	–	1	–	–	1	2
Windowpane	–	–	–	–	–	1	39	–	1	–	–	–	41
Northern stargazer	–	–	–	–	–	–	–	–	1	–	–	–	1
Gobiidae-gobies	–	–	–	–	–	–	–	9	–	–	–	–	9
Syngnathid uniden.	–	–	–	–	–	–	–	–	1	–	–	–	1
Gray snapper	–	–	–	–	–	–	–	–	–	–	1	–	1
Margined madtom	2	1	–	–	–	–	–	–	–	–	–	–	3
Freshwater drum	–	–	–	–	–	–	1	–	–	–	–	–	1
Sharptail goby	–	–	–	–	–	–	–	–	–	–	1	–	1
Total	62,992	21,199	426	3,099	442	3,748	3,078	6,200	2,627	1,100	1,083	2,557	108,551

NOTE: Dashes (–) = No catch.

TABLE B-5 TOTAL NUMBER ACTUALLY COLLECTED BY TAXON AND SEASONAL STRATUM AT INDIAN POINT UNIT 2 DURING 1990 (UNADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Stratum				Total
	Winter	Spring	Summer	Fall	
Alewife	7	6	15	18	46
Bay anchovy	–	2	507	62	571
American shad	–	–	47	9	56
Bluefish	–	87	50	1	138
Bluegill	3	–	18	52	73
Brown bullhead	4	1	1	3	9
Pumpkinseed	38	1	3	8	50
Black crappie	–	–	–	1	1
Carp	2	–	–	1	3
American eel	30	33	6	8	77
Goldfish	5	–	–	–	5
Golden shiner	9	–	–	1	10
Hogchoker	493	204	317	179	1,193
Tessellated darter	2	–	–	6	8
Banded killifish	5	1	1	–	7
Largemouth bass	–	–	2	–	2
Atlantic menhaden	–	4	14	5	23
Chain pickerel	1	–	–	–	1
Blueback herring	–	7	40	864	911
Atlantic silverside	–	–	–	1	1
Rainbow smelt	6	4	2	5	17
Spottail shiner	206	–	6	17	229
Striped bass	635	10	228	326	1,199
Atlantic tomcod	241	1,015	1,211	7	2,474
White catfish	171	16	28	38	253
White perch	45,304	906	500	3,062	49,772
Yellow perch	64	–	–	6	70
Redbreast sunfish	1	–	–	–	1
Atlantic needlefish	–	–	–	1	1
Crevalle jack	–	–	13	3	16
Weakfish	–	–	109	–	109
Lookdown	–	–	–	1	1
Clupeid unidentified	–	4	5	–	9
Winter flounder	3	–	–	1	4
Sea lamprey	3	–	–	–	3
Gizzard shad	190	–	1	45	236
Threespine stickleback	11	–	–	–	11
Butterfish	–	–	–	1	1
Red hake	1	–	–	–	1
Summer flounder	–	–	4	5	9
Creek chub	1	–	–	–	1
Striped searobin	–	–	1	–	1
Naked goby	–	–	1	1	2
Windowpane	–	–	2	–	2
Syngnathid unidentified	–	–	1	–	1
Gray snapper	–	–	–	1	1
Margined madtom	2	–	–	–	2
Freshwater drum	–	–	1	–	1
Sharptail goby	–	–	–	1	1
Total	47,438	2,301	3,134	4,740	57,613

NOTE: Dashes (–) = No catch.

TABLE B-6 TOTAL NUMBER ACTUALLY COLLECTED BY TAXON AND SEASONAL STRATUM AT INDIAN POINT UNIT 3 DURING 1990 (UNADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Stratum			Total
	Winter	Spring	Summer	
Alewife	20	27	105	152
Bay anchovy	–	4	1,214	1,218
American shad	–	11	259	270
Bluefish	–	153	272	425
Bluegill	1	3	6	10
Brown bullhead	9	6	–	15
Pumpkinseed	27	3	1	31
Carp	1	–	–	1
American eel	10	24	13	47
Goldfish	9	3	–	12
Golden shiner	11	3	–	14
Hogchoker	210	570	1,286	2,066
Tesselated darter	–	4	–	4
Banded killifish	5	–	–	5
Largemouth bass	2	1	4	7
Atlantic menhaden	–	4	62	66
Chain pickerel	3	–	–	3
Blueback herring	1	42	407	450
Atlantic silverside	1	–	–	1
Rainbow smelt	1	12	131	144
Smallmouth bass	1	–	–	1
Spottail shiner	91	11	1	103
Striped bass	338	13	198	549
Atlantic tomcod	98	659	3,167	3,924
White catfish	82	64	28	174
White perch	35,476	3,362	1,100	39,938
Yellow perch	9	1	1	11
Redbreast sunfish	1	–	1	2
Crevalle jack	–	–	17	17
Weakfish	–	–	258	258
Clupeid unidentified	1	4	42	47
Spot	–	–	3	3
Winter flounder	2	–	1	3
Gizzard shad	751	3	–	754
Threespine stickleback	13	–	–	13
Butterfish	–	–	119	119
Centrarchidae unidentified	–	–	1	1
Red hake	3	–	–	3
Summer flounder	–	–	24	24
Northern searobin	–	–	1	1
Hickory shad	–	–	1	1
Channel catfish	1	–	–	1
Windowpane	–	1	38	39
Northern stargazer	–	–	1	1
Gobiidae-gobies	–	–	9	9
Margined madtom	1	–	–	1
Total	37,179	4,988	8,771	50,938

NOTE: Dashes (–) = No catch.

TABLE B-7 TOTAL NUMBER ACTUALLY COLLECTED BY TAXON AND SEASONAL STRATUM AT INDIAN POINT UNITS 2 AND 3 COMBINED DURING 1990 (UNADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Stratum				Total
	Winter	Spring	Summer	Fall	
Alewife	27	33	120	18	198
Bay anchovy	–	6	1,721	62	1,789
American shad	–	11	306	9	326
Bluefish	–	240	322	1	563
Bluegill	4	3	24	52	83
Brown bullhead	13	7	1	3	24
Pumpkinseed	65	4	4	8	81
Black crappie	–	–	–	1	1
Carp	3	–	–	1	4
American eel	40	57	19	8	124
Goldfish	14	3	–	–	17
Golden shiner	20	3	–	1	24
Hogchoker	703	774	1,603	179	3,259
Tessellated darter	2	4	–	6	12
Banded killifish	10	1	1	–	12
Largemouth bass	2	1	6	–	9
Atlantic menhaden	–	8	76	5	89
Chain pickerel	4	–	–	–	4
Blueback herring	1	49	447	864	1,361
Atlantic silverside	1	–	–	1	2
Rainbow smelt	7	16	133	5	161
Smallmouth bass	1	–	–	–	1
Spottail shiner	297	11	7	17	332
Striped bass	973	23	426	326	1,748
Atlantic tomcod	339	1,674	4,378	7	6,398
White catfish	253	80	56	38	427
White perch	80,780	4,268	1,600	3,062	89,710
Yellow perch	73	1	1	6	81
Redbreast sunfish	2	–	1	–	3
Atlantic needlefish	–	–	–	1	1
Crevalle jack	–	–	30	3	33
Weakfish	–	–	367	–	367
Lookdown	–	–	–	1	1
Clupeid unidentified	1	8	47	–	56
Spot	–	–	3	–	3
Winter flounder	5	–	1	1	7
Sea lamprey	3	–	–	–	3
Gizzard shad	941	3	1	45	990
Threespine stickleback	24	–	–	–	24
Butterfish	–	–	119	1	120
Centrarchidae unidentified	–	–	1	–	1
Red hake	4	–	–	–	4
Summer flounder	–	–	28	5	33
Creek chub	1	–	–	–	1
Striped searobin	–	–	1	–	1
Northern searobin	–	–	1	–	1
Hickory shad	–	–	1	–	1
Channel catfish	1	–	–	–	1
Naked goby	–	–	1	1	2
Windowpane	–	1	40	–	41
Northern stargazer	–	–	1	–	1
Gobiidae-gobies	–	–	9	–	9
Syngnathid unidentified	–	–	1	–	1
Gray snapper	–	–	–	1	1
Margined madtom	3	–	–	–	3
Freshwater drum	–	–	1	–	1
Sharptail goby	–	–	–	1	1
Total	84,617	7,289	11,905	4,740	108,551

NOTE: Dashes (–) = No catch.

TABLE B-8 TOTAL ESTIMATED WEIGHT (GRAMS) OF FISH IMPINGED AT INDIAN POINT UNIT 2 DURING 1990, BY TAXON AND SEASONAL STRATUM (ADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Stratum				Total
	Winter	Spring	Summer	Fall	
Alewife	1,035	25,818	12,673	4,154	43,680
Bay anchovy	--	481	47,112	2,045	49,638
American shad	--	--	5,098	807	5,905
Bluefish	--	12,363	11,899	524	24,786
Bluegill	4,913	--	1,480	4,087	10,480
Brown bullhead	6,480	13,104	1,595	2,799	23,978
Pumpkinseed	26,010	4,914	2,430	1,025	34,379
Black crappie	--	--	--	50	50
Carp	2,798	--	--	630	3,428
American eel	79,148	169,689	11,400	15,528	275,765
Goldfish	14,610	--	--	--	14,610
Golden shiner	3,525	--	--	42	3,567
Hogchoker	79,860	86,866	110,937	37,854	315,517
Tessellated darter	83	--	--	315	398
Banded killifish	465	152	84	--	701
Largemouth bass	--	--	330	--	330
Atlantic menhaden	--	65,854	18,615	2,668	87,137
Chain pickerel	3,720	--	--	--	3,720
Blueback herring	--	21,203	18,722	36,984	76,909
Atlantic silverside	--	--	--	64	64
Rainbow smelt	1,313	1,482	1,702	78	4,575
Spottail shiner	14,685	--	1,426	1,260	17,371
Striped bass	148,620	5,434	38,755	36,283	229,092
Atlantic tomcod	58,553	406,146	390,655	2,994	858,348
White catfish	70,523	9,516	66,792	5,202	152,033
White perch	2,985,578	800,111	509,634	419,553	4,714,876
Yellow perch	32,640	--	--	3,036	35,676
Redbreast sunfish	1,373	--	--	--	1,373
Atlantic needlefish	--	--	--	21	21
Crevalle jack	--	--	644	1,536	2,180
Weakfish	--	--	21,106	--	21,106
Lookdown	--	--	--	42	42
Clupeid unidentified	--	106	1,058	--	1,164
Winter flounder	450	--	--	439	889
Sea lamprey	263	--	--	--	263
Gizzard shad	92,310	--	230	4,377	96,917
Threespine stickleback	300	--	--	--	300
Butterfish	--	--	--	149	149
Red hake	113	--	--	--	113
Summer flounder	--	--	5,190	25,258	30,448
Creek chub	30	--	--	--	30
Striped searobin	--	--	77	--	77
Naked goby	--	--	23	14	37
Windowpane	--	--	330	--	330
Syngnathid unidentified	--	--	130	--	130
Gray snapper	--	--	--	85	85
Margined madtom	758	--	--	--	758
Freshwater drum	--	--	38	--	38
Sharptail goby	--	--	--	99	99
Total	3,630,156	1,623,239	1,280,165	610,002	7,143,562

NOTE: Dashes (--) = No catch.

