ADULT, JUVENILE, AND LARVAL FISH POPULATIONS IN THE VICINITY OF THE JAMES H. CAMPBELL PLANT, 1981, WITH SPECIAL REFERENCE TO THE EFFECTIVENESS OF WEDGE-WIRE INTAKE SCREENS IN REDUCING ENTRAINMENT AND IMPINGEMENT OF FISH

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TABLE OF CONTENTS

INTRODUCTION

This report interprets, in part, data collected during a comprehensive environmental monitoring program performed near the J. H. Campbell Power Plant situated on eastern Lake Michigan. For 5 yr, 1977 to 1981, Great Lakes Research Division personnel sampled adult, juvenile and larval fish in Lake Michigan near the plant, and those fish impinged or entrained by the plant. Preoperational years 1977-1980 were compared with operational year 1981. One of the purposes of this report is to provide a tool for deciding whether the currently employed intake design at Campbell Plant Unit 3 reflects "the best technology available for minimizing environmental impact" as required by the Federal Water Pollution Control Act of 1972, Section 316(b) (Public Law 92-500). Due to the complexity of and variability between biological communities, the major terms in this law, "best technology available" and "adverse environmental impact," cannot be broadly applied, but can only be defined after careful examination of each site in question.

With the proliferation of power plants and increased demand for methodology which would limit adverse environmental impact, three main methods in the technology of water intakes have found broad application in reducing loss of fish at power plant intakes. All of these methods, to varying degrees, are employed presently at the Campbell Unit 3 intake. The first method relates to locating the water withdrawal structures in an area where field studies indicate there is the least probability of entrapping vulnerable life stages of organisms which are determined to be ecologically important at that site. The second method, which is becoming a widely accepted means of limiting entrainment and impingement of fishes, is to lower the intake velocity to a point at which even the most vulnerable stages of the organism to be protected can escape. This is generally accomplished by increasing the surface area over which the required water is withdrawn. Finally, the use of screening which will physically exclude even larval fishes has been widely used to limit entrainment and impingement of fish.

This study focuses primarily on the former two methodologies used at the Campbell Plant. The currently employed intake at Campbell Unit 3 is designed for maximum withdrawing currents of 15.2 cm/s (0.5 ft/s) through 9.5-mm square slot openings. Based only on the limiting fish larva dimension, body depth, Schneeberger and Jude (1981) suggested that very little exclusion of indigenous larval fishes would occur using 9.5-mm mesh. The question we attempt to resolve in this report, however, is whether larval fish avoidance responses to low velocity currents and the intake structure itself are sufficient enough to consider 9.5-mm slot opening screens as a viable alternative to use of screens having slot openings which would function to physically exclude larvae. Initial work performed within our study area using a scaled down replicate of the present intakes as well as a similar flow rate across the screens (15.2 cm/s) suggests that larval fish avoidance is as effective, if not more so than larval fish exclusion, in limiting entrainment of larval fish (Zeitoun et al. 1981). However, scale effects (i.e., actual intakes are much larger than the test screens) could modify their findings significantly. Our initial observations in September and October (1980) when Unit 3 was intermittently operating led us to believe that, due to the low intake velocity, juvenile and adult fish would suffer little, if any, impingement loss. This contention was confirmed by this study.

Unit 3 draws its condenser cooling water from an offshore submerged intake in Lake Michigan, at about the 11-m contour. The intake location was selected to minimize entrainment and impingement losses, based on biological surveys (Jude et al. 1981a) which showed the location to be an area of probable minimal impact. The cylindrical wedge-wire intake design and array were selected because the combination of an expanded withdrawal area, low approach velocity, smooth screen surface, cylindrical screen shape, slot width and low profile both minimize potential biological effects and enhance the probability of operational success.

Preoperational aquatic monitoring in Lake Michigan has been ongoing since 1977 to establish the basis for assessment of potential effects of Unit 3 operation. Commercial operation of Unit 3 began on 30 September 1980. The National Pollution Discharge Elimination System permit for the plant requires that "the permittee conduct a postoperational monitoring study to determine the effects of the Unit 3 cooling water intake structure on fish and ichthyoplankton." The 1-yr operational study began December 1980 and was completed December 1981.

Reported herein are operational impingement, entrainment and adult, juvenile and larval fish field data collected from January to December 1981, plus Units 1 and 2 entrainment data from 1980 (not previously reported) and 1981. Included are diver observations of the number and composition of fish in the vicinity of the intake and their utilization of the habitat afforded by the intake, discharge and riprap structures. Estimates of the number, length frequency and species composition of fish larvae entrained through all plant intakes are provided, along with estimates and comparisons of ichthyoplankton abundance and species composition in Lake Michigan in the vicinity of the new Unit 3 intake structure and at the reference transect. For adult, juvenile and larval fish, we compared seasonal distributions and abundances in field collections between preoperational years (1977-1980) and operational study year 1981, and examined any differences between the plant vicinity and the reference transect.

STUDY AREA

The J. H. Campbell Power Plant (fossil fuel) is located on the eastern shore of Lake Michigan in Port Sheldon Township (T6N, R6W), Ottawa County, Michigan. Presently there are three operating units. Units 1 and 2 have a combined capacity of 582 mw and draw a maximum of 1000 m^3/min of cooling water from Lake Michigan and Pigeon Lake (Fig. 1). An illustration of cooling water flow through Units 1 and 2 is provided in Figure 2. The newly constructed Unit 3 has a designed capacity of 810 mw and draws cooling water from an offshore submerged intake in Lake Michigan (Fig. 2) at a rate of 1280 m^3/min.

Cooling water for Unit 3 is withdrawn from the 11-m contour in Lake Michigan by gravity into an intake canal on shore. Located at the end of the canal are two Unit 3 condenser cooling water circulating pumps. After passing through the condensers, water flows into the discharge canal, which runs parallel to, but is separate from, the Unit 3 intake canal. The discharge canal also carries the cooling water discharges of Units 1 and 2. At the shoreline of Lake Michigan, the combined discharges from all three units are pumped offshore and released through diffusers situated at approximately the 6-m depth in Lake Michigan. In the canal system, two pressure differential flap gates ensure the passage of water from the intake forebay of Units 1 and 2 to the intake of Unit 3 in case insufficient flow is supplied by the Unit 3 intake structures in Lake Michigan. Additionally, the intake canal of Unit 3 is connected at the plant end with the common discharge canal of Units 1, 2 and 3 which under normal operating conditions may allow for up to 10% recirculation of intake water to the discharge channel.

The Campbell Unit 3 intake structure is located approximately 1070 m offshore in Lake Michigan at approximately the 11-m depth contour (Fig. 1). A 5.5-m diameter intake pipe is installed below the lake bottom and runs perpendicular to shore. Connected to it are four 2.4-m diameter horizontal header pipes alternately branching out at approximately 45-degree angles (Fig. 3). Each arm has seven evenly spaced vertical header pipes which extend from below lake bottom into the water column. On top of each vertical header pipe are two closed-ended, cylindrical wedge-wire screens which form a "T" (Fig. 4). The axes of the circular screens are thus horizontal and the orientation of most screens to the shoreline is approximately 45 degrees off parallel. The cylindrical wedge-wire screens are 1.2 m long (4 ft), have a diameter of 1.2 m and have 9.5-mm (0.375 in) square slot openings. During Unit 3 operation the maximum designed through-slot water velocity is 15.2 cm/s (0.5 ft/s) (Fig. 5). Under conditions of no obstruction to the screens, through-slot velocity is as low as 11.5 cm/s (0.38 ft/s) (Consumers Power Company 1978).

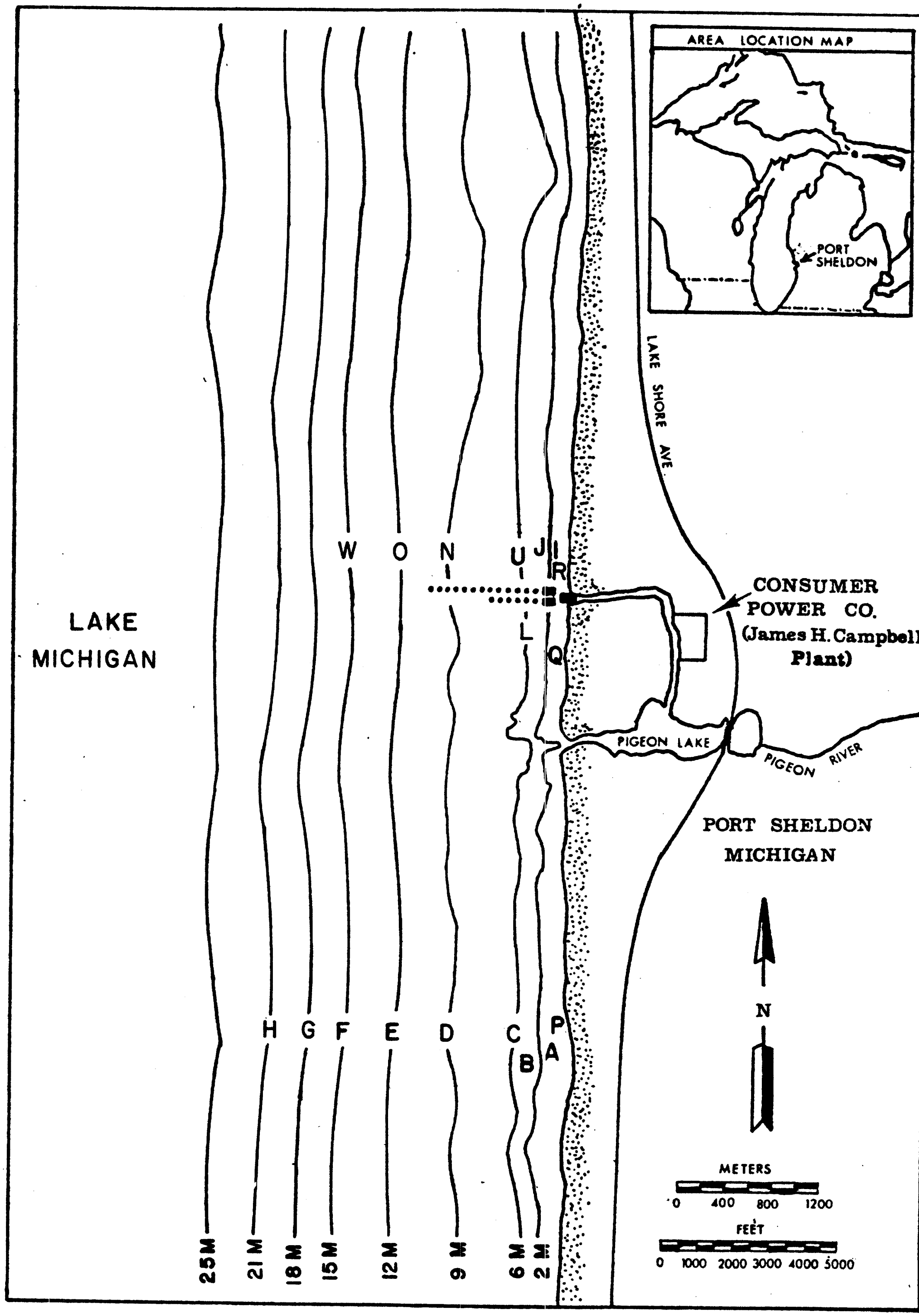


Fig. 1. Scheme of the J. H. Campbell Plant showing Lake Michigan and the 18 sampling stations (A, B, C, D, E, F, G, H, I, J, L, N, O, P, Q, R, U and W) established for fisheries monitoring.

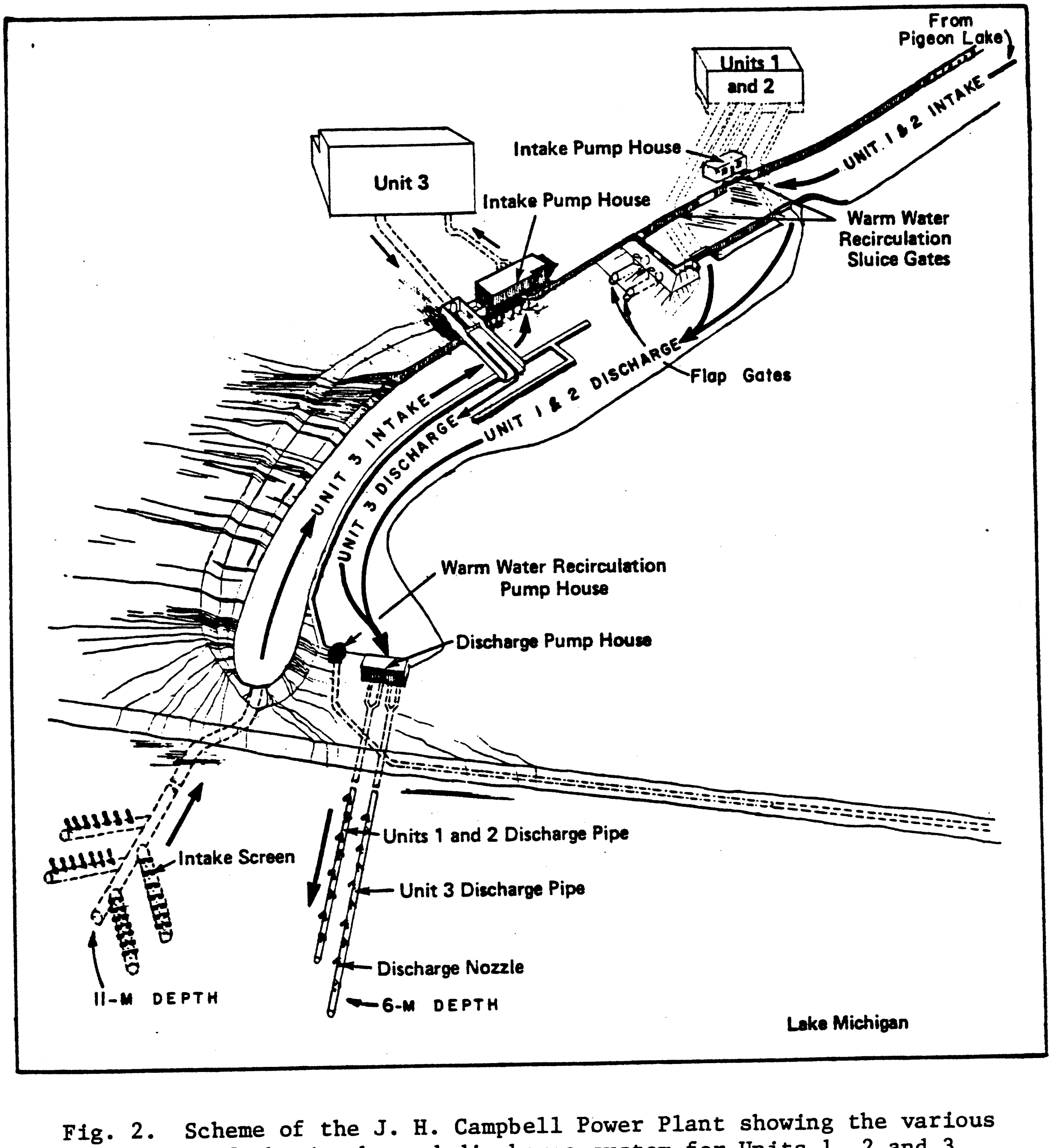


Fig. 2. Scheme of the J. H. Campbell Power Plant showing the various components of the intake and discharge system for Units 1, 2 and 3. Adapted from Randall and Landon (1981).

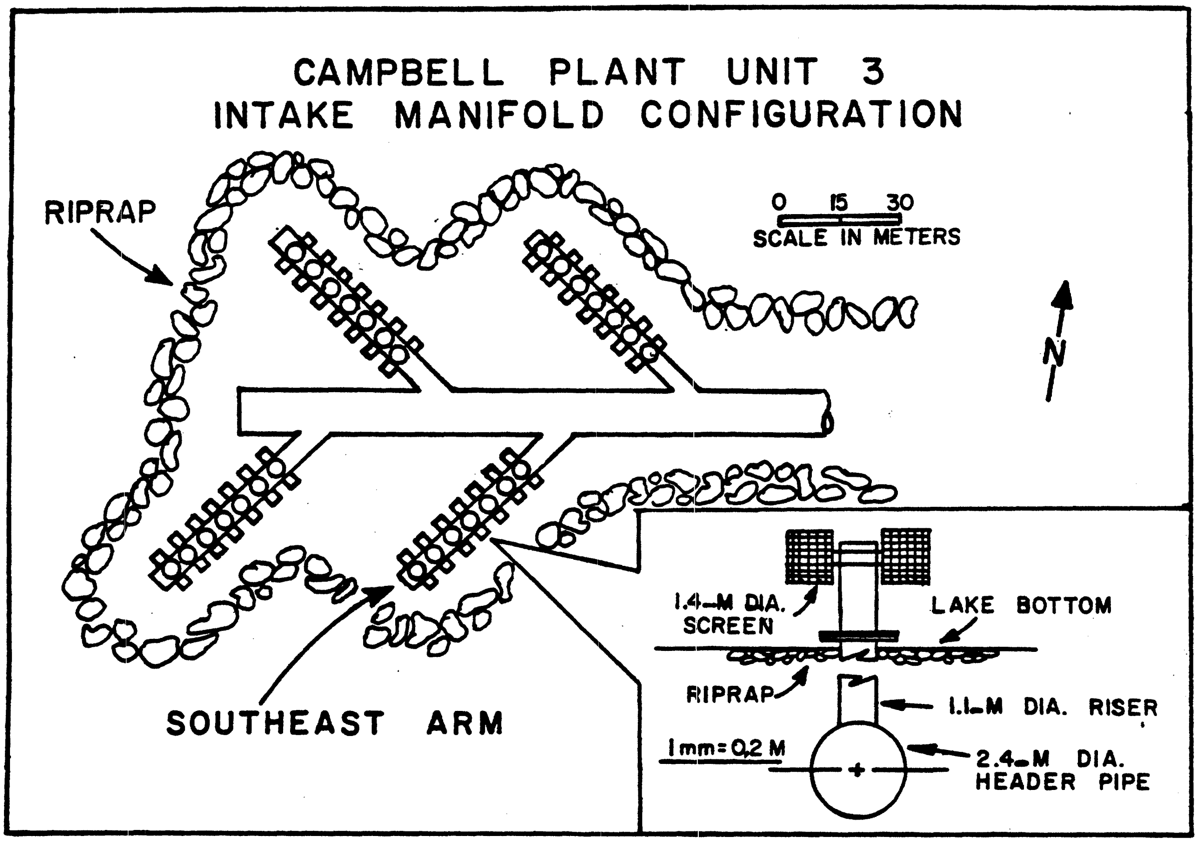


Fig. 3. Scheme of the J. H. Campbell Plant Unit 3 intake manifold depicting site of scuba observations during 1981. Inset shows enlargement of an individual riser with two accompanying screens.

Prior to installation of the intake and discharge structures, the lake bottom in the area was relatively featureless (Jude et al. 1978). Bottom features have changed as a result of the Unit 3 intake and discharge structures, which include intake vertical header pipes, cylindrical screens, 18 discharge diffuser vertical headers and complete diffuser nozzles and an extensive riprap field surrounding the intake manifold. This field varies in width from 9 to 18 m and is composed of variable-sized (predominantly 225-900 kg) crushed limestone.

To establish ambient larval fish densities in the Lake Michigan Unit 3 intake area, seven larval fish sampling stations were established in a transect perpendicular to shore and parallel to the Unit 3 intake line (Fig. 1). The transect was located as closely as possible to the structures and associated riprap. Stations R, I, J, L, N, O and W ranged in depth from 1 m

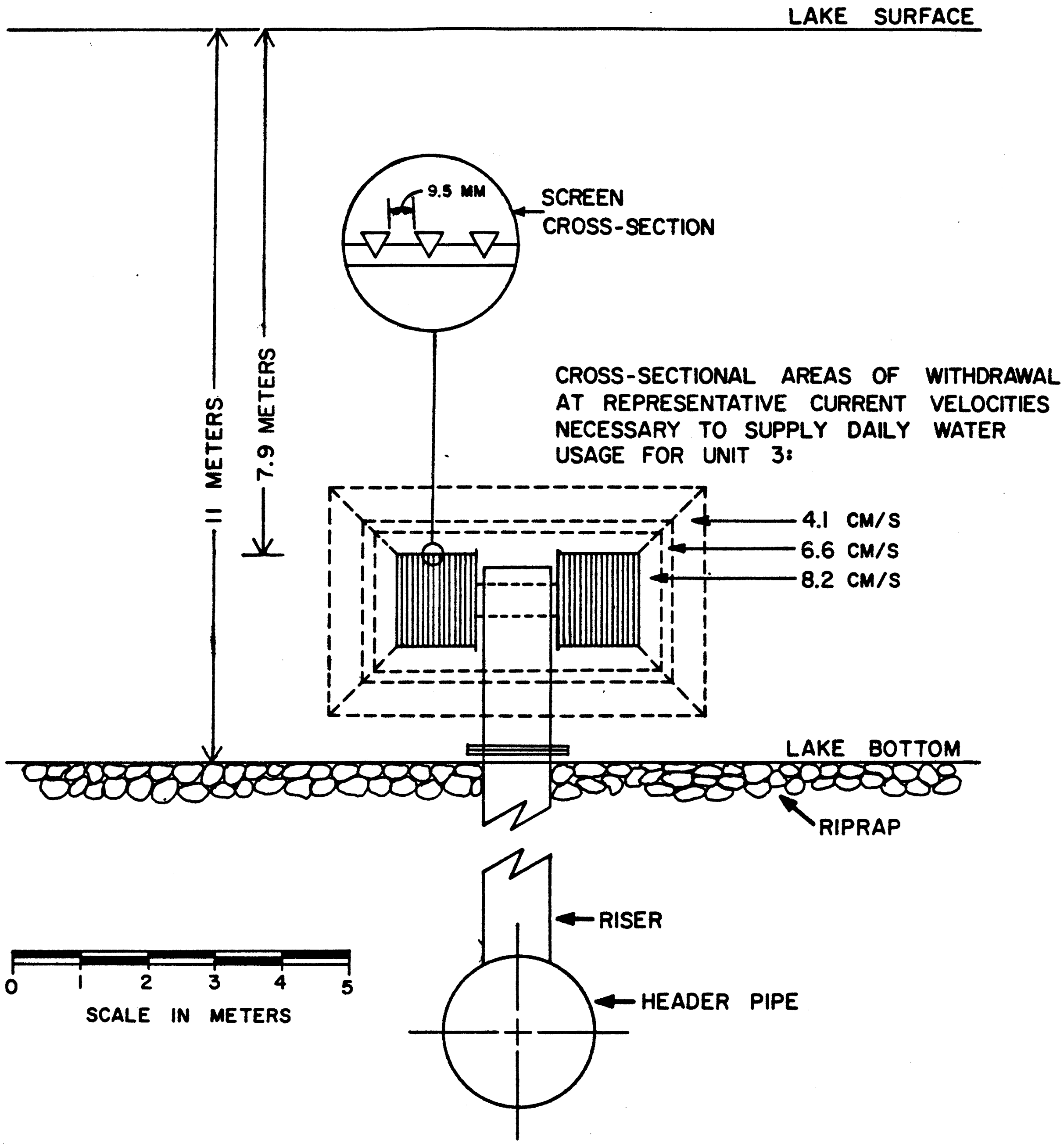


Fig. 4. Intake structure of Unit 3 at the J. H. Campbell Plant showing an individual riser with two accompanying screens. Dashed lines are boundaries of cross-sectional areas of lake water around each of the 28 screens which would be necessary to supply maximum daily water usage for Unit 3 at three representative lake current velocities.

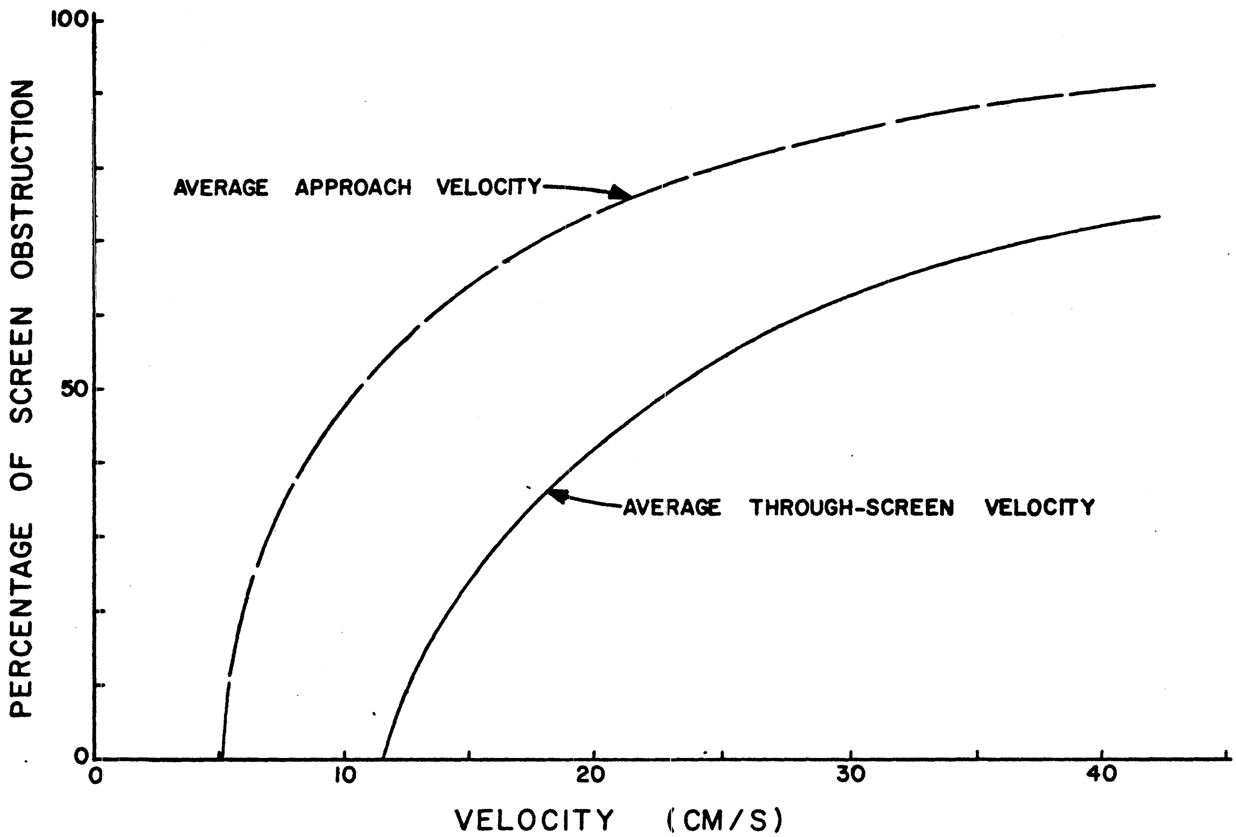


Fig. 5. Relationships between velocity of water current and the degree of obstruction of the Unit 3 intake screen. Approach velocity was measured at 0.305 m from the screen surface. Adapted from Consumers Power Company (1978).

at beach station R to 15 m at station W. Seven stations of depths equal to north transect stations were established at a reference transect 3.1 km south of the plant. To establish the presence of juvenile and adult fish in the area of the intake structures, four monitoring stations were selected. Two 6-m stations were chosen: station L, located approximately 0.3 km south of the common discharge of Units 1, 2 and 3, and station U, approximately 0.3 km north of the discharge. These locations were chosen to aid in the monitoring of the thermal plume and its effect on pelagic and migratory fish. In this part of the study these stations will supply additional information as to what fish are in the area of the discharges and hence may be exposed to the proximate (400 m) intake area. In conjunction with station N (9

m) and beach station R, these 6-m stations will also confirm the presence of spawning fish as well as indicate the timing of the annual inshore and offshore movement of juvenile and adult fishes. Diving observations of impingement were coordinated with the movement of juveniles into the area of the intakes. Stations for observation of fish during scuba dives were at the intake screens themselves and at reference areas which allowed us to observe whether fish were impinged, and allowed optimal comparison between abundance at the intake area and ambient abundance, as determined from field catches.

METHODS

INTRODUCTION

Sampling scheme changes from 1980 to 1981 were minimal. Because the Campbell Plant discharge was no longer onshore in 1981, and the beach zone was thus not exposed constantly to the discharge plume, one north transect beach station was thought to be sufficient. Therefore station Q was omitted from sampling. In order to evaluate the contribution of the discharge canal to fish larvae populations in Lake Michigan, tows were performed in the offshore discharge plume, and samples were taken in the onshore discharge canal near the pumps. Unit 3 entrainment sampling was performed where the intake pipe enters the onshore intake canal. Additional scuba diver observations were performed to inspect the offshore intake screens for possible impingement of smelt juveniles (May) and alewife juveniles (September and October) as they enter and leave the nearshore and nursery grounds. These additions to the sampling scheme were designed to give a more detailed evaluation of the wedge-wire screens. Station F (15 m, south) was not trawled during 1981. In other respects, the sampling scheme, methods and gear remained the same as in 1980.

SEINING

Seining was performed using a 0.6-cm (0.25 in) mesh nylon seine, 15.2 m x 1.8 m (50 ft x 6 ft) including a 1.8-m (6 ft) bag. The seine was hauled parallel to shore for a distance of 61 m (200 ft). Duplicate non-overlapping hauls were performed both day and night at beach stations R (plant transect) and P (reference transect). Monthly seining was performed from April through November. Hauls were performed against the current when possible. During times when waves and current did not permit seining against the current, hauls were made in the direction of the current. Limnological and physical data (water temperature, secchi disc, wind and wave height) were recorded each time a gear was fished (Appendixes 2-6).

GILLNETTING

Nylon experimental gill nets 36.6 m x 1.8 m (120 ft x 6 ft) were set once a month for approximately 12 h during daylight and 12 h during the night from April to November. Each gill net was composed of 12 panels, each 3 m long, starting with 1.3-cm (0.5 in) bar mesh and proceeding in 0.6-cm (0.25 in) increments up to 7.6-cm (3 in) mesh, with the last panel having 10.2-cm (4 in) mesh. Two of these nets fastened end to end were set together and considered replicates. All gill nets were set parallel to shore. Stations sampled with bottom gill nets at the north transect were L (6 m), U (6 m) and N (9 m). To distinguish the two 6-m gill net stations, station L in this report is referred to as 6 m, south discharge and station U is referred to as 6 m, north discharge, based on their relative orientation to the combined discharges of Units 1, 2 and 3. Surface gill nets, which were identical to bottom gill nets except for additional floats, were set at both 6-m stations. At the south (reference) transect, bottom gill nets were set at the 1.5-, 3-, 6-, 9- and 12-m depth contours, and surface gill nets at the 6-m station.

TRAWLING

A semi-balloon, nylon otter trawl having a 4.9-m (16 ft) headrope and a 5.8-m (19 ft) footrope was used. The body and cod end of the net were composed of 1.9-cm (0.75 in) and 1.6-cm (0.62 in) bar mesh respectively, while the cod end innerliner was 0.63-cm (0.25 in) bar mesh. All trawl hauls were taken parallel to shore with the University of Michigan's R/V Mysis following the station depth contour. Two replicate samples were obtained at each station by once trawling south to north and once trawling north to south. All trawl hauls were made at an average speed of 4.8 km/h (3 mph). Duplicate 10-min hauls were performed at stations L (6 m) and N (9 m) on the north transect and stations B (3 m) through E (12 m) on the south transect.

FISH LARVAE TOWS

Fish larvae, arbitrarily defined as any fish less than 2.54 cm total length, were collected using a 0.5-m diameter, nylon plankton net of no. 2 mesh (363-micron aperture). A Rigosha flowmeter (Rigosha and Co. Ltd., 10-4 Kajicho 1-Chome, Chiyoda-Ku, Tokyo, 101 Japan) attached to the center opening of the plankton net was used to calculate volume of water sampled. When flowmeters were not available or stopped functioning, average flowmeter values were computed from readings available from the same stations at other times or from stations of comparable depth. When flowmeter readings were conspicuously different from other tows at the same station, averages of readings for the appropriate station and diel period were used. All meter revolutions were converted to volume filtered using 1 revolution = 15 liters. Flowmeters were calibrated in a swimming pool by walking a measured distance with a flowmeter attached to a 0.5-m diameter hoop without the net (see Jude et al. 1979b).

Duplicate surface tow samples were collected at beach seining stations R (plant) and P (reference) in Lake Michigan (Fig. 1). Three people simultaneously hand-towed two nets for a distance of approximately 61 m (200 ft) once during the day and once at night. Beach tows were performed twice in May, June, July and August and once in April and September during 1981.

Horizontal 5-min fish larvae tows were also performed at discrete depths parallel to shore at 12 stations in Lake Michigan (I, J, L, N, O, W, A, B, C, D, E and F). A summary of station depths and sampling strata is presented in Table 1. Sampling was performed both day and night on the same schedule as beach tow samples. Additionally, surface tows were performed directly in the offshore discharge plume.

Table 1. Fish larvae sampling depths (m) from selected stations in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan 1981.

North transect stations	R	I	J	L	N	O	W
South transect stations	P	A	B	C	D	E	F
Tow depth (m)	0.5	0.5	0.5	0.5	0.5	0.5	0.5
			2.5	2.0	2.5	3.0	4.5
				4.0	4.5	6.0	8.5
				5.5	6.5	9.0	11.5
					8.5	11.0	14.0
Maximum depth (m)	1.0	1.5	3.0	6.0	9.0	12.0	15.0

Larvae tows performed in Lake Michigan at depths of 3 m and less, plus discharge plume tows, were taken from 6-7-m outboard motorboats. The University of Michigan's R/V Mysis was used for tows at deeper stations. For each tow, the procedure was similar and was as follows:

1) Plankton net with attached mason jar and depressor lowered to desired depth (average ship speed: 3-6 km/h or 2-4 mph).

2) Plankton net towed horizontally for 5 min starting at the desired depth which was obtained by measuring cable or rope angle and trigonometrically calculating the amount of cable or rope to be released to reach desired depth.
3) Plankton net hauled to surface and washed using a water hose from the vessel used.
4) Contents rinsed into the wide-mouth glass (0.47 liter) Mason jar, preserved (40 ml of buffered formaldehyde), labeled and sealed.

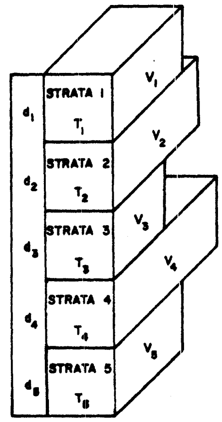
Total numbers of larvae captured in all tows (other than surface tows) were adjusted to compensate for upper strata contamination. The adjustment procedure is outlined in Figure 6. The method consists of sequential subtraction of numbers of larvae from the lower water depth levels based upon densities observed in upper water strata. We assumed that larvae were homogeneously distributed within a water stratum and that nets passing through a particular stratum from a lower level would catch larvae in proportion to the volume of water filtered. Larvae from all tows conducted below the surface stratum, which were probably caught during the vertical haul following termination of the horizontal tow, were removed via calculation from the final total larvae density presented. We assumed that contamination occurring while lowering the net was negligible. The effect of differential vertical distribution due to larvae size was mitigated by stratifying larvae from each sample into 0.5-mm length intervals. A total of 51 length intervals were defined for fish larvae.

Vertical net hauls, conducted in a 3.6-m-deep swimming pool, were used to estimate the volume of water filtered per meter of vertical tow. Mean volume filtered was 0.48 m^3 (28 ± 0.52 SE revolutions) yielding a correction factor of 0.18 m^3 water filtered/meter of vertical haul. An example of this adjustment procedure is presented in Table 2.

Length-frequency histograms were prepared for various combinations of the larval fish data. Data were presented as a percentage of the total based on densities. Thus, collection of two larvae of different sizes (n = 2) and presentation of these data would not necessarily yield a histogram showing 50%:50%.

SLED TOWS

Bottom tows were performed with a benthic fish larvae sled equipped with a flowmeter (Yocum and Tesar 1980) (Fig. 7). A single 5-min sled tow was performed once during the day and once



CALCULATION PROCEDURE:

1. Convert current meter reading to volume filtered (V_i)
2. Stratify total larval (T_i) catch for each sample depth interval into n 0.5-mm length intervals, denoted by $N_{i,m}$.

   Thus, $T_i = \sum_{m=1}^{n} N_{i,m}$
3. Calculate average concentration of larvae of length class m in the first stratum for all m.

   Thus, $\overline{C}_{1,m} = (N_{1,m}/V_1)\ 1000$
4. Begin iterative calculation of adjusted average concentrations of larvae for each depth stratum where

$$\overline{C}_{i,m} = \begin{cases} \dfrac{1000\,(N_{i,m} - \mathrm{trc}\,(0.18(\sum_{j=1}^{i-1} d_j\,\overline{C}_{j,m})/1000)}{V_i - 0.18 \sum_{j=1}^{i-1} d_j} = a \text{ if } a > 0 \\ 0 \quad \text{otherwise} \end{cases}$$

where d_i = vertical depth of water in the i-th water stratum

D = total depth of water column $D = \sum_{i=1}^{5} di$

T_i = total uncorrected catch of larvae in the i-th water stratum.

$N_{i,m}$ = total uncorrected catch of larvae of the m-th size class caught in the i-th water stratum.

V_i = estimates volume of water filtered by net towed in stratum i.

(0.18) = correction factor expressed in terms of volume of water filtered/meter of vertical tow.
i.e.,
$\text{units} = \dfrac{m^3}{m} = m^2$

trc(·) = function which truncates argument to nearest non-negative integer number.

$C_{i,m}$ = adjusted average concentration of larvae of the m-th length class in the j-th depth stratum.

Fig. 6. Schematic representation of adjustment calculations for upper level contamination in larvae samples. Blocks represent varying quantities of water filtered in five different water strata.

Table 2. Example of computational procedures used to correct fish larvae samples for upper level contamination. Refer to Figure 6 for definition of terms. Data values are hypothetical.

Tow depth i (m)	Height of stratum d_i (m)	Volume of water sampled V_i (m^3)	Actual total larvae caught T_i (no.)	Fish larvae length interval m (mm)	Actual number of larvae caught $N_{i,m}$ (no.)	Uncorrected concentration $(N_{i,m}/V_i)\cdot 1000$ (no./1000 m^3)	Corrected concentration $\overline{C}_{i,m}$ (no./1000 m^3)
0	2	30	500	6.6-7.0	200	6666	6666
				10.1-10.5	100	3333	3333
				15.1-15.5	100	3333	3333
				20.6-21.0	100	3333	3333
2	2	25	3	*6.6-7.0	1	40	0
				9.0-9.5	1	40	40
				13.6-14.0	1	40	40
4	2	20	7	7.1-7.5	1	50	51
				8.1-8.5	1	50	51
				*10.1-10.5	2	100	52
				21.1-21.5	1	50	51
				22.0-22.5	2	100	103
6	2	10	12	6.1-6.5	2	200	224
				*6.6-7.0	1	100	0
				*10.1-10.5	3	300	112
				10.6-11.0	2	200	224
				*15.1-15.5	4	400	336
				18.6-19.0	2	200	224
				20.1-20.5	1	100	112

* Adjustment for upper strata contamination performed.

at night at all Lake Michigan stations coincident with other fish larvae tows when time and weather permitted. All sled tows were performed from 6- to 7-m outboard motorboats.

ENTRAINMENT

Due to the unique design of the Unit 3 cooling system, entrainment sampling was performed at the opening of the 5.5-m (18 ft) diameter intake pipe which enters the uncovered intake canal near the Lake Michigan shoreline (Fig. 2). Collection at this point ensured that very few, if any, larvae produced in the intake canal would be sampled and thus bias the entrainment samples with larvae which did not originate from Lake Michigan. However, egg samples taken at this location may have been biased by eggs of adult fish from the intake canal spawning inside the intake system.

Entrainment sampling was performed from a raft situated directly above the juncture where the buried Lake Michigan intake pipe entered the on-land intake canal. A 0.5-m diameter plankton net, identical to that used for field sampling (363-micron mesh net) was lowered into a central position in the mouth of the intake pipe. A heavy weight (18 kg) was necessary to keep the net at the desired depth. The amount of cable necessary to maintain this central position was calculated trigonometrically. Location of the raft and amount of cable necessary to ensure the correct positioning of the net in the opening was verified by scuba diver observations.

Four replicates were taken four times (day, dawn, dusk and night) each 24-h period sampled. Each replicate consisted of a 10-min sample. Sampling was performed on a weekly basis from May through September, three times per month in April and October and twice per month January through March, November and December 1981. The periods of dawn and dusk were defined as the period extending from 1 h before to 1 h after both sunrise and sunset. Sunrise and sunset times were obtained from the Nautical Almanac Office (1981), United States Naval Observatory, Washington D. C. Lengths of daylight and dark hours were also calculated using this information.

Entrainment sampling at Units 1 and 2 was conducted by deploying a 0.5-m diameter conical plankton net in the discharge canal just below the surface of the water, as close as possible to the plant discharge. During 1980, four 10-min replicate samples were taken during each diel period in a 24-h sampling period: dawn, day, dusk and night. Entrainment sampling was done weekly May through August 1980 and approximately biweekly February through April and September through December 1980.

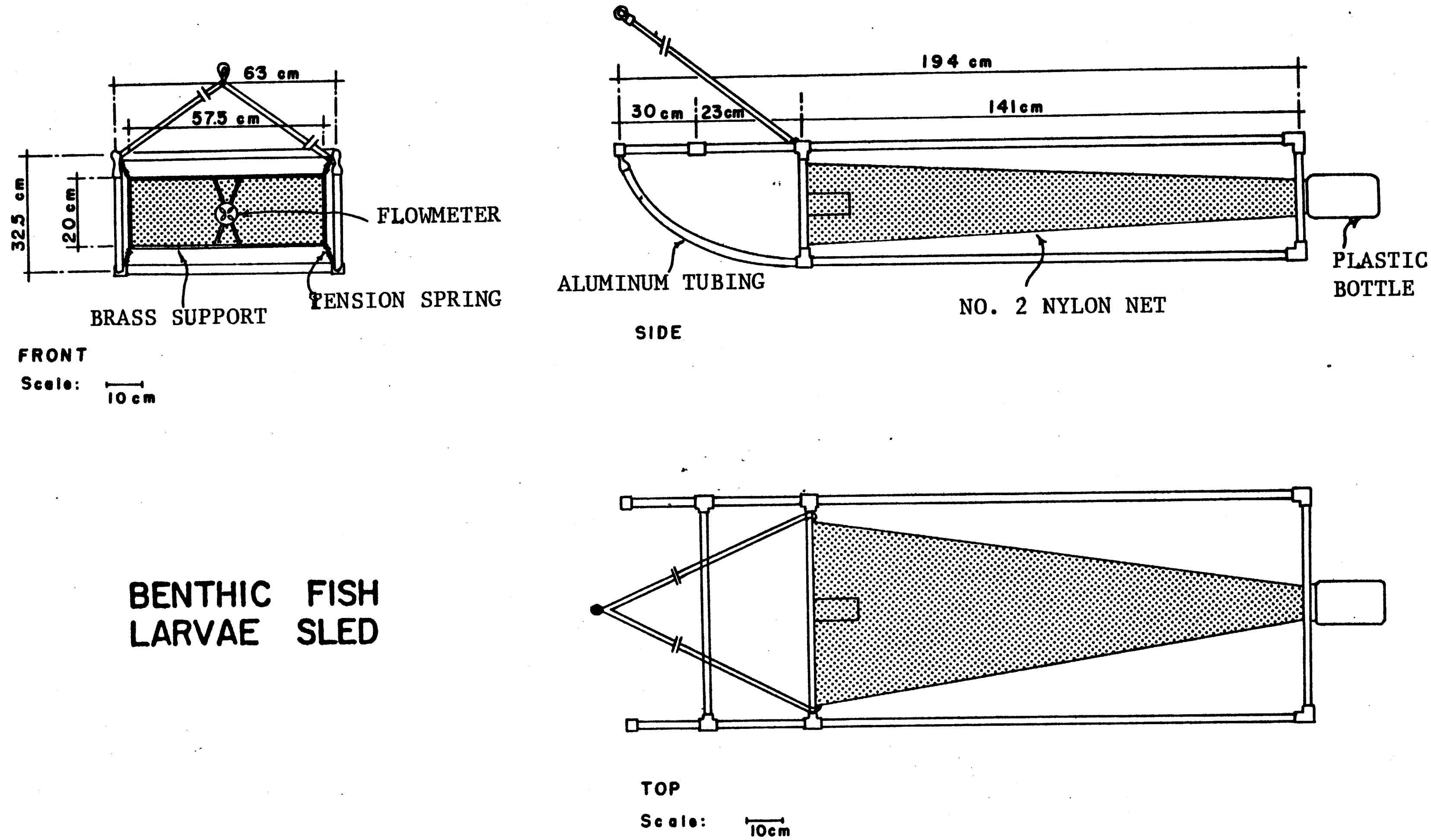


Fig. 7. Benthic fish larvae sled used to collect demersal larval fish. A no. 2, nylon 0.5-m diameter plankton net and Rigosha flowmeter were mounted on the aluminum frame as shown. A pint mason jar, fastened to the net by screwing into a permanently mounted wide mouth jar ring for ease of removal, was inserted into the plastic bottle to prevent damage to the jar.

During 1981, weekly samples were taken April through October, once in March and twice per month in November and December, during day and night only (no dawn or dusk sampling).

Entrainment results were presented as number of fish eggs or larvae entrained per period (two or four periods per 24 h) derived by the formula:

$$N = D \times V \times H$$

Where:

N = number of fish eggs or larvae entrained per period.

D = mean density of fish eggs or larvae entrained per 1000 m^3. Sample size per period was four.

V = volume of water in thousands of m^3 pumped per hour by the plant. These values were calculated based on the rated capacity of the pumps operating during our sampling period.

H = number of hours assigned each diel period. The number of daylight hours was considered to be the period between 1 h after sunrise and 1 h before sunset. The number of hours of darkness was considered to be the period between 1 h after sunset and 1 h before sunrise. The periods of sunrise (dawn) and sunset (dusk) were both arbitrarily defined by 2-h duration. For Units 1 and 2 during 1981, the two diel periods were day, defined as sunrise to sunset, and night, defined as sunset to sunrise. The above calculations were based on the assumption that the density of eggs or larvae entrained remained the same during each period.

Daily estimated entrainment losses were calculated in the following manner: the average density (n = 4) of each species and group of larvae collected in each period (day, dusk, night, dawn) was calculated. These densities were multiplied by the amount of water pumped through the plant (based on pump ratings) during that period. The total numbers of entrained larvae from each of the four periods (day, dawn, night, dusk) were then summed to get the total loss for each 24-h period.

Yearly entrainment estimates were extrapolated from larval fish density estimates derived from our 24-h sampling scheme which was conducted once per week during peak spawning months and less often at other times. To calculate yearly estimates, entrainment rate of larvae from each 24-h sample for each dawn, day, dusk and night period was assigned to a time interval which began at the midpoint between the last sample date and present sample date and ended at the midpoint between the present sample date and the next consecutive sample date. Interval estimates were then calculated based on daily flow rates through the plant during that interval and mean entrainment densities derived for each of the four periods. These estimates were added to give monthly, then yearly total entrainment estimates.

It was determined that the estimates of numbers of larvae entrained were accurate to three significant figures based on accuracy of revolution readings (and thus the accuracy of determining volume flow through the net); thus these estimates were presented to three significant figures (see RESULTS AND DISCUSSION - ENTRAINMENT SUMMARY). However, throughout the calculation procedure to arrive at the estimates no rounding of numbers was done. Once all estimates were calculated, each one was rounded to a value with three significant figures. Thus, adding up the monthly totals presented in a table for a particular taxon may not yield exactly the annual total number of larvae entrained presented in that table for that particular taxon. Likewise summing the annual totals for all taxons of fish larvae may not yield exactly the grand total for number of fish larvae entrained.

Bounds of error were calculated for the numbers of fish larvae and eggs estimated entrained during the year. (See RESULTS AND DISCUSSION - ENTRAINMENT SUMMARY and Madenjian and Jude in press). The upper bound of error for an estimate was defined as the estimate plus two standard deviations of the estimate, while the lower bound was the estimate minus two standard deviations of the estimate (the standard deviation is the square root of the variance). Within such bounds we can be confident that at least 75% (and probably closer to 95%) of the estimates generated from repeated sampling will fall within these limits.

The estimated variances for estimates of numbers of larvae entrained during the year were based on the sample variances for each diel period sampled (n=16). Number entrained during 1 wk is not necessarily independent of the number entrained some weeks later. Bounds were adjusted using a technique developed at the Great Lakes Research Division to account for non-independence among numbers of larvae entrained per 24-h sampling period throughout the year (Madenjian and Jude in press).

DISCHARGE CANAL SAMPLING

Fish larvae samples were collected from the discharge canal by lowering a 0.5-m plankton net into the canal on the north side of the pump house, approximately 5 m from the screens. Of all easily accessible areas, this was found to have the highest flow rate, as it was closest to the pumps which pump water to Lake Michigan. The net was attached to a boom via an extra line so that it could be moved to the area of greatest flow, thus minimizing net avoidance. Ten-minute samples were taken, concurrent with Lake Michigan fish larvae tows, once per month April and September and twice per month May through August.

MISSING LARVAL FISH AND EGG SAMPLES

During 1981, a few fish egg and larval fish samples were lost because of inadequate preservation or inability to collect them due to inclement weather. In the case of beach tows, the replicate was used to estimate the density of larvae in the missing sample. For entrainment and discharge canal samples, missing samples were omitted from analysis and remaining replicates averaged. These three samples were missing from our standard series due to one of the aforementioned reasons:

One on 7 May at station R (0.5 m tow - night)
One on 4 May at discharge canal (day)
One on 10 July at Unit 3 intake (dawn)

Unit 3 entrainment samples were not collected the weeks of 13 April or 24 August due to low flows at the intake. Pumping rates were too slow at these times to turn flowmeters, therefore larvae probably would not have been captured. Entrainment samples and field samples were collected on the same date, with two exceptions. Entrainment data from 22-23 April were compared with 15 April field sample data, and supplemental samples were collected from stations L (6 m, north) and N (9 m, north) on 27 April to compare with 27-28 April entrainment samples (see METHODS - ESTIMATION OF LARVAL FISH ABUNDANCE IN A SPECIFIED AREA OF LAKE MICHIGAN).

FISH EGG AND LARVAE PROCESSING

Fish eggs and larvae were removed from samples with the aid of a dissecting binocular microscope. Once larvae were extracted from samples, they were measured to the nearest 0.1 mm (total length), except when samples contained more than 20 larvae of any one species, at which time lengths were determined to the nearest 0.5 mm. Number, species and length of larvae as well as number of eggs found were entered on coding forms and later keypunched to allow for computer data processing. A computer program was developed to adjust numbers of larvae and eggs to number per 1000 m^3 of water filtered using flowmeter readings (see METHODS - FISH LARVAE TOWS for details).

Knowledge of fish populations and spawning times in southeastern Lake Michigan, specimen comparisons with those stored in the Great Lakes Regional Fish Larvae Collection (Dorr and Jude 1981) and the taxonomic works of Auer (1982), Dorr et al. (1976), Hogue et al. (1976), Lippson and Moran (1974), Nelson and Cole (1975) and Jude et al. (1979b) were used in larval fish identifications.

Problem areas exist in some species identifications of larval fish and some identifications were tentative. Alewife and gizzard shad could not easily be distinguished from one another from the time of yolk-sac absorption until fin formation had taken place. Larvae in the subfamily Coregoninae could not be identified more specifically. Occasionally damaged specimens could be identified to family, such as Centrarchidae or Cottidae. Larvae in the genera *Lepomis*, *Pomoxis* and *Catostomus* could not be identified to species. For a continued description of these problematic areas, see species sections in RESULTS AND DISCUSSION.

Quality Assurance

A quantitative evaluation of the effectiveness of our larval fish processing procedures was conducted. To ensure that larval fish samples were processed accurately, the quality control program previously used was continued in 1981. A random selection of about 10%, or 211 of the 2067 field and entrainment samples collected during 1981, was conducted and these samples were reprocessed. Also, 5%, or 25 of the 509 Units 1 and 2 entrainment samples from 1980, were reprocessed. Picking techniques were the same as those discussed in FISH EGG AND LARVAE PROCESSING.

In 1981 an average of 11.8% of the larvae were missed in the samples reprocessed, comparable to 11-12% in 1979-1980. An average of only 2.9% of the larvae were missed in Units 1 and 2 entrainment samples from 1980. The degree of difficulty in picking through the sample (presence of algae, zooplankton and debris), as well as time of year and thus size of larvae, obviously influenced the percentage of larval fish recovered from samples during the second processing. Lake Michigan samples tended to be filled with small crustaceans, algae and particles of debris. All larvae found during reprocessing were added to the sample totals; no adjustments were made to samples not repicked in the process.

LABORATORY ANALYSIS OF JUVENILE AND ADULT FISH

Each replicate from seine, gill net and trawl catches was labeled and kept separately in plastic bags. Fish were processed fresh when time permitted, or otherwise frozen at the Campbell Plant or on board the R/V Mysis (trawl catches). For laboratory examination, fishes in each bag were thawed, separated by species, then grouped into size classes. When large numbers of a particular size class for an unusually abundant species were present, a subsample was randomly selected from the group and the remaining fish weighed (herein referred to as the mass weight) and discarded. The following data on each fish from the subsample were recorded: total length (to the nearest millimeter, caudal fin pinched), weight (to the nearest 0.1 g using a P1000 Mettler balance), sex, gonad condition, presence or absence of food in the stomach, fin clips, lamprey scars and evidence of diseases and parasites. Identification of food items in piscivorous fish was made when possible. Large fish and fish in the mass weight (over 1000 g) were weighed with a hanging scale spring balance (KO23G Chatillon) to the nearest 20 g.

Gonad condition of adult fish was described according to five stages of development: 1) slightly developed, 2) moderately developed - for female, eggs discernible, but not fully ripe, 3) ripe, 4) ripe-running - sex products exiting with application of moderate pressure, 5) spent. Other gonad conditions recorded included: 6) immature, 7) unable to ascertain sex on adult fish, 8) reabsorbed eggs - for female fish, 9) fish decomposed or mutilated so that sex was impossible to determine.

All fish were identified to species using Hubbs and Lagler (1958), Trautman (1957), Scott and Crossman (1973) and Eddy (1957) with the exception of the genus *Coregonus* (subgenus *Leucichthys*). Satisfactory keys for this subgenus do not exist because of unsettled questions on the validity of several species (Scott and Crossman 1973) and the possibility of their introgression (Wells and McLain 1973). The only adult *Leucichthys* that can be positively identified is the lake herring, *Coregonus artedii*. Other *Leucichthys*, adult or juvenile, were pooled as unidentified Coregoninae (code XC). These were believed to be mostly bloaters, *C. hoyi* (see RESULTS AND DISCUSSION, Unidentified Coregoninae).

DATA PROCESSING AND CALCULATIONS

For each adult and juvenile fish examined, the following information was recorded on a 75-column coding form, one fish per line: date and time of sample collection, type of gear, day or night series, station, species code, a unique incrementing number, length, weight, sex, gonad condition and presence or absence of food in the stomach.

Data on subsampled fish were recorded on consecutive lines each having a subsampling code. Special columns were reserved for the corresponding mass weight. Computer programs searched for subsampled lots and calculated number of fish processed, their mean weight and the total number of mass-weighed fish not examined. Mass-weighed fish were proportionally assigned to length intervals based on the number of sampled fish found in each length interval. Fish were divided visually by length into many narrow size classes when originally subsampled to minimize error associated with this reconstruction of sample length frequencies.

Fishery data were keypunched, then read onto computer disks and tapes. For the bulk of our statistical analyses, we used the Michigan Interactive Data Analysis System (MIDAS) which was developed by the Statistical Laboratory of the University of Michigan. From our computer programs, we obtained summary statistics on seasonal gonad condition, temperature-catch relationships, catches by month, gear type, station and day and night series as well as length-frequency histograms. Most plots used in the report were drawn by the CALCOMP plotter at the University of Michigan Computing Center.

Gill nets were set for as close to 12 h as possible when there was available daylight or darkness. Due to unpredictable weather conditions and changing day length, however, actual time gill nets were fished varied from 4 h 25 min to 15 h 25 min, except for sets in October 1980 when, due to inclement weather, nets were in from 23 h 15 min to 24 h 10 min. Gill net catches for calculating statistics were adjusted to approximate numbers caught per 12 h by assuming that catch was a linear function of time. The above assumption is not completely valid as gill net catch-per-unit-time might be expected to decrease as the net fills with fish, but increased accuracy could not justify the cost of determining a precise relationship for each species.

ESTIMATION OF LARVAL FISH ABUNDANCE IN A SPECIFIED AREA OF LAKE MICHIGAN

Calculation of an estimate of the number of larval fish in Lake Michigan in the vicinity of the Campbell Plant was accomplished by assigning a volume of Lake Michigan water to each of the larval fish tows performed at the north transect. These volumes will be referred to as stratum volumes. To calculate these volumes, first the cross-sectional area of Lake Michigan from the beach to 2850 m from shore (an approximate pie-shaped wedge) was divided vertically into stratum cross-sectional areas based on station contours (Fig. 8). Each stratum cross-sectional area was represented by a rectangle. The horizontal dimension of each rectangle was equal to the width of the stratum cross-sectional area. These widths were arrived at by (1) locating on the lake surface line points whose soundings were equal to station contours, then (2) locating the midpoints on the lake surface line between adjacent station points found in the previous step and (3) for each midpoint, extending a vertical line from the midpoint at lake surface to lake bottom. Note that for the 15-m station, the midpoint between the 15-m and 18-m contours was used in marking the deeper boundary. Thus, the horizontal dimension was the same for all stratum cross-sectional areas at any one station. Distances on the lake surface between shore and each sampling station were estimated based on maps of the area (U. S. Geological Survey 1972; National Oceanic and Atmospheric Administration 1979). The depth or vertical dimension of each stratum cross-sectional area was found in the following manner. For any two adjacent strata tows at a particular station, the perpendicular bisector of the line segment connecting the locations of the two adjacent strata tows was constructed for the width of the stratum cross-sectional area. We considered the error introduced by treatment of the bottom stratum as a rectangle, rather than a trapezoid, as being negligible due to the estimated slope (0.009). Calculated stratum cross-sectional areas are presented in Table 3.

The third dimension in calculating volumes for each stratum was length of shoreline. This length was based on an average alongshore current speed, 0.082 m/s, for the area of Lake Michigan near the Campbell Plant (Consumers Power Company 1978). During 24 h, on the average, a given water mass would have travelled 7085 m along the lake shore. Thus, each stratum volume was calculated using 7085 m as the third dimension. Volumes were equal to products of the lengths of the three dimensions discussed above.

After stratum volumes were calculated in the manner described, densities of larval fish/1000 m^3 from each discrete tow on a given sampling date were multiplied times each corresponding stratum volume. All these estimated numbers of fish larvae were then summed to yield an estimate of the fish larvae population in the vicinity of the Campbell Plant during each field sampling period. Populations were estimated using night densities only, and also using means of day and night densities. Alternately, these estimates could be viewed as the total number of larvae passing by the plant each 24 h. These estimates were compared to entrainment projections for corresponding 24-h periods, and percentages of the estimated fish larvae populations that were entrained were calculated.

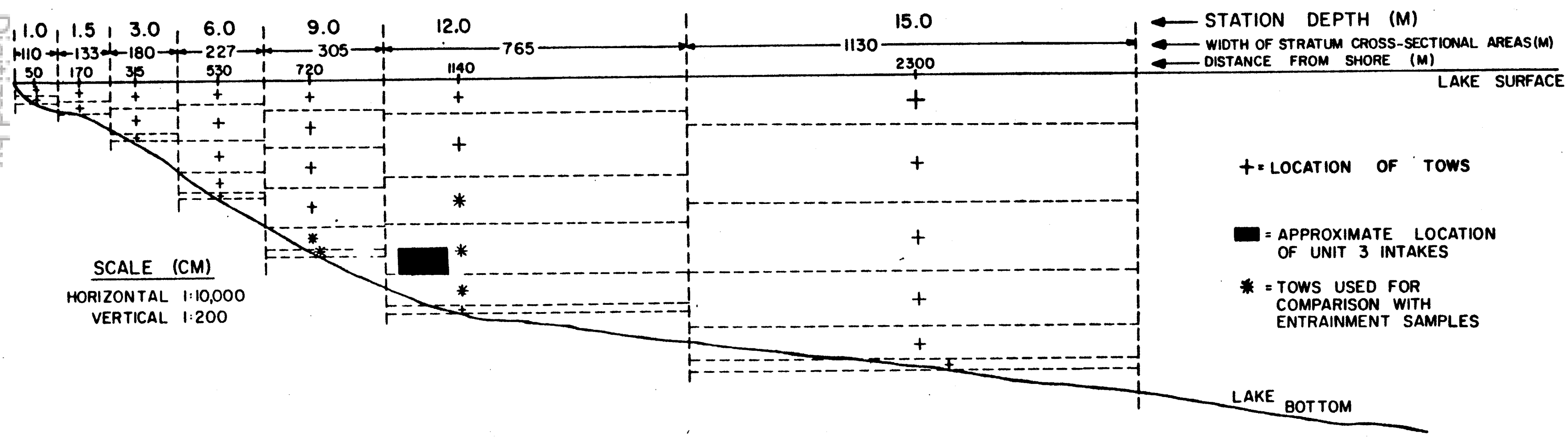


Fig. 8. Profile of Lake Michigan near the J. H. Campbell Plant showing sampling stations, location of Unit 3 intake structure and the stratum cross-sectional area represented by each tow at a given stratum. Dashed lines indicate boundaries of stratum cross-sectional areas which are defined in METHODS. Drawn to scale, but note that horizontal and vertical scales differ giving a distorted view of the Lake Michigan profile which is much more gradually sloping.

Table 3. Stratum (m) at which each tow was taken and in parentheses cross-sectional area (m^2) represented by each tow for north transect stations near the J. H. Campbell Plant, eastern Lake Michigan. Stratum cross-sectional area is defined in METHODS.

	Station						
Parameter	R	I	J	L	N	O	W
	0.5 (83)	0.5 (133)	0.5 (270)	0.5 (284)	0.5 (458)	0.5 (1339)	0.5 (2825)
	1.0 (28)	1.5 (67)	2.5 (225)	2.0 (397)	2.5 (610)	3.0 (2104)	4.5 (4520)
			3.0 (45)	4.0 (397)	4.5 (610)	6.0 (2295)	8.5 (3955)
				5.5 (227)	6.5 (610)	9.0 (1913)	11.5 (3108)
				6.0 (57)	8.5 (381)	11.0 (1148)	14.0 (1978)
					9.0 (76)	12.0 (383)	15.0 (565)
Maximum Depth (m)	1.0	1.5	3.0	6.0	9.0	12.0	15.0
Total cross-sectional area for each station	111	200	540	1362	2745	9182	16951

DEFINITION OF TERMS

Adult fish length intervals - for figures describing total lengths of adult fish, individuals were assigned to 10-mm intervals. For example, the 30-mm length interval would include fish from 25 to 34 mm. For length-frequency histogram figures for most abundant species, size ranges for adult, yearling and young-of-the-year were determined from length modes of fish collected during each sampling period. Size ranges of each of these groups may be slightly different for different months or years of capture.

Beach zone - refers to that area of water, usually less than 1.5 m, that is accessible to wading during seining and fish larvae sampling activities. Includes only beach stations.

Fish larvae - any fish less than or equal to 25.4 mm in total length.

Fry - any fish greater than 25.4 mm in total length caught in plankton nets. Fish were usually 25.5 to 100 mm.

Inshore - refers to that area of water between the shoreline and 21 m.

Larval fish length intervals - for figures describing total lengths of larval fish, a specimen was assigned to a 0.5-mm interval based on total length. For example, larvae 0.3 mm would be assigned to the interval 0.5 mm (which includes all larvae 0.1 to 0.5 mm), 5.6-mm larvae would be assigned to the interval 6 mm (which encompasses 5.6- to 6.0-mm larvae).

Nearshore - refers to that area of water less than or equal to 3 m and includes stations P, A, B, Q, R, I and J.

Offshore - term for that area of water, not beach zone, 21 m deep or greater. There are no stations in this zone. Same as deepwater.

Open water - refers to that area of water which is not beach zone and includes all stations 6 m to 21 m which were usually sampled by boat and which had no aquatic macrophytes present. The area includes stations C, D, E, F, G, H, L, N, O, U and W.

TL - total length - length of fish from most anteriorly projecting part of head to farthest tip of caudal fin when caudal rays are squeezed together.

Transition zone - area of water from 1.5 to 3 m.

Zone of influence - that area of Lake Michigan aquatic habitat actually or potentially affected by the presence of the intake and discharge structures of Units 1 and 2 and Unit 3 and their associated withdrawal and discharge of cooling water.

YOY - young-of-the-year - fish in their first year of life. They become yearlings January 1.

Water temperature intervals - catch of adult fish was assigned to 2 C water temperature intervals for the purposes of establishing temperature-catch relationships. For example, the 3 C temperature interval would include fish caught between 2.0 and 3.9 C.

DIVER OBSERVATIONS

Visual observations via scuba divers during 1981 were conducted at least once per month in April and June through September and at least three times per month in May and October, including two dives in the area of the intake structures (one day, one night), and one day dive at the reference area 3 km south of the plant. Substrates in the reference area were typical of those found in the inshore areas of southeast Lake Michigan and were comprised of uniform-size, shifting sand presenting a smooth and gently sloping surface profile. The intake station substrate consisted of riprap (crushed limestone 0.1-2.5 m in diameter; 225-900 kg) deposited during construction to reduce erosion of in-lake cooling water intake structures.

The standard series dives were conducted using two or three divers equipped with scuba. Divers always swam side by side either 1 or 2 m apart. Divers made observations by swimming southeast along the west side of the seven risers and back northwest along the east side of the risers (approximately 50 m) (Fig. 3). The northeast and northwest arms of the intake manifold were examined in this manner. While swimming each diver examined a plot 2 m in width. Weather and time permitting, 28 wedge-wire screens were inspected for impinged fish and periphytic growth; at least 14 screens were always inspected. In addition, divers swam side by side for 5 min over the sand bottom directly north of the northeast intake arm and at the 11-m contour of the south reference transect.

The previously described stations and observational methods comprise our monthly standard series sampling effort. Additional inspections of the wedge-wire screens to monitor fish impingement were conducted in May and October. Impingement monitoring was performed day and night at the northwest and northeast arms of the intake manifold. In November a low-light-sensitive underwater television system was employed to monitor the wedge-wire screens for periphytic growth. The screens of the northeast arm of the intake manifold were inspected and the results recorded on videotape.

Observations were made following the format of Dorr and Miller (1975) and were recorded on water-resistant paper or plastic slate. Because of the uneven nature of the riprap substrate at the Campbell Plant, abundance of cryptozoic or benthic organisms is probably underestimated. Large chunks of limestone (approximately 2 m in diameter) rest on the bottom in such a manner as to produce a large number of small fissures and interstices which cannot be examined and may contain demersal organisms.

STATISTICS

Introduction

One objective of this study was to detect differences in densities of fish larvae (and fish eggs) between the following areas: (1) north transect area in Lake Michigan in the immediate area of the intake structures and (2) the Unit 3 intake entrainment sampling station (Figs. 1, 2). Such information would hopefully provide some insight into: (1) the density of fish larvae and eggs in the immediate area of the intake structures relative to those observed in the north transect vicinity and (2) the behavior of fish larvae in response to the intake screens.

When comparing entrainment and field densities, exact locations of the sampling stations should be considered. North transect sampling was performed with tows parallel to shore with the entire tow in the general area north of the intake and discharge structures. Entrainment samples were collected in the Unit 3 intake canal. These samples, being taken from entrained water, were drawn from the immediate area of the intake structures. One other point which should be considered is the possibility of fish spawning in the intake pipe itself. Such an occurrence would inflate estimates of eggs entrained from Lake Michigan, but should not bias larval fish entrainment estimates, since eggs spawned far into the intake pipe would be carried out of the pipe long before they hatched. A possible exception would be species such as johnny darter and slimy sculpin which deposit their eggs on the undersides of rocks. Larvae from these species could inflate entrainment estimates although fecundities for these species are relatively low compared to alewife and spottail shiner.

Design and Analysis Considerations

Statistical analyses were performed on density data for fish eggs and for the seven most abundant taxons of fish larvae collected in Unit 3 1981 entrainment samples at the Campbell Plant. They included: alewife, spottail shiner, rainbow smelt, yellow perch, slimy sculpin, johnny darter and damaged larvae. Differences in densities between entrained larvae and those caught in the field were examined using analysis of variance (ANOVA). The experimental designs were analyzed as completely crossed, factorial models with MONTH PERIOD (sampling date), AREA and TIME OF DAY as design variables (Table 4). All factors were considered fixed. The response variable was either number of fish larvae (or eggs) per 1000 m^3 or a transform thereof. We transformed raw data by taking $\log_{10}$ of the sum of density plus one. The addition of one ensured inclusion of zero values of CPE in the transformed data. This transformation was performed to reduce data variance so ANOVA assumptions might be more closely met.

To match the four replicates used during each entrainment sampling period (day, dusk, dawn, night) and balance the design (that is, have an equal number of replicates for each cell in the design), four observations were selected from among the field samples collected. For Design I the four field-collected samples closest to the intake structures were included in the design (Fig. 8). These were the observations (densities) for the 8.5- and 9-m tows (sled tow) at the 9-m station and the 9- and 11-m tows at the 12-m station. Apparently alewife larvae exhibit a movement off the lake bottom at night; thus using plankton net densities from all four field replicates better represents the density of alewife larvae susceptible to entrainment since intake screens are 3 m above lake bottom. Therefore a second design, Design II, was employed which was identical to Design I, except that the sled tow observation at the 9-m station was replaced with the 6-m plankton net tow observation at the 12-m station.

Factorial ANOVA designs were chosen according to taxons and presence of zero values in data (Table 4). The MONTH PERIOD (or sampling date) factor was expected to explain a considerable amount of the variation attributable to seasonal changes in density. The AREA factor was designed to test for differences in densities between entrainment and field samples. TIME OF DAY was employed in all designs. A main effect or an interaction was considered significant if the attained significance (p) of its statistical test was less than 0.05 ($p < 0.05$); the main effect or interaction was considered highly significant if the attained significance (p) for its test was less than 0.01 ($p < 0.01$).

