RAVENSWOOD GENERATING STATION

IMPINGEMENT AND ENTRAINMENT REPORT,

FEBRUARY 1993 THROUGH JANUARY 1994

Prepared for

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EXECUTIVE SUMMARY

Normandeau Associates Inc. (NAI) conducted impingement and entrainment studies at Ravenswood Generating Station in Queens County, New York over a one-year period that began in February 1994. These were the second impingement and entrainment studies performed for the three electric generating units (Units 10, 20, and 30) that draw their condenser cooling water from the East River. Impingement sampling began in February and focused on the numbers of fish and blue crabs as well as the amount and type of debris impinged over a 24-hour period. Impingement sampling was conducted weekly, usually on Wednesday at 1200 hours. Entrainment sampling began in February and focused on entrainment of fish eggs, larvae and juveniles. Entrainment sampling was conducted concurrent with impingement sampling. Sampling was conducted once per week from May through August, and twice per month for the remainder of the year. For both impingement and entrainment, samples were collected and analyzed for four fixed diurnal periods.

Sixty-one species of fish were impinged during the study. The five most common species were winter flounder, grubby, northern pipefish, Atlantic silverside and Atlantic herring. Together these species made up 68% of the impingement collection. The total estimated number of fish impinged were 22,275 at Unit 10, 24,453 at Unit 20, and 35,575 at Unit 30 for a combined total of 82,303. Impingement rates were generally similar among units, during period of concurrent operation. Impingement rates were highest in April and January. The April peak was composed primarily of winter flounder, and the January peak was composed primarily of grubby.

An estimated blue crab impingement was 2,332 at Unit 10, 2,740 at Unit 20, and 1,988 at Unit 30 for a total of 7,060 blue crabs. Blue crabs were most abundant from May through December.

An estimated volume of 15,914 gallons of debris were impinged at Units 10, 20 and 30 combined. A total of 6,231 gallons were impinged at Unit 10, 6,119 gallons were impinged at Unit 20 and 3,564 gallons were impinged at Unit 30. Aquatic vegetation was the most common category of debris impinged (26.4%) followed by paper and plastic (24.5%) and terrestrial vegetation (19.7%). Aquatic vegetation and paper and plastic were collected throughout the study. Terrestrial vegetation was most common in the fall.

Thirty-eight taxonomic groups were entrained at Ravenswood Station comprising 17 egg, five yolk sac-larvae, 23 post yolk-sac larvae, and 16 young-of-the-year (YOY) species. An estimated 156.8 million fish eggs were entrained. Egg entrainment rates were highest in April and May primarily due to entrainment of fourbeard rockling eggs. An estimated total of 99.7 million larvae were entrained. Post yolk sac-larvae were the most common larval lifestage entrained. Entrainment of post yolk-sac larvae was highest in April, and July through September, primarily due to entrainment of grubby in April, bay anchovy in July through September.

An estimated total of 2.0 million YOY fish were entrained, based on the collection of 288 YOY fish in entrainment samples. Northern pipefish (55.0%), and smallmouth flounder (13.3%) were the most numerous YOY fish entrained.

1.0 INTRODUCTION

This is the second report on the Ravenswood Generating Station impingement and entrainment monitoring, which was conducted in accordance with Consolidated Edison Company of New York, Inc.'s (Con Edison), Request for Proposal (RFP) No. SC-92-0328E and its technical attachments. The first report presented results of studies on impingement and entrainment from September 1991 through September 1992 (LMS 1993). This report presents the results of impingement and entrainment studies conducted between February 1993 and January 1994, and follows the format of LMS (1993).

The objectives of studying impingement at the Ravenswood Station were to:

- Estimate the number of fish and blue crabs impinged by the cooling water intake screens of the station's three condenser cooled electrical generating units over a one-year period.
- Determine the species and size classes (young of year and yearling and older) of fish collected from each generating unit's cooling water intake screens during four discrete 6-hr sample periods (0000 to 0600, 0600 to 1200, 1200 to 1800, and 1800 to 2400 hrs).
- Measure lengths (to the nearest mm) of 50 individuals of each fish species and size class randomly selected from the combined 24-hr impingement sample at Units 10, 20, and 30.
- Determine the number of blue crabs impinged during each discrete 6-hr sample period and measure carapace widths (to the nearest mm) of 50 individuals randomly selected from the combined 24-hr impingement sample at Units 10, 20, and 30.
- Determine if there is a diel pattern in fish impingement rates.
- Characterize the debris collected from each unit's cooling water intake screens during each discrete 6-hr sample period by general type, measure the debris volume in gallons, and determine the proportionate contribution of various general types of debris (e.g., macrophytes, sessile invertebrates, floating plastic trash).
- Determine the collection efficiency for representative fish species once during each three-month interval over a 24-hr period.

The objectives of studying entrainment at the Ravenswood Station were to:

- Estimate the numbers of ichthyoplankton entrained by the station's three condenser cooled electric generating units over a one-year period.
- Determine the species and life stages (egg, yolk-sac, post yolk-sac, and juvenile) of entrained fish.
- Enumerate by species and life stage (egg, yolk-sac, post yolk-sac, and juvenile) entrained ichthyoplankton collected from each depth during four discrete 6-hr sample periods (0000 to 0600, 0600 to 1200, 1200 to 1800, and 1800 to 2400 hrs).

Section 2.0 of this report presents a description of the Ravenswood Generating Station, field and laboratory methods, sampling design, and analytical methods. Section 3.0 provides estimates of the number of fish and blue crabs impinged, species composition, and relative abundances, and describes seasonal and diurnal impingement patterns.

2.0 MATERIALS AND METHODS

Fifty-two weekly impingement surveys were conducted at the Ravenswood Station from 2 February 1993 through 24 January 1994. Samples were collected from each operating unit. Thirty-three entrainment surveys were conducted at the Ravenswood Station from 23 February 1993 through 18 January 1994. Entrainment samples were collected weekly from May through August 1993 and biweekly from February through April 1993 and September 1993 through January 1994.

Ravenswood Station descriptions, field collection procedures, sample analysis, and analytical procedures for impingement and entrainment are presented in the following sections.

2.1 STATION AND SITE DESCRIPTION

The Ravenswood Station (Long Island City, New York) is located on the East River just east of Roosevelt Island (Figures 2-1 and 2-2). The East River, which connects Long Island Sound to the northeast with upper New York Harbor to the south, is a tidal strait rather than a river.

The East River is a major waterway for commercial shipping traffic, with numerous industries, piers, and other developed areas along its shores. The East River shoreline has been bulkheaded and filled for development and shoreline stabilization, especially in the areas around the Ravenswood Station. Heavy noncommercial and pleasure boat traffic is transient through this area. Several sewage treatment plants and combined sewer outfalls enter into the East River. They discharge untreated sewage into the river during heavy storm events. Garbage loading facilities and garbage barge traffic through the area contribute to floating trash found in the river.

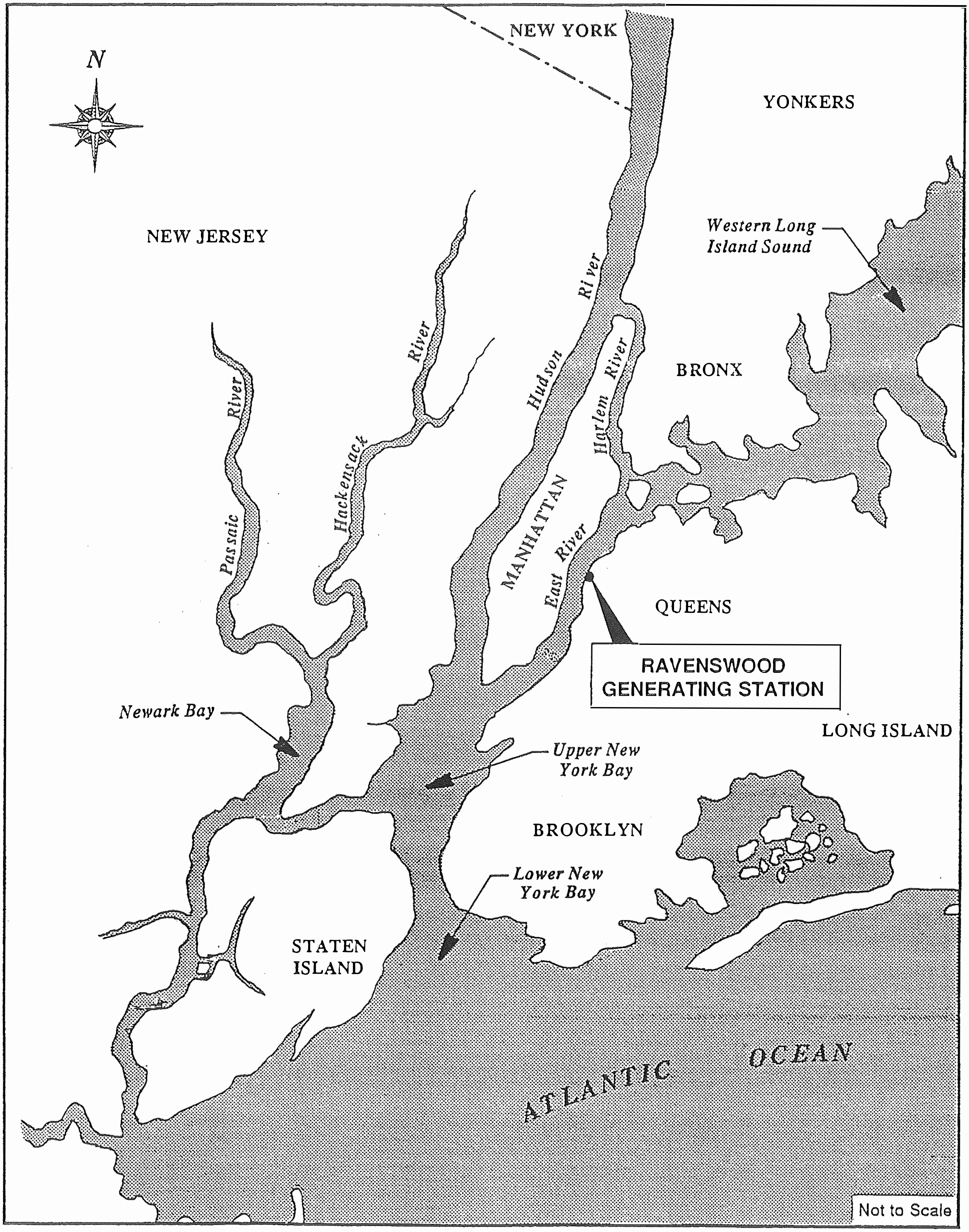


Figure 2-1. Location of Ravenswood Generating Station.

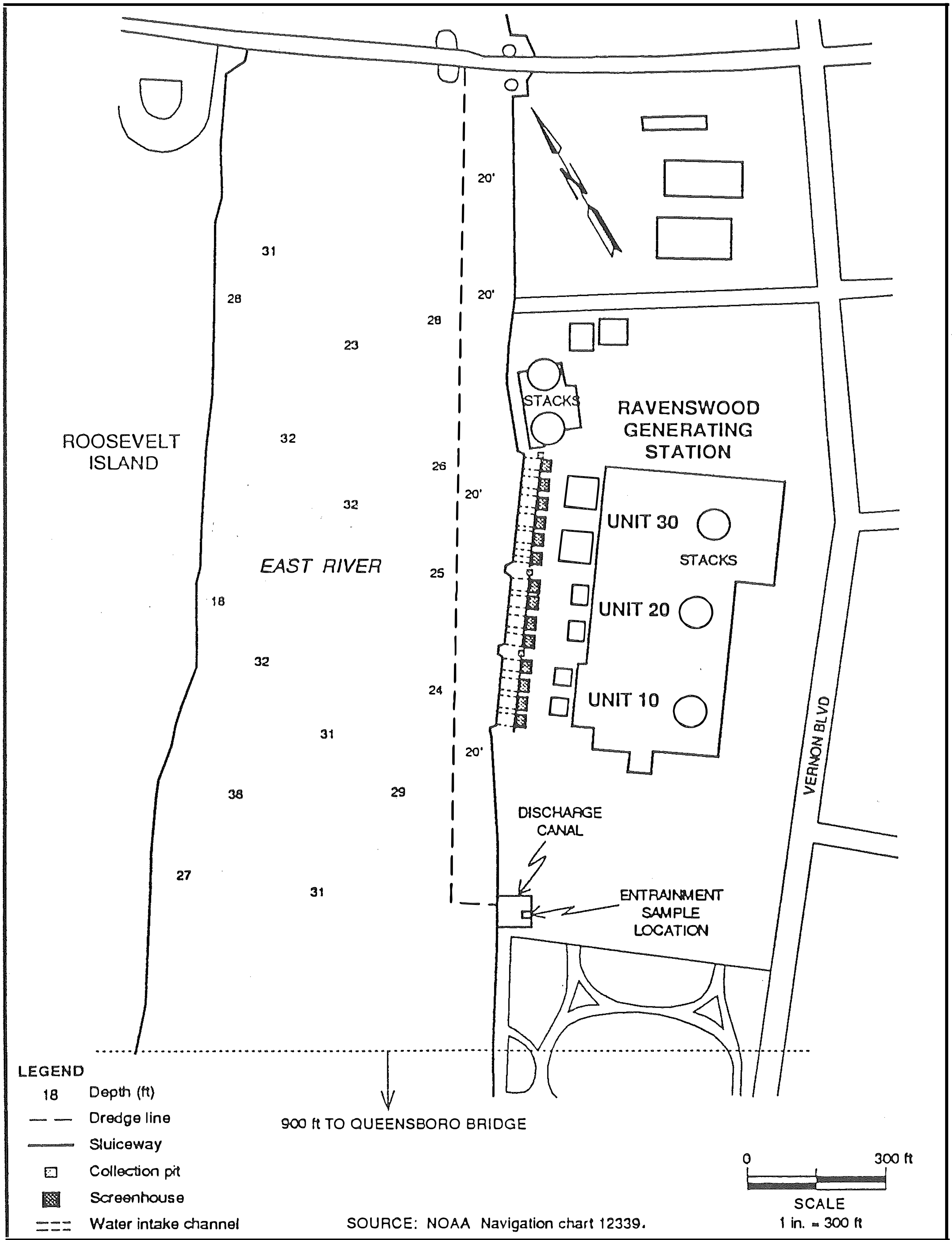


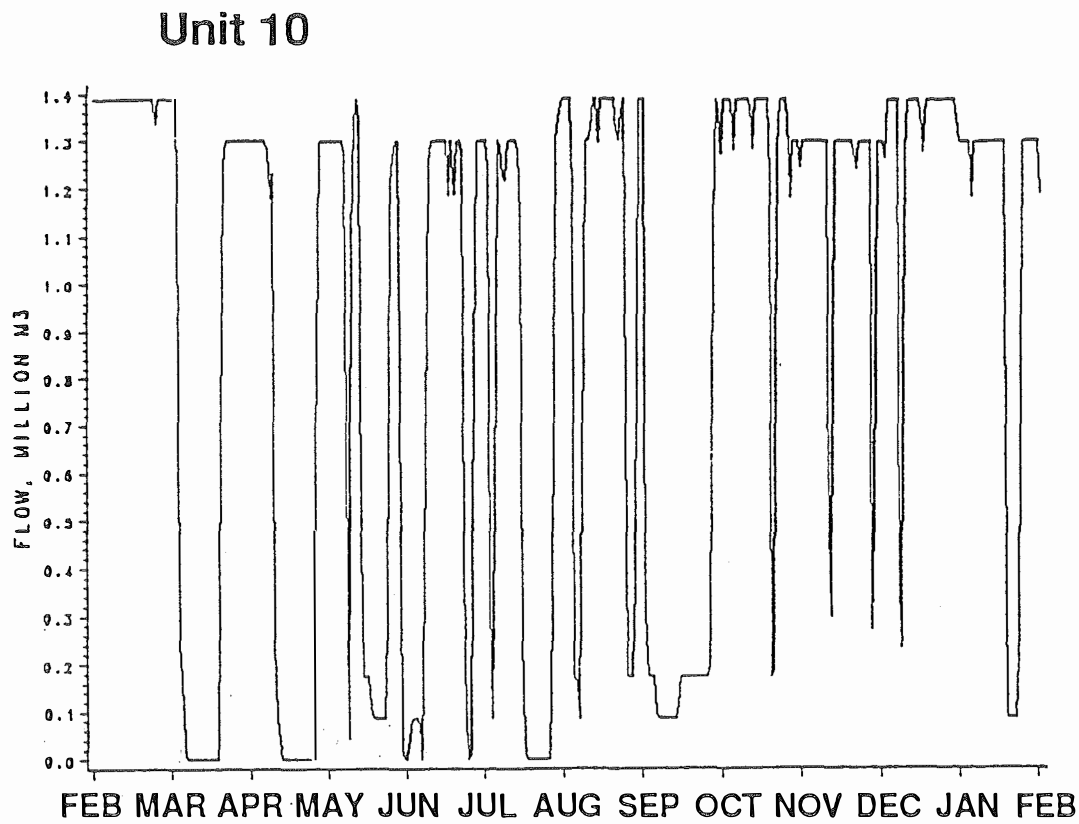
Figure 2-2. Ravenswood screenhousing and tailrace locations.

The northeast section of the East River is wide with shallow bays and marshes that provide nutrients as well as nursery areas for marine and estuarine species. Fifty-one species of fish were impinged at Ravenswood Station in 1991 through 1992 (LMS 1993). The five most common species were blueback herring, bay anchovy, silver hake, Atlantic silverside, and lined sea horse. Together these species made up 78% of the impingement collection. An estimated total of 83,111 fish were impinged at the three units. Twenty-nine species of fish were collected in entrainment collections. Ten species were present as eggs, two as yolk-sac larvae, 19 as post yolk-sac larvae, and 13 as young-of-the-year. An estimated 167 million eggs, 202,022 yolk-sac larvae, 6.4 million post yolk-sac larvae, and 1.2 million young-of-the-year were entrained at the three units.

The Ravenswood Station consists of three gas-/oil-fired units (Nos. 10, 20 and 30) with a rated capacity of 363, 363, and 1000 MW, respectively. Ravenswood Units 10, 20, and 30 began operation in 1963, 1963, and 1965, respectively. Once-through cooling water flow is 222,600 gallons per minute (gpm) at Unit 10, 214,000 gpm at Unit 20, and 537,000 gpm at Unit 30 (Table 2-1). Cooling water flows during the study period for Units 10, 20 and 30 are presented in Figure 2-3. The maximum service water flow is 16,000 gpm at each unit. Cooling and service water is drawn from the East River into a protected embayment directly in front of each unit's traveling screens (Figure 2-2). A log screen (bar rack) reduces the amount of floating debris and large material reaching the 3/8 in. square mesh traveling screens (Figures 2-4 and 2-5). Fish, crabs, and debris removed from the water by the traveling screens are washed from the screens' mesh panels into a screenwash sluiceway at each unit. Each sluiceway empties into an open pit. Currently a collection basket in each pit filters out fish, crabs, and debris which are periodically removed for disposal in a landfill. An improved return system for impinged fish and crabs is currently under development and will be installed shortly so that impinged fish and crabs will be delivered to the East River after being washed from the traveling screens. The filtered washwater flows from the pit through a large diameter pipe to the circulating water discharge canal.

TABLE 2-1. RAVENSWOOD PLANT DESIGN CHARACTERISTICS.

	UNIT 10	UNIT 20	UNIT 30
INTAKE			
Number of circulating pumps	2	2	2
GPM	222,600	214,000	537,000
Number of service water pumps	2	2	2
GPM	16,000	16,000	16,000
Number of traveling screens	4	4	6
Type of traveling screens	Conventional	Conventional	Conventional
Mesh size (in.)	0.375 x 0.375	0.375 x 0.375	0.375 x 0.375
GENERATORS			
Primary fuel	Gas	Gas	Low-sulfur oil
Alternate fuel	Low sulfur oil	Low sulfur oil	Gas
Capacity (Gross MW)	383	383	1,000
CONDENSERS			
Cooling system	Once through	Once through	Once through
Flow (CFS)	477.00	477.00	1,195.00
ΔT	8.7°C	8.7°C	10.4°C
	15.7°F	15.7°F	18.8°F
DISCHARGE			
Type		Common Discharge Canal	



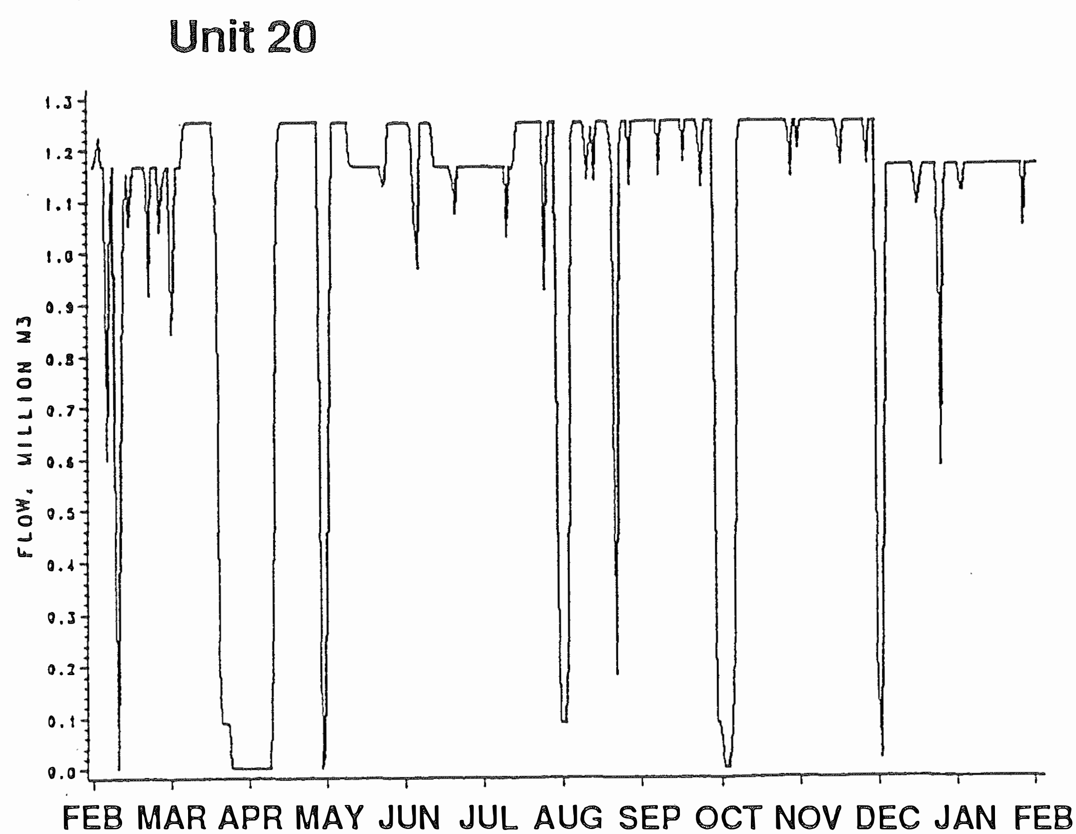


Figure 2-3. Cooling water flow at Units 10 and 20 at Ravenswood Generating Station, February 1993 through February 1994