TABLE B-9 TOTAL ESTIMATED WEIGHT (GRAMS) OF FISH IMPINGED AT INDIAN POINT UNIT 3 DURING 1990, BY TAXON AND SEASONAL STRATUM (ADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Stratum			
	Winter	Spring	Summer	Total
Alewife	1,262	30,700	5,604	37,566
Bay anchovy	–	145	22,393	22,538
American shad	–	66,947	5,220	72,167
Bluefish	–	4,372	10,367	14,739
Bluegill	8	575	991	1,574
Brown bullhead	6,130	6,122	–	12,252
Pumpkinseed	6,383	1,191	533	8,107
Carp	308	–	–	308
American eel	6,782	34,853	7,222	48,857
Goldfish	9,441	4,736	–	14,177
Golden shiner	1,180	347	–	1,527
Hogchoker	13,857	51,953	93,755	159,565
Tessellated darter	–	120	–	120
Banded killifish	146	–	–	146
Largemouth bass	4,865	91	563	5,519
Atlantic menhaden	–	6,730	12,753	19,483
Chain pickerel	4,628	–	–	4,628
Blueback herring	116	36,057	22,332	58,505
Atlantic silverside	33	–	–	33
Rainbow smelt	77	782	659	1,518
Smallmouth bass	759	–	–	759
Spottail shiner	2,272	447	41	2,760
Striped bass	27,747	1,663	9,640	39,050
Atlantic tomcod	11,473	131,301	111,942	254,716
White catfish	29,364	46,191	17,976	93,531
White perch	902,421	234,007	192,929	1,329,357
Yellow perch	4,518	112	1,498	6,128
Redbreast sunfish	–	–	319	319
Crevalle jack	–	–	164	164
Weakfish	–	–	6,785	6,785
Clupeid unidentified	17	17	308	342
Spot	–	–	317	317
Winter flounder	195	–	18	213
Gizzard shad	189,695	5,923	–	195,618
Threespine stickleback	132	–	–	132
Butterfish	–	–	4,016	4,016
Centrarchidae unidentified	–	–	6	6
Red hake	1,009	–	–	1,009
Summer flounder	–	–	8,116	8,116
Northern searobin	–	–	689	689
Hickory shad	–	–	862	862
Channel catfish	292	–	–	292
Windowpane	–	8	299	307
Northern stargazer	–	–	12	12
Gobiidae-gobies	–	–	79	79
Margined madtom	72	–	–	72
Total	1,225,182	665,390	538,408	2,428,980

NOTE: Dashes (–) = No catch.

TABLE B-10 TOTAL ESTIMATED WEIGHT (GRAMS) OF FISH IMPINGED AT INDIAN POINT UNITS 2 AND 3 COMBINED DURING 1990, BY TAXON AND SEASONAL STRATUM (ADJUSTED FOR COLLECTION EFFICIENCY)

Taxon	Stratum				Total
	Winter	Spring	Summer	Fall	
Alewife	2,297	56,518	18,277	4,154	81,246
Bay anchovy	–	626	69,505	2,045	72,176
American shad	–	66,947	10,318	807	78,072
Bluefish	–	16,735	22,266	524	39,525
Bluegill	4,921	575	2,471	4,087	12,054
Brown bullhead	12,610	19,226	1,595	2,799	36,230
Pumpkinseed	32,393	6,105	2,963	1,025	42,486
Black crappie	–	–	–	50	50
Carp	3,106	–	–	630	3,736
American eel	85,930	204,542	18,622	15,528	324,622
Goldfish	24,051	4,736	–	–	28,787
Golden shiner	4,705	347	–	42	5,094
Hogchoker	93,717	138,819	204,692	37,854	475,082
Tessellated darter	83	120	–	315	518
Banded killifish	611	152	84	–	847
Largemouth bass	4,865	91	893	–	5,849
Atlantic menhaden	–	72,584	31,368	2,668	106,620
Chain pickerel	8,348	–	–	–	8,348
Blueback herring	116	57,260	41,054	36,984	135,414
Atlantic silverside	33	–	–	64	97
Rainbow smelt	1,390	2,264	2,361	78	6,093
Smallmouth bass	759	–	–	–	759
Spottail shiner	16,957	447	1,467	1,260	20,131
Striped bass	176,367	7,097	48,395	36,283	268,142
Atlantic tomcod	70,026	537,447	502,597	2,994	1,113,064
White catfish	99,887	55,707	84,768	5,202	245,564
White perch	3,887,999	1,034,118	702,563	419,553	6,044,233
Yellow perch	37,158	112	1,498	3,036	41,804
Redbreast sunfish	1,373	–	319	–	1,692
Atlantic needlefish	–	–	–	21	21
Crevalle jack	–	–	808	1,536	2,344
Weakfish	–	–	27,891	–	27,891
Lookdown	–	–	–	42	42
Clupeid unidentified	17	123	1,366	–	1,506
Spot	–	–	317	–	317
Winter flounder	645	–	18	439	1,102
Sea lamprey	263	–	–	–	263
Gizzard shad	282,005	5,923	230	4,377	292,535
Threespine stickleback	432	–	–	–	432
Butterfish	–	–	4,016	149	4,165
Centrarchidae unidentified	–	–	6	–	6
Red hake	1,122	–	–	–	1,122
Summer flounder	–	–	13,306	25,258	38,564
Creek chub	30	–	–	–	30
Striped searobin	–	–	77	–	77
Northern searobin	–	–	689	–	689
Hickory shad	–	–	862	–	862
Channel catfish	292	–	–	–	292
Naked goby	–	–	23	14	37
Windowpane	–	8	629	–	637
Northern stargazer	–	–	12	–	12
Gobiidae-gobies	–	–	79	–	79
Syngnathid unidentified	–	–	130	–	130
Gray snapper	–	–	–	85	85
Margined madtom	830	–	–	–	830
Freshwater drum	–	–	38	–	38
Sharptail goby	–	–	–	99	99
Total	4,855,338	2,288,629	1,818,573	610,002	9,572,542

NOTE: Dashes (–) = No catch.

TABLE B-11 TOTAL NUMBER OF BLUE CRAB COLLECTED EACH MONTH AT INDIAN POINT UNITS 2 AND 3 DURING 1990

Unit 2	Month												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Male/Alive													
Intact	0	0	NS	NS	0	74	316	718	730	94	47	0	1,979
Missing parts	0	0	NS	NS	0	102	459	923	646	107	23	0	2,260
Male/Dead													
Intact	0	0	NS	NS	0	16	44	84	34	11	0	0	189
Missing parts	0	0	NS	NS	0	38	143	295	168	18	3	0	665
Female/Alive													
Intact	0	0	NS	NS	0	21	170	252	291	49	14	0	797
Missing parts	0	0	NS	NS	0	30	237	416	282	33	17	0	1,015
Female/Dead													
Intact	0	0	NS	NS	0	4	30	19	23	0	0	0	357
Missing parts	0	0	NS	NS	0	11	98	130	111	5	2	0	433
Undetermined/Alive													
Intact	0	0	NS	NS	0	0	0	0	0	0	0	0	0
Missing parts	0	0	NS	NS	0	0	0	0	0	0	0	0	0
Undetermined/Dead													
Intact	0	0	NS	NS	0	0	0	0	0	0	0	0	0
Missing parts	0	0	NS	NS	0	0	0	1	0	0	0	0	1

NOTE: Excludes crabs for which information for all categories was not recorded.
NS = Not sampled.

TABLE B-11 (Cont.)

Unit 3	Month												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Male/Alive													
Intact	1	0	0	0	7	47	279	386	197	NS	NS	NS	917
Missing parts	0	0	0	0	4	41	367	508	201	NS	NS	NS	1,121
Male/Dead													
Intact	0	0	0	0	1	16	40	34	16	NS	NS	NS	107
Missing parts	0	0	0	0	0	28	145	187	56	NS	NS	NS	416
Female/Alive													
Intact	0	0	0	0	4	8	165	186	113	NS	NS	NS	476
Missing parts	0	0	0	0	2	10	193	234	113	NS	NS	NS	552
Female/Dead													
Intact	0	0	0	0	0	2	27	22	14	NS	NS	NS	65
Missing parts	0	0	0	0	0	4	59	72	37	NS	NS	NS	172
Undetermined/Alive													
Intact	0	0	0	0	0	0	0	0	0	NS	NS	NS	0
Missing parts	0	0	0	0	0	0	0	0	0	NS	NS	NS	0
Undetermined/Dead													
Intact	0	0	0	0	0	0	0	0	0	NS	NS	NS	0
Missing parts	0	0	0	0	0	0	0	0	2	NS	NS	NS	2

TABLE B-11 (Cont.)

Units 2 and 3	Month												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Male/Alive													
Intact	1	0	0	0	7	121	595	1,104	927	94	47	0	2,896
Missing parts	0	0	0	0	4	143	826	1,431	847	107	23	0	3,381
Male/Dead													
Intact	0	0	0	0	1	32	84	118	50	11	0	0	296
Missing parts	0	0	0	0	0	66	288	482	224	18	3	0	1,081
Female/Alive													
Intact	0	0	0	0	4	29	335	438	404	49	14	0	1,273
Missing parts	0	0	0	0	2	40	430	650	395	33	17	0	1,567
Female/Dead													
Intact	0	0	0	0	0	6	57	41	37	0	0	0	141
Missing parts	0	0	0	0	0	15	157	202	148	5	2	0	529
Undetermined/Alive													
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
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	2	0	0	0	3

TABLE B-12 CARAPACE WIDTH (MM) DISTRIBUTION BY MONTH OF BLUE CRAB IN IMPINGEMENT COLLECTIONS AT INDIAN POINT DURING 1990

UNIT 2										
Month	10.0-<20.0	20.0-<30.0	30.0-<40.0	40.0-<50.0	50.0-<60.0	60.0-<70.0	70.0-<80.0	80.0-<90.0	90.0-<100.0	100.0-<110.0
JAN	---	---	---	---	---	---	---	---	---	---
FEB	---	---	---	---	---	---	---	---	---	---
MAR	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
APR	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
MAY	---	---	---	---	---	---	---	---	---	---
JUN	---	3	10	21	31	42	41	15	18	23
JUL	---	2	28	62	131	201	252	247	141	89
AUG	---	1	3	11	67	210	506	600	381	363
SEP	---	11	31	63	37	14	70	207	299	352
OCT	---	2	22	49	27	25	6	12	27	32
NOV	---	---	6	22	21	17	7	9	9	8
DEC	---	---	---	---	---	---	---	---	---	---
Total	---	19	100	228	314	509	882	1,090	875	867
Month	110.0-<120.0	120.0-<130.0	130.0-<140.0	140.0-<150.0	150.0-<160.0	160.0-<170.0	170.0-<180.0	180.0-<190.0	190.0-<200.0	≥200.0
JAN	---	---	---	---	---	---	---	---	---	---
FEB	---	---	---	---	---	---	---	---	---	---
MAR	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
APR	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
MAY	---	---	---	---	---	---	---	---	---	---
JUN	34	31	17	5	2	1	---	---	---	---
JUL	70	72	82	59	24	14	3	2	---	---
AUG	234	99	100	105	94	31	11	4	---	---
SEP	247	153	175	266	212	82	28	11	2	---
OCT	35	15	18	18	9	12	3	3	2	---
NOV	3	1	2	---	1	---	---	---	---	---
DEC	---	---	---	---	---	---	---	---	---	---
Total	623	371	394	453	342	140	45	20	4	---

NOTE: Dashes (---) = No catch; NS = Not sampled.