Assumptions for the ANOVA model were: (1) residuals are normally distributed, (2) variances of the population are constant for all partitions of the population and (3) observations are statistically independent. Balanced factorial ANOVAs are robust to the assumptions of normality and homogenous variances. In other words, moderate departures from these assumptions do not completely invalidate results of the model. Violation of the independence assumption may have more serious consequences. Examination of frequency histograms of residuals and plots of residuals versus cell means indicate that the assumptions of normality and homogeneous variances were violated for some models, but test results were still considered valid.

Table 4. Experimental designs employed to analyze density data for fish eggs and the seven most abundant taxons of fish larvae collected in entrainment samples for Unit 3 of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Observations for designs include Lake Michigan field samples and Unit 3 entrainment samples.

Design	Factor	Levels of factor	Taxons examined	Comments
I	MONTH PERIOD	18-19 May, 4-5 June, 15-16 June, 1-2 July, 20-21 July, and 6-7 August sampling periods	Fish eggs and following larval taxons: Alewife, Spottail shiner, Rainbow smelt, Yellow perch, Slimy sculpin, Johnny darter, Damaged larvae	For fish eggs, alewife larvae, spottail shiner larvae and johnny darter larvae, data for sampling periods of 15-16 June through 6-7 August were analyzed. For rainbow smelt larvae, data for 18-19 May through 15-16 June sampling periods were analyzed. For slimy sculpin larvae, data for the 4-5 June and 15-16 June sampling periods were examined. For yellow perch larvae and damaged larvae only data for the 15-16 June sampling period were included in the design.
	AREA	Unit 3 entrainment, field. Field included: 8.5- and 9-m observations at station N (9 m, north), 9- and 11-m observations at station O (12 m, north)		
	TIME	day,night		

Table 4 continued.

Design	Factor	Levels of factor	Taxons examined	Comments
IA	AREA	Unit 3 entrainment, field. Field included: 8.5- and 9-m observations at station N (9 m, north), 9- and 11-m observation at station O (12 m, north)	Alewife larvae	Only data for the 15-16 June sampling period were analyzed.
	TIME	day,night		
II	MONTH PERIOD	18-19 May, 4-5 June, 15-16 June, 1-2 July, 20-21 July and 6-7 August sampling periods	Fish eggs and following larval taxons: Alewife	See comments for Design I
	AREA	Unit 3 entrainment, field. Field included: 8.5-m observation at station N (9 m, north), 6-, 9- and 11-m observations at station O (12 m, north)	Spottail shiner Rainbow smelt Yellow perch Slimy sculpin Johnny darter Damaged larvae	
	TIME	day,night		

Given that these assumptions are met, sensitivity of the ANOVA model to detect the alternate hypothesis can be calculated. In this study, we were interested in detecting significant differences between areas. The least detectable true change (LDTC) is the minimum difference in mean abundance between areas that can be detected by our experimental design. The formula we used for LDTC, as presented by Jude et al. (1979b), is as follows:

$$\delta = s(2/n)^{1/2} \quad (t_{\alpha,\nu} + t_{2(1-P),\nu})$$

Where: δ = least detectable true change (LDTC)
s = within cell standard deviation of the ANOVA (i.e., the square root of the mean square error)
n = number of observations in each of the two groups being compared
α = significance level
t = Student's t-statistic
ν = degrees of freedom for the error sum of squares of the ANOVA
P = power (the probability that a true difference will be judged significant by the ANOVA test)

Results for all ANOVA models were computed using both raw and log-transformed data. Data for all taxons and gear types were initially screened by calculating mean density, its variance and percentage of zero values in the design matrix. Summary statistics for those data sets considered amenable to further statistical analyses (Table 5) showed that percentage of zero catches for these data usually exceeded 50%. Consequently, distribution of values was generally bimodal with modes at zero and near the geometric means. The transformation did, however, yield residuals which were slightly closer than residuals from raw-data values in meeting ANOVA assumptions. Unless stated otherwise, future references to density when discussing the ANOVA results will refer to geometric mean density derived from log-transformed data. Geometric means for various partitions of the data were derived by back transforming cell means from $\log_{10}$-transformed data. For example, if $\bar{x}$ represents the mean density for log-transformed data, then $\bar{x}' = 10^{\bar{x}}$ is the geometric mean density. Use of log-transformed data can yield cell means which are not in the same ranking order as cell means from the original data. If so, the geometric means will also differ in ranking order since the exponential function is monotonic.

When using log-transformed data, the LDTC or δ is expressed as the change in the logarithm of densities and not in terms of the actual densities. Back transforming δ yields 10^{δ}; 10^{δ} represents the ratio of the mean number of fish larvae (or eggs)

Table 5. Descriptive statistics for density data used in the experimental designs for fish eggs and the seven most abundant taxa of fish larvae entrained at Unit 3 intake of the J. H. Campbell Plant, eastern Lake Michigan, 1981. N = number of samples in the experimental design, $\bar{X}$ = the mean density of larvae or eggs (number per 1000 m^3) for the data set. $\bar{X}$(Ent) is the mean density of larvae or eggs for entrainment observations in the data set while $\bar{X}$(Field) is the mean density of larvae or eggs for field observations. See Table 4 for design descriptions.

	N	Maximum density no. fish/1000 m^3	$\bar{X}$	Standard deviation	Percentage of zero density data	$\bar{X}$(Ent)	$\bar{X}$(Field)
DESIGN I							
Fish eggs	64	13664	900.7	2554.6	51.6	1554.1	247.4
Alewife	64	2871	156.8	451.5	54.7	56.8	256.7
Spottail shiner	64	144	10.7	26.9	81.3	12.6	8.8
Rainbow smelt	48	170	14.7	37.2	79.2	9.8	19.7
Yellow perch	16	396	121.9	122.3	25.0	196.9	46.9
Slimy sculpin	32	250	37.4	61.4	59.4	64.3	10.4
Johnny darter	64	193	6.1	26.0	89.1	4.3	7.8
Damaged larvae	16	144	24.6	42.1	62.5	30.3	18.9
DESIGN IA							
Alewife	16	2871	577.1	774.6	0	188.1	966.1
DESIGN II							
Fish eggs	64	13664	834.6	2531.9	53.1	1554.1	115.2
Alewife	64	2871	173.1	461.3	51.6	56.8	289.3
Spottail shiner	64	144	8.2	24.6	85.9	12.6	3.8
Rainbow smelt	48	170	14.2	32.3	75.0	9.8	18.7
Yellow perch	16	396	142.8	120.4	12.5	196.9	88.8
Slimy sculpin	32	250	36.2	61.7	62.5	64.3	8.0
Johnny darter	64	56	3.0	10.7	90.6	4.3	1.8
Damaged larvae	16	144	24.6	42.1	62.5	30.3	18.9

per 1000 m³ plus one for entrained larvae EN to field densities FD. In the transformed coordinate system (i.e., log-transformed system) changes will be detectable if $|\bar{x}_{EN} - \bar{x}_{FD}| > \delta$ where $\bar{x}_{EN}$ and $\bar{x}_{FD}$ refer to the log-transformed mean catches for entrained larvae (EN) and field larvae (FD), respectively. In the original coordinate system, differences are detectable whenever:

$$\frac{\bar{x}'_{EN}}{\bar{x}'_{FD}} < 10^{-\delta} \qquad \text{or} \qquad \frac{\bar{x}'_{EN}}{\bar{x}'_{FD}} > 10^{\delta}$$

We shall refer to the quantity 10^{δ} as the least detectable true ratio (LDTR).

Wilcoxon Test

The Wilcoxon signed ranks test was performed on fish larvae and fish egg data to investigate differences in larvae and fish egg densities between the reference (south) transect and the plant-influenced or discharge (north) transect. This statistical technique is the nonparametric analogue of the t-test for paired observations (Conover 1971). With a few exceptions, for each tow performed at a particular depth contour and a particular stratum in the water column at one transect there was a corresponding tow performed at the same depth contour and stratum at the other transect for each sampling period. Thus, during a particular diel period of larvae sampling, pairs of densities could be calculated for all taxons of larvae found and this technique could be used. To apply this procedure, both beach tow replicate samples were averaged to yield one value for the 0.5-m depth in the beach zone. Any incomplete (one missing observation) pair of observations were ignored as well as all zero differences or ties between pairs of observations.

The Wilcoxon signed ranks test was applied to data for each of the more abundant taxons of larvae collected as well as fish eggs. A difference in densities between transects was considered significant if the attained significance level (α) for the statistic was less than 0.05.

RESULTS AND DISCUSSION

STATISTICS

Test Results

Results of the ANOVAs for fish eggs showed the AREA effect (entrained larvae vs. field-caught larvae) to be highly significant, with the mean entrainment density greater than that for the field samples (Tables 6 and 7). Egg densities in the immediate vicinity of the intake structures and the surrounding riprap may have been substantially higher than those densities observed just north of the intake structures where the field sampling was performed, due to attraction of fish to riprap and structures. Some spawning in the intake system from resident intake canal fish may be also occurring.

Interestingly enough, egg densities were significantly greater at night than during the day. Higher night egg densities were also observed for entrainment data for the D. C. Cook Plant (M. Perrone, personal communication, Univ. of Mich., Great Lakes Research Division, Ann Arbor, Mich.). Alewives, probably the major contributor to the eggs collected, spawn at night (Jude et al. 1979b; Scott and Crossman 1973). Eggs may water harden and then sink to the bottom. Thus, at night eggs may be more susceptible to our plankton nets and to being entrained, since eggs are present in high numbers (after just being deposited) and many of them probably had not water hardened and were not on the lake bottom.

Of the sampling periods included in the design, highest egg densities for both field and entrainment samples were observed in the mid-June sampling period (Fig. 9). The MONTH PERIOD x AREA (M x A) interaction was significant in the first design. Particularly during the mid-June sampling period, but also during early August, differences between field and entrainment mean densities were large. These sampling periods corresponded with the primary and secondary spawning peaks, respectively, according to our fish larvae data for alewives.

Alewife larvae, as was found with almost all of the other taxons of larvae examined in 1981, showed highest mean density during mid-June (Fig. 9). Densities of alewives for the other three sampling periods were much lower than observed during mid-June. For the first design (which included the sled tow at the 9-m station) with four sampling periods included, there was no significant difference detected between the entrainment and field mean larval fish densities (Table 8). However, when the July and August month periods were deleted, as was the case for Design IA, mean density in the field was significantly greater than observed

Table 6. Analysis of variance summary for fish eggs collected in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Fish eggs were collected in the 8.5-m plankton net tows and sled tows at station N (9 m, north) and the 9- and 11-m plankton net tows at station O (12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 15-16 June, 1-2 July, 20-21 July and 6-7 August sampling periods. (Design I - see METHODS - STATISTICS)

Source of variation	df	Mean square	F-statistic	Attained significance level
Month period (M)	3	13.0483	20.9272	<0.0001**
Area (A)	1	18.9707	30.4257	<0.0001**
Time (T)	1	17.6688	28.3378	<0.0001**
M x A	3	2.5314	4.0599	0.0119*
M x T	3	2.3786	3.8148	0.0157*
A x T	1	2.1712	3.4822	0.0681
M x A x T	3	0.9926	1.5919	0.2036
Within cell error	48	0.6235		

** Highly significant ($P < 0.01$).
* Significant ($P < 0.05$).

Table 7. Analysis of variance summary for fish eggs collected in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Fish eggs were collected in the 8.5-m plankton net tows at station N (9 m, north) and the 6-, 9- and 11-m plankton net tows at station O (12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 15-16 June, 1-2 July, 20-21 July and 6-7 August sampling periods. (Design II)

Source of variation	df	Mean square	F-statistic	Attained significance level
Month period (M)	3	7.8850	10.7039	<0.0001**
Area (A)	1	24.3195	33.0136	<0.0001**
Time (T)	1	18.4710	25.0743	<0.0001**
M x A	3	2.1643	2.9381	0.0425*
M x T	3	1.8768	2.5477	0.0668
A x T	1	1.9020	2.5819	0.1146
M x A x T	3	1.1054	1.5005	0.2264
Within cell error	48	0.7367		

** Highly significant ($P < 0.01$).
* Significant ($P < 0.05$).

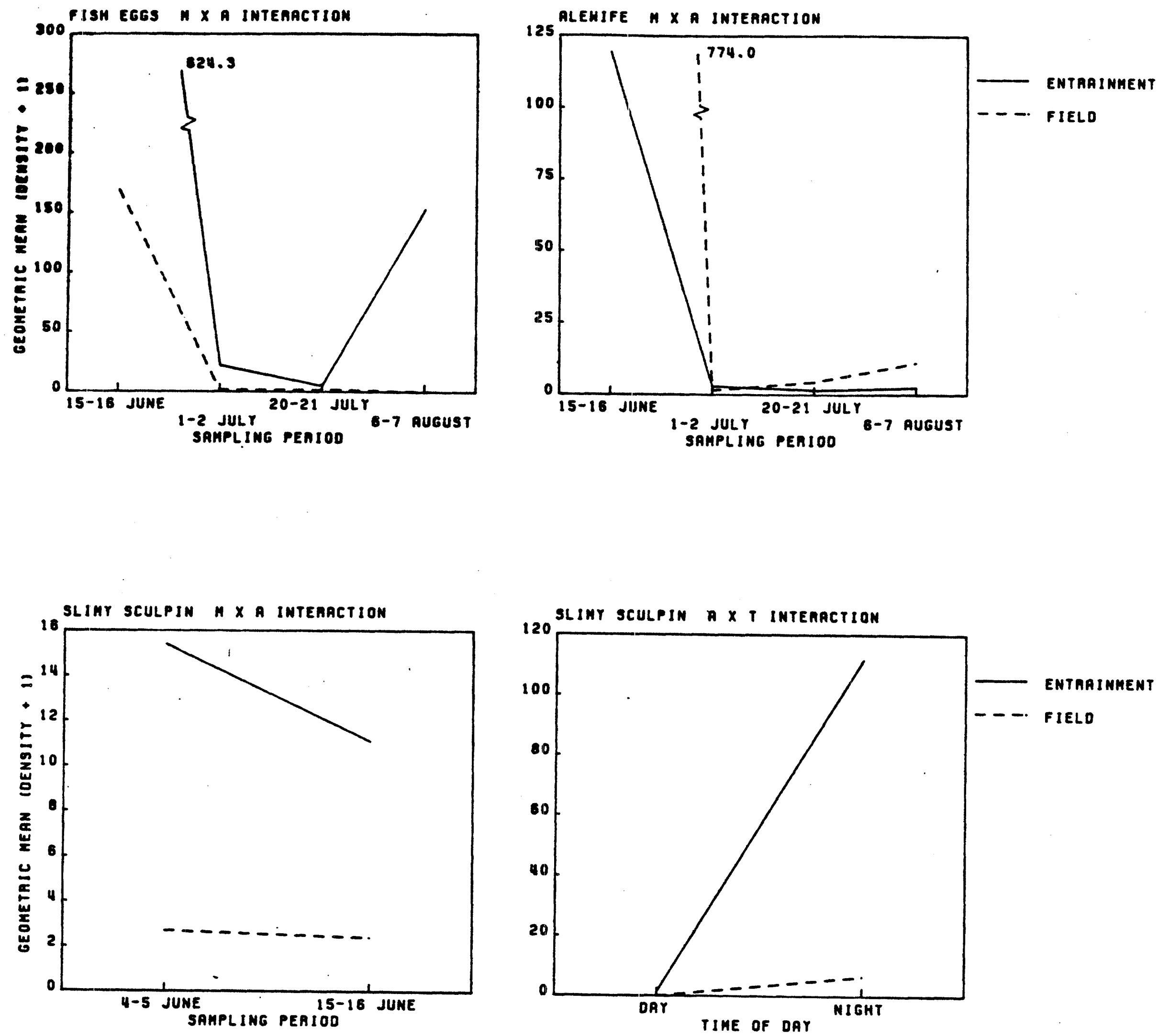


Fig. 9. Geometric mean density plus one of fish eggs and larval alewives and slimy sculpins in field and entrainment samples collected near the J. H. Campbell Plant, eastern Lake Michigan during 1981. Graphs illustrate the MONTH PERIOD x AREA interaction. For slimy sculpin larvae the AREA x TIME interaction is also shown. All interactions illustrated above are for Design I ANOVAs except the interaction for alewife larvae which is for the Design II ANOVA.

at the entrainment sampling site. Apparently the sampling periods in July and August diluted the difference observed between the entrainment and field sites in mid-June (Table 9). Additionally, we found that in most cases, and clearly for alewife, that as larvae grew larger their susceptibility to entrainment decreased. In June many species are newly hatched, do not resist currents or have much fin development and as a consequence are entrained in proportion to their abundance in the field, except alewife where fewer were entrained than would be expected from field densities. During subsequent months, a smaller proportion of the total fish larvae population is comprised of newly hatched larvae. Since this group is most susceptible to entrainment and larger larvae present in the population avoid entrainment, comparisons, as we found, between field and entrainment data show a large disparity between lengths of larvae in field samples and those in entrainment samples in waning months of the spawning and nursery season.

For the second design, when a plankton net tow observation at 6 m at the 12-m north station was substituted for the one for the sled tow at station N (9 m, north), again alewife mean field density was significantly higher than that for entrained larvae (Table 10). Of all the taxons examined, only data for alewife larvae showed a significantly higher field density than entrainment density.

Alewife larvae near the intake structures are probably in the same (or even higher) densities than were observed in our field samples, but avoided the intake. These larvae probably do not seek cover as do larvae of other species and may react to intake flow by swimming away from it and thus avoiding being entrained. Definitely, some behavioral response is involved.

The ANOVA for yellow perch larvae was performed on data for the mid-June sampling period only. Results show that the AREA effect was significant; yellow perch larvae density for entrainment samples was significantly greater than that for field samples (Tables 11 and 12). We feel yellow perch larvae were more concentrated in the immediate area of the intake structures where they are known to spawn than in most of the water sampled by our north transect tows. There is also a possibility that yellow perch larvae may have been attracted to the "cover" afforded by the intake structure itself.

Densities of slimy sculpin larvae were relatively high during early and mid-June (Fig. 9). ANOVA results for slimy sculpin larvae showed a significantly higher entrainment density than was found in the field (Tables 13 and 14). Field densities in the immediate vicinity of the intake structure for slimy sculpin larvae were very likely underestimated because larvae would probably have concentrated in the immediate riprap area

Table 8. Analysis of variance summary for alewife larvae collected in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Larvae were collected in the 8.5-m plankton net tows and sled tows at station N (9 m, north) and the 9- and 11-m plankton net tows at station O (12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 15-16 June, 1-2 July, 20-21 July and 6-7 August sampling periods. (Design I)

Source of variation	df	Mean square	F-statistic	Attained significance level
Month period (M)	3	15.2883	31.7186	<0.0001**
Area (A)	1	1.3392	2.7784	0.1021
Time (T)	1	4.5414	9.4219	0.0035**
M x A	3	0.6576	1.3644	0.2649
M x T	3	0.4175	0.8662	0.4651
A x T	1	0.0451	0.0935	0.7611
M x A x T	3	0.0772	0.1603	0.9225
Within cell error	48	0.4820		

** Highly significant ($P < 0.01$).
* Significant ($P < 0.05$).

Table 9. Analysis of variance summary for alewife larvae collected in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Larvae were collected in the 8.5-m plankton net tows and sled tows at station N (9 m, north) and the 9- and 11-m plankton net tows at station O (12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 15-16 June sampling period only. (Design IA)

Source of variation	df	Mean square	F-statistic	Attained significance level
Area (A)	1	1.6465	7.4969	0.0180*
Time (T)	1	1.0238	4.6617	0.0518
A x T	1	0.0040	0.0180	0.8954
Within cell error	12	0.2196		

** Highly significant ($P < 0.01$).
* Significant ($P < 0.05$).

Table 10. Analysis of variance summary for alewife larvae collected in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Larvae were collected in the 8.5-m plankton net tows at station N (9 m, north) and the 6-, 9- and 11-m plankton net tows at station O (12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 15-16 June, 1-2 July, 20-21 July and 6-7 August sampling periods. (Design II)

Source of variation	df	Mean square	F-statistic	Attained significance level
Month period (M)	3	16.3101	37.8829	<0.0001**
Area (A)	1	2.5543	5.9328	0.0186*
Time (T)	1	2.4882	5.7793	0.0201*
M x A	3	0.9528	2.2131	0.0987
M x T	3	0.6786	1.5762	0.2073
A x T	1	0.1165	0.2707	0.6053
M x A x T	3	0.2983	0.6928	0.5610
Within cell error	48	0.4305		

** Highly significant (P < 0.01).
* Significant (P < 0.05).

where they would not be collected by our north transect sampling efforts. The TIME effect was also highly significant with a higher night density than a day density. Also the AREA x TIME interaction was significant (Fig. 9). The most striking feature of the interaction was the high night entrainment density relative to the field densities or even the day entrainment density. Data indicate that slimy sculpin larvae were more active at night and consequently more susceptible to entrainment. These larvae may also have been attracted to the "cover" of the intake structure (including the intake screens). Many adults have been observed by divers to rest on these structures.

Of the four sampling periods included in the design, spottail shiner larvae showed peak densities during mid-June (Fig. 10). The night density was significantly higher than the day density (Tables 15 and 16). AREA was not a significant factor in either design; however, it was close to significance in the second design (when the TIME x AREA interaction was significant). Spottail shiner larvae were collected in the sled at the 9-m station, but not in the 6-m plankton net tow at the

Table 11. Analysis of variance summary for yellow perch larvae collected in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Larvae were collected in the 8.5-m plankton net tows and sled tows at station N (9 m, north) and the 9- and 11-m plankton net tows at station O (12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 15-16 June sampling period only. (Design I)

Source of variation	df	Mean square	F-statistic	Attained significance level
Area (A)	1	6.9555	11.6667	0.0051**
Time (T)	1	0.0003	0.0006	0.9811
A x T	1	0.5595	0.9384	0.3518
Within cell error	12	0.5962		

** Highly significant (P < 0.01).
* Significant (P < 0.05).

Table 12. Analysis of variance summary for yellow perch larvae collected in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Larvae were collected in the 8.5-m plankton net tows at station N (9 m, north) and the 6-, 9- and 11-m plankton net tows at station O(12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 15-16 June sampling period only. (Design II)

Source of variation	df	Mean square	F-statistic	Attained significance level
Area (A)	1	2.5271	5.0262	0.0446*
Time (T)	1	0.0385	0.0765	0.7868
A x T	1	0.8565	1.7034	0.2163
Within cell error	12	0.5028		

** Highly significant (P < 0.01).
* Significant (P < 0.05).

Table 13. Analysis of variance summary for slimy sculpin larvae collected in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Larvae were collected in the 8.5-m plankton net tows and sled tows at station N (9 m, north) and the 9- and 11-m plankton net tows at station O (12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 4-5 June and 15-16 June sampling periods. (Design I)

Source of variation	df	Mean square	F-statistic	Attained significance level
Month period (M)	1	0.0692	0.2280	0.6374
Area (A)	1	4.0519	13.3448	0.0013**
Time (T)	1	14.2932	47.0741	<0.0001**
M x A	1	0.0196	0.0646	0.8015
M x T	1	0.0672	0.2212	0.6424
A x T	1	2.2222	7.3186	0.0124*
M x A x T	1	0.1461	0.4811	0.4946
Within cell error	24	0.3036		

** Highly significant ($P < 0.01$).
* Significant ($P < 0.05$).

Table 14. Analysis of variance summary for slimy sculpin larvae collected in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Larvae were collected in the 8.5-m plankton net tows at station N (9 m, north) and the 6-, 9- and 11-m plankton net tows at station O (12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 4-5 June and 15-16 June sampling periods. (Design II)

Source of variation	df	Mean square	F-statistic	Attained significance level
Month period (M)	1	0.2984	1.0963	0.3055
Area (A)	1	5.2723	19.3666	0.0002**
Time (T)	1	12.2320	44.9318	<0.0001**
M x A	1	0.0205	0.0753	0.7862
M x T	1	0.0006	0.0021	0.9636
A x T	1	3.1467	11.5589	0.0024**
M x A x T	1	0.4427	1.6263	0.2144
Within cell error	24	0.2722		

** Highly significant ($P < 0.01$).
* Significant ($P < 0.05$).

12-m station at night during mid-June. Considering the high percentage of zero density observations in the data for the design, we can conclude that there was no significant difference in densities between entrained larvae and those caught in the field.

As for most species, peak density for rainbow smelt larvae was in mid-June for data included in the design, while for johnny darter, peak density occurred in early August (Fig. 10). For both species, night densities were greater than day densities (Tables 17-20). No significant difference was detected between entrainment and field mean larval fish densities for either species. Likewise for damaged larvae the AREA effect was not significant (Tables 21-22).

Power Analysis

The LDTRs (Least Detectable True Ratios) are ratios involving geometric mean number of fish larvae (or eggs) per 1000 m^3. Least detectable true ratios for the designs employed ranged from 2.81 to 117.63 with most occurring from 3.5 to 8.7 (for α = 0.01 and Power = 0.95) (Table 23). The lowest LDTR (for α = 0.01 and Power = 0.95), 2.81, was for the second design for johnny darter larvae. For this design the mean density at one area would have to be at least 281% greater than the mean density at the other area before a difference in density between areas could be detected. Overall LDTRs of ANOVAs for adult and juvenile fish data were dramatically lower than those observed for the ANOVAs calculated for larval fish data. This was undoubtedly due to the naturally high variability associated with fish larvae data compared with adult and juvenile fish data. The LDTRs for fish eggs were slightly higher than for most larvae, except for yellow perch and damaged larvae.

FIELD LARVAE SAMPLES - OVERVIEW

General Trends

Alewife and spottail shiner larvae were the most abundant larvae in field samples during 1981, as was found during the preoperational study. During times of hatching, alewife larvae were collected at all sampling stations. When upwellings occurred, alewife larvae were concentrated more inshore, 1-6 m. Alewife larvae appeared to migrate toward surface strata at night, as adult alewives do. Spottail shiner larvae were most abundant at nearshore stations; few were collected from 6 to 15 m. Larval spottail shiners were more demersal than alewife larvae, as evidenced by large catches in sled tows.

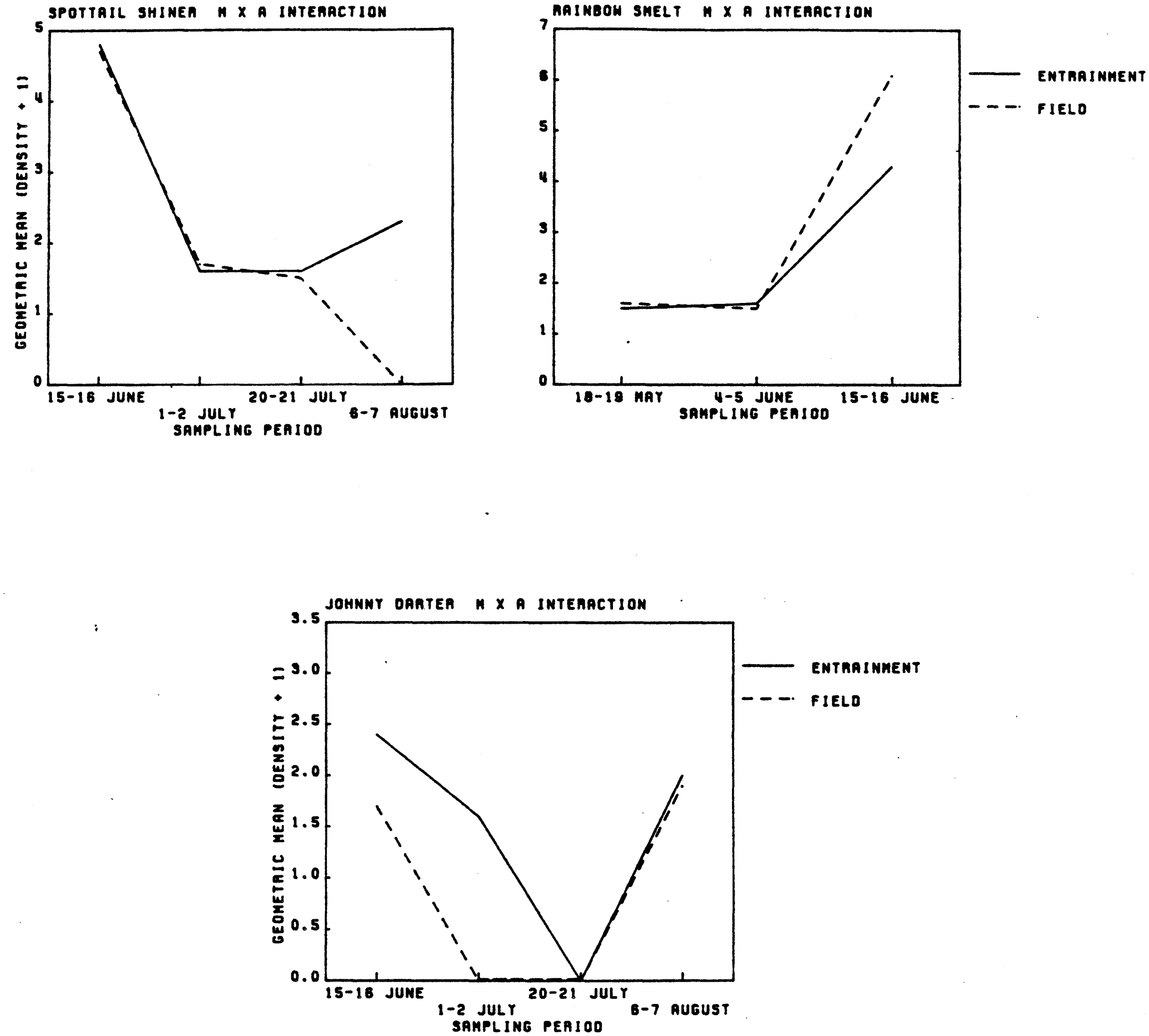


Fig. 10. Geometric mean density plus one of larval spottail shiners, rainbow smelt and johnny darters in field and entrainment samples collected near the J. H. Campbell Plant, eastern Lake Michigan during 1981. Graphs illustrate the MONTH PERIOD x AREA interaction. Interactions illustrated above are for Design I ANOVAs.

Table 15. Analysis of variance summary for spottail shiner larvae collected in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Larvae were collected in the 8.5-m plankton net tows and sled tows at station N (9 m, north) and the 9- and 11-m plankton net tows at station O (12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 15-16 June, 1-2 July, 20-21 July and 6-7 August sampling periods. (Design I)

Source of variation	df	Mean square	F-statistic	Attained significance level
Month period (M)	3	0.9290	2.4092	0.0785
Area (A)	1	0.1702	0.4415	0.5096
Time (T)	1	4.6419	12.0373	0.0011**
M x A	3	0.1245	0.3228	0.8088
M x T	3	0.3430	0.8895	0.4534
A x T	1	0.6276	1.6276	0.2082
M x A x T	3	0.1777	0.4609	0.7109
Within cell error	48	0.3856		

** Highly significant (P < 0.01).
* Significant (P < 0.05).

Table 16. Analysis of variance summary for spottail shiner larvae collected in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Larvae were collected in the 8.5-m plankton net tows at station N (9 m, north) and the 6-, 9- and 11-m plankton net tows at station O (12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 15-16 June, 1-2 July, 20-21 July and 6-7 August sampling periods. (Design II)

Source of variation	df	Mean square	F-statistic	Attained significance level
Month period (M)	3	0.7507	2.5913	0.0635
Area (A)	1	1.0813	3.7325	0.0593
Time (T)	1	2.3324	8.0508	0.0066**
M x A	3	0.0207	0.0716	0.9749
M x T	3	0.2461	0.8494	0.4738
A x T	1	2.0150	6.9551	0.0112*
M x A x T	3	0.1554	0.5363	0.6596
Within cell error	48	0.2897		

** Highly significant (P < 0.01).
* Significant (P < 0.05).

Table 17. Analysis of variance summary for rainbow smelt larvae collected in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Larvae were collected in the 8.5-m plankton net tows and sled tows at station N (9 m, north) and the 9- and 11-m plankton net tows at station O (12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 18-19 May, 4-5 June and the 15-16 June sampling periods.(Design I)

Source of variation	df	Mean square	F-statistic	Attained significance level
Month period (M)	2	1.4236	3.9653	0.0278*
Area (A)	1	0.0334	0.0930	0.7622
Time (T)	1	2.6633	7.4185	0.0099**
M x A	2	0.0340	0.0948	0.9098
M x T	2	2.7111	7.5515	0.0018**
A x T	1	0.5198	1.4478	0.2367
M x A x T	2	0.3864	1.0762	0.3516
Within cell error	36	0.3590		

** Highly significant ($P < 0.01$).
* Significant ($P < 0.05$).

Table 18. Analysis of variance summary for rainbow smelt larvae collected in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Larvae were collected in the 8.5-m plankton net tows at station N (9 m, north) and the 6-, 9- and 11-m plankton net tows at station O (12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 18-19 May, 4-5 June and 15-16 June sampling periods.(Design II)

Source of variation	df	Mean square	F-statistic	Attained significance level
Month period (M)	2	1.3855	2.9970	0.0625
Area (A)	1	0.3073	0.6647	0.4203
Time (T)	1	2.5444	5.5037	0.0246*
M x A	2	0.0441	0.0954	0.9092
M x T	2	1.5244	3.2973	0.0484*
A x T	1	0.5742	1.2421	0.2725
M x A x T	2	0.0838	0.1813	0.8349
Within cell error	36	0.4623		

** Highly significant ($P < 0.01$).
* Significant ($P < 0.05$).

Table 19. Analysis of variance summary for johnny darter larvae collected vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Larvae were collected in the 8.5-m plankton net tows and sled tows at station N (9 m, north) and the 9- and 11-m plankton net tows at station O (12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 15-16 June, 1-2 July, 20-21 July, and 6-7 August sampling period.(Design I)

Source of variation	df	Mean square	F-statistic	Attained significance level
Month period (M)	3	0.3422	1.3617	0.2657
Area (A)	1	0.1441	0.5735	0.4526
Time (T)	1	1.9336	7.6943	0.0079**
M x A	3	0.0444	0.1768	0.9116
M x T	3	0.3422	1.3617	0.2657
A x T	1	0.1441	0.5735	0.4526
M x A x T	3	0.0444	0.1768	0.9116
Within cell error	48	0.2513		

** Highly significant (P < 0.01).
* Significant (P < 0.05).

Table 20. Analysis of variance summary for johnny darter larvae collected in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Larvae were collected in the 8.5-m plankton net tows at station N (9 m, north) and the 6-, 9- and 11-m plankton net tows at station O (12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 15-16 June, 1-2 July, 20-21 July, and 6-7 August sampling periods.(Design II)

Source of variation	df	Mean square	F-statistic	Attained significance level
Month period (M)	3	0.2441	1.4400	0.2428
Area (A)	1	0.4430	2.6134	0.1125
Time (T)	1	1.2201	7.1971	0.0100**
M x A	3	0.0627	0.3696	0.7753
M x T	3	0.2441	1.4400	0.2428
A x T	1	0.4430	2.6134	0.1125
M x A x T	3	0.0627	0.3696	0.7753
Within cell error	48	0.1695		

** Highly significant (P < 0.01).
* Significant (P < 0.05).

Table 21. Analysis of variance summary for damaged larvae collected in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Larvae were collected in the 8.5-m plankton net tows and sled tows at station N (9 m, north) and the 9- and 11-m plankton net tows at station O (12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 15-16 June sampling period only. (Design I)

Source of variation	df	Mean square	F-statistic	Attained significance level
Area (A)	1	0.5211	0.7109	0.4156
Time (T)	1	2.3073	3.1477	0.1014
A x T	1	0.1287	0.1756	0.6825
Within cell error	12	0.7330		

** Highly significant (P < 0.01).
* Significant (P < 0.05).

Table 22. Analysis of variance summary for damaged larvae collected in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Larvae were collected in the 8.5-m plankton net tows at station N (9 m, north) and the 6-, 9- and 11-m plankton net tows at station O (12 m, north) and in entrainment samples for Unit 3 of the Campbell Plant. Data were for the 15-16 June sampling period only. (Design II)

Source of variation	df	Mean square	F-statistic	Attained significance level
Area (A)	1	0.5211	0.7109	0.4156
Time (T)	1	2.3073	3.1477	0.1014
A x T	1	0.1287	0.1756	0.6825
Within cell error	12	0.7330		

** Highly significant (P < 0.01).
* Significant (P < 0.05).

Table 23. Least detectable true ratios (LDTRs) for each experimental design employed for fish egg densities and for densities of larval alewife, spottail shiner, rainbow smelt, yellow perch, slimy sculpin, johnny darter and damaged larvae in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1981. Alpha (α) is the size of the type I error, which is the probability of rejecting the null hypothesis given that it is true; power is the probability of rejecting the null hypothesis given it is false. See Table 4 for design descriptions.

DESIGN	ALPHA (α)	FISH EGGS Power .90	FISH EGGS Power .95	ALEWIFE Power .90	ALEWIFE Power .95	SPOTTAIL SHINER Power .90	SPOTTAIL SHINER Power .95	RAINBOW SMELT Power .90	RAINBOW SMELT Power .95	YELLOW PERCH Power .90	YELLOW PERCH Power .95	SLIMY SCULPIN Power .90	SLIMY SCULPIN Power .95	JOHNNY DARTER Power .90	JOHNNY DARTER Power .95	DAMAGED LARVAE Power .90	DAMAGED LARVAE Power .95
DESIGN I	.01	6.11	7.26	4.91	5.71	4.15	4.75	4.97	5.79	50.44	73.68	6.33	7.55	3.16	3.52	77.27	117.63
	.02	5.39	6.40	4.40	5.12	3.76	4.31	4.44	5.17	36.19	52.86	5.52	6.59	2.91	3.25	53.47	81.40
	.05	4.50	5.35	3.75	4.37	3.27	3.74	3.77	4.39	23.16	33.83	4.56	5.44	2.60	2.90	32.60	49.62
	.10	3.87	4.59	3.29	3.82	2.90	3.32	3.30	3.84	16.28	23.78	3.89	4.64	2.36	2.63	22.05	33.57
DESIGN IA	.01			10.80	13.59												
	.02			8.83	11.11												
	.05			6.73	8.47												
	.10			5.44	6.84												
DESIGN II	.01	7.15	8.62	4.50	5.19	3.43	3.86	6.17	7.33	36.62	51.86	5.74	6.78	2.57	2.81	77.27	117.63
	.02	6.24	7.52	4.05	4.68	3.15	3.54	5.42	6.45	27.00	38.23	5.04	5.96	2.41	2.63	53.47	81.40
	.05	5.13	6.19	3.49	4.03	2.79	3.14	4.51	5.36	17.92	25.37	4.21	4.97	2.19	2.40	32.60	49.62
	.10	4.35	5.25	3.08	3.55	2.52	2.83	3.87	4.60	12.96	18.36	3.62	4.28	2.02	2.21	22.05	33.57

Fish collected as larvae in preoperational years, but not taken in 1981 larval fish field samples, included burbot, unidentified sucker, *Pomoxis*, *Lepomis* and lake trout. Ninespine stickleback larvae in field samples declined in abundance from 1980; however, they were collected more frequently in Unit 3 entrainment samples. Table 24 lists all taxons of larvae in field and entrainment collections covered by this report.

During 1981 at deeper stations, 9-15 m, few larvae were collected in surface tows during the day, while night surface tows collected many larvae. This may indicate vertical diel migration or net avoidance during daylight. Surface tows performed directly in the discharge plume by small outboard motorboats collected fewer larvae than surface tows at the same depth contour (6 m, plant transect) performed by the R/V Mysis. Turbulence in the discharge plume may physically displace to adjacent waters larvae already in the lake. Low densities in plume tows are similar to low densities in discharge canal samples. Dead fish larvae discharged from the plant may settle to the bottom and not be pumped to the lake, while live larvae are able, for the most part, to swim against the weak current and remain away from the pumps.

Mean total densities of fish larvae, all months combined, were lower in 1981 than during most preoperational years. Mean densities were calculated for all species together by month (Fig. 11) for the north transect, and indicated that local fish populations produced fewer larvae during 1981 than 1980. This was most marked during July, when larval fish densities were highest in most years. Densities during 1978 and 1979 (except for August 1979) were comparable to 1981. The water temperature regime was believed to be the primary reason for seasonal and yearly fluctuations in abundance of larvae. Warming trends during spring and early summer trigger spawning, and upwellings of cool water may inhibit spawning or cause larvae to move elsewhere. Water temperatures from 1977 to 1980 at the Grand Rapids Filtration Plant intake, depth 12 m (Jude et al. 1981a), showed that 1980 was the only year without a major upwelling of water <9 C before the mid- or late July sampling period, and July 1980 densities were highest of the 4 yr (Fig. 11). Overall, of the 5 yr, 1980 displayed high mean densities of larvae, while 1981 was a year of relatively low densities.

Seasonal Distribution

April, May, Early June--

Relatively few larvae were collected in early spring field samples during 1981. April samples yielded unidentified Coregoninae, probably round or lake whitefish, in the nearshore zone, mostly at the reference transect. One yellow perch larva

Table 24. Taxons and abbreviations of fish larvae captured from J. H. Campbell Plant study areas during 1980 and 1981. An L denotes presence of fish larvae in Lake Michigan or entrainment samples and an F represents fry. Names assigned according to Robins et al. 1980.

Scientific and Common Name	Code	Lake Michigan 1981	Entrainment Unit 3 1981	Entrainment Units 1 & 2 1981	Entrainment Units 1 & 2 1980
Atherinidae					
Labidesthes sicculus (Cope) Brook silverside	SV			L	L
Catostomidae					
Catostomidae spp. Unidentified Catostomidae	XS			L	
Centrarchidae					
Lepomis spp. Unidentified *Lepomis*	XL			L	L
Pomoxis spp. Unidentified *Pomoxis*	PM			L	L
Micropterus salmoides (Lacépède) Largemouth bass	LB	L			
Centrarchidae spp. Unidentified Centrarchidae	CT				L
Clupeidae					
Alosa pseudoharengus (Wilson) Alewife	AL	L,F	L	L,F	L,F
Dorosoma cepedianum (Lesueur) Gizzard shad	GS	L	L		L
Cottidae					
Cottus cognatus Richardson Slimy sculpin	SS	L	L		L
Cottus bairdi Girard Mottled sculpin	MS				L
Myoxocephalus thompsoni (Girard) Deepwater sculpin	FS	L	L		L
Cottidae spp. Unidentified Cottidae	UC				L
Cyprinidae					
Cyprinus carpio Linnaeus Common carp	CP	L	L	L	L

Table 24. Continued.

Scientific and Common Name	Code	Lake Michigan 1981	Entrainment Unit 3 1981	Entrainment Units 1 & 2 1981	Entrainment Units 1 & 2 1980
Notemigonus crysoleucas (Mitchill) Golden shiner	GL				L
Notropis atherinoides Rafinesque Emerald shiner	ES	L		L,F	L
Notropis hudsonius (Clinton) Spottail shiner	SP	L,F	L	L,F	L,F
Pimephales notatus (Rafinesque) Bluntnose minnow	BM	F		F	
Pimephales promelas Rafinesque Fathead minnow	PP	F		F	
Gadidae					
Lota lota (Linnaeus) Burbot	BR			L	L
Gasterosteidae					
Pungitius pungitius (Linnaeus) Ninespine stickleback	NS	L	L		
Osmeridae					
Osmerus mordax (Mitchill) Rainbow smelt	SM	L,F	L,F	L,F	L,F
Percidae					
Etheostoma nigrum Rafinesque Johnny darter	JD	L,F	L	L	L
Perca flavescens (Mitchill) Yellow perch	YP	L,F	L	L	L
Percopsidae					
Percopsis omiscomaycus (Walbaum) Trout-perch	TP	L	L	L	L
Salmonidae					
Coregoninae spp. Unidentified Coregoninae	XC	L,F		L	L
Larvae damaged beyond recognition	XP	L	L	L	L

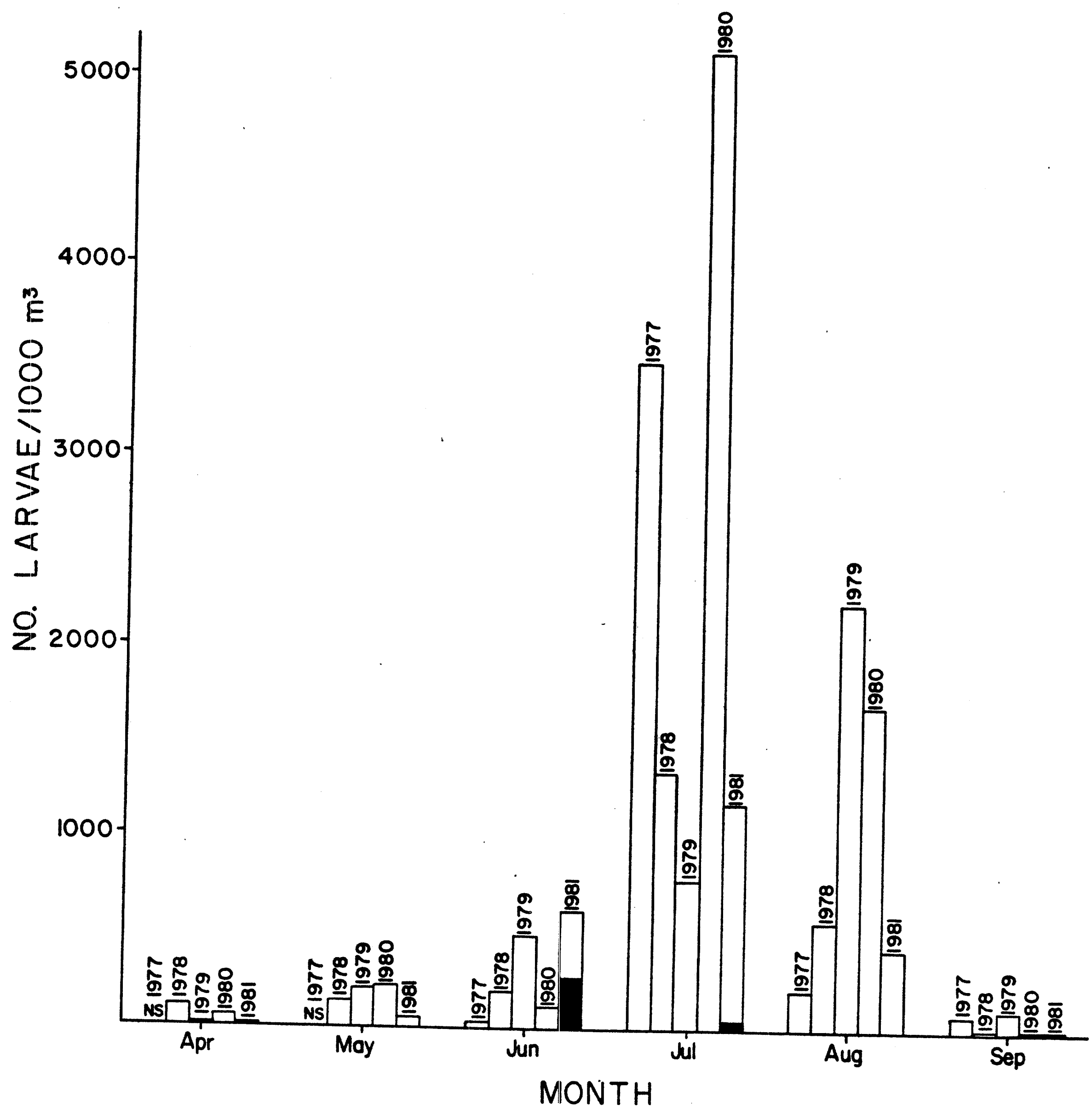


Fig. 11. Mean densities by month of total fish larvae collected at the north transect near the J. H. Campbell Plant, eastern Lake Michigan, 1977-1981. Data were pooled over all gear (sled and plankton nets) and all diel periods (day and night) for calculation of field larvae densities, and over all diel periods (day, dusk, night, dawn) for calculation of entrainment densities. Shaded areas are mean densities of fish larvae entrained by Unit 3 for June and July. Entrainment rates for other months were <15 larvae/1000 m³ and were not shown. NS = not sampled.

was collected in a beach tow. Smelt larvae appeared in early May, primarily in nearshore samples, along with a few yellow perch. Deepwater sculpin larvae were collected in late May at ≥ 3 m stations, which was later than their usual peak of occurrence (March-early May). A few smelt larvae continued to appear through July; however, by June they were more abundant at deeper stations (6-15 m). Slimy sculpin larvae were first collected in early June at 9-15 m.

Mid-June--

Alewife and spottail shiner spawning commenced in June, and abundance of larvae was much greater in mid-June than early June. Both species were collected at all depths, but spottails tended to concentrate near shore. Yellow perch larvae were common at all depths. Species diversity was greatest in mid-June. Other larvae collected included johnny darter, slimy sculpin, trout-perch, ninespine stickleback, gizzard shad, carp and unidentified Coregoninae (probably bloater), but most of these taxons were collected only at the plant transect (Appendixes 9, 10).

Early July--

Cool water temperatures in late June (9-13 C, Fig. 12) indicated an upwelling occurred. Depressed spawning or evacuation of the inshore zone by adult and larval fish due to the upwelling was evidenced by lower abundance of larvae in early July, except near shore (1-3 m). Both newly hatched and older alewives were collected there.

Late July--

Spawning and hatching rebounded after the upwelling, but larvae densities did not reach 1980 levels (Fig. 11). Alewives and spottails were more abundant at the plant transect than the reference transect (Appendixes 9, 10), with both newly hatched and larger larvae of both species common in the area. Newly hatched alewives were concentrated at 6 m. Spottails were most abundant at 1-1.5 m; a night sled tow at station I (1.5 m, north) yielded peak density for the year, 33,600 larvae/1000 m^3.

August and September--

Alewife larvae continued to be the most abundant species in August and September, followed by spottail shiner. The last newly hatched alewives appeared in early August. Abundance of alewives and spottails tapered off through September. Small numbers of trout-perch larvae appeared through late August.

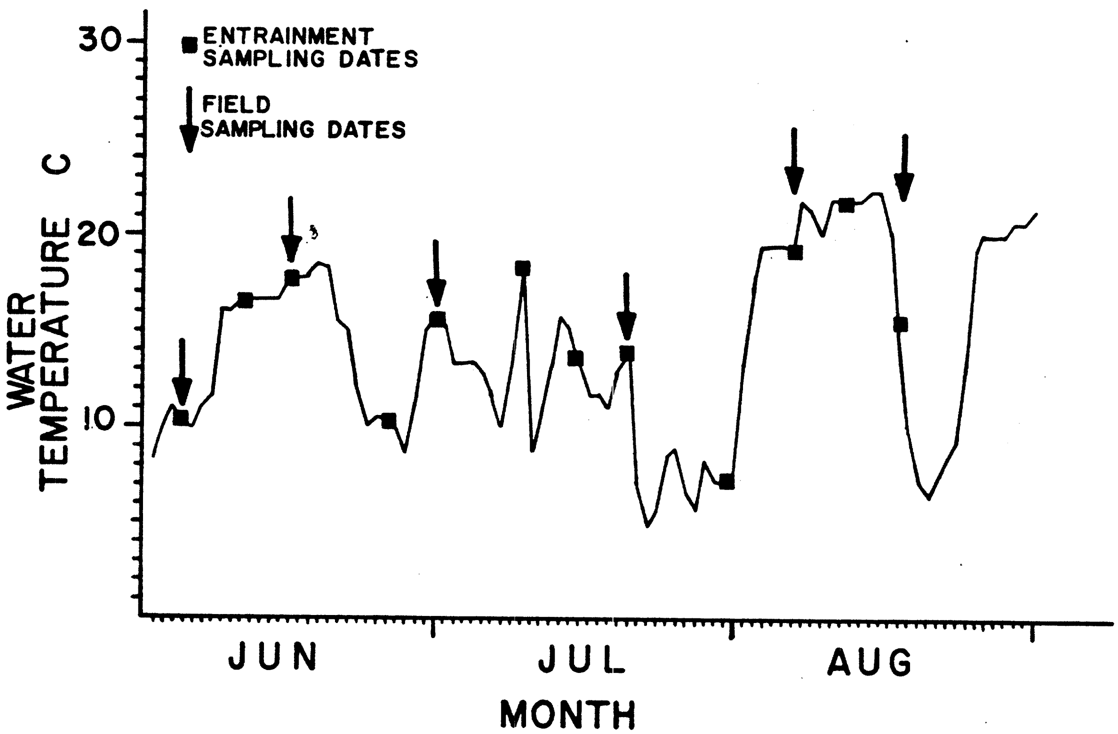


Fig. 12. Daily water temperatures taken at the entrainment sampling site at Unit 3, the J. H. Campbell Plant, eastern Lake Michigan during June-August 1981.

ENTRAINMENT SUMMARY

Projected Yearly Entrainment

Projected larvae entrainment at Units 1 and 2 during 1980 and 1981 was 186 and 22.2 million, respectively (Tables 25 and 26). Estimated numbers of larvae entrained at these two units ranged from 69.9 to 77.7 million per year during 1977-1979 (Jude et al. 1980). Fluctuations of yearly entrainment at Units 1 and 2 were due mainly to changes of abundance of larval alewives. The large projected loss during 1980 resulted mostly from extreme abundance of alewife larvae in Lake Michigan due to warm inshore water temperatures and few to no upwellings during the major spawning season (Jude et al. 1981a). Relatively low entrainment during 1981 was due to a weak year class of larval alewives and a year of frequent upwellings. Total number of alewife larvae entrained at Units 1 and 2 during 1980 and 1981 was 169 million and 9.3 million, respectively. The number of fish eggs entrained was estimated at 336 million in 1980 and 20.6 million in 1981 (Tables 25 and 26).

During 1980 Unit 3 was in operation only from September to December and approximately 95,000 fish larvae (alewives and trout-perch) were estimated entrained during this period (Table 27). Projected number of fish larvae entrained at Unit 3 during 1981 (10.2 million) (Table 28) was relatively low. During 1981 Unit 3 operated at a monthly average of 33 to 73% of kilowatt capacity (Table 29), with an annual mean of 59.1%. The mean percentage of capacity during May-September was 62.7%. An average operating level of 60 to 65% of capacity is considered normal for this type of power plant (J. Gulvas, personal communication, Consumers Power Company, 1945 Parnall Rd., Jackson, Michigan). These data suggested that, at the level of larval fish abundance observed in Lake Michigan during 1981 (see RESULTS AND DISCUSSION - 24-H POPULATION AND ENTRAINMENT COMPARISONS), the estimated 10.2 million larvae entrained represented a loss under normal operating conditions of Unit 3.

Taxons

During 1977-1980, 18 to 21 larval fish species were collected annually in Lake Michigan field sampling near the J. H. Campbell Plant (Jude et al. 1981a). During 1981 only 15 species were found at the north transect and 11 species, plus larvae too damaged to identify, were entrained at Unit 3 (Table 28). Larval fish taxons that occurred at the north transect, but were not entrained, included emerald shiner, unidentified Coregoninae and largemouth bass. Lake trout, burbot, suckers, sunfish and crappie larvae were caught in field samples during 1977-1980, but did not occur in north and south transects or entrainment samples during 1981. A large number of species, 23, 21, 21 and 16, respectively, were found in 1978-1981 Units 1 and 2 entrainment samples due to intake of both Lake Michigan and Pigeon Lake water.

The relative importance of species entrained by Unit 3 was substantially different from that observed at Units 1 and 2. Yellow perch was the most abundant species entrained by Unit 3 accounting for 31.8% of all larvae entrained. This species represented approximately 3.5% of the larvae entrained by Units 1 and 2 during 1980-1981 which is much lower than observed during 1978-1979, when larval yellow perch represented about 21% of all larvae entrained. Slimy sculpin, johnny darter, ninespine stickleback and trout-perch were also found in higher proportions in Unit 3 entrainment samples during 1981. Alewife remained one of the most abundant species entrained by Unit 3, but its relative importance was substantially lower than was found at

Table 25. Projected numbers of various taxons of fish larvae and of fish eggs entrained during February through December 1980 at Units 1 and 2 of the J. H. Campbell Plant, eastern Lake Michigan. Estimates were derived from densities of ichthyoplankton observed in 16 samples collected during a 24-h period, usually once per week during February through December 1980. Estimates were based on daily flow rates. Also included are estimated upper and lower bounds of error for the projected numbers of larvae and eggs entrained.

	MONTH												
TAXON	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	SUM	%OF TOTAL
Alewife	0	0	0	0	4,790,000	149,000,000	15,000,000	52,300	19,100	988	0	169,000,000	90.500
Upper Bound	0	0	0	0	5,660,000	174,000,000	18,800,000	88,800	39,800	2,870	0	194,000,000	
Lower Bound	0	0	0	0	3,930,000	123,000,000	11,300,000	15,800	0	0	0	143,000,000	
Yellow Perch	0	0	1,100,000	4,770,000	586,000	30,800	0	0	0	0	0	6,490,000	3.490
Upper Bound	0	0	1,670,000	6,070,000	903,000	72,800	0	0	0	0	0	8,420,000	
Lower Bound	0	0	540,000	3,470,000	269,000	0	0	0	0	0	0	4,550,000	
Spottail Shiner	0	0	0	4,520	1,060,000	3,620,000	134,000	0	0	0	0	4,810,000	2.590
Upper Bound	0	0	0	14,100	1,300,000	4,710,000	204,000	0	0	0	0	6,560,000	
Lower Bound	0	0	0	0	807,000	2,530,000	64,200	0	0	0	0	3,070,000	
Common Carp	0	0	0	37,400	1,010,000	1,570,000	32,200	0	0	0	0	2,650,000	1.420
Upper Bound	0	0	0	52,300	1,230,000	2,070,000	62,000	0	0	0	0	3,320,000	
Lower Bound	0	0	0	22,500	776,000	1,080,000	2,400	0	0	0	0	1,970,000	
Damaged Larvae	0	0	0	173,000	457,000	694,000	72,000	5,640	0	0	0	1,400,000	0.753
Upper Bound	0	0	0	307,000	713,000	1,250,000	131,000	18,300	0	0	0	2,640,000	
Lower Bound	0	0	0	39,500	202,000	141,000	12,600	0	0	0	0	166,000	
Pomoxis spp.	0	0	0	237,000	775,000	3,150	0	0	0	0	0	1,020,000	0.546
Upper Bound	0	0	0	310,000	1,080,000	11,000	0	0	0	0	0	1,330,000	
Lower Bound	0	0	0	165,000	473,000	0	0	0	0	0	0	704,000	
Rainbow Smelt	0	0	0	468,000	171,000	10,000	0	0	0	0	0	649,000	0.349
Upper Bound	0	0	0	631,000	231,000	23,500	0	0	0	0	0	824,000	
Lower Bound	0	0	0	305,000	111,000	0	0	0	0	0	0	474,000	
Lepomis spp.	0	0	0	1,280	174,000	54,900	9,130	0	0	0	0	239,000	0.129
Upper Bound	0	0	0	3,830	255,000	94,100	17,900	0	0	0	0	334,000	
Lower Bound	0	0	0	0	93,000	15,800	341	0	0	0	0	145,000	
Johnny Darter	0	0	0	1,620	106,000	50,300	1,900	0	0	0	0	160,000	0.086
Upper Bound	0	0	0	7,290	182,000	117,000	5,710	0	0	0	0	316,000	
Lower Bound	0	0	0	0	31,100	0	0	0	0	0	0	4,340	
Deepwater Sculpn	0	0	59,300	3,300	0	0	0	0	0	0	0	62,600	0.034
Upper Bound	0	0	136,000	7,550	0	0	0	0	0	0	0	143,000	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	
Trout-perch	0	0	0	1,870	32,000	4,520	2,280	5,640	0	0	0	46,300	0.025
Upper Bound	0	0	0	5,600	55,400	11,000	9,110	18,300	0	0	0	75,200	
Lower Bound	0	0	0	0	8,590	0	0	0	0	0	0	17,400	

Table 25. Continued.

TAXON	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	SUM	%OF TOTAL
Gizzard Shad	0	0	0	9,720	18,000	0	0	0	0	0	0	27,700	0.015
Upper Bound	0	0	0	22,400	54,000	0	0	0	0	0	0	65,900	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	
Unidentified Centrarchidae	0	0	0	0	19,300	0	0	0	0	0	0	19,300	0.010
Upper Bound	0	0	0	0	54,300	0	0	0	0	0	0	54,300	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	
Burbot	0	0	0	15,900	0	0	0	0	0	0	0	15,900	0.009
Upper Bound	0	0	0	34,900	0	0	0	0	0	0	0	34,900	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	
Emerald Shiner	0	0	0	0	8,590	2,690	1,900	0	0	0	0	13,200	0.007
Upper Bound	0	0	0	0	27,900	8,980	5,710	0	0	0	0	33,900	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	
Slimy Sculpin	0	0	0	0	6,420	0	0	0	0	0	0	6,420	0.003
Upper Bound	0	0	0	0	20,300	0	0	0	0	0	0	20,300	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	
Unidentified Coregoninae	0	0	0	2,550	1,680	0	0	0	0	0	0	4,230	0.002
Upper Bound	0	0	0	8,620	5,450	0	0	0	0	0	0	11,400	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	
Mottled Sculpin	0	0	0	0	3,190	0	0	0	0	0	0	3,190	0.002
Upper Bound	0	0	0	0	9,580	0	0	0	0	0	0	9,580	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	
Brook Silverside	0	0	0	0	0	2,690	0	0	0	0	0	2,690	0.001
Upper Bound	0	0	0	0	0	8,980	0	0	0	0	0	8,980	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	
Unidentified Cottidae	0	0	0	0	1,910	0	0	0	0	0	0	1,910	0.001
Upper Bound	0	0	0	0	6,710	0	0	0	0	0	0	6,710	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	
Golden Shiner	0	0	0	914	0	0	0	0	0	0	0	914	<0.001
Upper Bound	0	0	0	3,430	0	0	0	0	0	0	0	3,430	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	

Table 25. Continued.

TAXON	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	SUM	%OF TOTAL
	MONTH												
Total No. of Larvae													
Entrained	0	0	1,160,000	5,730,000	9,220,000	155,000,000	15,300,000	63,600	19,100	988	0	186,000,000	
Upper Bound	0	0	1,740,000	7,110,000	10,300,000	180,000,000	19,000,000	114,000	39,800	2,870	0	212,000,000	
Lower Bound	0	0	586,000	4,340,000	8,130,000	129,000,000	11,500,000	13,300	0	0	0	160,000,000	
Total No. of Eggs													
Entrained	49,000	0	0	355,000	245,000,000	89,900,000	0	0	0	0	0	336,000,000	
Upper Bound	106,000	0	0,	632,000	337,000,000	161,000,000	0	0	0	0	0	452,000,000	
Lower Bound	0	0	0	78,700	154,000,000	18,700,000	0	0	0	0	0	220,000,000	

Table 26. Projected numbers of various taxons of fish larvae and of fish eggs entrained during March 20 through December 1981 at Units 1 and 2 of the J. H. Campbell Plant, eastern Lake Michigan. Estimates were derived from densities of larvae observed in 8 samples collected during a 24-h period, usually once per week during March through December 1981. Estimates were based on daily flow rates. Also included are estimated upper and lower bounds of error for the projected numbers of larvae and eggs entrained.

	MONTH											
TAXON	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	SUM	%OF TOTAL
Alewife	0	0	0	2,410,000	2,210,000	4,290,000	387,000	13,800	3,540	28,700	9,350,000	42.200
Upper Bound	0	0	0	3,370,000	2,840,000	4,950,000	558,000	44,800	9,420	86,100	10,700,000	
Lower Bound	0	0	0	1,440,000	1,580,000	3,640,000	217,000	0	0	0	8,000,000	
Spottail Shiner	0	23,500	0	2,140,000	2,520,000	276,000	8,230	0	0	0	4,960,000	22.400
Upper Bound	0	64,500	0	3,700,000	2,820,000	325,000	26,100	0	0	0	6,770,000	
Lower Bound	0	0	0	576,000	2,220,000	227,000	0	0	0	0	3,160,000	
Common Carp	0	0	4,540	2,050,000	1,250,000	43,600	0	0	0	0	3,350,000	15.100
Upper Bound	0	0	20,500	2,720,000	1,520,000	74,900	0	0	0	0	4,070,000	
Lower Bound	0	0	0	1,390,000	977,000	12,400	0	0	0	0	2,630,000	
Unidentified Coregoninae	10,100	1,400,000	0	0	0	0	0	0	0	0	1,410,000	6.350
Upper Bound	22,400	1,620,000	0	0	0	0	0	0	0	0	1,630,000	
Lower Bound	0	1,180,000	0	0	0	0	0	0	0	0	1,180,000	
Damaged Larvae	9,010	10,200	33,500	624,000	202,000	114,000	6,930	0	0	0	999,000	4.510
Upper Bound	33,800	33,900	76,300	891,000	353,000	192,000	31,200	0	0	0	1,500,000	
Lower Bound	0	0	0	357,000	50,500	35,400	0	0	0	0	494,000	
Yellow Perch	0	549,000	96,600	116,000	24,700	0	0	0	0	0	787,000	3.550
Upper Bound	0	688,000	162,000	210,000	74,200	0	0	0	0	0	974,000	
Lower Bound	0	409,000	31,400	22,800	0	0	0	0	0	0	600,000	
Rainbow Smelt	0	0	307,000	449,000	27,900	0	0	0	0	0	784,000	3.540
Upper Bound	0	0	387,000	653,000	42,700	0	0	0	0	0	1,000,000	
Lower Bound	0	0	226,000	245,000	13,100	0	0	0	0	0	564,000	
Johnny Darter	0	0	12,500	128,000	39,300	13,100	0	0	0	0	193,000	0.873
Upper Bound	0	0	36,600	255,000	79,800	33,000	0	0	0	0	414,000	
Lower Bound	0	0	0	2,190	0	0	0	0	0	0	0	
Pomoxis spp.	0	0	47,600	55,400	0	0	0	0	0	0	103,000	0.465
Upper Bound	0	0	97,100	117,000	0	0	0	0	0	0	183,000	
Lower Bound	0	0	0	0	0	0	0	0	0	0	22,900	
Lepomis spp.	0	0	0	10,700	45,100	7,800	0	0	0	0	63,600	0.287
Upper Bound	0	0	0	30,500	84,000	23,400	0	0	0	0	113,000	
Lower Bound	0	0	0	0	6,140	0	0	0	0	0	13,900	
Burbot	0	36,900	17,900	0	0	0	0	0	0	0	54,700	0.247
Upper Bound	0	78,900	42,400	0	0	0	0	0	0	0	103,000	
Lower Bound	0	0	0	0	0	0	0	0	0	0	6 040	

Table 26. Continued.

TAXON	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	SUM	%OF TOTAL
	MONTH											
Trout-perch	0	0	0	30,000	18,600	0	0	0	0	0	48,600	0.219
Upper Bound	0	0	0	63,800	41,800	0	0	0	0	0	95,100	
Lower Bound	0	0	0	0	0	0	0	0	0	0	2,190	
Unidentified Centrarchidae	0	0	0	21,100	0	0	0	0	0	0	21,100	0.095
Upper Bound	0	0	0	66,800	0	0	0	0	0	0	66,800	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	
Unidentified Catostomidae	0	17,000	0	0	0	0	0	0	0	0	17,000	0.077
Upper Bound	0	41,200	0	0	0	0	0	0	0	0	41,200	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	
Emerald Shiner	0	0	0	4,740	10,700	0	0	0	0	0	15,400	0.069
Upper Bound	0	0	0	14,200	32,000	0	0	0	0	0	46,200	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	
Brook Silverside	0	0	0	0	11,900	2,590	0	0	0	0	14,500	0.065
Upper Bound	0	0	0	0	35,600	7,770	0	0	0	0	43,400	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	
Total No. of Larvae Entrained	19,100	2,030,000	519,000	8,040,000	6,360,000	4,750,000	402,000	13,800	3,540	28,700	22,200,000	
Upper Bound	46,800	2,330,000	627,000	10,800,000	7,060,000	5,450,000	578,000	44,800	9,420	86,100	26,400,000	
Lower Bound	0	1,730,000	412,000	5,220,000	5,650,000	4,050,000	227,000	0	0	0	17,900,000	
Total No. of Eggs Entrained	0	11,400	71,400	16,300,000	4,180,000	10,900	0	35,200	1,830	0	20,600,000	
Upper Bound	0	37,200	144,000	21,300,000	7,270,000	32,700	0	117,000	6,110	0	28,300,000	
Lower Bound	0	0	0	11,300,000	1,090,000	0	0	0	0	0	12,900,000	

Table 27. Projected numbers of various taxons of fish larvae and of fish eggs entrained during September through December 1980 at Unit 3 of the J. H. Campbell Plant, eastern Lake Michigan. Estimates were derived from densities of ichthyoplankton observed in 16 samples collected during a 24-h period, usually once per week during September through December 1980. Estimates were based on daily flow rates. Also included are estimated upper and lower bounds of error for the projected number of larvae and eggs entrained.

	MONTH					
TAXON	Sep	Oct	Nov	Dec	SUM	%OF TOTAL
Trout-perch	49,600	0	0	0	49,600	52.200
Upper Bound	154,000	0	0	0	154,000	
Lower Bound	0	0	0	0	0	
Alewife	0	0	45,400	0	45,400	47.800
Upper Bound	0	0	144,000	0	144,000	
Lower Bound	0	0	0	0	0	
Total No. of Larvae Entrained	49,600	0	45,400	0	95,000	
Upper Bound	154,000	0	144,000	0	239,000	
Lower Bound	0	0	0	0	0	
Total No. of Eggs Entrained	0	0	0	0	0	
Upper Bound	0	0	0	0	0	
Lower Bound	0	0	0	0	0	

Table 28. Projected numbers of various taxons of fish larvae and of fish eggs entrained during January through December 1981 at Unit 3 of the J. H. Campbell Plant, eastern Lake Michigan. Estimates were derived from densities of ichthyoplankton observed in 16 samples collected during a 24-h period, usually once per week during January through December 1981. Estimates were based on daily flow rates. Also included are estimated upper and lower bounds of error for the projected numbers of larvae and eggs entrained.