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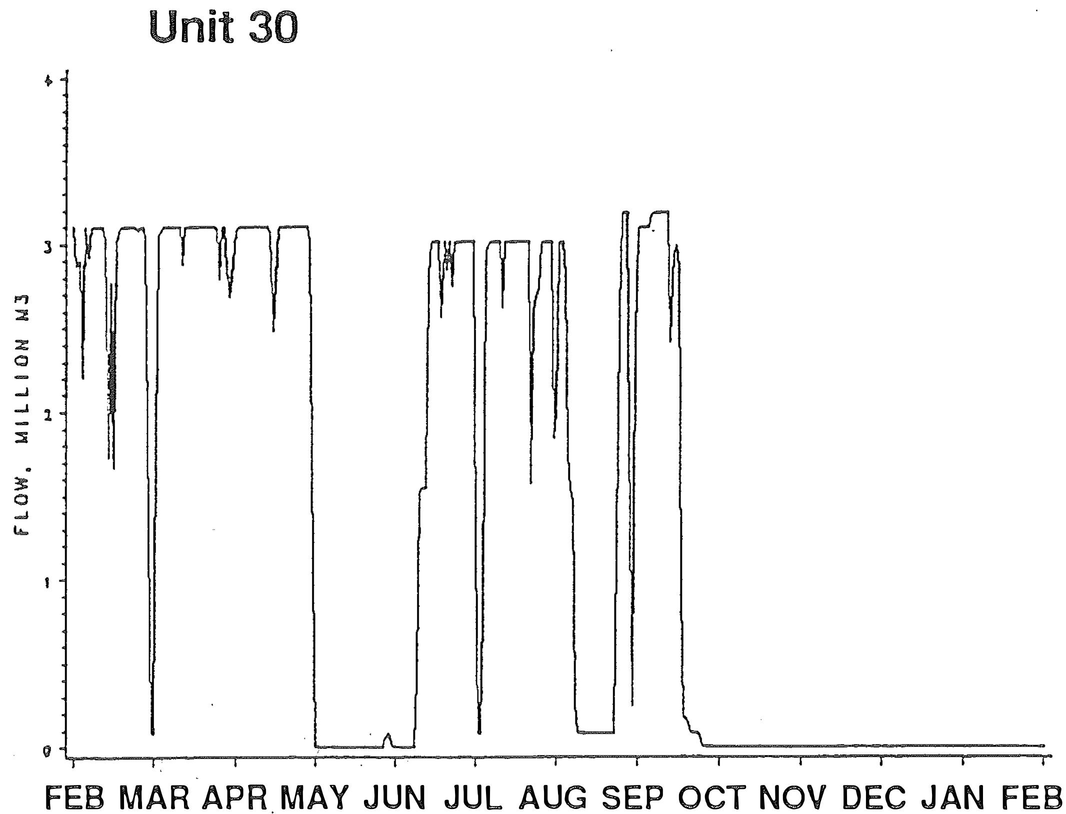


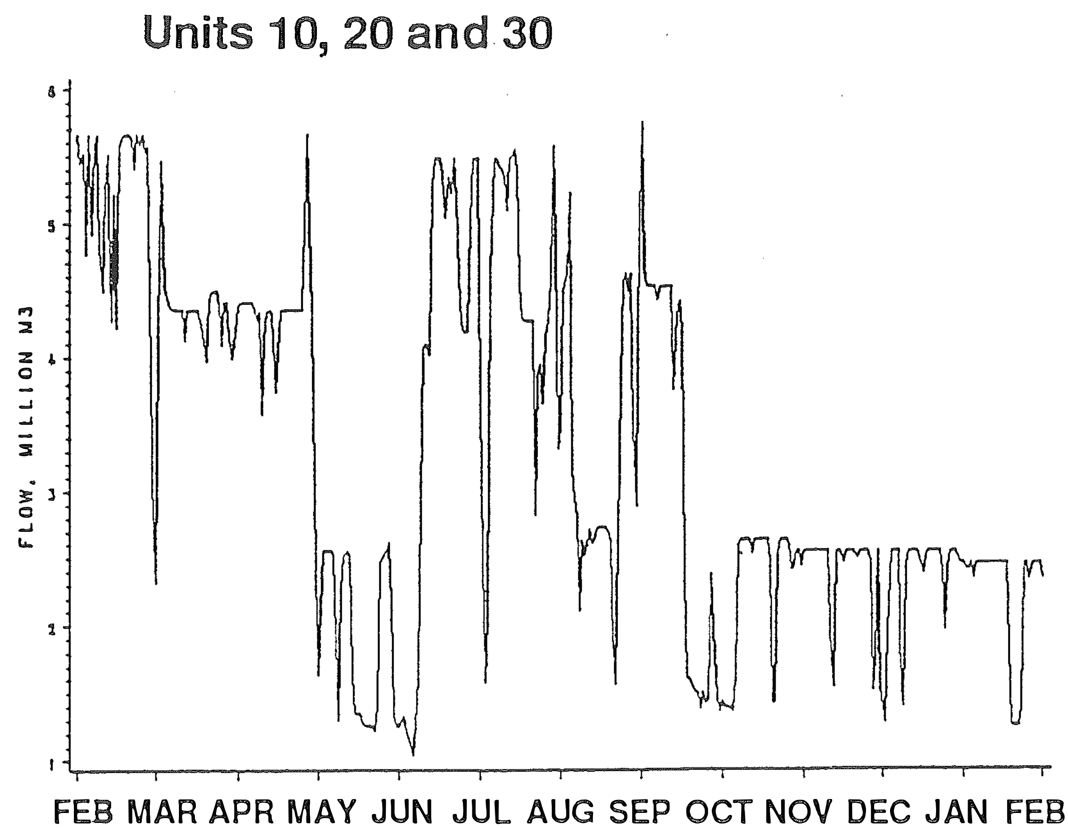


Figure 2-3 (Cont). Cooling water flow at Unit 30 and Units 10, 20 and 30 combined at Ravenswood Generating Station, February 1993 through February 1994

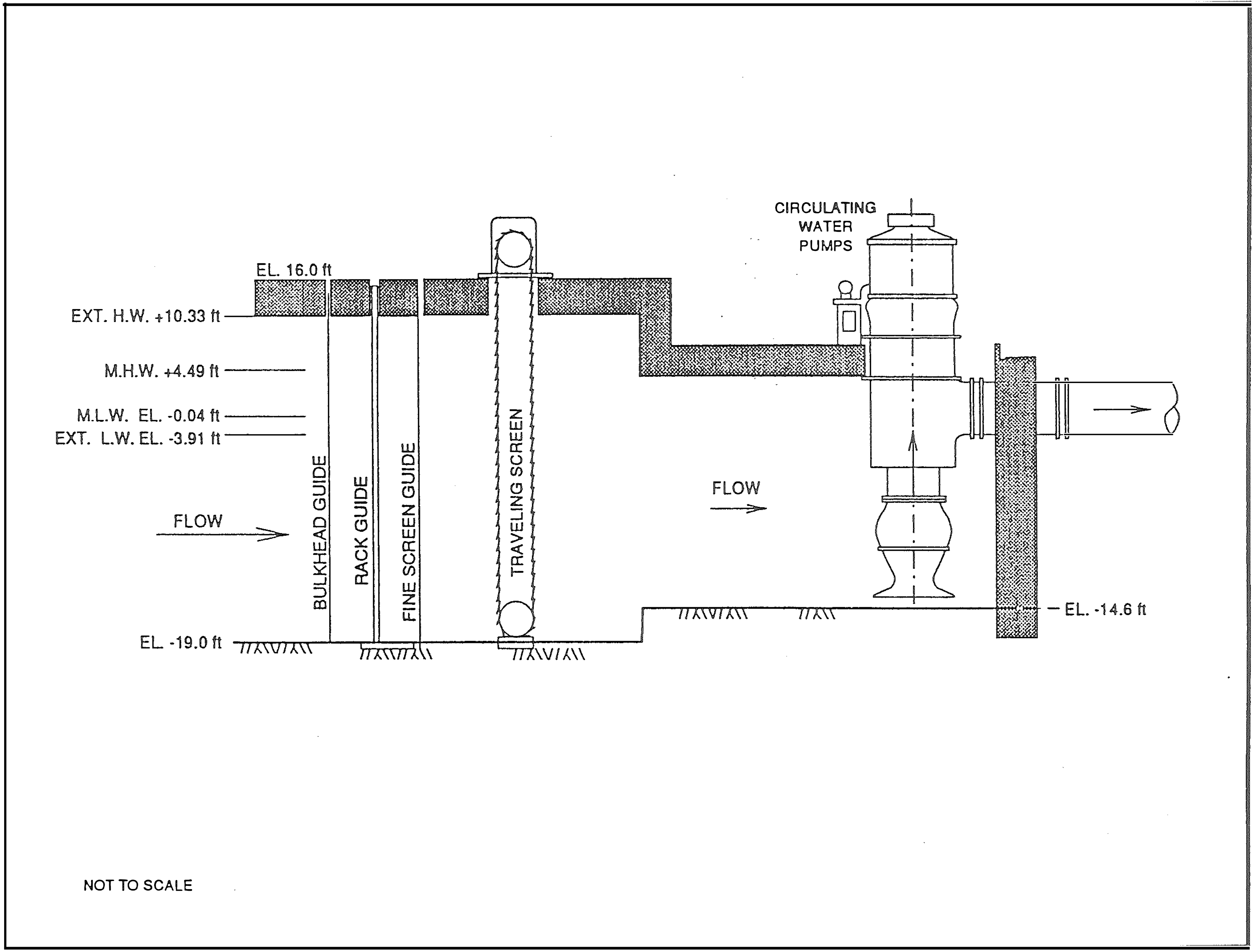


Figure 2-4. Cross section of intake bay and traveling screen units 10 and 20 at Ravenswood Generating Station.

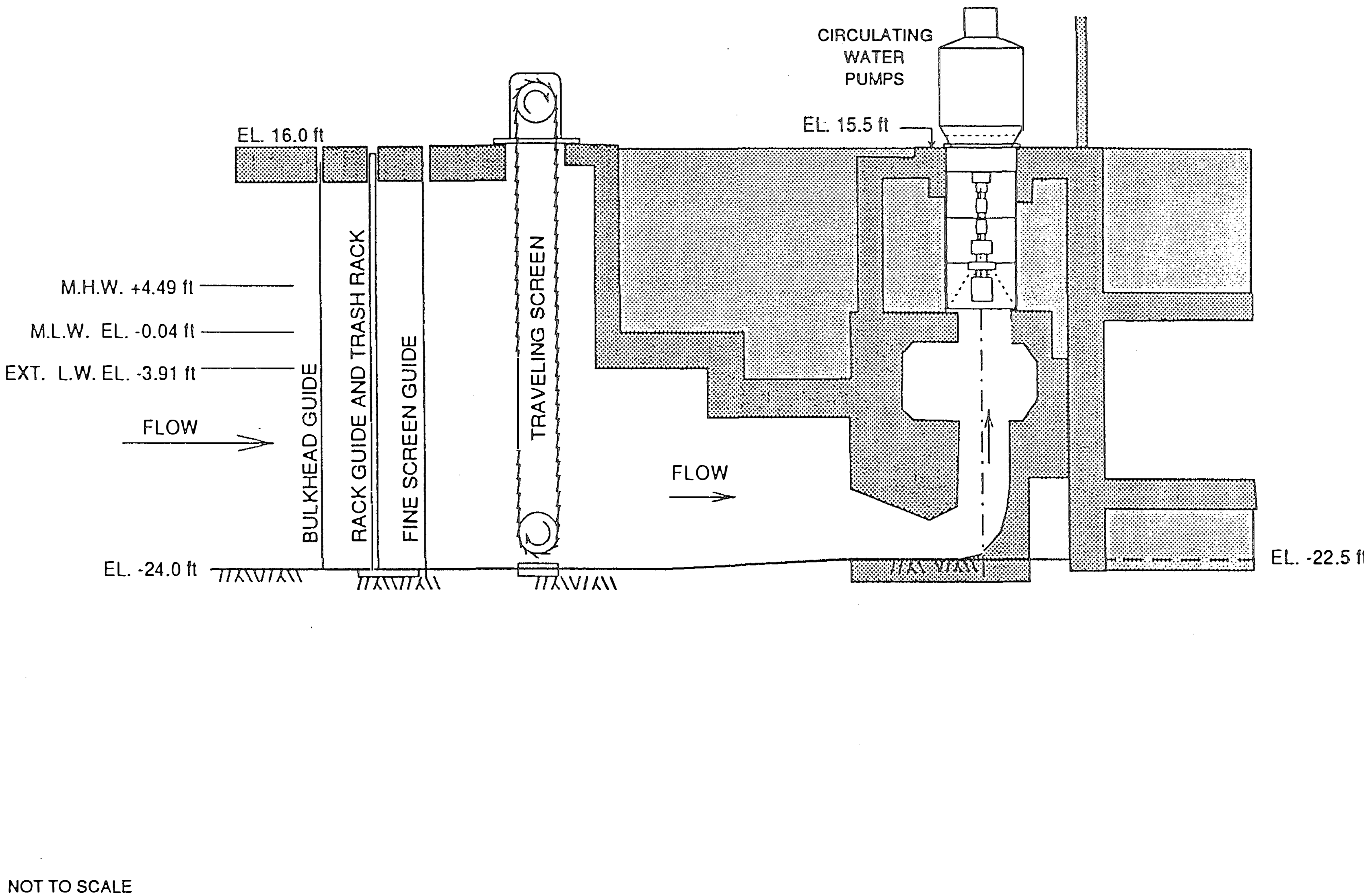


Figure 2-5. Cross section of intake bay and traveling screen unit 30 at Ravenswood Generating Station.

Entrained fish, invertebrates, and debris continue on with the cooling water passing through the intake bays to the open pump chamber where circulating and service pumps draw water for plant cooling and service water. A portion of the service water that is used to wash debris and organisms from the screens follows the same route as impinged fish and debris. Cooling water is pumped through large pipes to the condensing units, where it is used for cooling and as a result leaves the condensers and plant at a warmer temperature than when it entered the plant. The maximum design change in temperature (ΔT) with all units operating at maximum capacity is approximately 10°C (17°F). All three units discharge through a common canal at the south side of the plant.

2.2 FIELD METHODS

2.2.1 Impingement

Detailed impingement sample collection procedures are found in the Standard Operating Procedures for Impingement and Entrainment Sampling at Ravenswood Generating Station (NAI 1994). The station operates conventional traveling screens (four each at Units 10 and 20 and six at Unit 30) on an automated preset wash schedule of approximately one 10-min wash cycle every 1-2 hrs. Screenwash material is deposited in large collection baskets located in the open pit at the end of each unit's screenwash sluice. During the study on sampling days the existing basket was replaced with a sampling basket. Sampling baskets were 3 x 3 x 2-1/2 ft high and were constructed of 5/16 square-in. mesh slightly smaller than the 3/8 square-in. traveling screen mesh size (Figure 2-6). These baskets were suspended and secured below the screenwash discharge using a davit and winch system.

During each weekly 24-hr survey, fish, blue crabs, other invertebrates, and debris were collected in impingement baskets located at the end of each unit's screenwash sluice. Sample days usually began

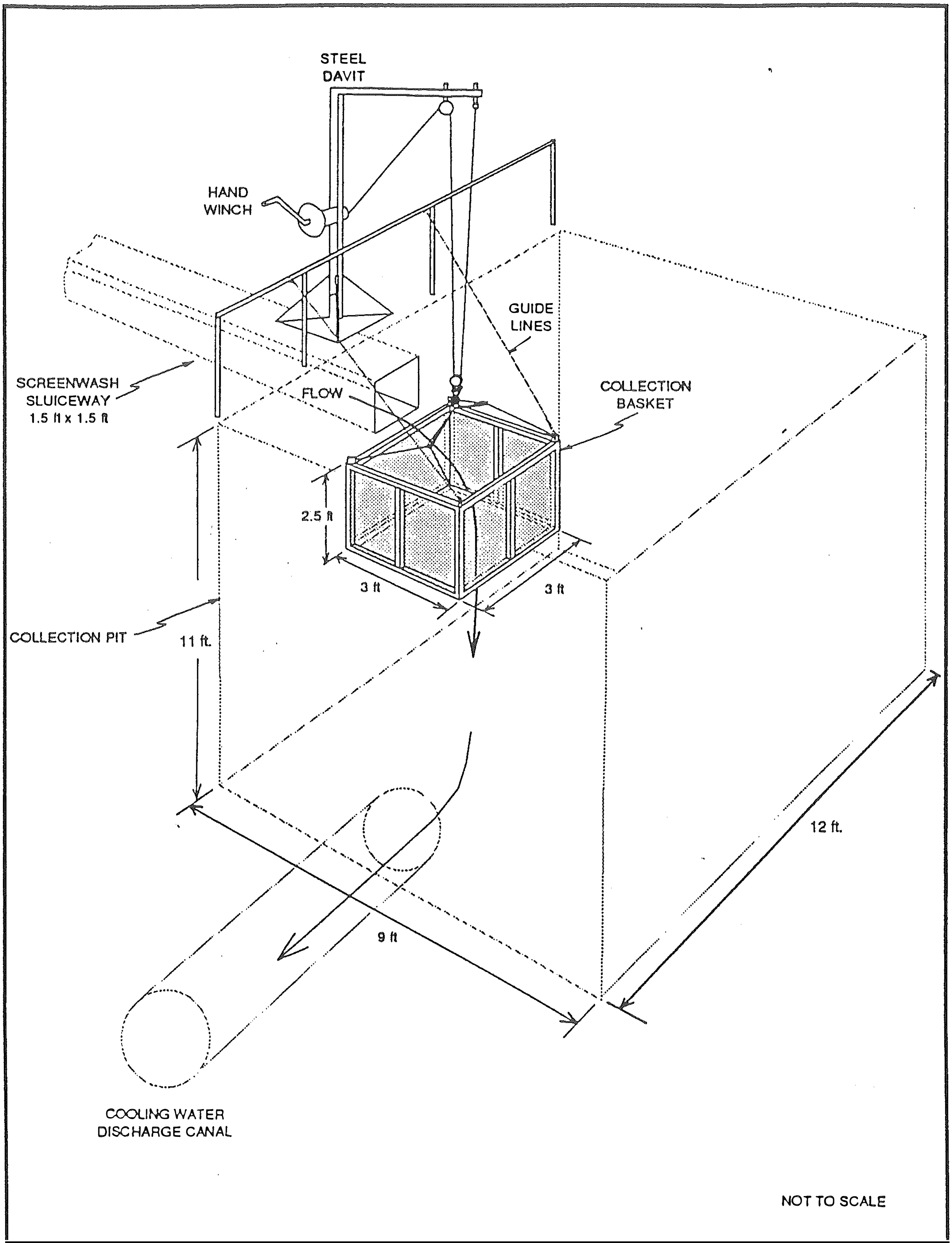


Figure 2-6. Schematic of impingement sampling station at Ravenswood Generating Station.

on Tuesdays at 1200 hrs, unless plant operating problems or a major holiday occurred on that date. A preset intermittent screenwash at Units 10, 20, and 30 was scheduled to begin at 1200 hrs on each Tuesday and end at 1200 on each Wednesday. The sample period began after wash cycle was observed and the impinged debris and fish were discarded. Collections were divided into four discrete 6-hr sample periods beginning at 1200 hrs (1200 to 1800, 1800 to 2400, 0000 to 0600, and 0600 to 1200 hrs). During periods of high debris loading the station washed the screens on a continuous wash schedule.

2.2.1.1 Sample Collection Procedures

Upon arrival at Ravenswood, the number of units on line, the screenwash schedule, number of screens washing, and circulating pumps operating were recorded. In preparation for a collection, the screens, screenhouse, and sluiceways of all operating units were flushed of all fish, blue crabs, and debris from 1100 to 1200 hrs. The sample day began at 1200 hrs with the insertion of collection baskets at Unit 10, 20, and 30. The washwater from the screens carried the fish, blue crabs, and debris down the sluiceway from the traveling screens to the collection area where they were retained in the collection basket.

Fish were removed from the basket at the end of each discrete 6-hr sampling period for identification of species and size/length class and enumeration. Blue crabs were also enumerated and debris was classified by type and volume was measured to the nearest 0.1 gal. Debris types included: plastic and paper, aquatic vegetation, terrestrial vegetation, shrimp and crabs, benthic organisms, bryozoans and tunicates, and ctenophores. The sample period ended after approximately 24 hrs with the withdrawal of the collecting baskets from Unit 10, 20, and then 30.

2.2.1.2 Screenwash Efficiency Studies

Screenwash efficiency studies were scheduled to occur once every three months (February to April, May to July, August to October, November to January). Species selected for collection efficiency determination were those fish species constituting greater than 10% of each quarter's total collection or those of recreational or commercial importance that were collected during that three-month period. If representatives of those species were not available, substitutes were selected from species of comparable size and body shape. Up to 100 tagged dead fish per species/size category were released (between the trash racks and the traveling screens at either Unit 10, 20, or 30) and the number of fish released and recovered in each size class was recorded.

Blue crabs were identified and counted separately from the debris "crabs and shrimp". No collection efficiency study was conducted for blue crabs. Factors contributing to losses for impinged fish such as being soft-bodied and therefore being vulnerable to disintegration and deterioration on the screen or in the collection basket prior to collection or loss due to river currents or wave action on inert bodies on the screen are not likely to contribute to large losses for blue crabs, which have a relatively hard cover and are mobile on the screen. In addition, because blue crabs are mobile, losses from collection efficiency releases due to their active avoidance of the screen or their ability to actively avoid being washed from the screen would not be separable from true sampling losses.

2.2.1.3 Water Quality Data Collection

At the beginning of each discrete 6-hr sample, water quality measurements were made at mid-depth, immediately in front of the center of the Unit 20 intake structure. If Unit 20 was not operating, measurements were taken in from of Unit 10 or 30, whichever was operating. Parameters included water temperature (nearest 0.1°C), conductivity (nearest µmho), salinity (nearest 0.1 ppt) calculated from the conductivity sample, DO (nearest 0.1 mg/l), and Ph (nearest 0.1 unit). Dissolved oxygen (DO) and water temperature were measured using a YSI Model 57 dissolved oxygen-water temperature meter. Conductivity was measured using a YSI Model 33 conductivity meter. A Cole Parmer Ph pen was used to measure Ph. Salinity was calculated from conductivity using the following formula:

$$Salinity\ (ppt) = -100\ \ln\left\{1 - \frac{C_T[-0.0858(\ln(T+3))^2 + 1.9488]}{178500}\right\} \tag{1}$$

where C_T = conductivity (μmho/cm) at temperature T

2.2.1.4 Station Operating Data

For each discrete 6-hr period, the operation of each unit, circulating pump, and traveling screen were recorded. Exact times when circulating water pumps and service water pumps were either turned on or off were obtained and entered into a computerized database which calculated exact water withdrawals during each collection period.

2.2.1.5 Sample Analysis

Enumeration of fish species and blue crabs along with a volume estimate of debris by category were made for each discrete 6-hr period at each unit being sampled. Each fish species was divided into two length classes (LC) for enumeration. LC1 fish were equal to or less than the upper length limit of young of year for a given species, as determined from the Hudson River Utilities' sponsored fisheries monitoring surveys; LC2 fish included all yearling and older fish (length >LC1 upper length limit). There was only one size class for blue crabs.

The length limits that define LC1 and LC2 were specific for each taxon and increased during the year as year classes of fish grew in length. January 1 was considered the birth date for all taxa and the upper length limit for LC1 was assigned a value of 20 mm for all species on 1 January. This convention is similar to that used by the National Marine Fisheries Service. Therefore, any species that was recruited as a YOY fish at the end of a given year was automatically considered age 1 after January of the next year.