TABLE B-12 (Cont.)

UNIT 3										
Month	10.0-<20.0	20.0-<30.0	30.0-<40.0	40.0-<50.0	50.0-<60.0	60.0-<70.0	70.0-<80.0	80.0-<90.0	90.0-<100.0	100.0-<110.0
JAN	---	---	---	---	---	---	---	---	---	---
FEB	---	---	---	---	---	---	---	---	---	---
MAR	---	---	---	---	---	---	---	---	---	---
APR	---	---	---	---	---	---	---	---	---	---
MAY	---	---	3	3	5	1	1	2	2	1
JUN	---	1	4	10	13	22	24	7	8	17
JUL	---	5	20	77	103	206	237	212	127	73
AUG	---	1	3	6	43	141	293	369	249	238
SEP	---	17	10	6	3	16	44	72	101	106
OCT	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
NOV	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
DEC	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Total	---	24	40	102	167	386	599	662	487	435

Month	110.0-<120.0	120.0-<130.0	130.0-<140.0	140.0-<150.0	150.0-<160.0	160.0-<170.0	170.0-<180.0	180.0-<190.0	190.0-<200.0	≥200.0
JAN	---	1	---	---	---	---	---	---	---	---
FEB	---	---	---	---	---	---	---	---	---	---
MAR	---	---	---	---	---	---	---	---	---	---
APR	---	---	---	---	---	---	---	---	---	---
MAY	---	---	---	---	---	---	---	---	---	---
JUN	11	16	9	9	4	---	1	---	---	---
JUL	61	27	37	45	22	11	2	---	---	---
AUG	99	61	29	39	37	12	4	2	1	1
SEP	80	52	54	70	73	26	5	4	---	---
OCT	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
NOV	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
DEC	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Total	251	157	129	163	136	49	12	6	1	1

TABLE B-12 (Cont.)

UNITS 2 & 3 COMBINED

Month	10.0-<20.0	20.0-<30.0	30.0-<40.0	40.0-<50.0	50.0-<60.0	60.0-<70.0	70.0-<80.0	80.0-<90.0	90.0-<100.0	100.0-<110.0
JAN	---	---	---	---	---	---	---	---	---	---
FEB	---	---	---	---	---	---	---	---	---	---
MAR	---	---	---	---	---	---	---	---	---	---
APR	---	---	---	---	---	---	---	---	---	---
MAY	---	---	3	3	5	1	1	2	2	1
JUN	---	4	14	31	44	64	65	22	26	40
JUL	---	7	48	139	234	407	489	459	268	162
AUG	---	2	6	17	110	351	799	969	630	601
SEP	---	28	41	69	40	30	114	279	400	458
OCT	---	2	22	49	27	25	6	12	27	32
NOV	---	---	6	22	21	17	7	9	9	8
DEC	---	---	---	---	---	---	---	---	---	---
Total	---	43	140	330	481	895	1,481	1,752	1,362	1,302

Month	110.0-<120.0	120.0-<130.0	130.0-<140.0	140.0-<150.0	150.0-<160.0	160.0-<170.0	170.0-<180.0	180.0-<190.0	190.0-<200.0	≥200
JAN	---	1	---	---	---	---	---	---	---	---
FEB	---	---	---	---	---	---	---	---	---	---
MAR	---	---	---	---	---	---	---	---	---	---
APR	---	---	---	---	---	---	---	---	---	---
MAY	---	---	---	---	---	---	---	---	---	---
JUN	45	47	26	14	6	1	1	---	---	---
JUL	131	99	119	104	46	25	5	2	---	---
AUG	333	160	129	144	131	43	15	6	1	1
SEP	327	205	229	336	285	108	33	15	2	---
OCT	35	15	18	18	9	12	3	3	2	---
NOV	3	1	2	---	1	---	---	---	---	---
DEC	---	---	---	---	---	---	---	---	---	---
Total	874	528	523	616	478	189	57	26	5	1

TABLE B-13 PROPORTION OF SUBSAMPLED BLUE CRAB BY SEX, SURVIVAL, AND CONDITION AT INDIAN POINT UNITS 2 AND 3 DURING 1990

Unit	Sex	Survival	Condition	Total	I/M, A/D BY M/F %[a]	I VS M BY A/D %[b]	I VS M BY M/F %[c]	A VS D BY M/F %[d]	M VS F %[e]
2	Male	Alive	Intact	1,979	38.9	46.7	42.6	83.2	69.4
			Missing Parts	2,260	44.4	53.3			
		Dead	Intact	189	3.7	22.1		16.8	
			Missing Parts	665	13.1	77.9	57.4		
	Female	Alive	Intact	797	35.5	44.0	38.9	80.7	30.6
			Missing Parts	1,015	45.2	56.0			
		Dead	Intact	76	3.4	17.6		19.3	
			Missing Parts	357	15.9	82.5	61.1		
3	Male	Alive	Intact	917	35.8	45.0	40.0	79.6	66.9
			Missing Parts	1,121	43.8	55.0			
		Dead	Intact	107	4.2	20.5		20.4	
			Missing Parts	416	16.2	79.5	60.0		
	Female	Alive	Intact	476	37.6	46.3	42.8	81.3	33.1
			Missing Parts	552	43.6	53.7			
		Dead	Intact	65	5.1	27.4		18.7	
			Missing Parts	172	13.6	72.6	57.2		
2 & 3	Male	Alive	Intact	2,896	37.8	46.1	41.7	82.0	68.6
			Missing Parts	3,381	44.2	53.9			
		Dead	Intact	296	3.9	21.5		18.0	
			Missing Parts	1,081	14.1	78.5	58.3		
	Female	Alive	Intact	1,273	36.3	44.8	40.3	80.9	31.4
			Missing Parts	1,567	44.6	55.2			
		Dead	Intact	141	4.0	21.0		19.1	
			Missing Parts	529	15.1	79.0	59.7		

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 by sex and unit.
d. Percent of alive and dead crabs by sex and unit.
e. Percent of male and female crabs by unit.

APPENDIX C

INDIAN POINT PLANT OPERATIONS, 1973-1990

APPENDIX C

LIST OF TABLES

TABLE C-1 MONTHLY COOLING WATER FLOW AVERAGES AT INDIAN POINT, 1973-1990

Year	Month	Gallons per Minute x 1,000								
		Unit 1			Unit 2			Unit 3		
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
1973	JAN	—	—	—	—	—	—	—	—	—
	FEB	—	—	—	—	—	—	—	—	—
	MAR	—	—	—	—	—	—	—	—	—
	APR	—	—	—	—	—	—	—	—	—
	MAY	—	—	—	—	—	—	—	—	—
	JUN	—	—	—	—	—	—	—	—	—
	JUL	—	—	—	—	—	—	—	—	—
	AUG	—	—	—	—	—	—	—	—	—
	SEP	—	—	—	—	—	—	—	—	—
	OCT	0.0	165.6	39.9	0.0	476.0	333.3	0.0	0.0	0.0
	NOV	0.0	89.0	48.9	0.0	308.5	106.5	0.0	0.0	0.0
	DEC	40.6	93.5	70.3	0.0	84.0	57.0	0.0	0.0	0.0
1974	JAN	71.4	143.4	99.8	0.0	504.0	92.1	0.0	0.0	0.0
	FEB	79.0	143.9	141.6	0.0	168.0	78.3	0.0	0.0	0.0
	MAR	100.4	143.9	140.2	0.0	420.0	172.8	0.0	0.0	0.0
	APR	143.9	143.9	143.9	84.0	700.0	343.0	0.0	0.0	0.0
	MAY	48.0	280.0	187.0	140.0	840.0	559.3	0.0	0.0	0.0
	JUN	140.0	280.0	274.3	280.0	840.0	739.4	0.0	0.0	0.0
	JUL	0.0	280.0	245.3	140.0	840.0	681.5	0.0	0.0	0.0
	AUG	158.1	280.0	275.3	140.0	840.0	704.1	0.0	0.0	0.0
	SEP	242.3	280.0	277.9	280.0	840.0	703.8	0.0	0.0	0.0
	OCT	140.0	280.0	265.4	140.0	700.0	530.5	0.0	0.0	0.0
	NOV	0.0	280.0	94.2	212.9	669.4	401.3	0.0	0.0	0.0
	DEC	84.0	168.0	118.9	252.0	336.0	264.4	0.0	0.0	0.0
1975	JAN	—	—	—	79.1	358.2	284.1	0.0	0.0	0.0
	FEB	—	—	—	60.4	534.9	316.2	0.0	0.0	0.0
	MAR	—	—	—	0.0	518.4	169.8	0.0	0.0	0.0
	APR	—	—	—	168.1	840.0	477.4	0.0	0.0	0.0
	MAY	—	—	—	168.1	840.0	663.3	0.0	0.0	0.0
	JUN	—	—	—	611.0	840.0	810.5	0.0	0.0	0.0
	JUL	—	—	—	0.0	840.0	732.4	0.0	0.0	0.0
	AUG	—	—	—	0.0	840.0	492.6	0.0	0.0	0.0
	SEP	—	—	—	140.1	840.0	700.8	0.0	0.0	0.0
	OCT	—	—	—	0.0	840.0	428.2	0.0	0.0	0.0
	NOV	—	—	—	140.1	840.0	630.8	0.0	0.0	0.0
	DEC	—	—	—	456.3	840.0	629.1	0.0	0.0	0.0

NOTE: Dashes (—) = Data is missing.

TABLE C-1 (Cont.)