TAXON	MONTH Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	SUM	%OF TOTAL
Yellow Perch	0	0	0	184,000	16,700	3,030,000	13,000	0	0	0	0	0	3,250,000	31.800
Upper Bound	0	0	0	509,000	46,300	3,610,000	39,700	0	0	0	0	0	3,930,000	
Lower Bound	0	0	0	0	0	2,450,000	0	0	0	0	0	0	2,570,000	
Alewife	0	0	0	0	0	2,290,000	581,000	108,000	0	0	0	0	2,980,000	29.200
Upper Bound	0	0	0	0	0	3,270,000	803,000	186,000	0	0	0	0	4,000,000	
Lower Bound	0	0	0	0	0	1,300,000	359,000	29,200	0	0	0	0	1,960,000	
Spottail Shiner	0	0	0	0	5,040	851,000	332,000	120,000	0	0	0	0	1,310,000	12.800
Upper Bound	0	0	0	0	15,400	1,150,000	469,000	205,000	0	0	0	0	1,820,000	
Lower Bound	0	0	0	0	0	552,000	195,000	33,900	0	0	0	0	790,000	
Slimy Sculpin	0	0	0	0	65,500	1,150,000	25,100	0	0	0	0	0	1,240,000	12.100
Upper Bound	0	0	0	0	119,000	1,470,000	65,000	0	0	0	0	0	1,570,000	
Lower Bound	0	0	0	0	12,000	816,000	0	0	0	0	0	0	897,000	
Damaged Larvae	0	0	0	0	0	493,000	51,800	0	0	0	0	0	545,000	5.340
Upper Bound	0	0	0	0	0	786,000	135,000	0	0	0	0	0	858,000	
Lower Bound	0	0	0	0	0	201,000	0	0	0	0	0	0	233,000	
Johnny Darter	0	0	0	0	0	127,000	144,000	33,500	0	0	0	0	304,000	2.980
Upper Bound	0	0	0	0	0	212,000	228,000	58,400	0	0	0	0	431,000	
Lower Bound	0	0	0	0	0	42,200	59,400	8,600	0	0	0	0	177,000	
Rainbow Smelt	0	0	0	0	105,000	191,000	0	0	0	0	0	0	296,000	2.900
Upper Bound	0	0	0	0	239,000	333,000	0	0	0	0	0	0	491,000	
Lower Bound	0	0	0	0	0	49,200	0	0	0	0	0	0	100,000	
Trout-perch	0	0	0	0	0	68,500	62,700	11,600	2,610	7,960	0	0	153,000	1.500
Upper Bound	0	0	0	0	0	128,000	146,000	31,500	9,150	27,900	0	0	301,000	
Lower Bound	0	0	0	0	0	9,230	0	0	0	0	0	0	5,770	
Ninespine Stickleback	0	0	0	0	0	33,000	28,600	6,370	0	0	0	0	68,000	0.666
Upper Bound	0	0	0	0	0	99,800	55,600	16,800	0	0	0	0	141,000	
Lower Bound	0	0	0	0	0	0	1,630	0	0	0	0	0	0	
Deepwater Sculpin	0	0	0	0	39,200	0	0	0	0	0	0	0	39,200	0.384
Upper Bound	0	0	0	0	93,700	0	0	0	0	0	0	0	93,700	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	

Table 28. Continued.

TAXON	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	SUM	%OF TOTAL
	MONTH													
Common Carp	0	0	0	0	0	21,800	8,880	0	0	0	0	0	30,700	0.300
Upper Bound	0	0	0	0	0	47,000	29,600	0	0	0	0	0	63,300	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Gizzard Shad	0	0	0	0	0	0	3,370	2,060	0	0	0	0	5,420	0.053
Upper Bound	0	0	0	0	0	0	10,100	7,200	0	0	0	0	13,900	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total No. of Larvae Entrained	0	0	0	184,000	231,000	8,250,000	1,250,000	281,000	2,610	7,960	0	0	10,200,000	
Upper Bound	0	0	0	509,000	384,000	9,350,000	1,550,000	418,000	9,150	27,900	0	0	11,400,000	
Lower Bound	0	0	0	0	78,600	7,150,000	951,000	144,000	0	0	0	0	8,990,000	
Total No. of Eggs Entrained	0	0	30,400	104,000	54,300	87,000,000	14,600,000	5,310,000	0	5,260	64,100	0	107,000,000	
Upper Bound	0	0	78,800	263,000	135,000	98,400,000	18,300,000	6,590,000	0	16,400	199,000	0	121,000,000	
Lower Bound	0	0	0	0	0	75,600,000	11,000,000	4,030,000	0	0	0	0	92,900,000	

Table 29. Percentage of kilowatt capacity for the J.H. Campbell Plant's Unit 3 during 1981.

Month	Average % of capacity	Month	Average % of capacity
Jan	51.6	Jul	60.9
Feb	61.5	Aug	62.9
Mar	73.7	Sep	67.5
Apr	33.2	Oct	44.5
May	59.1	Nov	67.5
Jun	63.0	Dec	63.6

Units 1 and 2 during 1977-1981. In 1981 spottail shiner larvae represented a lower percentage of the total larvae entrained at Unit 3 (12%) than at Units 1 and 2 (22.4%). During 1977-1980, the percentage larval spottail shiners comprised of total larvae entrained at Units 1 and 2 was relatively low (0.43-12.1%). Percentage of smelt larvae entrained at Unit 3 during 1981 (2.9%) was similar to percentages of this species comprised in Units 1 and 2 entrainment samples during 1978-1981 (0.35-3.5%).

Seasonal Occurrence

January-April--

Yellow perch larvae first appeared in Unit 3 entrainment samples during late April in 1981 (Table 28, Appendix 14). No other larval fish species were entrained during this month. Fish eggs, probably burbot eggs, were first collected during March. Increasing numbers of fish eggs were entrained during April as more species started to spawn in Lake Michigan.

During 1981 unidentified Coregoninae larvae and damaged larvae were first collected at Units 1 and 2 in March (Table 26). Spottail shiner, yellow perch, burbot and unidentified sucker larvae first appeared in Units 1 and 2 entrainment samples in April.

May--

Larval fish densities at the north transect and in the Unit 3 intake canal were relatively low during May 1981 (Fig. 13). Estimated larval fish entrainment at Unit 3 for May (231,000) was only slightly higher than that of April (Table 28). Rainbow smelt was the most common species entrained during May accounting for 44.5 percent of all larvae entrained. This species was abundant in the shallow area (1-3 m) and less common at stations L, N and O (6 to 12 m) (Fig. 13). Deepwater sculpin larvae made up 70.1 percent of all larval fish collected at stations L, N and O, but occurred in substantially lower proportions in entrainment samples (Table 30). Larval slimy sculpins were the second-most common species entrained during May. They were not found at stations L, N and O (Table 30). Larval yellow perch first appeared in north transect samples during May. This species was entrained at approximately the same rate as during late April (Table 28). Perch larvae represented 13.5 percent of all larvae entrained during May. The only other larval fish entrained during May was spottail shiner. Fewer fish eggs were entrained during May than during April (Table 28).

Rainbow smelt larvae were also the most abundant species found in Units 1 and 2 entrainment samples during May 1981. Common carp, johnny darter and *Pomoxis* larvae began to occur in entrainment samples, whereas yellow perch larvae started to decline at Units 1 and 2 during May.

June--

Larval fish densities at the north transect and the Unit 3 intake canal remained low during early June, but dramatically increased during late June (Fig. 13). Of the 10.2 million larvae lost at Unit 3 during 1981, 8.25 million (81%) were entrained during June. Yellow perch was the most abundant species in entrainment samples, accounting for 36.2 percent of all larvae entrained in June. This species, however, comprised only 10.0 percent of the larvae collected at stations L, N and O (Table 30). Larval alewives represented 79.9 percent of the larvae collected at stations L, N and O, but accounted for only 26.9 percent of entrained larvae. Rainbow smelt larvae comprised 4.5 percent of the larvae collected at stations L, N and O, but only 2.4 percent of the larvae entrained were smelt. For all other species entrained in June (spottail shiner, slimy sculpin, johnny darter and trout-perch) percentages observed in entrainment samples were higher than those found in the field at stations L, N and O (Table 30). These data suggested that larvae were not equally susceptible to entrainment by Unit 3. The ANOVA indicated that densities were significantly higher in the Unit 3 intake canal than at the lower strata of stations N and O (9 and 12 m) for yellow perch and slimy sculpin larvae; no difference in densities between these two areas was found for rainbow smelt, spottail shiner and johnny darter larvae (see RESULTS AND DISCUSSION - STATISTICS). For design II using only plankton net observations (see METHODS - STATISTICS) for stations N and O, larval alewife density was significantly greater in field samples than in entrainment samples. Avoidance of the intakes (alewife) and concentrated spawning on the riprap (other species) are proposed reasons for these differences.

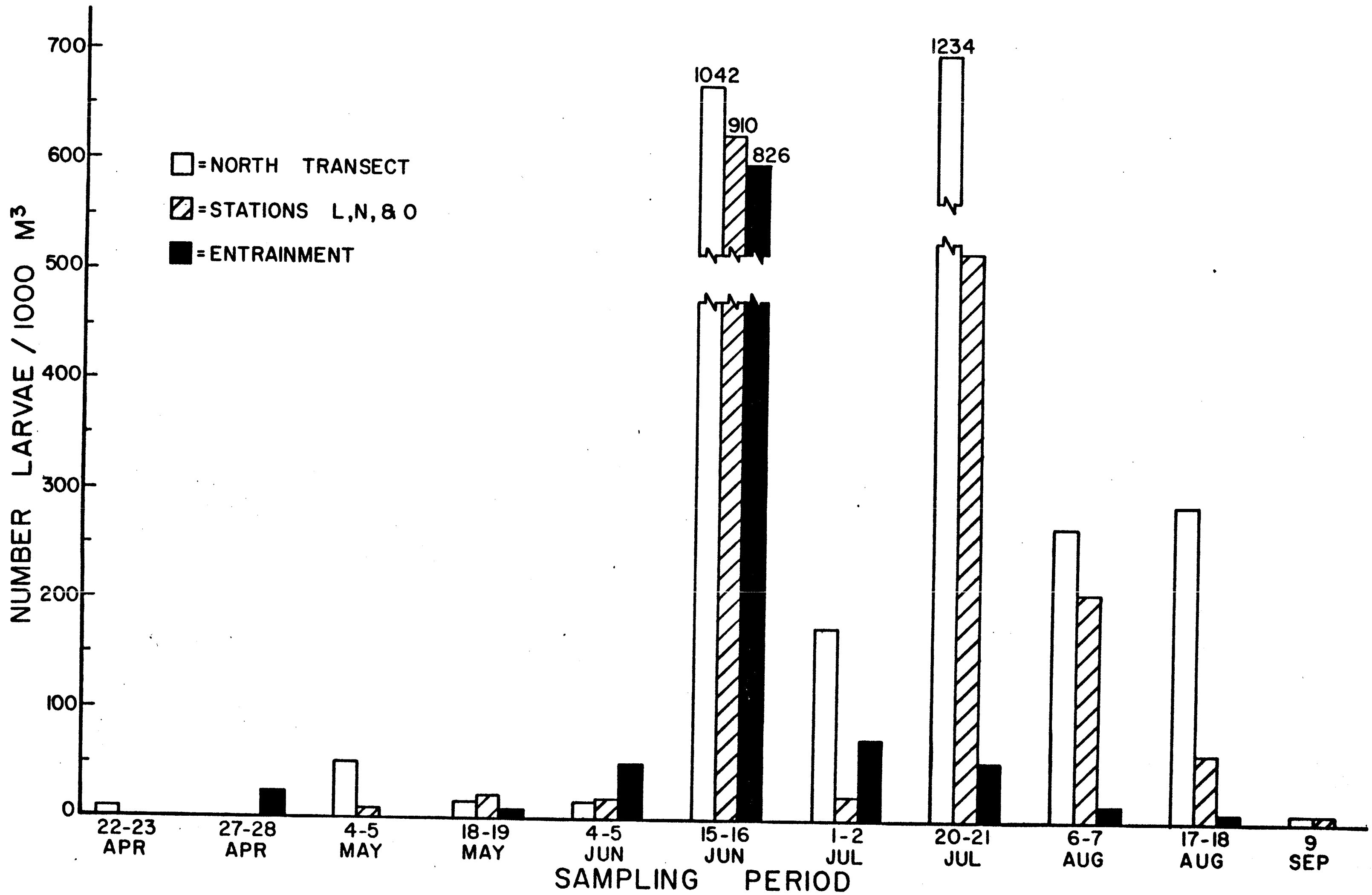


Fig. 13. Mean densities of larval fish for the north transect (stations combined), for selected tows near the intake structure (stations L, N and O) and for larvae entrained by Unit 3 at the J. H. Campbell Plant, eastern Lake Michigan, during April-September 1981. Data were pooled over all gear types (sleds and plankton nets) and diel periods (day and night) for calculation of field larvae densities and over all diel periods (day, dusk, night, dawn) for calculation of entrainment densities.

Table 30. Percent species composition of fish larvae from Lake Michigan (north transect stations L, N, O - designated Lake) and from entrainment samples collected from the J. H. Campbell Plant's Unit 3 offshore intake (designated Ent).

	Apr		May		Jun		Jul		Aug		Sep	
Species	Lake	Ent	Lake	Ent	Lake	Ent	Lake	Ent	Lake	Ent	Lake	Ent
Yellow perch	0	100	11.8	13.5	10.0	36.2	0.2	0.9	0	0	0	0
Alewife	0	0	0	0	79.9	26.9	97.2	44.8	92.3	37.1	100	0
Spottail shiner	0	0	0	2.2	3.1	11.6	1.9	27.0	0.9	44.5	0	0
Slimy sculpin	0	0	0	24.9	0.7	14.3	0	2.4	0	0	0	0
Damaged larvae	0	0	4.4	0	0.6	5.7	0.4	4.6	0.5	0	0	0
Rainbow smelt	0	0	13.7	44.5	4.5	2.4	0.3	0	0	0	0	0
Johnny darter	0	0	0	0	0.5	1.4	0	11.5	4.9	11.8	0	0
Deepwater sculpin	0	0	70.1	14.9	0	0	0	0	0	0	0	0
Trout-perch	0	0	0	0	0.2	0.8	0	5.7	1.2	3.9	0	100
Miscellaneous	0	0	0	0	0.5	0.7	0	3.1	0.2	2.6	0	0

Alewife, spottail shiner and common carp larvae were the dominant species in Units 1 and 2 entrainment samples during June. Rainbow smelt, yellow perch, johnny darter, *Lepomis*, *Pomoxis* and trout-perch larvae were also entrained at Units 1 and 2 during June.

July--

Mean densities of larval fish at the north transect and in the Unit 3 intake canal decreased substantially during early July 1981 (Appendixes 9, 14). Spawning and hatching of most fish species were probably slowed due to upwellings of cold water by the end of June. During late July larval fish populations at the north transect and at stations L, N and O increased to the levels observed during late June (Fig. 13) due mainly to an abundance of alewife and spottail shiner larvae. Entrainment losses, however, remained relatively low (Fig. 13, Table 28). Larval alewives and spottail shiners occurred mostly in shallow areas (1-6 m), far from the Unit 3 intake site. Despite being entrained in low numbers, alewife and spottail shiner larvae accounted for 71.8 percent of tótal larvae entrained. Johnny darter and trout-perch represented 11.5 and 5.7 percent of all entrained larvae, respectively. Other larval fish entrained in low densities during July were slimy sculpins, ninespine sticklebacks, yellow perch, gizzard shad, carp and damaged larvae (Table 28). Entrainment of fish eggs declined substantially during July (Table 28). At the north transect, however, greatest numbers of fish eggs were found during late July at nearshore stations (Appendix 9).

Alewife, spottail shiner and common carp larvae continued to be the most abundant species entrained at Units 1 and 2. Most species found in entrainment samples in June also occurred in July.

August-December--

Larval fish abundance in field and Unit 3 entrainment samples declined substantially during August 1981. Alewife and spottail shiner larvae continued to dominate in field and entrainment samples (Tables 28 and 30). Alewife larvae were the most common species at stations L, N and O, but were entrained at a lower rate than spottail shiner larvae. Other larval fish entrained during August were johnny darters, trout-perch, gizzard shad and ninespine sticklebacks. Larvae were scarce in the study area during September and October. Only larval alewives were found in field samples at stations L, N and O, and only trout-perch larvae were found in entrainment samples during September and October. No larvae were found in Unit 3 entrainment samples during November and December. Fish egg entrainment continued to decline during August. No eggs were entrained in September and December. A small number of fish eggs were entrained at Unit 3 during October and November (Table 28).

Monthly entrainment of alewife larvae at Units 1 and 2 was highest during August. Other larval fish species found at Units 1 and 2 during June and July substantially declined in August. Only larval alewives and spottail shiners were entrained during September. Alewife was the only larval fish species entrained at Units 1 and 2 during October, November and December.

24-H POPULATION AND ENTRAINMENT COMPARISONS

We calculated a population estimate for each larval fish species based on densities of larvae measured at each north transect station and stratum (see METHODS - ESTIMATION OF LARVAL FISH ABUNDANCE IN A SPECIFIED AREA OF LAKE MICHIGAN). The water body encompassed the area from shore to the 15-m contour and was based on length of shoreline realized by an "average" current (0.082 m/s) during a 24-h period. We compared these population estimates with our 24-h entrainment loss estimate to get a perspective on the magnitude of the impact on Lake Michigan fish larvae populations.

Estimated populations of larvae in the vicinity of the plant were greatest, on the average, for alewife (Table 31). Peak 24-h abundance of alewife larvae observed in the plant vicinity based on night sampling was 207 million during mid-June. Average percentage of the population estimate comprised by the corresponding entrainment estimate was low for alewife (0 to 0.53%) while the average percentage was highest for slimy sculpin larvae (over 100% in mid-June). The population of slimy sculpin larvae was apparently substantially underestimated. Density of slimy sculpin larvae within the immediate area of the intake structures, including the riprap, was most likely considerably higher than at north transect sampling areas. Entrained fish eggs, on the average, comprised a relatively high percentage (up to 32%) of the estimated population of fish eggs in the plant vicinity. As with slimy sculpin larvae, fish egg density was probably higher in the immediate riprap area than at the average north transect station. Behavior of fish larvae in response to the intake structures, including screens, influenced the calculated ratios of entrainment totals to field population. Alewife larvae may have avoided the intake screens whereas slimy sculpin larvae may have been attracted to them.

Table 31. Population estimates of larval fish and fish eggs in Lake Michigan in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan 1981. Population I estimates were based on densities observed at night while Population II estimates were based on densities averaged for both day and night. Also included are estimated number of fish larvae and fish eggs entrained (designated Entrainment) during 24-h sampling periods by the Campbell Plant's Unit 3. Estimates were made for each field sampling period from April to September 1981; entrainment sampling was performed concurrently with field sampling. Numbers in parentheses are percentages of each species' population estimate comprised by the corresponding entrainment estimate. A dash (-) indicates an undefined percentage. Vicinity of the plant was based on 7085 m of shoreline and extended from shore to 2850 m offshore (see METHODS - ESTIMATION OF LARVAL FISH ABUNDANCE IN A SPECIFIED AREA OF LAKE MICHIGAN). Population and entrainment estimates are given in thousands.

Species	22-23 Apr*	27-28 Apr#	4*5 May	18-19 May	4-5 Jun	15-16 Jun	1-2 Jul	20-21 Jul	6-7 Aug	17-18 Aug	9-10 Sep
Yellow perch											
Population I	32.3(0)	0(-)	183(0)	0(-)	66.2(0)	21,400(1.93)	608(0)	0(-)	0(-)	0(-)	0(-)
Population II	16.2(0)	0(-)	168(0)	0(-)	77.2(0)	24,600(1.68)	304(0)	0(-)	0(-)	0(-)	0(-)
Entrainment	0	33.4	0	0	0	414	0	0	0	0	0
Alewife											
Population I	0(-)	0(-)	0(-)	0(-)	0(-)	207,000(0.14)	3,780(0.46)	46,000(0.05)	22,000(0.04)	9,690(0.01)	1,010(0)
Population II	0(-)	0(-)	0(-)	0(-)	0(-)	135,000(0.22)	3,340(0.53)	25,300(0.09)	13,000(0.07)	8,570(0.01)	520(0)
Entrainment	0	0	0	0	0	293	17.6	22.8	8.62	1.03	0
Spottail shiner											
Population I	0(-)	0(-)	0(-)	0(-)	0(-)	11,400(0.43)	1,950(0.70)	22,800(0.02)	334(2.01)	661(0)	15.7(0)
Population II	0(-)	0(-)	0(-)	0(-)	0(-)	6,760(0.73)	1,110(1.23)	11,400(0.05)	319(2.11)	445(0)	21.6(0)
Entrainment	0	0	0	0	0	49.3	13.7	5.68	6.72	0	0
Slimy sculpin											
Population I	0(-)	0(-)	0(-)	0(-)	2,610(1.65)	96.6(106.39)	0(-)	0(-)	641(0)	0(-)	0(-)
Population II	0(-)	0(-)	0(-)	0(-)	1,300(3.30)	48.3(212.78)	0(-)	0(-)	371(0)	0(-)	0(-)
Entrainment	0	0	0	0	43	103	3.65	0	0	0	0
Damaged larvae											
Population I	0(-)	0(-)	0(-)	569(0)	0(-)	1,410(4.49)	114 (6.65)	189(0.23)	82.1(0)	39.4(0)	0(-)
Population II	0(-)	0(-)	0(-)	285(0)	0(-)	1,320(4.80)	67.4(11.28)	157(0.28)	71.3(0)	124(0)	0(-)
Entrainment	0	0	0	0	0	63.2	7.6	0.436	0	0	0
Rainbow smelt											
Population I	0(-)	0(-)	347(0)	0(-)	2,620(0.14)	5,030(0.41)	335(0)	0(-)	0(-)	0(-)	0(-)
Population II	0(-)	0(-)	703(0)	66.1(3.70)	1,620(0.23)	2,930(0.71)	742(0)	0(-)	0(-)	0(-)	0(-)
Entrainment	0	0	0	2.45	3.7	20.9	0	0	0	0	0

Table 31. Continued.

Species	22-23 Apr*	27-28 Apr#	4-5 May	18-19 May	4-5 Jun	15-16 Jun	1-2 Jul	20-21 Jul	6-7 Aug	17-18 Aug	9-10 Sep
Johnny darter											
Population I	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	807 (2.00)	0 (-)	0 (-)	264 (1.11)	13.5 (0)	0 (-)
Population II	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	404 (4.00)	0 (-)	0 (-)	132 (2.22)	6.73 (0)	0 (-)
Entrainment	0	0	0	0	0	16.2	4.1	0	2.94	0	0
Trout-perch											
Population I	0 (-)	0 (-)	0 (-)	0 (-)	423 (0)	21 (0)	0 (-)	0 (-)	35.7 (0)	20.7 (0)	0 (-)
Population II	0 (-)	0 (-)	0 (-)	0 (-)	211 (0)	10.5 (0)	0 (-)	0 (-)	167 (0)	10.4 (0)	0 (-)
Entrainment	0	0	0	0	0	0	7.6	0	0	0	0
Ninespine stickleback											
Population I	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	48.2 (9.12)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
Population II	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	24.1 (18.24)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
Entrainment	0	0	0	0	0	4.4	1.08	0	0	0.441	0
Deepwater sculpin											
Population I	0 (-)	0 (-)	0 (-)	1,760 (0.28)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
Population II	0 (-)	0 (-)	0 (-)	2,490 (0.20)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
Entrainment	0	0	0	4.91	0	0	0	0	0	0	0
Carp											
Population I	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	759 (0)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
Population II	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	379 (0)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
Entrainment	0	0	0	0	0	0	0	0	0	0	0
Gizzard shad											
Population I	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	590 (0)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
Population II	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	332 (0)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
Entrainment	0	0	0	0	0	0	0	0.436	0.294	0	0
Unidentified Coregoninae											
Population I	112 (0)	0 (-)	0 (-)	0 (-)	0 (-)	418 (0)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
Population II	86.7 (0)	0 (-)	0 (-)	0 (-)	0 (-)	209 (0)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
Entrainment	0	0	0	0	0	0	0	0	0	0	0
Largemouth bass											
Population I	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	39.4 (-)	0 (-)
Population II	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	19.7 (-)	0 (-)
Entrainment	0	0	0	0	0	0	0	0	0	0	0

Table 31. Continued.

Species	22-23 Apr*	27-28 Apr#	4-5 May	18-19 May	4-5 Jun	15-16 Jun	1-2 Jul	20-21 Jul	6-7 Aug	17-18 Aug	9-10 Sep
Emerald shiner											
Population I	0(-)	0(-)	0(-)	0(-)	0(-)	0(-)	77.6(-)	0(-)	0(-)	0(-)	0(-)
Population II	0(-)	0(-)	0(-)	0(-)	0(-)	0(-)	38.8(-)	0(-)	0(-)	0(-)	0(-)
Entrainment	0	0	0	0	0	0	0	0	0	0	0
Total no. larvae											
Population I	144(0)	0(-)	530(0)	2,330(0.32)	5,720(0.82)	249,000(0.39)	6,870(0.81)	69,100(0.04)	23,400(0.08)	10,400(0.01)	1,020(0)
Population II	103(0)	0(-)	871(0)	2,840(0.26)	3,210(1.45)	172,000(0.56)	5,600(0.99)	36,900(0.08)	14,100(0.13)	9,180(0.02)	542(0)
Entrainment	0	33.4	0	7.36	46.7	964	55.4	29.4	18.6	1.47	0
Fish eggs											
Population I	0(-)	0(-)	67.8(8.73)	0(-)	29.4(16.32)	59,900 (9.73)	5,850 (9.51)	135,000(0.04)	26,400(2.88)	14.5(0)	0(-)
Population II	0(-)	0(-)	211(2.80)	0(-)	14.7(32.64)	31,800(18.32)	5,180(10.75)	70,100(0.07)	16,700(4.54)	63.8(0)	0(-)
Entrainment	9.65	5.78	5.92	0	4.79	5,830	556	48.3	758	0	0

* Field sampling was on 13-15 April and entrainment on 22-23 April.

\# Field samples on 27-28 April were performed only at stations L (6 m, north) and N (9 m, north).

TOTAL CATCH OF JUVENILE AND ADULT FISH

During the 1981 study, 36 species of adult and juvenile fish representing 16 families were collected or observed in Lake Michigan near the J. H. Campbell Plant (Table 32). They included a wide variety of species, including marine forms (alewife, rainbow smelt, salmon), a threatened species (lake sturgeon), sport fish (yellow perch, trout), commercial fish (bloaters, yellow perch, lake whitefish, round whitefish), forage species and a primarily inland species (chestnut lamprey).

The 1981 catch of juvenile and adult fish was dominated by alewives (41%), rainbow smelt (40%), spottail shiner (8%), unidentified Coregoninae (6%) and yellow perch (1%) (Table 33). During the period 1977-1980 alewives were either first or second in order of abundance. Rainbow smelt were ranked first in total catch in 1979 (38%) and 1980 (44%). Alewives were first in order of abundance in 1977 (69%) and 1978 (49%). Spottail shiner catch was relatively stable over the 5-yr sampling period, ranging between 8 and 18% of the total catch for all years. Spottail shiner was the third-most common species in all years.

Unidentified Coregoninae, believed to be mostly bloaters, were the fourth-most often caught fish in 1980 and 1981. This subfamily has become more abundant in each study year. The increase is a lake-wide occurrence attributed to banning of commercial harvest and a decline or stabilization in alewife populations. Yellow perch numbers remained stable in 1981, comprising 1.5% of the total catch. They comprised 1 to 2% of the total catch during 1977-1981. Trout-perch fell from fifth-most common species in 1980 to sixth in 1981. They were the fourth- to sixth-most common species from 1977-1981.

Of the four gear types used for collecting juvenile and adult fish (trawls, surface and bottom gill nets and seines), trawls collected the vast majority of fish (Tables 34-37). Although surface gill nets caught the smallest numbers of fish, some unusual results were noted from surface gill net catches. Spottail shiners and lake trout, two normally benthic species, were the second- and third-most abundant species caught in surface gill nets. Lake trout were caught in surface gill nets in past years (especially during fall), but October 1981 was the only time that lake trout catches were greater in surface gill nets (74 fish) than in bottom gill nets (60 fish) (Tables 34, 35). Results were similar at both transects, precluding any effect from the thermal plume.

Table 32. Family name, scientific name, common name and codes for all species of juvenile and adult fish captured (from 1977 through 1981) in Lake Michigan near the J. H. Campbell Plant. An X denotes presence in a given year. Names assigned according to Robins et al. (1980).

Family, Scientific and Common Name	Code	1977	1978	1979	1980	1981
Acipenseridae						
Acipenser fulvescens Rafinesque	LG	X		X		X
Lake sturgeon						
Atherinidae						
Labidesthes sicculus (Cope)	SV	X				
Brook silverside						
Catostomidae						
Carpiodes cyprinus (Lesueur)	QL		X		X	X
Quillback						
Catostomus catostomus (Forster)	LS	X	X	X	X	X
Longnose sucker						
Catostomus commersoni (Lacépède)	WS	X	X	X	X	X
White sucker						
Moxostoma anisurum (Rafinesque)	MA	X	X	X	X	X
Silver redhorse						
Moxostoma erythrurum (Rafinesque)	GR		X	X	X	X
Golden redhorse						
Moxostoma macrolepidotum (Lesueur)	SR	X	X	X	X	X
Shorthead redhorse						
Centrarchidae						
Lepomis cyanellus Rafinesque	GN			X		
Green sunfish						
Lepomis gibbosus (Linnaeus)	PS	X				
Pumpkinseed						
Lepomis macrochirus Rafinesque	BG	X	X		X	X
Bluegill						
Micropterus dolomieui Lacépède	SB		X			
Smallmouth bass						
Pomoxis nigromaculatus (Lesueur)	BC				X	
Black crappie						
Clupeidae						
Alosa pseudoharengus (Wilson)	AL	X	X	X	X	X
Alewife						
Dorosoma cepedianum (Lesueur)	GS	X	X	X	X	X
Gizzard shad						

Table 32. Continued.

Family, Scientific and Common Name	Code	1977	1978	1979	1980	1981
Cottidae						
<u>Cottus</u> <u>bairdi</u> Girard Mottled sculpin	MS	X		X	X	X
<u>Cottus</u> <u>cognatus</u> Richardson Slimy sculpin	SS	X	X	X	X	X
<u>Myoxocephalus</u> <u>thompsoni</u> (Girard) Deepwater sculpin	FS				X	X
Cyprinidae						
<u>Carassius</u> <u>auratus</u> (Linnaeus) Goldfish	GF		X			
<u>Cyprinus</u> <u>carpio</u> Linnaeus Common carp	CP	X	X	X	X	X
<u>Notemigonus</u> <u>crysoleucas</u> (Mitchill) Golden shiner	GL				X	
<u>Notropis</u> <u>atherinoides</u> Rafinesque Emerald shiner	ES	X	X	X	X	X
<u>Notropis</u> <u>hudsonius</u> (Clinton) Spottail shiner	SP	X	X	X	X	X
<u>Pimephales</u> <u>notatus</u> (Rafinesque) Bluntnose minnow	BM		X	X		X
<u>Pimephales</u> <u>promelas</u> Rafinesque Fathead minnow	PP		X			X
<u>Rhinichthys</u> <u>cataractae</u> (Valenciennes) Longnose dace	LD	X			X	
Esocidae						
<u>Esox</u> <u>lucius</u> Linnaeus Northern pike	NP		X		X	
Gadidae						
<u>Lota</u> <u>lota</u> (Linnaeus) Burbot	BR	X	X		X	X
Gasterosteidae						
<u>Pungitius</u> <u>pungitius</u> (Linnaeus) Ninespine stickleback	NS	X	X	X	X	X
Ictaluridae						
<u>Ictalurus</u> <u>natalis</u> (Lesueur) Yellow bullhead	YB				X	
<u>Ictalurus</u> <u>punctatus</u> (Rafinesque) Channel catfish	CC	X	X	X	X	X

Table 32. Continued.

Family, Scientific and Common Name	Code	1977	1978	1979	1980	1981
Osmeridae						
Osmerus mordax (Mitchill) Rainbow smelt	SM	X	X	X	X	X
Percidae						
Etheostoma nigrum Rafinesque Johnny darter	JD	X	X	X	X	X
Perca flavescens (Mitchill) Yellow perch	YP	X	X	X	X	X
Stizostedion vitreum vitreum (Mitchill) Walleye	WL		X		X	X
Percopsidae						
Percopsis omiscomaycus (Walbaum) Trout-perch	TP	X	X	X	X	X
Petromyzontidae						
Ichthyomyzon castaneus Girard Chestnut lamprey	CL					X
Salmonidae						
Coregonus artedii Lesueur Lake herring or cisco	LH				X	
Coregonus clupeaformis (Mitchill) Lake whitefish	LW	X	X	X	X	X
Coregonus hoyi Bloater	BL	X	X	X	X	X
Coregonus spp. Unidentified Coregoninae	XC	X	X	X	X	X
Oncorhynchus kisutch (Walbaum) Coho salmon	CM	X	X	X	X	X
Oncorhynchus tshawytscha (Walbaum) Chinook salmon	CH	X	X	X	X	X
Prosopium cylindraceum (Pallas) Round whitefish	RW	X	X	X	X	X
Salmo gairdneri Richardson Rainbow trout	RT	X	X	X	X	X
Salmo trutta Linnaeus Brown trout	BT	X	X	X	X	X
Salvelinus namaycush (Walbaum) Lake trout	LT	X	X	X	X	X
Sciaenidae						
Aplodinotus grunniens Rafinesque Freshwater drum	FD		X		X	X

Table 32. Continued.

Family, Scientific and Common Name	Code	1977	1978	1979	1980	1981
Umbridae						
Umbra limi (Kirtland) Central mudminnow	MM				X	

MOST ABUNDANT SPECIES

Alewife

Introduction--

Alewife was the most abundant species of larval fish in Lake Michigan near the Campbell Plant from June to August of all years sampled, 1977-1981 (Jude et al. 1981a). The first substantial occurrence of larval alewives in the area of the Campbell Plant in any one year was related to the annual spring warming of Lake Michigan when temperatures approximated 17 C, which generally occurs from early to late June. Prior to this, adult alewives annually move inshore and initiate spawning when water temperatures approximate 15 C.

Total catch of alewives in 1981 was 63,618 fish, the highest total catch recorded from 1977 to 1981, when catches ranged from 15,993 in 1980 to 53,864 in 1977. Part of these differences in total catch were due to minor changes in stations fished, upwelling phenomena, and the population level in 1981. Seines comprised 15.7%, trawls 77.3%, surface gill nets 1.4% and bottom gill nets 5.5% of the total catch in 1981. Maximum catch (all gear) occurred in November when 33,804 fish, many YOY, were collected, while May was second with 10,643 fish caught. Alewives were ranked first or second through the 5 yr sampled, comprising the following percentages of total catch in the corresponding years: 1977 - 68.5, 1978 - 49.0, 1979 - 36.4, 1980 - 19.0 and 1981 - 41.0. Overall more fish were caught during the day (37,155) than at night (26,463) during 1981.

Larvae--

Introduction--The first major occurrence of larval alewives in Lake Michigan near the Campbell Plant generally occurred from late June to early July. Limited spawning and hatching activity

Table 33. Summary of fish species caught by all gear types in Lake Michigan near the Campbell Plant, eastern Lake Michigan, April-December 1981.

Species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	% of Total
Alewife	2677	10643	3216	3717	7555	822	1167	33804	17	63618	41.015
Rainbow smelt	11887	15175	11	7859	8626	4581	1102	11108	2184	62533	40.315
Spottail shiner	548	1295	6056	1034	842	1923	1015	113	116	12942	8.344
Unidentified Coregoninae	56	1447	2163	2714	1222	85	428	1201	837	10153	6.546
Yellow perch	9	10	466	842	561	104	180	150	48	2370	1.528
Trout-perch	65	68	167	130	246	197	343	41	14	1271	0.819
Johnny darter	39	84	92	54	168	62	10	8	6	523	0.337
White sucker	25	33	29	81	175	74	25	24	0	466	0.300
Lake trout	14	13	7	9	54	12	134	18	1	262	0.169
Longnose sucker	39	28	14	30	35	15	7	34	2	204	0.132
Gizzard shad	1	4	15	12	12	43	30	18	0	135	0.087
Round whitefish	15	5	1	4	15	25	44	24	1	134	0.086
Slimy sculpin	71	8	1	1	0	1	3	0	49	134	0.086
Chinook salmon	12	3	25	10	13	8	0	5	0	76	0.049
Coho salmon	7	45	0	0	1	2	0	5	0	60	0.039
Brown trout	9	27	2	1	1	3	0	3	0	46	0.030
Emerald shiner	2	0	0	0	8	19	3	0	0	32	0.021
Ninespine stickleback	0	20	3	9	0	0	0	0	0	32	0.021
Rainbow trout	2	2	1	2	0	2	4	5	0	18	0.012
Common carp	2	0	2	1	0	6	4	0	0	15	0.010
Shorthead redhorse	0	0	4	0	1	5	3	0	0	13	0.008
Lake whitefish	3	3	0	5	2	0	0	0	0	13	0.008
Silver redhorse	0	0	0	0	7	2	2	1	0	12	0.008
Burbot	0	1	1	0	0	0	2	8	0	12	0.008
Walleye	0	0	0	0	0	0	6	4	0	10	0.006
Bluntnose minnow	2	0	0	0	2	1	0	0	0	5	0.003
Channel catfish	0	0	1	0	1	3	0	0	0	5	0.003
Quillback	1	0	1	0	2	0	0	0	0	4	0.003
Freshwater drum	0	0	0	0	0	0	3	0	0	3	0.002
Deepwater sculpin	0	0	0	0	1	0	0	1	0	2	0.001
Golden redhorse	0	0	1	0	0	0	1	0	0	2	0.001
Mottled sculpin	1	0	0	0	0	0	0	0	0	1	0.001
Chestnut lamprey	0	0	0	0	0	0	1	0	0	1	0.001
Bluegill	0	0	0	0	0	0	1	0	0	1	0.001
Lake sturgeon	0	0	0	0	1	0	0	0	0	1	0.001
Fathead minnow	0	0	0	0	1	0	0	0	0	1	0.001
TOTALS	15487	28914	12279	16515	19552	7995	4518	46575	3275	155110	

Table 34. Summary of fish species caught by bottom gill net in Lake Michigan near the Campbell Plant, eastern Lake Michigan, April-November 1981.

Species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Sum	% of Total
Spottail shiner	264	599	3950	622	295	250	251	55	6286	48.298
Alewife	976	302	1411	572	208	34	2	4	3509	26.961
Yellow perch	6	7	178	574	280	77	154	147	1423	10.934
White sucker	24	32	27	80	166	64	25	24	442	3.396
Rainbow smelt	168	5	0	8	78	4	19	102	384	2.950
Trout-perch	11	6	17	19	28	49	60	28	218	1.675
Longnose sucker	39	28	14	18	24	8	7	34	172	1.322
Lake trout	13	5	1	4	49	12	60	14	158	1.214
Round whitefish	13	2	1	2	13	24	40	23	118	0.907
Gizzard shad	1	4	15	12	3	35	12	17	99	0.761
Brown trout	7	22	2	1	0	3	0	2	37	0.284
Chinook salmon	4	1	1	9	5	7	0	5	32	0.246
Unidentified Coregoninae	0	0	0	20	10	0	0	0	30	0.231
Common carp	1	0	2	1	0	6	4	0	14	0.108
Coho salmon	3	9	0	0	1	1	0	0	14	0.108
Shorthead redhorse	0	0	4	0	1	5	3	0	13	0.100
Lake whitefish	2	3	0	5	2	0	0	0	12	0.092
Silver redhorse	0	0	0	0	7	2	2	1	12	0.092
Burbot	0	1	1	0	0	0	2	7	11	0.085
Walleye	0	0	0	0	0	0	6	4	10	0.077
Rainbow trout	0	1	0	1	0	1	1	2	6	0.046
Quillback	1	0	1	0	2	0	0	0	4	0.031
Freshwater drum	0	0	0	0	0	0	3	0	3	0.023
Channel catfish	0	0	1	0	0	2	0	0	3	0.023
Golden redhorse	0	0	1	0	0	0	1	0	2	0.015
Slimy sculpin	1	0	0	0	0	0	1	0	2	0.015
Ninespine stickleback	0	0	1	0	0	0	0	0	1	0.008
TOTALS	1534	1027	5628	1948	1172	584	653	469	13015	

Table 35. Summary of fish species caught by surface gill net in Lake Michigan near the Campbell Plant, eastern Lake Michigan, April-November 1981.

Species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Sum	% of Total
Alewife	35	137	425	55	206	59	2	0	919	72.994
Spottail shiner	0	0	5	158	0	0	0	0	163	12.947
Lake trout	1	1	0	0	3	0	74	4	83	6.593
Rainbow smelt	15	1	0	0	15	0	2	0	33	2.621
Chinook salmon	8	1	0	0	8	1	0	0	18	1.430
Coho salmon	4	4	0	0	0	1	0	5	14	1.112
Gizzard shad	0	0	0	0	8	2	0	1	11	0.874
Rainbow trout	1	0	0	0	0	1	3	3	8	0.635
White sucker	0	0	0	0	6	0	0	0	6	0.477
Brown trout	1	0	0	0	1	0	0	1	3	0.238
Channel catfish	0	0	0	0	1	0	0	0	1	0.079
TOTALS	65	144	430	213	248	64	81	14	1259	

Table 36. Summary of fish species caught by trawl in Lake Michigan near the Campbell Plant, eastern Lake Michigan, April-December 1981.

Species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum	% of Total
Rainbow smelt	11644	14404	11	7851	7250	4393	1079	10989	2184	59805	46.825
Alewife	1655	7420	1301	3058	193	723	1163	33651	17	49181	38.507
Unidentified Coregoninae	56	1447	2163	2694	1160	84	428	1201	837	10070	7.884
Spottail shiner	242	690	2056	185	164	1662	761	24	116	5900	4.619
Trout-perch	45	62	150	111	218	148	283	12	14	1043	0.817
Yellow perch	3	3	288	267	253	27	26	3	48	918	0.719
Johnny darter	39	84	92	54	168	62	10	8	6	523	0.409
Slimy sculpin	70	8	1	1	0	1	2	0	49	132	0.103
Ninespine stickleback	0	20	2	9	0	0	0	0	0	31	0.024
Longnose sucker	0	0	0	9	11	7	0	0	2	29	0.023
Lake trout	0	7	6	5	2	0	0	0	1	21	0.016
Gizzard shad	0	0	0	0	0	4	15	0	0	19	0.015
White sucker	1	1	2	1	3	9	0	0	0	17	0.013
Round whitefish	2	3	0	2	2	1	4	1	1	16	0.013
Chinook salmon	0	0	5	1	0	0	0	0	0	6	0.005
Deepwater sculpin	0	0	0	0	1	0	0	1	0	2	0.002
Common carp	1	0	0	0	0	0	0	0	0	1	0.001
Chestnut lamprey	0	0	0	0	0	0	1	0	0	1	0.001
Mottled sculpin	1	0	0	0	0	0	0	0	0	1	0.001
Channel catfish	0	0	0	0	0	1	0	0	0	1	0.001
Bluntnose minnow	1	0	0	0	0	0	0	0	0	1	0.001
Lake whitefish	1	0	0	0	0	0	0	0	0	1	0.001
Lake sturgeon	0	0	0	0	1	0	0	0	0	1	0.001
Burbot	0	0	0	0	0	0	0	1	0	1	0.001
TOTALS	13761	24149	6077	14248	9426	7122	3772	45891	3275	127721	

Table 37. Summary of fish species caught by seine in Lake Michigan near the Campbell Plant, eastern Lake Michigan, April-November 1981.

Species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Sum	% of Total
Alewife	11	2784	79	32	6948	6	0	149	10009	76.317
Rainbow smelt	60	765	0	0	1283	184	2	17	2311	17.621
Spottail shiner	42	6	45	69	383	11	3	34	593	4.522
Unidentified Coregoninae	0	0	0	0	52	1	0	0	53	0.404
Emerald shiner	2	0	0	0	8	19	3	0	32	0.244
Coho salmon	0	32	0	0	0	0	0	0	32	0.244
Yellow perch	0	0	0	1	28	0	0	0	29	0.221
Chinook salmon	0	1	19	0	0	0	0	0	20	0.152
Trout-perch	9	0	0	0	0	0	0	1	10	0.076
Gizzard shad	0	0	0	0	1	2	3	0	6	0.046
Brown trout	1	5	0	0	0	0	0	0	6	0.046
Bluntnose minnow	1	0	0	0	2	1	0	0	4	0.030
Rainbow trout	1	1	1	1	0	0	0	0	4	0.030
Longnose sucker	0	0	0	3	0	0	0	0	3	0.023
Bluegill	0	0	0	0	0	0	1	0	1	0.008
White sucker	0	0	0	0	0	1	0	0	1	0.008
Fathead minnow	0	0	0	0	1	0	0	0	1	0.008
TOTALS	127	3594	144	106	8706	225	12	201	13115	

was indicated in early June of some years, however, larval alewife densities were generally minimal at this time (less than 25 larvae/1000 m^3). The single occurrence of larval alewives in May, 1979 (Jude et al. 1980) suggests that limited alewife spawning activity may begin in May of some years, however, the spawning site (either inland or coastal Lake Michigan) could not be determined. Newly hatched larval alewives are believed to be passively carried by water currents, and are suspected to be the progeny of alewives spawning in May in adjacent rivers (Grand, Muskegon and Kalamazoo Rivers). Progeny are then carried into Lake Michigan and transported by various alongshore currents.

The distributional patterns of larval alewives during times of maximum abundance in July and August were generally similar. Larval alewives at these times were found at most depth strata to a depth of at least 15 m. Densities of larval alewives in bottom strata, as indicated by benthic sled samples, were generally lower than densities in the overlying depth strata. During times when the thermocline intersected the Lake Michigan bottom within our study area, larval alewives were substantially diminished in abundance in the cold subthermocline strata (Heufelder et al. 1982). Additionally, drastic shifts in the position of the thermocline shoreward, such as occurred during an upwelling, altered appreciably the distributional trends as well as abundance of larval alewives in the study area as will be discussed later.

As the spawning season progressed and less and less recruitment of newly hatched alewife larvae occurred, there was some tendency for larval alewives to be distributed primarily at depths of 9 m or less, however, many stations and depth strata beyond 9 m continued to contain alewife larvae. Recruitment of newly hatched larval alewives generally continued until the end of August, but in 1979 newly hatched larval alewives were collected as late as mid-September. This exception was attributed to the effect of multiple and often intense upwellings in delaying and prolonging some portion of the alewife reproductive effort.

Water temperature was the primary factor responsible for the annual fluctuations in abundance of larval alewives near Port Sheldon (Jude et al. 1981a). Highest larval alewife abundance was directly related to the occurrence of favorable (for spawning) water temperatures for extended periods of time during June to August. Upwellings, which are a common occurrence on the eastern shore of Lake Michigan in early spring and summer, were shown to have a diminishing effect on the intensity of alewife spawning and hatching activity, thus decreasing larval alewife abundance.

Upwellings were shown to cause a more nearshore distribution of larval alewives, compared with the more widespread distribution to depths of 15 m when upwellings did not occur. Possible mechanisms by which upwellings cause changes in larval alewife abundance as well as shifts in the distributional trends are discussed in detail by Jude et al. (1981a) and Heufelder et al. (1982).

An examination of intake water temperatures taken at the Unit 3 pump house (Fig. 12) gives initial indication that upwellings occurred frequently in July and August 1981. These upwellings imposed similar distribution and abundance patterns as those observed in previous years such as 1978 and 1979 (Jude et al. 1981a). Although numerous and sometimes intense upwellings diminished larval alewife abundance during 1981, particularly when compared with 1980, all distributional patterns of larval alewives recognized in previous years were exhibited in 1981. We thus feel that data from 1981 offered an adequate basis for evaluating the effectiveness of the Unit 3 intake design in limiting larval alewife entrainment. Entrainment estimates for 1981 would be representative of years characterized by frequent upwellings, but not for years such as 1980 when no significant upwellings occurred during the peak spawning season. Thus, due to relatively low abundance of alewife larvae in 1981 field samples, use of 1981 entrainment values to predict future entrainment losses should be approached with caution.

The Wilcoxon signed ranks test showed that significantly more alewife larvae were found at the north transect than at the south transect ($\alpha = 0.05$). Adult alewives may be attracted to the warmwater discharge or to the vertical structures of the intake to spawn.

Seasonal distribution--No alewife larvae were collected during our May sampling and only one occurrence was noted during early June sampling. Alewife larvae in a density of 25/1000 m^3 were collected at 12-m station E (south transect) at the 6-m stratum (Appendix 10). Water temperatures during early June were generally cool, in the 12-15 C range. Some 9 and 19.2 C temperatures were, however, also recorded.

The second sampling period in June marked the maximum alewife densities and the most widespread distribution observed in 1981. Water temperatures were in the optimal spawning range (18-21 C) and densities were commonly 300-2000/1000 m^3 at most stations and strata (Fig. 14). Highest densities were observed at night, which was attributed to net avoidance. Since most larvae at this time were newly hatched (about 4 mm - Fig. 15), it suggests that even newly hatched larvae have some limited net avoidance capabilities. This pattern of avoidance by small larvae was also observed when the entrainment data were analyzed, again suggesting these larvae not only could avoid field plankton nets, but also the wedge-wire screen intakes.

By early July, upwellings had occurred (temperatures were 9.5-17 C) and caused larvae to be primarily distributed in nearshore water (3 m to beach). Up to 13,000 larvae/1000 m^3 were observed at south transect beach station P. At the north transect the inshore distribution pattern was the same, but the abundance was lower (less than 1000/1000 m^3). Most larvae during this early July period were again newly hatched 4-mm specimens, but a second cohort, most likely from late June hatchings, was present. This cohort had a mean length of approximately 10 mm.

In late July, densities were lower than in early July, around 600/1000 m^3 inshore, and less at deeper stations (Fig. 14). There were some present at almost all stations, with the highest (up to 5000/1000 m^3) found at north transect station L (6 m, north). A distinctly shoreward (≤9 m) aggregation of larvae was again noted, as offshore stations were affected by upwelled water. Two cohorts of larvae were present, the newly hatched group (about 4.4 mm) and some in the 15-20-mm range. These latter larvae are probably again from the strong late June spawnings.

By early August, abundance of alewife larvae at the south reference transect had diminished to around 120/1000 m^3 at some stations and strata, while slightly more (up to 2000/1000 m^3) were collected at the north transect. Water temperatures (17-23 C) were still conducive to spawning and a large percentage of larvae was newly hatched and inhabited the area ≤6 m on the north transect. Another group ranging from 10 to 25 mm was also noted (Fig. 15).

In late August, a modestly high abundance of larvae (1000/1000 m^3) was noted at some nearshore stations (≤3 m); densities were reduced considerably as depth increased. Since many of the larvae now being caught were of a larger average size ($\bar{x}$ = 11.7 mm on the south transect), net avoidance became more prominent leading to a higher proportion of larvae being caught at night. Water temperatures were still high, over 20 C in surface strata. A wide range of sizes of larvae were found in the area. Most were from 4 to 15 mm with another small cohort at 20-25 mm.

September was a time of low abundance (<40/1000 m^3) of alewife larvae in the study area. Larvae were present at 12- to 6-m stations plus the beach on the south transect and at more stations on the north transect. Almost all were collected at

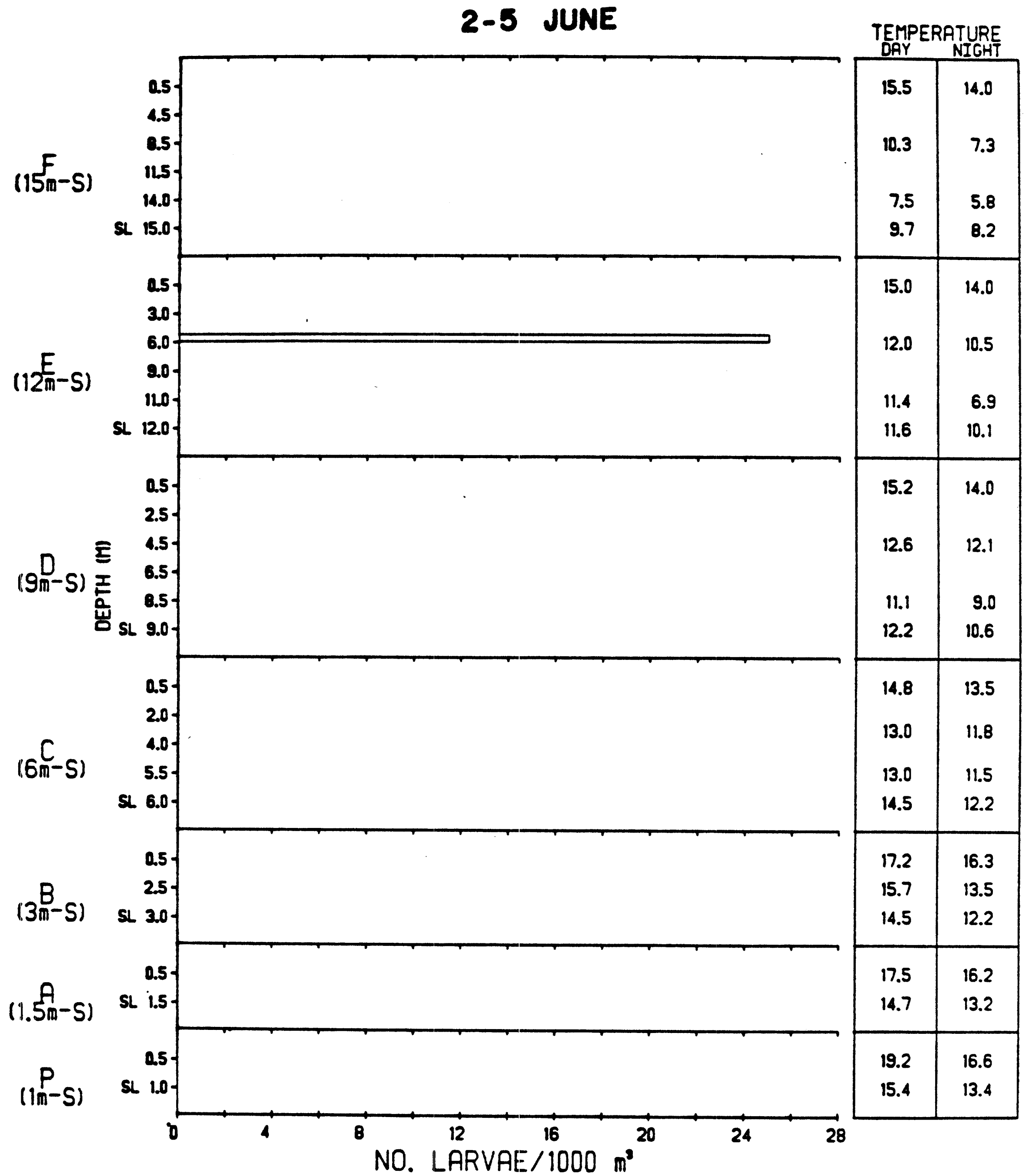
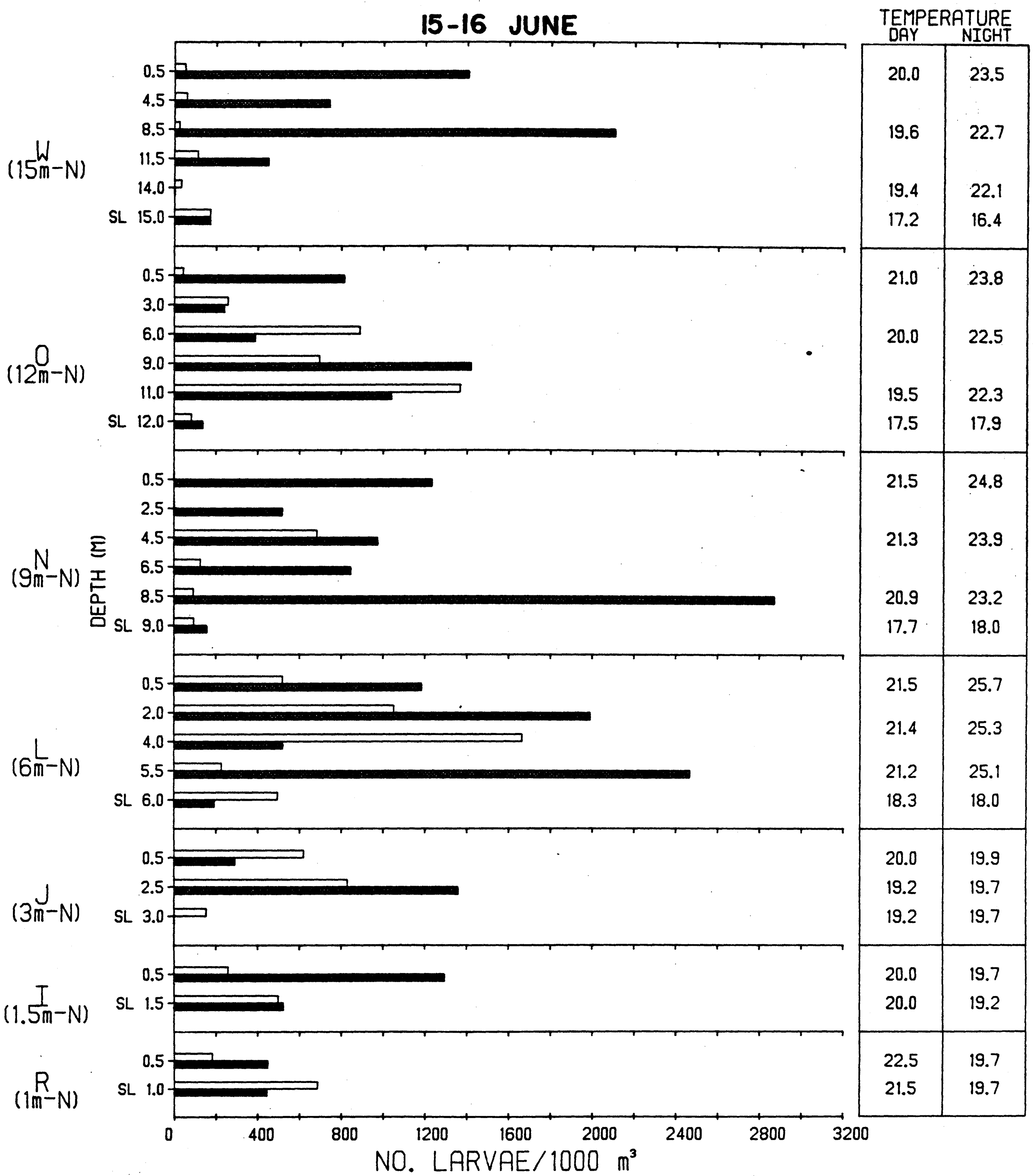


Fig 14. Density of larval alewives (no./1000 m^3) at north and south transect stations near the J. H. Campbell Plant, eastern Lake Michigan, April to September 1981. ☐ =day ■ =night, SL=sled.



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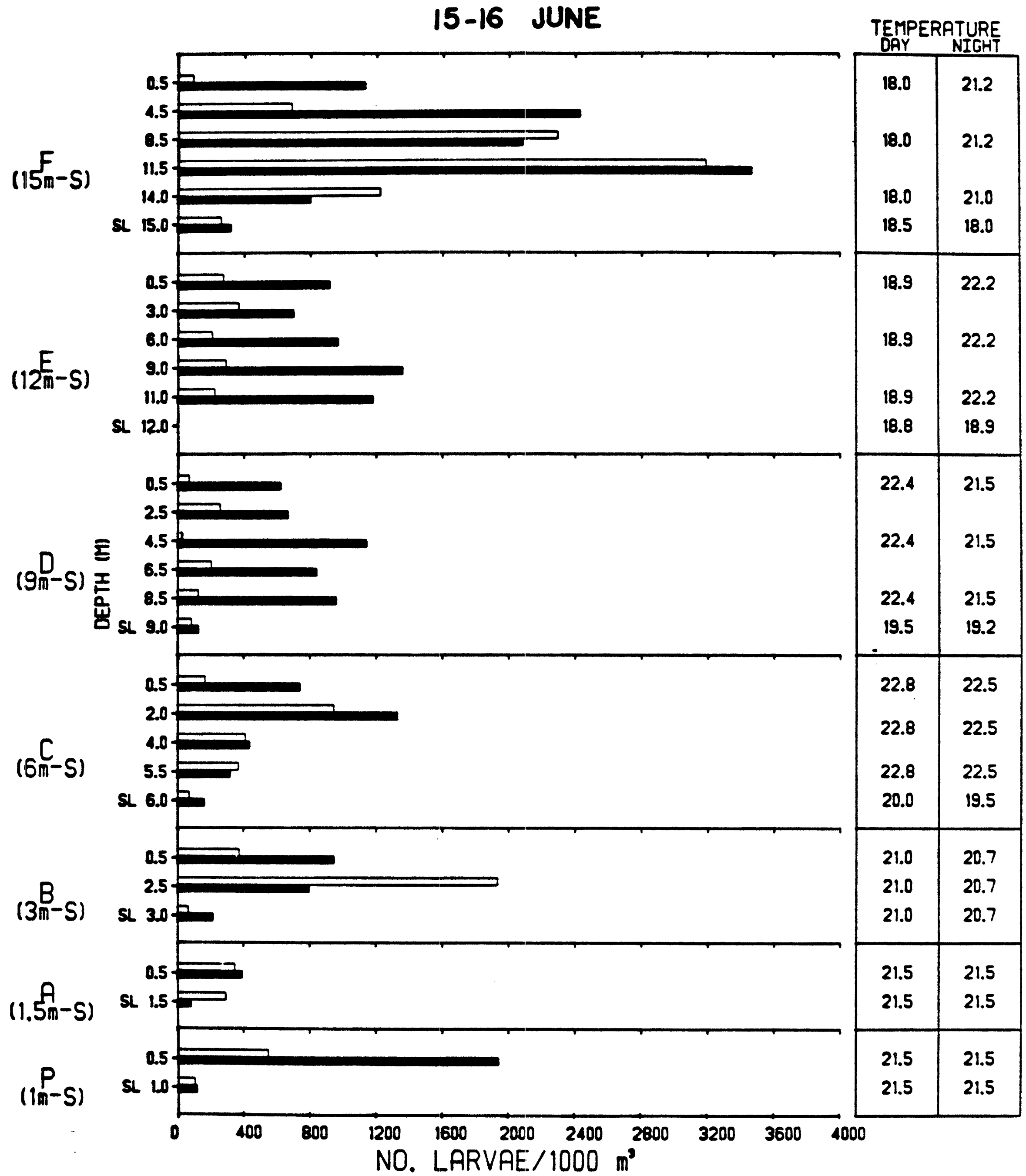

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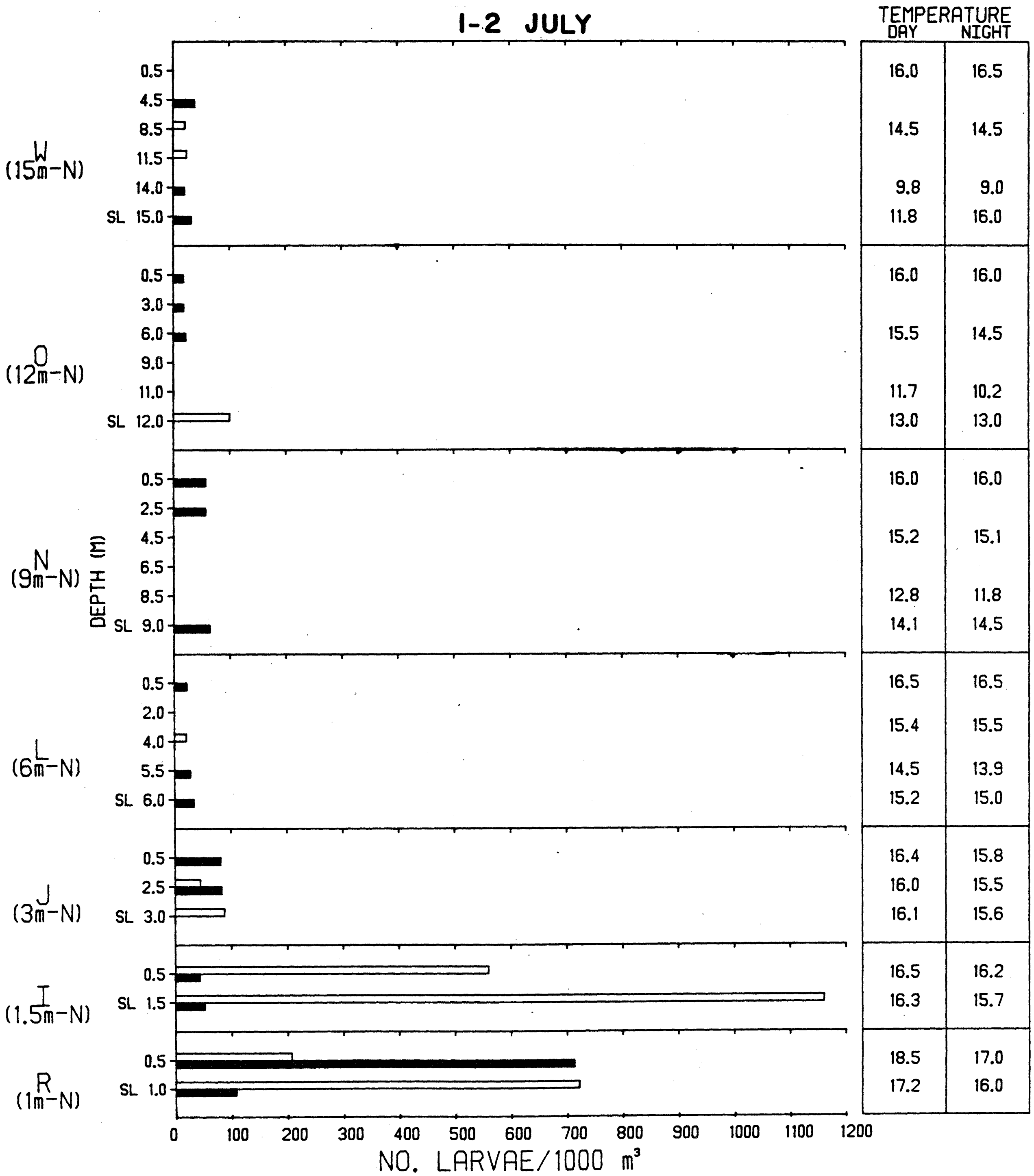

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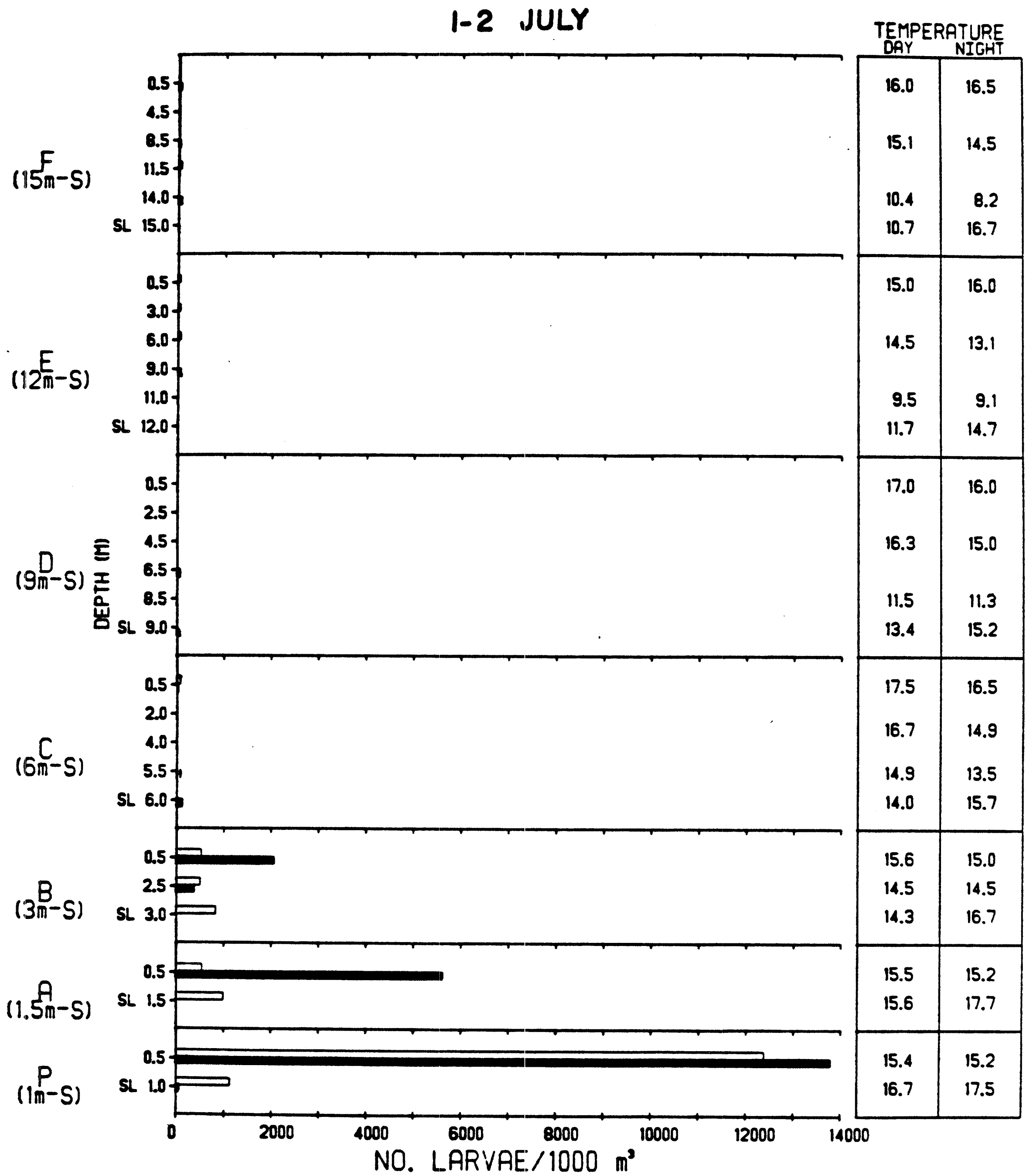