All field enumeration and weight subsampling for enumeration was subject to quality control (QC) checks. After enumeration, samples were combined by species and size class for length analysis. Up to 50 of each fish species and size class and up to 50 blue crabs were randomly selected to be measured (blue crab carapace width was measured from point to point). All measurements were made to the nearest 1 mm and were subject to QC checks.

Volumetric estimates were made on biological and nonbiological debris in terms of gallons (to the nearest 0.1 gal) for each unit and 6-hr period. Trace amounts were listed as less than 0.1 gal (<0.1 gal). Debris was placed in the following classes: paper and plastic; terrestrial vegetation; aquatic vegetation; benthic organisms; crabs and shrimp; bryozoans and tunicates: ctenophores.

2.2.1.6 Analytical Procedures

Weekly impingement samples were used to estimate the number of fish impinged at Ravenswood Station. Each month was divided into weekly periods of seven days each. As a result, the first two months of a calendar quarter contained four weeks and the last month of a quarter contained five weeks. The number of fish collected in each 24-hour sampling period was divided by the total plant flow sampled within that period to estimate the weekly impingement rate. Weekly rates were averaged to produce a monthly mean impingement rate per unit volume (M_j). Monthly estimates were that rate times the plant flow for the month (F_j). The monthly estimates (F_jM_j) were summed to obtain an annual estimate ($\hat{A}$). The coefficient of variation (CV) was calculated as the standard deviation of the monthly estimates divided by the mean of the monthly estimates. A similar procedure was used to estimate the amount of debris and blue crabs collected from the traveling screens. Prior to calculating impingement rates for fish, the number of fish collected was adjusted for collection efficiency and this adjusted count was used in calculating impingement rates.

The estimated variance of the annual total was calculated by summing the monthly variances. The following formula was used to calculate the variance of monthly estimates ($F_j M_j$):

$$VAR(F_j M_j) = F_j^2 \frac{s_j^2}{n_j} \left(\frac{N_j - d_j}{N_j} \right) \quad (2)$$

where

F_j = total monthly cooling water volume
s_j = standard deviation of the weekly interval impingement rates
d_j = number of collection dates per month
n_j = number of weekly intervals sampled per month
N_j = number of days in the month

A monthly diel distribution index was computed to determine the temporal impingement distribution of common species and life stages. Data were used only when all four diel periods were sampled for a given sample date. Diel periods 1-4 were defined as the four discrete 6-hr sample periods 1200 to 1800 hrs, 1800 to 2400 hrs, 0000 to 0600, and 0600 to 1200 hrs.

$$DL_{ds} = \frac{I_{ds}}{\sum_{d=1}^{4} I_{ds}} x\ 100 \quad (3)$$

where

DL_{ds} = diel index for diel period d on sample date s
I_{ds} = impingement rate for diel period d on sample date s

2.2.2 Entrainment

Detailed entrainment sample collection procedures are found in the Standard Operating Procedures for Impingement and Entrainment Sampling at Ravenswood Generating Station (NAI 1994). Entrainment sampling was conducted within the combined discharge of Units 10, 20, and 30. Samples were collected from three 4-in. sampling pipes in the discharge canal that enabled simultaneous sample collection from the surface (3 ft below MLW), middepth (8 ft below MLW), and bottom (13 ft below MLW). Discharge water was pumped from each depth using Homelite 4-in. trash pumps. Actual gallons per minute (gpm) as measured by in-line Signet flow meters were adjusted to 310 to 330 gpm when possible; however, due to increased head at low water times, this pumping rate was not always attained. Collected discharge water was filtered through 505-micron conical nets suspended in 270-gal sample containers (Figure 2-7). Sample days usually began at 1200 hrs on Tuesday, unless plant operational problems or a major holiday occurred during the period. Collections were divided into four discrete 6-hr sample periods beginning at 1200 hrs (1200 to 1800, 1800 to 2400, 0000 to 0600, and 0600 to 1200 hrs).

The nets were set into position to filter the sample water at the beginning of each discrete 6-hr sample period. The time that water began to enter the sampling nets, the number of gallons pumped, and metered flow rates (gpm) were recorded. Each 6-hr sample was composited from shorter intervals. Total sample time and gallons recorded for each 6-hr sample. A total of 12 samples were collected over the 24-hr period (three depths x four discrete 6-hr sample periods).

2.2.2.1 Pump Calibration

The pumping rate was calibrated by timing (to the nearest 0.1 sec) the filling of a 270-gallon calibration tank. The amount of gallons pumped was divided by the number of seconds, this value was multiplied by 60 sec to give a gallon per minute rate.

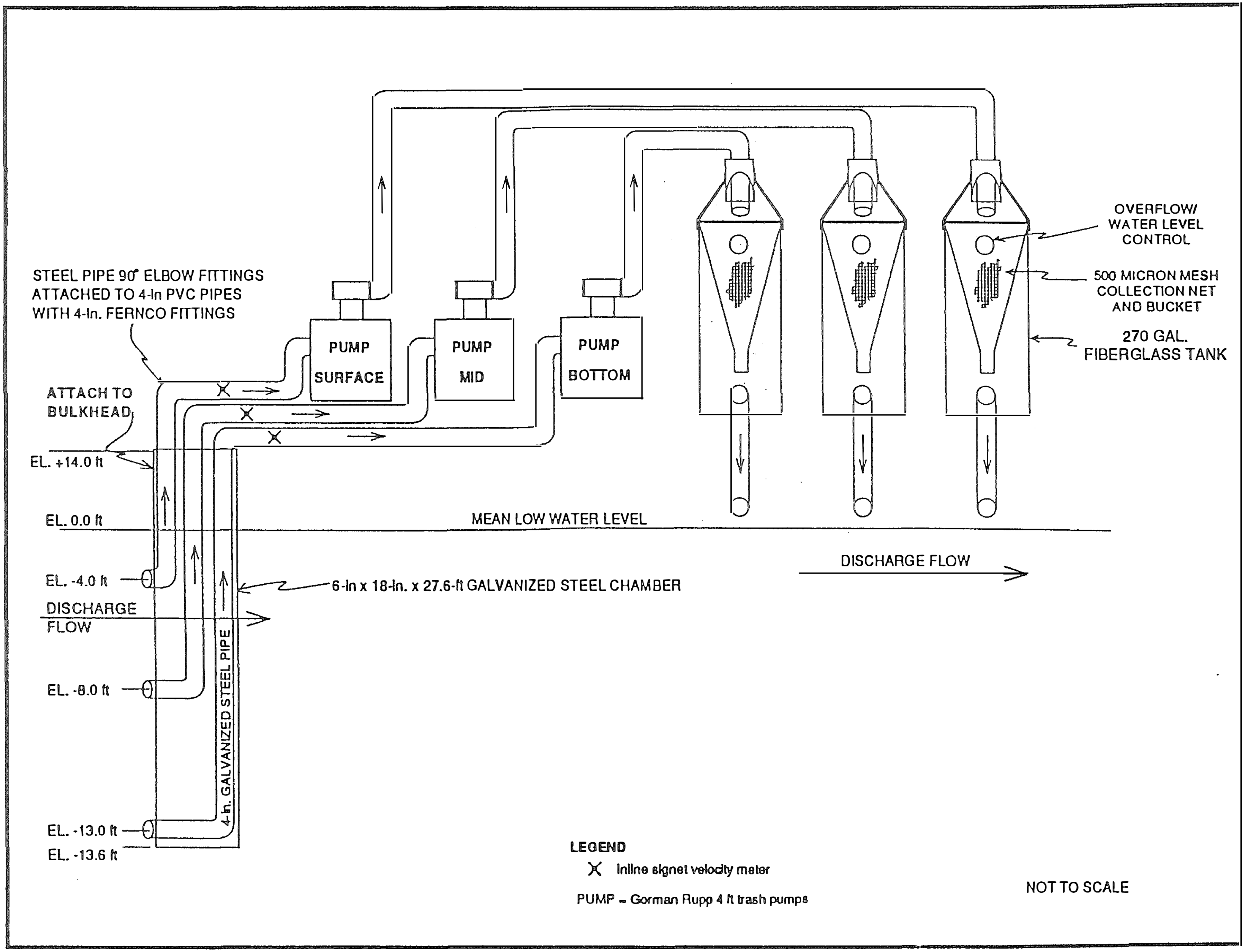


Figure 2-7. Entrainment sampling system at Ravenswood Generating Station.

2.2.2.2 Sample Handling Procedures

Plankton nets were exchanged every 20 to 120 min. A washdown pump was used to condense the sample into the cup at the bottom of the net. The contents were funneled or poured into labeled sample containers. Care was used to ensure that the net and collection cup were completely emptied of their contents. At times, a 500-micron or smaller sieve was used to remove excess water from the sample prior to preservation. Each subsample was preserved with 5% buffered formalin to equal a minimum of 2.5% (50:50 mix of 5% formalin to sample by volume).

2.2.2.3 Water Quality Data Collection

At the beginning of each 6-hr sample, water quality measurements were made at the surface in the discharge canal. Parameters included water temperature (nearest 0.1°C) and DO (nearest 0.1 mg/l).

2.2.2.4 Sample Analysis

Entrainment samples were analyzed by Lawler, Matusky and Skelly, Engineers. A sample consisted of those ichthyoplankton collected from each discrete 6-hr collection at the combined discharge of Units 10, 20, and 30 at the surface, middepth, and bottom. Each sample was assigned a unique field sample number in sequence by depth, day, and time order, beginning with 6001.

Fish eggs, larvae, and juveniles were removed from the samples using the following procedure:

- Samples were stained with rose bengal to facilitate sorting.

- The sample contents were poured into a sieve with a mesh equivalent to or finer than 505 μm and rinsed with water to remove the preservative. Any yearling and older fish were recorded by length class.

- If the sample contained large numbers of eggs or larvae, a subsample was prepared following accepted procedures.

- Fish eggs, larvae, and juveniles were removed from the sample using forceps, pipettes, and probes. Only those fragments that included the head were counted.

- A total count of eggs and "larvae" (i.e., yolk-sac larvae, post yolk-sac larvae, and juveniles combined that were removed from the sample) was maintained.

- When sorting was completed, the sample was rechecked for organisms. After the sample was rechecked, vials containing the sorted organisms were labeled and placed in a box designated for sorted samples. The sorting results and date and time completed were recorded in a log.

- The remaining sample contents were carefully washed into the original sample container, appropriately preserved, and returned to the storage area.

After sorting, ichthyoplankton were identified by species and life stage and were counted using the following procedure:

- The pertinent list of upper total length limits for young-of-the year and yearling Hudson River fish were recorded to determine whether any specimens were yearlings or older. These limits were developed from the Hudson River Utilities' fish monitoring surveys.

- Specimens were rinsed free of preservative and submerged in water in a petri dish. A binocular microscope with an ocular micrometer was used to examine the specimens and identify them to the lowest practical taxon (usually species) by referring to the literature, the reference collections, and by consulting with fellow identifiers.

- The life stage of each specimen was determined. Pertinent life stages were defined and identified as follows:

  Egg: The embryonic development stage, from spawning until hatching. Eggs frequently become damaged during collection and sample processing. Damaged eggs were counted only if an embryo could be matched to an egg capsule (chorion).

Yolk-sac larva: The transition stage from hatching through the development of a complete, functional digestive system (regardless of the degree of yolk and/or oil globule retention).

Post yolk-sac larva: The transition stage from development of a complete, functional digestive system to transformation to juvenile form (regardless of the degree of yolk and/or oil globule retention), including the leptocephalus stage of eels.

Juvenile: The stage from completed transformation to Age 1. Eels were considered juveniles until their length reached their LC2 cutoff length in effect for the date of sample collection. A juvenile has a full complement of fin rays identical to that of an adult.

- The specimens of each life stage were counted and counts recorded by species and life stage.
- No measurements were taken.
- Identified organisms were placed in vials with an adequate amount of preservative for storage. Specimens were removed for inclusion in the reference collection. For those removed, the species, life stage, and numbers were listed in the comments section of the form and their removal was noted on a tag retained inside the appropriate vial. All vials were labeled for a single sample, initialed, and banded together. The number of vials for the sample were recorded on the data form.

Characteristics considered in identifying specimens included the following:

- Morphology (overall shape, relative size, and position of various body parts and structures)
- Presence of specialized structures (e.g., oil droplets)
- Meristics (counts of myomeres, fin rays)
- Pigmentation (presence or absence of melanophores in specific positions)
- Rate of development (size when certain characteristics are acquired or lost)
- Spawning season
- Geographic range

Higher taxonomic categories (e.g., genus, family) were used only when a specimen was damaged or belonged to a group or stage that was not described adequately enough to make a conclusive assignment to a species.

2.2.2.5 Analytical Procedures

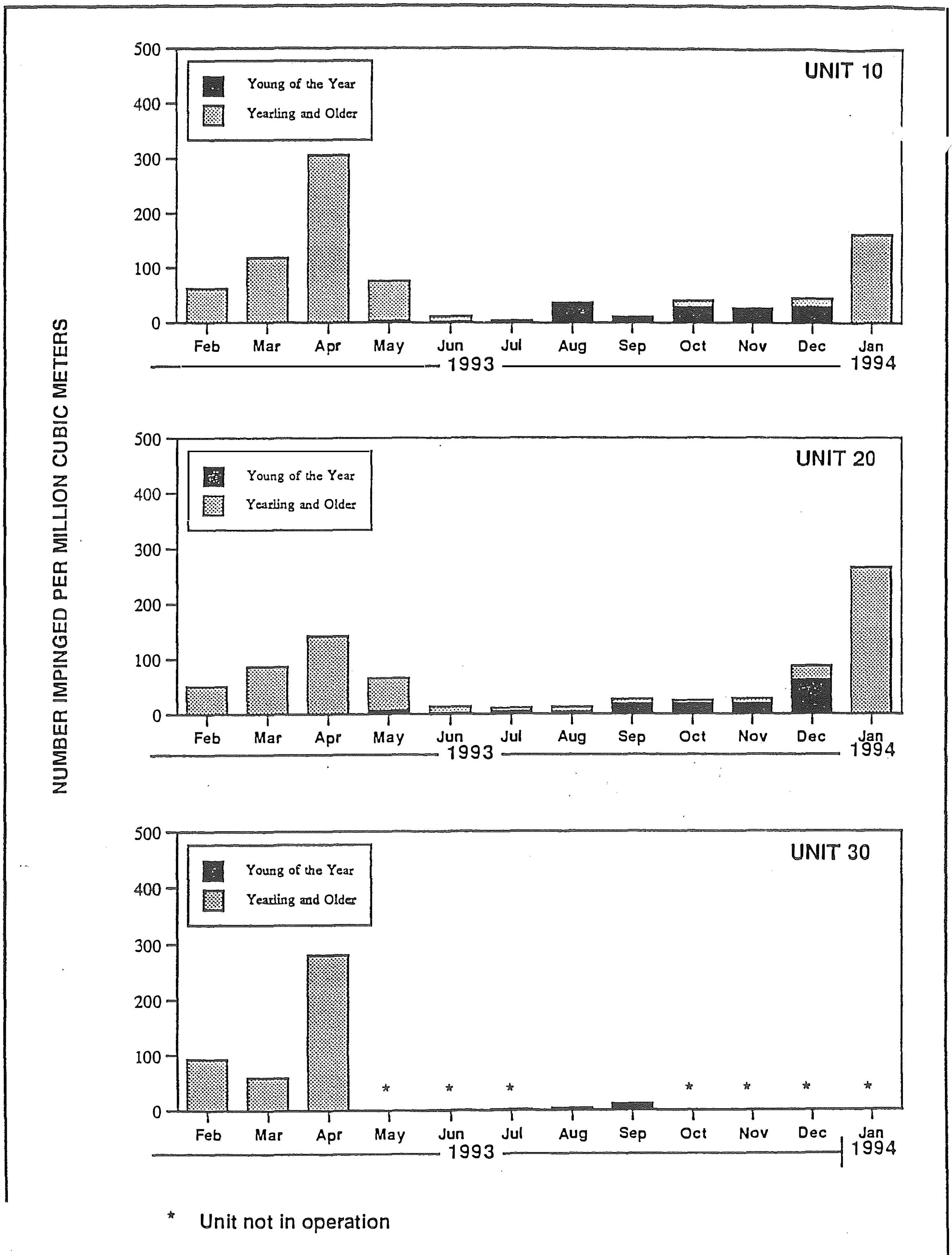
Weekly and biweekly entrainment samples were used to estimate the number of ichthyoplankton entrained at Ravenswood. Each month was divided into four periods of seven days each corresponding to the assignment of periods and months for impingement analysis. The number of ichthyoplankton (fish eggs, yolk-sac larvae, post yolk-sac larvae and young of year) collected in each 6-hr period (summed over surface, mid and bottom sampling depths) was divided by the total volume sampled in each period to estimate the weekly entrainment rate. The weekly rates were averaged to produce a monthly mean entrainment rate per unit volume (M_j). The monthly estimates were that rate times the plant cooling water flow for the month (F_j). The monthly estimates (F_jM_j) were summed to obtain an annual estimate ($\hat{A}$). The coefficient of variation (CV) was calculated as the standard deviation of the monthly estimates divided by the mean of the monthly estimates.

The estimated variance of the annual total was calculated by summing the monthly variances. The following formula was used to calculate the variance of monthly estimates (F_jM_j).

$$VAR(F_jM_j) = F_j^2 \frac{s_j^2}{n_j} \left(\frac{N_j - d_j}{N_j} \right) \qquad (4)$$

where

F_j = total monthly cooling water volume
s_j = standard deviation of the weekly interval entrainment rates
d_j = number of collection dates per month
n_j = number of weekly intervals sampled per month
N_j = number of days in the month



ıonthly impingement rates of young of year and yearling and older at Units 10, 20, · Ravenswood Generating Station. February 1993 through January 1994.

TABLE 3-10. (CONTINUED)

TAXON	UNITS 10, 20, AND 30 COMBINED			
	TOTAL YOUNG-OF-THE YEAR FISH	YOUNG-OF-THE-YEAR FISH PERCENT	TOTAL YEARLING AND OLDER FISH	YEARLING AND OLDER FISH PERCENT
WINTER FLOUNDER	349	3.7	24,912	34.2
GRUBBY	45	0.5	15,898	21.8
NORTHERN PIPEFISH	427	4.6	6,062	8.3
ATLANTIC SILVERSIDE	601	6.4	3,725	5.1
ATLANTIC HERRING	19	0.2	4,017	5.5
NORTHERN SEAROBIN	3,469	37.2	49	0.1
SMALLMOUTH FLOUNDER	354	3.8	3,051	4.2
BAY ANCHOVY	694	7.4	1,425	2.0
BLUEBACK HERRING	377	4.0	1,395	1.9
SPOTTED HAKE	0	0.0	1,670	2.3
STRIPED BASS	229	2.5	1,430	2.0
CUNNER	0	0.0	1,490	2.0
THREESPINE STICKLEBACK	0	0.0	1,246	1.7
SILVER HAKE	473	5.1	440	0.6
WINDOWPANE	155	1.7	774	1.1

3.0 RESULTS AND DISCUSSION

3.1 WATER QUALITY

Average intake water temperatures on sample days followed a seasonal pattern throughout the study period. At the beginning of the study in early February 1993 the average temperature was 4.0°C (Figure 3-1; Appendix A) and remained fairly steady through early March. A rapid increase was observed through the spring and early summer months to a high temperature of 25.3°C during the 3 August 1993 sampling event. Temperatures remained around 24°C through mid-September when a decreasing trend was observed reaching a low of 1.8°C during the 18 January 1994 sampling event. Average discharge temperatures followed a similar seasonal pattern (Figure 3-1). The lowest average discharge temperature of 7.1°C occurred during the 18 January 1994 sample and the highest (30.8°C) with the 3 August 1993 sample. Average discharge temperatures ranged from approximately 1° to 7°C higher than average intake temperatures (Figure 3-1 and Appendix A). The design maximum ΔT with all units operating at maximum capacity is 10°C.

Average dissolved oxygen (DO) also exhibited a seasonal pattern (Figure 3-1). Ambient water temperature was a primary influence on DO concentrations during the study. At the start of the study on 2 February 1993 the DO in the intake water averaged 11.3 mg/l. DO concentrations remained above 11 mg/l through early April 1993. DO in the intake water began to decline as temperatures rose during the spring dropping to around 4.5 mg/l to 5.5 mg/l during the July and August 1993 collections. The lowest average observed DO concentration of 3.5 mg/l occurred during the 13 July 1993 collection. DO concentrations then gradually increased with dropping temperatures through the fall.

DO values were generally higher in the discharge than the intake samples during the warmer months and lower during the colder months. The lowest average DO observed in the discharge, 3.7 mg/l , occurred during the 13 July 1993 sample and the highest, 12.2 mg/l, occurred in the winter during the 2 March, 16 March 1993 and again during the 11 January 1994 sample.

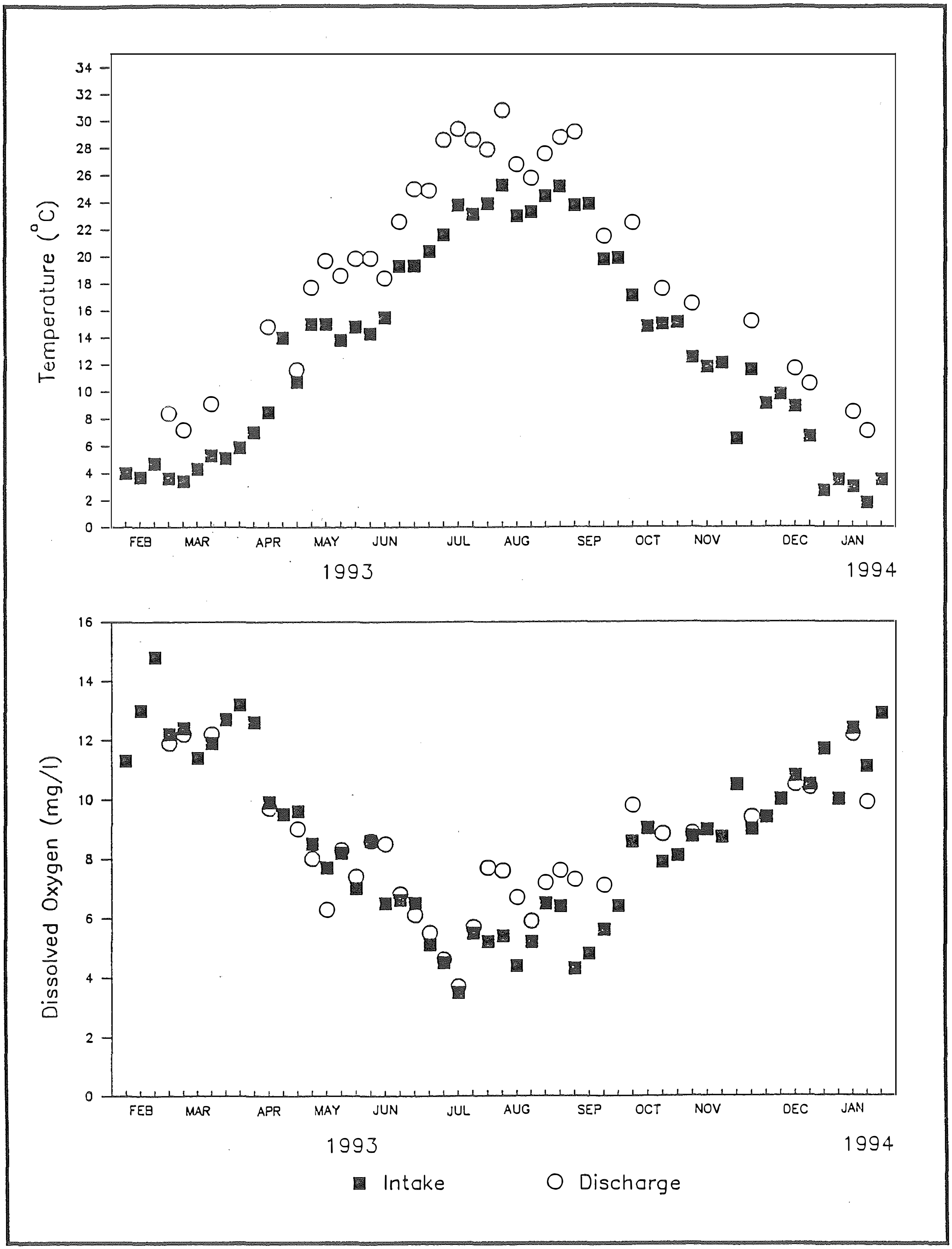


Figure 3-1. Average intake and discharge water temperature and dissolved oxygen at Ravenswood Generating Station, February 1993 through January 1994.