Year	Month	Gallons per Minute x 1,000								
		Unit 1			Unit 2			Unit 3		
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
1976	JAN	0.0	168.0	71.7	252.0	504.0	445.1	0.0	0.0	0.0
	FEB	0.0	61.3	2.3	252.0	504.0	462.1	0.0	361.3	128.9
	MAR	0.0	0.0	0.0	177.6	504.0	460.8	87.3	268.3	141.8
	APR	0.0	0.0	0.0	0.0	84.0	8.6	52.6	420.0	289.0
	MAY	0.0	0.0	0.0	0.0	0.0	0.0	140.0	560.0	463.0
	JUN	0.0	0.0	0.0	0.0	140.0	59.7	280.0	560.0	422.3
	JUL	0.0	0.0	0.0	0.0	0.0	0.0	280.0	700.0	613.8
	AUG	0.0	112.0	90.3	0.0	0.0	0.0	432.2	700.0	557.2
	SEP	0.0	112.0	37.7	0.0	531.9	170.5	280.0	700.0	469.6
	OCT	0.0	0.0	0.0	280.0	780.7	618.3	280.0	700.0	605.1
	NOV	0.0	112.0	7.3	0.0	280.0	87.7	448.0	728.0	585.5
	DEC	0.0	0.0	0.0	0.0	504.0	285.1	252.0	532.0	424.4
1977	JAN	—	—	—	87.2	420.0	330.7	394.8	420.0	417.1
	FEB	—	—	—	0.0	420.0	350.5	336.0	420.0	406.0
	MAR	—	—	—	168.0	420.0	390.6	388.3	504.0	473.4
	APR	—	—	—	0.0	784.0	224.2	36.5	840.0	596.7
	MAY	—	—	—	0.0	840.0	473.6	775.2	840.0	836.1
	JUN	0.0	140.0	116.5	625.5	840.0	814.8	560.0	840.0	808.4
	JUL	0.0	280.0	89.3	0.0	840.0	55.2	404.5	840.0	814.6
	AUG	0.0	161.4	54.9	0.0	840.0	607.9	840.0	840.0	840.0
	SEP	0.0	140.0	71.9	805.6	840.0	838.4	757.8	840.0	837.3
	OCT	0.0	109.2	38.2	348.6	840.0	679.3	0.0	840.0	208.5
	NOV	0.0	109.2	65.6	467.2	572.2	531.3	0.0	0.0	0.0
	DEC	0.0	109.2	68.0	420.0	532.0	508.3	0.0	504.0	266.9
1978	JAN	0.0	109.2	8.2	420.0	504.0	450.2	470.3	504.0	501.6
	FEB	0.0	0.0	0.0	0.0	420.0	206.5	168.0	504.0	448.7
	MAR	0.0	0.0	0.0	0.0	0.0	0.0	420.0	504.0	489.8
	APR	0.0	109.2	39.5	0.0	0.0	0.0	420.0	643.9	436.8
	MAY	0.0	13.1	0.4	0.0	840.0	215.6	620.2	644.0	642.6
	JUN	0.0	137.1	16.3	840.0	840.0	840.0	0.0	644.0	248.6
	JUL	0.0	140.0	88.5	700.0	840.0	832.9	0.0	0.0	0.0
	AUG	0.0	280.0	149.9	770.6	840.0	831.9	0.0	700.0	207.4
	SEP	0.0	280.0	176.0	140.0	840.0	476.1	560.0	840.0	712.8
	OCT	140.0	280.0	207.7	210.5	840.0	737.7	675.0	840.0	801.3
	NOV	0.0	119.1	9.1	140.0	840.0	632.2	560.0	840.0	791.1
	DEC	0.0	22.8	0.7	156.5	840.0	634.9	36.8	840.0	495.4

TABLE C-1 (Cont.)

Year	Month	Gallons per Minute x 1,000								
		Unit 1			Unit 2			Unit 3		
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
1979	JAN	0.0	0.0	0.0	489.3	504.0	503.5	394.9	420.0	419.2
	FEB	0.0	0.0	0.0	252.0	504.0	471.6	336.0	420.0	411.3
	MAR	0.0	0.0	0.0	447.1	504.0	501.3	136.5	420.0	362.5
	APR	0.0	5.3	0.2	464.6	840.0	676.4	373.0	840.0	776.9
	MAY	0.0	0.0	0.0	840.0	840.0	840.0	717.5	840.0	834.3
	JUN	0.0	140.0	63.5	0.0	840.0	436.9	700.0	840.0	809.0
	JUL	0.0	140.0	40.9	0.0	0.0	0.0	710.2	840.0	827.1
	AUG	0.0	140.0	15.7	0.0	0.0	0.0	560.0	840.0	753.7
	SEP	140.0	140.0	140.0	0.0	700.0	383.4	0.0	809.1	305.6
	OCT	0.0	102.6	3.3	560.0	700.0	641.9	0.0	0.0	0.0
	NOV	0.0	0.0	0.0	280.0	700.0	599.3	0.0	0.0	0.0
	DEC	0.0	140.0	18.3	0.0	684.3	472.8	0.0	0.0	0.0
1980	JAN	0.0	0.0	0.0	84.0	532.0	300.3	0.0	0.0	0.0
	FEB	0.0	0.0	0.0	0.0	504.0	277.5	0.0	336.0	201.2
	MAR	0.0	0.0	0.0	407.6	504.0	488.8	168.0	420.0	333.1
	APR	0.0	0.0	0.0	400.5	784.0	603.9	35.3	560.0	310.6
	MAY	0.0	0.0	0.0	614.6	840.0	717.0	559.1	700.0	626.2
	JUN	0.0	0.0	0.0	0.0	700.0	565.7	513.1	700.0	689.8
	JUL	0.0	60.0	3.3	662.1	840.0	799.1	140.0	700.0	456.9
	AUG	0.0	280.0	235.2	635.3	840.0	768.0	677.7	840.0	722.4
	SEP	0.0	280.0	187.7	597.9	840.0	718.4	508.4	840.0	764.0
	OCT	0.0	118.9	3.8	140.5	840.0	619.9	0.0	350.0	123.6
	NOV	280.0	280.0	280.0	0.0	0.0	0.0	0.0	140.0	42.5
	DEC	280.0	280.0	280.0	0.0	140.0	52.7	0.0	700.0	326.5
1981	JAN	140.0	280.0	170.6	140.0	140.0	140.0	252.0	700.0	486.2
	FEB	0.0	140.0	39.7	140.0	224.0	198.1	0.0	252.0	130.2
	MAR	0.0	0.0	0.0	220.1	224.3	223.9	0.0	336.0	211.6
	APR	0.0	0.0	0.0	0.0	224.0	86.2	252.0	502.3	406.2
	MAY	0.0	0.0	0.0	0.0	700.0	286.3	420.0	588.0	536.5
	JUN	0.0	0.0	0.0	615.9	736.8	694.5	643.9	840.0	800.5
	JUL	0.0	0.0	0.0	390.8	840.0	800.3	589.5	840.0	762.2
	AUG	0.0	0.0	0.0	0.0	840.0	565.7	625.7	840.0	795.4
	SEP	0.0	3.7	0.1	0.0	840.0	400.4	0.0	840.0	216.3
	OCT	0.0	0.0	0.0	140.0	840.0	573.4	0.0	0.0	0.0
	NOV	0.0	0.0	0.0	0.0	504.0	329.3	0.0	420.0	138.7
	DEC	0.0	0.0	0.0	420.0	504.0	497.7	342.3	504.0	448.0

TABLE C-1 (Cont.)

Year	Month	Gallons per Minute x 1,000								
		Unit 1			Unit 2			Unit 3		
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
1982	JAN	0.0	0.0	0.0	467.3	504.0	501.7	420.0	504.0	470.2
	FEB	0.0	0.0	0.0	504.0	504.0	504.0	412.9	504.0	483.0
	MAR	0.0	0.0	0.0	420.0	504.0	467.6	84.0	504.0	428.6
	APR	0.0	0.0	0.0	252.0	504.0	482.7	0.0	84.0	25.8
	MAY	0.0	0.0	0.0	140.0	840.0	629.7	0.0	0.0	0.0
	JUN	0.0	0.0	0.0	756.4	840.0	819.7	0.0	0.0	0.0
	JUL	0.0	0.0	0.0	778.8	840.0	834.4	0.0	0.0	0.0
	AUG	0.0	0.0	0.0	645.3	840.0	811.5	0.0	0.0	0.0
	SEP	0.0	139.0	9.5	280.0	840.0	580.4	0.0	140.0	21.4
	OCT	140.0	140.0	140.0	0.0	145.8	124.7	0.0	140.0	60.1
	NOV	140.0	140.0	140.0	0.0	0.0	0.0	0.0	140.0	72.3
	DEC	140.0	140.0	140.0	0.0	88.0	4.9	0.0	0.0	0.0
1983	JAN	0.0	140.0	57.5	292.3	504.0	435.7	0.0	0.0	0.0
	FEB	0.0	157.7	80.5	0.0	429.6	295.0	0.0	0.0	0.0
	MAR	0.0	0.0	0.0	346.5	504.0	433.7	0.0	0.0	0.0
	APR	0.0	0.0	0.0	461.7	504.0	490.6	0.0	0.0	0.0
	MAY	0.0	0.0	0.0	494.0	840.0	798.0	0.0	420.0	30.1
	JUN	0.0	0.0	0.0	787.7	977.6	835.5	140.0	840.0	390.2
	JUL	0.0	0.0	0.0	803.3	840.0	836.2	0.0	140.0	65.4
	AUG	0.0	0.0	0.0	759.8	840.0	829.2	0.0	0.0	0.0
	SEP	0.0	0.0	0.0	756.9	840.0	826.8	0.0	0.0	0.0
	OCT	0.0	140.0	89.8	0.0	820.6	222.7	0.0	0.0	0.0
	NOV	0.0	0.0	0.0	420.0	504.0	499.5	0.0	0.0	0.0
	DEC	0.0	0.0	0.0	504.0	504.0	504.0	0.0	0.0	0.0
1984	JAN	0.0	0.0	0.0	451.8	504.0	496.0	0.0	252.0	35.2
	FEB	0.0	0.0	0.0	0.0	504.0	247.5	252.0	504.0	385.5
	MAR	0.0	0.0	0.0	441.3	504.0	499.4	416.3	504.0	489.8
	APR	0.0	0.0	0.0	441.0	504.0	491.6	420.0	504.0	494.4
	MAY	0.0	0.0	0.0	468.1	820.2	677.6	481.5	840.0	767.7
	JUN	0.0	140.0	123.3	0.0	784.0	65.6	701.8	840.0	826.2
	JUL	0.0	140.0	114.2	0.0	0.0	0.0	681.0	840.0	828.0
	AUG	0.0	140.0	61.3	0.0	36.2	1.4	25.0	840.0	732.4
	SEP	0.0	140.0	102.5	0.0	128.8	12.8	700.0	840.0	834.9
	OCT	0.0	0.0	0.0	0.0	645.5	285.9	0.0	840.0	375.9
	NOV	0.0	0.0	0.0	460.6	675.2	510.1	0.0	338.5	45.8
	DEC	0.0	0.0	0.0	0.0	570.8	364.4	363.0	504.0	425.5

TABLE C-1 (Cont.)