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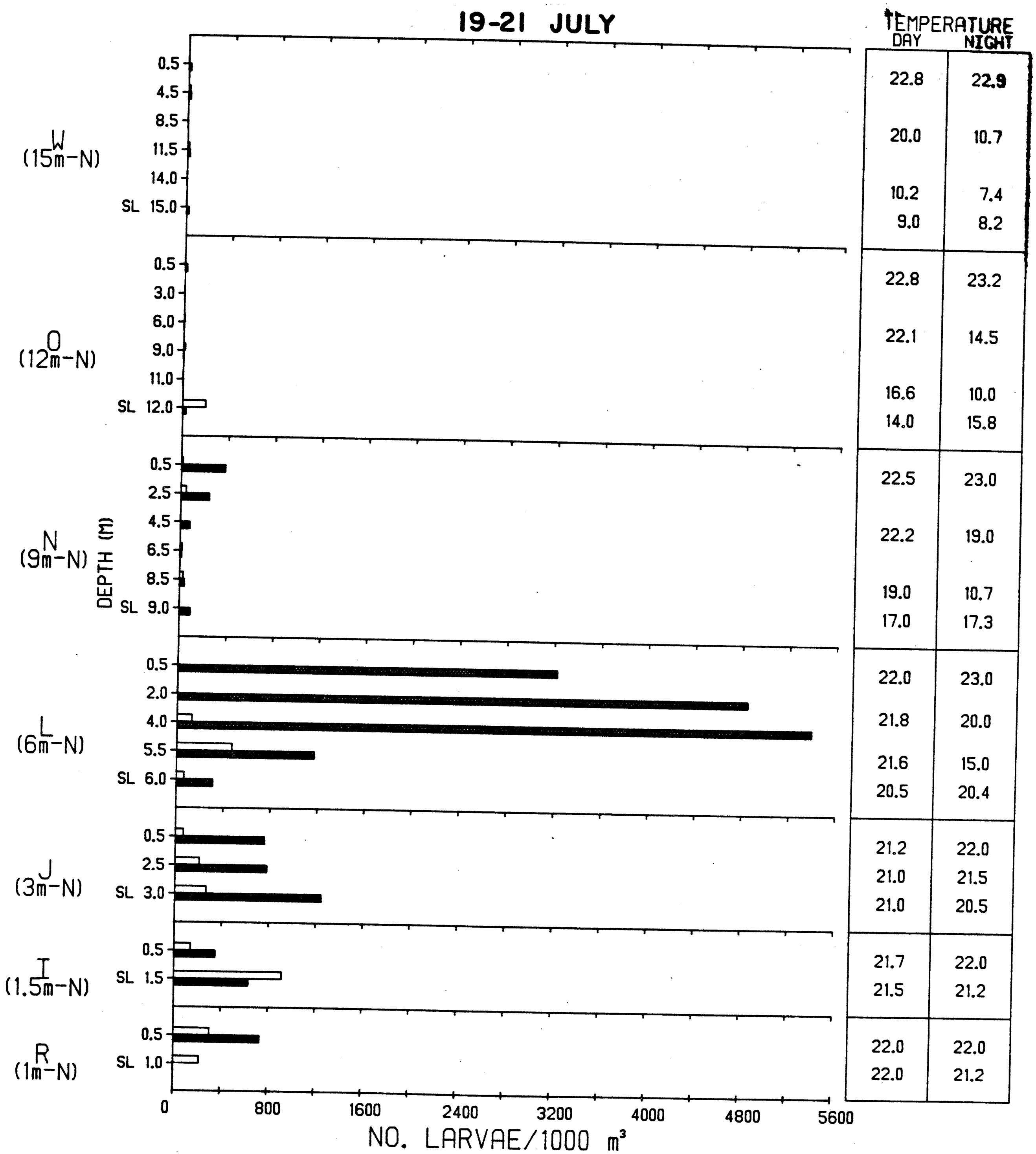

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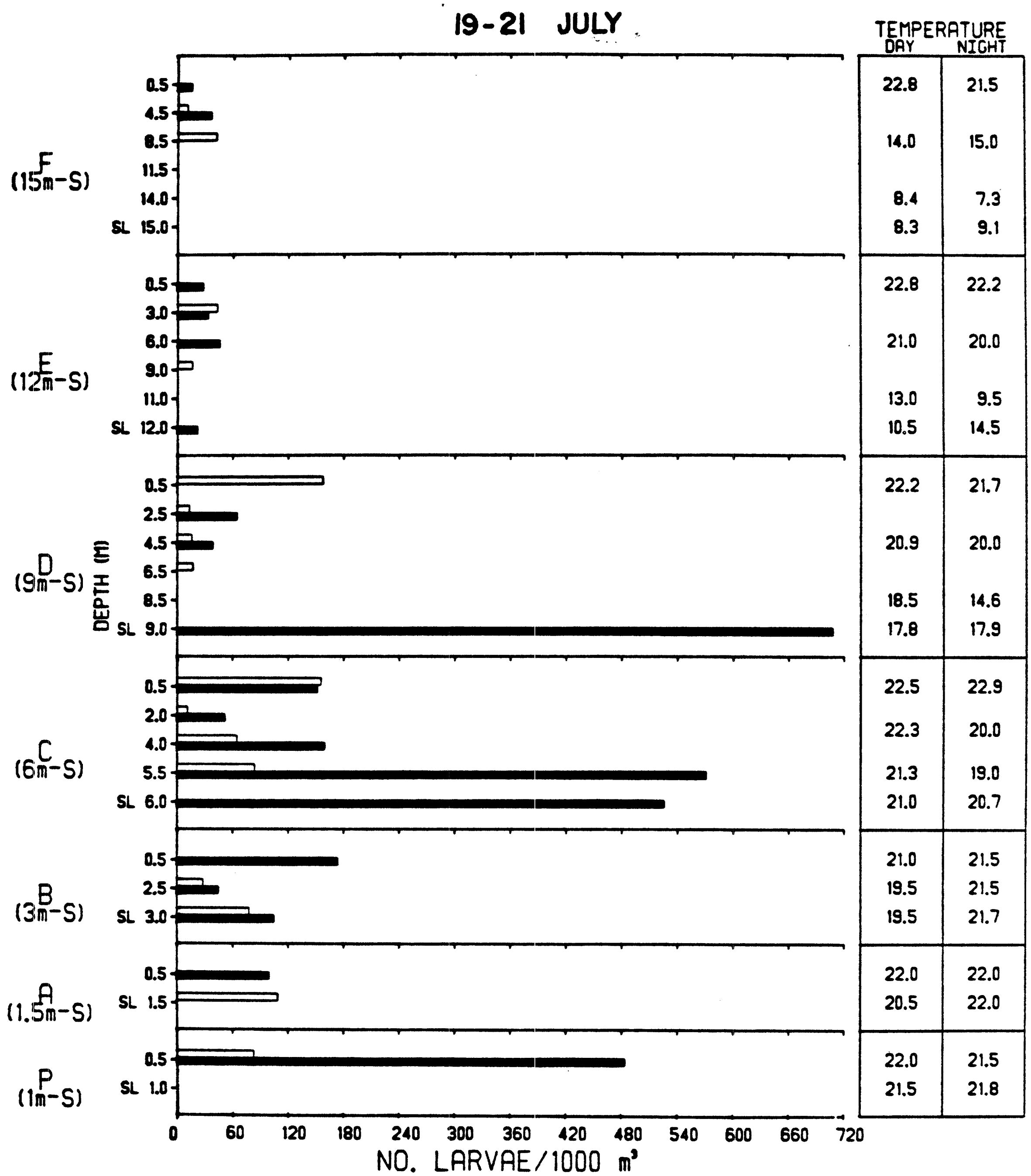

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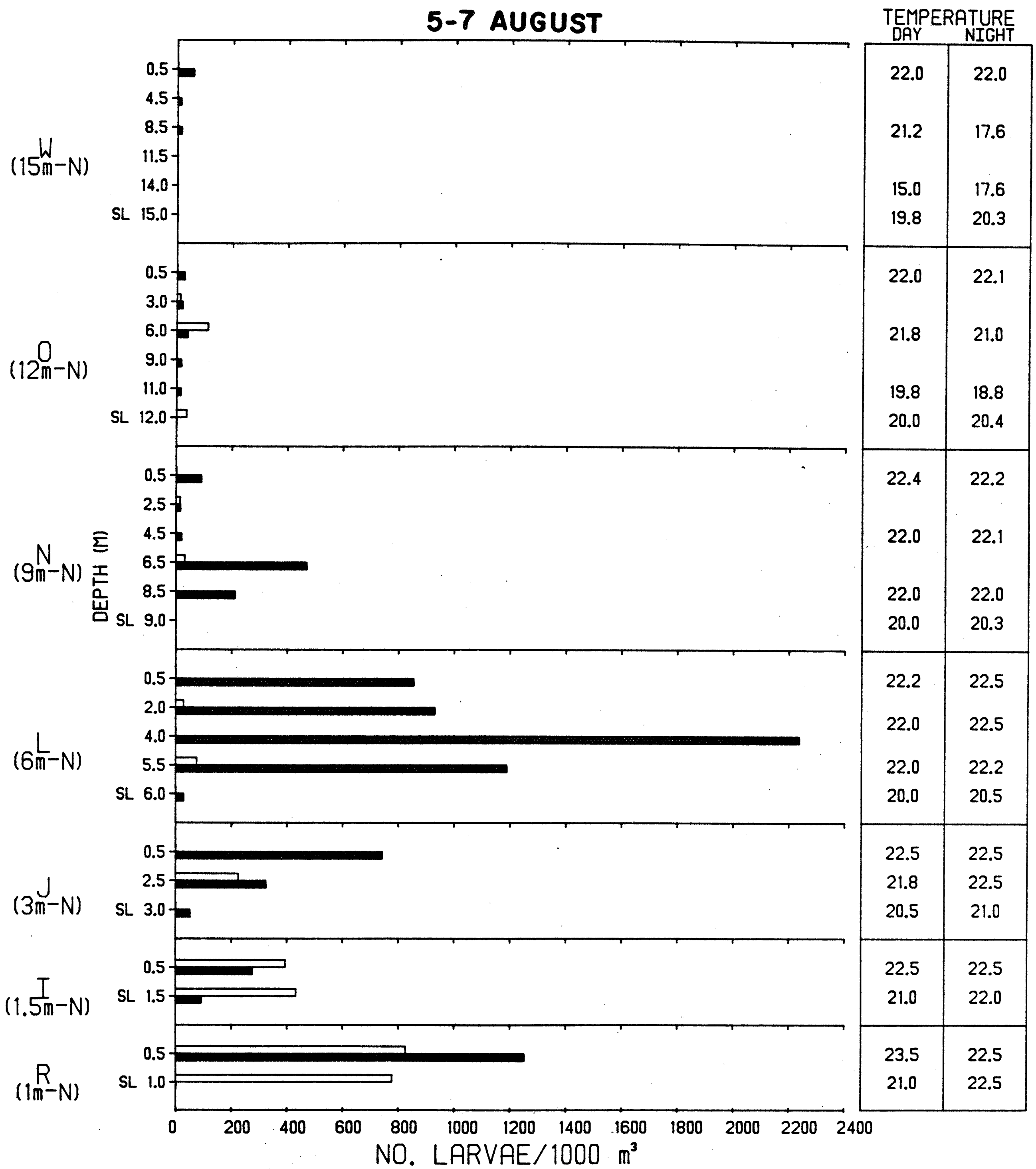

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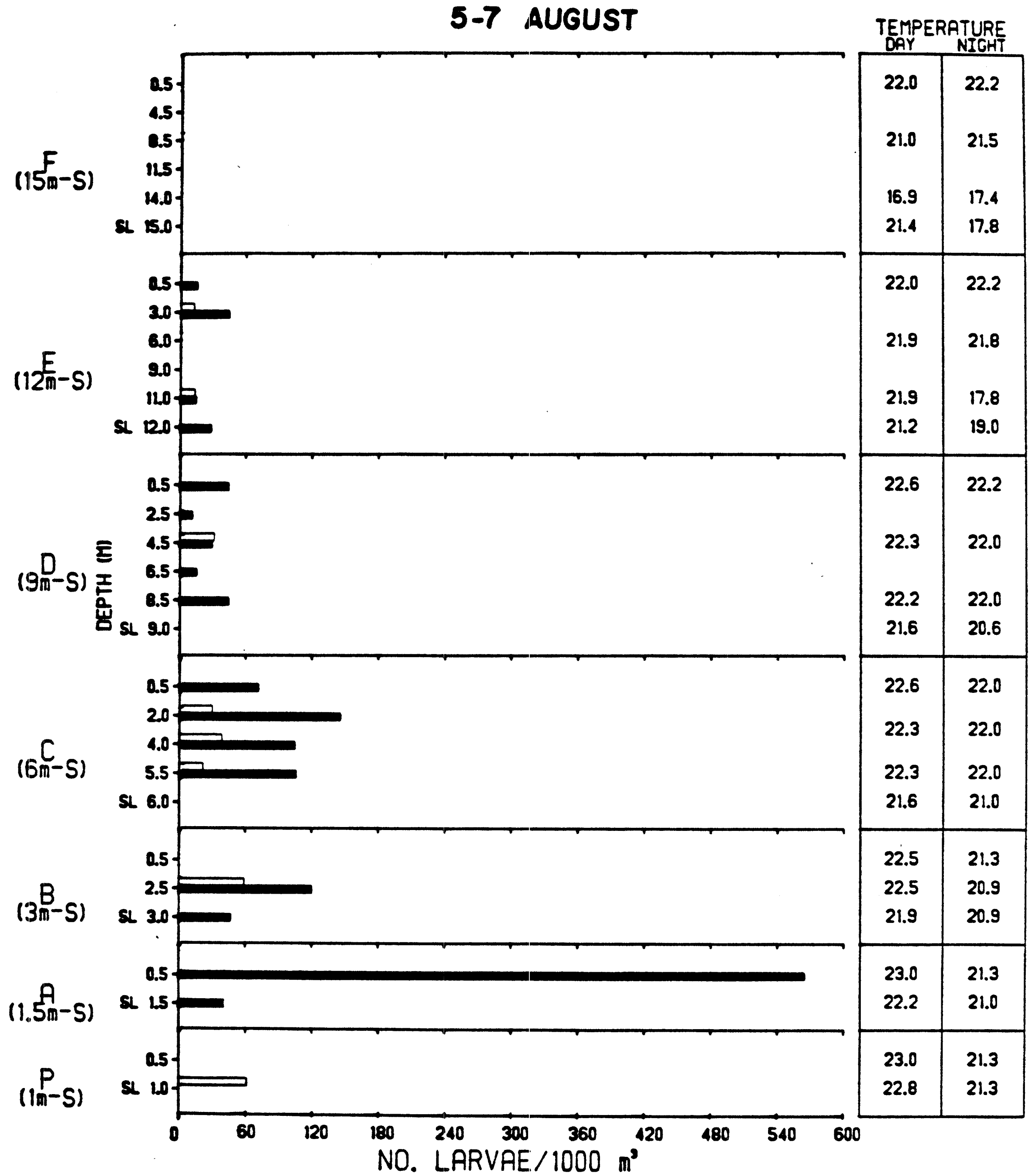

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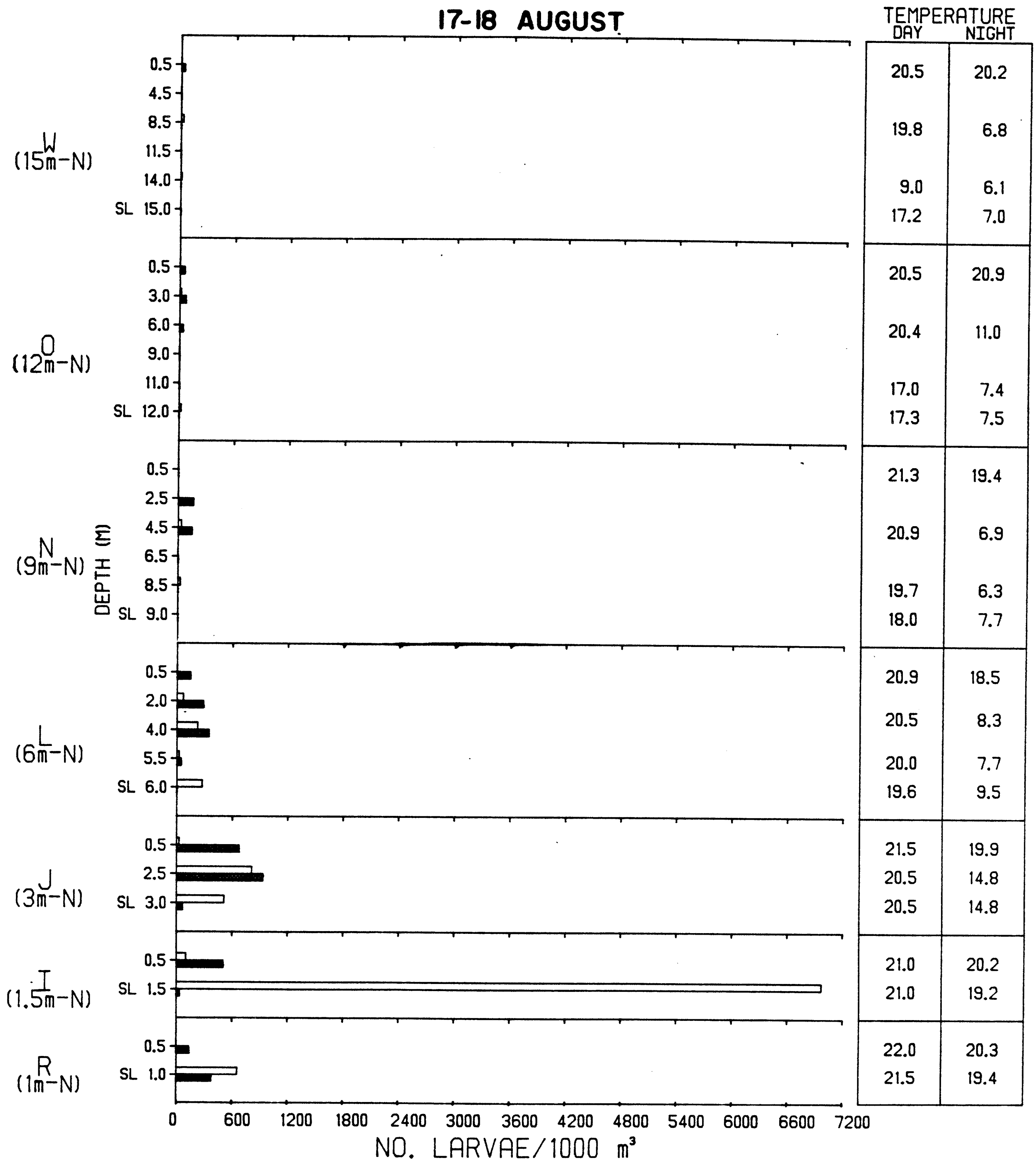

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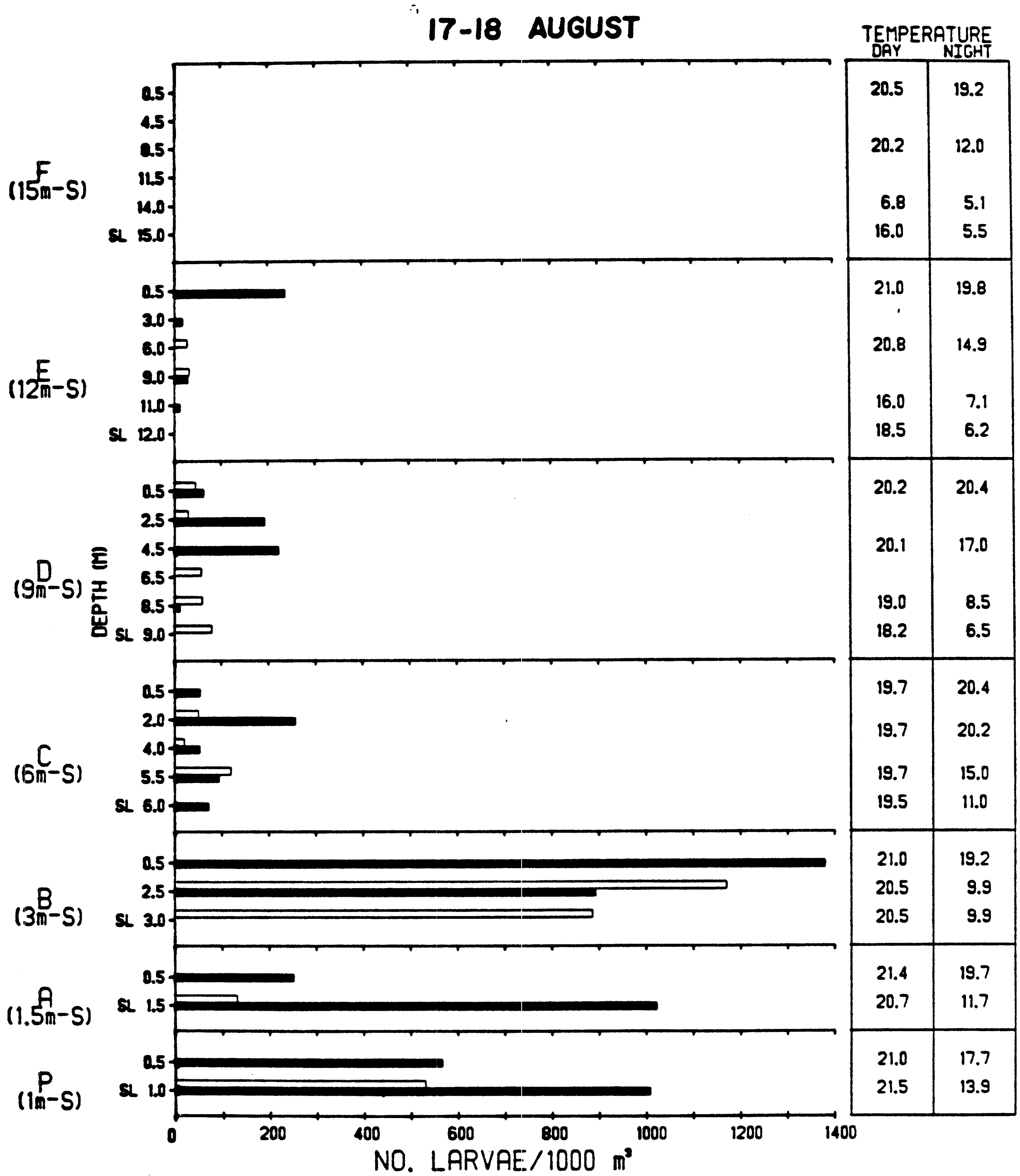

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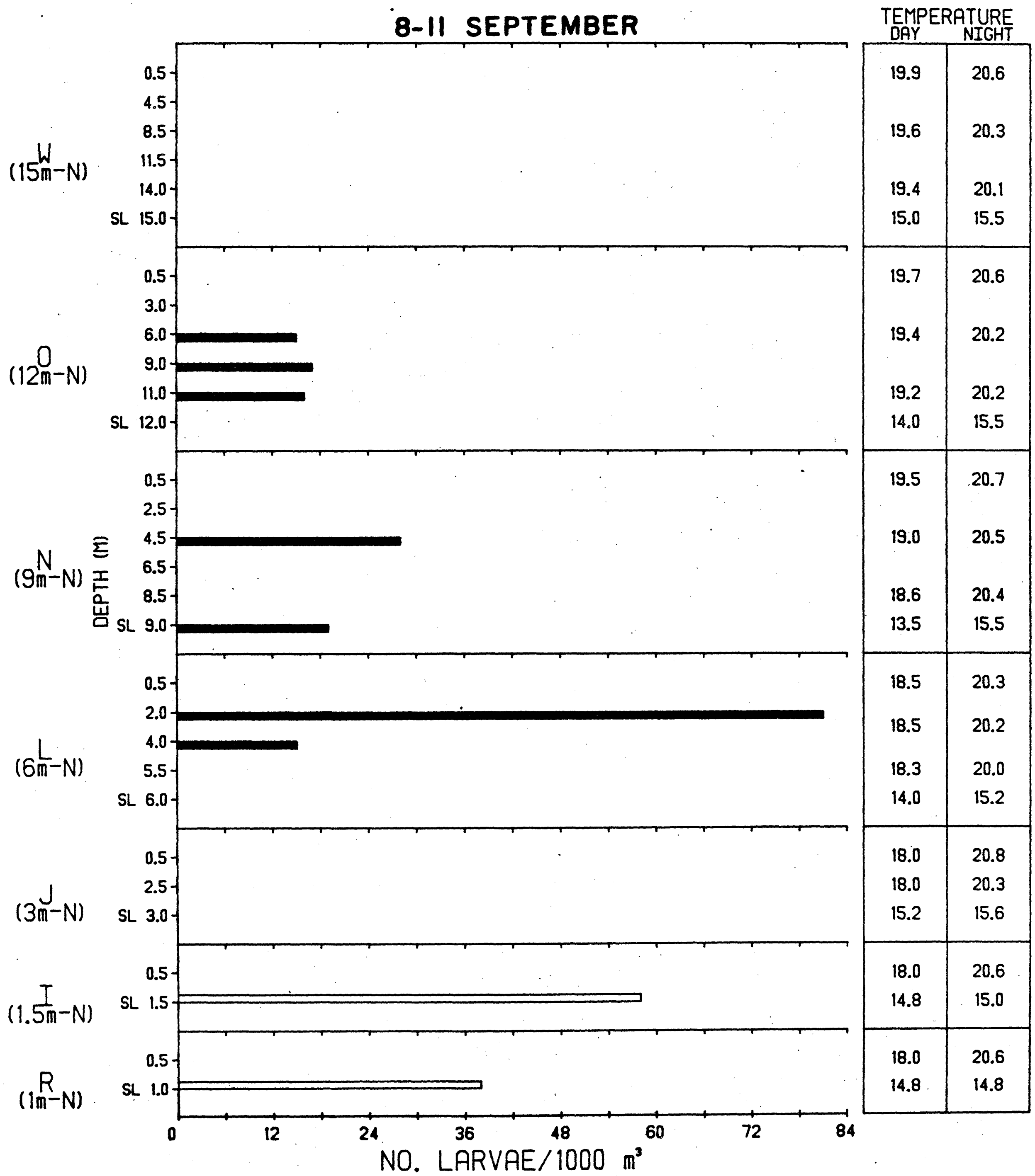

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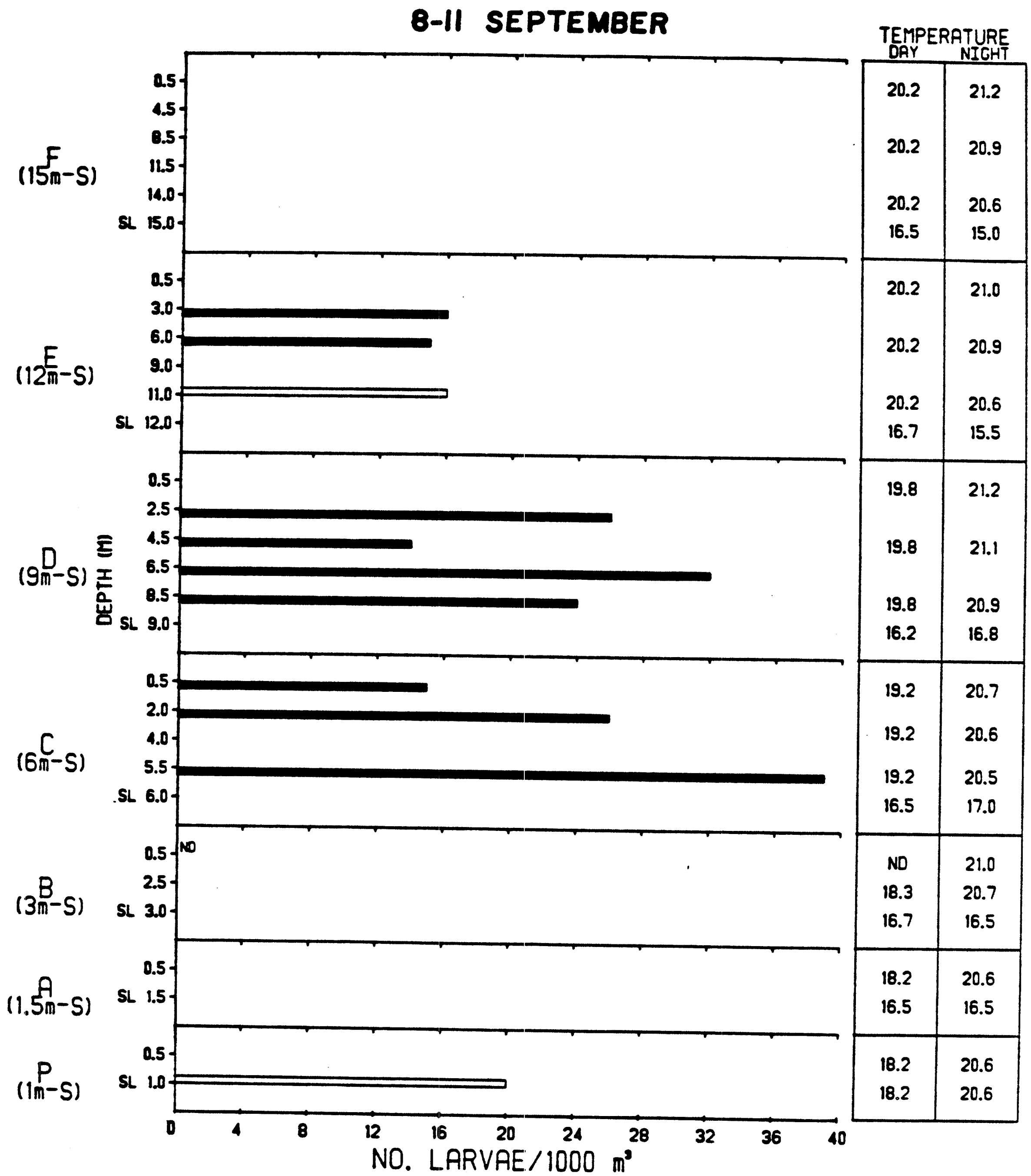

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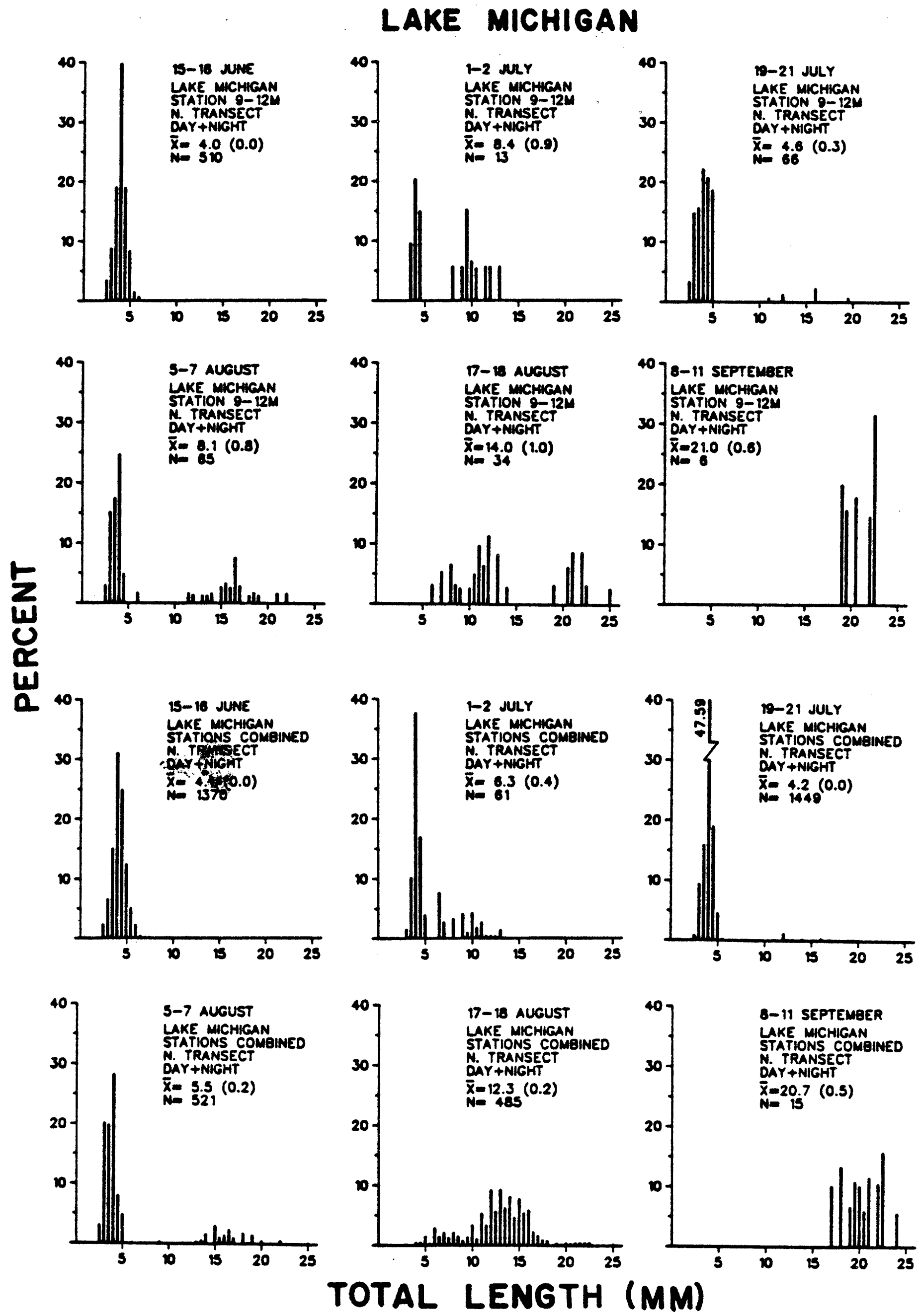
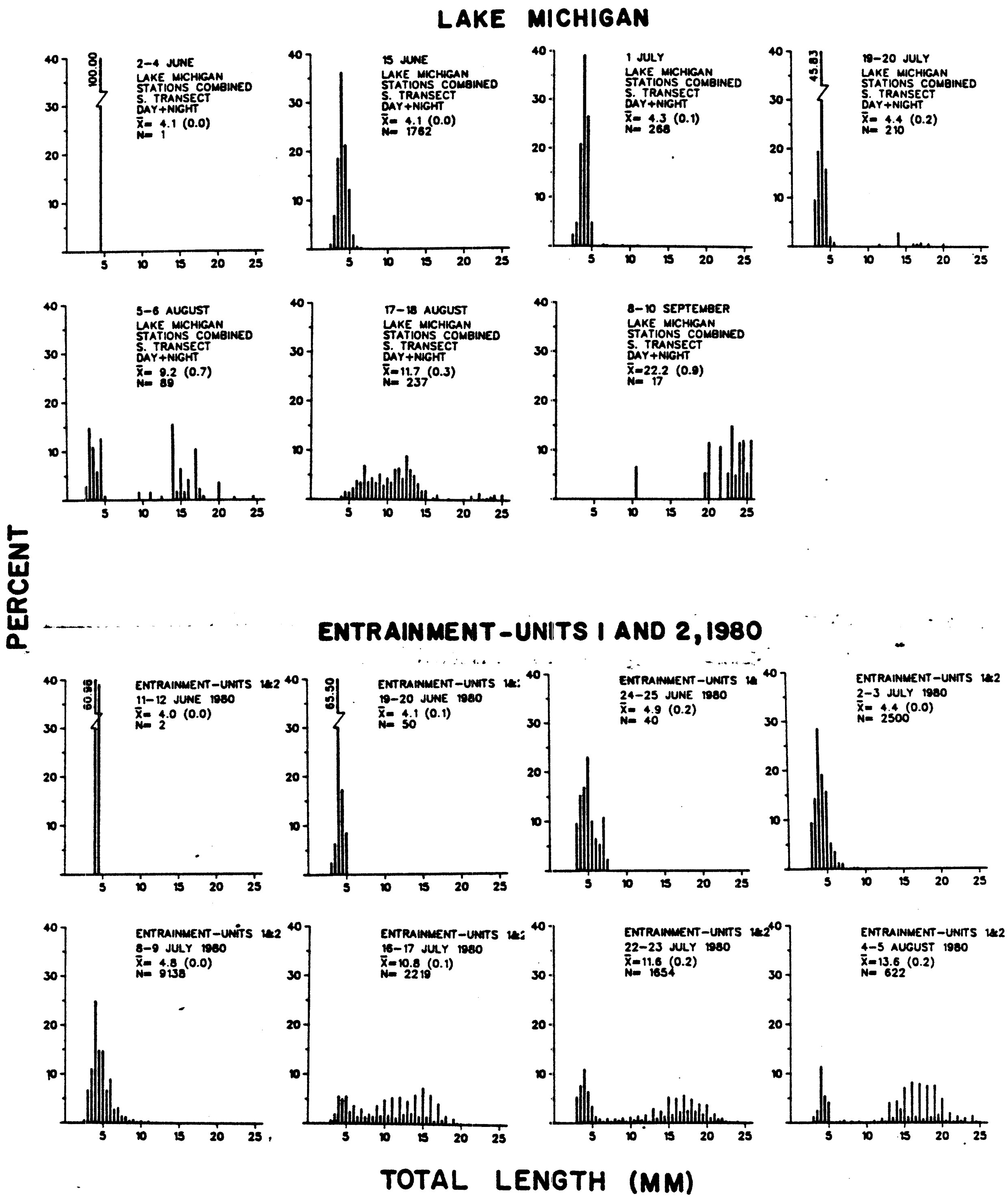


Fig. 15. Length-frequency histograms for larval alewives observed in field and entrainment samples collected during 1981 near the J. H. Campbell Plant, eastern Lake Michigan. Length-frequency histograms for alewife larvae entrained during 1980 were also included. All plankton net and sled tow samples were combined. $\bar{X}$ = mean, N = total number of larvae, standard error is given in parentheses.



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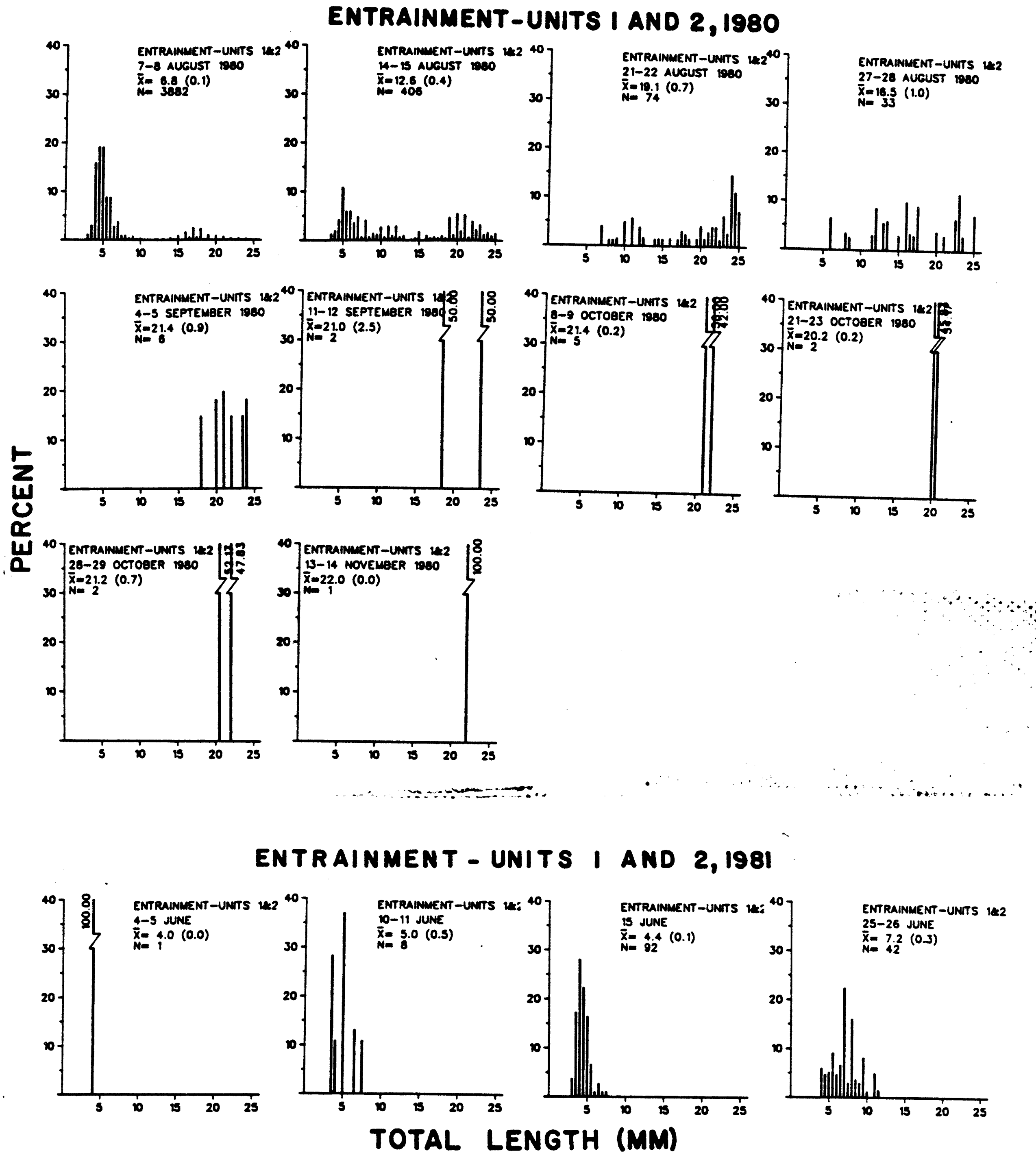

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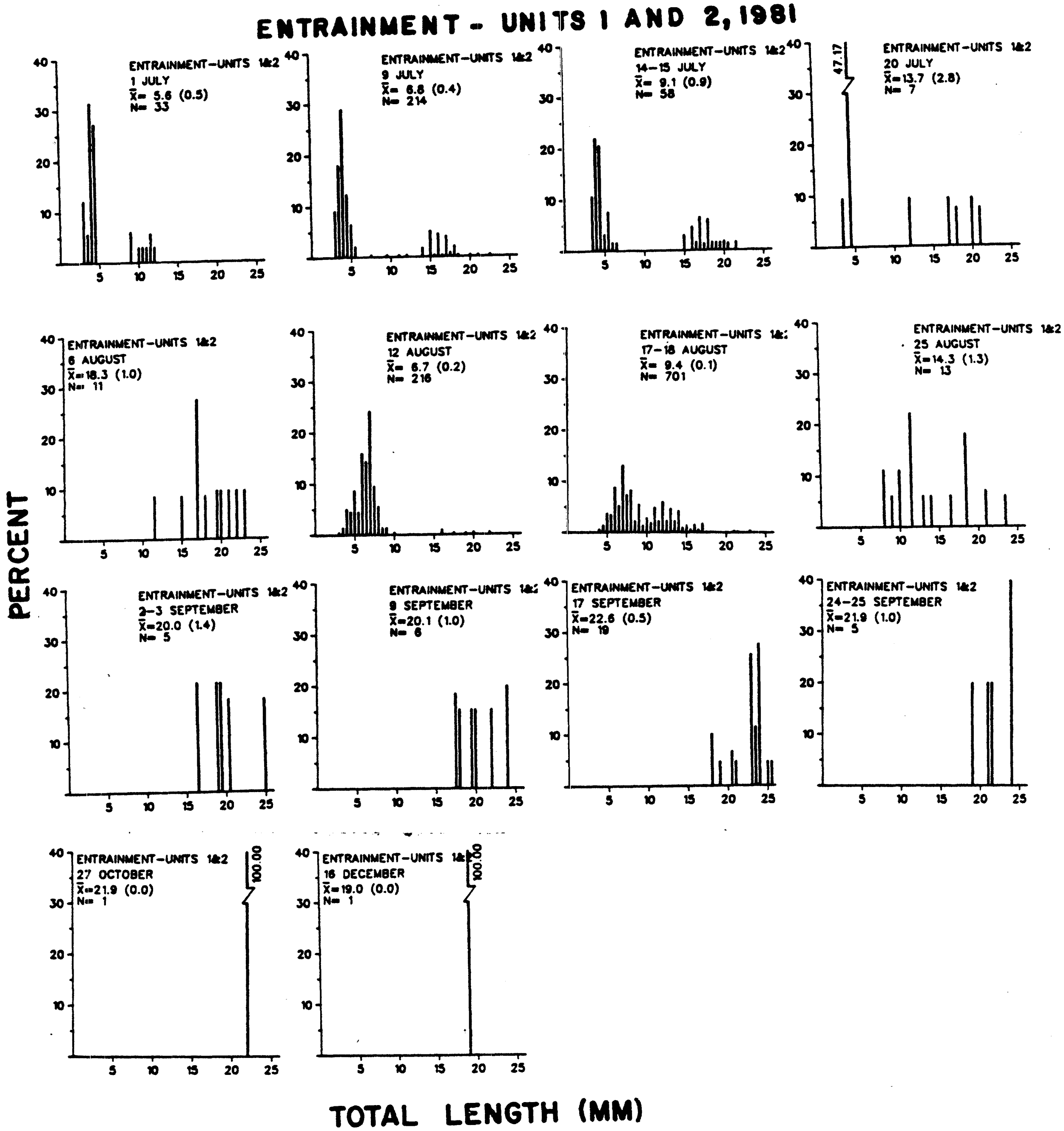

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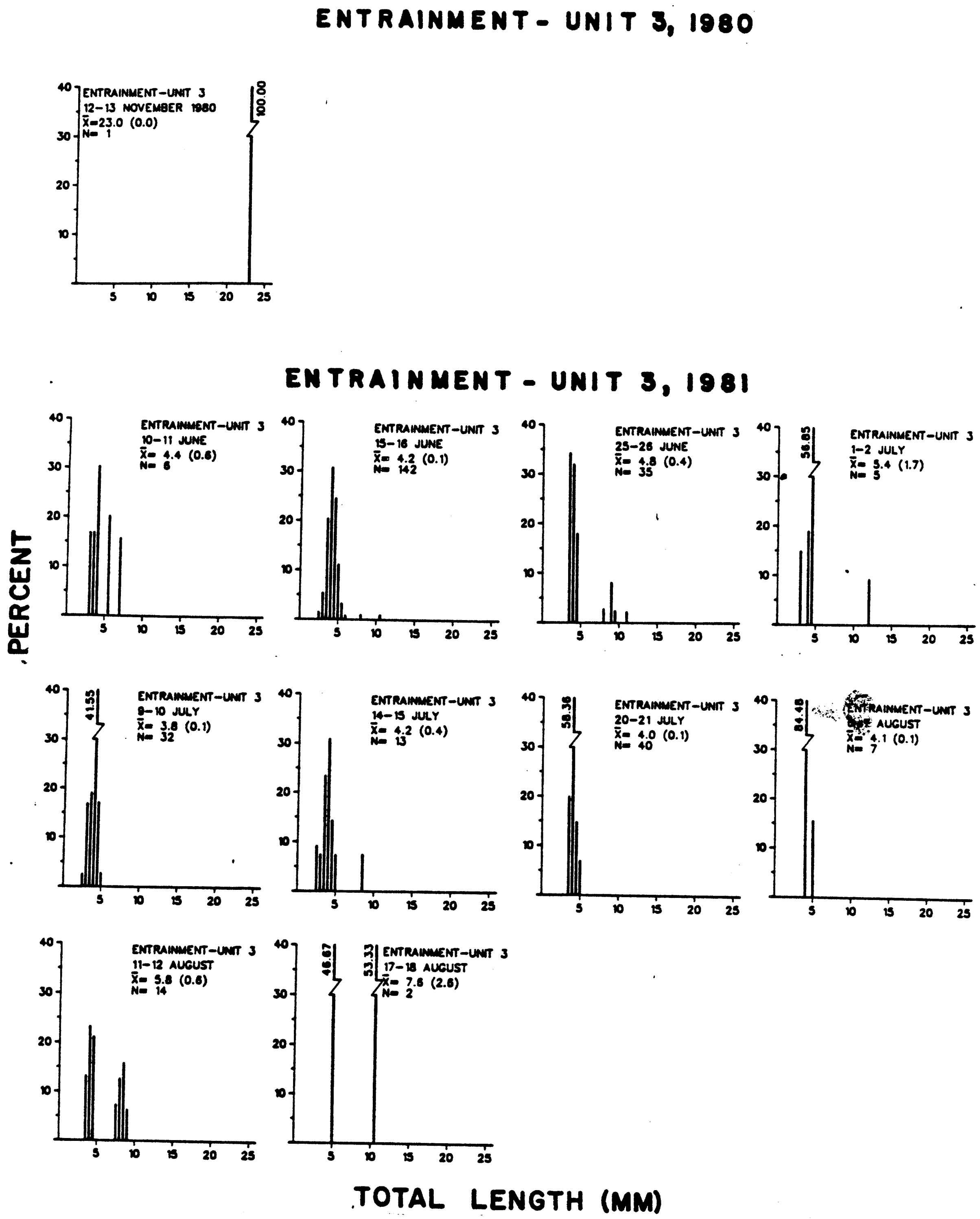


Fig. 15. Continued.

night. Water temperatures were still fairly high, from 16 to 20 C. All larvae caught were over 20 mm TL, except for one 10-mm specimen.

The distribution of alewife fry (fish greater than 25.4 mm but less than 100 mm) in field samples was spread out over 6 months, April to September (Appendix 15). Densities, except for two (414 and 1401/1000 m^3), were always less than 200/1000 m^3. No consistent spatial or temporal patterns were evident from the data set.

Entrainment--

Units 1 and 2, 1980--In 1980, alewife comprised 90.5% or 169 million of the 186 million larvae which passed through Units 1 and 2 of the J. H. Campbell Plant (Table 25). Alewives were first entrained on 11 June 1980 and the last record was on 13 November (Appendix 11). Maximum entrainment densities (1000-2000/1000 m^3) occurred from 3 July through 15 August (Fig. 16). Densities were always one or two orders of magnitude lower on other dates.

Examination of the data set revealed a tendency during peak entrainment for highest densities to occur during the night and lowest during the day. Of the seven sampling periods from 3 July to 15 August, the lowest densities were recorded during the day four times; night densities were never the lowest (Fig. 16). Highest densities were recorded twice at night and three times at dawn among the seven sampling periods. As noted earlier in the discussion of the seasonal distribution of larvae, most were caught at night in the field. This pattern was also carried over to entrainment and suggests that not only are larvae less able to avoid a plankton net at night but that they are also more susceptible to being entrained at night. This may imply that larvae are more active at night, as the water path to Units 1 and 2 (from Lake Michigan through Pigeon Lake, the intake canal and then into the plant) is unchanged at night. Many larvae are carried passively to the screens and the increased entrainment abundances noted at night are attributable to more larvae being in the water mass which enters the plant or their inability to avoid the intake screens at night. The same pattern was noted at the Unit 3 wedge-wire screen intakes; more larvae were entrained at night. In this case, we also felt that larvae were reacting to the currents and the physical structure of the screens (9.5-mm openings) and avoiding them during the day. At night visual cues were less and entrainment of even small, newly hatched larvae was relatively much higher than what occurred during the day.

A comparison of the peak field densities of alewife larvae during 1980 (see Jude et al. 1981a) showed a close correspondence with peak numbers entrained at Units 1 and 2. Compared with

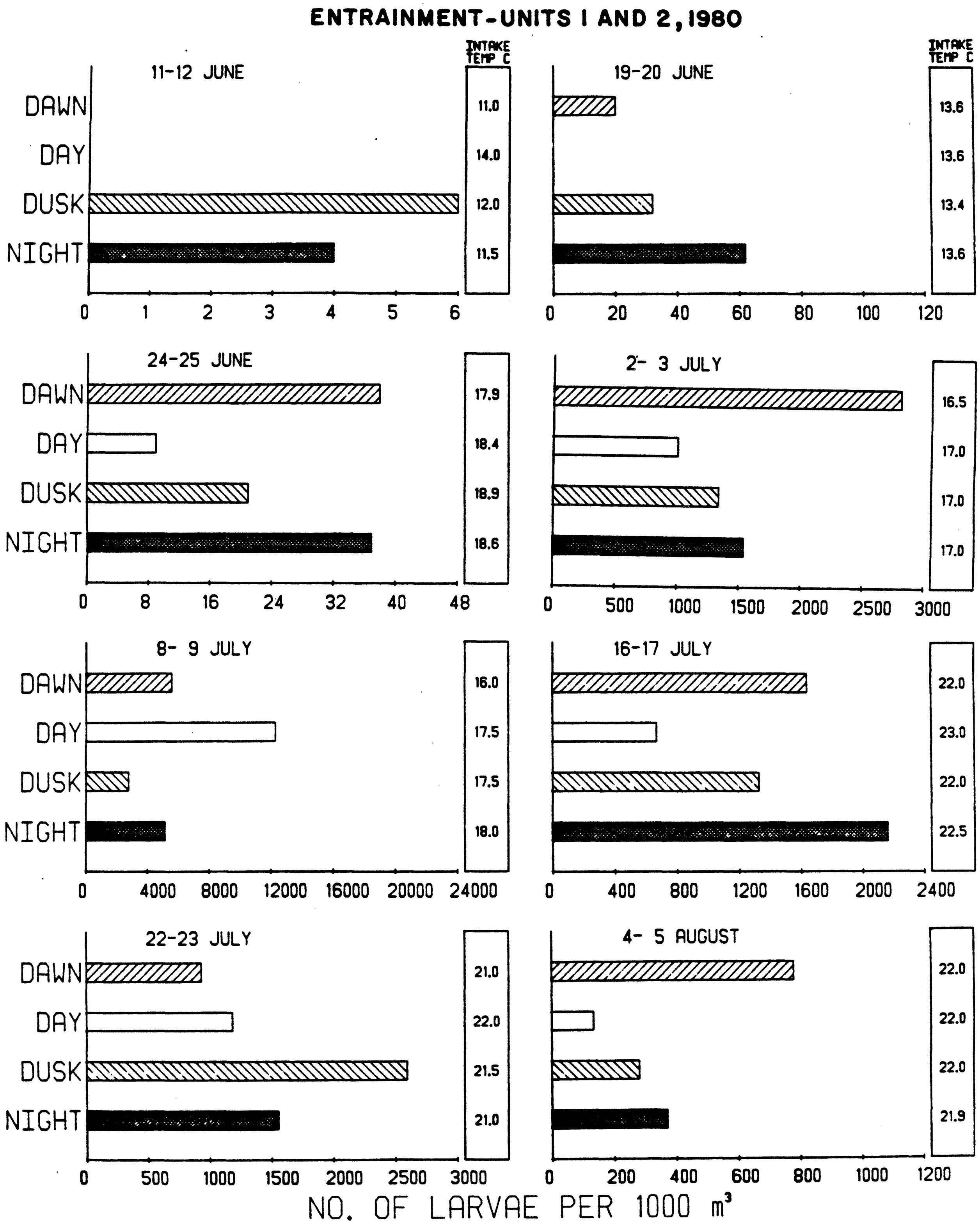
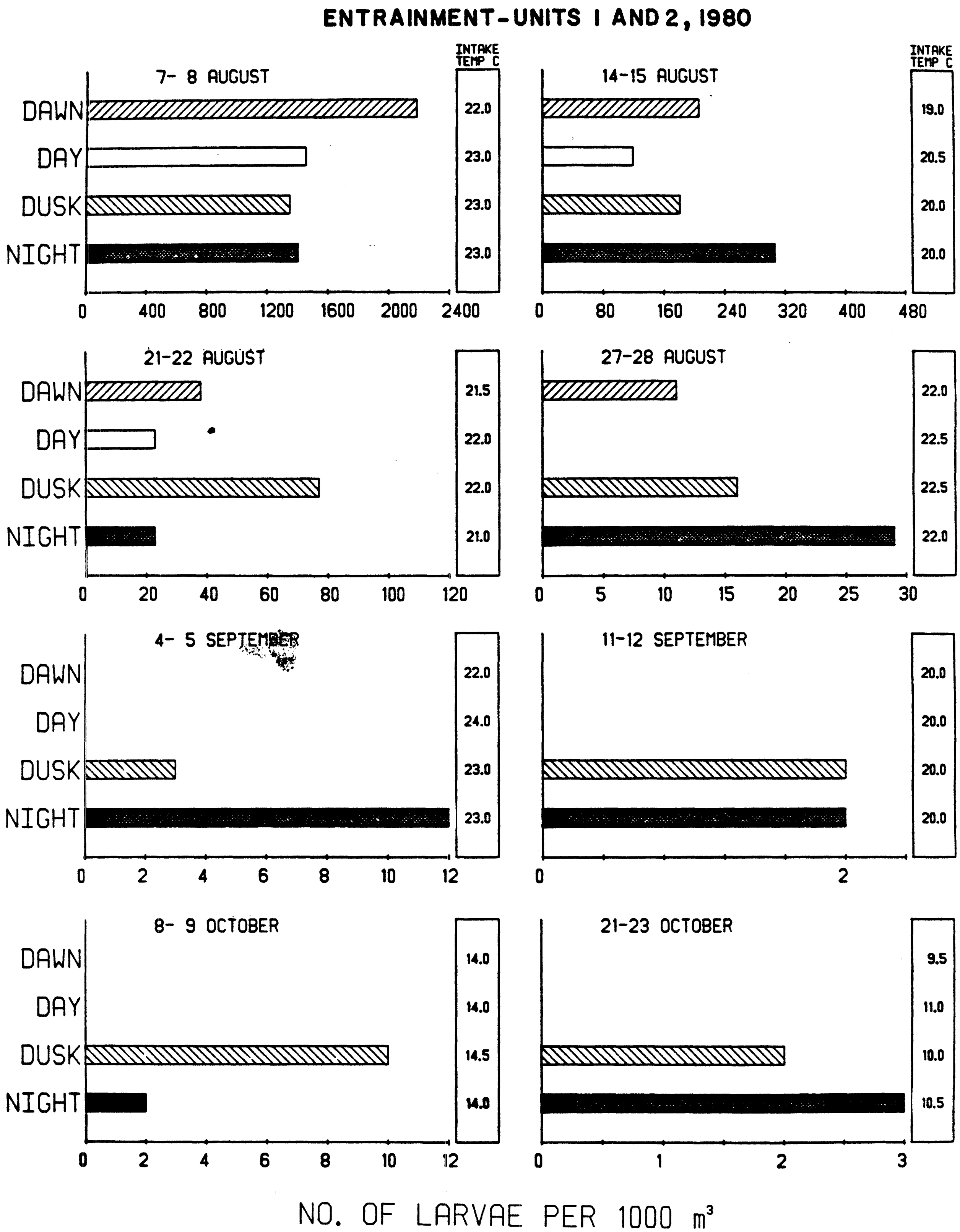


Fig. 16. Density of larval alewives (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at the J. H. Campbell Plant's Units 1 and 2 and Unit 3 during 1980 and 1981. Only day and night densities were shown for Units 1 and 2 during 1981.



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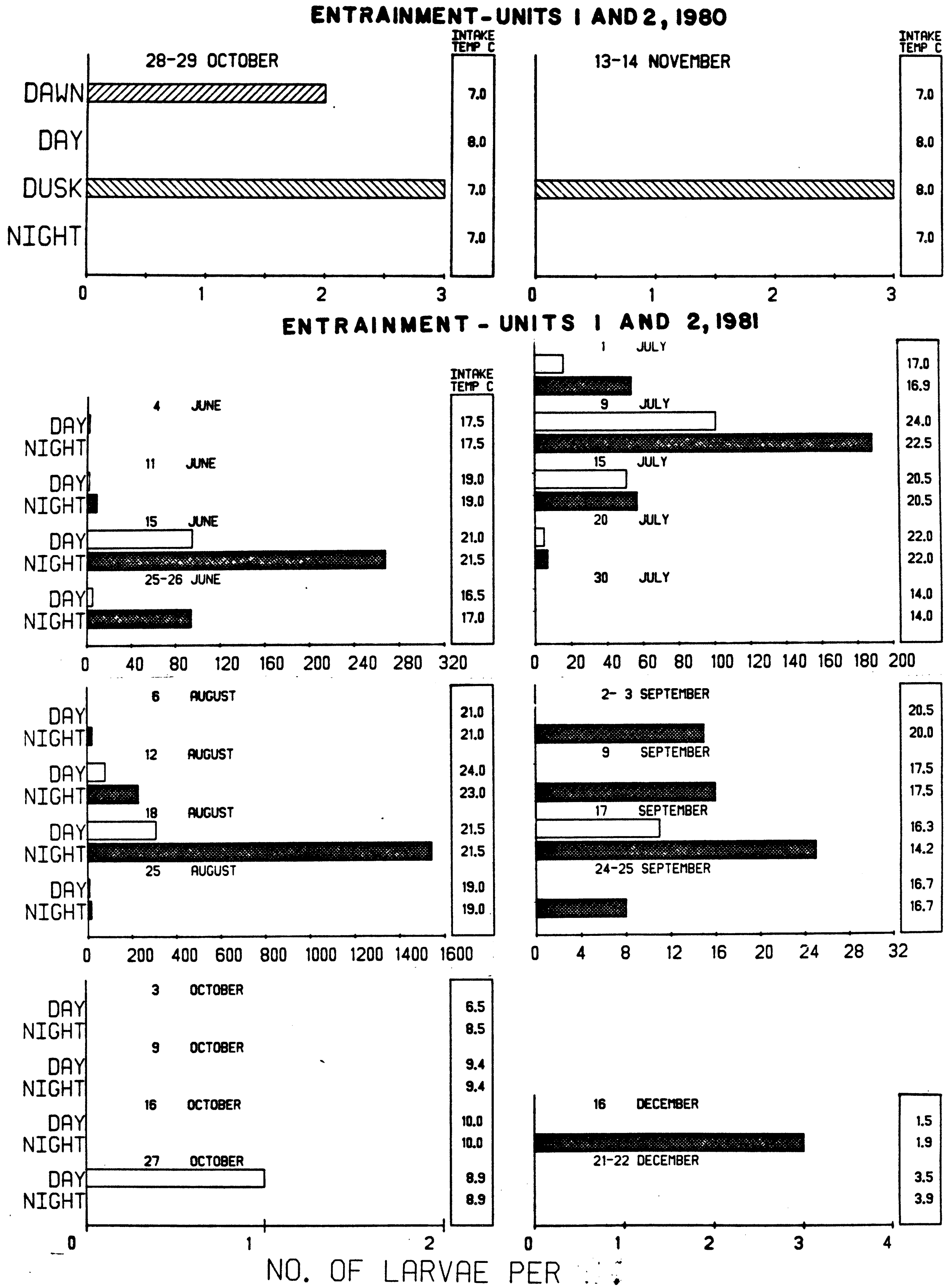

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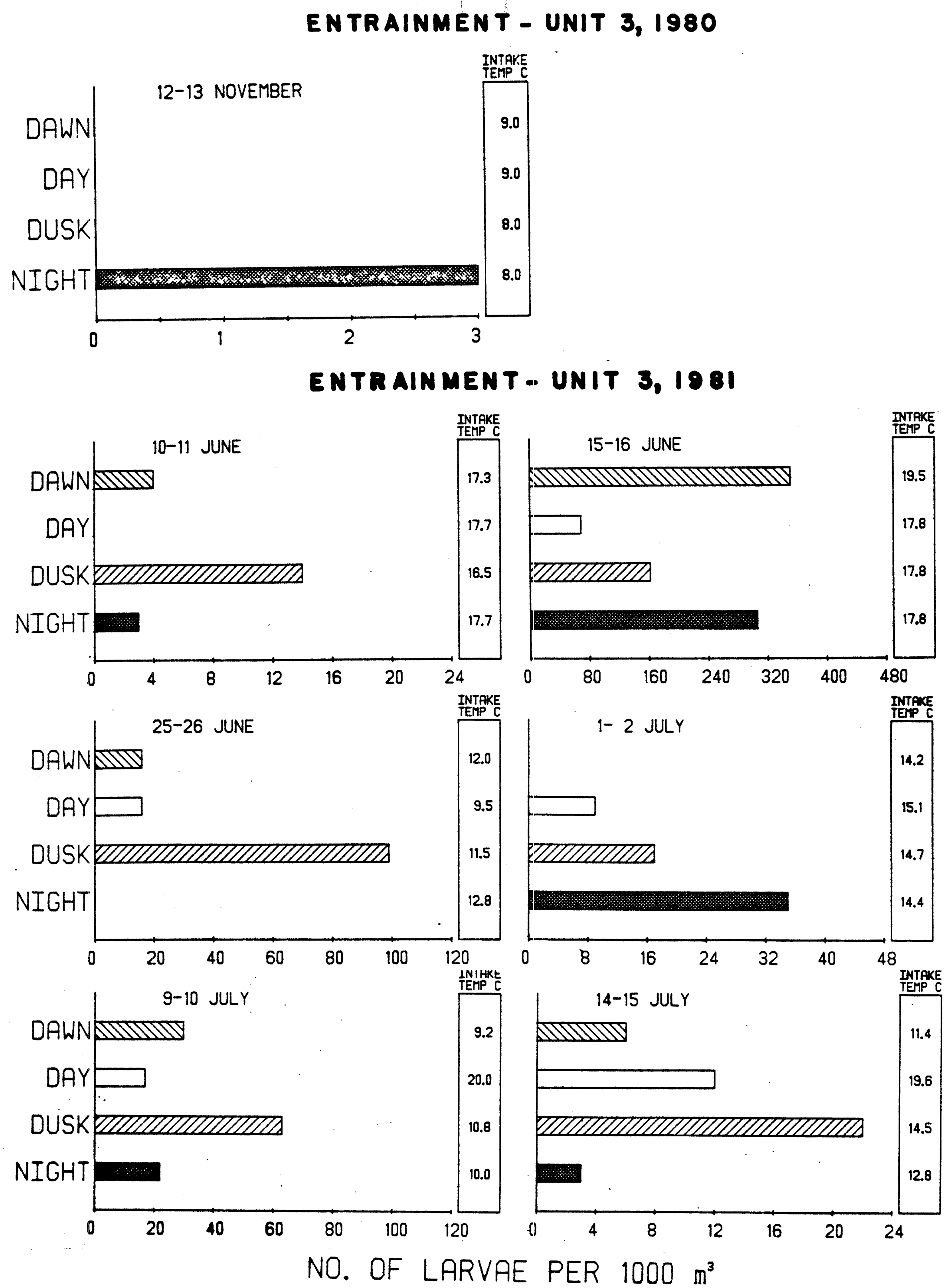

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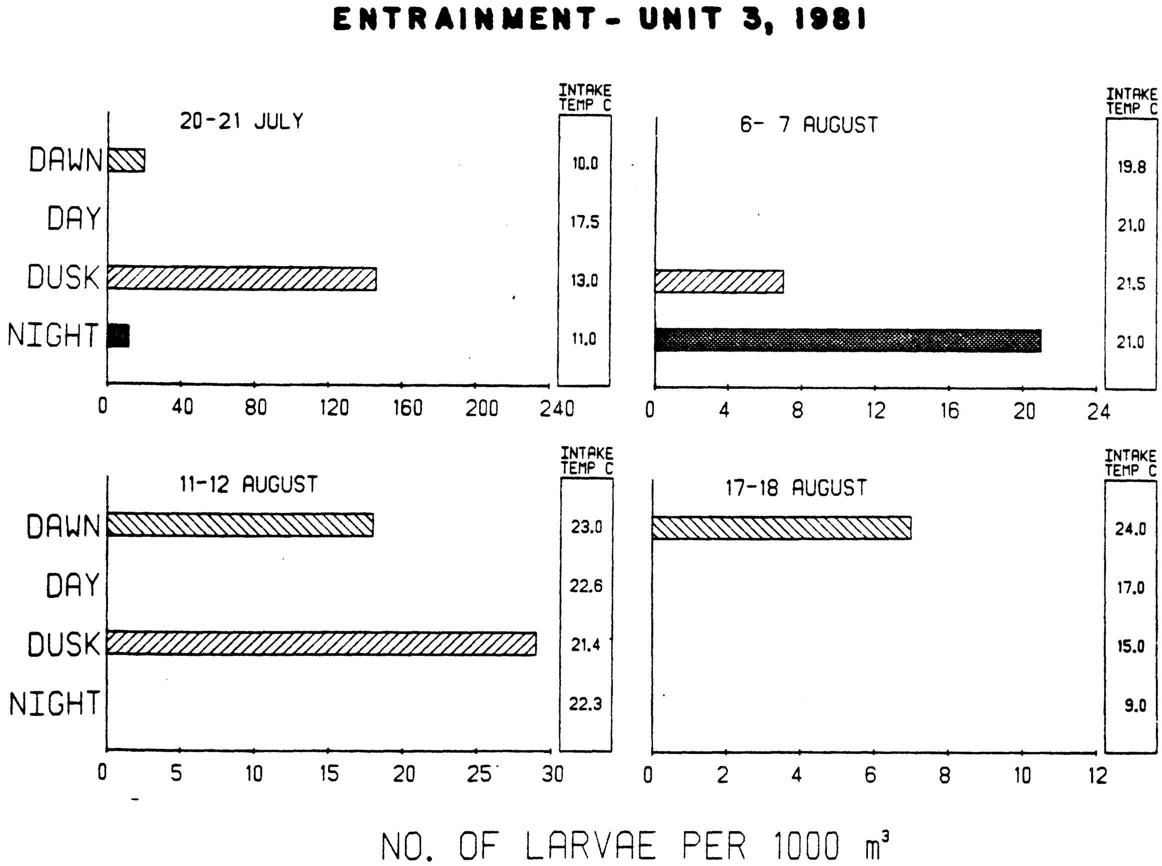


Fig. 16 continued.

other years, 1980 was a year of relatively warm inshore water with very few upwellings. Alewife larvae were abundant and widespread throughout the period July-August, the same period high entrainment of larvae was noted.

Length-frequency histograms for each sampling period (Fig. 15) showed that larvae entrained by Units 1 and 2 from 11-12 June through 8-9 July 1980 were mostly newly hatched with mean lengths ranging from 4.0 to 4.8 mm. In latter July and the first week in August, alewife larvae with a wide range of sizes were entrained. Larvae from 3 to almost 20 mm were equally represented in the catch, a pattern which is not observed during years of intensive upwellings. In late July and the first three periods in August, a strong peak of newly hatched larvae and another peak around 18 mm were noted in the length-frequency histograms. The absence of strong upwellings in 1980 was responsible for the wide range of lengths and the almost continual presence of these larvae during the peak spawning months around the Campbell Plant. By late August, September, October and November, no newly hatched larvae were observed in entrainment samples. This corresponds with the documented behavior of alewives (Heufelder et al. 1982) which reproduce in the first half of the potential spawning season when upwellings are rare and water temperatures are warm over long periods of time. In years characterized by upwellings (such as 1979), reproduction is postponed until water temperatures are conducive to spawning, leading to some spawning all the way into September. Also length-frequency histograms from years of frequent upwellings typically showed large gaps in their distribution, with the dominant size group usually being newly hatched fish.

During 1980, alewife fry were entrained by Units 1 and 2 from 3 July to 12 September. Densities were highest in August, peaking at 130 fry/1000 m³ (Appendix 16). Most alewife fry were entrained during dusk or night, due to higher activity levels during these periods or their ability to avoid the intakes during daylight.

Units 1 and 2, 1981--In 1981, substantially fewer alewife larvae were entrained (9.35 million - Table 26) than in 1980 when an estimated 169 million passed through Units 1 and 2 at the plant. Peak entrainment in 1981 was during June (2.41 million), July (2.21 million) and August (4.29 million). The remaining 0.44 million larvae were entrained during September-December. Alewife comprised only 42.2% of the total number of larvae entrained in 1981. Reasons for the reduced entrainment loss in 1981 could be related to upwellings and cool water temperatures which characterized that year. As was discussed earlier, 1980 was a unique year in that upwellings were few and warm temperatures prevailed leading to sustained high densities of larvae and greatly increased entrainment rates. In 1981, conditions were not favorable for alewives as cooler temperatures and upwellings depressed alewife abundance and prolonged the spawning season.