Salinity at Ravenswood is characteristic of a mixed fresh- and seawater system. The average observed intake salinity levels fluctuated between 18 and 22 ppt from the start of sampling on 2 February 1993 through early June 1993 (Appendix A). A low of 15 ppt occurred during the 20 April 1993 sampling event. From mid-June through late October 1993 the salinity range increased to 22 to 25 ppt and then dropped slightly to 20 to 24 ppt from November through the end of the study in late January 1994. Intake pH values varied throughout the sampling period, ranging from a low of 6.7 to a high of 8.5; pH values were generally higher (ranging from 7.8 to 8.5) during late winter and early spring, with the typical range the rest of the year from 7.3 to 7.8.

3.2 SPECIAL STUDIES

3.2.1 Collection Efficiency

Impingement collections from the intake screens of Ravenswood Station do not account for 100% of the fish impinged because fish can be lost prior to impingement due to: (1) scavenging by crabs, fish and birds; (2) river currents and wave action; (3) screenwash procedures; and (4) deterioration and disintegration of impinged fish on the screen or collection nets prior to basket retrieval. Collection efficiency studies were conducted at ERGS to measure these losses.

Collection efficiency studies were conducted in March, September, and December of 1993. Species targeted for use in the study were those fish constituting greater than 10% of each quarter's collection and fish of recreational or commercial importance.

Ten species of fishes, bay anchovy, hogchoker, rainbow smelt, white perch, winter flounder, grubby, Atlantic silverside, cunner, striped bass, and three spine stickleback were used in collection efficiency studies. Collection efficiency data for individual species were used to adjust the impingement counts for that species by quarter. Collection efficiency data were also used to adjust impingement counts for fishes with similar morphology. As examples, impingement counts of all flatfish were adjusted by the collection efficiency factor for hogchokers or winter flounder, depending which was used. Impingement counts for bay anchovies were adjusted by the collection efficiency factor for the similar bodied rainbow smelt. For other fishes, impingement counts were adjusted by the mean collection efficiency for that quarter.

Mean collection efficiency was relatively high during the study, ranging from 53.3% at Unit 20 during the fourth quarter to 93.7% at Unit 30 during the first quarter (Table 3-1). No collection efficiency studies were performed during the second quarter. Collection efficiency values for the third quarter were used for the second quarter. If a given unit was not operating on the scheduled day for collection efficiency studies, impingement counts at that unit for the quarter were adjusted by the mean collection efficiency values for the other units.

Collection efficiency was relatively constant among units and quarters with the exception of Unit 20 during the fourth quarter. The overall collection efficiency 53.3% at Unit 20 during the fourth quarter was the lowest recorded during the study. Collection efficiency for individual species ranged from 100% for various species in the third quarter to 51.1% for white perch in the fourth quarter.

TABLE 3-1. QUARTERLY COLLECTION EFFICIENCY RESULTS FOR THE RAVENSWOOD GENERATING STATION.

QUARTER	UNIT	SPECIES	NUMBER RELEASED	PERCENT RECOVERY
1	10	Winter flounder	155	68.0
		Grubby	224	79.0
		Atlantic silverside	30	90.0
		Cunner	26	61.5
		Striped bass	4	75.0
		Three spine stickleback	3	66.7
		Total	442	74.4
	30	Winter flounder	195	91.7
		Grubby	274	94.5
		Atlantic silverside	47	91.5
		Cunner	29	100.0
		Striped bass	2	100.0
		Three spine stickleback	7	100.0
		Total	554	93.7
3	10	Bay anchovy	300	57.0
		Hogchoker	300	57.6
		Rainbow smelt	300	73.3
		White perch	300	100.0
		Total	12,00	72.0
4	10	Winter flounder	60	95.0
		Grubby	100	94.0
		White perch	200	84.0
		Atlantic silverside	60	76.7
		Total	420	86.9
	20	Winter flounder	208	55.8
		Grubby	192	54.7
		White perch	360	51.1
		Total	160	53.3

3.3 IMPINGEMENT

Fifty-two weekly impingement surveys were conducted at Ravenswood Station from 2 February 1993 through 24 January 1994. Sampling dates (start date of 24-hr sample) and days that a unit operated are listed for each unit in Tables 3-2, 3-3, and 3-4. Operating dates cover the 52-week sampling period. Average daily sampling volumes were similar to the average daily operating volumes.

3.3.1 Fish Abundance and Composition

A combined total of 9,710 fish were collected at Ravenswood Units 10, 20, and 30 from February 1993 to January 1994 (Appendix B). When adjusted for collection efficiency and scaled to operating volume, an estimated total of 82,203 fish were impinged (Table 3-5). The estimated total number impinged was 22,275 fish at Unit 10, 24,453 at Unit 20, and 35,575 at Unit 30 (Tables 3-6, 3-7, and 3-8). As a measure of precision, the coefficients of variation for these annual estimates were 19, 11, and 41% for Units 10, 20 and 30, respectively. The 9,710 fish actually collected comprised 61 species at Units 10, 20 and 30 combined (Table 3-9). Most of these were marine species tolerant of only minimal freshwater influences, seven were euryhaline species tolerant of lower salinity conditions, seven were anadromous, one was catadromous, and two could be considered primarily freshwater. The five numerically dominant species at all three units combined were winter flounder, grubby, northern pipefish, Atlantic silverside and Atlantic herring, together accounting for 68% of the estimated total number of fish impinged (Table 3-10). Winter flounder and grubby were by far the most abundant at each unit, accounting for 30.7 and 19.4% of the total impinged, respectively.

Unit 10 had the highest total monthly estimated impingement abundances during the winter months with the highest during January 1994 (4,908 fish), which was 22% of the total for the year (Table 3-6). Average monthly impingement rates at Unit 10 ranged from 3.9 fish/10^6 m^3 in July to 305.9 fish/10^6 m^3 in April (Figure 3-2; Appendix C).

TABLE 3-2. COMPARISON OF IMPINGEMENT SAMPLING DATES, AVERAGE SAMPLING VOLUMES, OPERATING DATES AND AVERAGE DAILY OPERATING VOLUMES AT UNIT 10 DURING FEBRUARY 1993 THROUGH JANUARY 1994.

MONTH	YEAR	SAMPLING DATES[a]	AVERAGE DAILY SAMPLING VOLUME ($10^6 m^3$)	STANDARD DEVIATION	OPERATING DATES	AVERAGE DAILY OPERATING VOLUME ($10^6 m^3$)[b]	STANDARD DEVIATION
Feb	93	2,9, 16,23	1.28	0.14	2-28	1.39	0.01
Mar	93	2,23, 30	1.29	0.02	1-6, 20-31	0.63	0.64
Apr	93	6,27	1.29	0.01	1-12, 26-30	0.59	0.63
May	93	4,11, 25	1.26	0.05	1-30	0.73	0.57
Jun	93	8,15, 21,29	1.15	0.16	2-6, 8-4, 26-30	0.80	0.59
Jul	93	7,13	1.24	0.05	1-17, 28-31	0.67	0.62
Aug	93	3,10, 17,24,31	1.27	0.10	1-31	1.05	0.51
Sep	93	14,28	0.71	0.66	1-30	0.34	0.44
Oct	93	5,12, 19,26	0.92	0.45	1-31	1.27	0.30
Nov	93	2,9, 16,23,30	1.28	0.02	1-30	1.18	0.32
Dec	93	7,14, 21,28	1.27	0.18	1-31	1.30	0.27
Jan	94	4,11, 18,24	1.05	0.36	1-31	1.08	0.45

[a]Date is start of 24-hr sample.
[b]Includes service water, except days when no circulating pump operated.

TABLE 3-3. COMPARISON OF IMPINGEMENT SAMPLING DATES, AVERAGE DAILY SAMPLING VOLUMES, OPERATING DATES AND AVERAGE DAILY OPERATING VOLUMES AT UNIT 20 DURING FEBRUARY 1993 THROUGH JANUARY 1994.

MONTH	YEAR	SAMPLING DATES[a]	AVERAGE DAILY SAMPLING VOLUME ($10^6 m^3$)	STANDARD DEVIATION	OPERATING DATES	AVERAGE DAILY OPERATING VOLUME ($10^6 m^3$)[b]	STANDARD DEVIATION
Feb	93	2,16, 23	1.14	0.05	1-9, 11-28	1.04	0.28
Mar	93	2,9, 16	1.19	0.04	1-24	0.74	0.57
Apr	93	13,20, 27	1.21	0.03	10-28,30	0.73	0.60
May	93	4,11, 18,25	1.18	0.05	1-31	1.17	0.17
Jun	93	1,8, 15,21, 29	1.10	0.11	1-30	1.17	0.07
Jul	93	7,13, 20,27	1.16	0.07	1-31	1.14	0.24
Aug	93	10,17, 24,31	1.18	0.06	1-31	1.06	0.39
Sep	93	8,14, 21	1.22	0.01	1-30	1.14	0.31
Oct	93	12,19, 26	1.25	0.01	1,5-31	1.02	0.48
Nov	93	2,9, 16,21, 23	1.05	0.41	1-30	1.21	0.19
Dec	93	7,14, 21,28	1.08	0.14	1-31	1.04	0.30
Jan	94	4,11, 18,24	1.14	0.02	1-31	1.16	0.02

[a]Date is start of 24-hr sample.
[b]Includes service water, except days when no circulating pump operated.

TABLE 3-4. COMPARISON OF IMPINGEMENT SAMPLING DATES, AVERAGE DAILY SAMPLING VOLUMES, OPERATING DATES AND AVERAGE DAILY OPERATING VOLUMES AT UNIT 30 DURING FEBRUARY 1993-JANUARY 1994.

MONTH	YEAR	SAMPLING DATES[a]	AVERAGE DAILY SAMPLING VOLUME ($10^6 m^3$)	STANDARD DEVIATION	OPERATING DATES	AVERAGE DAILY OPERATING VOLUME ($10^6 m^3$)	STANDARD DEVIATION
Feb	93	2,9, 16,23	2.83	0.33	1-28	2.76	0.72
Mar	93	2,9, 16,23, 30	2.84	0.22	1-31	2.91	0.58
Apr	93	6,13, 20,27	3.03	0.03	1-30	3.00	0.38
May	93	--			28-30	0.01	0.02
Jun	93	15,21, 29	2.56	0.37	9-30	1.94	1.33
Jul	93	7,13, 27	2.97	0.04	1-31	2.56	0.87
Aug	93	3,31	2.75		1-31	1.13	1.24
Sep	93	8,14	2.99	0.09	1-24	1.69	1.51
Oct	93	--			--		
Nov	93	--			--		
Dec	93	--			--		
Jan	94	--			--		

[a]Date is start of 24-hr sample.
[b]Includes service water, except days when no circulating pump operated.

TABLE 3-5. ESTIMATE OF THE TOTAL NUMBER OF FISH IMPINGED FROM FEBRUARY 1994 THROUGH JANUARY 1994 AT RAVENSWOOD UNITS 10, 20, AND 30 COMBINED.

TAXON	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	TOTAL	PERCENT
ALEWIFE	48	99	39	25	0	0	11	8	0	152	214	13	610	0.74
AMERICAN EEL	25	8	44	0	23	10	0	0	21	0	15	0	144	0.18
AMERICAN SHAD	17	7	23	0	0	10	9	0	16	91	34	13	220	0.27
ATLANTIC CROAKER	0	0	0	0	0	0	0	0	0	0	0	27	27	0.03
ATLANTIC HERRING	11	52	3,362	353	227	18	0	0	0	0	0	13	4,036	4.90
ATLANTIC MENHADEN	81	0	0	0	0	0	0	0	0	11	62	0	153	0.19
ATLANTIC SEASNAIL	10	68	0	0	0	0	0	0	0	0	0	0	78	0.10
ATLANTIC SILVERSIDE	820	1,040	156	29	0	17	83	211	120	139	1,008	703	4,326	5.26
ATLANTIC TOMCOD	11	0	21	262	62	9	0	11	35	21	0	0	432	0.53
BAY ANCHOVY	26	0	0	399	119	34	750	164	302	239	102	0	2,135	2.59
BLACK SEA BASS	0	0	0	0	0	0	0	0	0	65	233	27	325	0.39
BLUEBACK HERRING	286	498	353	232	9	9	35	35	39	128	148	0	1,772	2.15
BLUEFISH	0	0	0	0	33	0	0	0	0	0	0	0	33	0.04
BUTTERFISH	0	0	0	0	10	12	260	38	0	0	0	0	319	0.39
COD FAMILY	0	0	7	0	0	0	0	0	0	0	0	0	7	0.01
CONGER EEL	7	8	23	0	135	0	0	0	0	0	7	20	199	0.24
CUNNER	171	669	272	15	37	9	54	48	0	0	21	194	1,490	1.81
FEATHER BLENNY	0	10	7	12	0	0	10	0	0	22	55	0	116	0.14
FLYING GURNARD	0	0	0	0	0	0	0	10	0	0	0	0	10	0.01
FOURBEARD ROCKLING	28	89	42	0	11	9	0	0	0	0	7	7	192	0.23
FOURSPINE STICKLEBACK	7	0	0	0	0	0	0	0	0	0	0	0	7	0.01
FOURSPOT FLOUNDER	0	0	0	0	0	0	0	0	0	0	13	97	110	0.13
GIZZARD SHAD	0	0	0	0	0	0	0	0	0	7	0	74	81	0.10
GOOSEFISH	0	0	0	0	0	0	0	0	0	0	0	7	7	0.01
GRUBBY	4,660	2,458	4,449	246	30	0	35	142	0	0	145	3,779	15,943	19.37
GULF STREAM FLOUNDER	7	0	0	0	0	0	0	0	0	0	0	0	7	0.01
HOGCHOKER	0	0	0	10	0	0	0	0	0	0	0	0	10	0.01
INLAND SILVERSIDE	27	0	0	0	0	0	0	0	0	0	0	0	27	0.03
INSHORE LIZARDFISH	0	0	0	0	0	0	0	0	55	18	0	0	73	0.09
LINED SEAHORSE	0	76	352	366	0	0	0	0	0	0	26	0	820	1.00
LITTLE SKATE	0	0	0	0	0	0	0	0	0	0	7	0	7	0.01
LOOKDOWN	0	0	0	0	0	0	13	0	0	0	0	0	13	0.02

TABLE 3-5. (CONTINUED)

TAXON	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	TOTAL	PERCENT
NAKED GOBY	39	94	13	0	0	0	0	0	0	0	0	0	146	0.18
NORTHERN KINGFISH	0	0	0	0	0	0	0	0	12	0	0	0	12	0.01
NORTHERN PIPEFISH	473	1,977	2,248	635	134	108	39	53	239	136	139	308	6,489	7.88
NORTHERN PUFFER	0	0	0	0	25	0	0	63	137	32	8	0	264	0.32
NORTHERN SEAROBIN	0	0	0	10	22	9	45	459	1,028	536	1,407	0	3,518	4.27
NORTHERN STARGAZER	0	0	0	0	0	0	0	0	0	11	14	0	24	0.03
POLLOCK	0	0	7	0	0	0	0	0	0	0	0	0	7	0.01
RAINBOW SMELT	7	44	117	0	0	0	0	0	0	0	100	423	691	0.84
RED HAKE	101	99	29	0	0	0	0	0	0	0	0	207	436	0.53
ROCK GUNNEL	79	106	168	18	0	0	0	48	0	0	0	0	419	0.51
SCUP	0	0	0	0	0	0	0	0	0	0	7	0	7	0.01
SEABOARD GOBY	0	0	0	0	0	0	0	20	0	0	0	0	20	0.02
SILVER HAKE	195	40	44	15	0	0	0	0	39	65	401	115	913	1.11
SILVER PERCH	0	0	0	0	0	0	0	0	82	10	32	0	125	0.15
SMALLMOUTH FLOUNDER	110	164	1,587	440	9	0	0	0	15	13	332	735	3,405	4.14
SPOT	0	0	0	0	0	0	0	0	0	0	0	7	7	0.01
SPOTFIN BUTTERFLYFISH	0	0	0	0	0	0	0	0	0	7	0	0	7	0.01
SPOTTED HAKE	18	108	1,328	118	0	0	0	0	9	32	0	57	1,670	2.03
STRIPED BASS	105	153	111	14	8	7	50	4	0	16	159	1,031	1,659	2.02
STRIPED CUSK-EEL	10	0	7	0	0	0	0	0	0	0	0	0	17	0.02
STRIPED KILLIFISH	0	8	0	0	0	0	0	0	0	0	0	0	8	0.01
STRIPED SEAROBIN	0	0	7	24	0	0	0	314	0	0	0	0	346	0.42
SUMMER FLOUNDER	0	0	7	22	0	0	0	0	0	0	0	0	29	0.03
TAUTOG	10	27	42	10	20	0	0	11	0	0	0	20	140	0.17
THREESPINE STICKLEBACK	343	549	13	25	0	0	0	0	0	0	22	294	1,246	1.51
WEAKFISH	0	0	0	0	0	0	55	8	16	30	43	0	151	0.18
WHITE CATFISH	0	0	0	0	0	0	0	0	0	0	0	7	7	0.01
WHITE PERCH	28	16	421	66	0	0	0	0	0	16	22	49	619	0.75
WINDOWPANE	32	18	140	87	0	48	19	0	15	24	86	460	929	1.13
WINTER FLOUNDER	3,167	2,362	14,106	313	49	178	44	108	35	0	59	4,841	25,261	30.69
TOTAL	10,957	10,845	29,545	3,747	962	489	1,512	1,754	2,214	1,821	4,929	13,529	82,303	100.0

TABLE 3-6. ESTIMATE OF THE TOTAL NUMBER OF FISH IMPINGED FROM FEBRUARY 1994 THROUGH JANUARY 1994 AT RAVENSWOOD UNIT 10.

TAXON	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	TOTAL	PERCENT	STDERR	CV
ALEWIFE	31	18	26	15	0	0	0	0	0	67	44	0	201	0.90	72	35.86
AMERICAN EEL	11	0	9	0	10	0	0	0	9	0	15	0	54	0.24	23	42.64
AMERICAN SHAD	0	0	9	0	0	0	9	0	16	59	15	0	108	0.48	60	55.54
ATLANTIC CROAKER	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
ATLANTIC HERRING	0	0	427	95	59	0	0	0	0	0	0	0	581	2.61	102	17.56
ATLANTIC MENHADEN	10	0	0	0	0	0	0	0	0	0	43	0	54	0.24	34	62.63
ATLANTIC SEASNAIL	0	18	0	0	0	0	0	0	0	0	0	0	18	0.08	9	47.82
ATLANTIC SILVERSIDE	337	525	16	29	0	0	14	32	86	62	385	228	1,714	7.69	350	20.40
ATLANTIC TOMCOD	0	0	0	61	10	0	0	11	35	0	0	0	117	0.52	60	50.98
BAY ANCHOVY	0	0	0	190	38	0	631	13	258	62	68	0	1,261	5.66	576	45.69
BLACK SEA BASS	0	0	0	0	0	0	0	0	0	44	99	0	143	0.64	45	31.19
BLUEBACK HERRING	104	289	94	124	0	0	0	0	16	96	74	0	797	3.58	250	31.37
BLUEFISH	0	0	0	0	23	0	0	0	0	0	0	0	23	0.11	22	94.11
BUTTERFISH	0	0	0	0	0	0	189	0	0	0	0	0	189	0.85	117	61.89
COD FAMILY	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
CONGER EEL	0	0	0	0	76	0	0	0	0	0	7	7	90	0.40	35	39.22
CUNNER	55	56	26	15	18	0	31	0	0	0	7	141	349	1.57	113	32.44
FEATHER BLENNY	0	0	0	0	0	0	10	0	0	0	26	0	36	0.16	18	48.92
FLYING GURNARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
FOURBEARD ROCKLING	0	9	9	0	0	0	0	0	0	0	7	7	32	0.14	15	47.73
FOURSPINE STICKLEBACK	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
FOURSPOT FLOUNDER	0	0	0	0	0	0	0	0	0	0	0	33	33	0.15	24	71.74
GIZZARD SHAD	0	0	0	0	0	0	0	0	0	7	0	20	27	0.12	20	71.97
GOOSEFISH	0	0	0	0	0	0	0	0	0	0	0	7	7	0.03	6	92.58
GRUBBY	960	341	835	66	10	0	8	53	0	0	101	1,203	3,576	16.06	1,009	28.21
GULF STREAM FLOUNDER	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
HOGCHOKER	0	0	0	10	0	0	0	0	0	0	0	0	10	0.04	9	94.49
INLAND SILVERSIDE	20	0	0	0	0	0	0	0	0	0	0	0	20	0.09	18	92.58
INSHORE LIZARDFISH	0	0	0	0	0	0	0	0	32	7	0	0	39	0.18	30	77.09
LINED SEAHORSE	0	19	51	167	0	0	0	0	0	0	8	0	244	1.10	87	35.75
LITTLE SKATE	0	0	0	0	0	0	0	0	0	0	7	0	7	0.03	7	92.11

TABLE 3-6. (CONTINUED)

TAXON	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	TOTAL	PERCENT	STDERR	CV
LOOKDOWN	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
NAKED GOBY	20	18	0	0	0	0	0	0	0	0	0	0	37	0.17	25	66.54
NORTHERN KINGFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
NORTHERN PIPEFISH	178	615	402	263	51	27	10	7	136	24	38	141	1,893	8.50	426	22.49
NORTHERN PUFFER	0	0	0	0	0	0	0	11	102	22	8	0	142	0.64	42	29.92
NORTHERN SEAROBIN	0	0	0	0	0	0	22	18	643	272	533	0	1,488	6.68	336	22.62
NORTHERN STARGAZER	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
POLLOCK	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
RAINBOW SMELT	0	18	48	0	0	0	0	0	0	0	38	143	247	1.11	81	32.63
RED HAKE	11	37	0	0	0	0	0	0	0	0	0	87	134	0.60	73	54.57
ROCK GUNNEL	0	18	32	18	0	0	0	0	0	0	0	0	68	0.31	36	53.47
SCUP	0	0	0	0	0	0	0	0	0	0	7	0	7	0.03	7	92.11
SEABOARD GOBY	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
SILVER HAKE	66	0	0	15	0	0	0	0	16	22	144	34	297	1.33	110	37.22
SILVER PERCH	0	0	0	0	0	0	0	0	70	0	0	0	70	0.31	65	92.58
SMALLMOUTH FLOUNDER	43	66	87	193	9	0	0	0	0	13	109	236	756	3.39	229	30.35
SPOT	0	0	0	0	0	0	0	0	0	0	0	7	7	0.03	7	92.58
SPOTFIN BUTTERFLYFISH	0	0	0	0	0	0	0	0	0	7	0	0	7	0.03	7	92.58
SPOTTED HAKE	11	84	136	59	0	0	0	0	9	22	0	7	327	1.47	118	36.20
STRIPED BASS	39	35	48	0	0	7	28	4	0	16	99	402	678	3.05	151	22.21
STRIPED CUSK-EEL	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
STRIPED KILLIFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
STRIPED SEAROBIN	0	0	7	15	0	0	0	11	0	0	0	0	33	0.15	19	56.87
SUMMER FLOUNDER	0	0	0	9	0	0	0	0	0	0	0	0	9	0.04	8	94.49
TAUTOG	10	9	0	0	0	0	0	11	0	0	0	7	37	0.17	18	47.84
THREESPINE STICKLEBACK	78	264	0	0	0	0	0	0	0	0	8	126	476	2.14	220	46.25
WEAKFISH	0	0	0	0	0	0	55	0	16	30	43	0	143	0.64	62	43.61
WHITE CATFISH	0	0	0	0	0	0	0	0	0	0	0	7	7	0.03	6	92.58
WHITE PERCH	11	0	120	37	0	0	0	0	0	16	8	21	212	0.95	30	14.26
WINDOWPANE	10	9	35	64	0	0	0	0	0	13	20	217	369	1.66	118	31.98
WINTER FLOUNDER	407	436	2,206	92	9	41	29	13	20	0	20	1,829	5,101	22.90	2,299	45.06
TOTAL	2,412	2,884	4,621	1,535	314	75	1,036	184	1,464	863	1,980	4,908	22,275	100.0	4,330	19.44

TABLE 3-7. ESTIMATE OF THE TOTAL NUMBER OF FISH IMPINGED FROM FEBRUARY 1994 THROUGH JANUARY 1994 AT RAVENSWOOD UNIT 20.