Year	Month	Gallons per Minute x 1,000								
		Unit 1			Unit 2			Unit 3		
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
1985	JAN	0.0	0.0	0.0	400.5	504.0	495.5	454.9	504.0	499.9
	FEB	0.0	0.0	0.0	353.7	504.0	496.9	376.8	504.0	456.3
	MAR	0.0	0.0	0.0	432.7	504.0	496.3	488.4	504.0	503.3
	APR	0.0	0.0	0.0	387.2	504.0	495.2	325.7	504.0	441.9
	MAY	0.0	0.0	0.0	497.8	672.0	561.9	476.0	672.0	629.2
	JUN	0.0	0.0	0.0	682.1	840.0	792.1	0.0	672.0	165.6
	JUL	0.0	0.0	0.0	791.1	840.0	829.0	0.0	0.0	0.0
	AUG	0.0	0.0	0.0	729.8	840.0	806.4	0.0	0.0	0.0
	SEP	0.0	116.1	9.1	0.0	840.0	639.6	0.0	519.6	118.7
	OCT	0.0	0.0	0.0	280.0	840.0	734.5	99.7	504.5	413.8
	NOV	0.0	0.0	0.0	457.7	504.0	483.5	418.1	420.0	419.9
	DEC	0.0	0.0	0.0	470.6	504.0	477.5	419.7	510.0	473.1
1986	JAN	0.0	0.0	0.0	0.0	504.0	220.0	420.0	483.0	458.3
	FEB	0.0	0.0	0.0	0.0	0.0	0.0	407.0	420.0	419.2
	MAR	0.0	0.0	0.0	0.0	280.0	70.8	418.1	498.0	471.4
	APR	0.0	0.0	0.0	0.0	185.2	74.1	249.0	498.0	455.0
	MAY	0.0	0.0	0.0	52.5	644.0	322.7	0.0	504.5	231.7
	JUN	0.0	0.0	0.0	140.0	840.0	698.3	334.9	564.5	515.0
	JUL	0.0	0.0	0.0	522.3	840.0	805.2	110.5	782.0	235.1
	AUG	0.0	0.0	0.0	765.8	840.0	822.7	132.0	197.3	136.7
	SEP	0.0	0.0	0.0	761.2	840.0	831.3	312.3	785.0	710.5
	OCT	0.0	0.0	0.0	308.0	728.0	658.0	711.0	784.0	760.6
	NOV	0.0	0.0	0.0	226.5	672.0	499.1	487.4	757.0	521.7
	DEC	0.0	0.0	0.0	432.8	531.8	498.4	470.1	500.2	488.7
1987	JAN	0.0	0.0	0.0	422.6	504.0	491.6	468.5	502.0	490.3
	FEB	0.0	0.0	0.0	0.0	504.0	369.7	252.0	502.0	445.3
	MAR	0.0	1.0	0.0	484.0	504.0	500.7	431.0	504.0	476.2
	APR	0.0	0.0	0.0	483.7	516.8	500.8	309.1	504.0	464.3
	MAY	0.0	0.0	0.0	493.8	672.0	561.7	0.0	504.0	41.5
	JUN	0.0	140.0	61.1	420.0	840.0	772.8	0.0	0.0	0.0
	JUL	0.0	0.0	0.0	752.0	840.0	827.3	0.0	0.0	0.0
	AUG	0.0	0.0	0.0	735.0	840.0	824.1	0.0	420.0	85.9
	SEP	0.0	0.0	0.0	742.8	840.0	817.8	140.0	840.0	713.2
	OCT	0.0	0.0	0.0	84.0	728.0	256.4	688.5	720.0	718.8
	NOV	0.0	0.0	0.0	0.0	140.5	98.5	461.2	536.3	500.8
	DEC	0.0	0.0	0.0	0.0	140.2	65.4	489.1	519.8	502.1

TABLE C-1 (Cont.)

Year	Month	Gallons per Minute x 1,000								
		Unit 1			Unit 2			Unit 3		
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
1988	JAN	0.0	0.0	0.0	0.0	504.0	209.6	408.0	504.0	464.9
	FEB	0.0	0.0	0.0	426.7	504.0	496.9	445.6	504.0	490.1
	MAR	0.0	0.0	0.0	494.1	504.0	503.1	495.7	550.3	502.4
	APR	0.0	0.0	0.0	461.1	504.0	498.9	449.8	510.6	494.4
	MAY	0.0	0.0	0.0	453.0	672.0	561.4	0.0	660.0	243.6
	JUN	0.0	0.0	0.0	140.0	840.0	632.0	501.0	840.0	768.4
	JUL	0.0	0.0	0.0	281.5	840.0	599.8	786.6	840.0	832.2
	AUG	0.0	0.0	0.0	778.8	840.0	830.8	833.5	840.0	839.1
	SEP	0.0	0.0	0.0	643.7	840.0	805.4	831.8	840.0	837.9
	OCT	0.0	0.0	0.0	588.0	728.0	710.1	137.0	720.0	446.3
	NOV	0.0	0.0	0.0	487.6	504.0	502.6	68.5	519.0	210.2
	DEC	0.0	0.0	0.0	470.2	504.3	499.7	429.4	501.0	473.6
1989	JAN	0.0	0.0	0.0	460.1	505.5	494.2	402.0	501.0	469.1
	FEB	0.0	0.0	0.0	502.4	506.9	504.0	0.0	501.0	84.0
	MAR	0.0	0.0	0.0	0.0	504.0	319.3	0.0	10.1	0.5
	APR	0.0	0.0	0.0	0.0	140.0	22.9	0.0	93.1	17.6
	MAY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	140.0	38.8
	JUN	0.0	0.0	0.0	0.0	423.6	159.1	69.7	840.0	280.0
	JUL	0.0	0.0	0.0	627.1	840.0	803.5	800.4	840.0	813.5
	AUG	0.0	0.0	0.0	782.8	840.0	833.0	775.8	840.0	819.5
	SEP	0.0	0.0	0.0	776.8	840.0	830.7	802.6	840.0	833.9
	OCT	0.0	0.0	0.0	168.0	840.0	656.6	160.1	840.0	667.8
	NOV	0.0	0.0	0.0	167.4	504.0	436.1	489.5	502.9	499.8
	DEC	0.0	0.0	0.0	199.8	560.0	471.7	386.0	501.0	444.0
1990	JAN	0.0	0.0	0.0	492.8	504.0	503.3	417.5	539.5	492.9
	FEB	0.0	0.0	0.0	168.0	504.0	447.1	492.9	501.0	500.4
	MAR	0.0	0.0	0.0	139.0	168.0	145.6	0.0	501.0	111.6
	APR	0.0	0.0	0.0	140.0	194.5	164.1	196.6	501.1	442.9
	MAY	0.0	0.0	0.0	127.4	144.4	139.6	494.0	666.0	560.1
	JUN	0.0	0.0	0.0	128.1	840.0	471.2	715.4	840.0	791.7
	JUL	0.0	0.0	0.0	608.1	840.0	807.2	802.4	840.0	826.8
	AUG	0.0	0.0	0.0	593.5	840.0	783.9	608.8	840.0	813.3
	SEP	0.0	0.0	0.0	248.7	840.0	747.4	0.0	840.0	426.3
	OCT	0.0	0.0	0.0	644.0	836.6	731.6	0.0	0.0	0.0
	NOV	0.0	0.0	0.0	476.3	544.3	502.8	0.0	0.0	0.0
	DEC	0.0	0.0	0.0	487.5	504.0	501.4	0.0	503.5	210.9

TABLE C-2 SUMMARY OF MONTHLY ELECTRIC PRODUCTION AT INDIAN POINT, 1973-1990

Year	Month	Megawatt Hours					
		Unit 2			Unit 3		
		Minimum	Maximum	Average	Minimum	Maximum	Average
1973	JAN	—	—	—	—	—	—
	FEB	—	—	—	—	—	—
	MAR	—	—	—	—	—	—
	APR	—	—	—	—	—	—
	MAY	—	—	—	—	—	—
	JUN	—	—	—	—	—	—
	JUL	—	—	—	—	—	—
	AUG	—	—	—	—	—	—
	SEP	—	—	—	—	—	—
	OCT	—	—	—	—	—	—
	NOV	—	—	—	—	—	—
	DEC	—	—	—	—	—	—
1974	JAN	—	—	—	—	—	—
	FEB	—	—	—	—	—	—
	MAR	—	—	—	—	—	—
	APR	—	—	—	—	—	—
	MAY	—	—	—	—	—	—
	JUN	—	—	—	—	—	—
	JUL	—	—	—	—	—	—
	AUG	—	—	—	—	—	—
	SEP	—	—	—	—	—	—
	OCT	—	—	—	—	—	—
	NOV	—	—	—	—	—	—
	DEC	—	—	—	—	—	—
1975	JAN	—	—	—	—	—	—
	FEB	—	—	—	—	—	—
	MAR	—	—	—	—	—	—
	APR	—	—	—	—	—	—
	MAY	—	—	—	—	—	—
	JUN	—	—	—	—	—	—
	JUL	—	—	—	—	—	—
	AUG	—	—	—	—	—	—
	SEP	—	—	—	—	—	—
	OCT	—	—	—	—	—	—
	NOV	—	—	—	—	—	—
	DEC	—	—	—	—	—	—

NOTE: Dashes (—) = data is missing.

TABLE C-2 (Cont.)

Year	Month	Megawatt Hours					
		Unit 2			Unit 3		
		Minimum	Maximum	Average	Minimum	Maximum	Average
1976	JAN	0	21710	0	0	0	16299
	FEB	0	21060	0	0	0	16126
	MAR	0	21710	0	0	0	19853
	APR	0	0	0	0	0	0
	MAY	0	0	5844	0	16550	0
	JUN	0	0	11340	0	23180	0
	JUL	0	0	11349	0	18940	0
	AUG	0	0	14098	1730	19200	0
	SEP	0	3068	6499	0	24000	173
	OCT	0	22290	17126	0	24070	17204
	NOV	0	0	20944	8990	23810	0
	DEC	0	21380	18281	0	22070	9072
1977	JAN	0	20780	17715	—	23170	12306
	FEB	0	20950	15818	13040	23220	21260
	MAR	0	21000	17082	14140	21990	21121
	APR	0	20860	6539	0	21940	16792
	MAY	0	21770	10800	19380	24080	22034
	JUN	12650	21470	20231	10920	21780	21074
	JUL	0	19880	641	2070	21610	20321
	AUG	0	20690	11875	18420	21460	21180
	SEP	13000	20900	19983	14000	21400	20820
	OCT	12800	21100	18941	0	21500	3987
	NOV	19500	28800	20236	0	0	0
	DEC	17800	20200	19851	0	22100	8529
1978	JAN	14900	20190	21678	17410	22060	19626
	FEB	0	19980	8287	0	22020	14256
	MAR	0	0	0	9620	22050	21097
	APR	0	0	0	6630	24450	18460
	MAY	0	19120	20082	10330	22080	2621
	JUN	12870	21340	20135	0	21480	4599
	JUL	0	20870	0	0	0	18534
	AUG	19880	20840	2835	0	20850	20467
	SEP	0	20730	19841	0	23550	9856
	OCT	0	22000	22811	12460	24640	16293
	NOV	0	21270	23694	20600	24000	15060
	DEC	0	21350	17306	0	23970	19146

TABLE C-2 (Cont.)

Year	Month	Megawatt Hours					
		Unit 2			Unit 3		
		Minimum	Maximum	Average	Minimum	Maximum	Average
1979	JAN	12390	21310	20821	8480	23930	22894
	FEB	5330	21990	19355	23410	23960	23825
	MAR	2660	20890	19662	0	23890	17324
	APR	8900	20980	19767	12970	23740	19280
	MAY	18910	20900	20454	23070	23580	23470
	JUN	0	20550	9986	15480	23380	21867
	JUL	0	0	0	14780	16050	15401
	AUG	0	0	0	—	—	—
	SEP	0	17860	4058	0	16930	5316
	OCT	10640	21430	19631	0	0	0
	NOV	0	21180	17949	0	0	0
	DEC	0	21010	13920	0	0	0
1980	JAN	0	17000	5929	0	0	0
	FEB	0	20700	7108	0	9160	2321
	MAR	2050	20620	18262	0	17890	8898
	APR	—	—	—	—	—	—
	MAY	—	—	—	—	—	—
	JUN	—	—	—	—	—	—
	JUL	—	—	—	—	—	—
	AUG	—	—	—	—	—	—
	SEP	—	—	—	—	—	—
	OCT	—	—	—	—	—	—
	NOV	—	—	—	—	—	—
	DEC	—	—	—	—	—	—
1981	JAN	0	0	19484	4620	21260	0
	FEB	0	0	0	0	0	0
	MAR	0	0	0	0	0	0
	APR	0	0	9566	0	13220	0
	MAY	0	7440	12709	7780	13770	994
	JUN	5952	19820	12855	8000	13270	16393
	JUL	0	20080	12472	2480	13340	18080
	AUG	0	20080	12846	7530	13280	13277
	SEP	0	21020	1716	0	13190	9186
	OCT	0	22070	0	0	0	13682
	NOV	0	21430	3740	0	20440	12176
	DEC	21000	21480	18912	0	20950	21229

TABLE C-2 (Cont.)