The pattern of more larvae being entrained at night was striking for 1981 since in 16 of 18 cases alewives were entrained in higher densities at night (Appendix 12, Fig. 16). This pattern has been a consistent trend through most of our field and entrainment collections. Even newly hatched larvae were involved, since only this size of larvae was collected during the first three sampling periods in June (Fig. 15). Starting in July (the first three sampling dates), there was a bimodal distribution with a peak of newly hatched larvae around 4 mm and another around 10-18 mm. The latter peak was undoubtedly the mid-June cohort. As was noted in earlier discussions, these length-frequency histograms show the gaps in the size distribution of larvae which we attributed to the influence of upwellings on adult spawning and drift of larvae. Note that in 1980, an almost continuous length-frequency histogram with a wide range of sizes equally represented was observed. Again we felt the lack of upwellings in 1980 caused this size-frequency distribution.

In latter August, delayed spawning effort, presumably because of frequent upwellings in 1981, caused a large peak of newly hatched larvae to appear. Another large group in the 12-mm range was also present. After August 17-18, only larger larvae (>8 mm) were observed in entrainment samples. The last alewife larva (almost 20 mm) was collected on 16 December 1981. Only two incidences of fry being entrained in the discharge canal at the plant were recorded; both were on 18 May 1981 at night.

Entrainment of alewife fry by Units 1 and 2 (see Appendix 17) was always less than 100 fry/1000 m^3 during 1981. Fry were entrained starting in April and continued through 12 November. Three times as many fry were caught at night as during the day, which suggests they avoided the intakes during the day, but were more susceptible to entrainment at night.

Unit 3--Using all Unit 3 entrainment samples during which coincident field samples were taken in 1981, ANOVA comparisons indicated that during mid-June, densities of larval alewives in entrained water (Fig. 16) were significantly less than densities of larval alewives at those stations chosen to represent ambient densities at the point where Unit 3 withdraws water (sled tow and 8.5-m tow at station N and 9.0- and 11.0-m tow at station O, Fig. 14 - see METHODS - STATISTICS). Since alewife larvae from past studies were shown not to be highly demersal, ANOVAs were also run by substituting the 6-m tow at station O (12 m) in place of the sled tow at station N (9 m). This ANOVA again indicated that larval alewife densities in coincidentally taken entrainment samples were significantly lower than ambient larval alewife densities at the point of Unit 3 withdrawal.

In conjunction with these ANOVA comparisons, length-frequency data (Fig. 15) revealed two significant findings relative to the effectiveness of the Unit 3 intakes in limiting larval alewife entrainment. Initially in mid-June, when field sampling indicated that the vast majority of larval alewives at the 9-12-m contours were newly hatched (mean total length = 4.0 mm, SE < 0.05), the mean length of those alewife larvae in entrainment samples was not substantially different (mean total length = 4.2 mm, SE = 0.1). Since there were lower densities of entrained larval alewives compared with ambient densities of larvae in mid-June, these length-frequency data indicate that even newly hatched yolk-sac larvae, to some degree, were exhibiting an avoidance reaction to the Unit 3 intake. Although the detection mechanism (visual or lateral line) is not known and avoidance behavior has not been observed, it is apparent that the low intake velocity (maximum of 15.2 cm/s at the screen surface) does allow escape of even newly hatched larval alewives.

In addition to indicating that some small, newly hatched larval alewives were able to avoid entrainment, length-frequency data also indicated that larger alewife larvae were less subject to entrainment compared with newly hatched larvae. During both early and later August field sampling, a wide size range of larval alewives (2.5-25.0 mm) was observed in field samples taken at the 9-12-m contours, while alewife larvae only 9 mm or smaller were observed in entrainment samples (Fig. 15). The increased ability of larger larvae to avoid entrainment is also exhibited by the absence of larval alewives from September entrainment samples, when coincident field sampling indicated the presence of large (19-25 mm) larval alewives in the vicinity of the intake. Additionally, from June to August, no larval alewives exceeding 12.5 mm were entrained. An overview of length-frequency data from all entrainment samples (Fig. 15) makes plausible the contention that the most significant reduction in vulnerability to entrainment occurs shortly after larvae attain a length of 5.0 mm. This may be related to the process of yolk absorption, which is completed at about this length (Auer 1982). The occurrence in entrainment samples of larval alewives in the size range 5.5-12.5 mm was sporadic, and gave no indication of a gradual diminishing of entrainment susceptibility following the most significant decline after 5.0 mm. Decreased susceptibility of larval alewives to entrainment at the Unit 3 intakes may also be related to fin ray formation in the caudal, dorsal and pectoral fins which occurs at lengths of 4.3 to 11.8 mm (Norden 1967).

Peak entrainment occurred most often at dusk (five of eight sampling periods), followed by night (two periods) and dawn (one period) (Fig. 16). Entrainment rates were consistently lowest during the day, suggesting visual cues at the intake may significantly affect the number of larvae that eventually become entrained.

An estimated 2.98×10^6 larval alewives were entrained at Unit 3 during 1981, which was 29.2% of the total number of larvae entrained. Yellow perch were the most often entrained larvae (31.8% of the total) followed by alewife (Table 28). The alewife loss for 1981 was an order of magnitude lower than estimates of alewife larvae entrained by Units 1 and 2 (23.4 million to 63.7 million) during 1977-1979 (Jude et al. 1980). In 1980, 169 million were entrained at Units 1 and 2, while 9.35 million were entrained in 1981 (Tables 25, 26). The difference in absolute numbers of larvae entrained, despite similar volumes of water pumped by Unit 3 and Units 1 and 2, suggests the intake design of

Unit 3 is more effective in limiting entrainment than Units 1 and 2. At Units 1 and 2 during 1977-1981 alewife larvae were the most frequently entrained species, ranging from 33 to 93% of the total number of larvae entrained. Relative importance of alewife larvae was lower at Unit 3 (29%), most likely because other species such as yellow perch and slimy sculpins were attracted to the riprap to spawn, while alewives were not.

The majority of larval alewives entrained by Unit 3 in 1981 were lost during June (2.29×10^6) while entrainment during July and August showed progressive declines, 581,000 and 108,000, respectively. The actual entrainment loss for larval alewives at Unit 3 in any year will be highly dependent upon the distributional patterns of the most vulnerable stages (5.0 mm TL or less for alewives). Location of the intakes at the 11-m depth was probably the most important factor minimizing entrainment of larval alewives during years when upwellings are frequent and intense. At these times, the distribution of larval alewives is primarily at depths of 6 m or less (Figs. 14, 17). It should be pointed out, however, that during years in which upwellings are less frequent or rare, the distribution of larval alewives is more widespread out to 15 m, and thus more newly hatched larvae would be exposed to the intake. In 1980, no upwellings were detected and densities of larval alewives at those stations we designated as representative of ambient conditions at the point of Unit 3 water withdrawal approximated 10 times their peak abundance in June 1981 (Jude et al. 1981a). Additionally, the general distribution of larvae to the 15-m depth was more common in 1980 compared with operational year 1981. Thus we believe that the actual number of larvae entrained in any year will depend somewhat upon the extent of upwelling in the area, which serves as a mechanism regulating the distribution of larvae relative to the position of the intakes.

24-h population and entrainment estimates--To place the 1981 entrainment losses at Unit 3 in perspective, Table 31 contrasts our 24-h entrainment estimates with our concurrent estimate of the larval fish population in the vicinity of the plant in the same 24-h period (see METHODS - ESTIMATION OF LARVAL FISH ABUNDANCE IN A SPECIFIED AREA OF LAKE MICHIGAN). Using the most conservative estimates of field populations on each date, the highest percentage of larval alewives entrained relative to field populations was 0.53%. Since these estimates only consider depths to 15 m or less, these percentages are likely exaggerated. Jude et al. (1978) have documented the presence of larval alewives to depths of 21 m, and it is likely that some alewife larvae are present in deeper water.

Although difficult to interpret, these data (Table 31) indicate that entrainment of mostly small larvae and escapement of some newly hatched alewife larvae and most larvae longer than

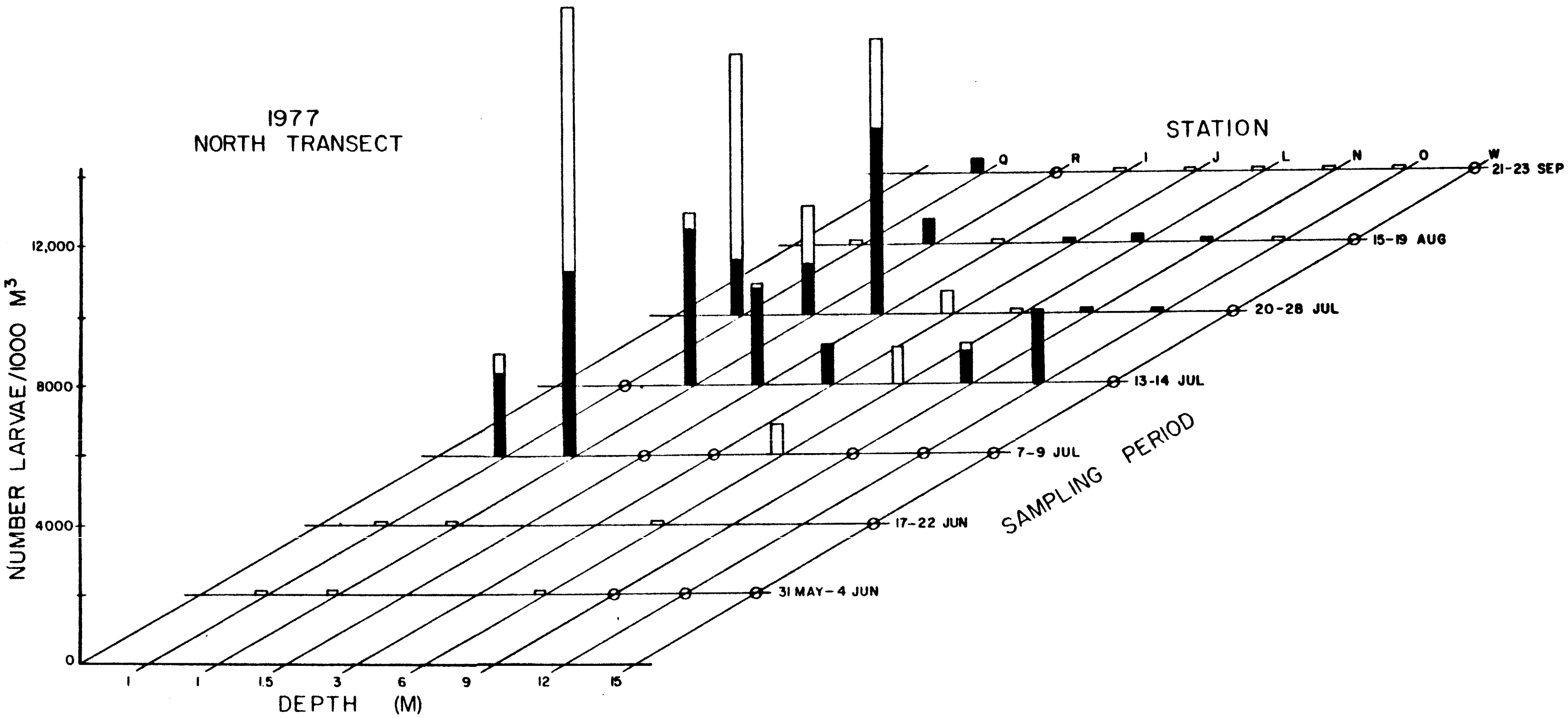
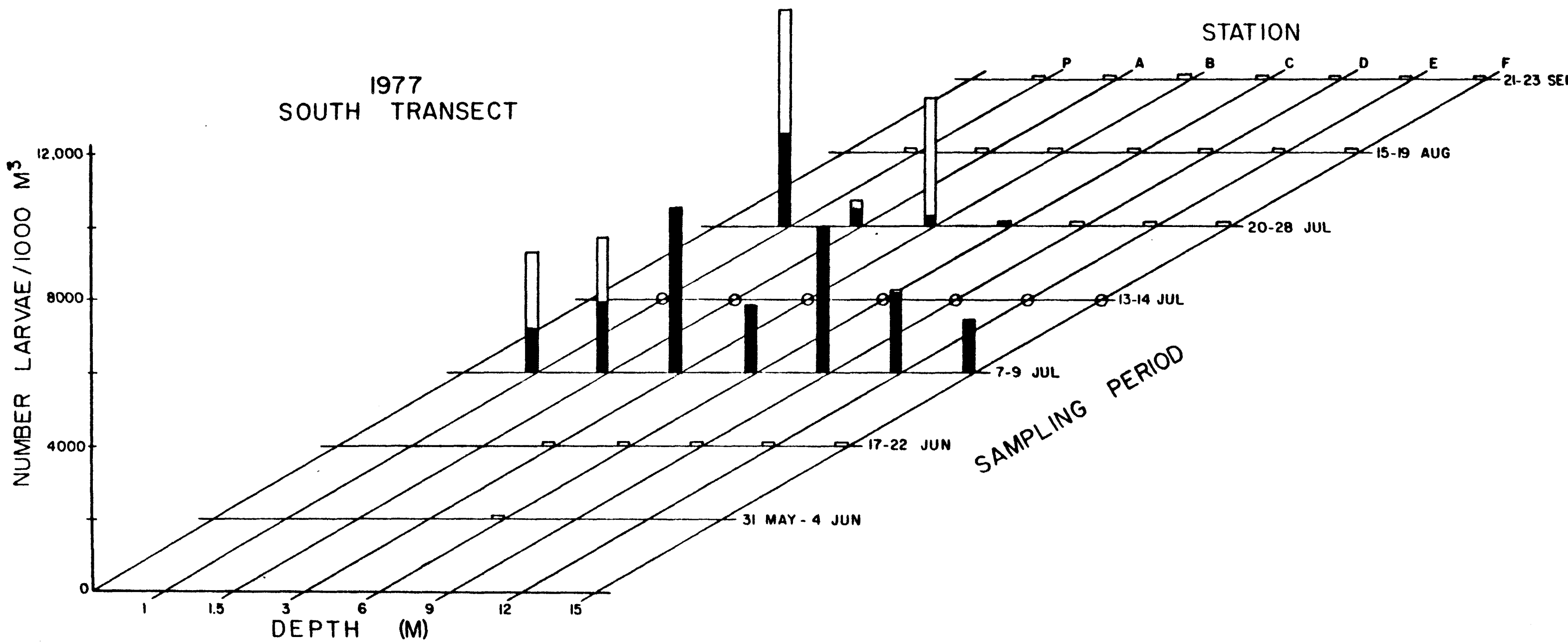


Fig. 17. Mean density (no./1000 m^3) of fish larvae (all species combined) at north and south transect stations in Lake Michigan near the J. H. Campbell Plant, 1977 to 1981. Mean densities were calculated by averaging densities over all gear (plankton nets and sleds), strata and diel periods (day and night) sampled. Darkened portions of bars represent mean densities of larval alewives. O = no sampling performed.



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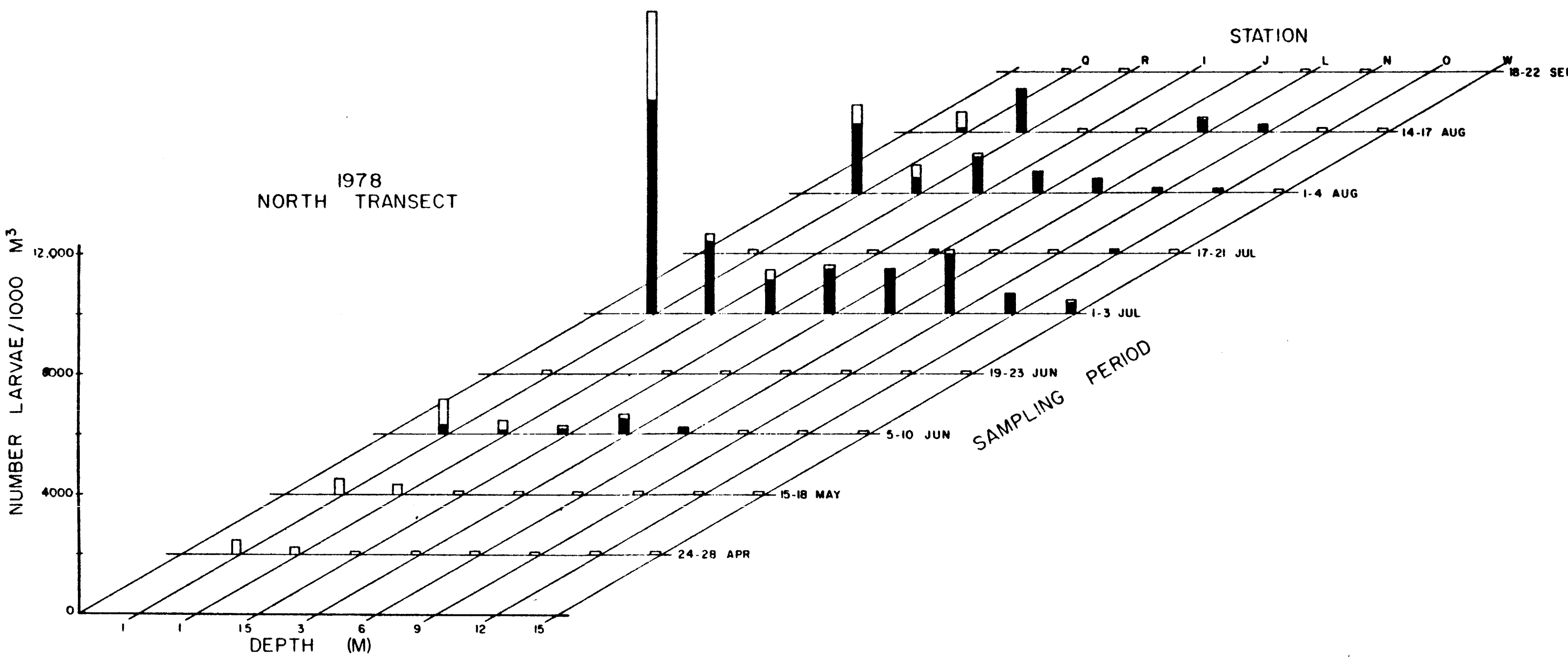

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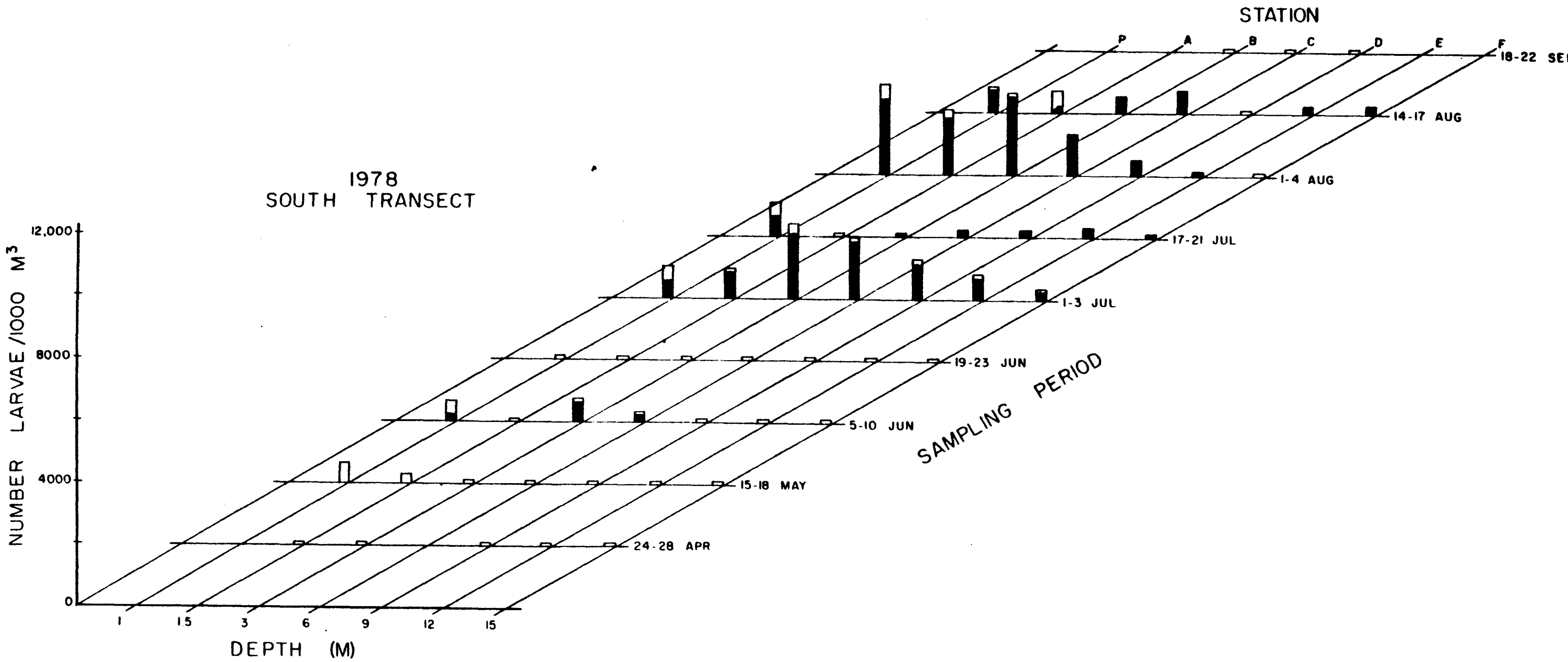

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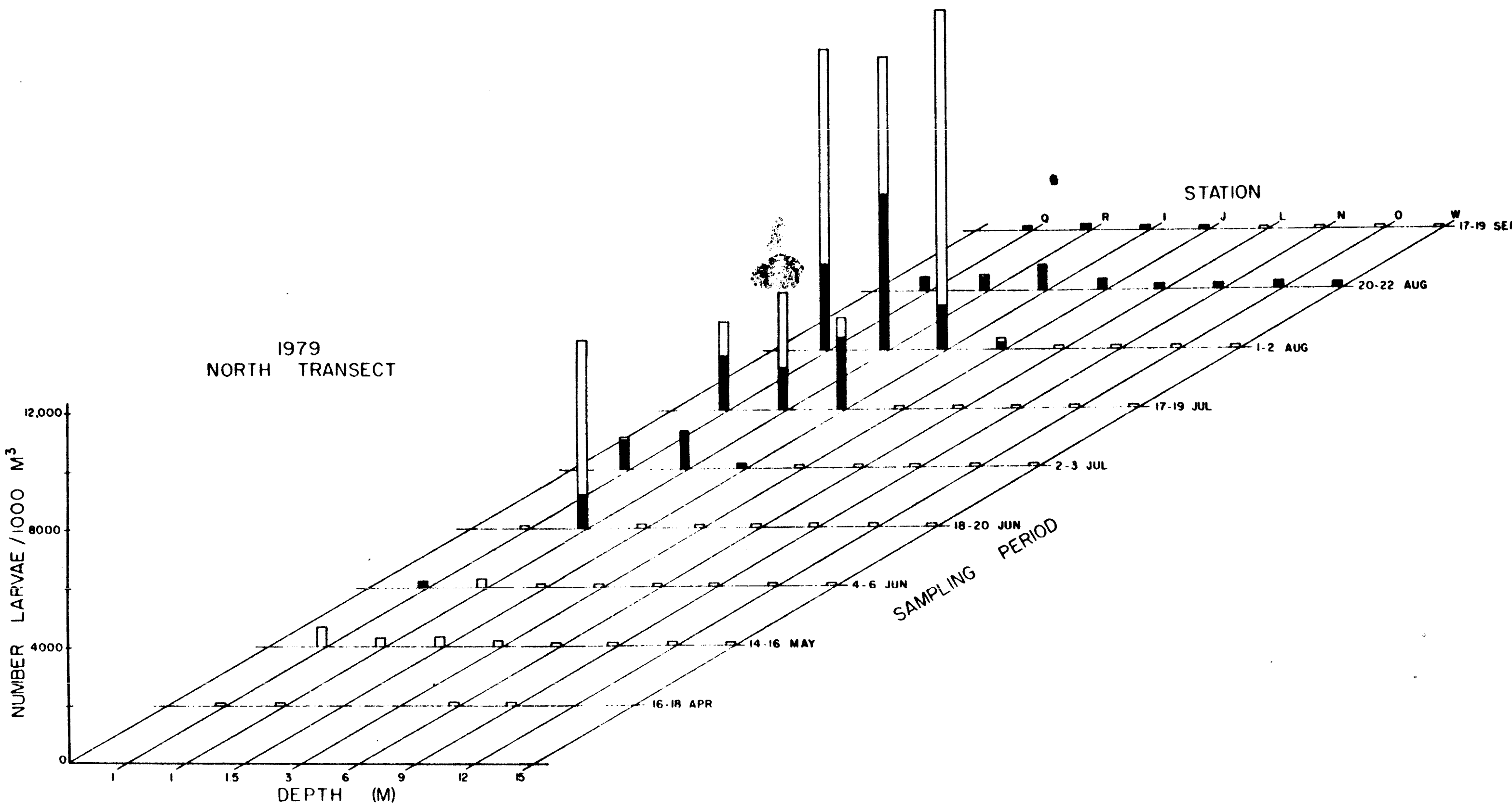

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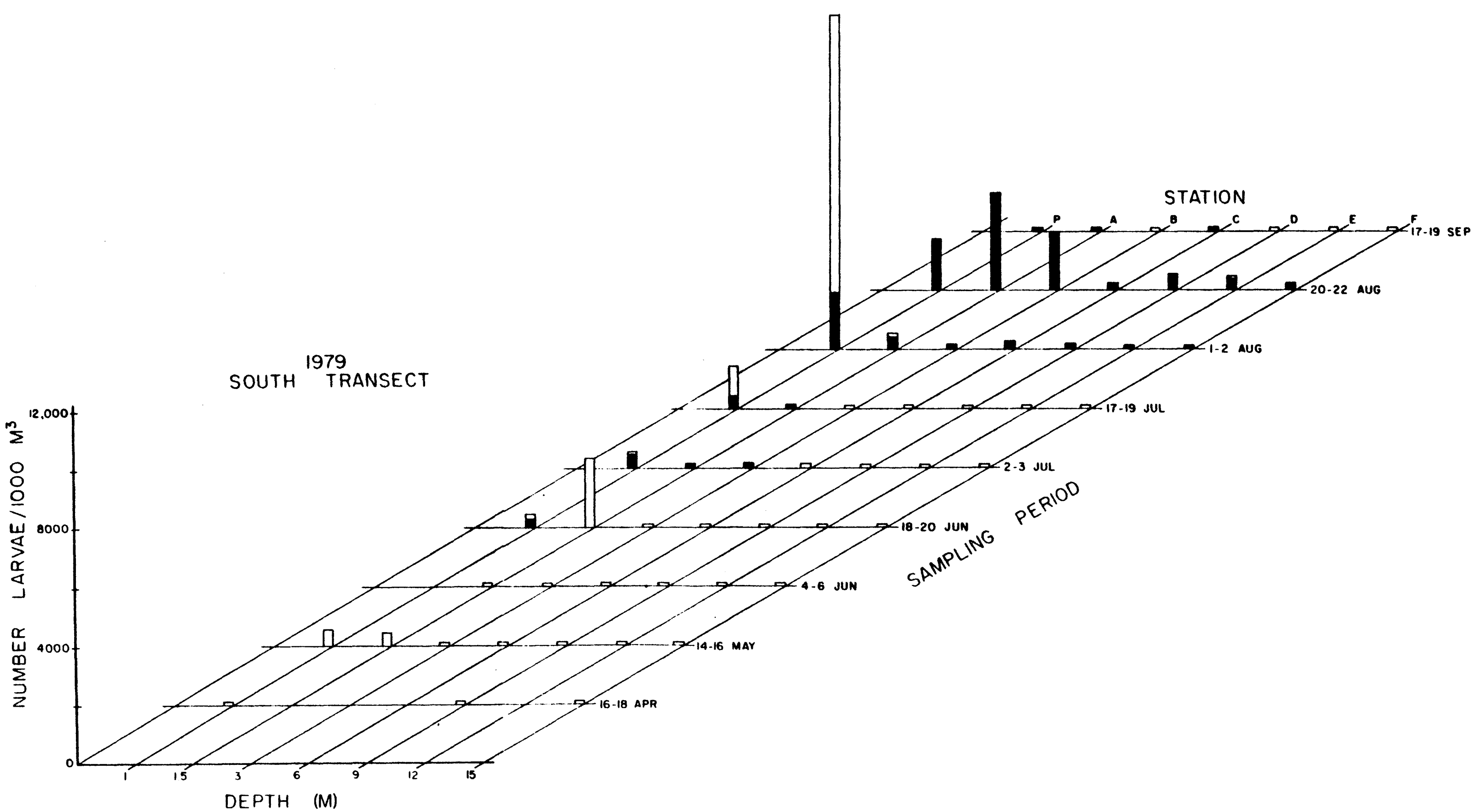

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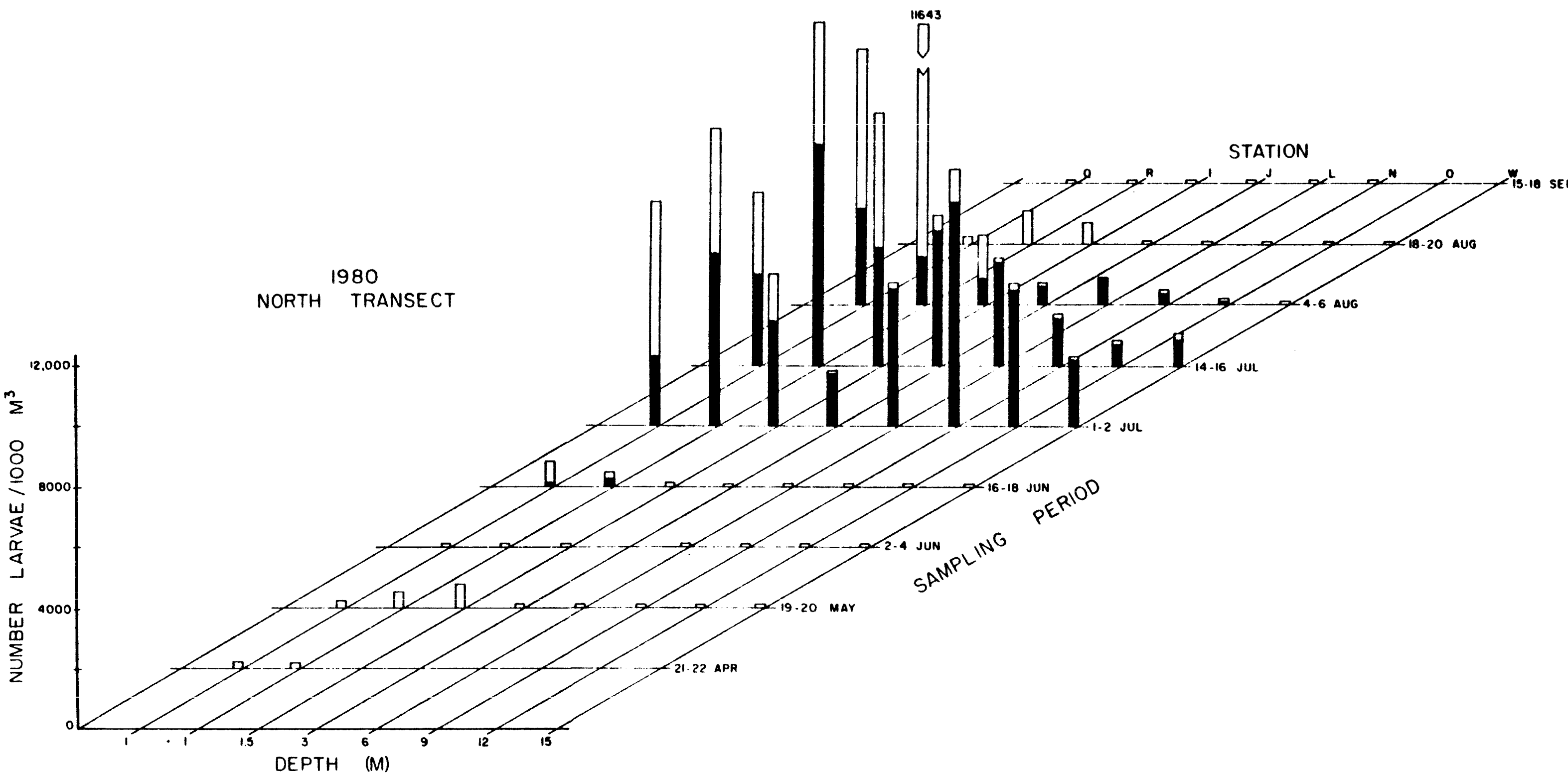

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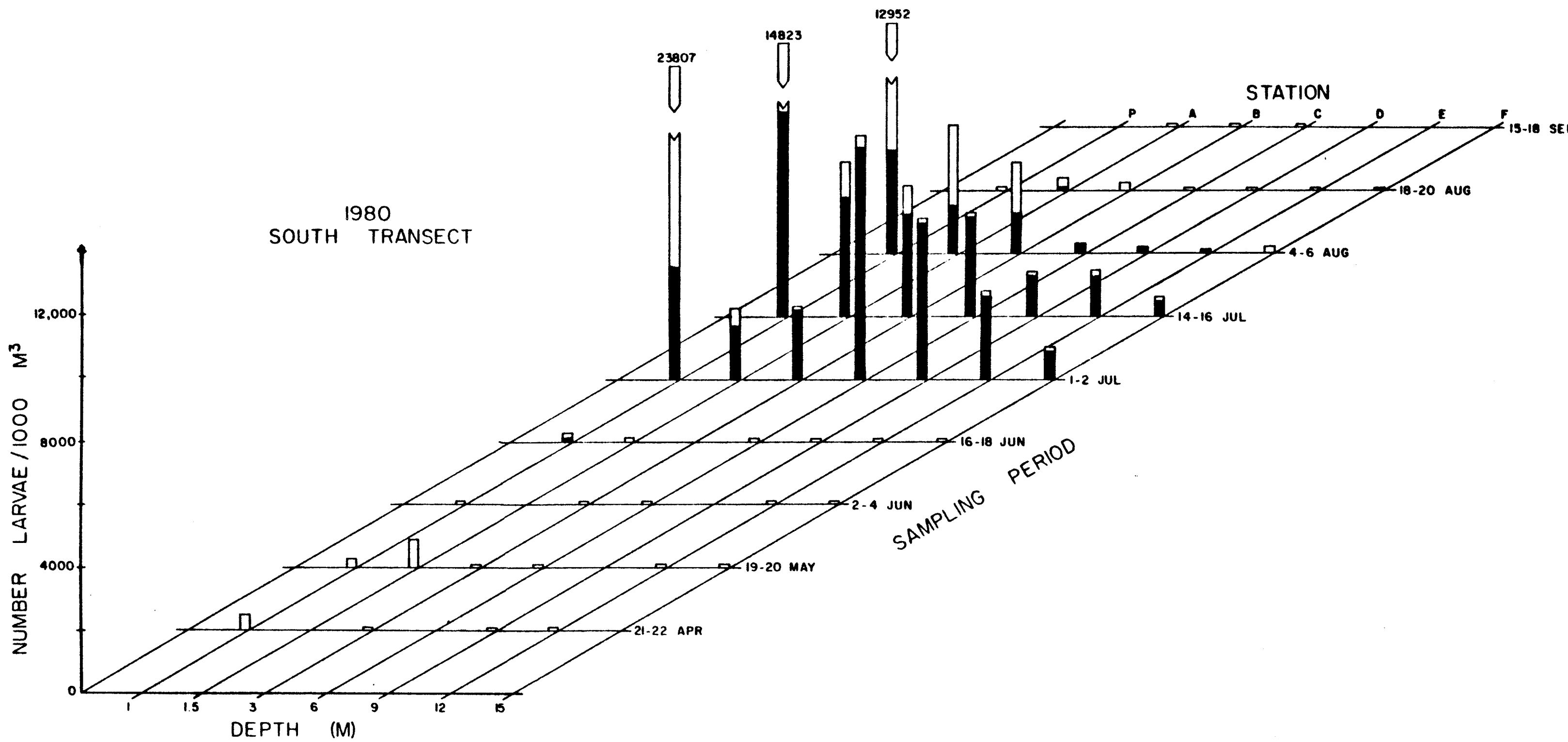

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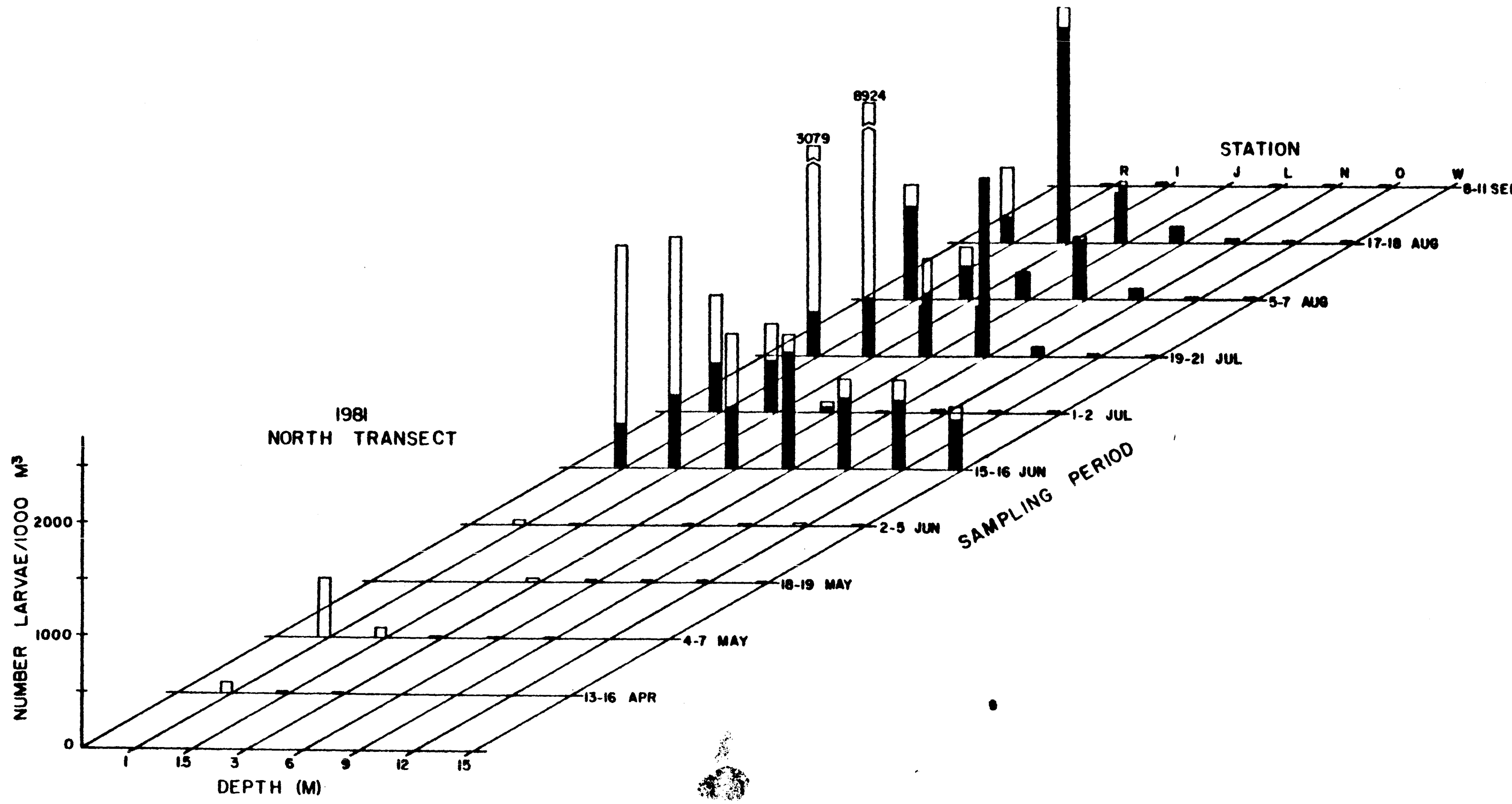

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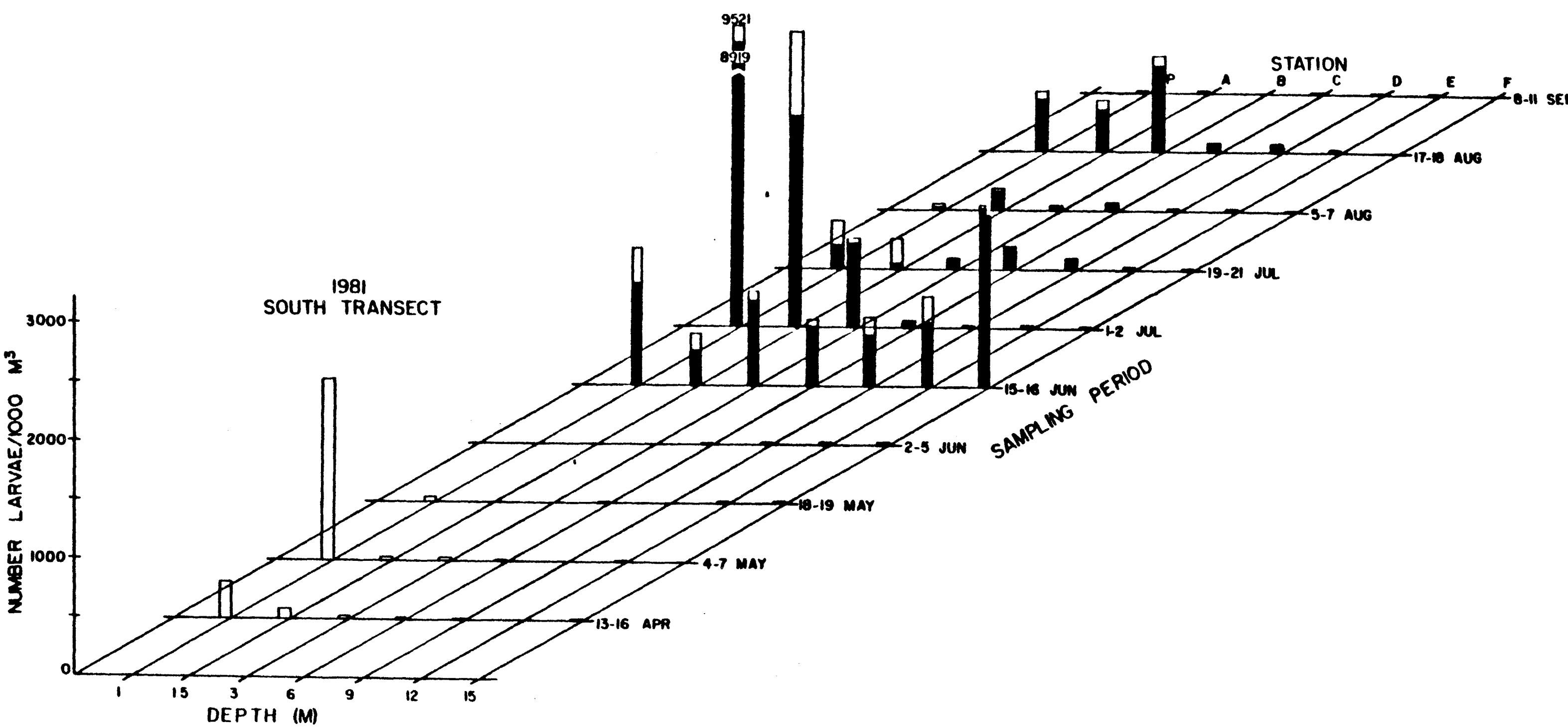

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10 mm will decrease impact of the plant because only a minimal proportion of the larval alewife population in the area is entrained. Larger larvae (12.5 mm or greater), which have survived highest mortality, do not appear to be removed from the population. Although we observed sporadic entrainment of larval alewives in the size range 5.5-12.5 mm, the major size group impacted appeared to be newly hatched larvae 5.0 mm or less.

Young-of-the-Year--

The first YOY recruited to our adult and juvenile fishing gear were 11 fish in the 20- to 30-mm length intervals (Fig. 18). These fish were collected in July with seines at both the reference and plant beach stations. By August fish in modal length intervals of 30 and 40 mm were collected in large numbers (over 6000 fish) at beach stations, with disproportionately higher numbers (over 90%) caught at the reference station. Most were seined during the day. Only one YOY was trawled, attesting to the nearshore distribution of this alewife life stage.

In September YOY were in the 50- and 60-mm length intervals. Interestingly, only 6 fish were seined, while trawls at 6- to 12-m stations captured over 500 fish, documenting the offshore movement of YOY. Most fish were trawled at night. These data and our previous studies have shown that the largest YOY move offshore earlier in the season than smaller YOY.

Fish were about 50 to 70 mm in October; again none were caught in the beach zone. YOY were trawled almost exclusively during the day at 6- to 12-m stations, a pattern also noted by Brandt (1980), who attributed this to vertical migration upward at night and to the bottom during the day. Almost twice as many alewives were collected at the plant transect as at reference stations. The offshore migration by YOY was well under way by October.

November was the month of maximum YOY catch when over 33,000 fish were collected. Only 149 were seined; most of the remaining fish were trawled during the day from 3- to 12-m stations. Almost three times as many YOY were caught at 6- and 9-m north transect stations as were caught at the comparable reference stations.

Because of cold inshore temperatures in December most YOY were farther offshore than our deepest station (12 m). Only 14 fish were collected, most trawled at night at our 6- to 12-m stations.

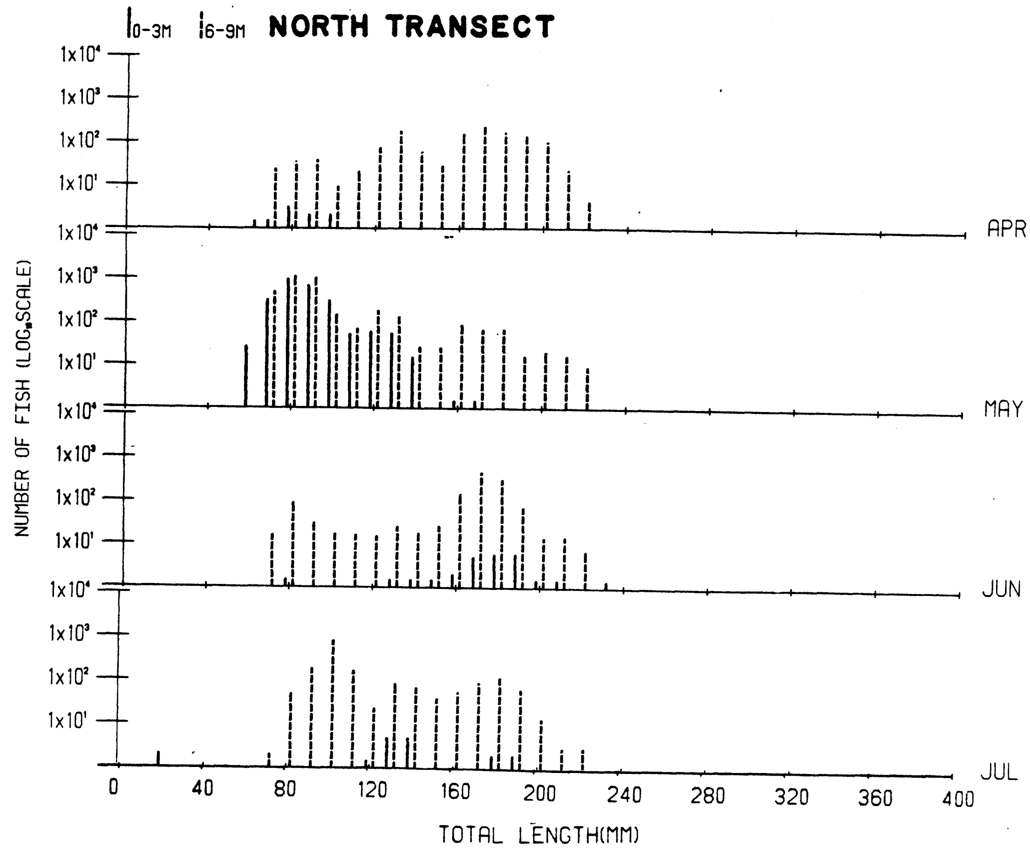
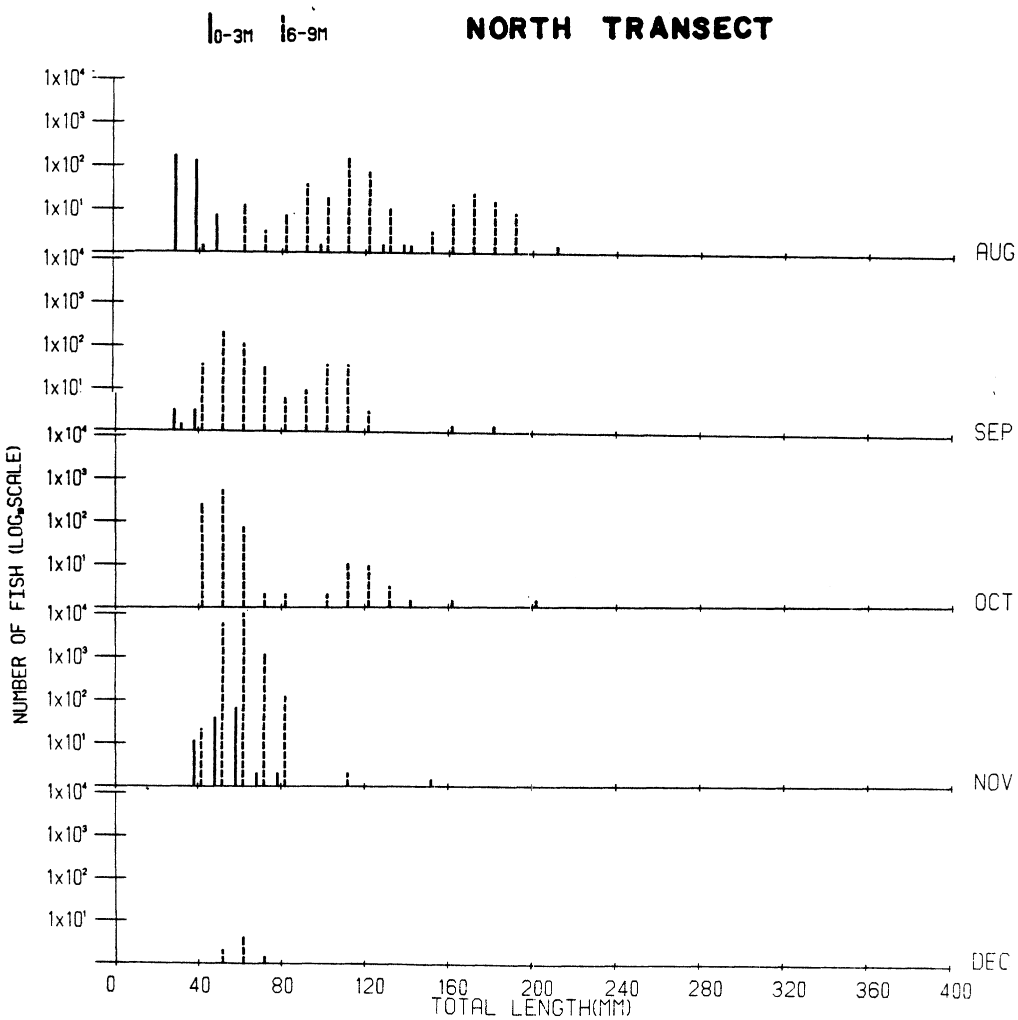


Fig. 18. Length-frequency histograms for alewives collected during April - December 1981 at the north and south transects. Stations were combined into two groups for the north transect: beach and 3 m; 6 and 9 m and into three groups for the south transect: beach, 1.5 and 3 m; 6 and 9 m; and 12 m. Diel periods and gear types were pooled.



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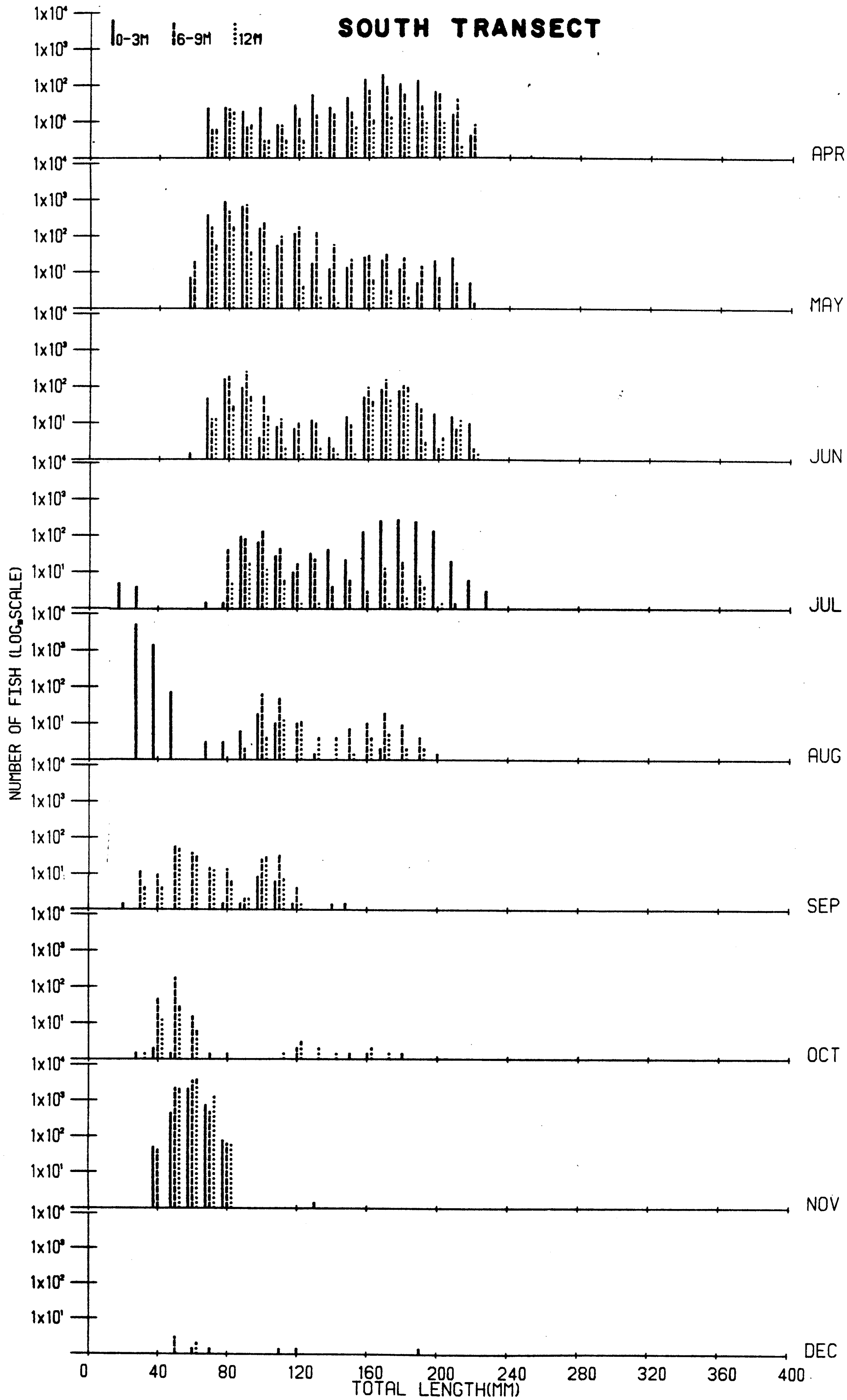


Fig. 18. Continued.

Yearlings--

Yearling alewives are usually pelagic and reside far offshore; we seldom catch large numbers during our netting activities. However, during 1981 we found yearlings were a major component of the catch from April through September. Comparable numbers were collected from both transects.

In April we collected over 250 yearling alewives in about equal numbers during the day and night. Fish were in the 60- to 100-mm length intervals (Fig. 18), and the vast majority of fish were trawled at 3- to 12-m stations. Less than 10 fish were caught in gill nets and seines.

May was the month of maximum catch when over 6000 yearling alewives were collected. Almost twice as many fish were caught during the night as during the day. Trawls fished at 3 to 12 m accounted for most of the catch, while gill nets caught very few. Seines collected approximately 1900 fish at beach station R (plant) while only about 400 were taken at reference beach station P.

In June about equal numbers of fish were collected during the day and night, but catches were down considerably from the peak May catch. Fish again were in the 60- to 100-mm range and almost exclusively collected with trawls. None were seined and only a few were gillnetted in surface nets. At trawling stations fish were collected in numbers ranging from about 20 at station L (6 m, north) to 400 at station D (9 m, south). Some fish were trawled at all stations indicating a widespread distribution at that time. Again collection of this many yearlings is somewhat surprising, since most reside farther offshore. Apparently 1981 was a favorable year for yearlings, or the hypothesis advanced by Crowder and Magnuson (1982) of bloaters "forcing" alewives more inshore may be supported by our data.

Fish collected in July were mainly in the 80- to 110-mm length intervals, with all but 7 of the over 1500 fish collected during the day. Trawls accounted for virtually all fish collected, with hauls at plant station L (6 m, south) the highest among stations with over 80% of the total catch. The warm water or currents may have attracted fish to this station. Catches were modest at all other stations, but a strong presence of yearlings was established from 3 to 12 m in the vicinity of the plant during July.

Catches of yearlings were considerably reduced in the remaining 3 mo, August - October. Fish caught were in the 80- to 120-mm length intervals. In August more were caught at night than during the day, and trawls, with highest catch again at plant station L (6 m, north), dominated total catch. By

September, the yearling catch was reduced below what was observed in August; day-night catches were similar. Trawls accounted for most of the catch which came from 12-m station E (reference transect) and 6-m station L (plant). A few were seined and caught in surface gill nets. In October only about 30 yearlings were caught. They were in the 70- to 120-mm length intervals and were almost exclusively trawled during the day at plant station N (9 m, north). In November and December only three and two fish respectively were collected, some by trawl, gill net and seine. Most fish resided in deep water outside our study area by this time.

Adults--

The proportion of our catch made up of adult fish has remained relatively consistent over the years of our study. In 1981 adults were approximately 11% of the catch (about 7000 fish), substantially higher than the previous years' catches which ranged from 3180 to 4858 adult alewives in 1977 - 1980 (Jude et al. 1981a). Since total catch of alewives was also higher than previous years' total alewife catch, it is to be expected that the adult component of the catch would also be high. The 1981 seine catch (10,009) was intermediate among values from 1977 - 1980, while surface and bottom gill net catches were comparable to previous years' catches. The big change occurred with trawls which collected 49,164 fish, almost 13,000 more fish than trawls had obtained in 1978, the year of peak trawl catch. As noted, a large component of the catch was yearlings (approximately 17%), while YOY dominated with 72% of the catch.

Adults were roughly defined as fish larger than 104 mm from April through June, then larger than 124 mm for the remainder of the year (Fig. 18). In April, the first sampling month, roughly equal numbers of adults were caught during the day and the night. April through August were months of peak catches; thereafter very few adults were caught in the study area. Most adult alewives collected in April were in 160- to 200-mm length intervals. They appeared to be concentrated in inshore waters (≤ 9 m) as highest trawl and bottom gill net catches were observed at 3- to 9-m stations. Alewives usually make pre-spawning runs into inshore waters as soon as temperatures there rise above 4 C.

In May, adult fish were smaller than the majority of those caught in April. The larger individuals usually lead the inshore migration. More fish were caught at night. Fish were again concentrated in 3- to 6-m water as was demonstrated by trawl catches. A number of fish were gillnetted, including 137 fish caught in surface gill nets only at night. Alewives are known to perform diel vertical migrations and are collected in higher numbers in our surface nets at night as a result.

Spawning probably began in earnest in June as gonad data (Table 38) showed a large number of males, and a few females were ripe-running. Many of the remaining fish had well developed gonads and a few were already spent. Larval fish data (see RESULTS AND DISCUSSION, Alewife, Larvae) showed that mid-June and early July were times of peak alewife larvae abundance, which corresponds well with our juvenile and adult fish findings. The modal (those most frequently caught) length intervals of adults were 170 and 180 mm. Fish caught were in the 120- to the 230-mm intervals. Adults were found at all stations sampled, with peak trawl catches observed at station L (6 m, north); a similar finding was observed with gill net data. Since the currents of the Campbell Plant discharge and the heated water effluent influence the fish in the vicinity of our stations, this may account for the congregation of adults in this area. We observed many adults during our scuba dives on the intake structures. Highest catches were observed at night. Gill net catches at the south reference transect were highest at the 3-, 6- and 12-m stations. As noted, far higher catches were recorded at the plant transect at both 6- and 9-m plant stations. More fish were also seined at the plant beach station when compared with the reference station.

In July, most alewives we collected were in the 170- to 190-mm length intervals; twice as many were caught during the day as at night. The largest number of adults (about 1000) were trawled at 3 m during the day. They were presumably inshore because of warmer water temperatures and spawning activities. Very few (<40) were captured at all other trawling stations, except for about 300 (all during the day) at plant station L (6 m, north). A few alewives were seined at beach stations, most at the south transect. Gill net data confirmed trawl catch trends, as highest numbers were caught at the 3-m station. Catches were highest at night. A few adults were observed in surface gill nets, and again nocturnal vertical migratory behavior by alewives was responsible for the exclusive night catches.

August was the last month that large numbers of adult alewives were noted in our gear. Some spawning was still continuing as attested by gonad data (Table 38) and the presence of some newly hatched larvae (see RESULTS AND DISCUSSION, Alewife, Larvae). No adults were collected in the beach zone. Bottom gill nets contained the highest number of fish, over 100. Trawls (about 38 fish) and surface gill nets (about 20 fish) accounted for the remaining adults captured in the study area. Among gill net stations, catches were highest at 6 and 9 m, on both transects. None were collected at 12 m.

In remaining months catches of adult alewives declined precipitously, as they moved to deeper water. This offshore movement appeared to be complete by September as only four adults

Table 38. Monthly gonad conditions of alewives caught during 1981 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Males	Slight development	159	182	55	101	41	21	18	2	
	Mod. development	169	133	238	86	8		1		
	Well developed	2	27	194	11	1				
	Ripe-running			16						
	Spent	1	2	40	40	20				
Females	Slight development	161	61	6	37	33	9	13		
	Mod. development	316	119	34	75	3	1		2	
	Well developed	1	56	82	47	1				
	Ripe-running			6		3				
	Spent	2	2	5	31	8				
Immature			3	12	18	23	7		1	
Unable to distinguish		10	23	11	3	14	4			

were collected in our fishing at 1.5- to 12-m stations. All fish collected were taken in bottom gill nets. By October only 15 were present in our catches; 11 were trawled at 9- and 12-m stations, while remaining fish were caught in bottom gill nets at 1.5- and 9-m stations and surface gill nets at 6-m stations. In November and December only one fish per month was caught in a trawl and gill net respectively.

Temperature-Catch Relationships--

Examination of what temperatures various size groups of alewives were most frequently collected at showed that over 46% of all fish we collected in trawls, seines and gill nets were obtained in the 11 C temperature interval (includes fish caught at 10 to 11.9 C). A large majority of these fish were collected in the spring when this water temperature was the warmest available in that area of the lake. The next largest group of fish was collected when temperatures were 16 to 17.9 C; many of these were YOY. Most YOY were collected at two temperature ranges (10 to 11.9 C and 16 to 17.9 C). A large group was also collected at higher temperatures, from 17 to 24 C, a reflection of their usual residence in warm beach zone waters. Yearlings were collected in a wide range of temperatures; one peak occurred from 4 to 13.9 C, while another was predominant from 16 to 23.9 C. Adults also showed two modes where they were most often caught, one at 4 to 13.9 C and another at 16 to 23.9 C. Alewives generally respond to the warmest temperatures available by concentrating in these areas. Some of the increased catches noted at plant stations may be a reflection of this preference. Maximum catches of alewife by temperature interval in individual gear generally followed the same trends as was seen for pooled gear catches. One exception was the seines, where 64% of the catch (all YOY) was caught at 16-17.9 C in this gear. Surface gill nets also had a relatively high proportion of the catch (64%) caught in one temperature interval, 18 to 20.9 C.

Rainbow Smelt

Introduction--

Rainbow smelt migrate inshore to spawn in spring. Near the J. H. Campbell Plant, smelt spawning generally starts around mid-April, reaches a peak by the end of April, and ends around mid-May. Smelt spawning may take place along shores of lakes or in streams. Most smelt larvae collected in the study area probably originated from shore spawning, as no smelt spawning run was observed in tributary streams in the vicinity of the J. H. Campbell Plant. Rainbow smelt was the most abundant species collected in trawls, gill nets and seines during 1979 and 1980, but smelt larvae were less abundant than those of alewife, spottail shiner and yellow perch. Smelt larvae are 5 mm at hatching. They are pelagic and widely dispersed in the study area, except during the early hatching season when they were concentrated in the shallow area. They were commonly found from 6 to 15 m from June to September. Entrainment of smelt larvae by the Unit 3 intake, which is located at the 11-m depth contour, may be influenced by the distributional patterns of these larvae in the deeper part of the study area.

Larvae--

Seasonal distribution--

May--During 1981 smelt larvae first occurred in the study area during 4-5 May. During 1978-1980 smelt larvae were first collected around mid-May (Jude et al. 1979a, 1980 and 1981a). This slight difference in the timing of first smelt larvae hatching may be due to difference in water temperature during spring. On the north transect most larvae were collected at 1 and 1.5 m (Fig. 19). Low numbers of smelt larvae occurred at 3 and 9 m, while none were found at 6, 12 and 15 m. Highest density (990 larvae/1000 m^3) was observed at the 1-m station. On the south transect smelt larvae occurred from 1 to 3 m, but were not found in water deeper than 3 m (Fig. 19). Highest density at the south transect (3755 larvae/1000 m^3) was observed at 1 m. Since water temperatures were higher in the shallow areas than at deeper stations during spring (Appendix 5), larvae collected during 4-5 May probably hatched in shallow areas. During 1978 and 1980, smelt larvae were also most abundant in shallow water when they first hatched (Jude et al. 1979a, 1980, 1981a). Larvae may, however, quickly disperse to deeper water as has been found at the south transect during 15-16 May 1979. Distributional patterns observed during 4-5 May 1981 (Fig. 19) suggested that similar dispersal was taking place during this sampling period.

Mean density of smelt larvae was 45 larvae/1000 m^3 for the north transect and 147 larvae/1000 m^3 for the south transect. During May 1978 smelt larvae were slightly more common on the south transect (19 larvae/1000 m^3) than the north transect (11 larvae/1000 m^3). During May 1979-1980 more smelt larvae were caught at the north transect than at the south transect (Jude et al. 1981a). Differences in abundance of smelt larvae between the two transects during May may be due to differences in timing of the first hatching and in larva dispersal from the beach zone. Vertical-diel distribution of smelt larvae varied considerably during May. On the north transect smelt larvae were found mostly in the upper strata and were more common at night than during the day (Fig. 19). On the south transect larvae occurred more commonly during the day than at night and showed no preference for any stratum. Smelt larvae exhibited no consistent pattern of diel vertical distribution during May 1978-1980. All smelt larvae collected during 4-5 May 1981 were newly hatched with a mean length of 5.3 mm (range 4 to 6.5 mm) (Fig. 20).

During 18-19 May smelt larvae were scarce in the study area (Fig. 19). Only one smelt larva (6.8 mm) was collected on the north transect. Two larvae (5.5, 6.5 mm) occurred on the south transect. Upwellings of cold water (6.3 to 9 C) during 18-19 May probably caused smelt larvae that hatched during 4-5 May to move to other areas. While newly hatched smelt larvae were abundant by mid-May during 1978-1980 (Jude et al. 1981a), very little hatching occurred in the study area around mid-May 1981. Low water temperatures may have delayed smelt hatching.

June--Smelt larvae were more common during 2-5 June than during late May. On the north transect they occurred from 6 to 15 m, in densities ranging from 16 to 80 larvae/1000 m^3 (Fig. 19). On the south transect smelt larvae were found from 9 to 15 m. Mean density during early June was 7 and 10 larvae/1000 m^3 for north and south transects respectively. Low densities of larval smelt (2 to 13 larvae/1000 m^3) were also observed during early June 1978-1980 (Jude et al. 1981a).