TAXON	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	TOTAL	PERCENT	STDERR	CV
ALEWIFE	10	73	0	10	0	0	11	0	0	85	170	13	374	1.53	89	23.80
AMERICAN EEL	0	8	8	0	12	10	0	0	12	0	0	0	49	0.20	21	42.68
AMERICAN SHAD	10	0	8	0	0	10	0	0	0	32	18	13	91	0.37	32	35.46
ATLANTIC CROAKER	0	0	0	0	0	0	0	0	0	0	0	27	27	0.11	25	92.58
ATLANTIC HERRING	11	8	653	258	168	18	0	0	0	0	0	13	1,129	4.62	438	38.76
ATLANTIC MENHADEN	41	0	0	0	0	0	0	0	0	11	18	0	69	0.28	32	45.99
ATLANTIC SEASNAIL	10	0	0	0	0	0	0	0	0	0	0	0	10	0.04	10	94.49
ATLANTIC SILVERSIDE	355	341	66	0	0	17	69	113	34	77	623	475	2,170	8.88	331	15.25
ATLANTIC TOMCOD	11	0	8	201	41	9	0	0	0	21	0	0	291	1.19	140	48.02
BAY ANCHOVY	12	0	0	209	81	34	119	119	44	177	33	0	828	3.38	209	25.29
BLACK SEA BASS	0	0	0	0	0	0	0	0	0	21	133	27	182	0.74	45	24.86
BLUEBACK HERRING	92	141	69	108	9	9	35	10	23	32	74	0	604	2.47	119	19.75
BLUEFISH	0	0	0	0	10	0	0	0	0	0	0	0	10	0.04	9	92.58
BUTTERFISH	0	0	0	0	0	0	25	21	0	0	0	0	46	0.19	26	57.05
COD FAMILY	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
CONGER EEL	0	8	16	0	59	0	0	0	0	0	0	13	96	0.39	47	49.02
CUNNER	0	125	8	0	10	9	23	31	0	0	14	53	273	1.12	62	22.55
FEATHER BLENNY	0	10	0	12	0	0	0	0	0	22	29	0	73	0.30	33	45.53
FLYING GURNARD	0	0	0	0	0	0	0	10	0	0	0	0	10	0.04	10	94.11
FOURBEARD ROCKLING	0	24	0	0	0	9	0	0	0	0	0	0	33	0.13	15	46.70
FOURSPINE STICKLEBACK	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
FOURSPOT FLOUNDER	0	0	0	0	0	0	0	0	0	0	13	64	77	0.32	47	60.47
GIZZARD SHAD	0	0	0	0	0	0	0	0	0	0	0	54	54	0.22	29	53.46
GOOSEFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
GRUBBY	422	346	361	180	20	0	12	32	0	0	45	2,576	3,993	16.33	704	17.64
GULF STREAM FLOUNDER	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
HOGCHOKER	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
INLAND SILVERSIDE	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
INSHORE LIZARDFISH	0	0	0	0	0	0	0	0	23	10	0	0	34	0.14	15	43.03
LINED SEAHORSE	0	0	109	199	0	0	0	0	0	0	18	0	327	1.34	58	17.72
LITTLE SKATE	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
LOOKDOWN	0	0	0	0	0	0	13	0	0	0	0	0	13	0.05	12	94.49

TABLE 3-7. (CONTINUED)

TAXON	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	TOTAL	PERCENT	STDERR	CV
NAKED GOBY	12	10	0	0	0	0	0	0	0	0	0	0	22	0.09	15	67.68
NORTHERN KINGFISH	0	0	0	0	0	0	0	0	12	0	0	0	12	0.05	11	94.49
NORTHERN PIPEFISH	65	262	561	372	83	81	29	13	103	112	101	167	1,949	7.97	249	12.76
NORTHERN PUFFER	0	0	0	0	25	0	0	52	35	10	0	0	122	0.50	64	52.47
NORTHERN SEAROBIN	0	0	0	10	22	9	23	333	385	264	875	0	1,922	7.86	474	24.66
NORTHERN STARGAZER	0	0	0	0	0	0	0	0	0	11	14	0	24	0.10	16	66.02
POLLOCK	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
RAINBOW SMELT	0	19	9	0	0	0	0	0	0	0	62	279	370	1.51	63	17.12
RED HAKE	21	31	15	0	0	0	0	0	0	0	0	120	187	0.77	82	43.86
ROCK GUNNEL	14	0	0	0	0	0	0	27	0	0	0	0	41	0.17	28	70.05
SCUP	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
SEABOARD GOBY	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
SILVER HAKE	53	17	23	0	0	0	0	0	23	42	258	81	496	2.03	97	19.60
SILVER PERCH	0	0	0	0	0	0	0	0	12	10	32	0	54	0.22	23	42.23
SMALLMOUTH FLOUNDER	10	16	628	247	0	0	0	0	15	0	224	499	1,639	6.70	410	25.00
SPOT	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
SPOTFIN BUTTERFLYFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
SPOTTED HAKE	0	0	407	59	0	0	0	0	0	10	0	51	527	2.15	213	40.50
STRIPED BASS	39	68	9	14	8	0	0	0	0	0	60	630	828	3.39	199	24.08
STRIPED CUSK-EEL	10	0	0	0	0	0	0	0	0	0	0	0	10	0.04	10	94.49
STRIPED KILLIFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
STRIPED SEAROBIN	0	0	0	9	0	0	0	178	0	0	0	0	187	0.77	141	75.54
SUMMER FLOUNDER	0	0	0	13	0	0	0	0	0	0	0	0	13	0.05	12	92.58
TAUTOG	0	0	8	10	20	0	0	0	0	0	0	13	51	0.21	21	40.14
THREESPINE STICKLEBACK	66	107	0	25	0	0	0	0	0	0	14	168	380	1.55	91	23.99
WEAKFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
WHITE CATFISH	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	-
WHITE PERCH	10	16	85	29	0	0	0	0	0	0	14	28	183	0.75	40	21.85
WINDOWPANE	0	0	8	23	0	33	0	0	15	10	66	243	398	1.63	94	23.53
WINTER FLOUNDER	176	351	188	221	27	77	15	52	15	0	39	3,012	4,174	17.07	969	23.22
TOTAL	1,450	1,980	3,247	2,212	594	325	373	992	751	958	2,948	8,622	24,453	100.0	2,727	11.15

TABLE 3-8. ESTIMATE OF THE TOTAL NUMBER OF FISH IMPINGED FROM FEBRUARY 1994 THROUGH JANUARY 1994 AT RAVENSWOOD UNIT 30.

TAXON	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	TOTAL	PERCENT	STDERR	CV
ALEWIFE	7	7	13	-	0	0	0	8	-	-	-	-	36	0.10	17	48.66
AMERICAN EEL	14	0	27	-	0	0	0	0	-	-	-	-	41	0.12	17	40.08
AMERICAN SHAD	7	7	7	-	0	0	0	0	-	-	-	-	21	0.06	11	53.47
ATLANTIC CROAKER	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
ATLANTIC HERRING	0	44	2,282	-	0	0	0	0	-	-	-	-	2,326	6.54	782	33.62
ATLANTIC MENHADEN	30	0	0	-	0	0	0	0	-	-	-	-	30	0.08	11	35.83
ATLANTIC SEASNAIL	0	50	0	-	0	0	0	0	-	-	-	-	50	0.14	23	46.74
ATLANTIC SILVERSIDE	129	175	73	-	0	0	0	65	-	-	-	-	442	1.24	78	17.65
ATLANTIC TOMCOD	0	0	14	-	11	0	0	0	-	-	-	-	24	0.07	13	51.59
BAY ANCHOVY	14	0	0	-	0	0	0	32	-	-	-	-	46	0.13	32	69.01
BLACK SEA BASS	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
BLUEBACK HERRING	90	67	190	-	0	0	0	25	-	-	-	-	372	1.04	129	34.78
BLUEFISH	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
BUTTERFISH	0	0	0	-	10	12	46	17	-	-	-	-	85	0.24	17	20.01
COD FAMILY	0	0	7	-	0	0	0	0	-	-	-	-	7	0.02	6	92.58
CONGER EEL	7	0	7	-	0	0	0	0	-	-	-	-	14	0.04	9	65.47
CUNNER	116	488	239	-	10	0	0	16	-	-	-	-	868	2.44	326	37.56
FEATHER BLENNY	0	0	7	-	0	0	0	0	-	-	-	-	7	0.02	6	92.58
FLYING GURNARD	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
FOURBEARD ROCKLING	28	56	34	-	11	0	0	0	-	-	-	-	128	0.36	32	24.78
FOURSPINE STICKLEBACK	7	0	0	-	0	0	0	0	-	-	-	-	7	0.02	6	92.58
FOURSPOT FLOUNDER	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
GIZZARD SHAD	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
GOOSEFISH	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
GRUBBY	3,278	1,770	3,254	-	0	0	15	57	-	-	-	-	8,374	23.54	2,485	29.68
GULF STREAM FLOUNDER	7	0	0	-	0	0	0	0	-	-	-	-	7	0.02	7	92.58
HOGCHOKER	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
INLAND SILVERSIDE	7	0	0	-	0	0	0	0	-	-	-	-	7	0.02	6	92.58
INSHORE LIZARDFISH	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
LINED SEAHORSE	0	57	192	-	0	0	0	0	-	-	-	-	249	0.70	81	32.33
LITTLE SKATE	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-

TABLE 3-8. (CONTINUED)

TAXON	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	TOTAL	PERCENT	STDERR	CV
LOOKDOWN	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
NAKED GOBY	7	67	13	-	0	0	0	0	-	-	-	-	87	0.24	55	62.90
NORTHERN KINGFISH	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
NORTHERN PIPEFISH	230	1,099	1,285	-	0	0	0	32	-	-	-	-	2,647	7.44	529	19.98
NORTHERN PUFFER	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
NORTHERN SEAROBIN	0	0	0	-	0	0	0	108	-	-	-	-	108	0.30	57	52.37
NORTHERN STARGAZER	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
POLLOCK	0	0	7	-	0	0	0	0	-	-	-	-	7	0.02	6	92.58
RAINBOW SMELT	7	7	60	-	0	0	0	0	-	-	-	-	74	0.21	48	65.32
RED HAKE	70	31	14	-	0	0	0	0	-	-	-	-	115	0.32	67	58.37
ROCK GUNNEL	66	88	136	-	0	0	0	21	-	-	-	-	311	0.87	71	22.95
SCUP	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
SEABOARD GOBY	0	0	0	-	0	0	0	20	-	-	-	-	20	0.06	19	95.62
SILVER HAKE	76	23	21	-	0	0	0	0	-	-	-	-	120	0.34	49	40.70
SILVER PERCH	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
SMALLMOUTH FLOUNDER	57	82	872	-	0	0	0	0	-	-	-	-	1,011	2.84	423	41.82
SPOT	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
SPOTFIN BUTTERFLYFISH	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
SPOTTED HAKE	7	25	784	-	0	0	0	0	-	-	-	-	816	2.29	213	26.07
STRIPED BASS	27	50	53	-	0	0	22	0	-	-	-	-	153	0.43	48	31.21
STRIPED CUSK-EEL	0	0	7	-	0	0	0	0	-	-	-	-	7	0.02	6	92.58
STRIPED KILLIFISH	0	8	0	-	0	0	0	0	-	-	-	-	8	0.02	8	92.58
STRIPED SEAROBIN	0	0	0	-	0	0	0	126	-	-	-	-	126	0.35	79	62.65
SUMMER FLOUNDER	0	0	7	-	0	0	0	0	-	-	-	-	7	0.02	6	92.58
TAUTOG	0	17	34	-	0	0	0	0	-	-	-	-	51	0.14	29	55.84
THREESPINE STICKLEBACK	198	179	13	-	0	0	0	0	-	-	-	-	391	1.10	50	12.92
WEAKFISH	0	0	0	-	0	0	0	8	-	-	-	-	8	0.02	8	95.62
WHITE CATFISH	0	0	0	-	0	0	0	0	-	-	-	-	0	0.00	0	-
WHITE PERCH	7	0	217	-	0	0	0	0	-	-	-	-	224	0.63	133	59.27
WINDOWPANE	21	9	97	-	0	15	19	0	-	-	-	-	161	0.45	38	23.71
WINTER FLOUNDER	2,584	1,575	11,711	-	13	61	0	42	-	-	-	-	15,986	44.94	10,500	65.68
TOTAL	7,095	5,981	21,677	-	54	88	102	578	-	-	-	-	35,575	100.0	14,556	40.92

TABLE 3-9. SPECIES COMPOSITION OF FISH COLLECTED IN IMPINGEMENT SAMPLES AT RAVENSWOOD UNITS 10, 20, AND 30, FEBRUARY 1993 THROUGH JANUARY 1994.

ASSEMBLAGE	COMMON NAME	SCIENTIFIC NAME
Catadromous	American eel	*Anguilla rostrata*
Estuarine	Alewife	*Alosa pseudoharengus*
	American shad	*Alosa sapidissima*
	Atlantic tomcod	*Microgadus tomcod*
	Bay anchovy	*Anchoa mitchilli*
	Blueback herring	*Alosa aestivalis*
	Fourspine stickleback	*Apeltes quadracus*
	Hogchoker	*Trinectes maculatus*
	Inland silverside	*Menidia beryllina*
	Rainbow smelt	*Osmerus mordax*
	Striped bass	*Morone saxatilis*
	Striped killifish	*Fundulus majalis*
	Threespine stickleback	*Gasterosteus aculeatus*
	White perch	*Morone americana*
Freshwater	Gizzard shad	*Dorosoma cepedianum*
	White catfish	*Ameiurus catus*
Marine	Atlantic croaker	*Micropogonias undulatus*
	Atlantic herring	*Clupea harengus*
	Atlantic menhaden	*Brevoortia tyrannus*
	Atlantic seasnail	*Liparis atlanticus*
	Atlantic silverside	*Menidia menidia*
	Black sea bass	*Centropristis striata*
	Blue crab	*Callinectes sapidus*
	Bluefish	*Pomatomus saltatrix*
	Butterfish	*Peprilus triacanthus*
	Cod family	*Gadidae*
	Conger eel	*Conger oceanicus*
	Cunner	*Tautogolabrus adspersus*
	Feather blenny	*Hypsoblennius hentzi*
	Flying gurnard	*Dactylopterus volitans*
	Fourbeard rockling	*Enchelyopus cimbrius*
	Fourspot flounder	*Paralichthys oblongus*
	Goosefish	*Lophius americanus*
	Grubby	*Myoxocephalus aenaeus*
	Gulf stream flounder	*Citharichthys arctifrons*
	Inshore lizardfish	*Synodus foetens*
	Lined seahorse	*Hippocampus erectus*
	Little skate	*Raja erinacea*
	Lookdown	*Selene vomer*
	Naked goby	*Gobiosoma bosci*
	Northern kingfish	*Menticirrhus saxatilis*

(continued)

TABLE 3-9. (CONTINUED)

ASSEMBLAGE	COMMON NAME	SCIENTIFIC NAME
	Northern pipefish	*Syngnathus fuscus*
	Northern puffer	*Sphoeroides maculatus*
	Northern searobin	*Prionotus carolinus*
	Northern stargazer	*Astroscopus guttatus*
	Pollock	*Pollachius virens*
	Red hake	*Urophycis chuss*
	Rock gunnel	*Pholis gunnellus*
	Scup	*Stenotomus chrysops*
	Seaboard goby	*Gobiosoma ginsburgi*
	Silver hake	*Merluccius bilinearis*
	Silver perch	*Bairdiella chrysoura*
	Smallmouth flounder	*Etropus microstomus*
	Spot	*Leiostomus xanthurus*
	Spotfin butterflyfish	*Chaetodon ocellatus*
	Spotted hake	*Urophycis regia*
	Striped cusk-eel	*Ophidion marginatum*
	Striped searobin	*Prionotus evolans*
	Summer flounder	*Paralichthys dentatus*
	Tautog	*Tautoga onitis*
	Weakfish	*Cynoscion regalis*
	Windowpane	*Scophthalmus aquosus*
	Winter flounder	*Pleuronectes americanus*

TABLE 3-10. PERCENT COMPOSITION OF THE 15 MOST ABUNDANT FISH SPECIES IN RAVENSWOOD IMPINGEMENT COLLECTIONS, FEBRUARY 1993 THROUGH JANUARY 1994.

TAXON	UNIT 10		UNIT 20		UNIT 30		UNITS 10, 20, AND 30 COMBINED		
	TOTAL	PERCENT	TOTAL	PERCENT	TOTAL	PERCENT	TOTAL	PERCENT	CUMULATIVE PERCENT
WINTER FLOUNDER	5,101	22.9	4,174	17.1	15,986	44.9	25,261	30.7	30.7
GRUBBY	3,576	16.1	3,993	16.4	8,374	23.5	15,943	19.4	50.1
NORTHERN PIPEFISH	1,893	8.5	1,949	8.0	2,647	7.4	6,489	7.9	58.0
ATLANTIC SILVERSIDE	1,714	7.7	2,170	8.9	442	1.2	4,326	5.3	63.3
ATLANTIC HERRING	581	2.6	1,129	4.6	2,326	6.5	4,036	4.9	68.2
NORTHERN SEAROBIN	1,488	6.7	1,922	7.9	108	0.3	3,518	4.3	72.5
SMALLMOUTH FLOUNDER	756	3.4	1,639	6.7	1,011	2.8	3,405	4.1	76.6
BAY ANCHOVY	1,261	5.7	812	3.3	46	0.1	2,119	2.6	79.2
BLUEBACK HERRING	797	3.6	604	2.5	372	1.0	1,772	2.2	81.4
SPOTTED HAKE	327	1.5	527	2.2	816	2.3	1,670	2.0	83.4
STRIPED BASS	678	3.0	828	3.4	153	0.4	1,659	2.0	85.4
CUNNER	349	1.6	273	1.1	868	2.4	1,490	1.8	87.2
THREESPINE STICKLEBACK	476	2.1	380	1.6	391	1.1	1,246	1.5	88.7
SILVER HAKE	297	1.3	496	2.0	120	0.3	913	1.1	90.9
WINDOWPANE	369	1.7	398	1.6	161	0.5	929	1.1	89.8

Estimated total numbers of fish impinged (8,622, Table 3-7) and monthly impingement rates (265.4 fish/10^6 m^3, Figure 3-2; Appendix C) at Unit 20 were highest during January 1994. This peak was associated with the impingement of yearling and older winter flounder. The higher numbers and rates occurred during the winter and early spring months when yearling and older fish dominated the sampling collections. From September through December 1993 young-of-the-year fish were more dominant during which time northern sea robin was the most abundant species.

At Unit 30 samples were collected only during the months of operation (February - March 1993, June - September 1993). April exhibited the highest total estimated numbers of fish (21,677) 73% of which were yearling and older winter flounder (Table 3-7). Monthly impingement rates were also highest during April (279.5 fish/10^6 m^3) (Figure 3-2; Appendix C).

Monthly impingement rates were higher for Unit 10 than the other two units during March through May, August, October and January. Impingement rates were generally higher at Unit 20 during the remaining months. Based on an annual average impingement rate, Unit 10 (75.3 fish/10^6 m^3) was slightly higher than Unit 20 (67.4 fish/10^6 m^3) (Appendix C). Since Unit 30 was not in operation during the entire study period, an annual comparison cannot be made. However, for those months when Unit 30 was operating, the monthly rates were similar or lower than those of Units 10 and 20 except in February when the rate was highest.

3.3.2 Fish Length Frequency Distribution

Length-frequency distributions for young-of-the-year (YOY) and yearling and older fish collected in the impingement samples are given in Appendix D. Winter flounder were the most numerous fish impinged at Ravenswood Station during the sampling year. Few YOY winter flounder were collected (Table 3-10). YOY winter flounder first appeared in impingement collections in June 1993 at a mean length of 44 mm (Appendix D-87). The mean length of YOY winter flounder generally increased through the sampling year. Yearling and older winter flounder were present in impingement collections every month except June, August and November. Few yearling and older fish greater than 200 mm were impinged. Based on the monthly mean lengths, the majority of the winter flounder impinged were yearling fish (Appendix D-88).

Grubby were the second most abundant fish impinged at Ravenswood Station during the sampling year. Few YOY grubby were impinged and it is not possible to determine recruitment patterns. Mean lengths of yearling and older grubby were relatively constant during the sampling year indicating either little growth, or emigration of larger and older individuals (Appendix D-38). Length frequencies indicated that yearling fish predominated in impingement collections.

Northern pipefish were the third most abundant species impinged. Newly spawned YOY northern pipefish first appeared in impingement collections in October and November (Appendix D-48). Relatively few northern pipefish were impinged and it is not possible to determine recruitment patterns. Yearling and older northern pipefish were present in impingement collections every month of the sampling year (Appendix D-49). During the winter and early spring months when northern pipefish were most common, average mean length increased steadily and length frequencies were unimodal indicating the presence of one year class, probably yearling fish.

3.3.3 Diel Occurrence of Abundant Fish Species

Diel indices for two life stages (young-of-the-year and yearling and older) are presented in Figures 3-3 through 3-9 for the three most abundant species at each unit. Only dates when all four diel periods were sampled are included. Diel impingement rates are presented in Appendix E.