Year	Month	Megawatt Hours					
		Unit 2			Unit 3		
		Minimum	Maximum	Average	Minimum	Maximum	Average
1982	JAN	12060	21340	19665	6280	20950	20534
	FEB	3790	21470	16586	9580	18320	19586
	MAR	11450	21020	13809	0	17990	20365
	APR	0	21010	0	0	0	17761
	MAY	0	21310	0	0	0	14774
	JUN	10520	20960	0	0	0	19695
	JUL	9990	20790	0	0	0	19842
	AUG	0	20300	0	0	0	15165
	SEP	0	17850	0	0	0	6020
	OCT	0	0	0	0	0	0
	NOV	0	0	0	0	0	0
	DEC	0	0	0	0	0	0
1983	JAN	0	21220	0	0	0	11153
	FEB	0	21110	0	0	0	6201
	MAR	1940	21130	0	0	0	18649
	APR	19080	21920	0	0	0	20972
	MAY	2140	21310	0	0	0	19898
	JUN	19750	21220	2284	0	13410	20809
	JUL	18960	20780	0	0	0	20498
	AUG	0	20680	0	0	0	18741
	SEP	18010	20800	0	0	0	19954
	OCT	0	21490	0	0	0	4779
	NOV	0	21200	0	0	0	19179
	DEC	17740	21250	0	0	0	20992
1984	JAN	0	21240	0	0	5	18529
	FEB	0	20790	16643	2360	23160	8220
	MAR	18720	21060	22066	8090	23160	20919
	APR	18710	21110	23636	22900	24050	20780
	MAY	12769	21090	21770	2190	24000	15511
	JUN	0	12870	23093	3000	24020	430
	JUL	0	0	22551	3980	23750	0
	AUG	0	0	19335	0	23910	0
	SEP	0	0	23323	22490	23550	0
	OCT	0	19380	8976	0	23640	4112
	NOV	17080	21210	957	0	10860	20497
	DEC	0	21530	23488	18730	24060	11184

TABLE C-2 (Cont.)

Year	Month	Megawatt Hours					
		Unit 2			Unit 3		
		Minimum	Maximum	Average	Minimum	Maximum	Average
1985	JAN	0	21280	22036	0	24060	20176
	FEB	100	21260	23720	23490	23900	18908
	MAR	7920	21280	19303	0	25550	19974
	APR	290	21250	20157	17590	21070	19067
	MAY	18010	21150	21695	21470	22430	20807
	JUN	13190	21190	4834	0	21440	20612
	JUL	20070	21120	0	0	0	20731
	AUG	14560	20710	0	0	0	19490
	SEP	0	20670	0	0	0	14198
	OCT	0	21870	7322	0	21710	15177
	NOV	4160	20980	22654	3190	24180	19074
	DEC	5592	21090	21200	5490	24170	19956
1986	JAN	0	21080	24135	24080	24180	8222
	FEB	0	0	23571	8950	24220	0
	MAR	0	0	23006	4610	24110	0
	APR	0	0	19854	0	24101	0
	MAY	0	4680	2497	0	11980	586
	JUN	0	20940	12189	60	16660	11605
	JUL	0	20900	1690	0	13130	19028
	AUG	9100	20780	0	0	0	19847
	SEP	9660	20920	15721	0	23260	19777
	OCT	0	21360	22452	10640	24240	16025
	NOV	0	21070	21347	4790	23230	16422
	DEC	7600	21160	23215	23160	23260	19364
1987	JAN	0	20830	22883	13580	23250	19177
	FEB	0	21520	19084	0	23210	13178
	MAR	19210	21470	19845	0	23180	21143
	APR	12310	21310	18815	0	22890	20706
	MAY	19260	21120	591	0	18240	20849
	JUN	0	20940	0	0	0	18359
	JUL	18630	20600	0	0	0	20180
	AUG	14180	20500	0	0	0	19998
	SEP	7700	20750	15637	0	21950	19761
	OCT	0	20660	23335	20870	24770	2589
	NOV	0	0	23924	23050	24210	0
	DEC	0	0	21989	0	24170	0

TABLE C-2 (Cont.)

Year	Month	Megawatt Hours					
		Unit 2			Unit 3		
		Minimum	Maximum	Average	Minimum	Maximum	Average
1988	JAN	0	19851	24032	23920	24080	3069
	FEB	0	22101	22860	880	24040	17966
	MAR	21754	22063	23703	14270	24110	21954
	APR	21021	22050	22092	0	24100	21800
	MAY	21009	21883	8225	0	24090	21633
	JUN	0	21677	19635	0	24010	13486
	JUL	0	20905	23283	22840	23540	8619
	AUG	12343	21099	22534	10670	23310	20184
	SEP	0	21381	23352	23210	23510	17312
	OCT	18579	22641	8987	0	23450	20955
	NOV	0	21793	19416	860	23790	18691
	DEC	18617	21870	23807	23700	23980	21625
1989	JAN	12407	21844	23688	21730	24030	20971
	FEB	12921	21870	2163	0	21410	21423
	MAR	0	21690	0	0	0	10022
	APR	0	0	0	0	0	0
	MAY	0	0	0	0	0	0
	JUN	0	0	2086	0	16880	0
	JUL	0	21304	23418	21430	24040	15153
	AUG	21060	21523	23792	23610	23890	21292
	SEP	21240	21741	23852	22000	24120	21447
	OCT	0	21985	20342	0	25300	16910
	NOV	0	22114	24257	24110	24340	9273
	DEC	0	22242	24291	23340	24380	17034
1990	JAN	21972	22178	24077	21690	24420	22069
	FEB	0	22869	24192	23340	24370	18101
	MAR	0	0	1464	0	24350	0
	APR	0	0	17274	0	24340	0
	MAY	0	0	24283	24160	25250	0
	JUN	0	23065	22980	0	24250	4297
	JUL	244	23117	23486	12590	24040	21422
	AUG	19899	22950	21945	0	23890	22385
	SEP	0	23438	10341	0	23690	19219
	OCT	22461	24428	0	0	0	23293
	NOV	23246	23760	0	0	0	23510
	DEC	23490	23773	2038	0	16280	23640

TABLE C-3 SUMMARY OF INTAKE AND DISCHARGE TEMPERATURES AT INDIAN POINT, 1973-1990

Year	Month	Degrees F					
		Intake			Discharge		
		Minimum	Maximum	Average	Minimum	Maximum	Average
1973	JAN	—	—	—	—	—	—
	FEB	—	—	—	—	—	—
	MAR	—	—	—	—	—	—
	APR	—	—	—	—	—	—
	MAY	—	—	—	—	—	—
	JUN	—	—	—	—	—	—
	JUL	—	—	—	—	—	—
	AUG	—	—	—	—	—	—
	SEP	—	—	—	—	—	—
	OCT	60.0	70.7	65.7	60.0	83.0	68.6
	NOV	49.0	59.8	52.5	49.7	60.0	52.8
	DEC	32.0	48.0	40.0	33.3	49.0	40.8
1974	JAN	31.0	32.5	31.9	33.0	50.2	37.3
	FEB	31.4	32.6	31.8	33.2	54.1	44.3
	MAR	32.0	39.4	36.2	43.5	60.8	52.7
	APR	38.9	51.5	44.0	50.5	66.4	59.2
	MAY	52.5	61.2	56.7	55.0	74.2	64.6
	JUN	61.0	70.3	67.1	68.1	85.8	77.8
	JUL	71.0	76.1	75.0	76.6	90.2	85.2
	AUG	75.8	79.0	77.6	80.2	92.5	87.3
	SEP	68.7	77.8	73.4	77.3	88.0	83.3
	OCT	56.5	68.0	61.8	64.5	77.0	71.0
	NOV	45.0	56.8	51.4	53.4	72.4	63.5
	DEC	35.5	41.2	38.1	50.4	66.1	58.9
1975	JAN	—	—	—	—	—	—
	FEB	—	—	—	—	—	—
	MAR	—	—	—	—	—	—
	APR	—	—	—	—	—	—
	MAY	—	—	—	—	—	—
	JUN	—	—	—	—	—	—
	JUL	—	—	—	—	—	—
	AUG	—	—	—	—	—	—
	SEP	—	—	—	—	—	—
	OCT	—	—	—	—	—	—
	NOV	—	—	—	—	—	—
	DEC	—	—	—	—	—	

NOTE: Dashes (—) = data is missing.

TABLE C-3 (Cont.)

Year	Month	Degrees F					
		Intake			Discharge		
		Minimum	Maximum	Average	Minimum	Maximum	Average
1976	JAN	31.0	33.1	32.1	31.0	51.6	44.9
	FEB	30.0	34.7	32.2	30.0	57.0	45.2
	MAR	35.9	43.1	39.1	40.1	65.6	57.6
	APR	42.0	51.0	45.7	43.0	55.7	47.0
	MAY	51.5	61.4	57.6	51.5	77.5	64.5
	JUN	59.2	73.0	65.3	61.8	90.7	77.5
	JUL	73.2	77.7	76.0	74.1	93.4	86.7
	AUG	73.9	76.1	75.1	76.4	96.0	88.0
	SEP	68.3	74.5	71.9	68.9	89.0	76.2
	OCT	49.5	68.1	60.4	63.1	86.8	78.7
	NOV	40.7	50.6	43.8	52.4	69.1	64.3
	DEC	33.2	39.7	35.5	47.1	76.7	60.2
1977	JAN	31.7	34.5	32.6	47.2	74.6	61.2
	FEB	32.9	35.8	34.5	55.4	77.3	66.5
	MAR	34.9	40.0	37.3	51.3	68.7	64.2
	APR	40.6	52.6	46.2	44.5	73.7	65.4
	MAY	52.8	65.6	57.8	67.5	81.0	73.1
	JUN	65.4	73.0	68.4	75.6	92.1	83.5
	JUL	73.5	79.7	76.5	80.1	95.4	90.8
	AUG	76.5	80.4	78.4	1.5	96.0	89.0
	SEP	68.2	79.2	74.9	84.0	94.9	90.8
	OCT	51.1	68.5	57.7	67.4	86.2	76.1
	NOV	43.7	53.7	49.9	68.7	76.6	72.7
	DEC	33.0	42.8	36.5	46.0	66.8	57.7
1978	JAN	32.7	35.1	33.7	54.7	62.8	59.5
	FEB	32.5	35.0	33.6	43.2	61.6	54.2
	MAR	32.7	36.5	34.3	48.5	66.5	59.4
	APR	38.0	49.0	43.8	57.4	79.6	67.1
	MAY	49.5	63.8	54.8	65.2	83.3	73.5
	JUN	64.9	75.8	69.3	78.8	92.0	85.2
	JUL	72.9	80.8	77.0	78.3	98.6	92.1
	AUG	78.8	81.5	79.7	91.6	97.7	94.3
	SEP	71.0	80.0	75.5	80.0	98.0	90.9
	OCT	61.0	71.0	65.8	75.0	84.0	80.8
	NOV	50.0	63.0	57.7	65.0	89.0	74.8
	DEC	37.0	50.0	43.8	57.0	72.0	64.1

TABLE C-3 (Cont.)