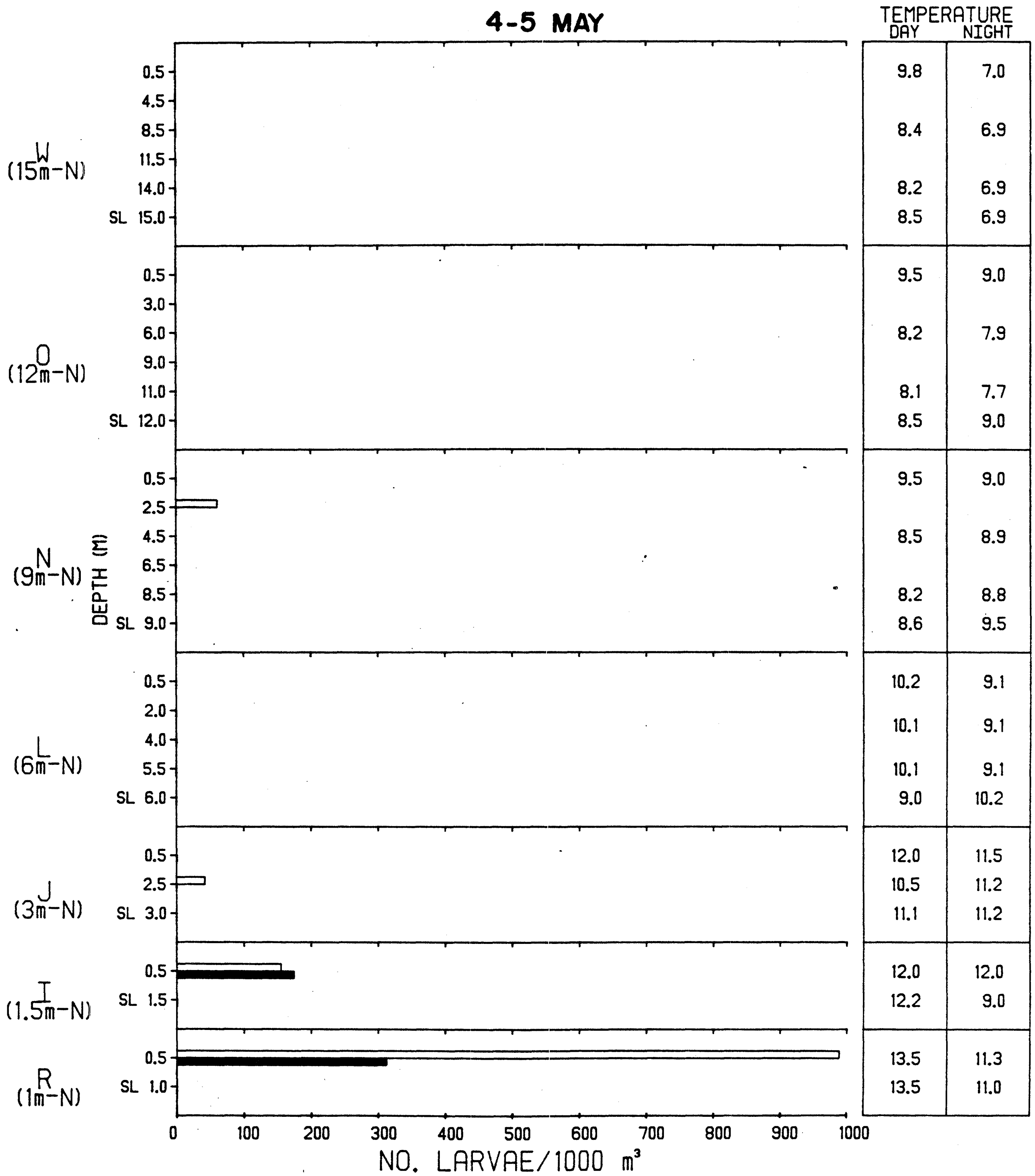
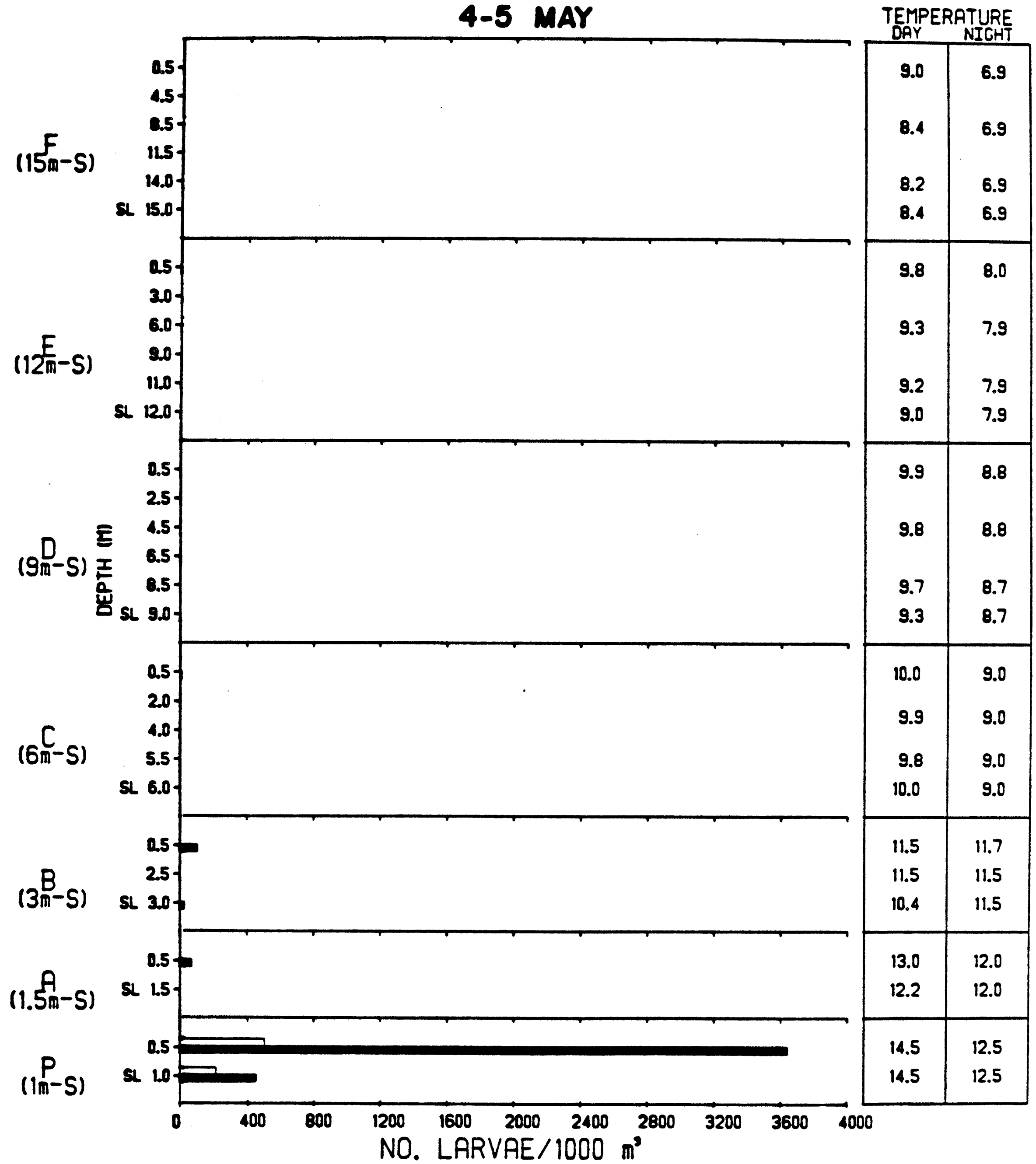


Fig 19. Density of larval rainbow smelt (no./1000 m^3) at north and south transect stations near the J. H. Campbell Plant, eastern Lake Michigan, April to September 1981. ☐ =day ■ =night, SL=sled.



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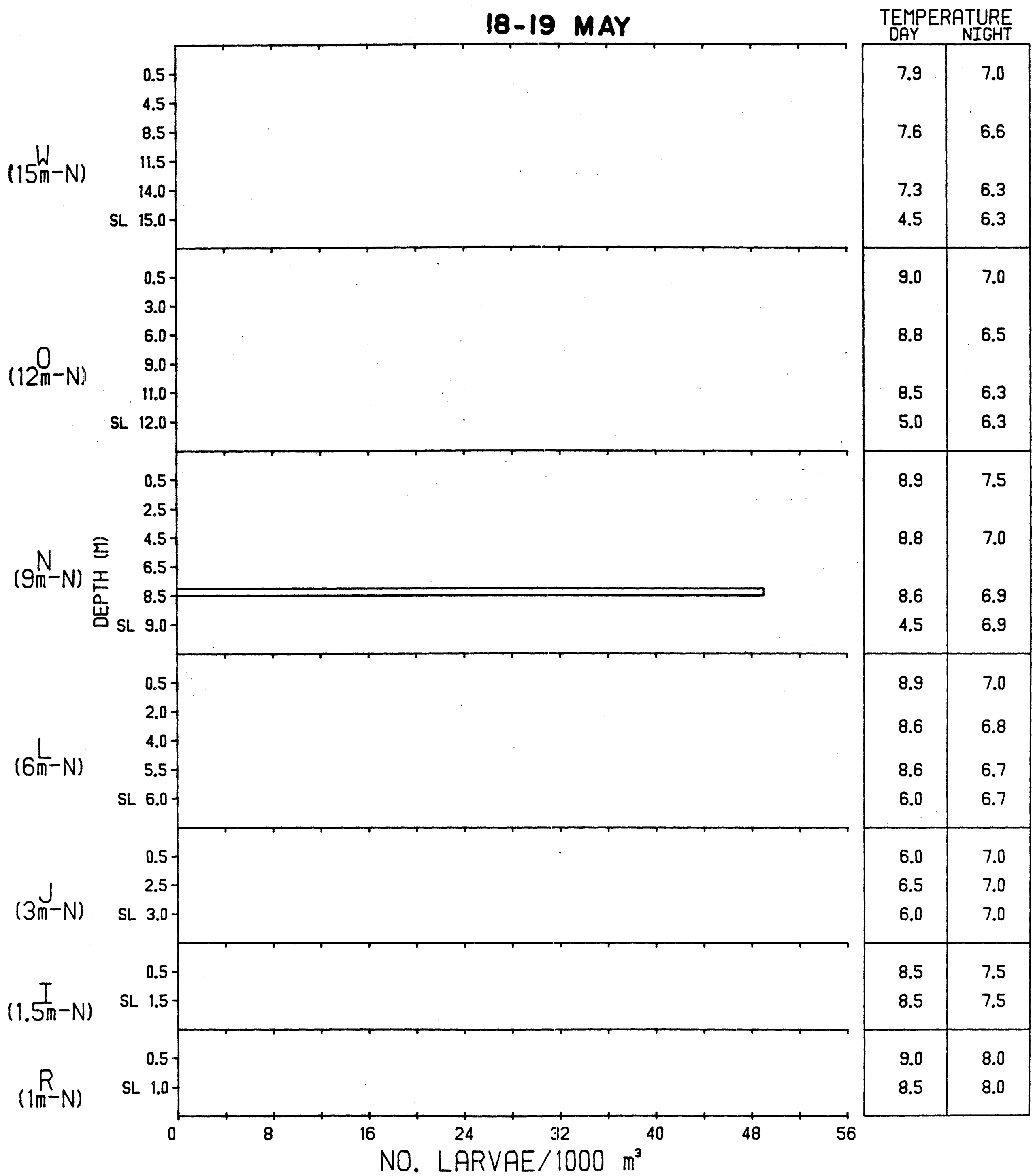

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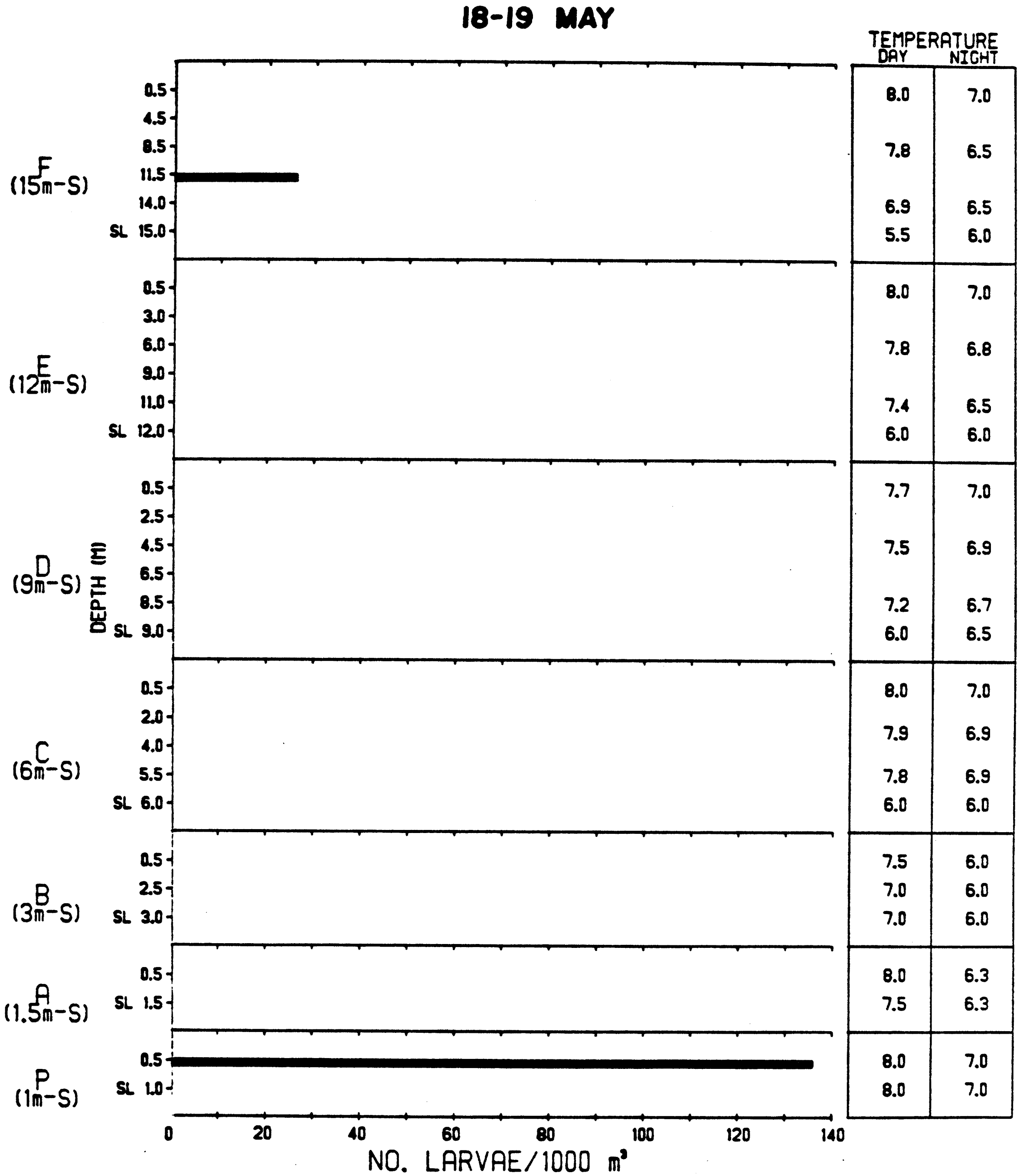

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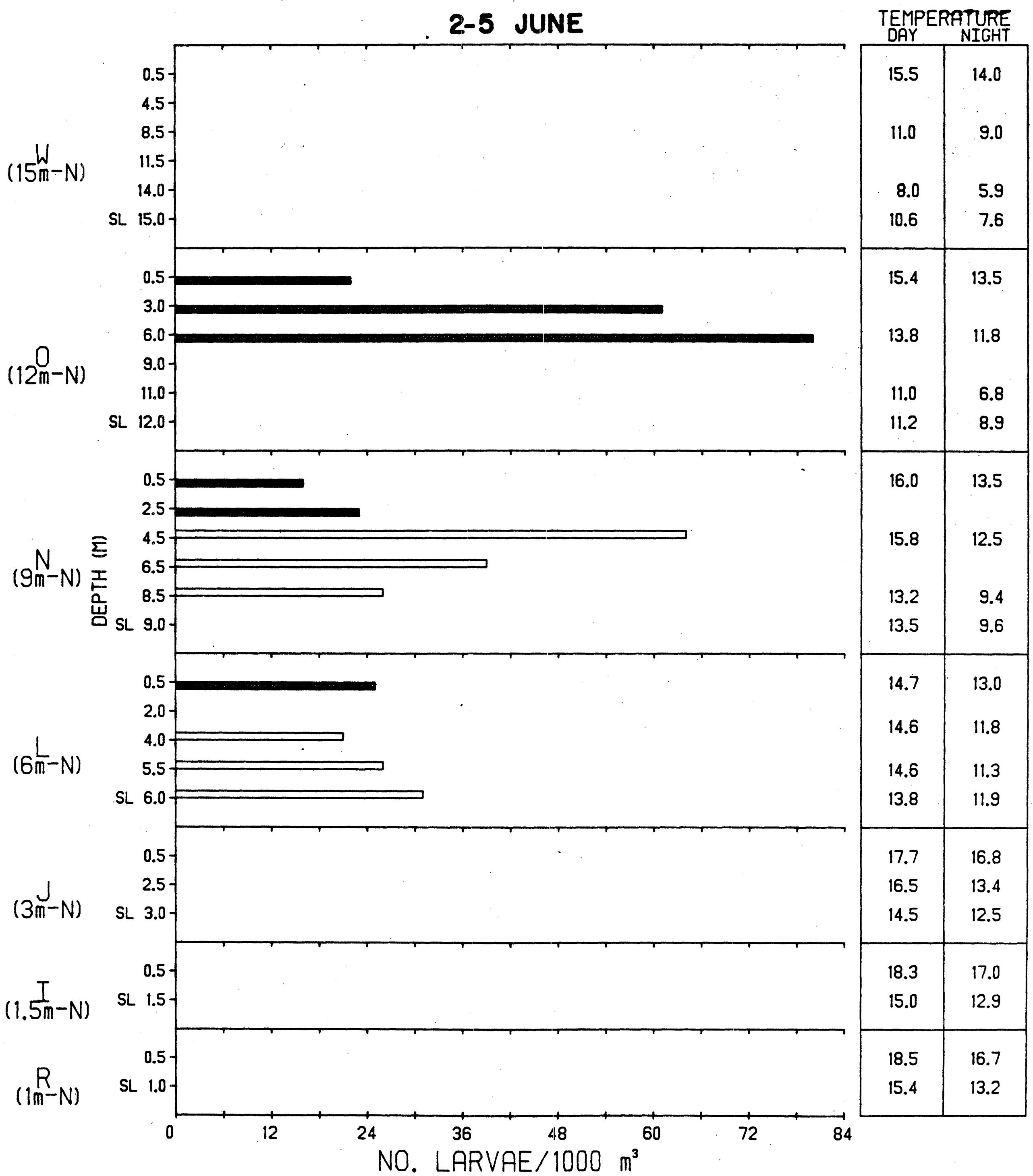

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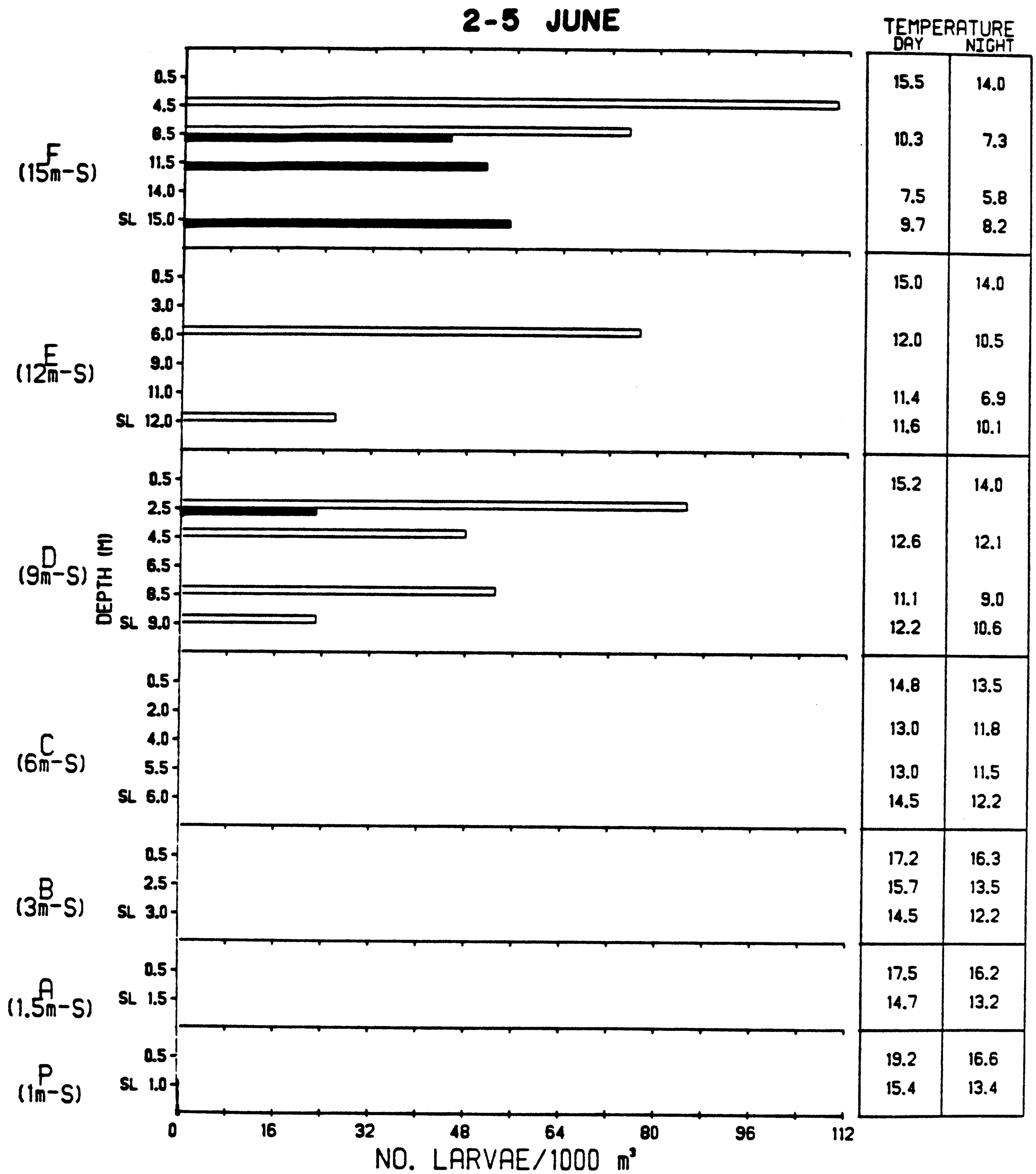

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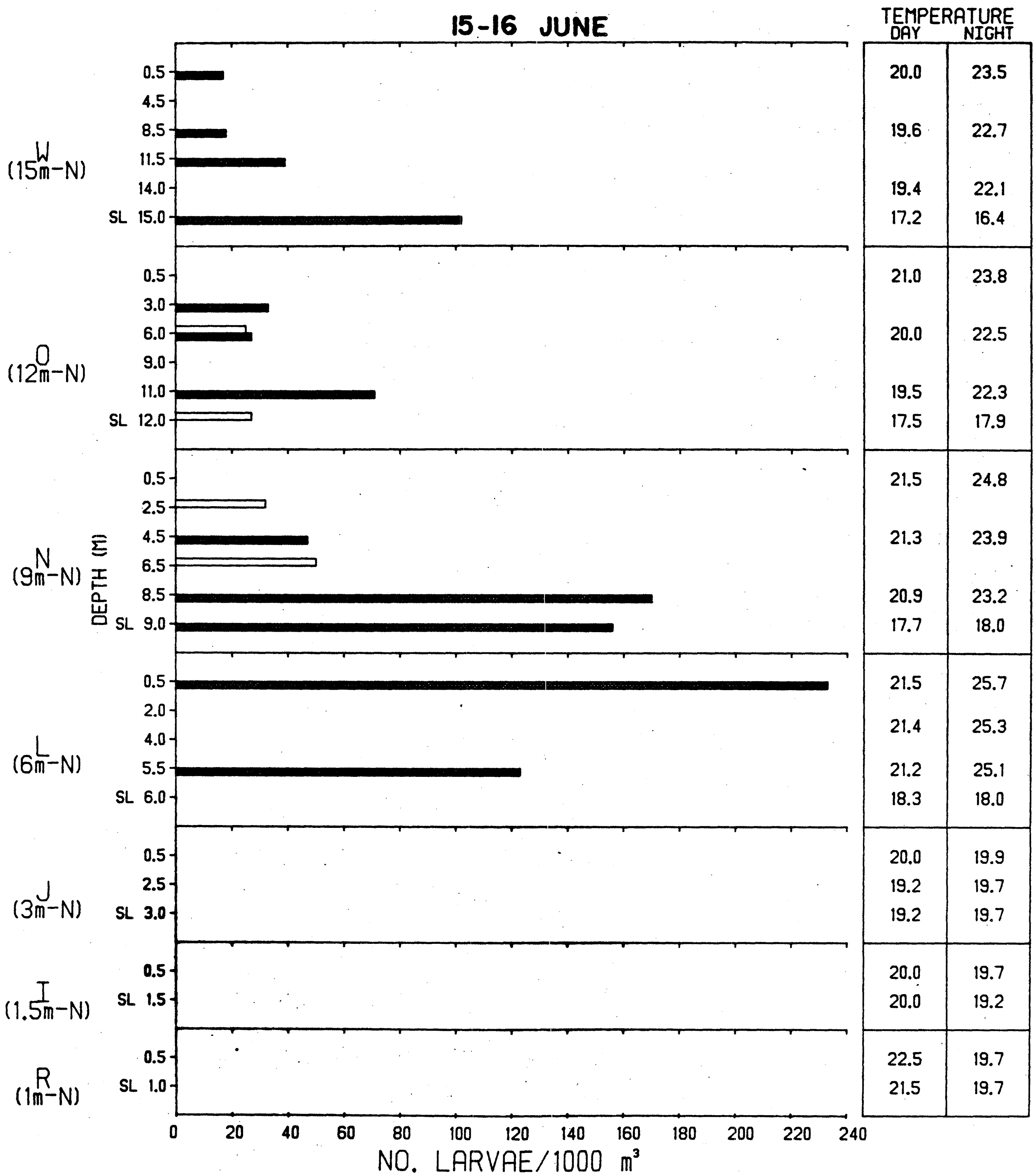

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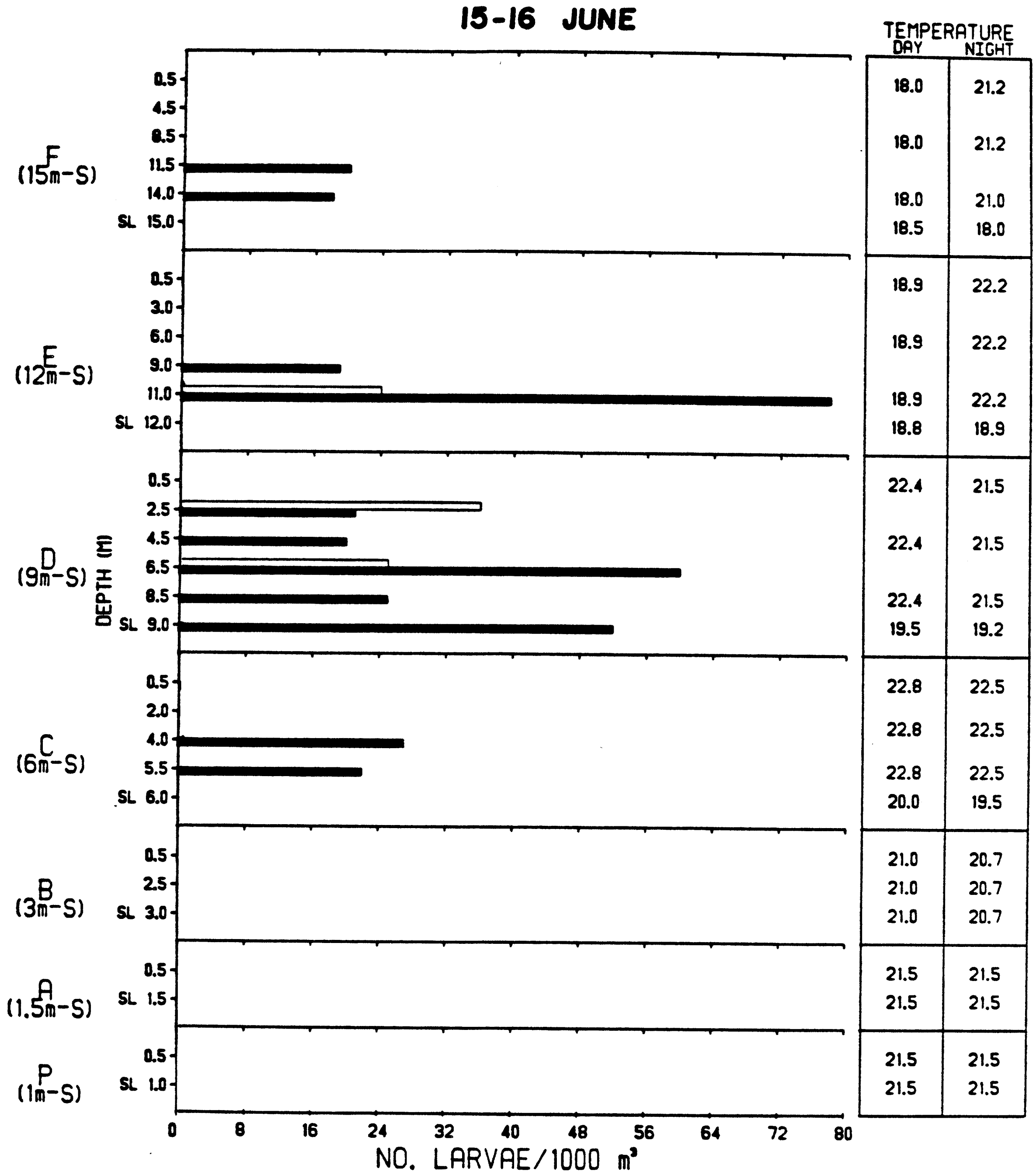

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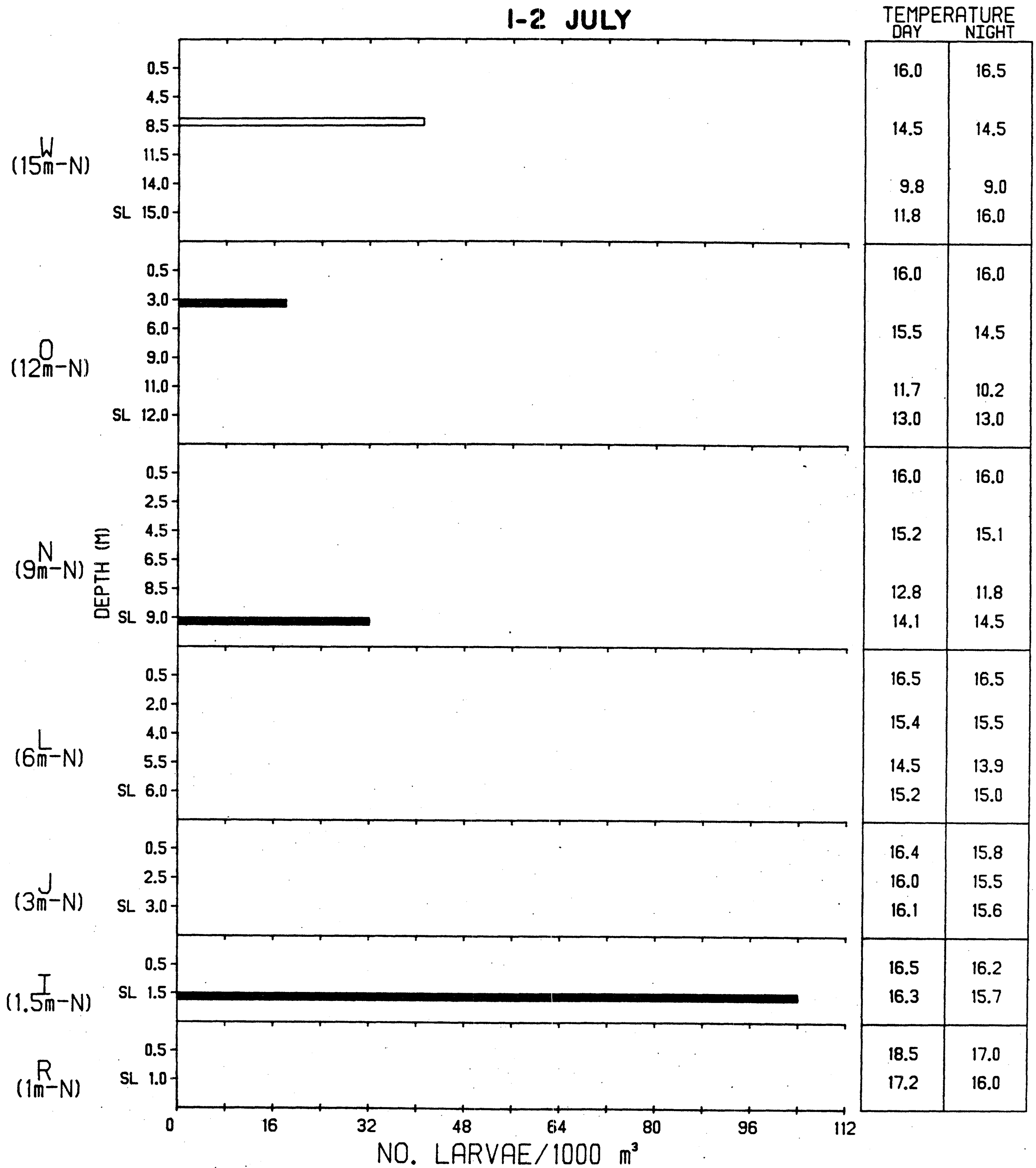

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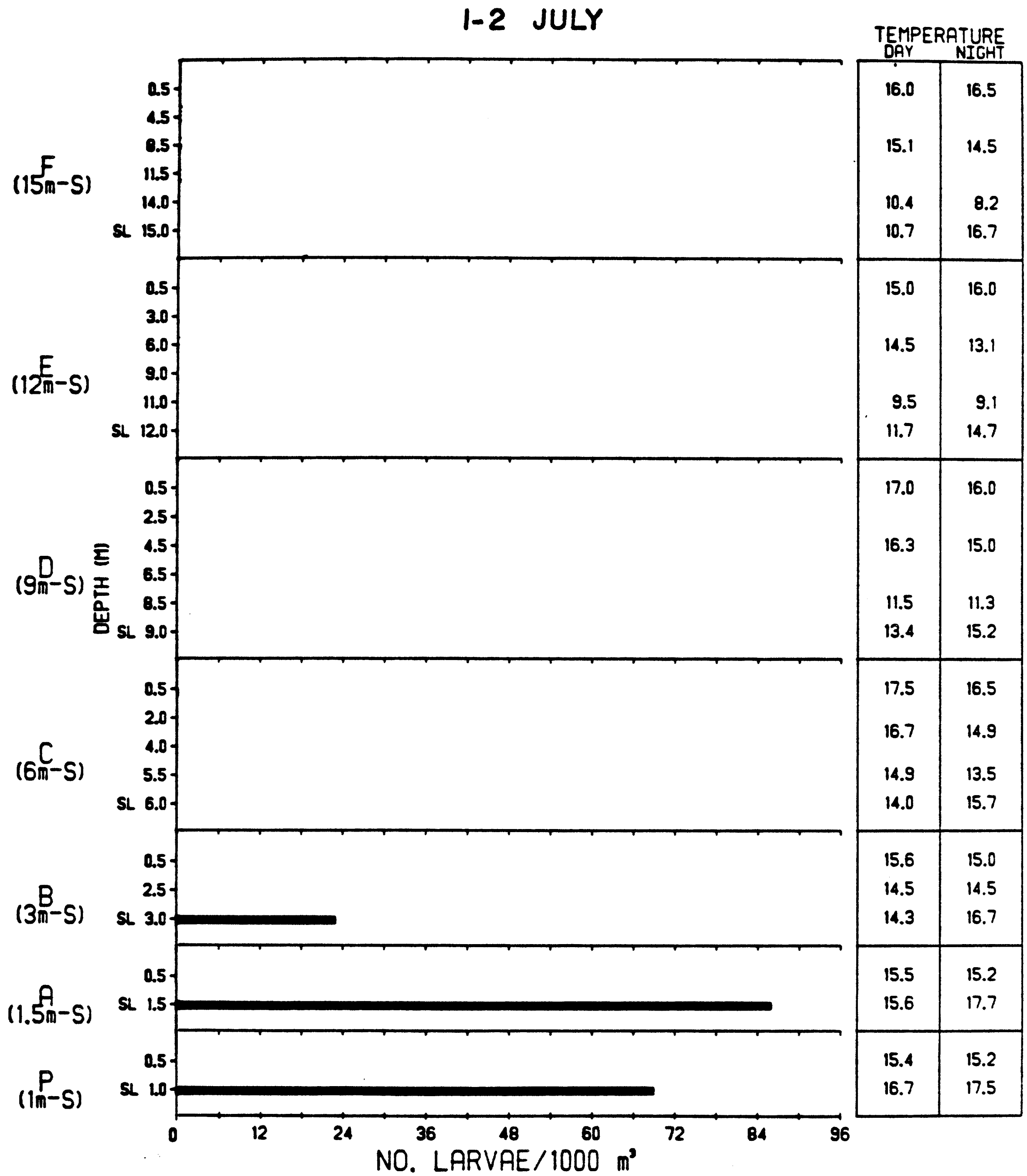

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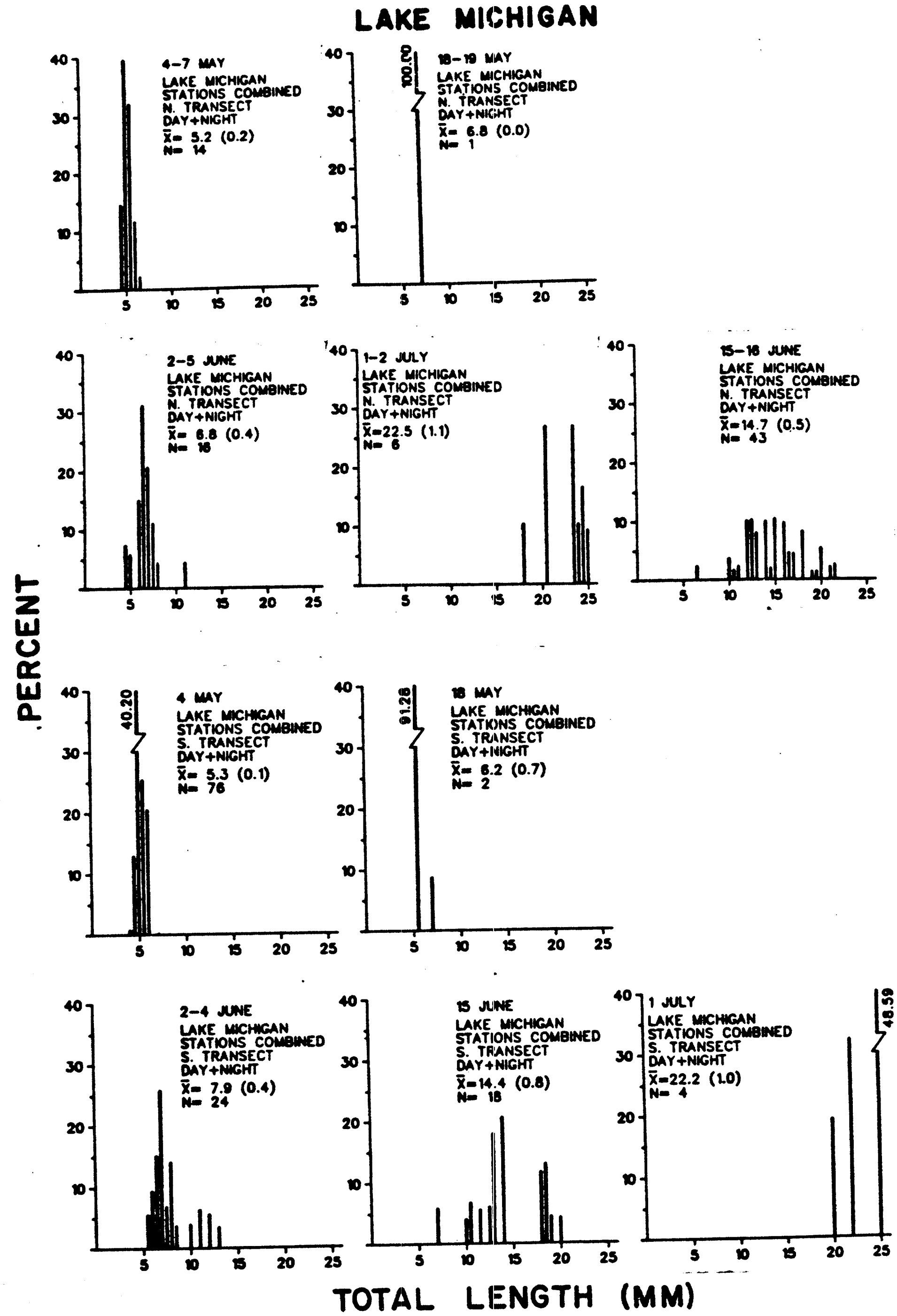
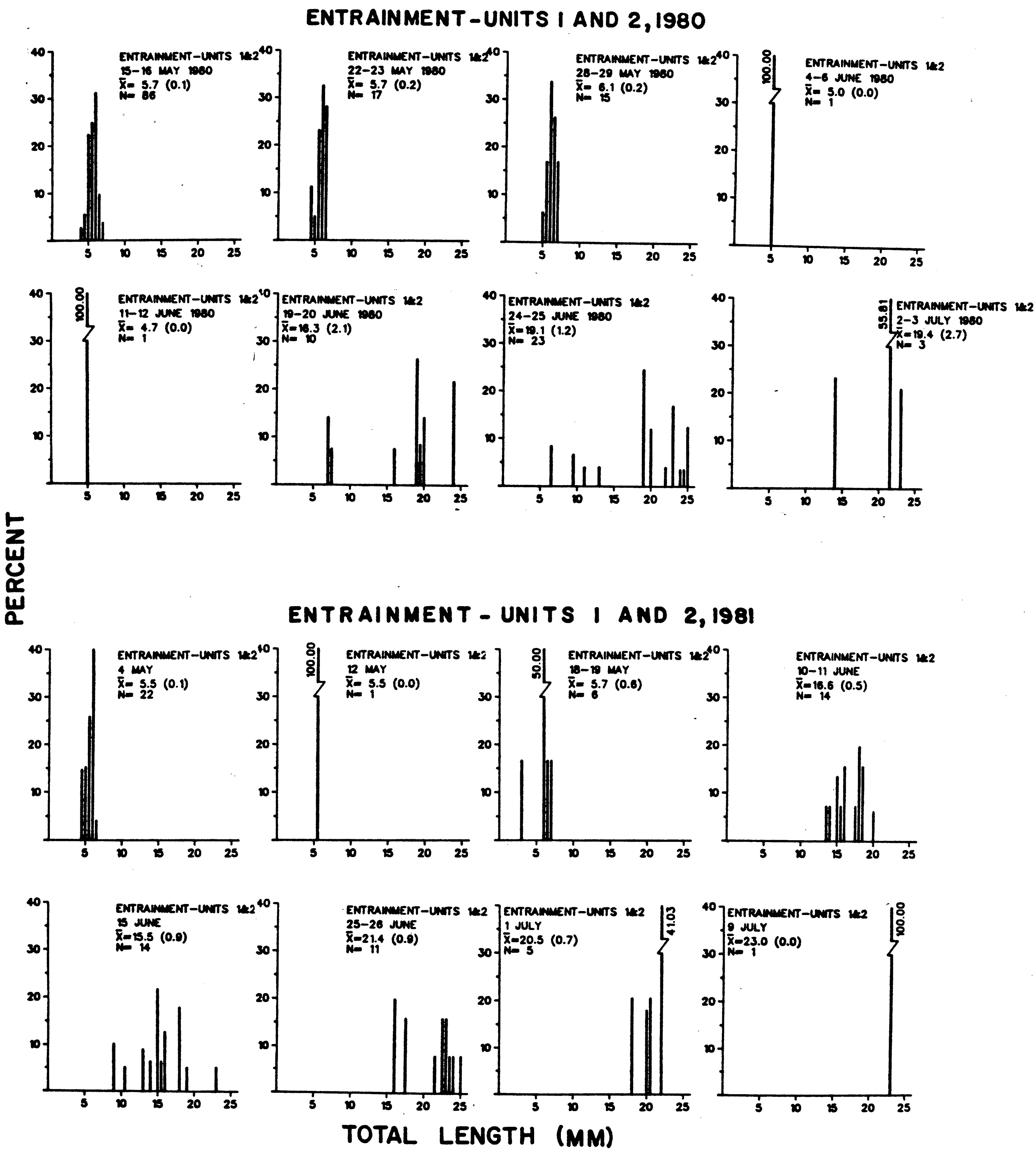


Fig. 20. Length-frequency histograms for larval rainbow smelt observed in field and entrainment samples collected during 1981 near the J. H. Campbell Plant, eastern Lake Michigan. Length-frequency histograms for rainbow smelt larvae entrained during 1980 were also included. All plankton net and sled tow samples were combined. $\bar{X}$ = mean, N = total number of larvae, standard error is given in parentheses.



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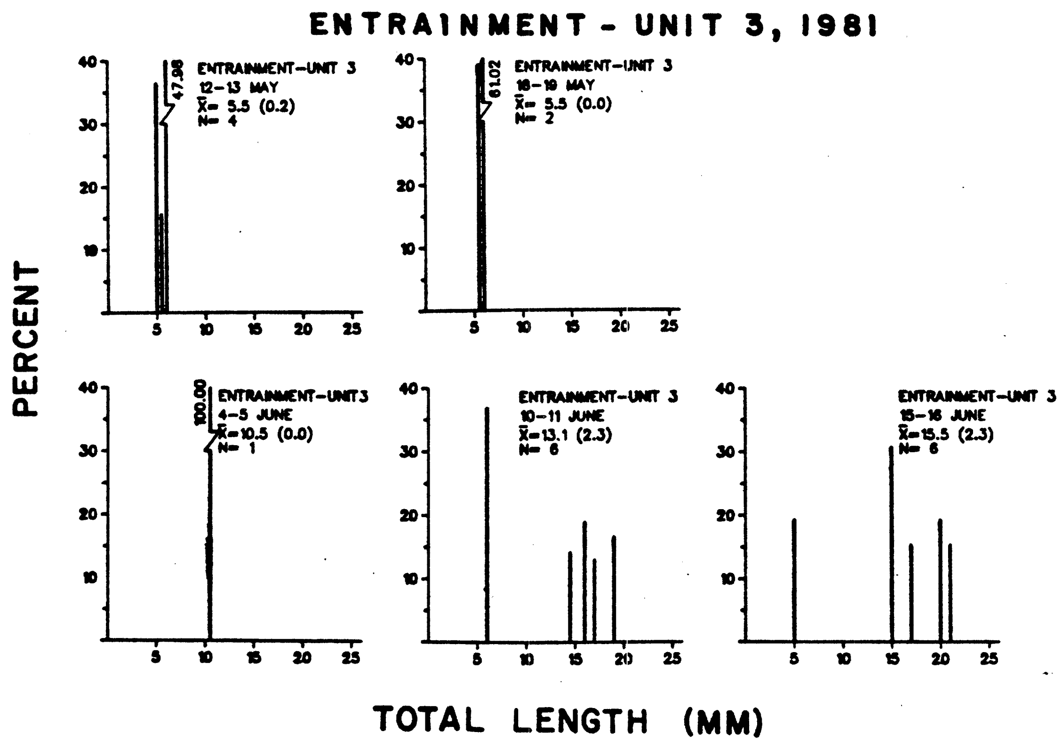


Fig. 20. Continued.

Most larvae were 4.5 to 8 mm (Fig. 20) indicating that hatching took place in the study area between 19 May and 2 June. These larvae were a result of the second hatching peak, which was generally observed around mid-June during 1978-1980 (Jude et al. 1981a). Since all smelt eggs spawned in shallow water (1-3 m) hatched by early May, hatching of smelt larvae between 19 May and 2 June probably took place in deeper water (6 to 15 m). Smelt larvae that hatched during 4-5 May were approximately 1-mo old by early June and should range from approximately 14 to 18 mm based on data collected during 1978-1980 (Jude et al. 1981a). Larvae in this first cohort were scarce during 2-5 June, probably due to their widespread distribution. Only a few large smelt larvae (10-13 mm) were found on both transects during 2-5 June (Fig. 20). On the north transect smelt larvae were found mostly in upper strata at night and in lower strata during the day (Fig. 19). Smelt larvae tended to remain in mid-water both during the day and at night at the south transect (Fig. 19).

During June 15-16 smelt larvae were found from 6 to 15 m on both transects in densities ranging from 17 to 233 larvae/1000 m³ (Fig. 19). More larvae were caught on the north than south transects. Mean densities were 19 and 7 larvae/1000 m³ for north and south transects respectively. During late June 1978-1980 mean larval smelt densities ranged from 3 to 50 larvae/1000 m³ for the north transect and from 6 to 38 larvae/1000 m³ for the south transect. During late June larvae were in several strata at night, but tended to be more common near bottom, except at station L (6 m, north) where larvae were most abundant at the surface (Fig. 19). Most larvae were collected at night. During the day smelt larvae were found only at 9 and 12 m on both transects.

Smelt larvae collected during 15-16 June ranged from 6.5 to 22 mm, most being 10 to 22 mm (Fig. 20). These larger larvae were undoubtedly members of the cohort that hatched during early May. Recently hatched larvae were scarce. Only a few larvae less than 10 mm were found on both transects (Figs. 19 and 20), indicating that smelt hatching ended by mid-June during 1981. During 1978-1980 smelt larvae were most abundant in water temperatures of 11 to 16 C and were scarce at higher temperatures. During 15-16 June 1981, however, appreciable numbers of smelt larvae occurred in water 16 to 23.5 C (Fig. 19). These data indicated that smelt larvae tolerate relatively warm water.

July-September--Smelt larvae were scarce in the study area during July. During early July 1978-1980 mean larval smelt densities for north and south transects ranged from 3 to 20 larvae/1000 m³. During 1-2 July 1981 mean densities were 3 larvae/1000 m³ for both transects. Larvae were found only in the shallow water (1-3 m) at the south transect, but were scattered to water 1.5, 9, 12 and 15 m deep at the north transect. Smelt larvae collected during 1-2 July ranged from 18 to 25 mm. Smelt larvae were not collected in the study area after 2 July.

A few smelt fry 26-29 mm were also collected in plankton nets and sleds during 2 July. Most of these YOY smelt were probably from the first cohort which was approximately 2-mo old by early July. During 1978-1980 2-mo-old smelt YOY reached a similar size range (20-38 mm). No smelt fry were collected during late July. Appreciable numbers of smelt fry 33 to 48 mm were collected in plankton nets and sleds during August and September. Fry occurred at several stations in the study area, but tended to be more common in shallow water (1 to 3 m) (Appendix 15).

Entrainment--

May--In 1980 smelt larvae were first entrained at Units 1 and 2 during 15-16 May. Densities in intake water were 59, 10, and 10 larvae/1000 m^3 during 15, 22, and 29 May respectively (Fig. 21). These data suggested that peak hatching took place around mid-May in 1980. All larvae entrained during May 1980 were recently hatched (4-7 mm) (Fig. 20). In 1978 and 1979 smelt larvae also first occurred in entrainment samples around mid-May. Projected smelt larvae entrainment during May 1980 was 468,000.

Smelt larvae were first observed in Units 1 and 2 entrainment samples during 4-5 May in 1981 (Fig. 21). As was previously mentioned, first hatching of smelt larvae in the study area took place in the shallow area of Lake Michigan. Entrainment occurred earlier at Units 1 and 2 than Unit 3 because the intake for Units 1 and 2 is located in shallower water than that of Unit 3. Smelt larvae were entrained at Units 1 and 2 at densities of 21, 1 and 5 larvae/1000 m^3 during 4, 12 and 18 May 1981 respectively. No smelt larvae were found in samples collected at the end of May. These data suggested that peak hatching of smelt larvae took place during early May in 1981. A continued decline in smelt entrainment through May probably resulted from offshore dispersal of larvae which took place soon after hatching. Low entrainment at Units 1 and 2 during 12 May (1 larva/1000 m^3) coincided with the first entrainment of smelt larvae at Unit 3 at the rate of 11 larvae/1000 m^3. Projected number of smelt larvae entrained at Units 1 and 2 during May 1981 was 307,000. Larvae entrained during May were all newly hatched (4.5-7 mm) (Fig. 20). Absence of larvae in entrainment samples between 19 and 31 May suggested no hatching took place in the shallow area during this period.

Smelt larvae were abundant at the north transect during early May, but were not entrained at Unit 3 during this period because they were mostly in shallow water. Mean larval smelt density at 9-12 m, based on day and night samples, was only 3 larvae/1000 m^3. Smelt larvae were first entrained at Unit 3 during 12-13 May during day, dusk and night in densities of 5 to 21 larvae/1000 m^3 (Fig. 21). Mean density of entrained larvae was 11/1000 m^3. Projected losses during the 24-h period on 12 and 13 May were approximately 12,000 larvae. During 18-19 May smelt larvae were entrained at a mean density of 4 larvae/1000 m^3 which corresponds to a 24-h entrainment loss of 2440 larvae. Low entrainment rates during this sampling period were due to scarcity of larval smelt in the vicinity of the intake structure (9-12 m) where mean density was 2 larvae/1000 m^3. Larvae entrained during May were all recently hatched (5-6 mm) (Fig. 20). No smelt larvae were found in entrainment samples at Unit 3 during 28-29 May probably because of scarcity of larvae in Lake Michigan. Projected entrainment of larval smelt at Unit 3

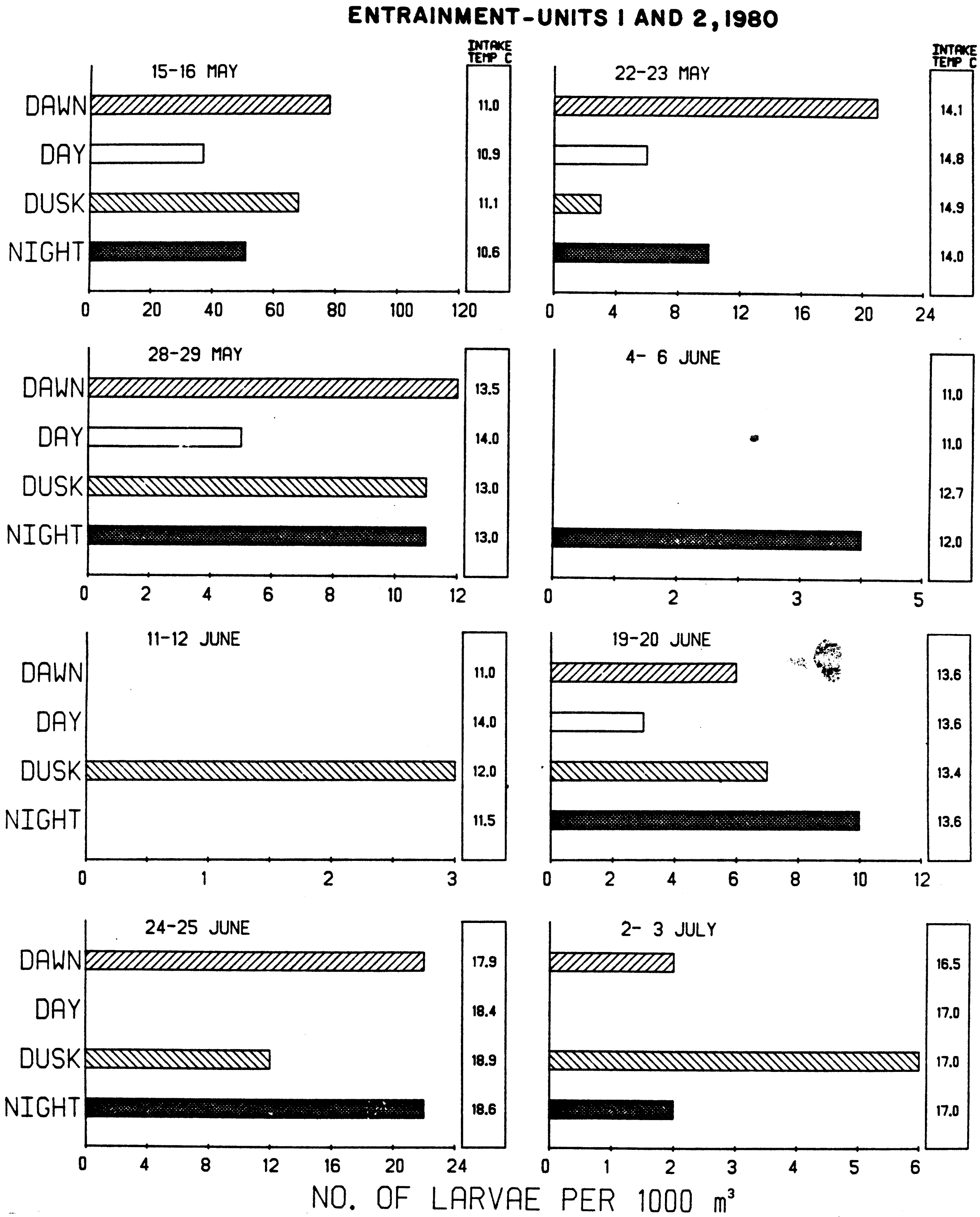
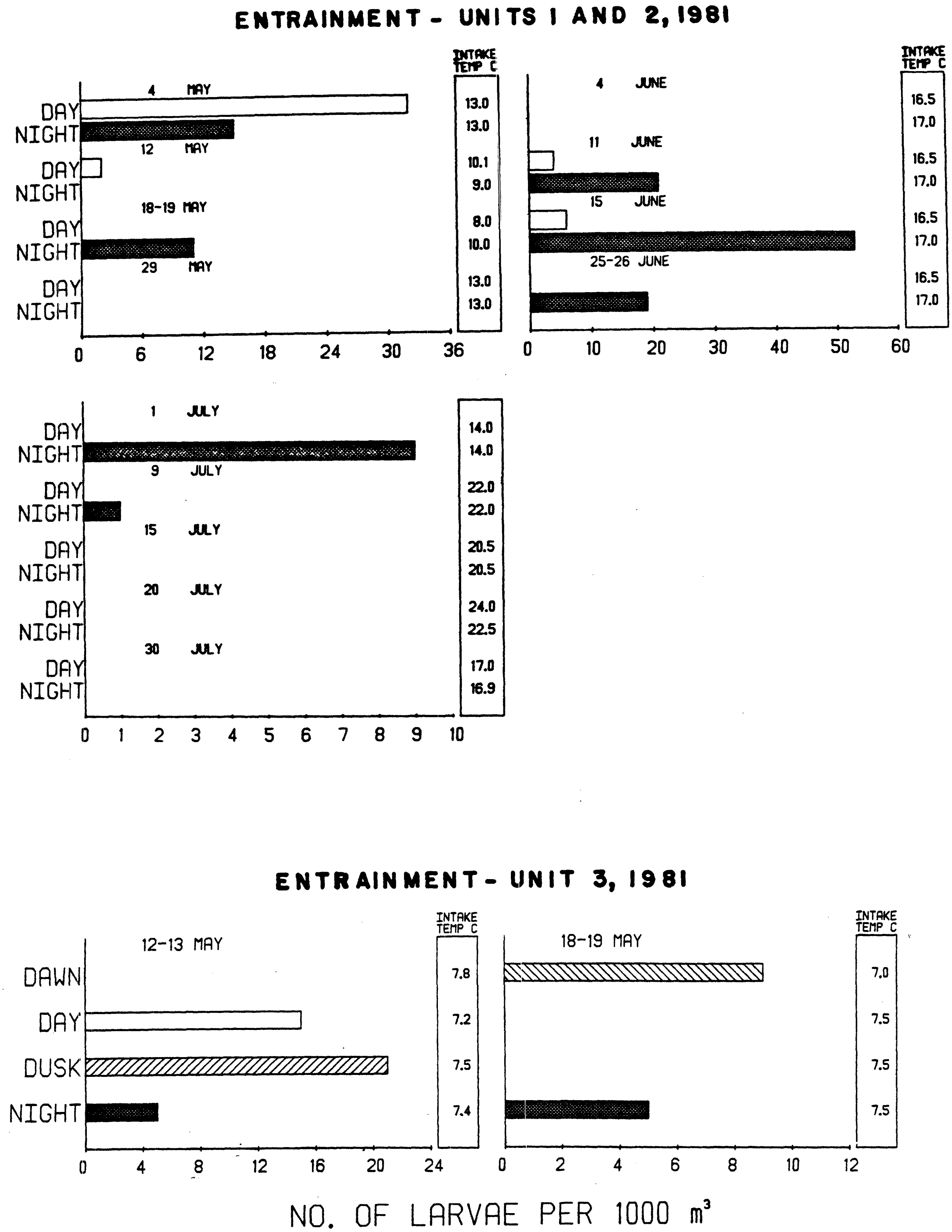


Fig. 21. Density of larval rainbow smelt (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at the J. H. Campbell Plant's Units 1 and 2 and Unit 3, during 1980 and 1981. Only day and night densities were shown for Units 1 and 2 during 1981.



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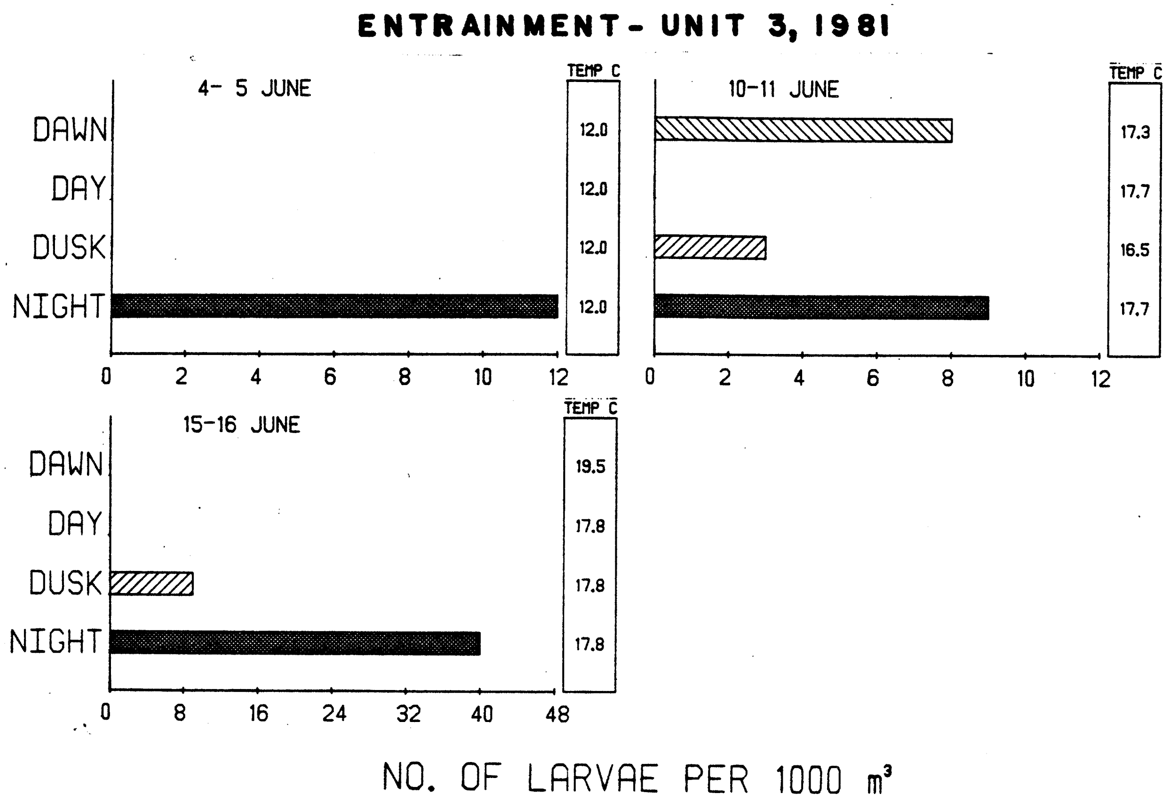

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during May was 105,000 larvae (Table 28). As was found for 1978 and 1979, smelt larvae were vulnerable to being drawn into Units 1 and 2 cooling water mostly during a short period after the first hatching in May during 1980 and 1981.

June-September--In 1980 low numbers of smelt larvae were entrained at Units 1 and 2 during early June (Fig. 21). They ranged from 5 to 25 mm, most being 9-25 mm (Fig. 20). A few newly hatched larvae (5-7.5 mm) occurred in entrainment samples at Units 1 and 2 during June 1980. Sampling in Lake Michigan revealed that most newly hatched larvae remained in deep water (12-15 m) during June (Jude et al. 1981a). Projected losses of smelt larvae at Units 1 and 2 during June 1980 was 171,000.

During 1981 smelt larvae were entrained at Units 1 and 2 at densities of 12, 29 and 9 larvae/1000 m^3 during 11, 15 and 26 June respectively (Fig. 21). Lower densities were observed in Unit 3 entrainment samples during June. Smelt larvae entrained at Units 1 and 2 were relatively large (9-23 mm). Recently hatched larvae were found from 6 to 15 m in Lake Michigan. They occurred in small numbers in Unit 3 entrainment samples, but were not found in entrainment samples taken at Units 1 and 2 during early June 1981. These data substantiate our earlier contention that late hatching of smelt larvae took place in deep water. Projected number of smelt larvae entrained at Units 1 and 2 during June 1981 was 449,000.

Smelt larvae 14-23 mm were entrained in low numbers at Units 1 and 2 during early July 1980 and 1981 (Figs. 20 and 21). No smelt larvae were found in Units 1 and 2 entrainment samples after 9 July in 1981 and 3 July in 1980. During 1978-1979 larval smelt entrainment also ended in July. Projected losses of larval smelt were 10,000 and 27,900 during July 1980 and 1981 respectively.

Entrainment of smelt larvae at Unit 3 increased steadily from the beginning of June to late June (Fig. 21). Mean densities of entrained larvae were 3, 5 and 13 larvae/1000 m^3 respectively during 4-5, 10-11 and 15-16 June. Estimated numbers of smelt larvae entrained at Unit 3 during 24-h were 3,700, 4,500 and 21,000 larvae respectively during these sampling periods. Mean larval smelt densities at 9-12 m during 2-5 June (14 larvae/1000 m^3) and during 15-16 June (26 larvae/1000 m^3) were slightly higher than mean densities of larvae entrained at Unit 3 during the corresponding sampling periods. Densities in the lower strata of the 9- and 12-m contours and those observed in entrainment samples were, however, not significantly different (see RESULTS AND DISCUSSION - STATISTICS).

Smelt larvae entrained at Unit 3 from 2 to 16 June were 5 to 21 mm (Fig. 20). Smelt larvae that hatched in deep water during 4-5 June probably dispersed quickly from the bottom as only low numbers of newly hatched larvae were entrained during this sampling period (Fig. 20). Most larvae entrained during June were 10.5 to 21 mm (Fig. 20) indicating that relatively large larvae may be drawn through the intake screen of Unit 3. Since smelt larvae often concentrate in strata where the intake structure is located (Jude et al. 1979a, 1980, 1981a), they remained vulnerable to entrainment during most of the larval stage. More data on abundance of larvae in field and entrainment samples are needed to determine if smelt larvae may be able to avoid being entrained by the Unit 3 intake. No smelt larvae were entrained at Unit 3 after 16 June in 1981. Projected loss of smelt larvae during June was 191,000 (Table 28).

Relative importance of smelt larvae in entrainment samples was similar between Unit 3 entrainment and Units 1 and 2 (2-3% of the total larvae entrained by the respective unit). However, Units 1 and 2 entrained an estimated 1.5 and 1.6 million smelt larvae in 1978 and 1979 (Jude et al. 1980), while Unit 3 entrained only 296,000 in 1981 (Table 28).

Low numbers of smelt fry 35-42 mm were found in Unit 3 entrainment samples during August and September 1981 (Appendix 18). During 1980-1981 a few smelt fry (26-45 mm) occurred in Units 1 and 2 entrainment samples taken in early July and early August (Appendixes 16 and 17). Fry entrainment at Units 1 and 2 increased substantially during late August and September both in 1980 and 1981. Densities ranged from 8 to 428 fry/1000 m^3. The number of fry entrained at Units 1 and 2 declined substantially during October and November (Appendixes 16 and 17). No fry were entrained at Units 1 and 2 during December 1980-1981. A similar pattern of fry entrainment was observed during 1978-1979. Fry entrainment was lower at Unit 3 than at Units 1 and 2 during July-December. Since smelt fry were relatively common at all Lake Michigan stations during August and September, these data suggested that smelt fry were able to avoid the Unit 3 intake.

<u>24-h population and entrainment estimates</u>-- The estimated total number of larval rainbow smelt in the vicinity of the plant during a 24-h period ranged from 66,000 to 293,000 during the five sampling periods from early May to early July 1981 (Table 31). Relatively small fractions of these larvae were drawn into the Unit 3 intake. Entrainment losses of smelt larvae per 24-h period for these five sampling periods were from 0 to 20,900 larvae (0 to 3.7% of the estimated total number in the plant vicinity).

Young-of-the-Year--

<u>July and August</u>--As was found during July 1977-1980 only low numbers of YOY (42) were collected during July 1981 (Fig. 22). Smelt YOY were still too small to be retained in trawls during this month.

YOY catches increased substantially during August. YOY were found from 1 to 12 m (Appendix 8). Their distribution in the inshore water was probably influenced by water temperature. YOY were abundant during August 1979 and 1980 when water temperatures in the study area were 8 to 18 C. Catches of YOY per trawl haul were 703 and 638 during August 1979 and 1980 respectively. Low catches of YOY during August 1981 (300/trawl haul) were probably due to upwelling of cold water. Bottom temperatures were from 6 to 9 C from 3 to 12 m during August 1981. Low catches of YOY during August 1978 (183/trawl haul) probably resulted from relatively high temperatures in the study area (18-24 C in water up to 12 m). During August 1977 catches of 330 YOY were obtained when bottom temperatures ranged from 9 to 22 C.