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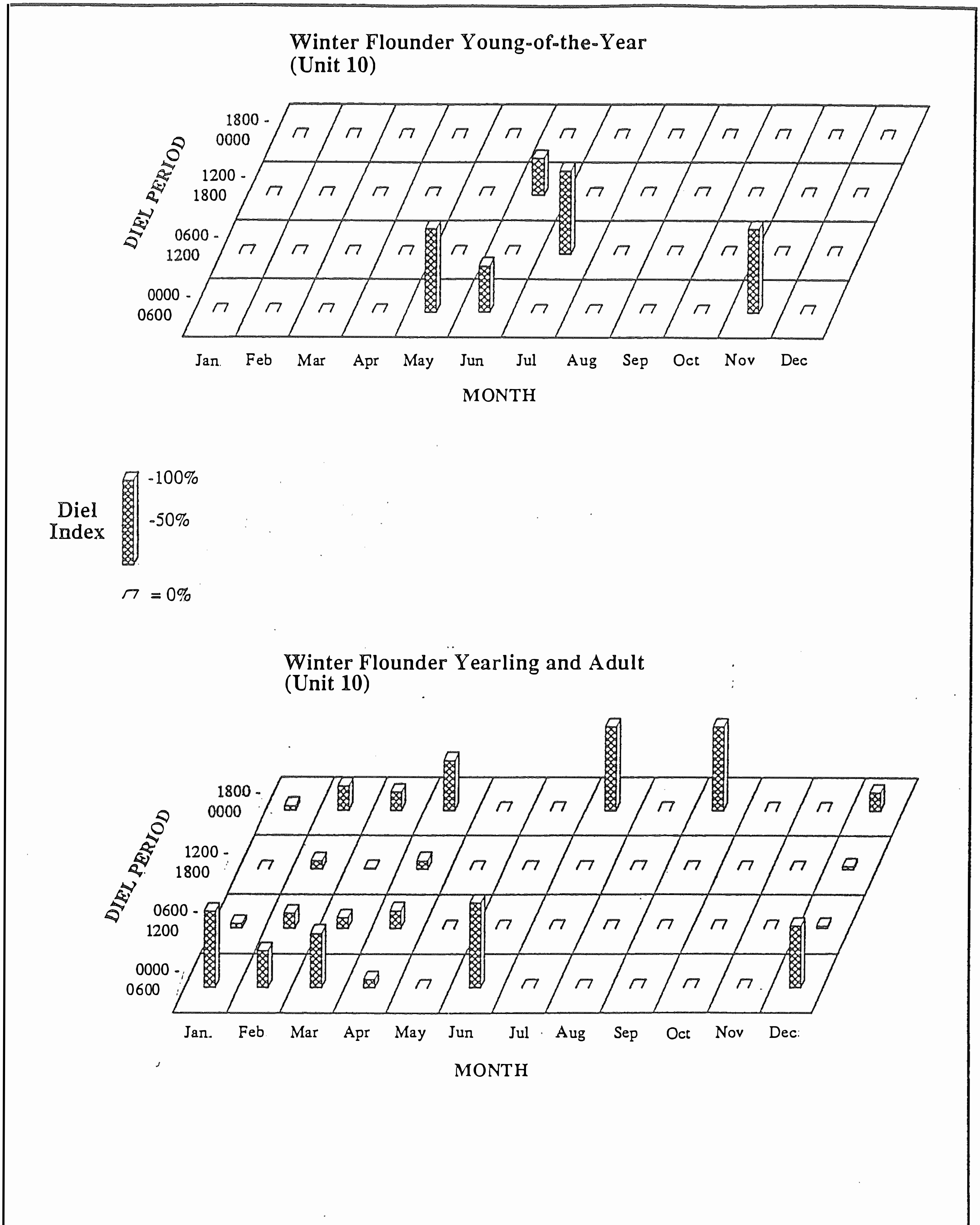

Figure 3-3. Diel impingement indices for young-of-the-year and yearling and older winter flounder at Unit 10 of Ravenswood Generating Station, February 1993 through January 1994.

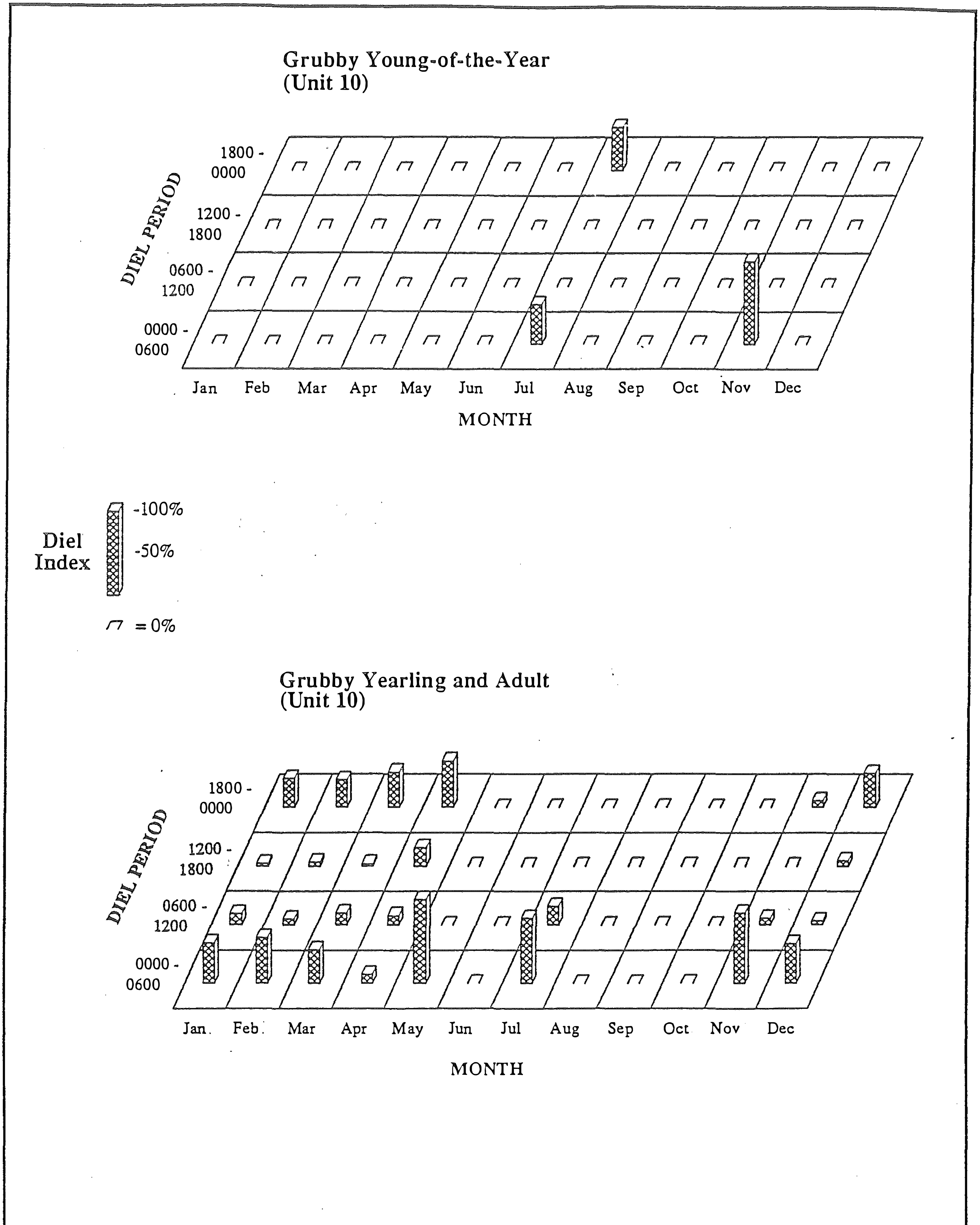

Figure 3-4. Diel impingement indices for young-of-the-year and yearling and older grubby at Unit 10 of Ravenswood Generating Station, February 1993 through January 1994.

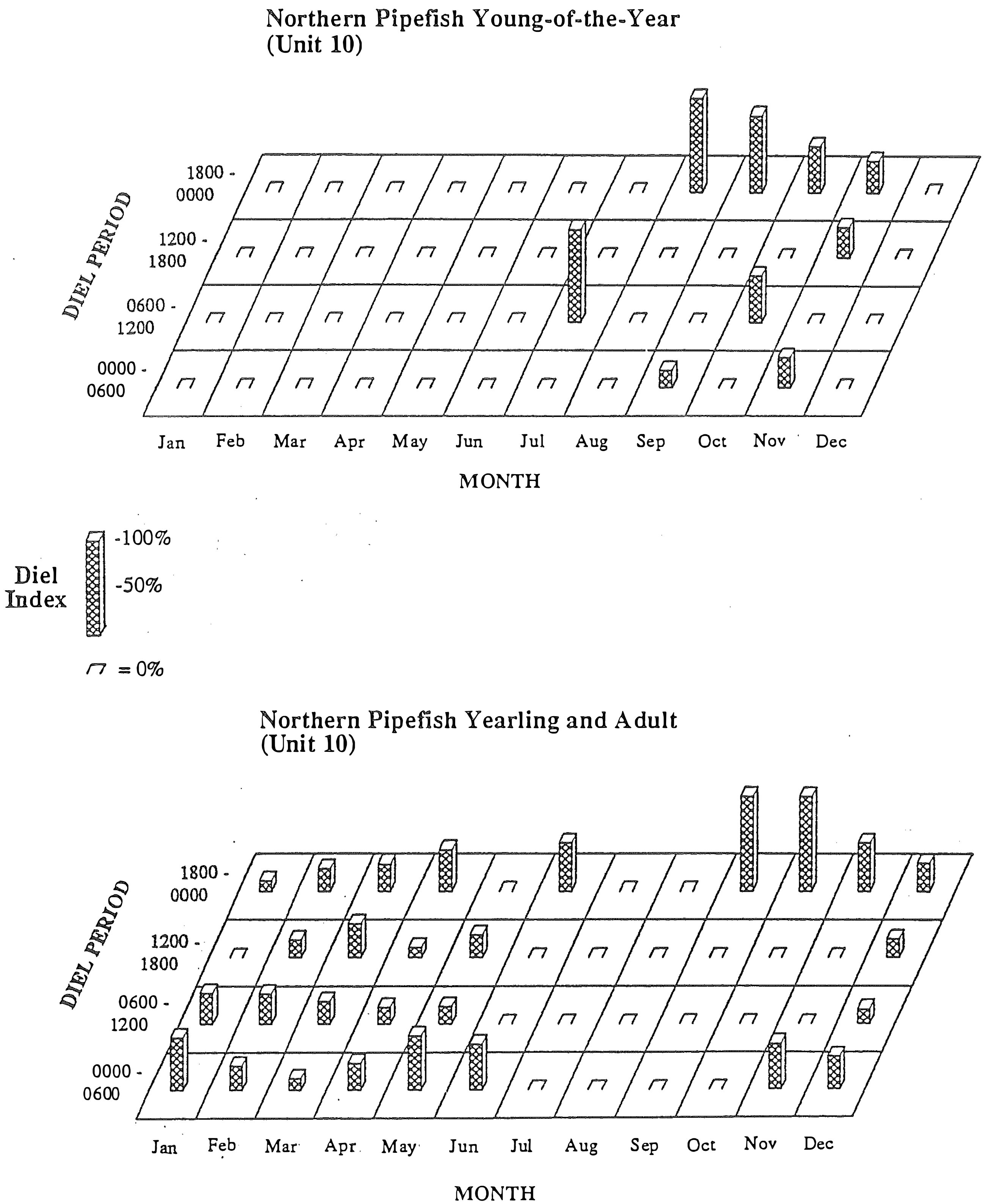

Figure 3-5. Diel impingement indices for young-of-the-year and yearling and older northern pipefish at Unit 10 of Ravenswood Generating Station, February 1993 through January 1994.

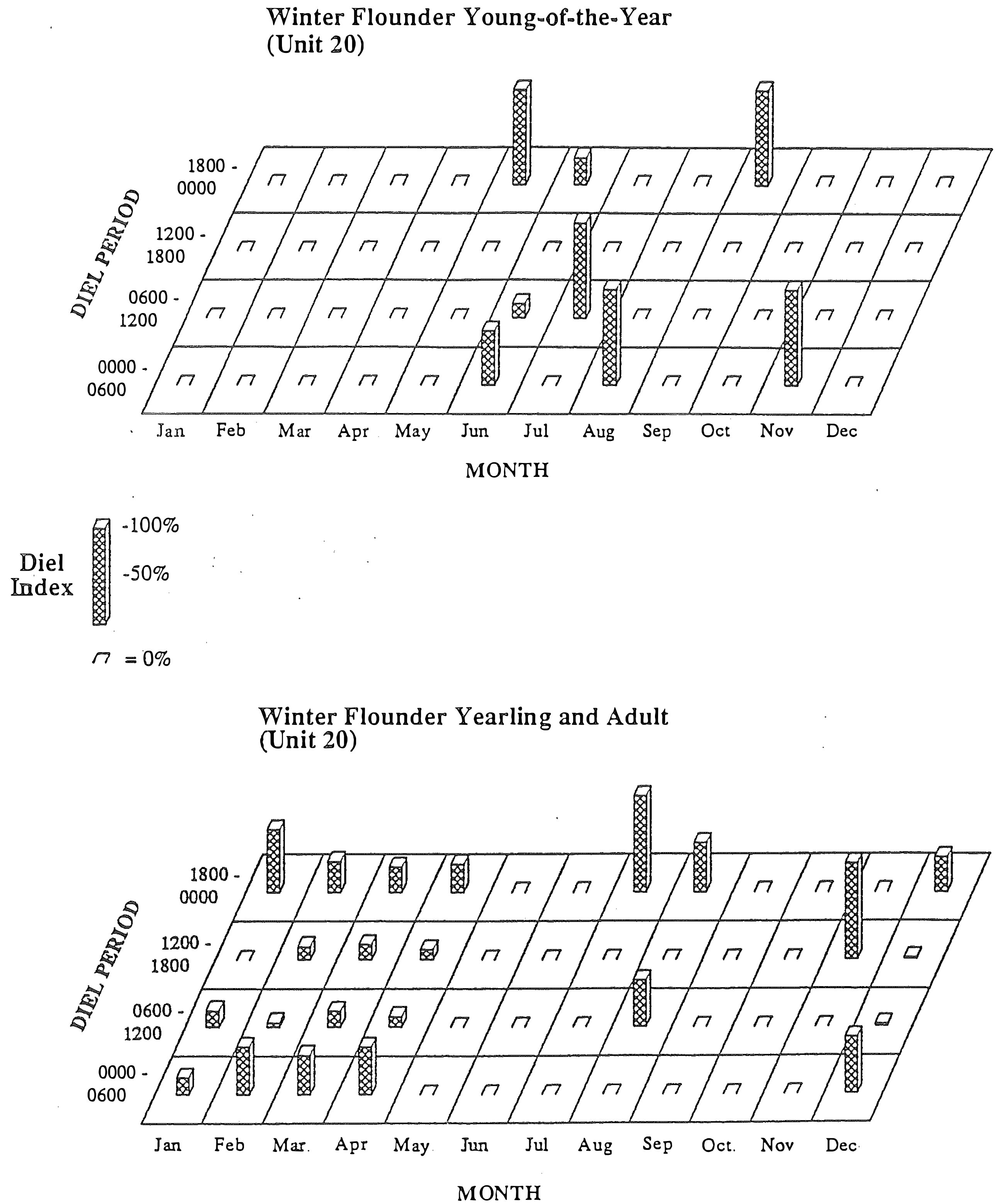

Figure 3-6. Diel impingement indices for young-of-the-year and yearling and older winter flounder at Unit 20 of Ravenswood Generating Station, February 1993 through January 1994.

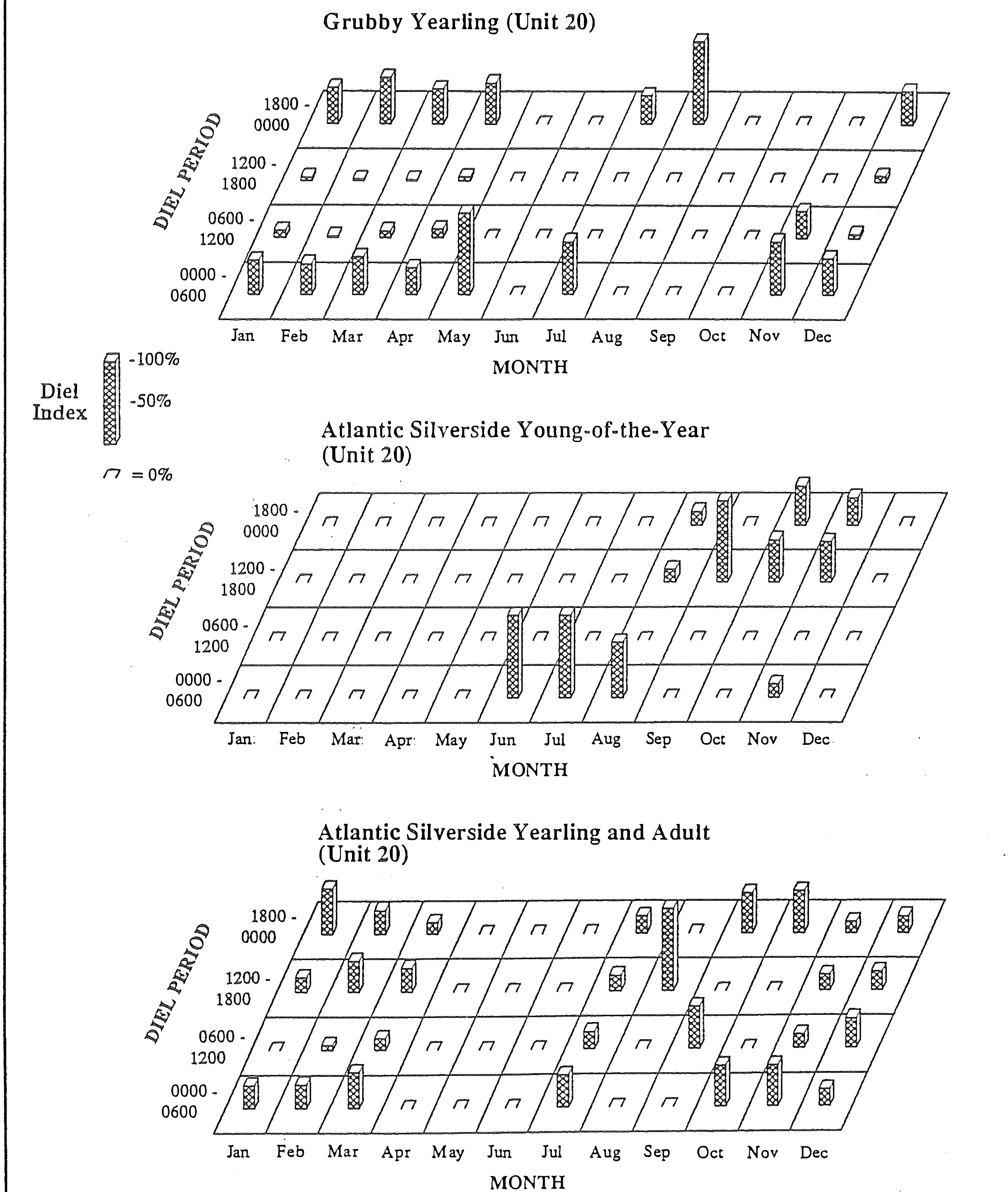

Figure 3-7. Diel impingement indices for yearling grubby, young-of-the-year and yearling and older Atlantic silverside at Unit 30 of Ravenswood Generating Station, February 1993 through January 1994.

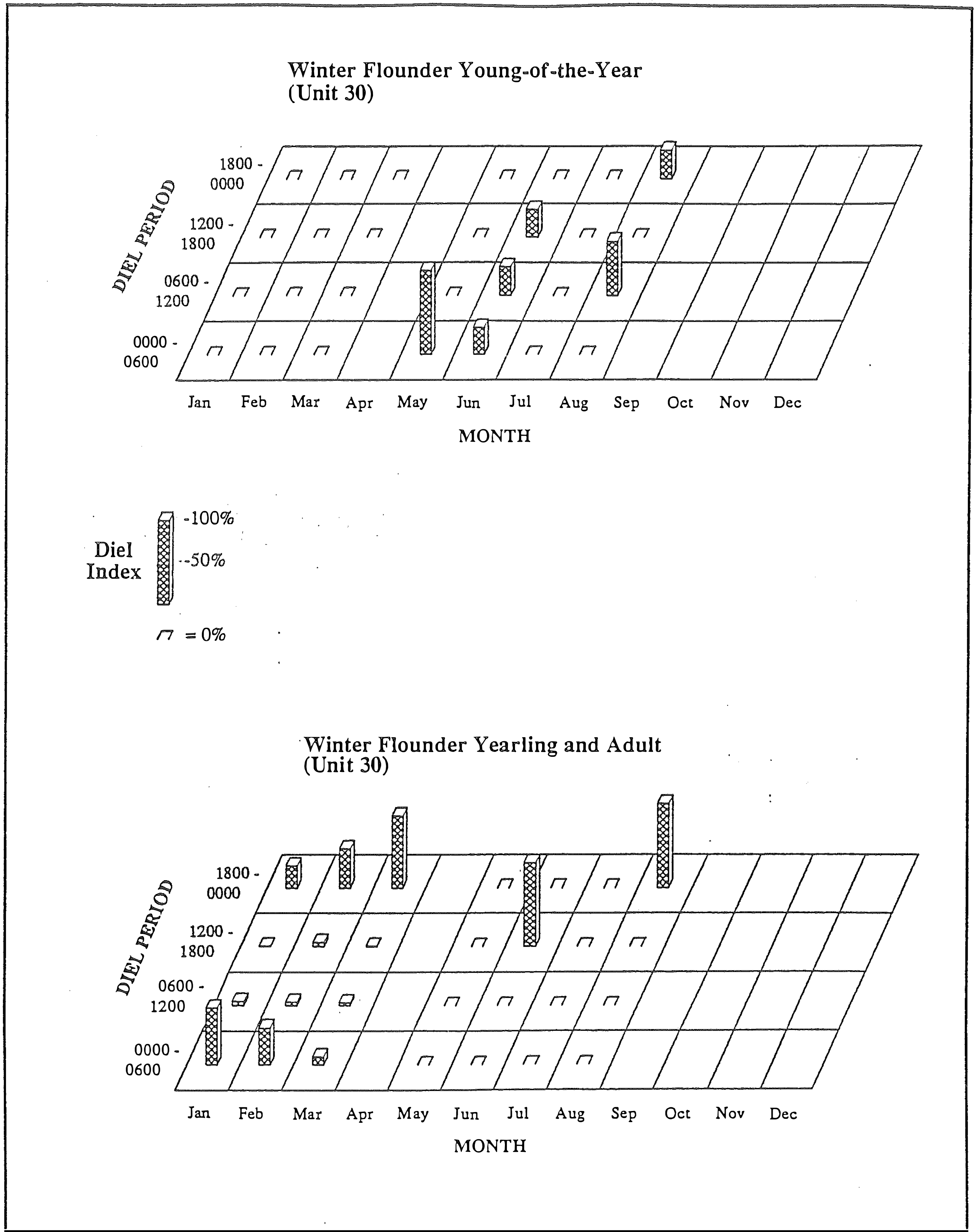

Figure 3-8. Diel impingement indices for young-of-the-year and yearling and older winter flounder at Unit 30 of Ravenswood Generating Station, February 1993 through January 1994.