Year	Month	Degrees F					
		Intake			Discharge		
		Minimum	Maximum	Average	Minimum	Maximum	Average
1979	JAN	32.2	39.5	34.3	51.0	68.8	61.1
	FEB	33.0	35.2	34.2	52.4	74.4	64.6
	MAR	33.7	43.7	37.7	52.9	71.9	62.7
	APR	43.1	52.2	45.9	58.3	76.9	65.6
	MAY	53.7	66.9	62.2	71.0	83.5	79.1
	JUN	66.0	73.7	70.9	82.9	88.6	86.6
	JUL	72.8	81.3	77.0	83.3	94.3	88.3
	AUG	74.7	81.7	78.1	80.4	96.8	92.2
	SEP	70.4	78.2	74.7	73.9	96.1	84.0
	OCT	58.9	70.9	64.2	76.6	89.9	82.7
	NOV	50.1	58.9	54.4	48.7	81.0	71.9
	DEC	42.5	49.1	45.4	44.5	73.3	60.6
1980	JAN	32.7	41.2	36.1	33.8	67.4	44.8
	FEB	32.7	36.1	34.2	33.5	58.5	43.9
	MAR	34.1	43.2	38.6	46.0	65.5	55.5
	APR	41.1	53.8	48.7	64.0	83.1	70.4
	MAY	53.7	68.0	61.2	72.4	90.5	81.5
	JUN	67.2	74.7	70.9	76.4	97.5	90.4
	JUL	75.6	83.1	80.1	89.6	99.5	95.6
	AUG	78.6	84.5	81.9	90.0	99.7	96.6
	SEP	73.5	82.8	78.0	89.4	97.8	93.9
	OCT	57.8	74.7	66.2	57.8	87.4	73.3
	NOV	45.0	57.3	50.1	45.0	57.2	50.9
	DEC	39.8	46.0	41.1	43.7	67.3	48.9
1981	JAN	32.2	40.5	35.6	42.4	72.8	62.4
	FEB	32.3	35.7	33.9	40.0	41.9	40.6
	MAR	34.5	41.6	37.8	39.0	48.5	42.0
	APR	42.0	54.4	48.5	44.1	75.1	63.6
	MAY	54.2	68.2	60.1	70.3	80.2	73.5
	JUN	67.8	75.7	72.3	79.0	93.9	88.1
	JUL	76.3	82.3	80.3	89.5	99.2	95.7
	AUG	77.4	82.9	80.9	90.2	98.0	95.9
	SEP	68.8	77.8	74.1	74.9	94.6	84.2
	OCT	55.9	68.2	61.7	64.5	85.1	74.6
	NOV	44.9	55.0	50.4	51.1	79.3	68.1
	DEC	38.7	45.6	41.3	57.0	79.4	67.8

TABLE C-3 (Cont.)

Year	Month	Degrees F					
		Intake			Discharge		
		Minimum	Maximum	Average	Minimum	Maximum	Average
1982	JAN	34.0	49.6	38.8	53.5	67.8	62.9
	FEB	35.0	41.2	37.6	50.0	63.3	58.6
	MAR	34.2	42.0	36.7	51.0	66.5	63.5
	APR	40.9	54.3	45.5	42.6	83.5	69.3
	MAY	53.7	65.6	59.1	60.1	82.1	74.1
	JUN	65.3	71.5	68.0	78.0	90.1	84.9
	JUL	70.9	80.9	76.5	85.1	98.0	92.6
	AUG	75.4	80.8	78.8	89.8	99.0	94.4
	SEP	69.6	75.9	74.4	69.6	91.6	80.2
	OCT	58.0	69.0	64.0	58.0	69.0	64.1
	NOV	52.0	58.0	54.6	52.0	58.0	54.6
	DEC	40.0	52.0	45.5	40.0	52.0	45.5
1983	JAN	34.9	40.8	37.9	38.7	69.2	52.1
	FEB	32.3	35.0	32.9	32.0	68.6	43.4
	MAR	35.5	44.2	39.1	43.4	83.5	73.9
	APR	43.3	51.6	46.2	64.3	72.8	67.6
	MAY	50.0	62.3	58.1	59.3	79.6	74.1
	JUN	61.9	74.5	69.6	74.4	88.5	83.1
	JUL	74.5	81.0	78.4	88.5	98.8	94.5
	AUG	74.0	82.0	79.1	78.9	99.2	96.0
	SEP	73.2	81.1	77.6	91.5	99.4	96.1
	OCT	59.5	72.6	67.1	61.8	93.0	71.6
	NOV	40.3	59.4	54.4	51.1	81.4	75.0
	DEC	34.5	47.2	40.0	58.9	72.7	66.1
1984	JAN	30.6	36.0	33.5	33.7	66.4	56.7
	FEB	32.7	40.1	35.4	39.8	67.2	59.7
	MAR	38.0	42.2	39.2	61.3	71.0	67.5
	APR	41.7	53.2	48.4	69.0	85.9	77.4
	MAY	50.9	63.3	58.2	31.4	87.6	77.2
	JUN	60.3	83.6	69.1	71.1	90.2	82.7
	JUL	75.2	81.8	80.0	78.6	96.9	92.9
	AUG	75.9	83.2	80.8	77.0	100.9	94.1
	SEP	65.5	82.1	75.0	84.6	94.2	90.4
	OCT	63.2	70.5	65.7	63.7	92.4	76.3
	NOV	49.4	64.0	55.8	62.4	90.0	78.5
	DEC	38.7	49.9	45.1	58.7	79.0	70.3

TABLE C-3 (Cont.)

Year	Month	Degrees F					
		Intake			Discharge		
		Minimum	Maximum	Average	Minimum	Maximum	Average
1985	JAN	33.1	44.2	36.1	47.6	68.3	63.2
	FEB	30.4	54.3	36.2	52.4	66.5	63.5
	MAR	35.1	45.2	38.7	58.4	68.5	63.4
	APR	42.5	55.7	47.6	64.8	83.6	75.1
	MAY	56.6	70.4	62.8	82.1	89.7	86.1
	JUN	66.6	70.9	68.7	80.6	91.4	87.3
	JUL	71.1	79.7	75.9	88.7	97.0	93.5
	AUG	76.0	79.8	78.3	91.7	98.4	96.4
	SEP	71.1	76.8	74.7	76.1	97.2	89.4
	OCT	59.7	71.2	65.5	68.1	85.9	78.3
	NOV	43.1	61.9	51.4	60.3	88.0	80.2
	DEC	34.7	43.7	38.6	57.3	76.0	66.9
1986	JAN	32.9	40.0	36.9	54.2	63.8	60.1
	FEB	31.7	33.5	33.0	59.8	78.3	65.1
	MAR	31.8	39.4	34.9	55.4	68.4	61.8
	APR	39.9	50.9	46.6	51.4	78.7	67.8
	MAY	49.5	70.1	57.6	53.5	80.9	62.7
	JUN	65.1	74.0	70.0	71.4	88.1	83.6
	JUL	63.9	79.7	73.7	76.1	93.6	88.5
	AUG	77.0	80.2	79.4	85.4	93.7	91.8
	SEP	68.5	76.0	71.7	81.0	92.2	87.0
	OCT	57.7	70.9	63.7	71.8	89.6	81.6
	NOV	39.6	58.1	49.9	55.8	89.4	76.0
	DEC	34.0	40.2	36.2	63.5	73.0	70.0
1987	JAN	29.8	35.7	33.0	53.3	72.3	68.1
	FEB	32.7	41.7	36.2	52.0	67.4	62.3
	MAR	36.5	44.7	40.0	60.2	73.5	66.7
	APR	45.4	55.7	50.4	63.3	84.1	76.9
	MAY	52.8	66.0	59.0	72.6	84.5	81.4
	JUN	62.9	78.3	71.8	76.6	93.0	86.8
	JUL	75.1	80.7	78.1	92.3	99.5	96.6
	AUG	74.8	80.2	78.1	87.5	99.0	95.8
	SEP	66.8	75.7	72.1	86.3	95.7	90.9
	OCT	55.3	68.4	61.2	75.7	89.6	80.6
	NOV	40.7	55.1	48.4	—	—	—
	DEC	37.2	46.6	39.8	—	—	—

TABLE C-3 (Cont.)

Year	Month	Degrees F					
		Intake			Discharge		
		Minimum	Maximum	Average	Minimum	Maximum	Average
1988	JAN	32.7	42.6	36.8	58.5	69.6	62.8
	FEB	32.7	38.4	35.6	35.1	69.8	60.0
	MAR	41.6	44.8	43.0	64.7	70.2	67.4
	APR	41.4	51.1	47.1	55.2	81.9	75.1
	MAY	49.0	62.0	55.0	75.9	84.6	81.2
	JUN	62.1	74.6	69.0	78.7	92.5	86.7
	JUL	71.4	83.1	76.2	90.2	99.5	94.0
	AUG	79.3	86.8	83.7	95.7	105.3	100.9
	SEP	74.0	81.4	77.9	82.8	96.7	91.0
	OCT	58.7	74.0	66.0	67.4	92.0	80.0
	NOV	46.6	58.3	52.3	55.4	75.5	71.1
	DEC	39.5	47.2	42.5	58.1	72.0	63.9
1989	JAN	—	—	—	—	—	—
	FEB	—	—	—	—	—	—
	MAR	—	—	—	—	—	—
	APR	—	—	—	—	—	—
	MAY	—	—	—	—	—	—
	JUN	—	—	—	—	—	—
	JUL	74.7	81.9	78.6	86.2	99.0	94.7
	AUG	79.5	82.8	80.8	81.0	99.0	97.5
	SEP	76.3	81.0	79.4	87.5	98.0	93.6
	OCT	55.0	76.8	64.1	65.0	89.5	79.2
	NOV	49.0	62.0	54.0	66.0	79.5	71.9
	DEC	28.0	48.0	37.4	52.5	72.0	63.7
1990	JAN	34.0	42.0	39.3	57.5	67.5	63.5
	FEB	35.5	41.5	38.7	50.5	67.0	63.2
	MAR	35.5	44.0	40.0	32.5	59.5	42.0
	APR	41.9	52.8	46.2	40.9	73.0	58.7
	MAY	53.5	60.1	57.2	62.3	76.2	70.5
	JUN	58.1	60.6	59.6	62.0	64.1	63.4
	JUL	73.1	79.0	75.0	84.0	96.3	92.0
	AUG	75.3	81.3	77.8	85.4	102.5	93.4
	SEP	68.1	75.6	72.7	78.2	89.9	84.4
	OCT	55.9	68.0	64.6	72.2	87.5	80.1
	NOV	41.7	56.5	48.0	65.0	76.7	71.1
	DEC	34.5	44.3	39.2	51.0	67.9	58.8

APPENDIX D

COMPARISON OF ANNUAL ESTIMATES TO PREVIOUSLY REPORTED ESTIMATES, 1974-1990

APPENDIX D

LIST OF TABLES

APPENDIX D

COMPARISON OF ANNUAL ESTIMATES TO PREVIOUSLY REPORTED ESTIMATES 1974-1990

Methods used to calculate annual impingement estimates at Indian Point progressed from simple summations of daily impingement counts to summations of seasonally stratified estimates that were adjusted for collection efficiency based on mean daily intake temperature and scaled by the ratio of sampling days to plant operational days within a stratum (Table D-1). The method for estimating annual impingement collections as presented in Chapter 4 of this report used the following collection efficiency equations which were first developed in 1982:

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

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

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.