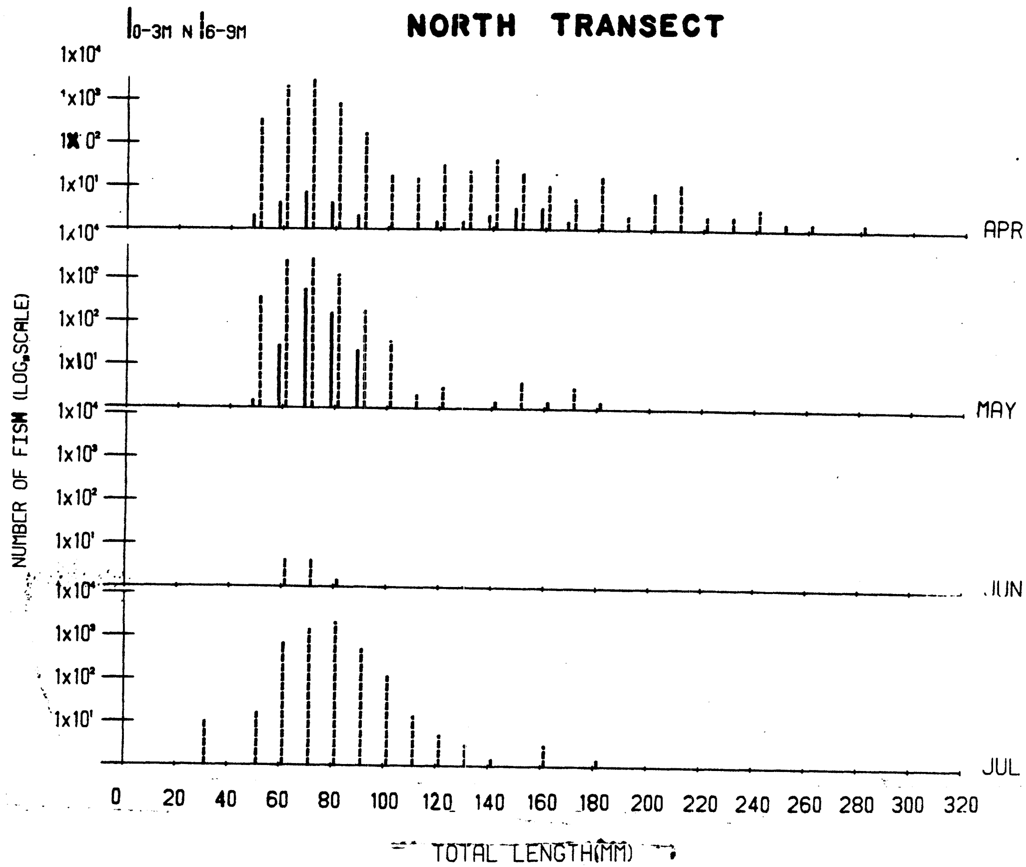
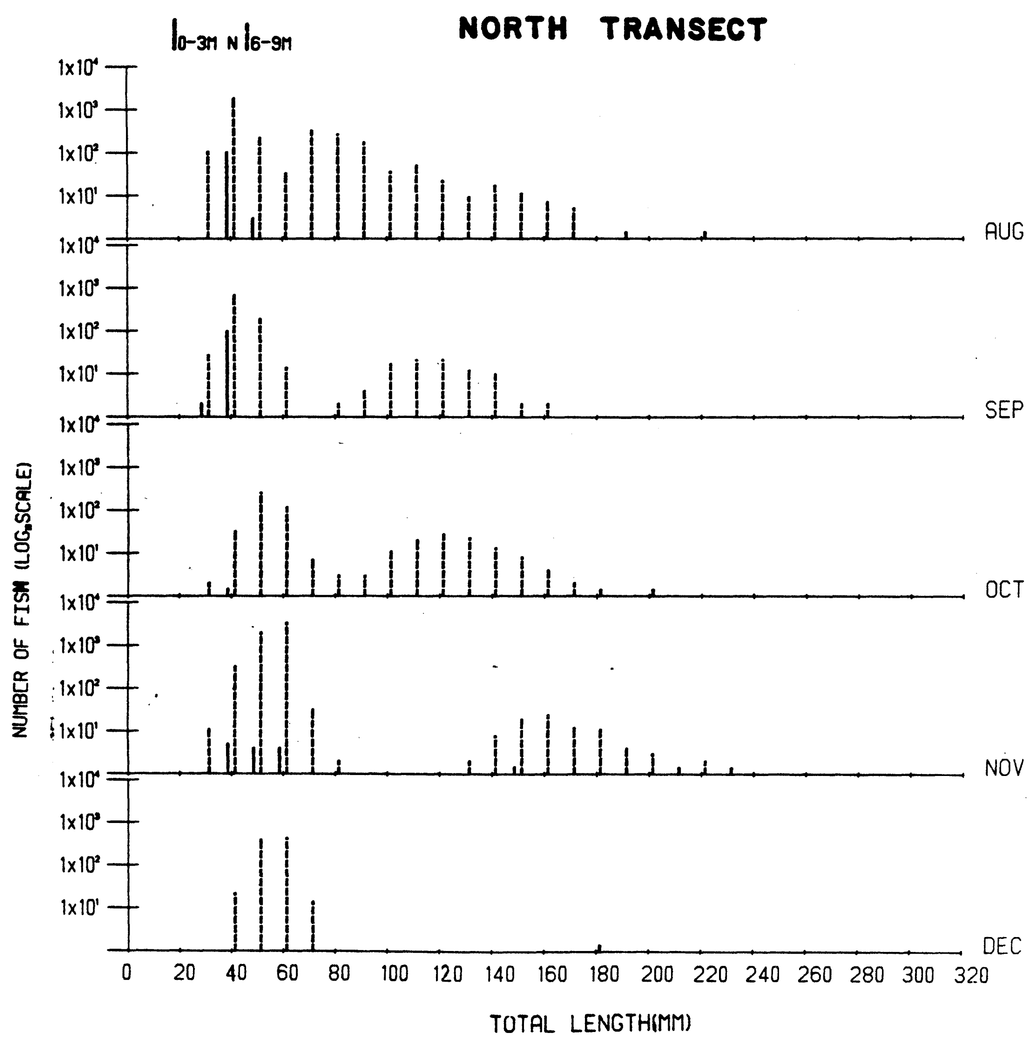


Fig. 22. Length-frequency histograms for rainbow smelt collected during April - December 1981 at the north and south transects. Stations were combined into two groups for the north transect: beach and 3 m; 6 and 9 m and into three groups for the south transect: beach, 1.5 and 3 m; 6 and 9 m; and 12 m. Diel periods and gear types were pooled.



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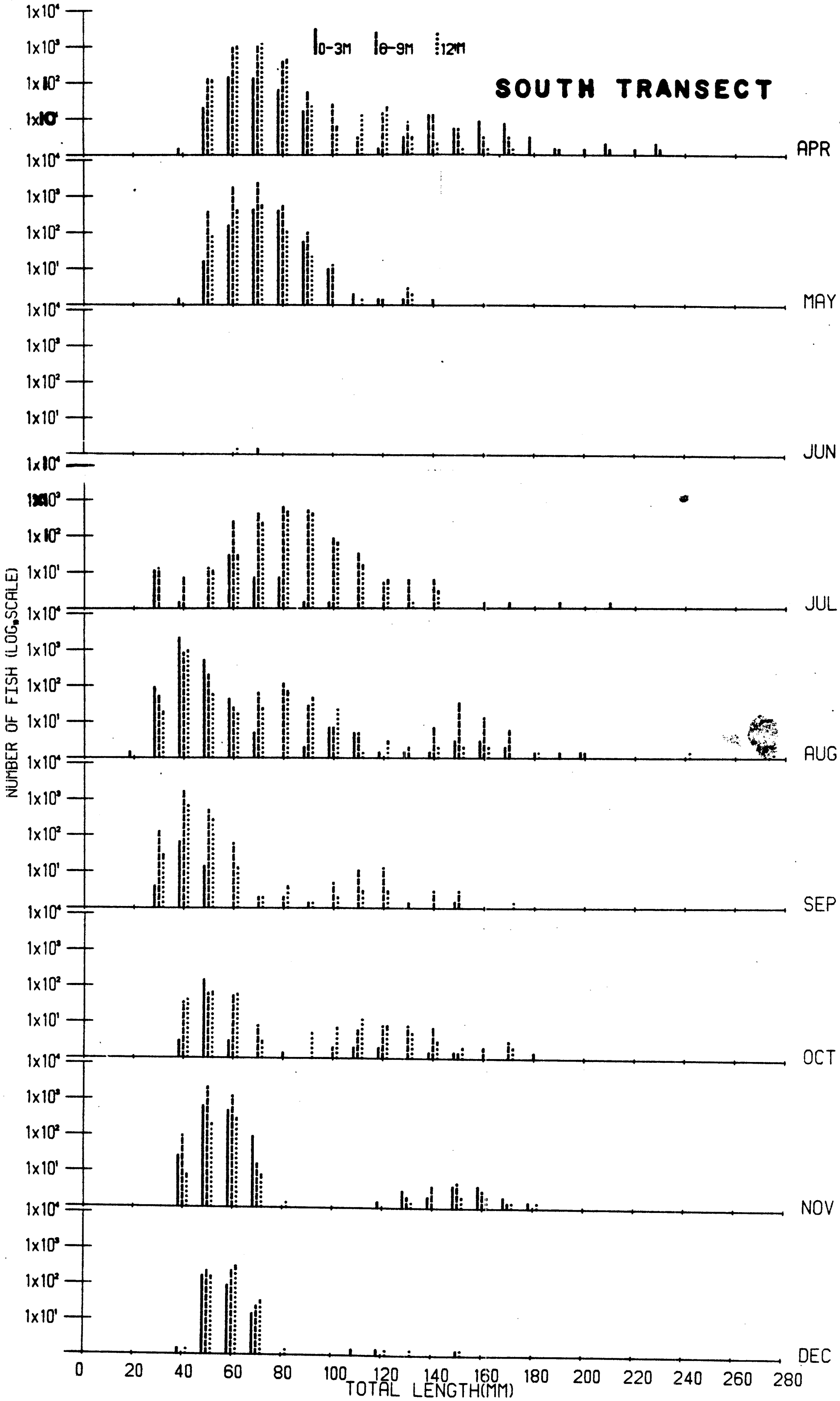


Fig. 22. Continued.

YOY generally avoid shallow water and were more common in deeper water in August. During August 1981 however, more YOY were caught in shallow water (1-3 m) than at deeper stations (6-12 m) due to cold water (5-7 C) at deeper stations and relatively mild temperatures (9-12 C) in shallow areas. More YOY were seined in August 1981 than any year during August 1977-1980.

YOY smelt collected during August were 30-45 mm. As was found during 1977-1980, smelt YOY had a modal length of 40 mm during August 1981. These data indicated growth rates of YOY smelt were similar during August 1977-1981.

September-December--Offshore migration caused the decline of YOY catches in the fall. September catches of YOY (184/trawl haul) were substantially lower than August catches (300/trawl haul). Most YOY were found at 6 and 9 m (Fig. 22). YOY abundance continued to decline in October with catches of 13/ trawl haul. In contrast to October, relatively high catches of YOY (180/trawl haul) were made during November 1981. Water temperatures were slightly higher in October (11-12.6 C) than in November (9.3-11.6 C) in 1981. These data suggested factors other than temperature influenced the return of YOY to inshore water during November 1981. November catches were generally low during 1977-1980. Low catches of YOY were observed in December. YOY catches in 1981 (25,000) were comparable to those of 1980 (26,000). These data suggested smelt had another strong year class in 1981. YOY catches tended to be higher at the north transect than the south transect.

Yearlings--

April and May--Yearlings occurred at all stations during April with most being found at 12 m (Fig. 22). Yearlings were more abundant during April 1981 than during April 1978-1980. Yearling catches were 4-60/trawl haul during April 1977-1980 and 482/trawl haul in April 1981. A large inshore migration in April may have been caused by relatively warm water (6-9 C). Water temperatures were 1.5-9 C during April 1978-1980.

Yearlings ranged from 40 to 110 mm during April 1981. Yearling modal length in April 1981 (70 mm) was similar to that of April 1980. During April 1978-1979 modal length of yearlings was 60 mm. Difference in yearling growth among years probably resulted from a low sample size of yearlings in April 1978-1979 samples.

Yearlings were most abundant in May during 1978-1981. Higher catches were observed in May 1981 (632/trawl haul) than during May 1978-1980 (112-132/trawl haul). Abundance of yearlings in May 1981 was due to a strong 1980 year class. During May 1981 yearlings occurred at all stations, being most common at 6 and 9 m. A similar depth distribution of yearlings was observed in May 1978-1980. Yearling modal length in May (70 mm) was the same as in April, suggesting there was little growth from April to May.

June-December--A dramatic decline in yearling catches was observed in June 1981 when only 11 yearlings were collected. Yearlings were generally common in the study area during June. Scarcity of yearling smelt during June 1981 may be related to relatively high temperatures (19-22 C) in the study area. Yearling catches increased substantially during July as a result of an upwelling of cold water (5-7 C). Mean catch of yearlings per trawl haul was greater in July 1981 (324) than July 1977-1980 (100-150). Yearlings were found from 3 to 12 m with highest concentrations at 9 m (Fig. 22).

Yearlings generally migrated offshore by August during 1977-1980 (Jude et al. 1981a). During August 1981 yearlings were still common in the study area due probably to an upwelling of cold water (6.5-18 C). Catches of yearlings in August 1981 were estimated at 53/trawl haul. Small numbers of yearlings continued to occur during September and October 1981 (Fig. 22). Yearlings were scarce in inshore water during September and October 1977-1980. Few yearlings were collected during November and December. Total catch of yearlings during 1981 (36,200) was substantially higher than annual yearling catches during 1978-1980 (4300-14,400). As previously mentioned these high catches were due to the exceptionally strong year class of yearlings in 1981. More yearlings were caught at the north than at the south transects.

Adults--

April and May--Adult smelt 120-280 mm were caught in substantial numbers during April (Fig. 22). Most adults collected had well developed, ripe or spent gonads (Table 39), suggesting that spawning was in progress. During April 1979-1980 few ripe adults were caught, probably because the sampling period did not coincide with with the spawning run. In 1978 substantial spawning occurred during 22-24 April (Jude et al. 1979a). Smelt spawning was reported to take place in water temperatures of 5-7 C (Liston et al. 1980) and reached a peak at 10 C (Daly and Wiegert 1958; Jude et al. 1979b). Similar water temperatures (6-9 C) were observed in the study area during 13-15 April 1981. Adult smelt were caught in water 1 to 12 m, most being found at 3 and 6 m (Fig. 22). Spawning generally takes place in shallow areas (Rupp 1959; Jude et al. 1979b). Some spawning was reported to occur in deep water 9-22 m (Legault and Delisle 1968; MacCallum and Regier 1970).

Table 39. Monthly gonad conditions of rainbow smelt caught during 1981 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Males	Slight development	30	3		14	60	40	31	17	1
	Mod. development	7	1		1	2	3	32	38	3
	Well developed	39	2						3	
	Ripe-running	1	1							
	Spent	38	7			1				
Females	Slight development	28			8	28	24	20	18	1
	Mod. development	2						5	31	2
	Well developed	32								
	Ripe-running	24								
	Spent	21				2				
Immature		991	884	11	682	535	406	318	540	311
Unable to distinguish		8			9	7	7	14		

Adults were scarce during 18-19 May. A few ripe and spent adults were collected, indicating that spawning was ending by late May in 1981. During 1978-1980 a substantial number of ripe adults were found during mid-May.

June-December--Adult smelt generally moved offshore soon after spawning. Few adults were found in the study area during June 1977-1980. High water temperatures in the study area during June 1981 (19-22 C) also caused early departure of adults, as one was collected. Low catches of adults were observed in July. In August a substantial number of adults were collected due to an upwelling of cold water (6-18 C). Adults were scarce from September to December.

Smelt catches of 62,500 (YOY, yearlings and adults) in 1981 were substantially higher than 1980 catches (36,700). Our data indicated that smelt abundance in the study area was increasing during 1977-1981.

Spottail Shiner

Introduction--

Spottail shiners are very abundant in the vicinity of the J. H. Campbell Plant. Jude et al. (1981a) reported that spottails were third-most abundant in collections during the period 1977-1980. Spottails exhibit a pattern of biological activity similar to many fish in the study area: they move into the study area in the spring (May to early June) prior to spawning which is usually completed by August. During spawning, fish are most concentrated in the beach zone; when water is warm enough ($\geq$ 15 C) they are found out to 6 m. Spottails then migrate out to deeper water (15 m or more) where they overwinter by November or December. The area of the lake extending from the beach to 3 m is an important nursery area for spottail larvae (Jude et al. 1981a). YOY spottails, which first appear in mid-August, are the last age class to migrate to deeper water in the fall and can be found in the study area as late as December.

During 1981 spottail shiners were the third-most numerous species collected in juvenile and adult fish sampling gear, comprising 8.3% of the total catch. Spottails comprised a larger percentage of the total catch (10-18%) during preoperational years. The numbers of spottails caught from 1977 to 1981 have remained rather constant with an average of 11,667 fish caught per sampling season.

Larvae--

Seasonal distribution--Highest larval spottail densities occurred during July or August depending on stability of water temperatures (i.e., no upwellings, which interrupt spawning). Maximum densities were always found from the beach to 3-m depths (Fig. 23). Mean lengths of larvae caught in the beach zone (5.0 mm $\pm$ 0.3 mm SE - Fig. 24) indicated larvae were recently hatched and documented the beach to 3-m zone as an important nursery area for spottails. Larval spottail densities were greater at the north plant transect than at south transect stations during Unit 3 preoperational years, and during operational year 1981. During 1979, 1980 and 1981 the difference between transects was statistically significant (α = 0.05), as shown by the Wilcoxon signed ranks test (Jude et al. 1981a).

YOY spottails were first collected in adult sampling gear in mid-August and due to yearly fluctuations in water temperatures during spawning, sizes of YOY fish varied by month depending on peak spawning time. YOY spottails were the last size group to migrate to deeper water in the fall and were present in the study area as late as December.

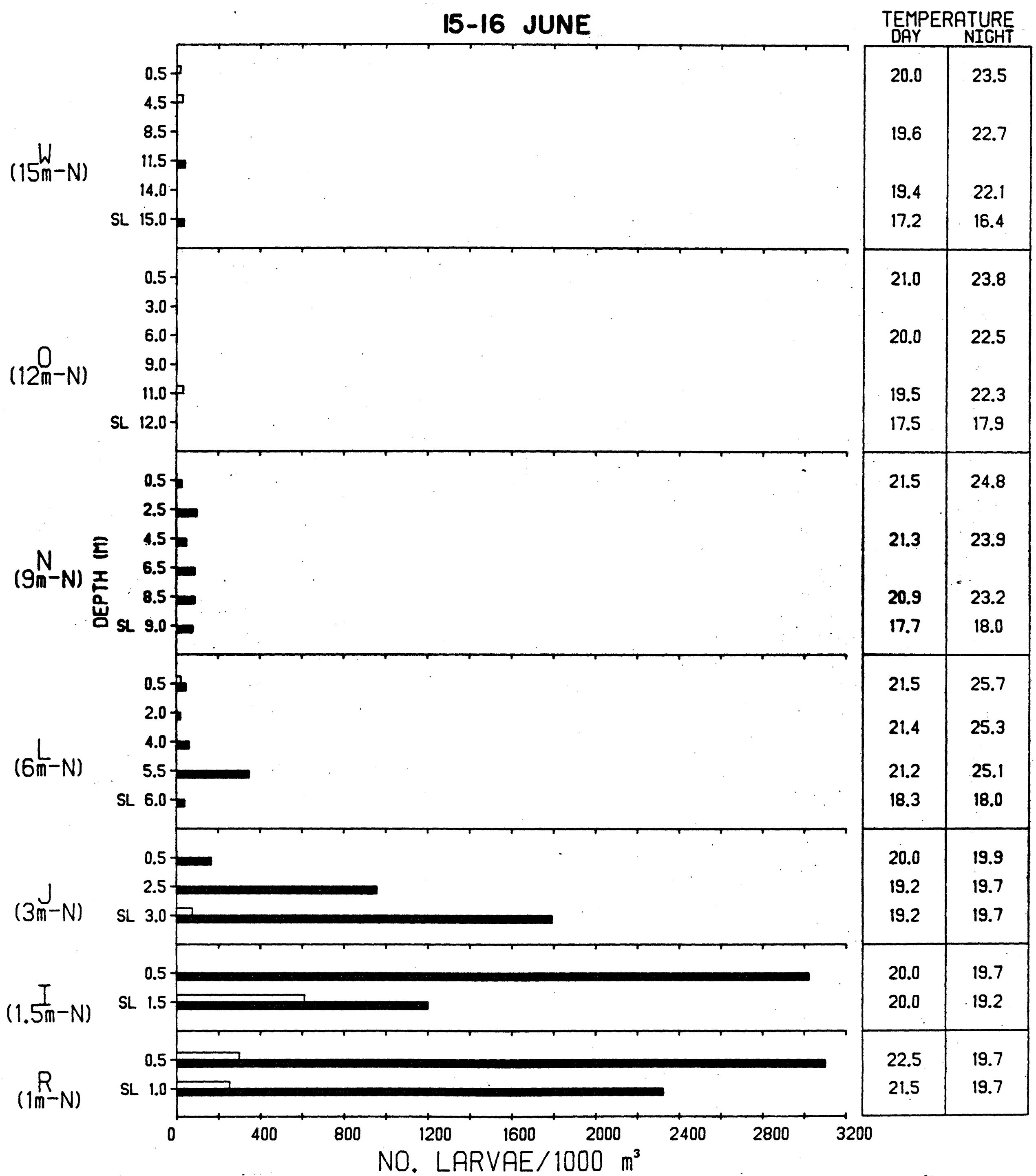
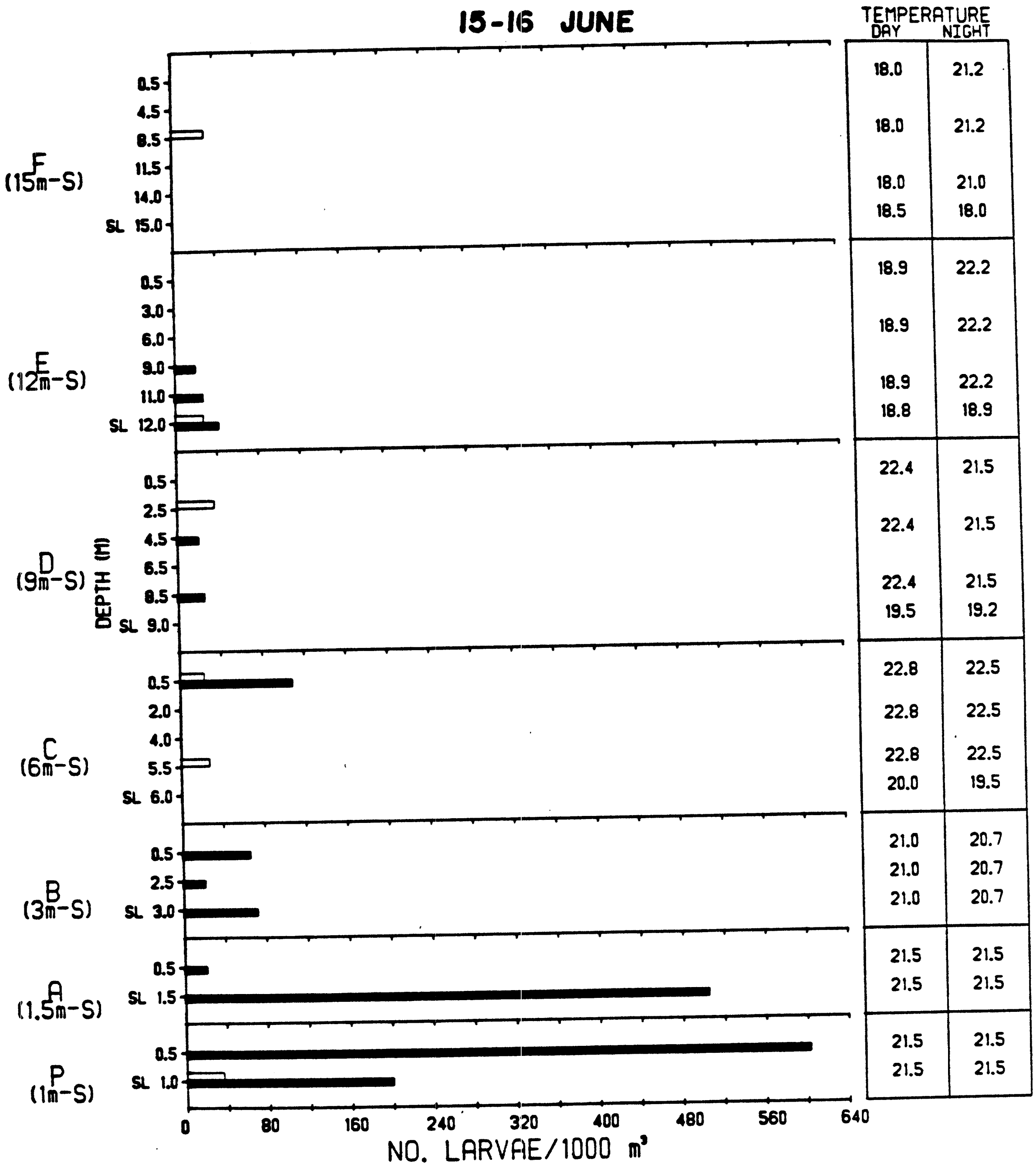


Fig 23. Density of larval spottail shiners (no./1000 m^3) at north and south transect stations near the J. H. Campbell Plant, eastern Lake Michigan, April to September 1981. □ =day ■ =night, SL=sled.



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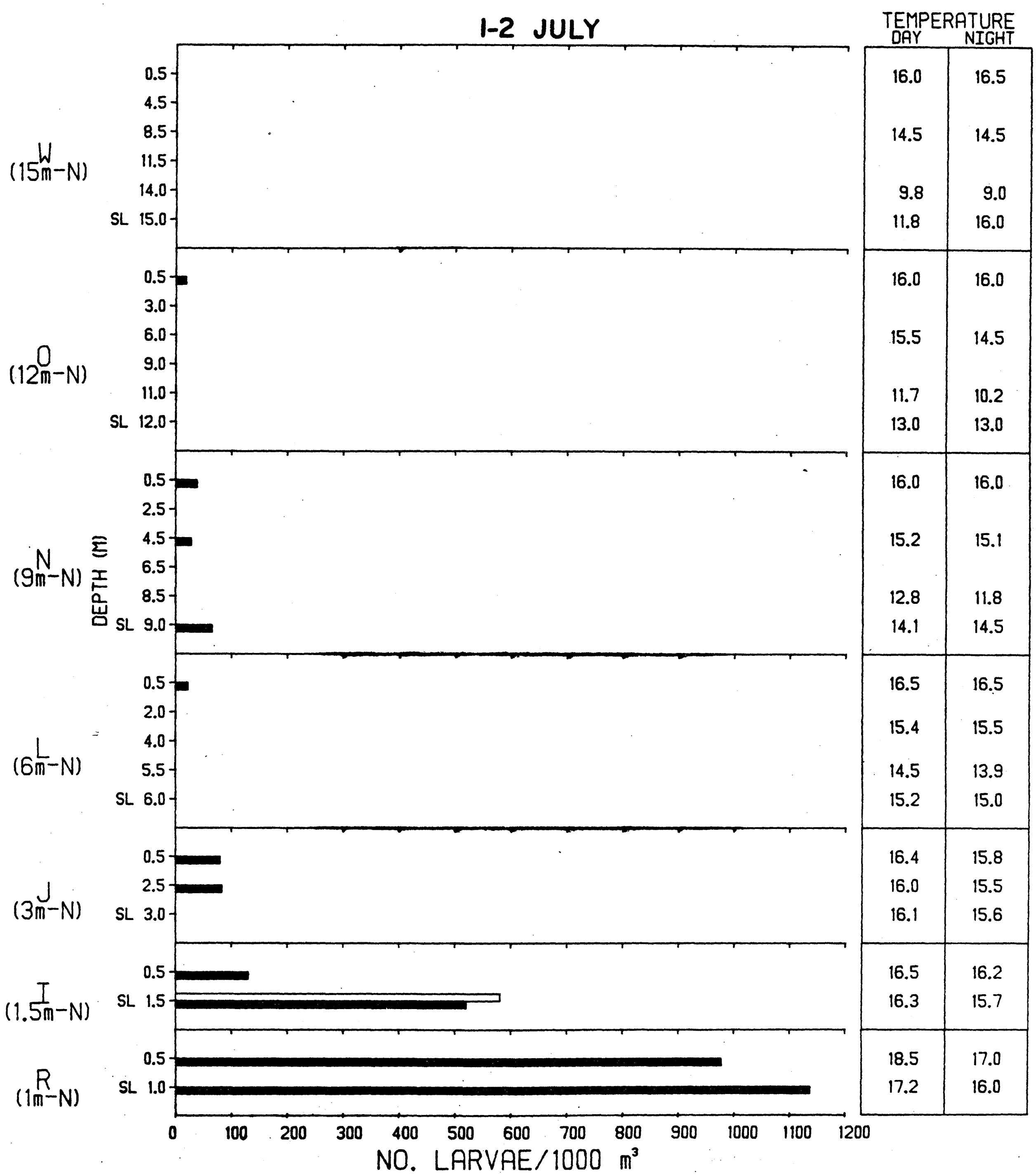

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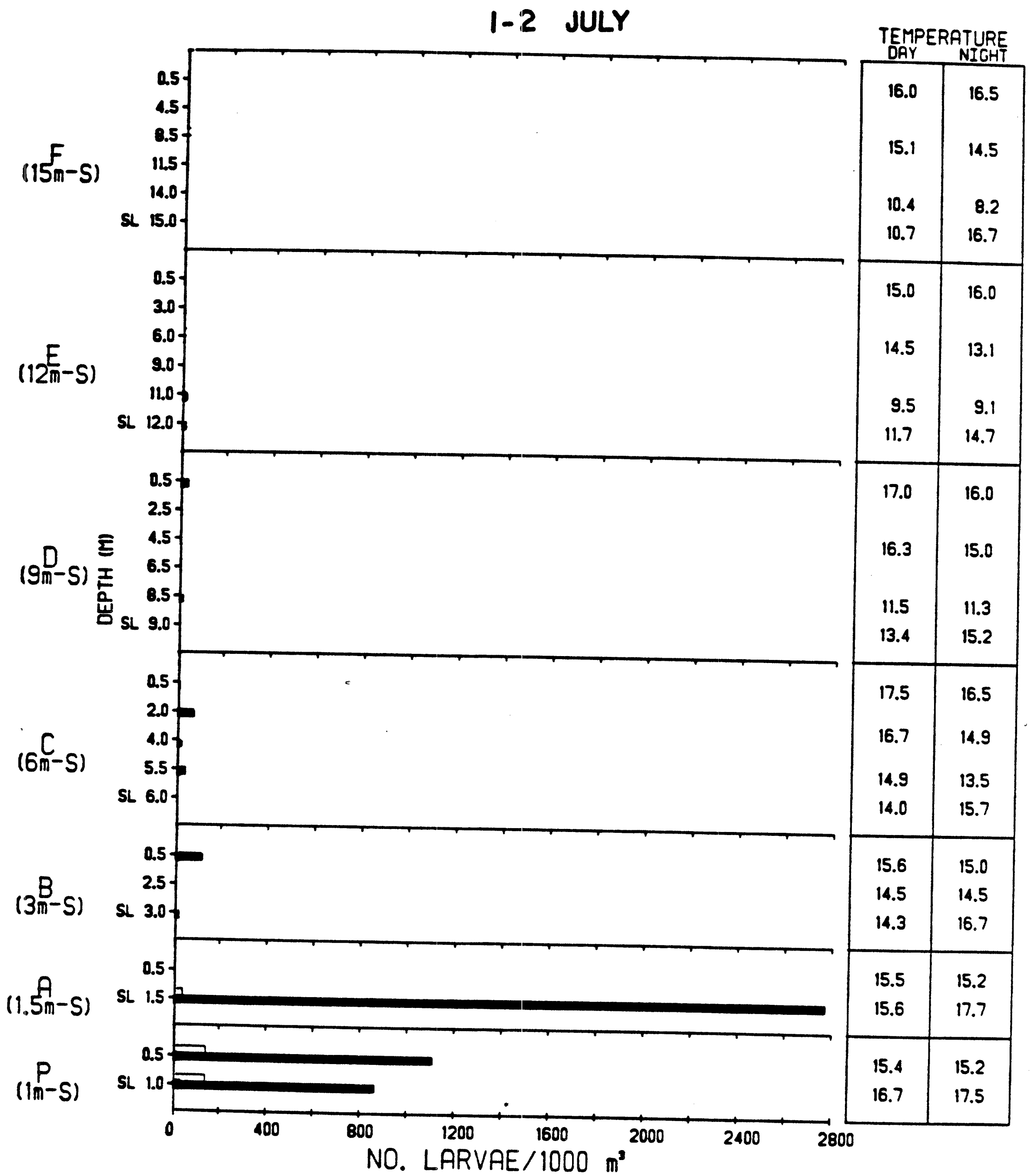

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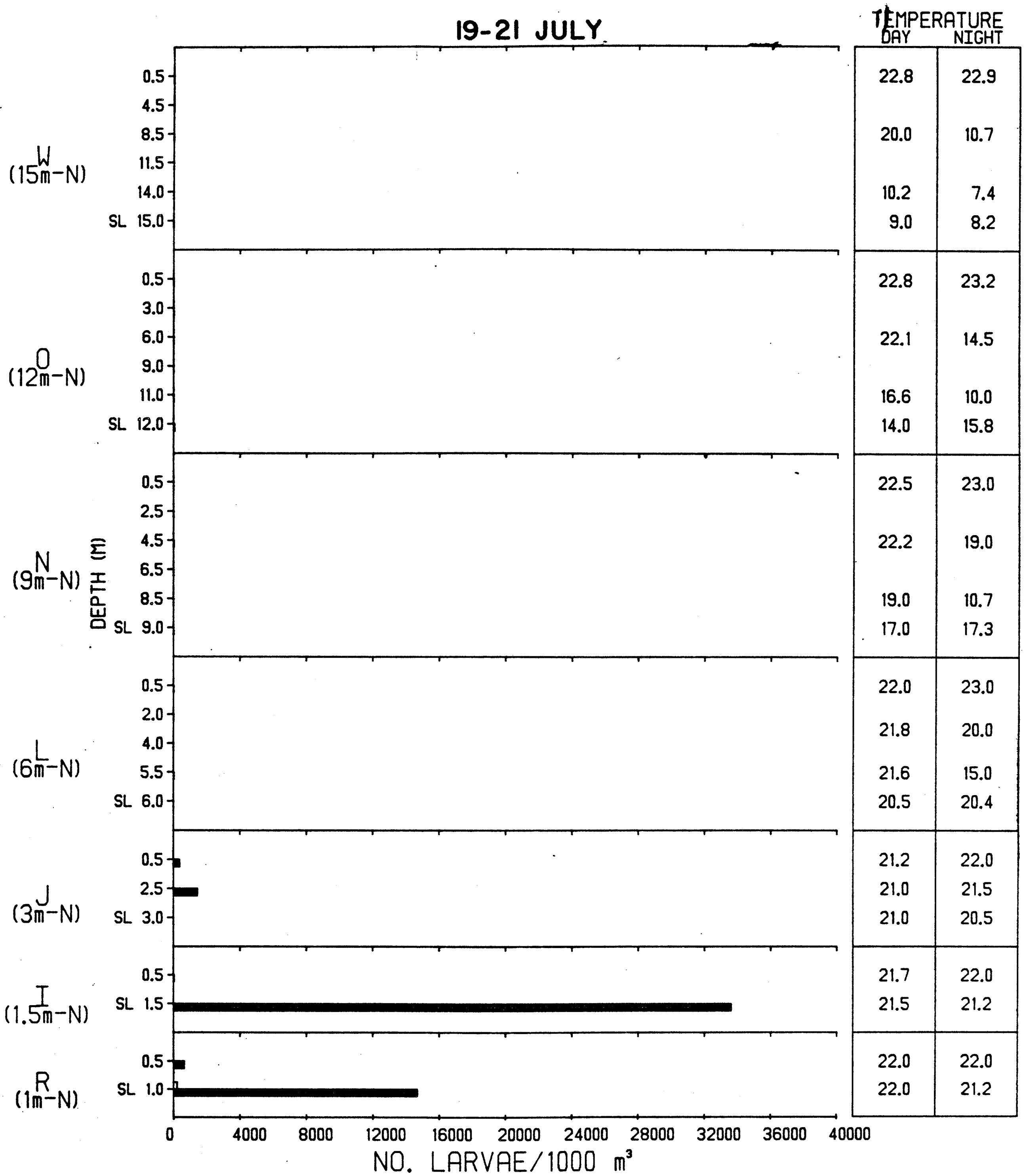

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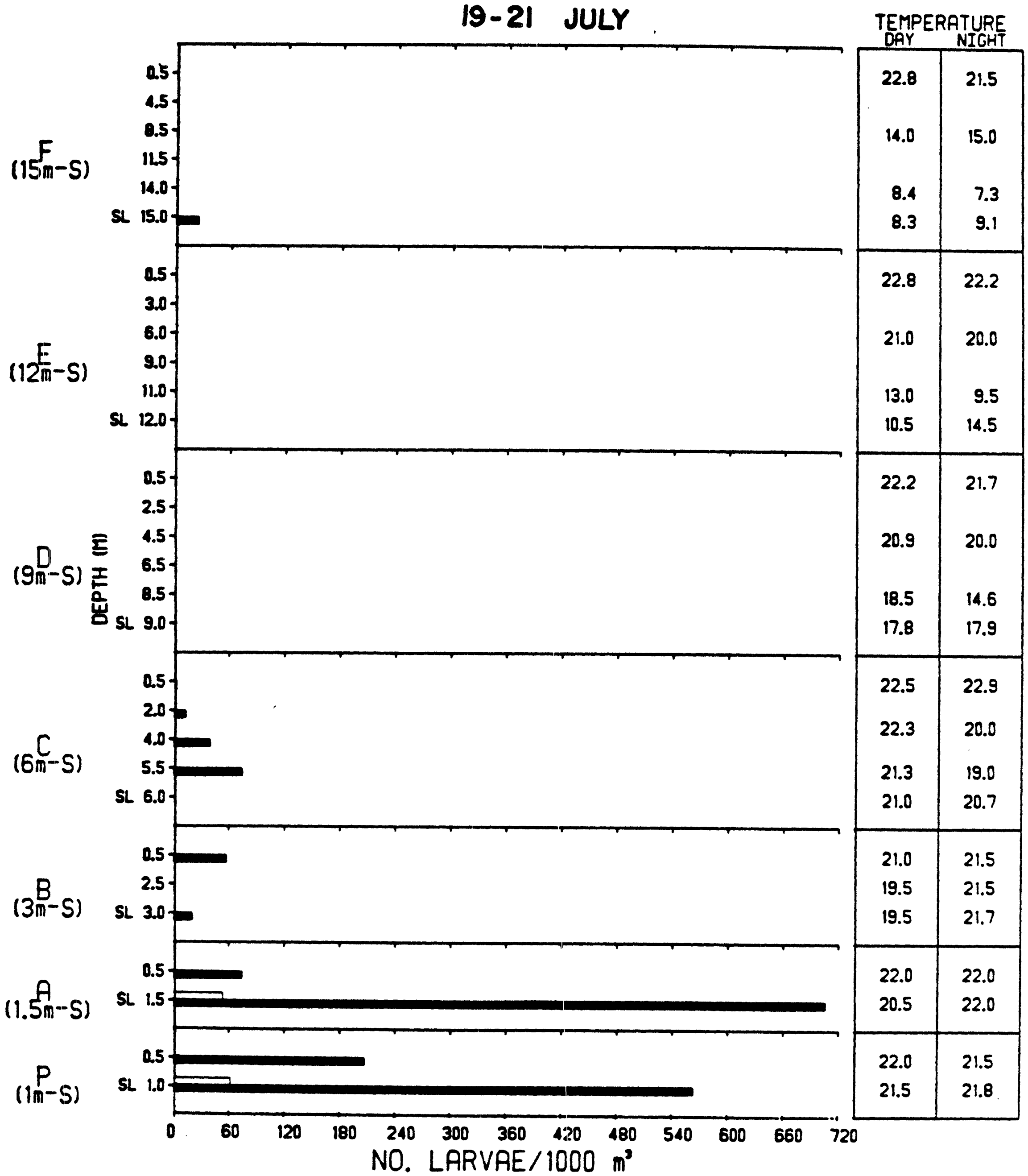

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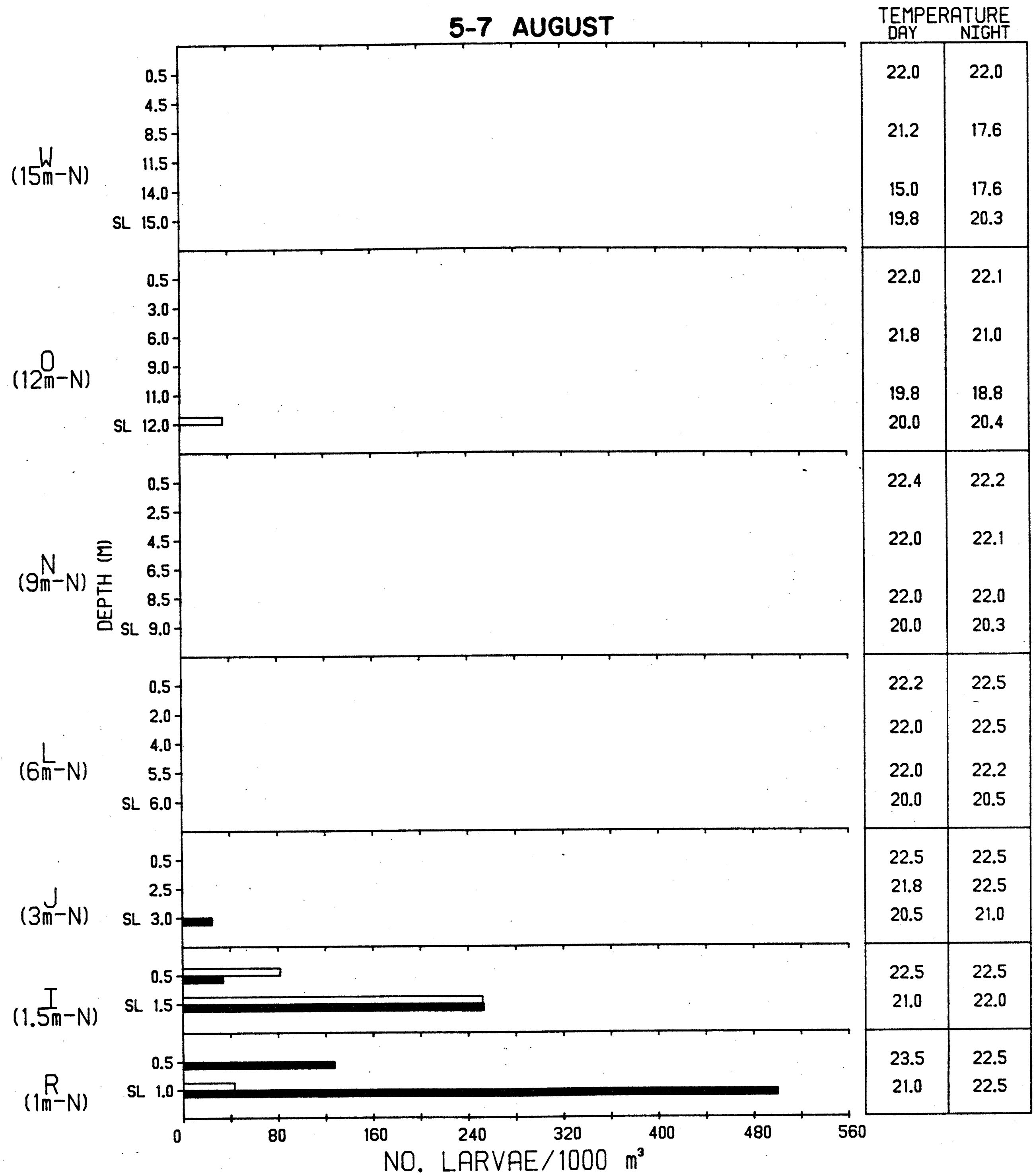

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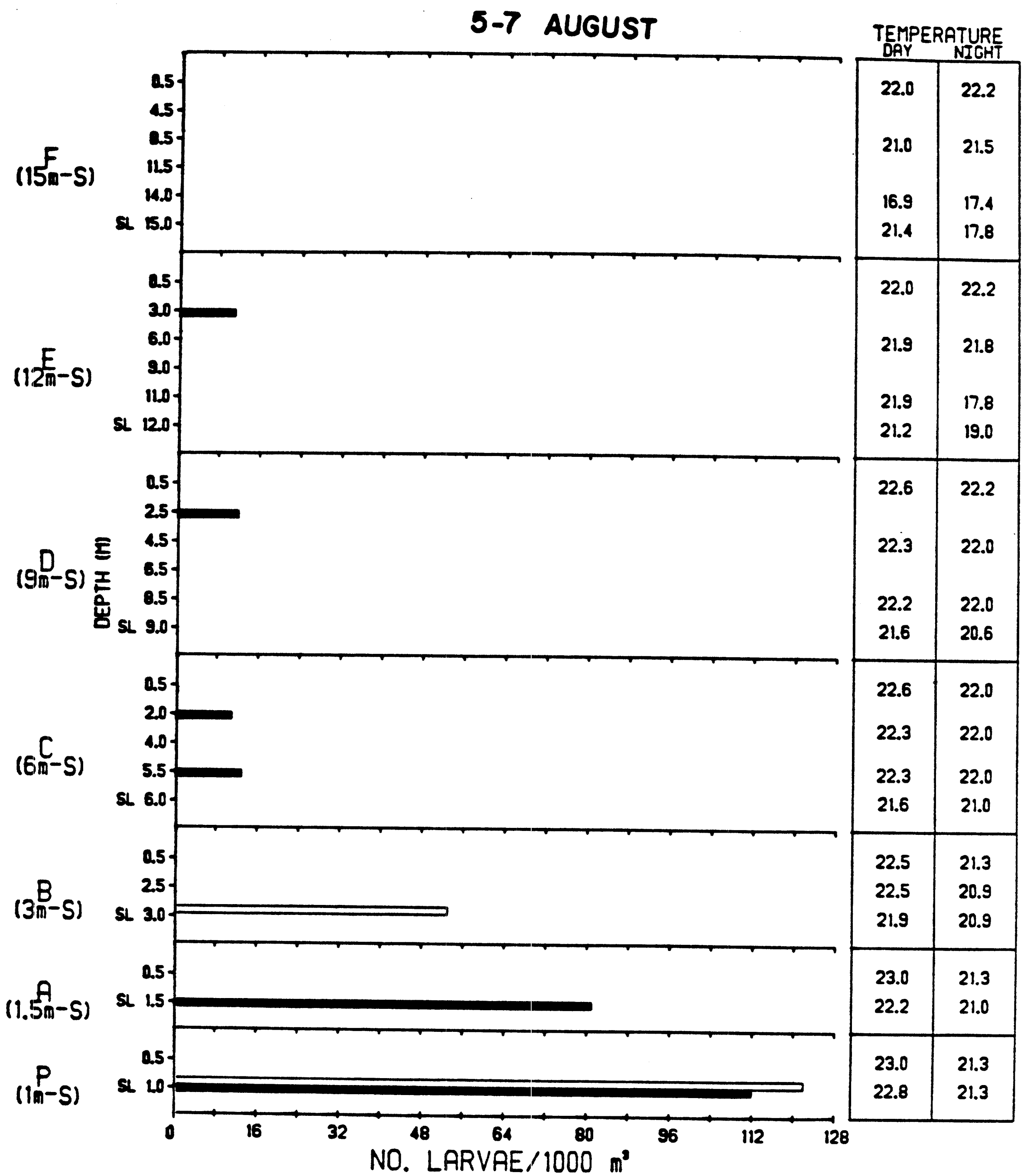

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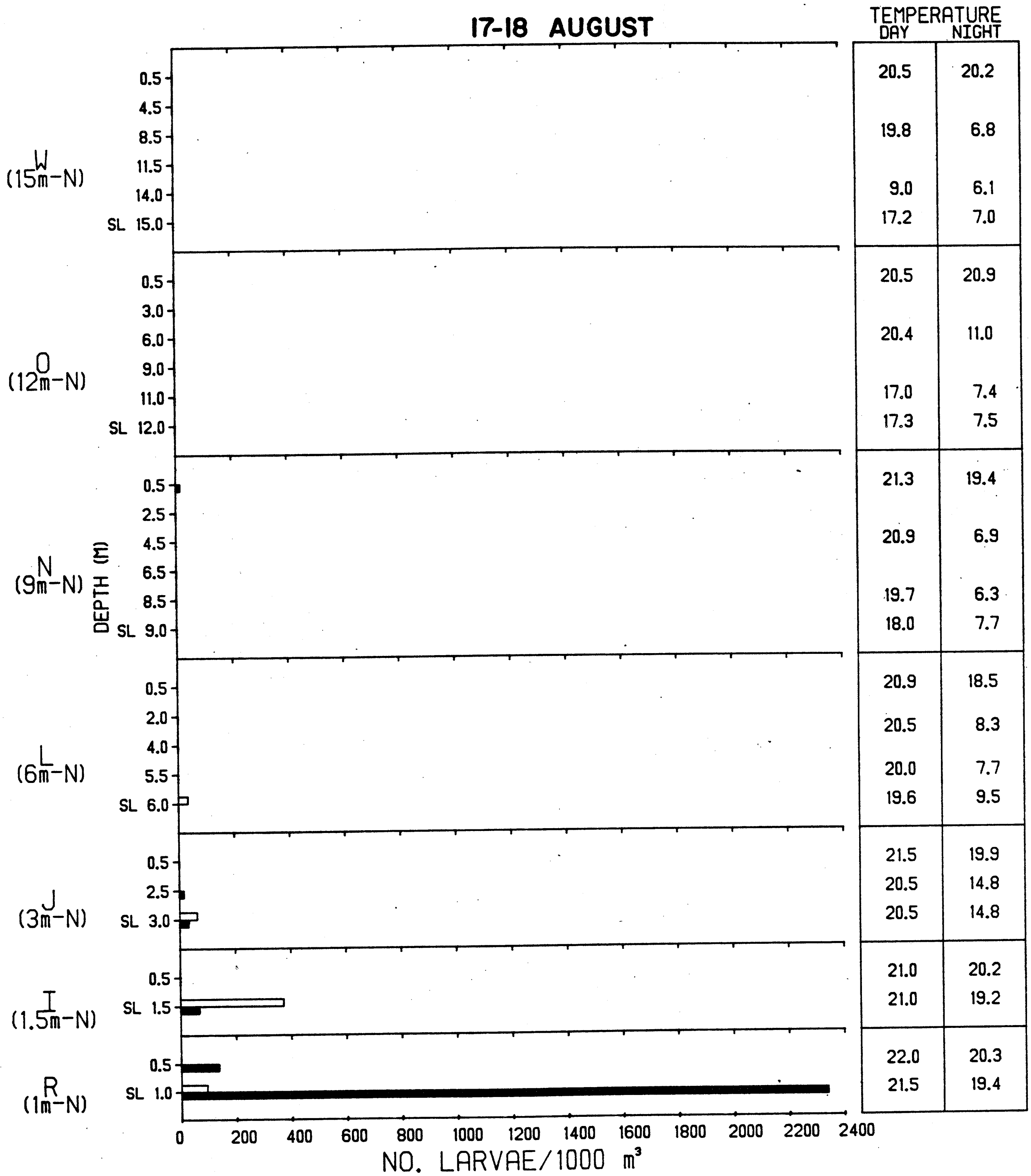

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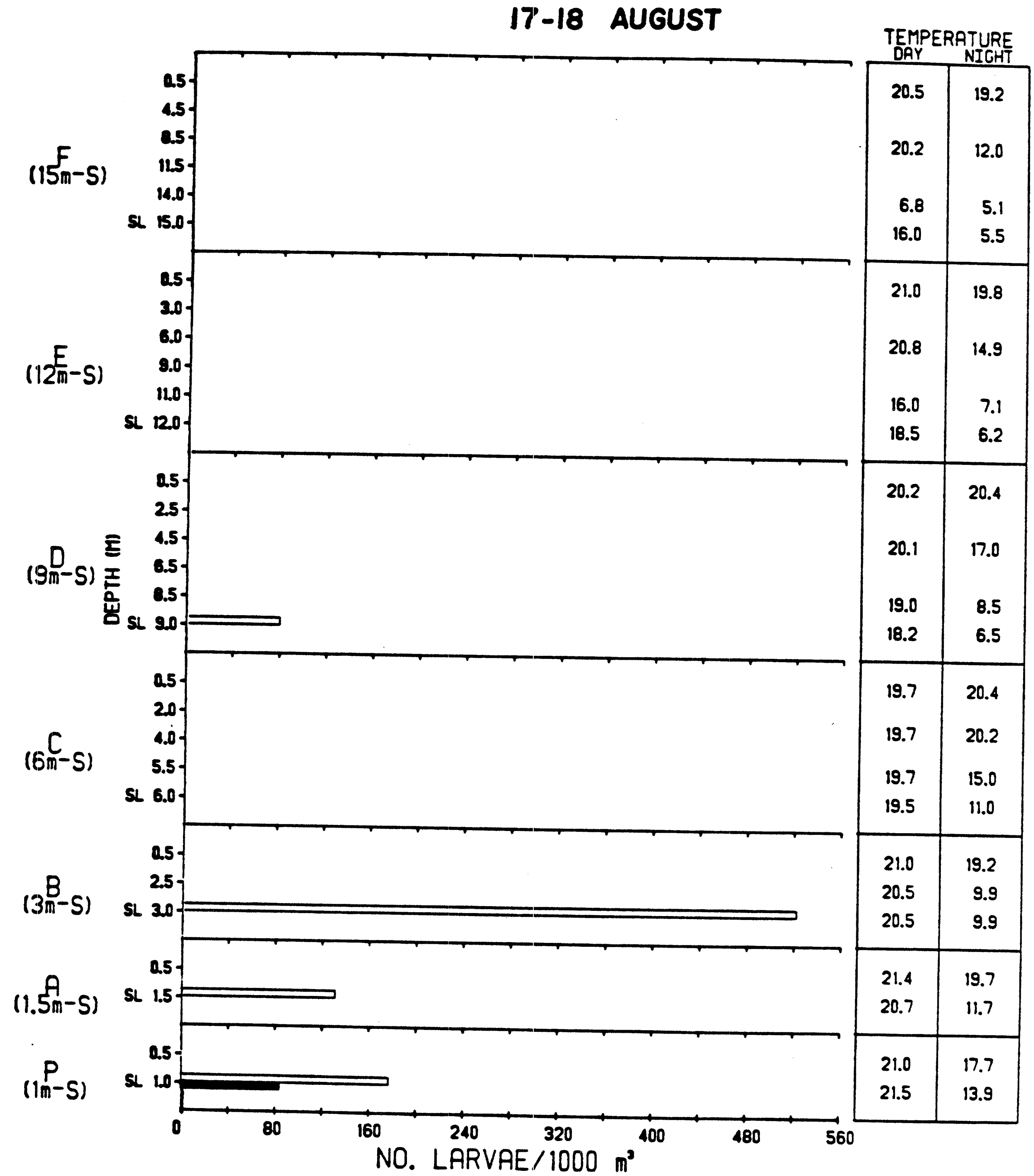

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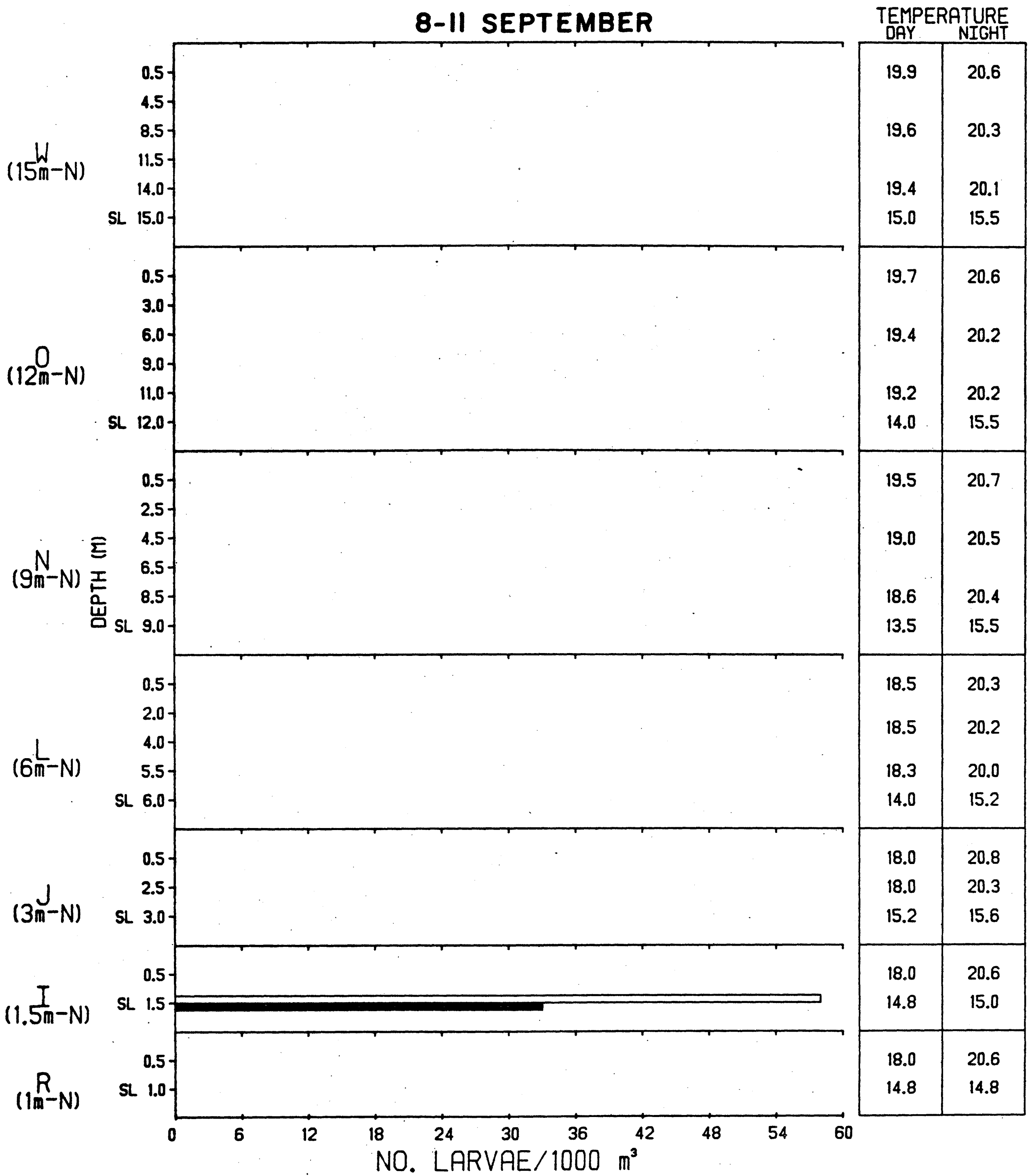

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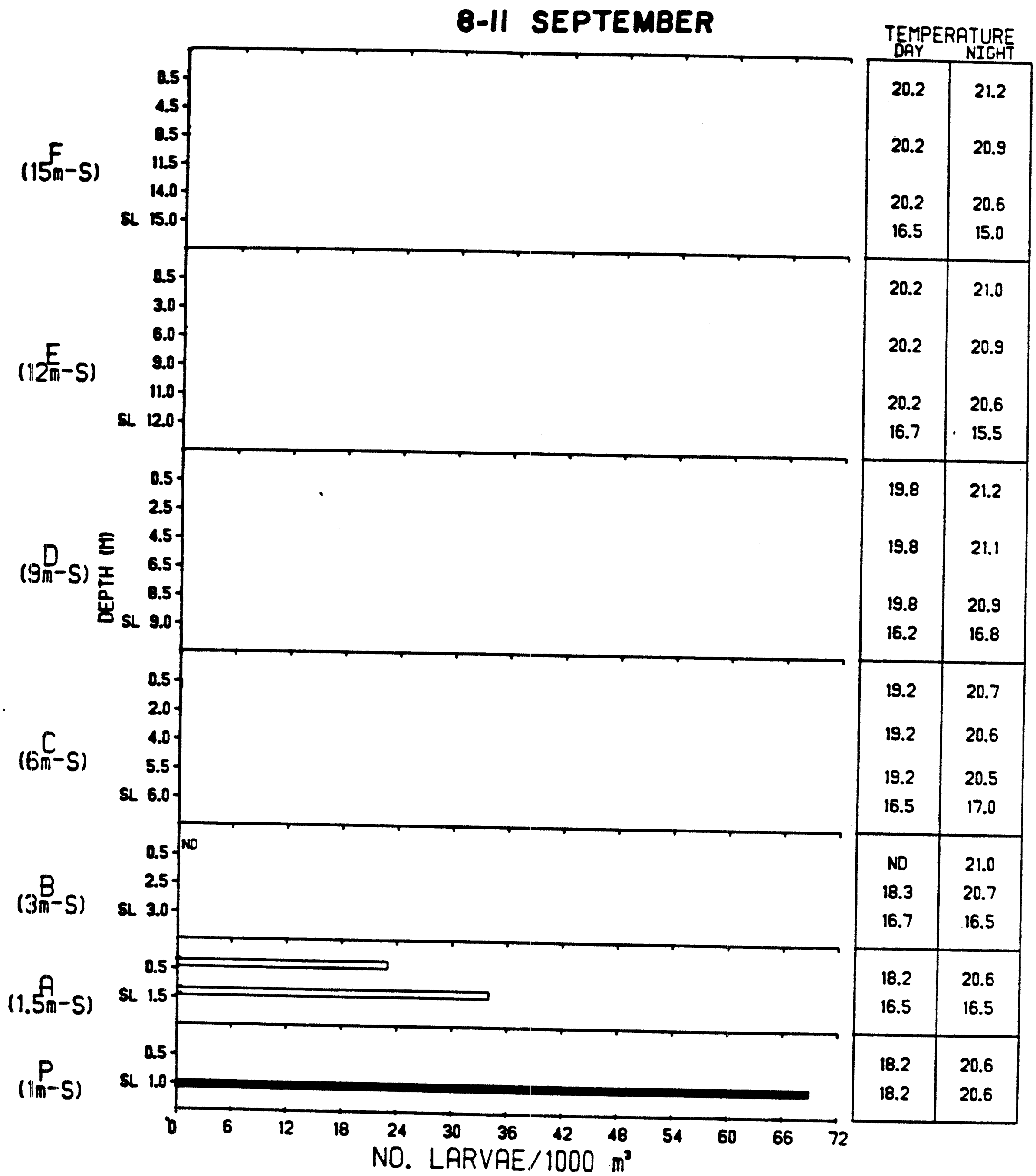

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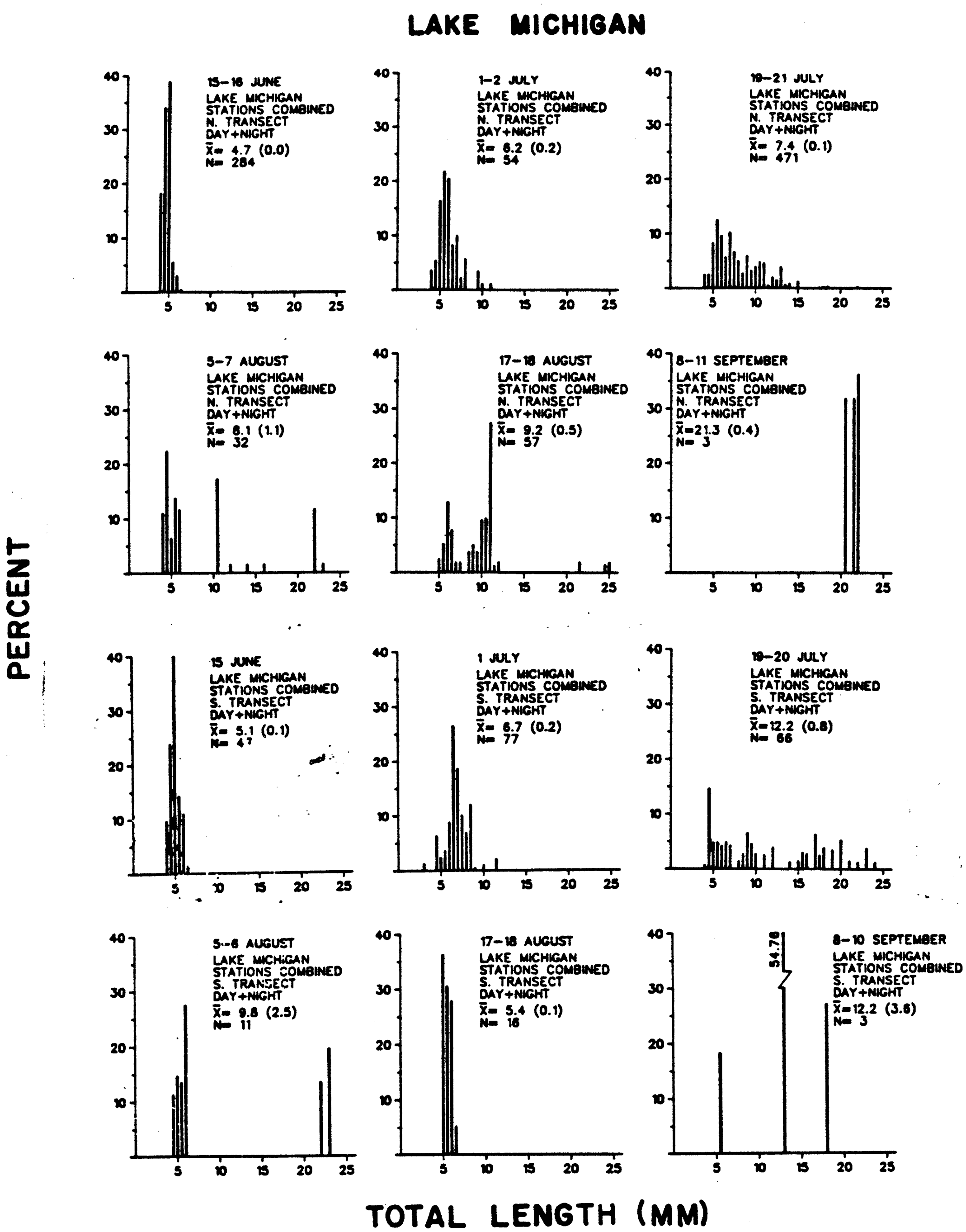
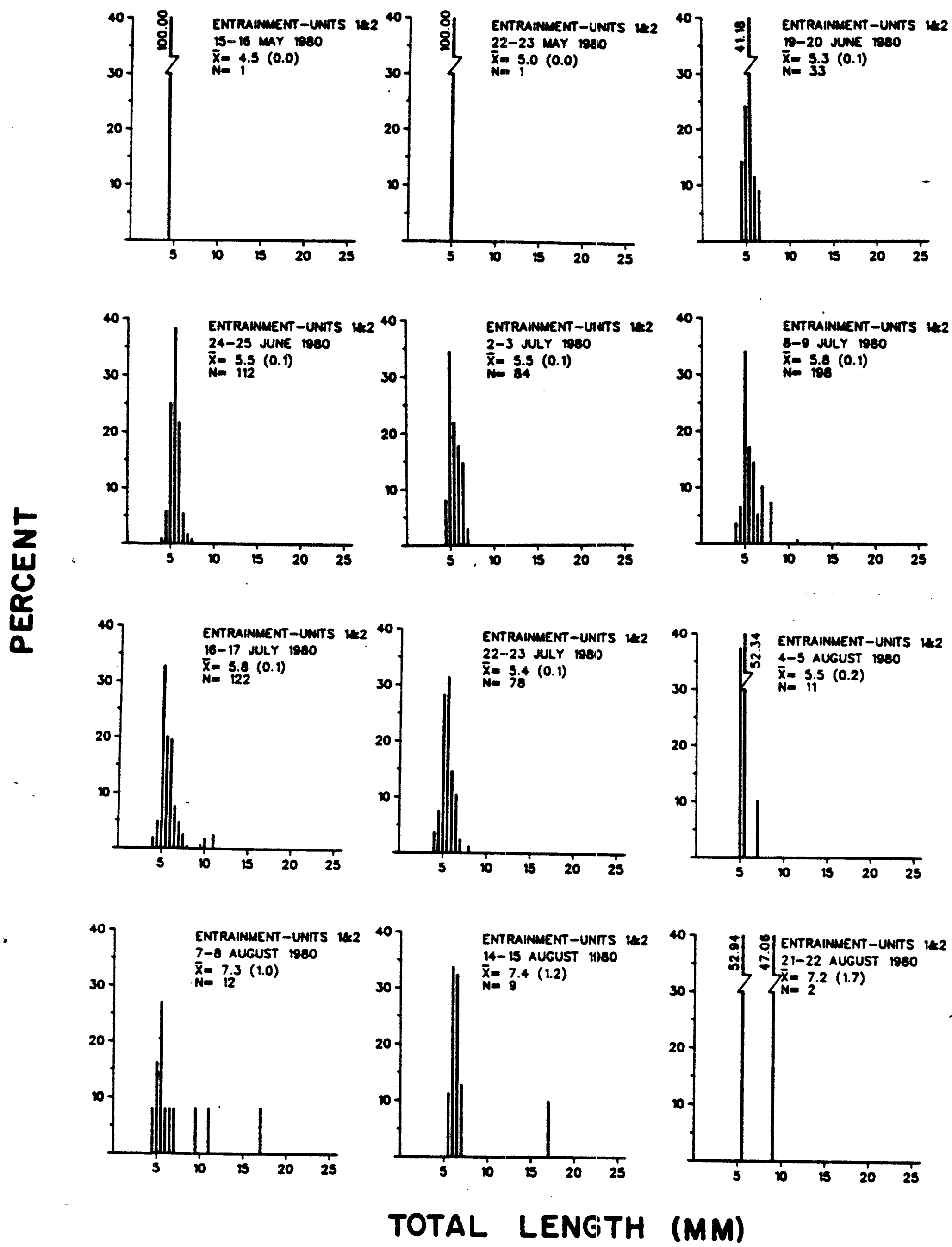


Fig. 24. Length-frequency histograms for larval spottail shiners observed in field and entrainment samples collected during 1981 near the J. H. Campbell Plant, eastern Lake Michigan. Length-frequency histograms for spottail shiner larvae entrained during 1980 were also included. All plankton net and sled tow samples were combined. $\bar{X}$ = mean, N = total number of larvae, standard error is given in parentheses.