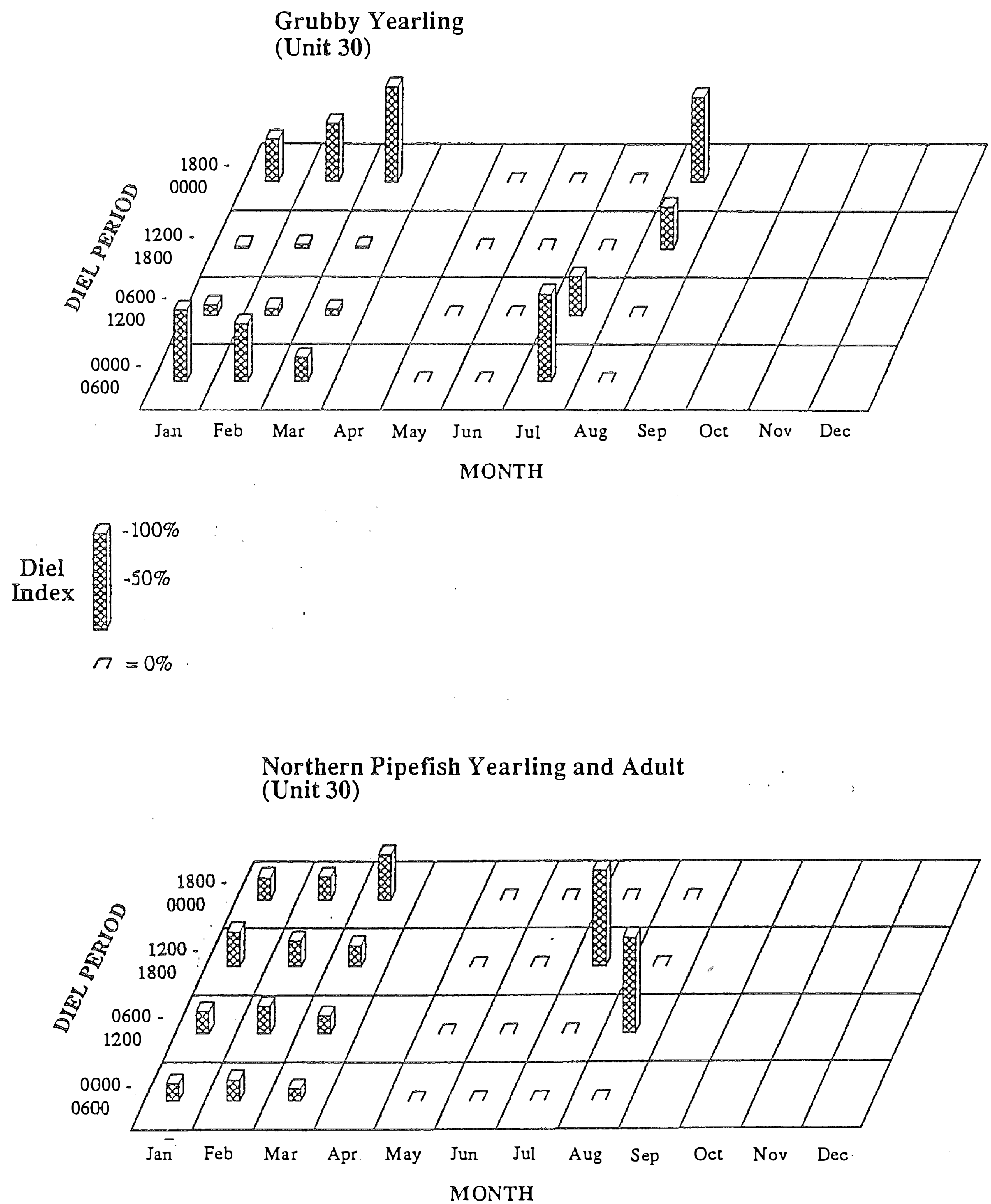

Figure 3-9. Diel impingement indices for yearling grubby and yearling and older northern pipefish at Unit 30 of Ravenswood Generating Station, February 1993 through January 1994.

At Unit 10 the most abundant species were winter flounder, grubby, and northern pipefish. Relatively few YOY winter flounder were impinged during the sampling year. The majority of impingement of YOY winter flounder occurred during the 1200, 0600 and 0000 hr sampling periods (Figure 3-3). No YOY winter flounder were impinged between 1800 and 0000 hours. Yearling and older winter flounder showed a different diel impingement pattern. The diel impingement index was greatest during the night during the 1800 and 0000 hr sampling periods. Very few yearling and older winter flounder were impinged during the 1200 hr sampling period. YOY grubby collections occurred only during the 0000 and 1800 hr sampling periods in August and December. The majority of yearling and older grubby were generally impinged during the 0000 and 1800 hr sampling periods (Figure 3-4). There were no distinct diel patterns for either young-of-the-year or yearling or older pipefish; although some months showed a similar pattern to grubby with higher numbers during the 0000-0600 and 1800-2400 hr sampling periods (Figure 3-5).

The three most abundant species at Unit 20 were winter flounder, grubby, and Atlantic silverside. Both life stages of winter flounder showed slightly higher impingement rates during the 0000-0600 and 1800-2400 hr sampling periods (Figure 3-6). As with Unit 10, yearling and older grubby were impinged primarily during the 0000 and 1800 hr sampling periods (Figure 3-7). No young-of-the-year grubby were caught. Atlantic silverside showed no distinct diel pattern for either life stage although no YOY Atlantic silverside were impinged during the 0600-1200 hr sampling period (Figure 3-7).

At Unit 30 the most abundant species were winter flounder, grubby, and northern pipefish. Unit 30 was not operating during March 1993 and October 1993 through January 1994, so no diel data are available during those months. Yearling and older and YOY winter flounder showed no distinct diel patterns although relatively few yearling and older winter flounder were impinged during the 0600-1200 sampling period (Figure 3-8). Yearling and older grubby again showed somewhat of a pattern with the majority of fish impinged during the 0000-0600 and 1800-2400 hr periods (Figure 3-9). Too few young-of-the-year grubby were impinged to be meaningful. There was also no diel impingement pattern for yearling and older northern pipefish (Figure 3-9). No young-of-the-year northern pipefish were impinged.

3.3.4. Blue Crabs

A total of 928 blue crabs (unadjusted for collection efficiency) were collected at Ravenswood Units 10, 20, and 30 combined from February 1993 to January 1994 (Appendix F). When scaled to the operating volume, the estimated total number impinged was 2,332 at Unit 10, 2,740 at Unit 20, and 1,988 at Unit 30 (Table 3-11), for a total estimated impingement of 7,060 blue crabs.

Monthly impingement rates followed similar patterns for each unit when all units were operating (Figure 3-10). Few blue crabs were impinged during February through April 1993 and January 1994. Two distinct peaks in impingement rates occurred. The first peak occurred during June at Unit 10 (39.5 blue crabs/10^6 m^3) and in July at Unit 20 (86.4 blue crabs/10^6 m^3). The second peak occurred in November at Unit 10 (69.7 blue crabs/10^6 m^3) and Unit 20 (94.8 blue crabs/10^6 m^3) (Figure 3-10; Appendix G). Monthly impingement rates for Unit 30 ranged from 18.1 to 38.2 blue crabs/10^6 m^3 for June through September 1993.

During the winter of 1993 very few blue crabs of any size were collected. The early spring collections were composed primarily of smaller blue crabs, in the length range of 20 to 50 mm (Appendix H). As summer progressed the length distribution reflected blue crab growth and the appearance of larger crabs. In the early fall 1993 collections, smaller individuals, primarily in the range of 20 to 60 mm, and larger crabs around 100 to 150 mm, appeared in the collections. As fall progressed larger crabs disappeared from samples, and the smaller crabs again disappeared in the winter months.

The disappearance of blue crabs from Ravenswood impingement collections coincided with declining water temperatures (Figure 3-1). The seasonal fluctuation observed at Ravenswood closely mirrored known extensive spawning movements of blue crabs into and out of coastal waters. As temperatures rise in spring and early summer, mature male and female blue crabs migrate into estuaries of shallow water and low salinity to mate. As temperatures begin to decline in early fall, females move downriver into deeper waters with higher salinities (20-30 ppt) to spawn (Lippson et al. 1980). Male and juvenile blue crabs

TABLE 3-11. ESTIMATED NUMBERS OF BLUE CRABS IMPINGED AT RAVENSWOOD UNITS 10, 20, 30, AND COMBINED, FEBRUARY 1993 THROUGH JANUARY 1994.

	1993											1994			
	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT.	NOV	DEC	JAN	TOTAL	STD ERROR	CV
Unit 10	0	6	6	59	265	69	139	12	826	766	184	0	2,332	478	20.5
Unit 20	17	0	6	175	467	663	68	135	494	642	57	15	2,740	360	13.2
Unit 30	0	7	6	--	671	621	441	242	--	--	--	--	1,988	330	16.6
Total	17	13	18	234	1,403	1,352	649	389	1,320	1,408	241	15	7,060		

-- Unit not operating.

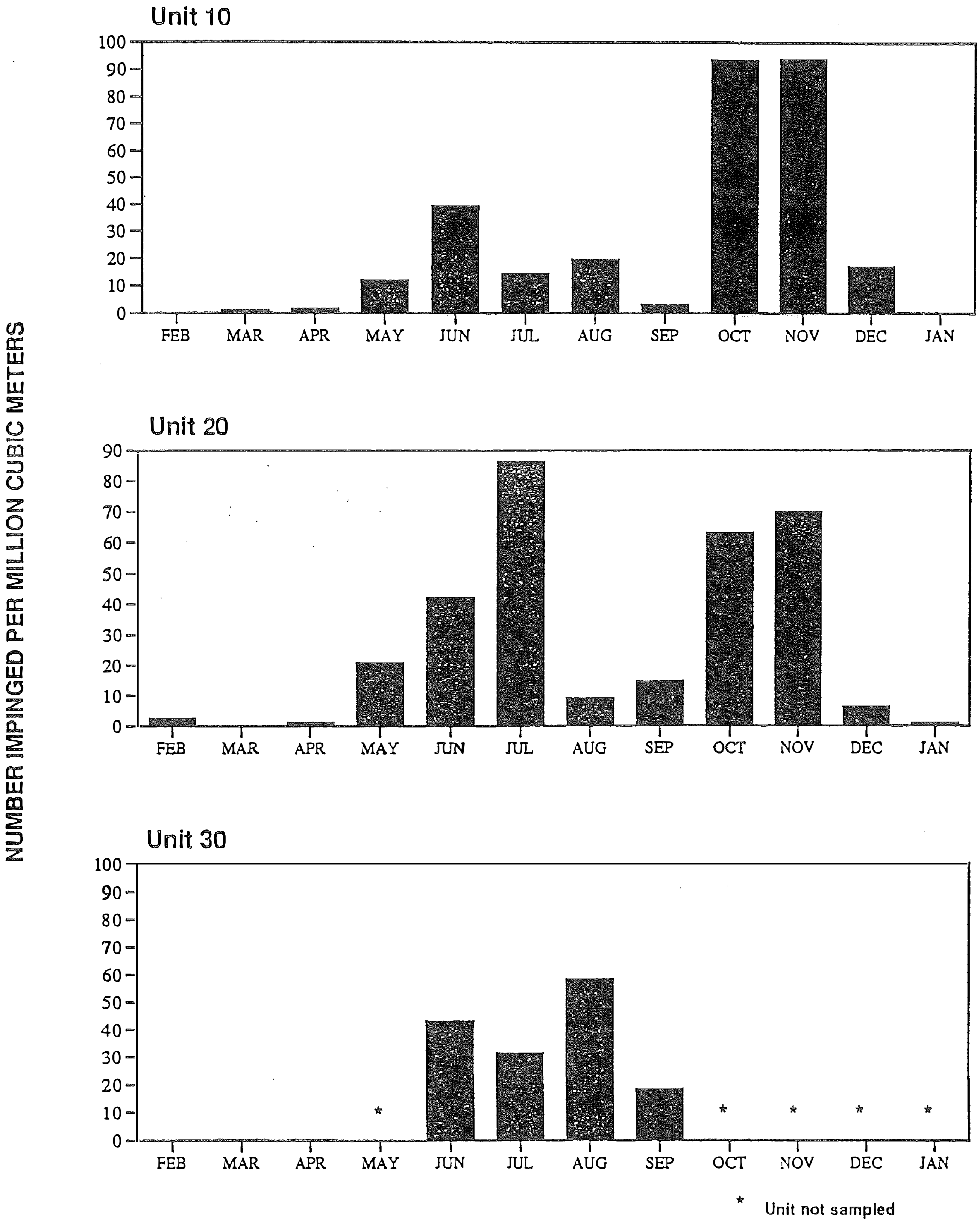

Figure 3-10. Average monthly impingement rate of blue crabs at Units 10, 20, and 30 of Ravenswood Generating Station, February 1993 through January 1994.

remain in lower salinity water (Williams 1965) until moving into deeper waters during late fall and winter, where they burrow into the bottom and become inactive.

Debris

A combined total of 2,087 gal of debris was collected at Ravenswood Units 10, 20, and 30 from February 1993 through January 1994 (Appendix I). Adjusted for operating volumes an estimated 6,231 gal, 6,119 gal, and 3,564 gal were impinged at Units 10, 20, and 30 respectively (Tables 3-12, 3-13, and 3-14), for a combined total of 15,914 gal (Table 3-15).

Monthly average impingement rates for debris at Units 10 and 20 followed a seasonal pattern with peak rates occurring in October (Figure 3-11; Appendix J). Peak average monthly impingement rates were 33.3 gal/10^6 m^3 in October at Unit 10 and 23.6 gal/10^6 m^3 in October at Unit 20 (Figure 3-11 and Appendix J). For the months when Unit 30 was operating the peak rate was 14.2 gal/10^6 m^3 which occurred during September (Figure 3-11; Appendix J).

The majority of the debris impinged by all three units (70.6%) consisted of aquatic vegetation, paper and plastic, and terrestrial vegetation (Table 3-11). Seasonal patterns impingement rates were discernable: bryozoans and tunicates were found in collections primarily from May through November; ctenophores in late summer; and terrestrial vegetation in the fall (Figure 3-11). Paper and plastic and aquatic vegetation were collected throughout the study.

3.4 ENTRAINMENT

Thirty-three entrainment surveys were conducted at the Ravenswood Station from 23 February 1993 through 18 January 1994. Sampling dates (start date of 24-hr sample) and days that Ravenswood operated (any day a unit was in operation was considered an operating

TABLE 3-12. ESTIMATED VOLUME OF DEBRIS (IN GALLONS) IMPINGED AT RAVENSWOOD UNIT 10, FEBRUARY 1993 THROUGH JANUARY 1994.

DEBRIS TYPE	1993 FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	1994 JAN	TOTAL	PERCENT	STDERR	CV
Aquatic vegetation	39	67	55	89	132	136	157	47	270	132	135	189	1,449	23.2	19	55.4
Benthic organisms	8	6	6	4	4	1	13	6	4	1	5	9	68	1.1	1	60.4
Bryozoans and tunicates	12	12	6	152	41	57	96	112	354	158	73	17	1,091	17.5	28	108.6
Crabs and shrimp	9	4	7	6	17	13	41	2	33	17	16	3	168	2.7	3	86.0
Ctenophores	0	0	0	0	27	10	34	11	25	0	1	0	108	1.7	4	139.5
Other	29	29	2	41	5	1	15	9	3	0	158	0	293	4.7	13	181.8
Paper and plastic	89	71	48	73	78	42	82	29	236	72	255	499	1,573	25.2	39	104.1
Terrestrial vegetation	40	22	25	13	48	1	73	18	252	190	505	296	1,482	23.8	45	126.7
TOTAL	227	212	150	379	351	261	510	234	1,177	569	1,149	1,012	6,231	100.0	10	152.1

TABLE 3-13. ESTIMATED VOLUME OF DEBRIS (IN GALLONS) IMPINGED AT RAVENSWOOD UNIT 20, FEBRUARY 1993 THROUGH JANUARY 1994.

	1993											1994				
DEBRIS TYPE	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	TOTAL	PERCENT	STDERR	CV
Aquatic vegetation	16	48	97	99	217	204	229	179	151	105	80	126	1,551	25.3	20	52.6
Benthic organisms	8	16	5	4	9	1	8	14	5	1	5	8	81	1.3	1	67.3
Bryozoans and tunicates	8	15	38	248	55	53	86	312	179	94	29	21	1,138	18.6	29	104.6
Crabs and shrimp	4	3	5	7	33	25	8	13	16	16	7	2	138	2.3	3	82.6
Ctenophores	0	0	0	4	28	33	18	99	13	2	0	0	196	3.2	8	184.8
Other	19	24	16	61	18	8	5	13	0	12	0	0	176	2.9	5	114.4
Paper and plastic	50	76	68	83	229	66	102	129	189	94	106	382	1,575	25.7	27	72.3
Terrestrial vegetation	26	36	35	13	107	7	97	45	189	227	245	237	1,264	20.7	27	89.0
TOTAL	132	218	264	519	695	396	553	803	741	551	470	776	6,119	100.0	8	128.2

TABLE 3-14. ESTIMATED VOLUME OF DEBRIS (IN GALLONS) IMPINGED AT RAVENSWOOD UNIT 30, FEBRUARY 1993 THROUGH JANUARY 1994.

	1993											1994				
DEBRIS TYPE	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	TOTAL	PERCENT	STDERR	CV
Aquatic vegetation	74	223	319	-	157	187	95	143	-	-	-	-	1,200	33.7	39	48.3
Benthic organisms	10	19	8	-	33	1	0	18	-	-	-	-	89	2.5	4	92.3
Bryozoans and tunicates	17	36	60	-	35	48	62	296	-	-	-	-	555	15.5	37	122.3
Crabs and shrimp	10	12	11	-	33	41	12	8	-	-	-	-	128	3.6	5	71.3
Ctenophores	1	0	3	-	28	46	70	117	-	-	-	-	265	7.4	17	115.4
Other	34	80	12	-	8	12	0	42	-	-	-	-	187	5.3	11	104.7
Paper and plastic	109	299	115	-	65	49	28	82	-	-	-	-	746	20.9	34	84.9
Terrestrial vegetation	93	104	111	-	19	1	15	50	-	-	-	-	393	11.0	17	82.2
TOTAL	348	775	639	-	379	384	281	757	-	-	-	-	3,564	100.0	10	119.9

- Unit not operating

TABLE 3-15. PERCENT COMPOSITION OF DEBRIS IMPINGED AT RAVENSWOOD UNITS 10, 20, AND 30, FEBRUARY 1994 THROUGH JANUARY 1994.

	UNIT 10		UNIT 20		UNIT 30		COMBINED		
DEBRIS TYPE	TOTAL (gal)	PERCENT	TOTAL (gal)	PERCENT	TOTAL (gal)	PERCENT	TOTAL (gal)	PERCENT	CUMULATIVE PERCENT
Aquatic vegetation	1,449	23.2	1,551	25.3	1,200	33.7	4,199	26.4	26.4
Paper and plastic	1,573	25.2	1,575	25.7	746	20.9	3,894	24.5	50.9
Terrestrial vegetation	1,482	23.8	1,264	20.7	393	11.0	3,140	19.7	70.6
Bryozoans and tunicates	1,091	17.5	1,138	18.6	555	15.6	2,783	17.5	88.1
Other	293	4.7	176	2.9	187	5.3	656	4.1	92.2
Ctenophores	108	1.7	196	3.2	265	7.4	569	3.6	95.8
Crabs and shrimp	168	2.7	138	2.3	128	3.6	434	2.7	98.5
Benthic organisms	68	1.1	81	1.3	89	2.5	238	1.5	100.0
TOTAL	6,231		6,119		3,564		15,913		

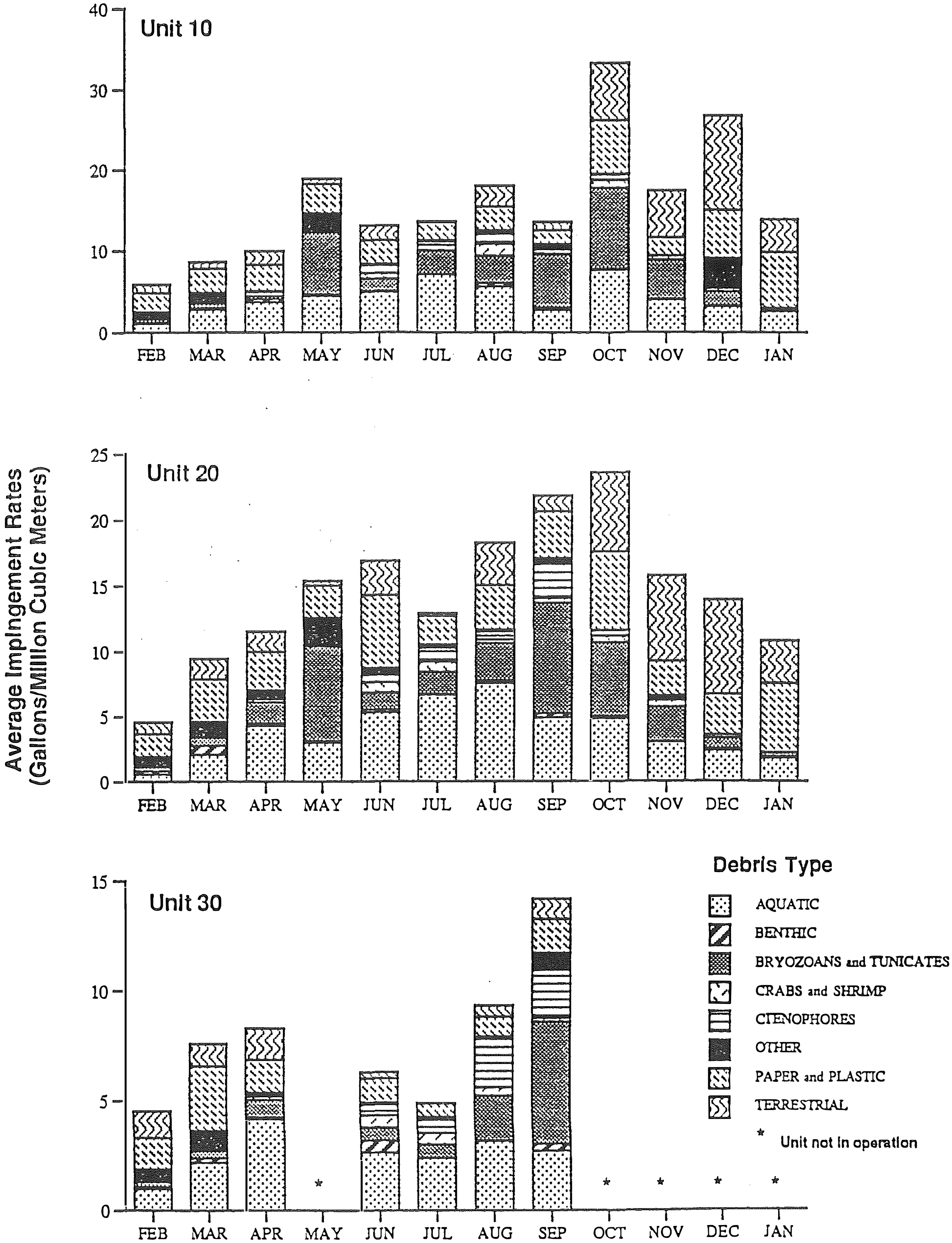

Figure 3-11. Average monthly impingement rates of categories of debris at Units 10, 20 and 30 of Ravenswood Generating Station, February 1993-January 1994.

day) are listed in Table 3-16. Entrainment samples were collected weekly from May through August and biweekly from February through April and from September through January from the surface, middepth, and bottom strata of the common discharge canal. Sample volumes given in Table 3-16 are summed over depth.