For the early years of impingement sampling (1974-1981) when daily collections were made, the recalculated annual impingement estimate presented in this report is the sum of the daily impingement counts adjusted for collection efficiency with the above equations. This adjustment resulted in generally higher impingement estimates than previously reported for 1974-1981 (Tables D-2 through D-4). For the subsequent years of impingement sampling (1982-1989), the impingement estimates presented in each annual report used the aforementioned collection efficiency equations and, therefore, those results are directly reported in Chapter 4.

TABLE D-1 METHODS FOR CALCULATING PREVIOUSLY REPORTED ANNUAL IMPINGEMENT ESTIMATES FOR INDIAN POINT UNITS 2 AND 3, 1974-1989

Year	Unit 2	Unit 3
1974, 1975	Sum of daily impingement counts	Not in operation
1976, 1977	Sum of daily impingement counts	Sum of daily impingement counts
1978	Sum of (daily impingement counts mutiplied by 3.5)	Sum of (daily impingement counts multiplied by 1.4)
1979	Sum of (daily impingement counts in January, February, March, April, November, and December multiplied by 2.1) and (daily impingement counts in May, June, July, August, September, and October multiplied by 3.8)	Sum of (daily impingement counts in January, February, March, April, November, and December multiplied by 1.2) and (daily impingement counts in May, June, July, August, September, and October multiplied by 1.5)
1980	Sum of (daily impingement counts divided by E_2 where E_2 = -0.00945 Temperature + 0.54708)	Sum of (daily impingement counts divided by E_3 where E_3 = -0.00792 Temperature + 0.71640)
1981	Sum of (daily impingement counts in January-June divided by E_2 where E_2 = -0.00945 Temperature + 0.54708) and (mean of [daily counts divided by E_2] in a stratum multiplied by number of plant operation days in that stratum for July-December)	Sum of (daily impingement counts in January-June divided by E_3 where E_3 = -0.00792 Temperature + 0.71640) and (mean of [daily counts divided by E_3] in a stratum multiplied by number of plant operation days in that stratum for July-December)
1982-1986	Sum of (mean of [daily counts divided by E_2 where E_2 = -0.00871 Temperature + 0.51858] in a stratum multiplied by number of plant operation days in that stratum)	Sum of (mean of [daily counts divided by E_3 where E_3 = -0.00792 Temperature + 0.71640] in a stratum multiplied by number of plant operation days in that stratum)
1987-1989	Same as 1982-1986 except E_2 for Intake 26 = 0.744 (January-March), 0.187 (July, August), and 0.296 (September)	Same as 1982-1986

TABLE D-2 COMPARISON OF PREVIOUSLY REPORTED ANNUAL IMPINGEMENT ESTIMATES TO RECALCULATED ESTIMATES FOR SELECTED SPECIES AT INDIAN POINT UNIT 2, 1974-1981

Taxon	1974		1975		1976		1977	
	Previous	Recalculated	Previous	Recalculated	Previous	Recalculated	Previous	Recalculated
Alewife	3,561	10,377	4,117	12,920	706	1,751	15,880	43,333
American shad	NA	2,532	NA	3,462	NA	3,015	3,891	10,674
Atlantic tomcod	297,582	929,266	76,523	244,024	12,159	28,783	270,178	815,623
Bay anchovy	76,468	250,547	95,756	318,261	3,402	9,851	58,456	191,016
Blueback herring	21,719	55,678	152,561	380,795	132,290	344,739	579,019	1,494,065
Bluefish	NA	7,009	NA	5,021	NA	33	4,136	12,425
Gizzard shad	NA	136	NA	1,959	NA	3,214	5,428	11,944
Hogchoker	NA	37,134	NA	59,089	NA	8,270	12,165	33,839
Rainbow smelt	NA	1,901	NA	15,368	NA	4,965	14,623	36,262
Striped bass	4,568	11,738	4,914	14,543	3,781	8,491	17,486	42,472
Weakfish	NA	3,577	NA	30,000	NA	485	4,387	14,363
White perch	319,056	644,585	256,659	591,107	283,524	596,746	857,682	1,829,955
All species	750,182	1,978,263	646,432	1,713,038	460,020	1,048,022	1,891,087	4,654,398

Taxon	1978		1979		1980		1981	
	Previous	Recalculated	Previous	Recalculated	Previous	Recalculated	Previous	Recalculated
Alewife	40,142	34,479	2,916	2,493	9,391	10,322	53,365	58,346
American shad	51,991	45,763	13,813	12,420	40,450	44,285	207,598	227,867
Atlantic tomcod	390,451	356,881	99,404	79,980	611,565	672,329	350,606	382,531
Bay anchovy	310,322	290,090	117,443	91,512	318,648	347,559	1,218,744	1,327,578
Blueback herring	904,165	712,363	406,677	305,261	27,180	29,346	233,232	255,782
Bluefish	2,725	2,541	168	129	9,619	10,603	9,914	10,874
Gizzard shad	2,677	1,556	NA	1,273	NA	132	650	719
Hogchoker	79,419	65,287	42,847	34,304	38,376	42,244	23,322	25,591
Rainbow smelt	73,335	55,393	42,229	37,002	19,503	21,458	668	725
Striped bass	87,593	59,838	82,861	77,756	27,622	30,206	55,255	60,601
Weakfish	38,909	37,003	8,478	7,059	42,804	46,530	50,037	55,112
White perch	1,454,822	912,198	2,775,203	2,621,218	1,072,269	1,172,364	1,327,335	1,463,046
All species	3,530,561	2,645,048	3,661,753	3,331,060	2,248,909	2,461,564	3,573,103	3,914,962

NOTE: NA = Not available.

TABLE D-3 COMPARISON OF PREVIOUSLY REPORTED ANNUAL IMPINGEMENT ESTIMATES TO RECALCULATED ESTIMATES FOR SELECTED SPECIES AT INDIAN POINT UNIT 3, 1976-1981

Taxon	1976		1977		1978		1979		1980		1981	
	Previous	Recalc.	Previous	Recalc.	Previous	Recalc.	Previous	Recalc.	Previous	Recalc.	Previous	Recalc.
Alewife	2,843	4,928	42,712	82,827	27,232	32,862	11,702	15,054	6,302	6,493	8,814	9,101
American shad	NA	5,361	8,813	17,037	24,002	29,010	30,532	39,500	13,517	13,885	21,709	22,421
Atlantic tomcod	21,970	40,814	477,524	912,514	12,230	15,764	194,885	255,695	157,555	162,343	75,892	78,202
Bay anchovy	8,636	16,468	88,422	170,809	25,323	32,664	148,389	189,302	74,863	77,129	113,878	117,433
Blueback herring	125,949	216,651	58,501	106,905	353,393	429,699	9,620	12,140	11,088	11,418	15,276	15,788
Bluefish	NA	2,908	17,266	32,590	154	216	6,003	7,550	9,756	10,094	8,041	8,297
Gizzard shad	NA	1,736	1,208	1,737	1,293	1,376	NA	542	NA	2,508	2,463	2,593
Hogchoker	NA	21,837	13,307	24,119	33,388	41,738	14,662	17,638	16,908	17,477	22,625	23,289
Rainbow smelt	NA	1,544	12,365	21,821	25,218	28,594	22,653	26,833	5,975	6,164	927	961
Striped bass	2,348	4,009	10,191	18,386	24,195	25,950	15,270	18,480	17,809	18,320	25,939	26,911
Weakfish	NA	715	3,200	6,201	2,546	3,450	8,767	11,342	12,531	12,887	11,691	12,104
White perch	156,672	242,100	236,910	368,598	548,237	590,108	430,484	525,397	527,632	539,459	673,225	698,867
All species	355,212	588,245	1,005,148	1,825,618	1,105,208	1,263,954	909,644	1,139,314	872,888	895,259	995,163	1,031,126

NOTE: NA = Not available.

TABLE D-4 COMPARISON OF PREVIOUSLY REPORTED ANNUAL IMPINGEMENT ESTIMATES TO RECALCULATED ESTIMATES FOR SELECTED SPECIES AT INDIAN POINT UNITS 2 AND 3 COMBINED, 1974-1981

Taxon	1974*		1975*		1976		1977	
	Previous	Recalculated	Previous	Recalculated	Previous	Recalculated	Previous	Recalculated
Alewife	3,561	10,377	4,117	12,920	3,549	6,679	58,592	126,160
American shad	NA	2,532	NA	3,462	NA	8,376	12,704	27,711
Atlantic tomcod	297,582	929,266	76,523	244,024	34,129	69,597	747,702	1,728,137
Bay anchovy	76,468	250,547	95,756	318,261	12,038	26,319	146,878	361,825
Blueback herring	21,719	55,678	152,561	380,795	258,239	561,390	637,520	1,600,970
Bluefish	NA	7,009	NA	5,021	NA	2,941	21,402	45,015
Gizzard shad	NA	136	NA	1,959	NA	4,950	6,636	13,681
Hogchoker	NA	37,134	NA	59,089	NA	30,107	25,472	57,958
Rainbow smelt	NA	1,901	NA	15,368	NA	6,509	26,988	58,083
Striped bass	4,568	11,738	4,914	14,543	6,129	12,500	27,677	60,858
Weakfish	NA	3,577	NA	30,000	NA	1,200	7,587	20,564
White perch	319,056	644,585	256,659	591,107	440,196	838,846	1,094,592	2,198,553
All species	750,182	1,978,263	646,432	1,713,038	815,232	1,636,267	2,896,235	6,480,016

* Unit 2 only.

Taxon	1978		1979		1980		1981	
	Previous	Recalculated	Previous	Recalculated	Previous	Recalculated	Previous	Recalculated
Alewife	67,374	67,341	14,618	17,547	15,693	16,815	62,179	67,447
American shad	75,993	74,773	44,345	51,920	53,967	58,170	229,307	250,288
Atlantic tomcod	402,681	372,645	294,289	335,675	769,120	834,672	426,498	460,733
Bay anchovy	335,645	322,754	265,832	280,814	393,511	424,688	1,332,622	1,445,011
Blueback herring	1,257,558	1,142,062	416,297	317,401	38,268	40,764	248,508	271,570
Bluefish	2,879	2,757	6,171	7,679	19,375	20,697	17,955	19,171
Gizzard shad	3,970	2,932	NA	1,815	NA	2,640	3,113	3,312
Hogchoker	112,807	107,025	57,509	51,942	55,284	59,721	45,947	48,880
Rainbow smelt	98,553	83,987	64,882	63,835	25,478	27,622	1,595	1,686
Striped bass	111,788	85,788	98,131	96,236	45,431	48,526	81,194	87,512
Weakfish	41,455	40,453	17,245	18,401	55,335	59,417	61,728	67,216
White perch	2,003,059	1,502,306	3,205,687	3,146,615	1,599,901	1,711,823	2,000,560	2,161,913
All species	4,635,769	3,909,002	4,571,397	4,470,374	3,121,797	3,356,823	4,568,823	4,946,088

NOTE: NA = Not available.