A combined total of 25,363 fish eggs and larvae and 288 YOY were collected at Ravenswood (Appendix L). When scaled to operating volume a total of 256.5 million fish eggs and larvae were estimated to have been entrained during the sampling year (Table 3-17), consisting of 156.8 million eggs and 99.7 million larvae (including unidentifiable life stages). An additional 2.0 million YOY were estimated to have been entrained during this time, based on the collection of 288 YOY fish in entrainment samples. Logistics of sampling device setup resulted in placement of the entrainment sampling intake downstream of where fish were impinged. Fish that were small enough to go through the impingement sampling collection basket would be discharged to the canal. It is therefore likely that some YOY entrainment estimates included impinged fish.

Estimated numbers of fish eggs entrained at Ravenswood were highest during April (Figure 3-12) due to a large concentration of fourbeard rockling eggs. Fourbeard rockling eggs were also the most abundant egg entrained in May but at a much lower density than in April. Estimated numbers of winter flounder eggs were higher than any other species in February and March. Fourbeard rockling eggs accounted for 64.3% of the eggs. Eggs of 13 taxa were identified in entrainment samples including 4 groups of eggs identified to the family level (Table 3-18). Most of the eggs were entrained from February through July. A peak entrainment rate of 1,166 eggs/10^3 m^3 occurred on 13 April 1993 (Figure 3-12 and Appendix M).

Yolk-sac larvae were observed from February through May and again in August. Grubby (sculpin family) made up 98.6% of the yolk-sac larvae entrainment estimate. Some larval grubby from February through May could not be identified to life stage and were therefore excluded from the yolk-sac and post yolk-sac calculations but are included in total entrainment estimates under unidentifiable life stage (Table 3-17). Other yolk-sac larvae

TABLE 3-16. COMPARISON OF ENTRAINMENT SAMPLING DATES, AVERAGE SAMPLING VOLUMES, OPERATING DATES AND AVERAGE DAILY OPERATING VOLUMES AT RAVENSWOOD STATION DURING FEBRUARY 1993 THROUGH JANUARY 1994.

MONTH	YEAR	SAMPLING DATES[a]	AVERAGE DAILY SAMPLING VOLUME (m^3)	STANDARD DEVIATION	OPERATING DATES	AVERAGE DAILY OPERATING VOLUME ($10^6 m^3$)	STANDARD DEVIATION
Feb	93	23	3,222	--	1-28	5.18	0.72
Mar	93	2,16	3,743	756.9	1-31	4.28	0.44
Apr	93	13,27	4,227	29.1	1-30	4.31	0.51
May	93	4,11, 18,25	4,219	74.5	1-31	1.90	0.58
Jun	93	1,8,15, 21,29	3,759	582.1	1-30	3.91	1.73
Jul	93	7,13, 20,27	4,224	71.9	1-31	4.37	1.07
Aug	93	3,10, 17,24,31	4,221	66.0	1-31	3.24	0.98
Sep	93	8,21	4,183	71.8	1-30	3.18	1.50
Oct	93	5,19	4,108	55.2	1-31	2.29	0.52
Nov	93	2,23	4,055	26.7	1-30	2.39	0.35
Dec	93	14,21	4,174	24.5	1-31	2.34	0.40
Jan	94	11,18	4,254	46.8	1-31	2.24	0.45

[a]Date is start of 24-hr sample.
[b]Includes service water, except days when no circulating pump operated.

TABLE 3-17. ESTIMATED NUMBER OF EGGS, LARVAE, AND JUVENILES ENTRAINED FROM FEBRUARY 1993 TO JANUARY 1994 AT RAVENSWOOD GENERATING STATION.

LIFESTAGE TAXON	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	TOTAL	PERCENT	STDERR	CV
UNIDENTIFIED																
BUTTERFISH	0	0	0	0	0	0	5,195	0	0	0	0	0	5,195	0.73	4,809	92.58
GRUBBY	315,067	263,466	41,089	29,531	0	0	0	0	0	0	0	0	649,153	91.45	123,175	18.97
SMALLMOUTH FLOUNDER	0	0	0	0	0	0	10,457	0	0	0	0	0	10,457	1.47	5,590	53.45
UNIDENTIFIABLE	45,010	0	0	0	0	0	0	0	0	0	0	0	45,010	6.34	0	0.00
TOTAL	360,077	263,466	41,089	29,531	0	0	15,652	0	0	0	0	0	709,814	100.0	123,520	17.40
EGG																
ATLANTIC MENHADEN	0	0	96,185	473,219	1,445,882	15,065	0	0	0	0	0	0	2,030,351	1.30	869,074	42.80
BAY ANCHOVY	0	0	0	0	5,035,932	4,132,870	487,413	0	0	0	0	0	9,656,215	6.16	2,049,541	21.23
CUNNER	0	0	0	0	0	1,455,854	246,189	0	0	0	0	0	1,702,043	1.09	619,711	36.41
FEATHER BLENNY	0	0	0	0	9,228	0	0	0	0	0	0	0	9,228	0.01	8,544	92.58
FOURBEARD ROCKLING	360,077	1,727,459	85,389,269	13,284,450	42,800	0	0	0	0	0	0	0	100,804,055	64.30	36,403,351	36.11
FOURSPOT FLOUNDER	0	0	0	16,036	0	0	0	0	0	0	0	0	16,036	0.01	14,846	92.58
GOBY FAMILY	0	0	0	0	0	15,065	0	0	0	0	0	0	15,065	0.01	13,948	92.58
GRUBBY	585,124	228,340	671,032	547,501	0	0	0	0	0	0	0	0	2,031,997	1.30	537,620	26.46
HERRING FAMILY	0	0	0	0	6,125	0	0	0	0	0	0	0	6,125	0.00	5,671	92.58
HOGCHOKER	0	0	0	9,769	0	0	0	0	0	0	0	0	9,769	0.01	5,805	59.42
MUMMICHOG	0	0	0	0	114,816	196,311	0	0	0	0	0	0	311,126	0.20	141,750	45.56
SILVER HAKE	0	0	0	22,080	3,666,777	528,370	10,777	0	0	0	0	0	4,228,003	2.70	1,381,913	32.68
SILVERSIDE FAMILY	0	0	0	0	27,684	0	0	0	0	0	0	0	27,684	0.02	25,631	92.58
SUMMER FLOUNDER	0	0	0	0	0	0	0	221,366	395,075	0	0	0	616,441	0.39	355,731	57.71

TABLE 3-17. (CONTINUED)

LIFESTAGE TAXON	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	TOTAL	PERCENT	STDERR	CV
TAUTOG	0	0	0	133,853	3,250,369	966,114	5,388	0	0	0	0	0	4,355,724	2.78	894,282	20.53
WINTER FLOUNDER	7,471,589	17,331,224	5,906,047	3,281	0	0	0	0	0	0	0	0	30,712,141	19.59	5,764,115	18.77
WRASSE FAMILY	0	0	0	0	0	23,224	181,493	25,657	0	0	0	0	230,375	0.15	102,312	44.41
TOTAL	8,416,790	19,287,023	92,062,534	14,490,189	13,599,613	7,332,874	931,261	247,024	395,075	0	0	0	156,762,381	100.0	41,817,124	26.68
YOLK SAC LARVAE																
AMERICAN SAND LANCE	0	35,126	0	0	0	0	0	0	0	0	0	0	35,126	0.19	34,108	97.10
BAY ANCHOVY	0	0	0	0	0	0	181,820	0	0	0	0	0	181,820	0.98	168,332	92.58
GOBY FAMILY	0	0	0	0	0	0	10,390	0	0	0	0	0	10,390	0.06	9,619	92.58
GRUBBY	4,320,919	4,689,826	9,098,570	193,019	0	0	0	0	0	0	0	0	18,302,334	98.63	2,067,966	11.30
WINTER FLOUNDER	0	0	27,215	0	0	0	0	0	0	0	0	0	27,215	0.15	26,225	96.36
TOTAL	4,320,919	4,724,952	9,125,785	193,019	0	0	192,209	0	0	0	0	0	18,556,884	100.0	2,117,086	11.41
POST-YOLK SAC LARVAE																
AMERICAN SAND LANCE	765,163	158,067	177,031	6,448	0	0	0	0	0	0	0	21,883	1,128,591	1.40	210,675	18.67
ATLANTIC CROAKER	0	0	0	0	0	0	0	0	0	0	9,145	0	9,145	0.01	8,864	96.92
ATLANTIC HERRING	0	0	0	0	0	0	0	0	0	33,185	45,880	0	79,065	0.10	33,144	41.92
ATLANTIC MENHADEN	0	0	0	0	0	7,533	0	0	0	0	0	0	7,533	0.01	6,974	92.58
ATLANTIC SILVERSIDE	0	0	0	6,308	0	22,595	0	0	0	0	0	0	28,903	0.04	21,719	75.14
ATLANTIC TOMCOD	0	46,849	1,213,198	47,962	0	0	0	0	0	0	0	0	1,308,009	1.63	747,365	57.14
BAY ANCHOVY	0	0	0	0	6,883	12,324,431	7,102,882	14,563,309	96,989	50,087	9,145	0	34,153,727	42.49	8,770,538	25.68

TABLE 3-17. (CONTINUED)

LIFESTAGE TAXON	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	TOTAL	PERCENT	STDERR	CV
BUTTERFISH	0	0	0	0	0	15,483	0	0	0	0	0	0	15,483	0.02	14,334	92.58
CUNNER	0	0	0	0	0	7,532	0	0	0	0	0	0	7,532	0.01	6,973	92.58
GOBY FAMILY	0	0	0	0	6,110	876,814	698,098	1,063,505	137,671	16,747	0	0	2,798,945	3.48	406,375	14.52
GRUBBY	7,516,598	8,238,292	18,842,530	1,756,237	0	0	0	0	0	0	0	0	36,353,657	45.23	3,010,281	8.28
HERRING FAMILY	0	0	0	0	6,883	7,532	0	0	0	0	0	0	14,414	0.02	9,446	65.53
HOGCHOKER	0	0	0	0	0	0	5,236	0	0	0	0	0	5,236	0.01	4,848	92.58
INSHORE LIZARDFISH	0	0	0	0	0	0	15,585	0	0	0	0	0	15,585	0.02	14,428	92.58
NORTHERN PIPEFISH	0	0	0	0	0	75,529	36,716	16,918	8,044	0	0	0	137,207	0.17	49,737	36.25
SILVERSIDE FAMILY	0	0	0	0	12,250	0	0	0	0	0	0	0	12,250	0.02	11,342	92.58
SMALLMOUTH FLOUNDER	0	0	0	0	0	0	5,236	0	8,198	0	0	0	13,434	0.02	9,269	68.99
SPOTTED HAKE	0	0	0	0	20,090	0	0	0	0	0	0	0	20,090	0.02	12,295	61.20
SUMMER FLOUNDER	0	0	0	0	0	0	0	0	8,044	0	0	14,626	22,670	0.03	7,752	34.19
TAUTOG	0	0	0	0	0	38,140	0	0	0	0	0	0	38,140	0.05	13,590	35.63
UNIDENTIFIABLE	0	0	0	0	0	7,741	5,262	0	0	0	0	0	13,003	0.02	8,666	66.64
WEAKFISH	0	0	0	0	0	155,048	15,652	8,514	0	0	0	0	179,214	0.22	92,686	51.72
WINDOWPANE	0	0	0	0	213,653	7,532	0	0	0	0	0	0	221,185	0.28	67,642	30.58
WINTER FLOUNDER	0	0	864,469	2,331,158	599,731	0	0	0	0	0	0	0	3,795,358	4.72	958,875	25.26
TOTAL	8,281,761	8,443,208	21,097,227	4,148,114	865,601	13,545,909	7,884,667	15,652,246	258,946	100,020	64,171	36,509	80,378,379	100.0	9,481,748	11.80

TABLE 3-17. (CONTINUED)

LIFESTAGE TAXON	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	TOTAL	PERCENT	STDERR	CV
YOUNG OF THE YEAR																
ATLANTIC TOMCOD	0	0	0	41,186	0	0	0	0	0	0	0	0	41,186	2.05	26,812	65.10
BAY ANCHOVY	0	0	0	0	0	15,544	10,473	8,459	0	8,374	119,044	0	161,893	8.08	82,294	50.83
BUTTERFISH	0	0	0	0	0	15,483	10,390	0	0	0	0	0	25,872	1.29	17,263	66.72
FEATHER BLENNY	0	0	0	0	0	0	5,195	0	0	0	0	0	5,195	0.26	4,809	92.58
GOBY FAMILY	0	0	0	0	0	7,741	31,294	102,350	0	0	0	0	141,385	7.05	66,589	47.10
GRUBBY	0	0	0	3,207	0	0	0	0	0	0	0	0	3,207	0.16	2,969	92.58
NAKED GOBY	0	0	0	0	0	0	10,524	0	0	0	0	0	10,524	0.53	9,743	92.58
NORTHERN PIPEFISH	0	0	0	0	41,297	260,581	328,980	447,758	24,286	0	0	0	1,102,902	55.03	184,252	16.71
NORTHERN PUFFER	0	0	0	0	0	0	0	8,459	0	0	0	0	8,459	0.42	8,089	95.62
NORTHERN SEAROBIN	0	0	0	0	0	0	0	0	16,396	0	0	0	16,396	0.82	15,800	96.36
NORTHERN STARGAZER	0	0	0	0	0	7,741	0	0	0	0	0	0	7,741	0.39	7,167	92.58
PRIONOTUS SPECIES	0	0	0	0	0	46,448	10,583	8,459	8,044	0	0	0	73,535	3.67	44,797	60.92
SEABOARD GOBY	0	0	0	0	0	0	15,719	17,478	0	16,747	9,145	0	59,090	2.95	26,554	44.94
SMALLMOUTH FLOUNDER	0	0	0	0	0	0	114,836	86,101	48,726	16,747	0	0	266,410	13.29	57,858	21.72
SUMMER FLOUNDER	0	0	0	0	0	0	0	8,739	0	0	0	0	8,739	0.44	8,356	95.62
WINDOWPANE	0	0	0	0	64,165	7,533	0	0	0	0	0	0	71,698	3.58	33,612	46.88
TOTAL	0	0	0	44,393	105,462	361,072	537,993	687,804	97,452	41,869	128,189	0	2,004,233	100.0	272,990	13.62

258.4 million

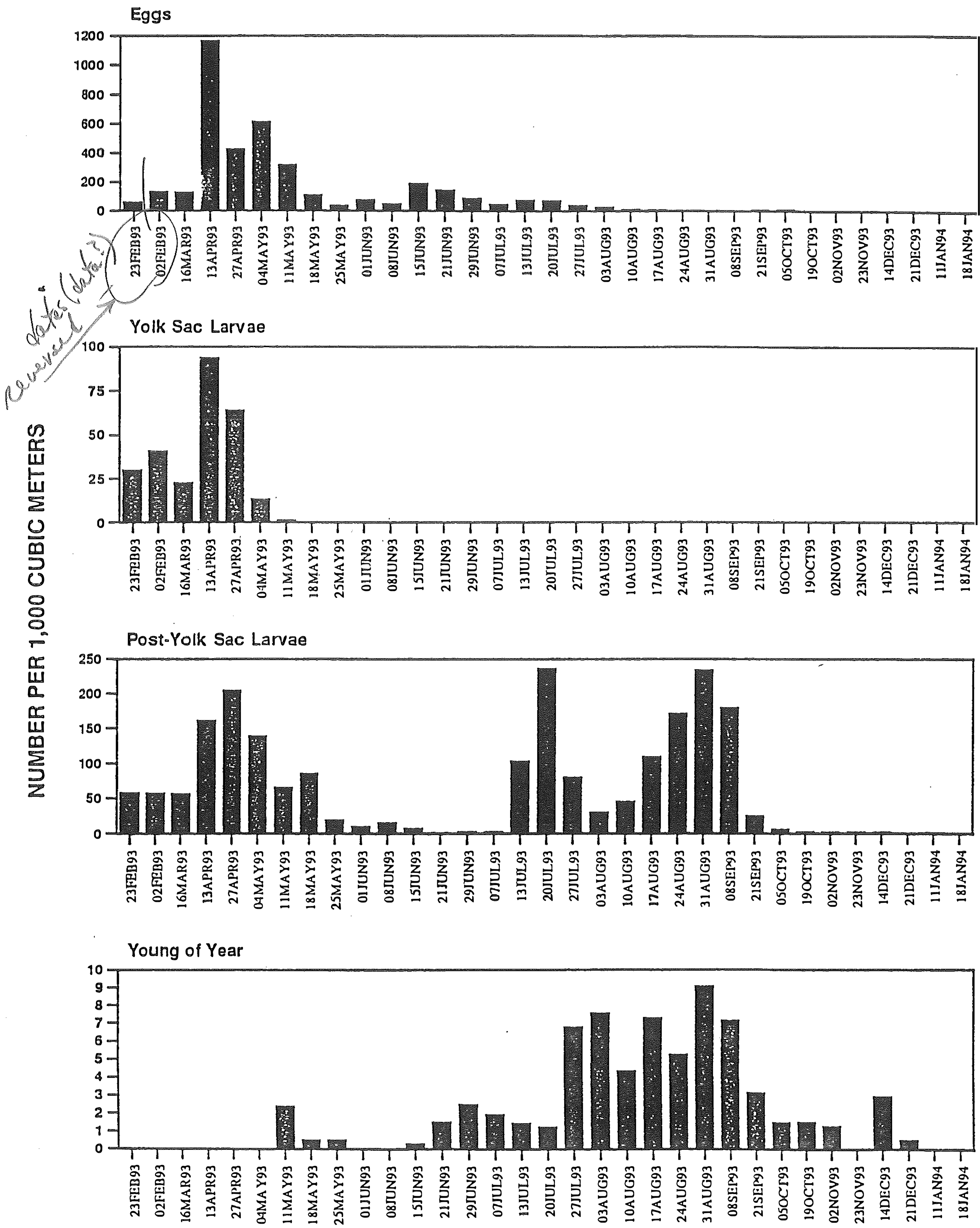

Figure 3-12. Daily egg, larval, and juvenile entrainment rates (No./10^3 m^3) at Ravenswood Generating Station, February 1993 through January 1994.

TABLE 3-18. SPECIES AND LIFE STAGE COMPOSITION OF FISH COLLECTED IN ENTRAINMENT SAMPLES AT RAVENSWOOD GENERATING STATION, FEBRUARY 1993 THROUGH JANUARY 1994.

LIFE STAGE	COMMON NAME	SCIENTIFIC NAME	ASSEMBLAGE
EGGS	Atlantic menhaden	*Brevoortia tyrannus*	M
	Bay anchovy	*Anchoa mitchilli*	E
	Cunner	*Tautogolabrus adspersus*	M
	Feather blenny	*Hypsoblennius hentzi*	M
	Fourbeard rockling	*Enchelyopus cimbrius*	M
	Fourspot flounder	*Paralichthys oblongus*	M
	Goby family	Gobiidae	M
	Grubby	*Myoxocephalus aenaeus*	M
	Herring family	Clupeidae	E-M
	Hogchoker	*Trinectes maculatus*	E
	Mummichog	*Fundulus heteroclitus*	E
	Silver hake	*Merluccius bilinearis*	M
	Silverside family	Atherinidae	E-M
	Summer flounder	*Paralichthys dentatus*	M
	Tautog	*Tautoga onitis*	M
	Winter flounder	*Pleuronectes americanus*	M
	Wrasse family	Labridae	M
YOLK-SAC LARVAE	American sand lance	*Ammodytes americanus*	M
	Bay anchovy	*Anchoa mitchilli*	E
	Goby family	Gobiidae	M
	Grubby	*Myoxocephalus aenaeus*	M
	Winter flounder	*Pleuronectes americanus*	M
POST YOLK-SAC LARVAE	American sand lance	*Ammodytes americanus*	M
	Atlantic croaker	*Micropogonias undulatus*	M
	Atlantic herring	*Clupea harengus*	M
	Atlantic menhaden	*Brevoortia tyrannus*	M
	Atlantic silverside	*Menidia menidia*	M
	Atlantic tomcod	*Microgadus tomcod*	E
	Bay anchovy	*Anchoa mitchilli*	E
	Butterfish	*Peprilus triacanthus*	M
	Cunner	*Tautogolabrus adspersus*	M
	Goby family	Gobiidae	M
	Grubby	*Myoxocephalus aenaeus*	M
	Herring family	Clupeidae	E-M
	Hogchoker	*Trinectes maculatus*	E
	Inshore lizardfish	*Synodus foetens*	M
	Northern pipefish	*Syngnathus fuscus*	M
	Silverside family	Atherinidae	E-M

TABLE 3-18. (CONTINUED)

LIFE STAGE	COMMON NAME	SCIENTIFIC NAME	ASSEMBLAGE
	Smallmouth flounder	*Etropus microstomus*	M
	Spotted hake	*Urophycis regia*	M
	Summer flounder	*Paralichthys dentatus*	M
	Tautog	*Tautoga onitis*	M
	Weakfish	*Cynoscion regalis*	M
	Windowpane	*Scophthalmus aquosus*	M
	Winter flounder	*Pleuronectes americanus*	M
YOUNG OF THE YEAR	Atlantic tomcod	*Microgadus tomcod*	E
	Bay anchovy	*Anchoa mitchilli*	E
	Butterfish	*Peprilus triacanthus*	M
	Feather blenny	*Hypsoblennius hentzi*	M
	Goby family	Gobiidae	M
	Grubby	*Myoxocephalus aenaeus*	M
	Naked goby	*Gobiosoma bosci*	M
	Northern pipefish	*Syngnathus fuscus*	M
	Northern puffer	*Sphoeroides maculatus*	M
	Northern searobin	*Prionotus carolinus*	M
	Northern stargazer	*Astroscopus guttatus*	M
	Prionotus species	*Prionotus* sp.	M
	Seaboard goby	*Gobiosoma ginsburgi*	M
	Smallmouth flounder	*Etropus microstomus*	M
	Summer flounder	*Paralichthys dentatus*	M
	Windowpane	*Scophthalmus aquosus*	M
UNIDENTIFIED			
	Butterfish	*Peprilus triacanthus*	M
	Grubby	*Myoxocephalus aenaeus*	M
	Smallmouth flounder	*Etropus microstomus*	M

A - Anadromous
C - Catadromous
E - Euryhaline
M - Marine
E-M - Euryhaline-Marine

collected were American sand lance in March, winter flounder in April and goby and bay anchovy in August.

Of the estimated 99 million larvae assigned a life stage, 81.2% were post yolk-sac larvae. Grubby (45.2%) and bay anchovy (42.5%) made up the estimated majority of post yolk-sac larvae entrained at Ravenswood. Grubby were predominant between February and may while bay anchovy were predominant between June and December. Post yolk-sac larvae of 20 species and three families were identified in entrainment collections.

YOY of year of 15 species were present in entrainment samples from May through December. Northern pipefish accounted for 55% of the estimated young of year entrainment, followed by smallmouth flounder (13.3%), bay anchovy (8.1%) and gobies (7.1%). Highest rates occurred in the summer when several species of fish were present.