ENTRAINMENT-UNITS I AND 2, 1980



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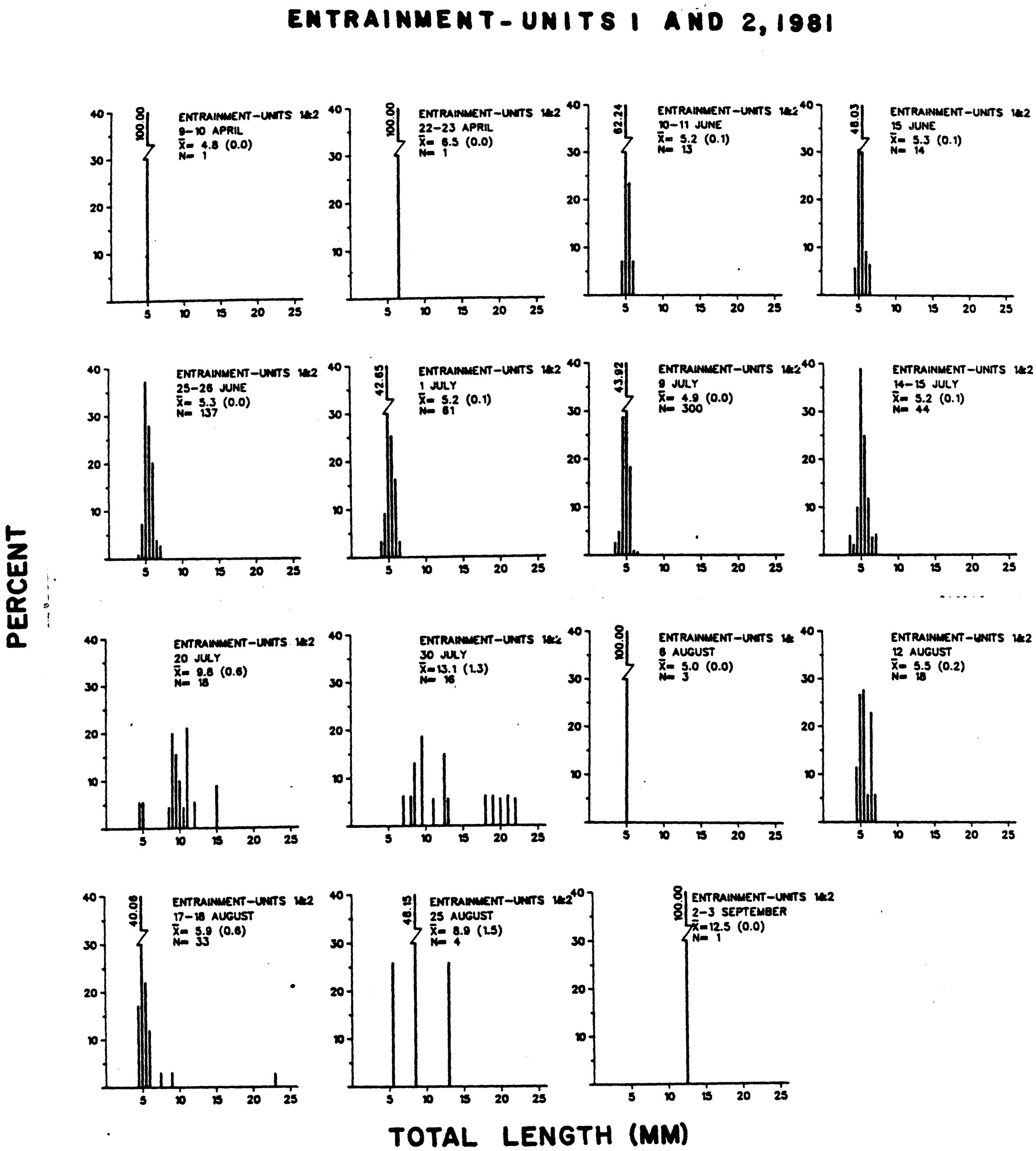

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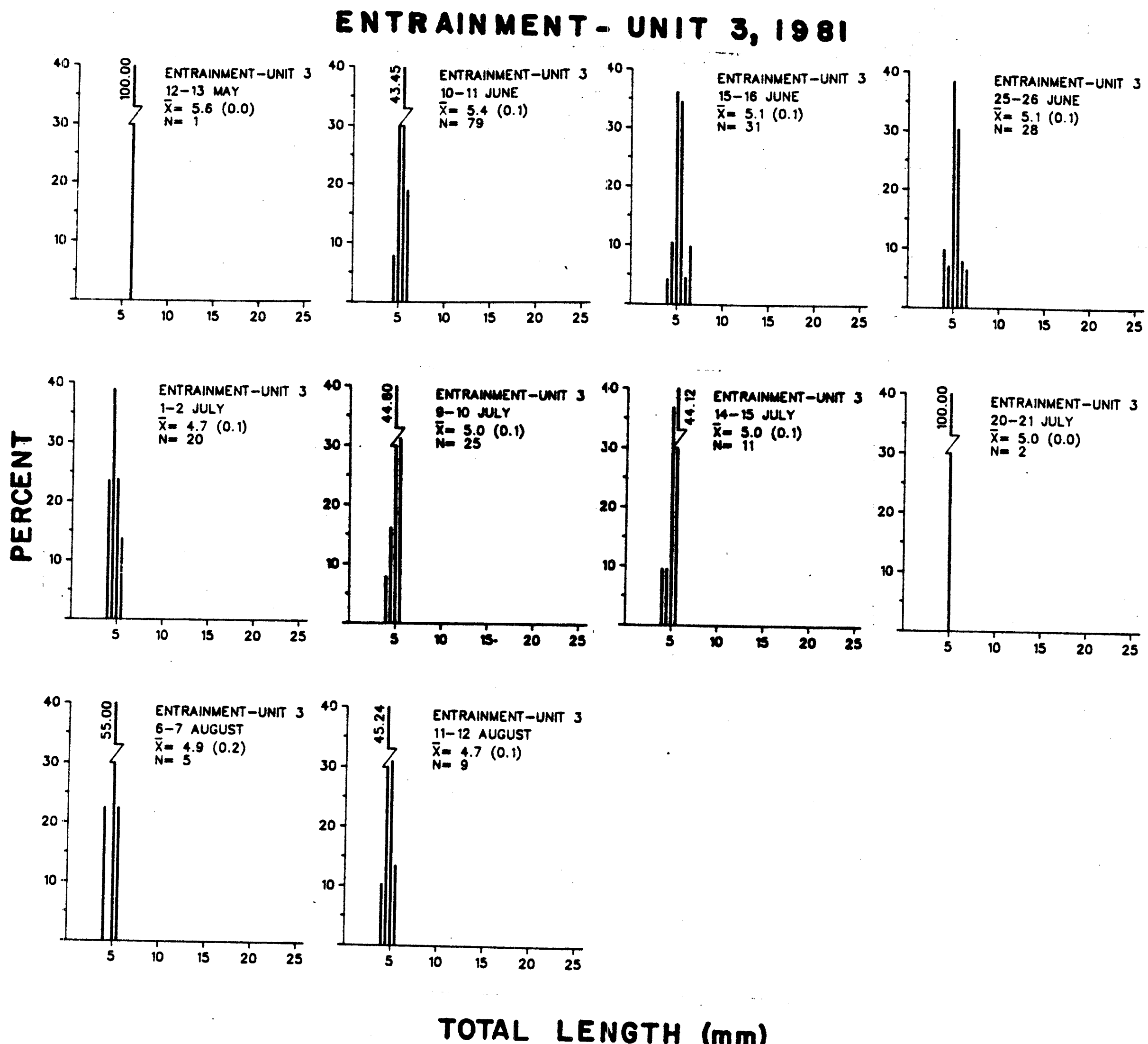


Fig. 24 continued.

Entrainment--

Units 1 and 2, 1980--Yearly entrainment loss of spottail shiners at Units 1 and 2 during 1980 was projected at 6.5 million larvae. This is a decrease in numbers of larvae entrained from 1979 when losses were 8.8 million spottail shiner larvae. July was the month of maximum entrainment for spottails (4.7 million larvae) followed by June (1.3 million larvae). During 1980, spottail shiners comprised 1.4% of the total number of fish larvae entrained at Units 1 and 2.

Units 1 and 2, 1981--Projected number of spottail shiner larvae entrained at Units 1 and 2 in 1981 (4,960,000) was less than in all other sampling years except 1978. Peak numbers of fish were entrained in July 1981, as was the case in all other years. Pigeon Lake, which is an important spawning and nursery area for spottails (Jude et al. 1981a), is most likely the major source of spottail larvae entrained by Units 1 and 2. Only 1.3 million spottail larvae were lost at Unit 3, compared with the 4.96 million at Units 1 and 2. This is a reduction in entrainment losses which we consider to be due to placement of the intakes in deep (11-m) water and branched design of the intakes resulting in reduced flow rate.

Unit 3--First occurrence of spottail larvae in 1981 Unit 3 entrainment samples was on 13 May indicating that some isolated spawning took place in May, most likely in inland lakes or rivers. No spottail larvae were observed in field samples during May. Spottail larvae were absent from all samples (field and entrainment) between 13 May and 9 June. Entrainment sampling on 10-11 June marked the first major occurrence of spottail larvae when as many as 68,432 larvae/24-h were entrained at densities of 93-168 larvae/1000 m^3 (Fig. 25). Spottail larvae were absent from 9- and 12-m north transect field samples until 15 June when day and night densities of 26-99 larvae/1000 m^3 and 32 larvae/1000 m^3 were found at 9 and 12 m respectively (Fig. 23). Larvae at 9 and 12 m were concentrated near or at bottom at both stations. Water temperatures were similar (17.5 C bottom, 21.5 C surface) at both stations. Larvae collected in field samples at 9- and 12-m north transect stations were similar in size to those in entrainment samples (Fig. 24 - mean length 4.9 mm for field larvae and 5.3 mm for entrained larvae indicating they were recently hatched). Data from entrainment samples collected on 15-16 and 25-26 June were quite similar to those of 10-11 June. Densities of entrained larvae ranged from 6 to 72 larvae/1000 m^3 with total losses of 19,949 to 49,284 larvae/24 h for the latter part of June (Appendix 14). Although night field samples from north transect beach stations contained high densities of larvae (over 3000 larvae/1000 m^3) entrainment losses were relatively small, because spottail larvae were concentrated inshore, away from the intakes which are located at 11 m. Mean length of spottail larvae entrained during June was 5.3 mm and none were entrained during day sampling periods. Peak spottail entrainment occurred during June with projected losses of 851,000 larvae that month.

Although field densities in July remained similar to those observed in June, entrainment losses were reduced by 65%. During July an estimated 332,000 (Table 28) spottail larvae were entrained for the month with a mean length of 4.9 mm (Fig. 24).

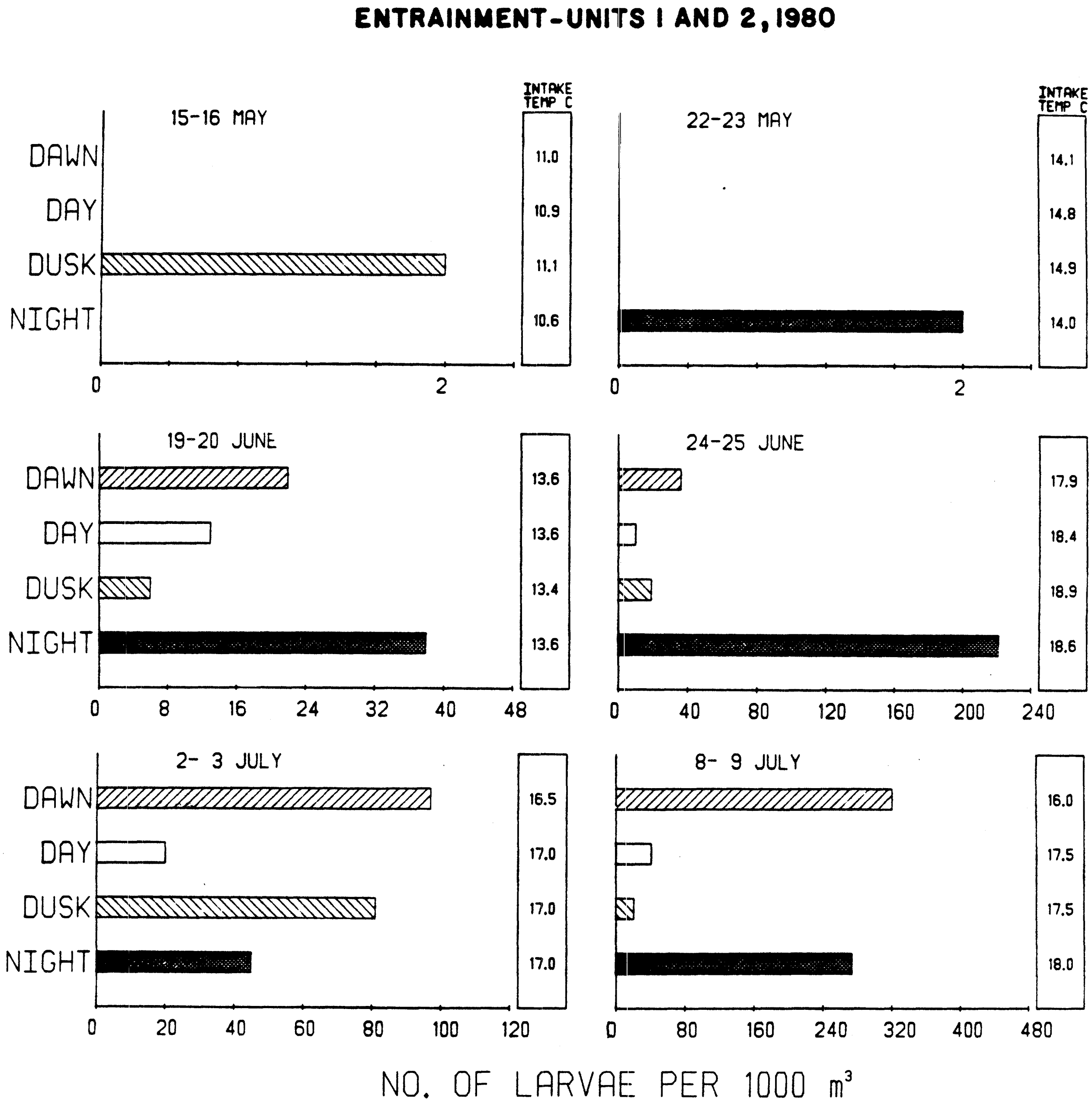
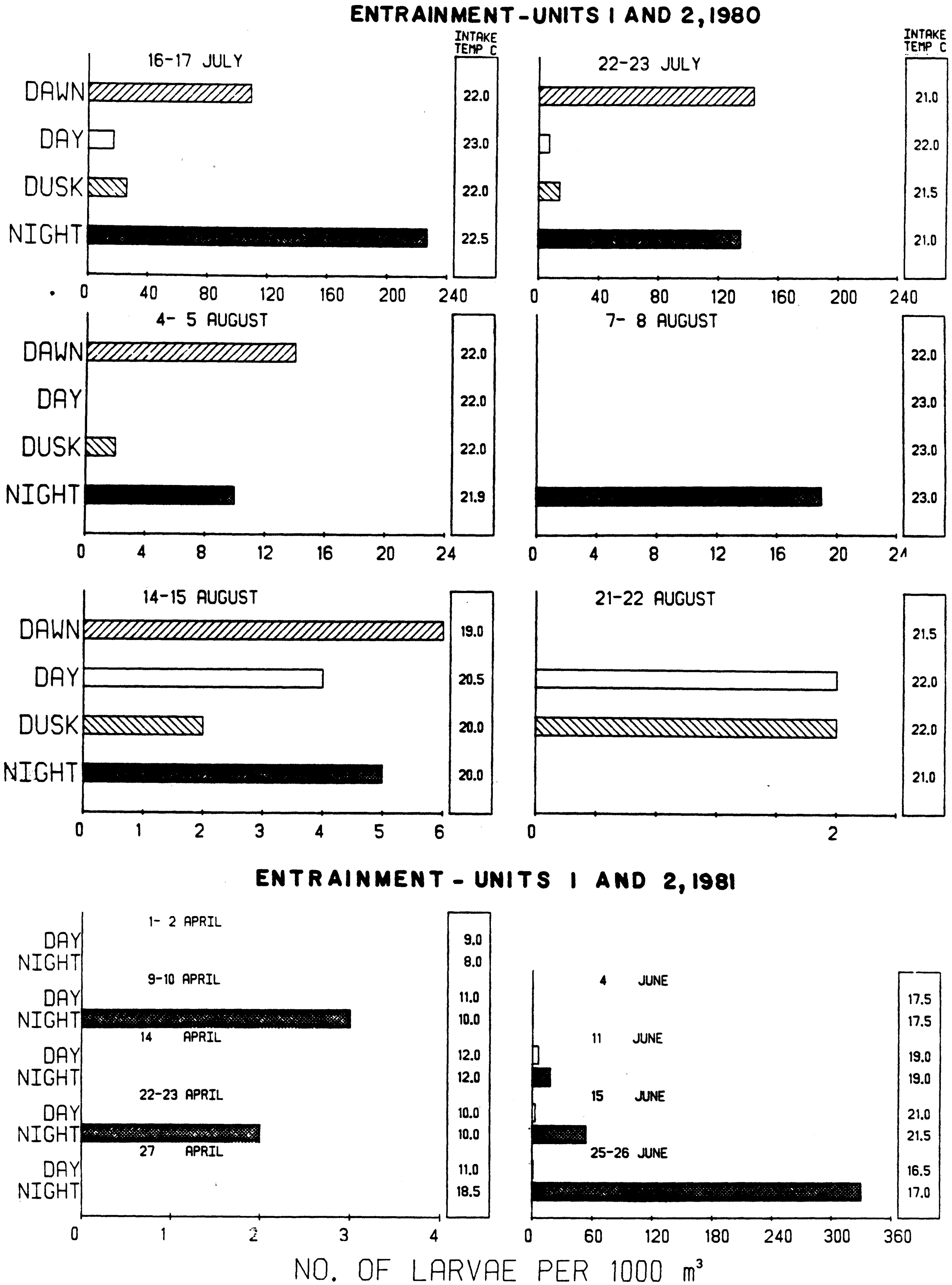


Fig. 25. Density of larval spottail shiners (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at the J. H. Campbell Plant's Units 1 and 2 and Unit 3 during 1980 and 1981. Only day and night densities were shown for Units 1 and 2 during 1981.



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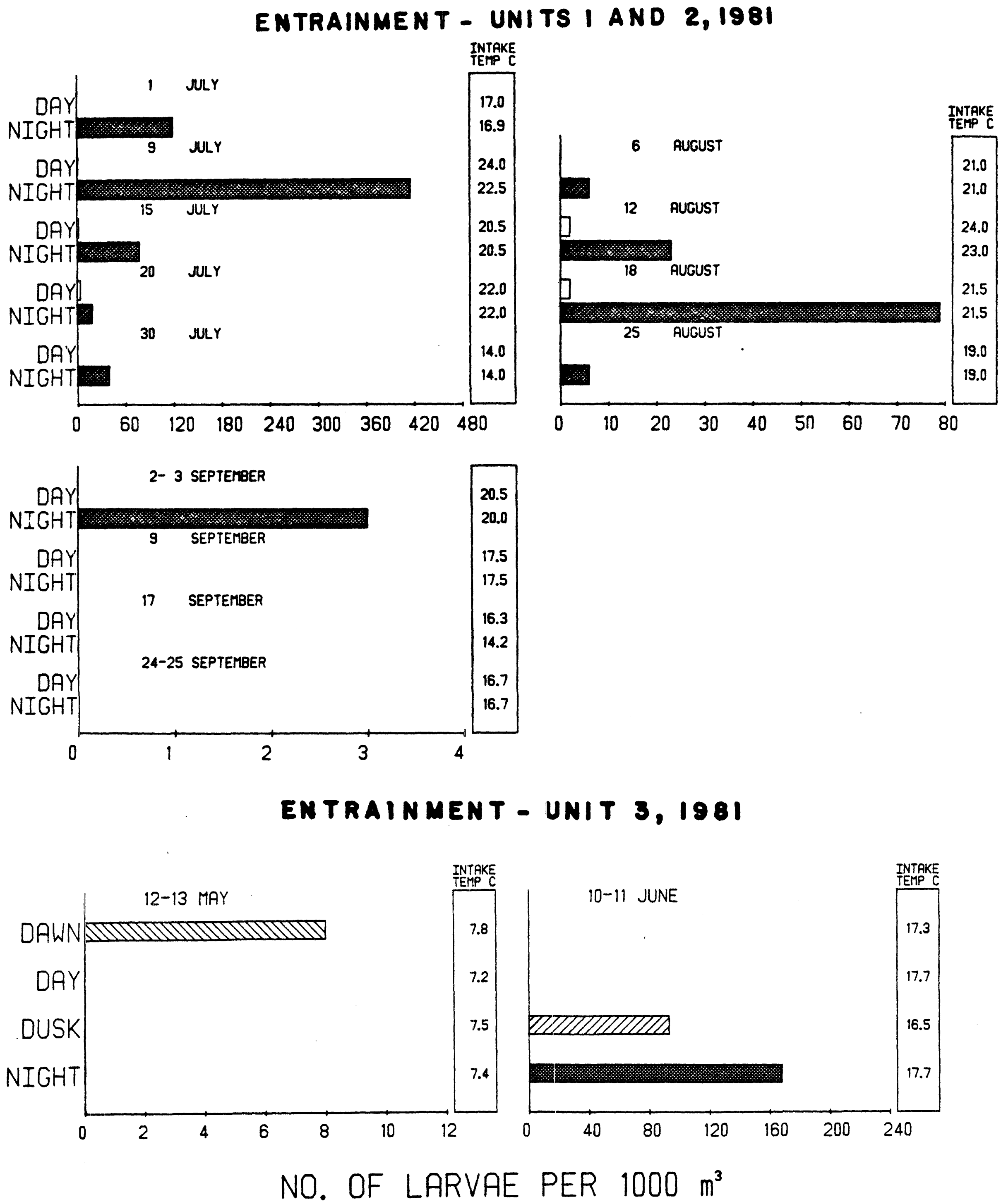

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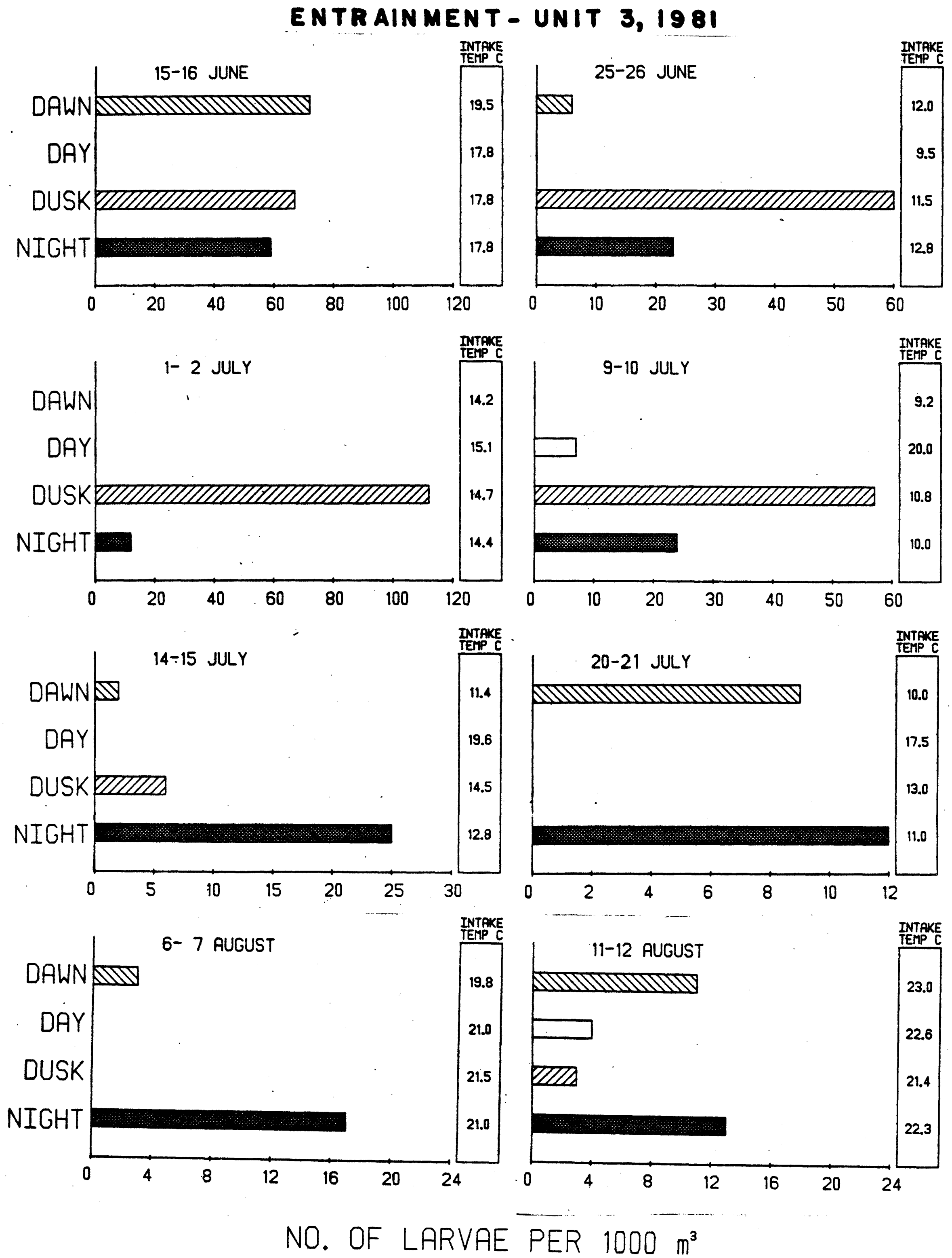


Fig. 25. Continued.

Greatest entrainment losses for July occurred during 1-2 July when 13,700 larvae/24 h were entrained. Spottail larvae were absent from all day entrainment samples in July.

Field samples from early July revealed that high densities of spottail larvae (over 1100 larvae/1000 m^3) were present in the north transect beach zone. Jude et al. (1980) documented the importance of the beach to 3-m depth zone as a nursery area for larval spottails. Densities of larvae decreased with increasing depth as indicated by densities of 28-65 larvae/1000 m^3 at 9 m and only 18 larvae/1000 m^3 at the 12-m north transect station. These were all newly hatched larvae with a mean length of 5.1 mm (Fig. 24).

Peak field densities of larval spottails for the entire year were found during mid-July at beach to 3-m north transect stations; densities over 33,000 larvae/1000 m^3 were found (Fig. 23). As in early July comparatively few spottail larvae were collected at 9- and 12-m north transect stations. Densities of only 14-55 larvae/1000 m^3 were found at those stations; larvae had a mean length of 4.5 mm (Fig. 24). Water temperatures remained conducive to spawning (Fig. 12) during most of July.

During August only an estimated 120,000 spottail larvae were entrained/mo compared with 332,000 larvae lost during the preceding month. Maximum losses of spottail larvae for August occurred during 6-7 and 11-12 August when 6720 and 13,176 larvae/24 h were entrained by Unit 3. After 12 August, no spottail larvae were entrained. Mean length of spottail larvae entrained during August was 4.7 mm. Entrainment samples were not collected during the last week of August due to plant shutdown.

While moderate to large densities (500-2300 larvae/1000 m^3) of spottail shiner larvae were present at the north transect beach station during early and mid-August, they were nearly absent from 9- and 12-m north transect stations, confirming their preference for shallower water.

<u>24-h population and entrainment estimates</u>--The numbers of spottail shiner larvae lost due to entrainment by Unit 3 are slight when compared with the total number of larvae present in the area of the plant. Estimates of total number of spottail larvae in the plant vicinity have been made (Table 31) and were compared with entrainment losses (Table 28) during that same temporal period. The highest ratio of spottail larvae entrained to those present in the area was only 2.11 percent, which occurred during 6-7 August when 6720 larvae were entrained from an estimated 318,000 present in the vicinity of the Unit 3 intake system, based on day and night field samples. Percentages of fish entrained from the estimated number present were most often

≤1%. During entrainment sampling on 20-21 July only 5680 spottail larvae were entrained from an estimated 22.8 million larvae present in the immediate vicinity.

The life history of the spottail shiner in the vicinity of the Campbell Plant (Jude et al. 1978, 1979a, 1980 and 1981a) indicates that a preference for the beach to 3-m depth zones during early life stages exists. Densities of spottail larvae at 9 and 12 m were always minimal in contrast to densities at beach to 3-m stations. As with many species of fish larvae the stage just after hatching appears to be most susceptible to entrainment. The mean length of 5.1 mm for all spottails entrained by Unit 3 indicated that larger larvae were able to avoid being entrained.

Yearly entrainment losses of approximately 1.3 million spottail larvae from Unit 3 are very low when compared to field populations and to projected losses of 11.2, 2.9 and 8.8 million spottail shiner larvae entrained by Units 1 and 2 during 1977, 1978 and 1979 respectively (Jude et al. 1980). The depth at which the Unit 3 intake manifold is situated (11 m) is very advantageous for reducing spottail entrainment. Placement of screens 2.3 m off the bottom also reduces the numbers of spottail larvae entrained. Spottail larvae are benthic as evidenced by high densities present in benthic sled samples and bottom strata plankton net tows (Jude et al. 1978, 1979a, 1980).

Young-of-the-Year--

During 1981, seasonal distribution of spottail YOY and adults followed the same trends as in most other years. Jude et al. (1981a) found that YOY spottails first appeared usually in August in the vicinity of the Campbell Plant. Interruptions of spawning, due to upwellings, could delay first occurrence of YOY spottails. YOY spottails move to deeper water as winter approaches and are the last spottail age-group to leave the study area.

As in past years, YOY spottails first appeared in adult fish sampling gear during August 1981. Approximately 200 YOY spottails were seined at the north transect beach station during the day with half as many seined during the day at the south transect beach station (Fig. 26). YOY spottails were nearly absent from beach stations after August. During September, YOY spottails were concentrated in 6 and 9 m of water and absent from the beach zones. By November, YOY spottails, traditionally the last age-class to leave for deeper water, were nearly absent from the study area, suggesting that the annual migration to deeper water was completed earlier than usual.

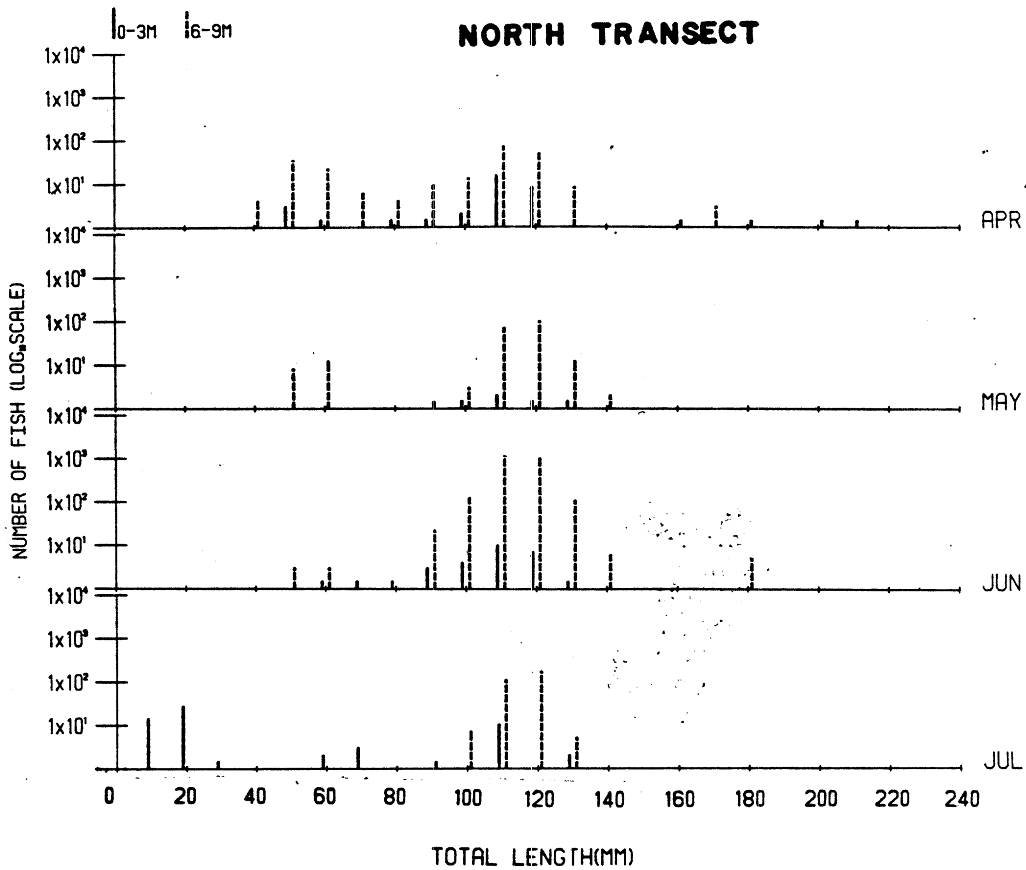
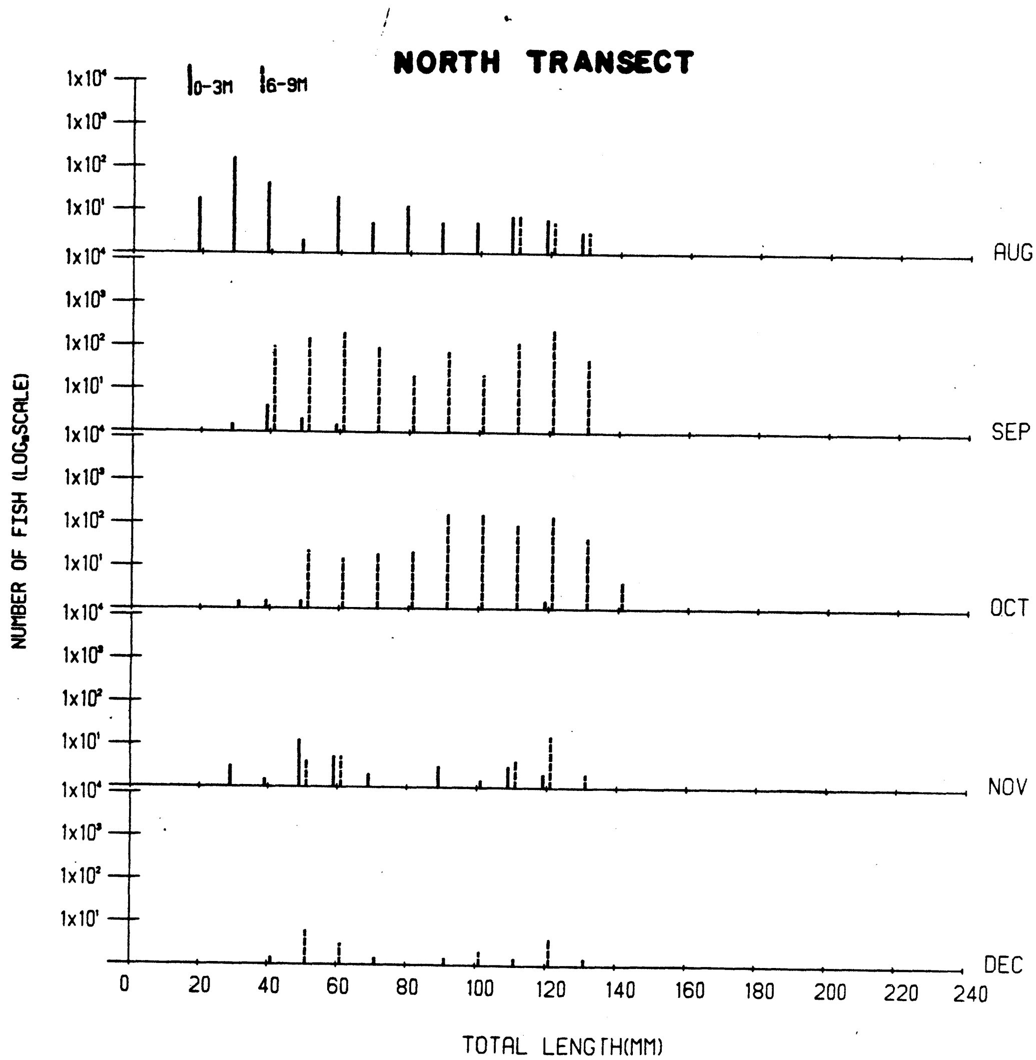


Fig. 26. Length-frequency histograms for spottail shiners collected during April - December 1981 at the north and south transects. Stations were combined into two groups for the north transect: beach and 3 m; 6 and 9 m and into three groups for the south transect: beach, 1.5 and 3 m; 6 and 9 m; and 12 m. Diel periods and gear types were pooled.



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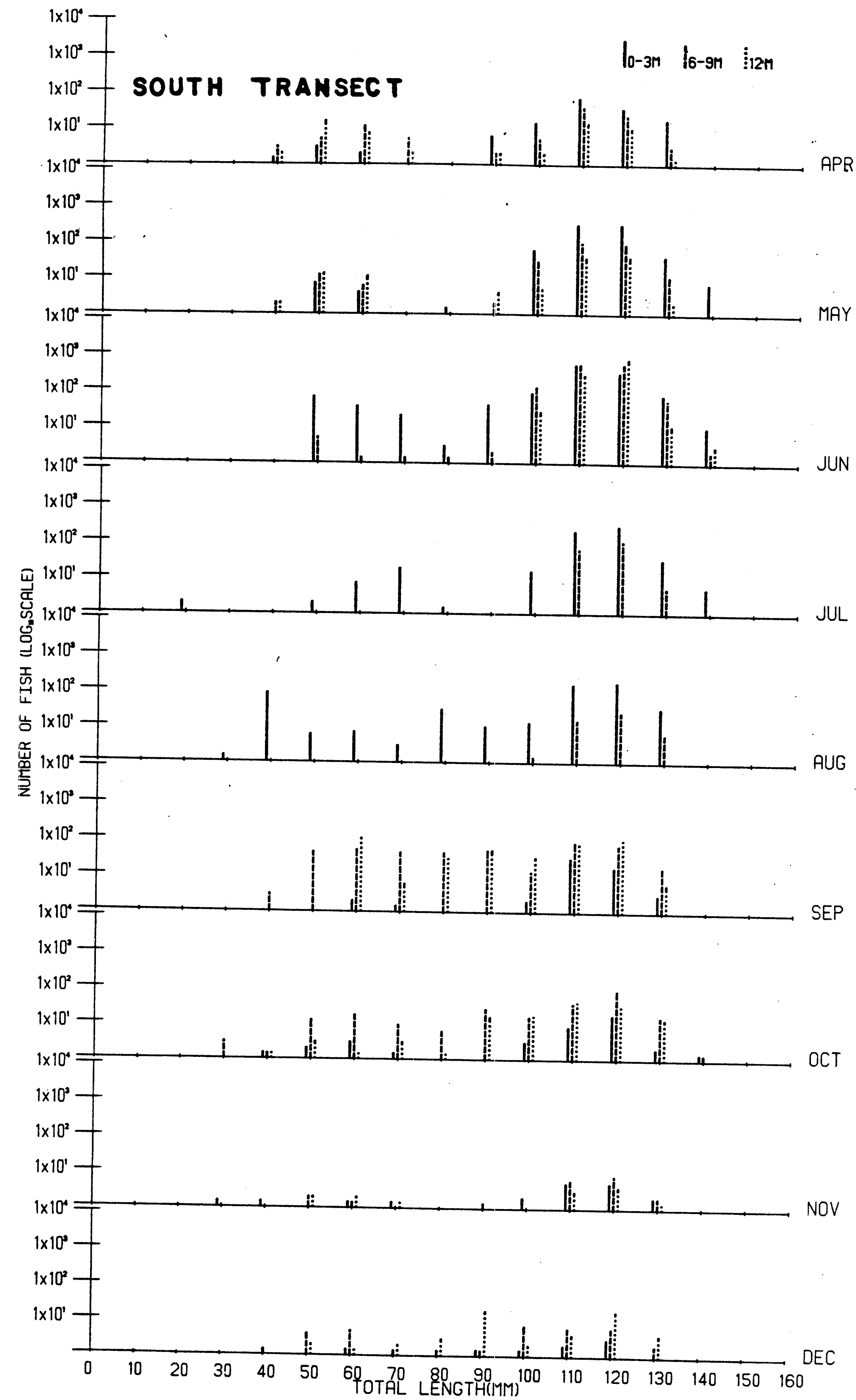


Fig. 26. Continued.

Adults--

Jude et al. (1981a) found that the spring inshore migration of spottail shiners was usually at its peak during May, when large adults (85-135 mm) move inshore prior to spawning. Distribution of adult spottails during May 1981 was typical of past years: sporadic catches occurred at all sampling depths with greatest numbers caught in 9 m of water or less. Gonad development data showed that spawning took place primarily in June with sporadic spawning in July and August. June through August has been the spawning time of spottails during all years of the study. During June, most fish were caught between 1.5- and 9-m depths, suggesting these depths were also the major spawning areas. After spawning was completed, adult spottails were found throughout the study area with greatest densities at the 6- and 9-m stations (Fig. 26). During September, increasing numbers of adults were found with increased depth. By November very few adults were collected in the study area, suggesting that most spottails were out beyond 15 m and that the annual migration to deeper water was nearly complete.

Unidentified Coregoninae

Introduction--

Members of the subfamily Coregoninae occurring in the vicinity of the Campbell Plant include lake whitefish, round whitefish, bloater and lake herring. Round and lake whitefish collected in adult and juvenile fish sampling gear can be identified to species, while most bloaters and lake herring, and other ciscoes which may be present, cannot. Variation in meristic characters and possible introgression between species (Scott and Crossman 1973) prevent positive identification of bloaters or lake herring in most cases, except for large specimens which are not numerous in our samples. During our study, most unidentified Coregoninae collected by adult and juvenile fish sampling gear were believed to be bloaters, *Coregonus hoyi*, or hybrids thereof (Jude et al. 1978).

During 1981 unidentified Coregoninae were fourth in abundance of fish collected in adult and juvenile fish sampling gear (Table 32). Over 10,000 were collected, 6.6% of the total catch, compared with 1980 when almost 9,000 were collected, comprising 10.6% of he catch. Each year of the study, the number of unidentified Coregoninae caught has increased.

As larvae, all Coregoninae are very similar, including round and lake whitefish. Therefore larvae of all members of the subfamily were designated unidentified Coregoninae. Speculations as to the identity of larvae were based upon descriptions of larvae by Hinrichs (1979) and seasonal distribution and gonad conditions of adult Coregoninae.

Larvae--

Seasonal distribution--Round whitefish, lake whitefish and lake herring all spawn in late fall (November-December) in shallow water, less than 10 m (Scott and Crossman 1973; Machniak 1975). During our study, however, round whitefish was the only species captured as adults during October-November in the inshore zone near the Campbell Plant. Round whitefish with well developed and spent gonads were collected, indicating spawning occurred in the plant vicinity. Only a few lake whitefish and no adult unidentified Coregoninae were collected during October-November. However, lake whitefish are more readily collected by gill nets set perpendicular to shore, rather than parallel as we set them, due to their tendency to cruise parallel to shore (N. A. Auer, personal communication, Mich. Tech. Univ., Houghton, Mich). Therefore lake whitefish may spawn in the plant vicinity but may not be detected by our sampling scheme. Lake whitefish are reported to spawn on a rocky reef near Ludington 93 km north of the Campbell Plant (Liston et al. 1981). No YOY lake whitefish were collected during our study, but a few YOY round whitefish, 50-97 mm, were collected during summer 1980. Coregoninae larvae collected in April during our study may have been round or lake whitefish, or lake herring larvae. These larvae were collected from beach stations to 3 m (Fig. 27) and generally averaged 13 to 15 mm TL (Fig. 28). A 24-mm individual collected in April 1979 was positively identified as a lake whitefish. During 1981, densities at the north transect ranged from 22 to 110 larvae/1000 m^3. South transect densities were higher, 28-752 larvae/1000 m^3 (Fig. 27). In 1981, coregonine larvae were collected during April at stations D (9 m, south) and F (15 m, south) for the first time. Water temperatures during April when unidentified Coregoninae larvae were collected were 6-11.5 C.

After April, Coregoninae larvae were absent from field samples until summer. From June to August, low densities of Coregoninae larvae were observed, mostly at deeper stations (12-15 m), at water temperatures from 14.5 to 22.0 C. These larvae were smaller than those collected in April, usually 11-13 mm TL. The bloater, *Coregonus hoyi*, spawns during late winter (February-March), usually in water deeper than 36 m (Scott and Crossman 1973). Larvae are primarily distributed deeper than 80 m and are most abundant in late June and early July (Wells 1966). For these reasons, Coregoninae larvae collected during summer were believed to have been bloater larvae. Bloaters hatch over a

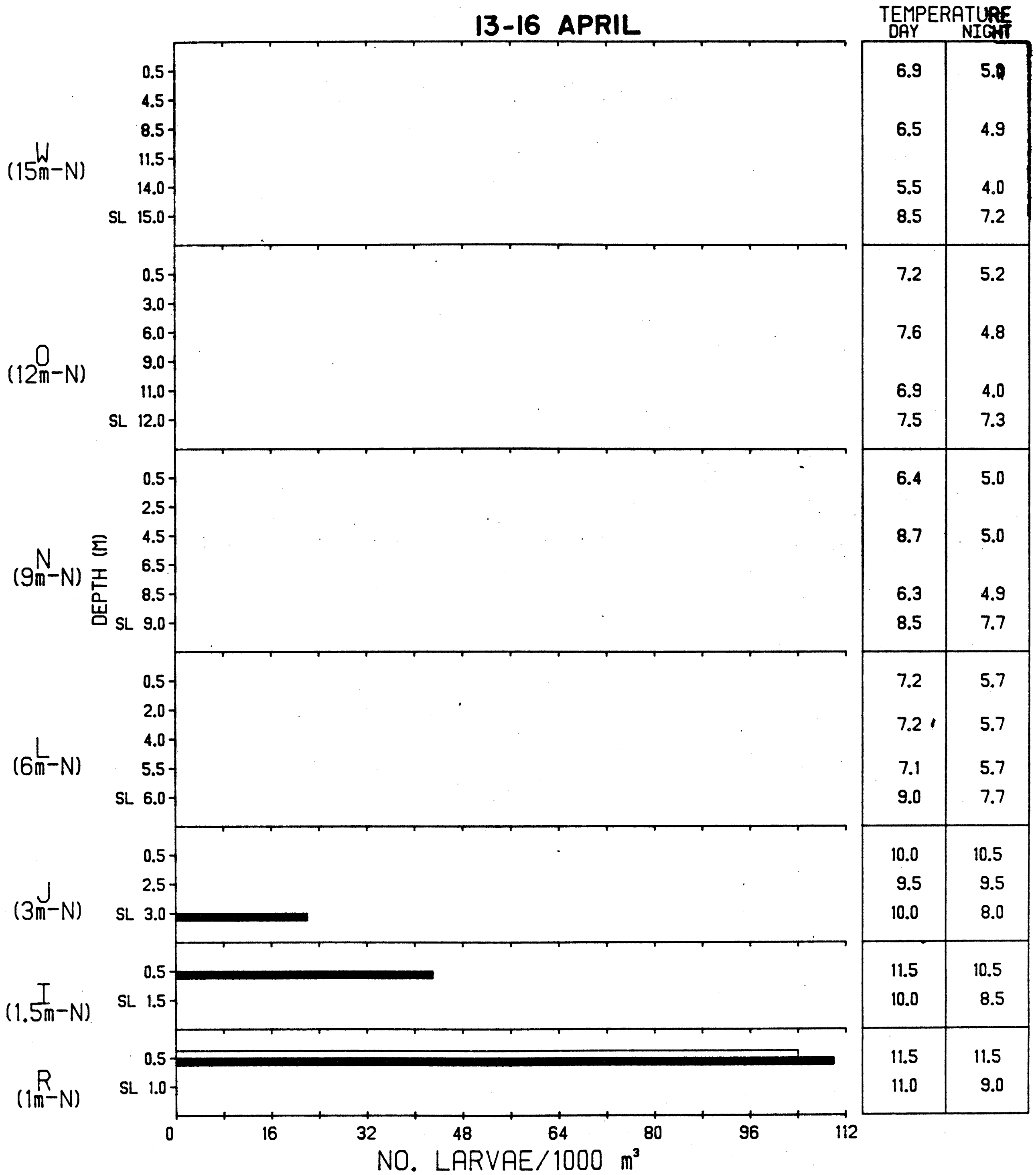
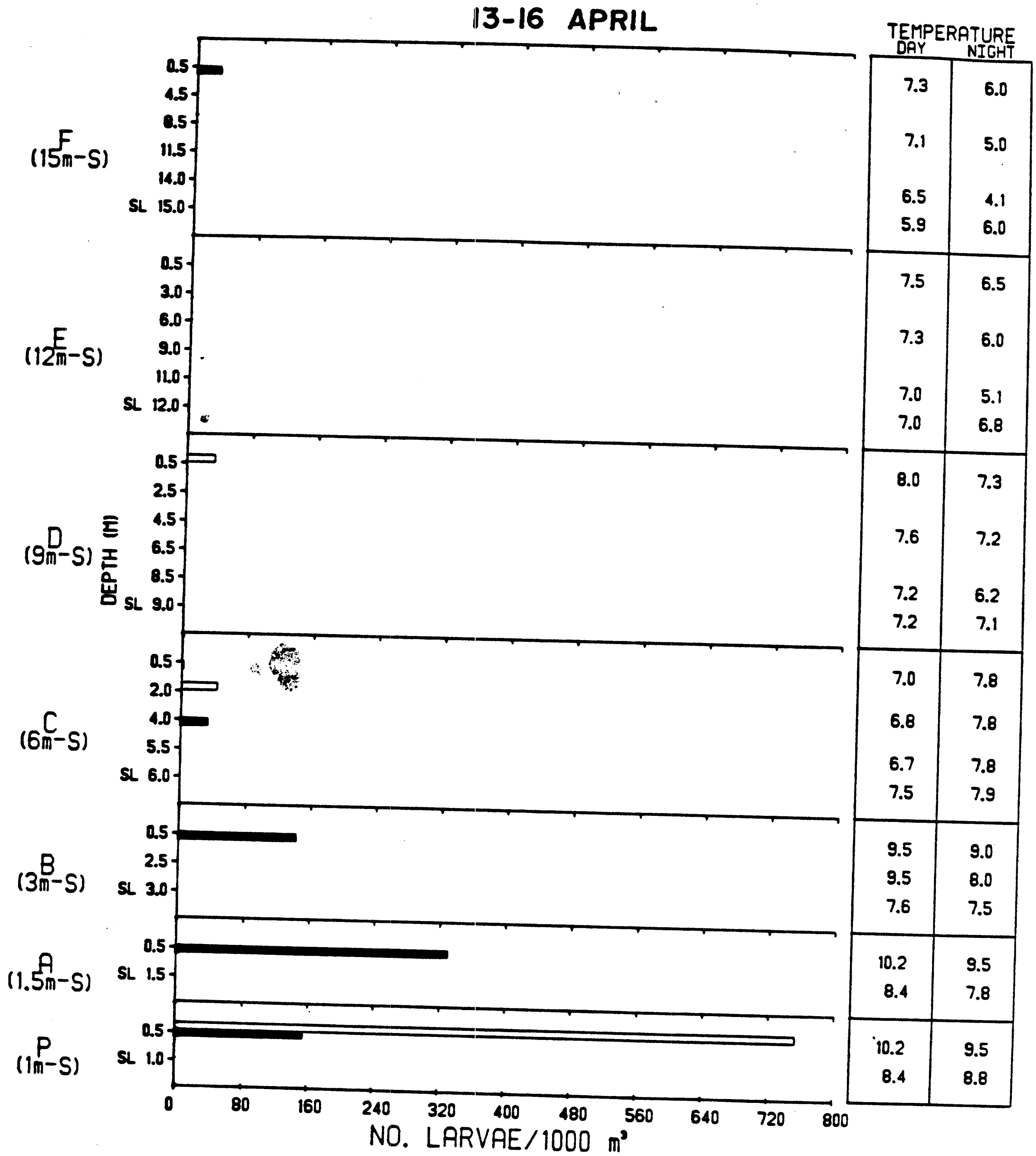
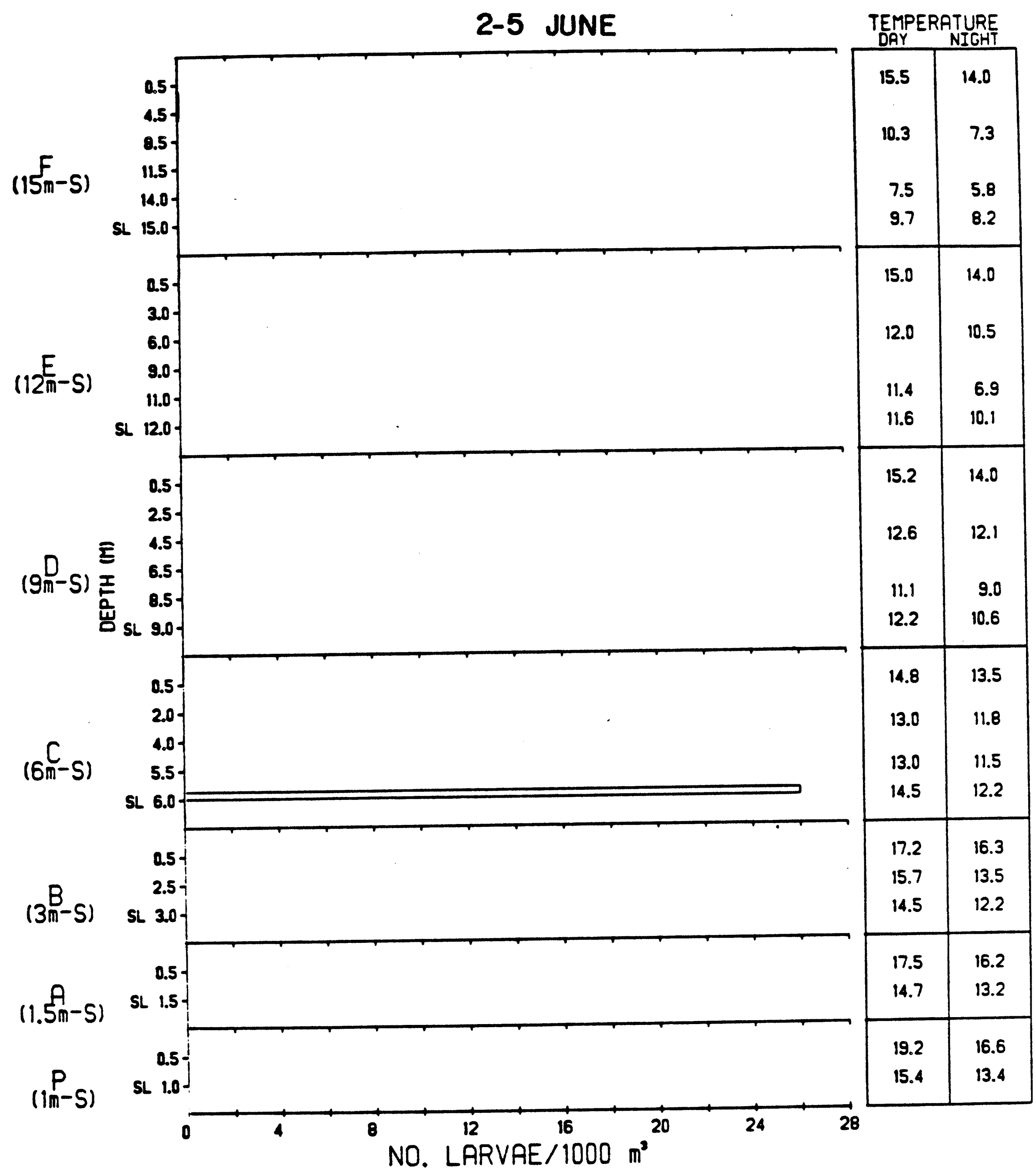


Fig 27. Density of larval unidentified Coregoninae (no./1000 m³) at north and south transect stations near the J. H. Campbell Plant, eastern Lake Michigan during April and June 1981. ☐=day ■=night, SL=sled.



Station	Depth (m)	Temperature Day	Temperature Night
F (15m-S)	0.5	7.3	6.0
		7.1	5.0
		6.5	4.1
	SL 15.0	5.9	6.0
E (12m-S)	0.5	7.5	6.5
		7.3	6.0
		7.0	5.1
	SL 12.0	7.0	6.8
D (9m-S)	0.5	8.0	7.3
		7.6	7.2
		7.2	6.2
	SL 9.0	7.2	7.1
C (6m-S)	0.5	7.0	7.8
		6.8	7.8
		6.7	7.8
	SL 6.0	7.5	7.9
B (3m-S)	0.5	9.5	9.0
	2.5	9.5	8.0
	SL 3.0	7.6	7.5
A (1.5m-S)	0.5	10.2	9.5
	SL 1.5	8.4	7.8
P (1m-S)	0.5	10.2	9.5
	SL 1.0	8.4	8.8

Fig. 27. Continued.



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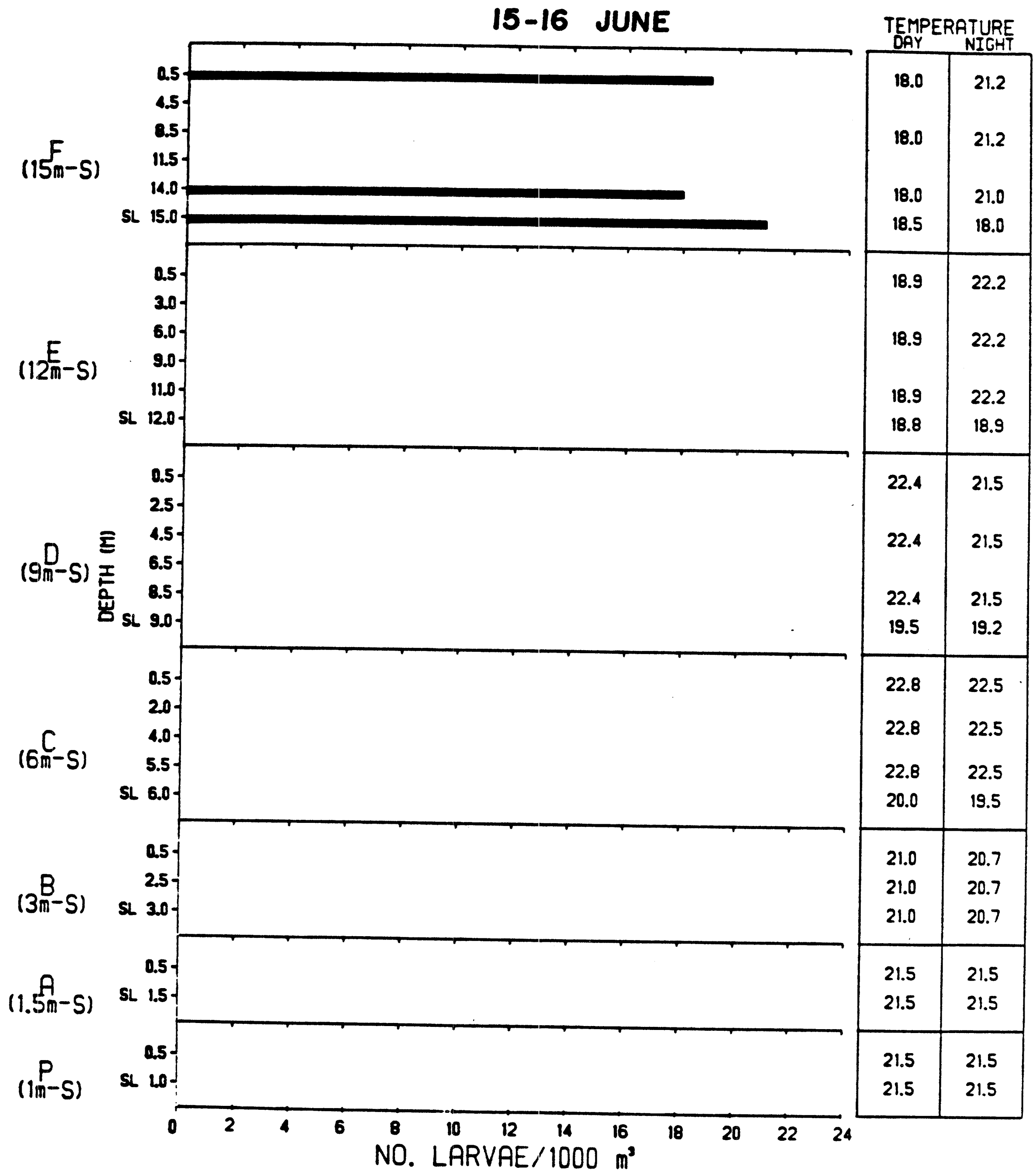

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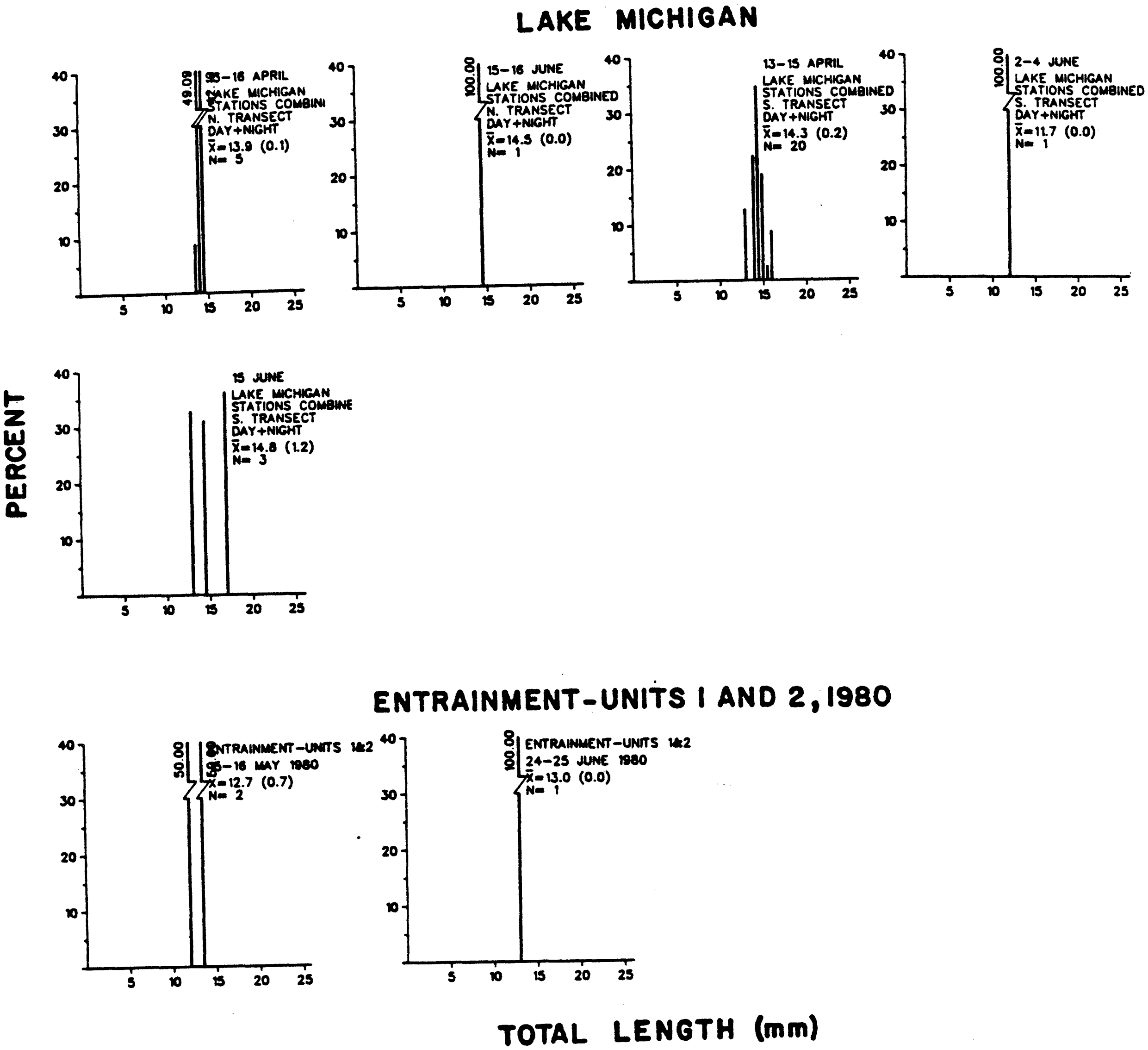


Fig. 28. Length-frequency histograms for larval unidentified Coregoninae observed in field and Units 1 and 2 entrainment samples collected during 1981 near the J. H. Campbell Plant, eastern Lake Michigan. Length-frequency histograms for unidentified Coregoninae larvae entrained during 1980 were also included. All plankton net and sled tow samples were combined. $\bar{X}$ = mean, N = total number of larvae, standard error is given in parentheses.

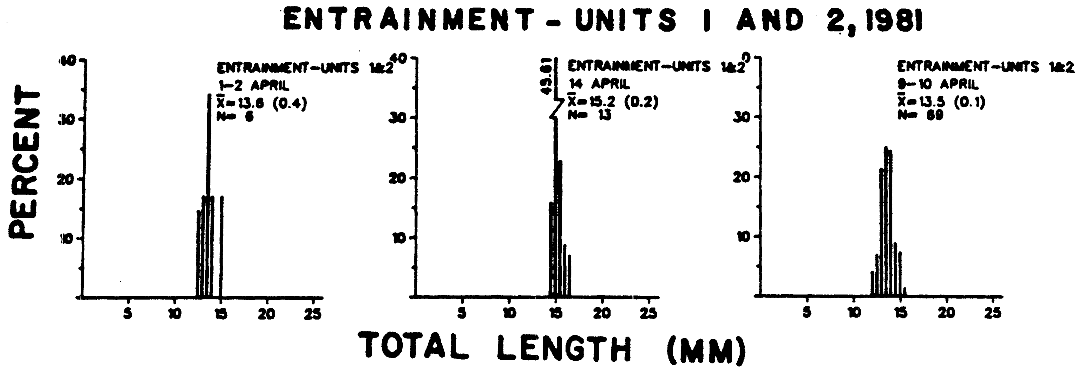


Fig. 28. Continued.

long period, as length distributions in Wells' data did not change over the season (mean lengths 11-11.3 mm) and larvae with yolk were collected from April to August.

During a study of lake trout reproduction at the Campbell Plant riprap (Dorr et al. 1981), evidence was discovered of whitefish reproduction on the riprap. Eggs 3.0-3.5 mm in diameter, probably those of lake or round whitefish, were collected from the rocks on 16 December 1981. Coregonine larvae were collected with emergent fry traps set on the riprap during April-May 1982 (J. A. Dorr III, personal communication, Great Lakes Research Division, Ann Arbor, Michigan).

Entrainment--No Coregoninae larvae were found in Unit 3 entrainment samples. Larvae believed to be round or lake whitefish, occurring regularly in April, inhabited waters shallower than the intake depth. Presumably by the time these fish migrated to deeper water, they were large enough to avoid entrainment as they passed the intakes. Bloater larvae in summer were collected near the intake depth and may have been entrained in such low densities that our entrainment sampling scheme missed them, or they may have been able to avoid entrainment. In any case, bloater larvae at the 11-m intake depth would be at the fringes of the population, which is primarily in deeper water (Wells 1966).

Units 1 and 2 entrained an estimated 22,900 Coregoninae larvae in April and May 1978, 607 in April 1979, 4230 in May and June 1980 and 1,410,000 in March and April 1981 (Jude et al. 1980; Tables 25, 26). Larvae entrained by Units 1 and 2 during March through May were most likely lake or round whitefish from the nearshore zone. These larvae apparently avoided the Unit 3 intake as none were entrained by Unit 3. Those entrained at Units 1 and 2 in June were probably bloaters. Densities in 1981 entrainment samples from Units 1 and 2 ranged from 6 to 157 larvae/1000 m³ and peaked on 9-10 April (Fig 29). Entrainment densities were similar to field densities at the north transect, but lower than south transect densities. Entrained larvae were similar in size to larvae in field samples (13.5-15 mm - Fig. 28). Unidentified Coregoninae larvae were entrained at low densities in 1980 (2-4 larvae/1000 m³ - Fig. 29).

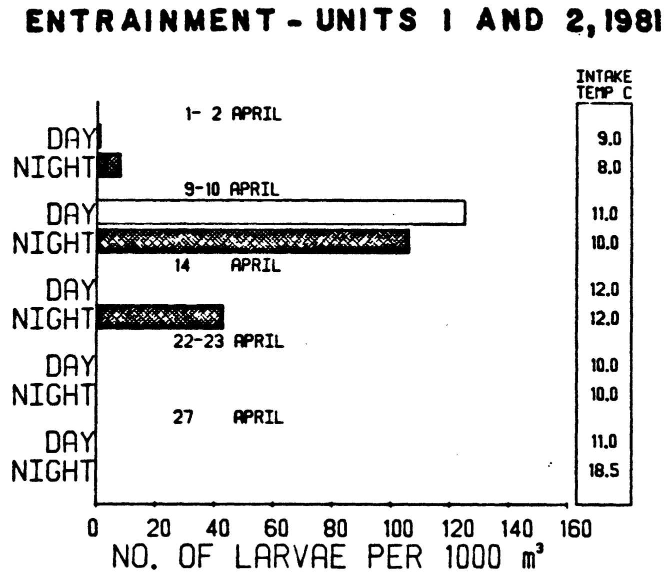


Fig. 29. Density of larval unidentified Coregoninae (no./1000 m^3) in weekly day and night entrainment samples at the J. H. Campbell Plant's Units 1 and 2 during 1981.

Young-of-the-Year--

YOY and yearling Coregoninae were separated by inspection of length-frequency histograms and data from preoperational years. Most unidentified Coregoninae collected in August through December 1981 were YOY. These fish grew from 45-74 mm TL in August to 55-104 mm TL in December (Fig. 30). Most YOY were collected in trawl hauls from 3 to 12 m, but a few were taken in seines. Particularly high catches of YOY were trawled from station B (3 m, south) in November (697 fish) and at station N (9 m, north) in December (289 fish). Water temperatures when YOY were collected were cool, usually 5-12 C. Catches of YOY Coregoninae at stations C (6 m, south) and D (9 m, south) were similar to catches at stations L (6 m, north) and N (9 m, north) respectively. Most YOY unidentified Coregoninae were believed to be bloaters, *Coregonus hoyi*, as was postulated during preoperational years (Jude et al. 1981a). The long hatching period of bloaters, April to August (Wells 1966), partially accounts for the wide size range of YOY. The largest and earliest appearing YOY may, however, have been another species with an earlier spawning period than bloaters, such as lake whitefish or lake herring.

Yearlings--

Most unidentified Coregoninae collected April through July 1981 were yearlings. Yearling Coregoninae ranged in size from 55 to 94 mm TL in April, and grew to 85-134 mm TL in August (Fig. 30). Most yearlings were collected by trawl, but a few were collected by bottom gill net. Fish were collected at water temperatures ranging from 2 to 24 C. More yearlings were collected at deeper stations, 9-12 m, than at stations 3-6 m in depth. Similar catches were recorded at north and south transects, unlike preoperational years when significantly more unidentified Coregoninae were trawled at the plant transect than the south reference transect (Jude et al. 1981a).

Adults--

Very few unidentified Coregoninae age 2 or older were collected during 1981 (13), in contrast to 1980 when over 2000, 155-314 mm TL, were collected. During preoperational years, adult unidentified Coregoninae increased in abundance (Jude et al. 1981a), which may have been a response of the population to closure of the commercial fishery for all chubs in 1976. U. S. Fish and Wildlife Service fall surveys in eastern Lake Michigan found adult bloaters continued to increase during 1981 for the fourth consecutive year, at depths from 20 to 100 m (Wells and Hatch 1982). Our sampling was not conducted in deep enough water to detect this trend. We collected only stragglers from the greater offshore population.

During preoperational years, significantly more unidentified Coregoninae were collected at the plant transect than the reference transect (Jude et al. 1981a), perhaps because construction activity increased turbidity (thus decreasing net avoidance) or stirred food organisms into the water column, attracting fish. Construction was finished before the 1981 field season, which may account for part of the decrease in catch of adult unidentified Coregoninae.

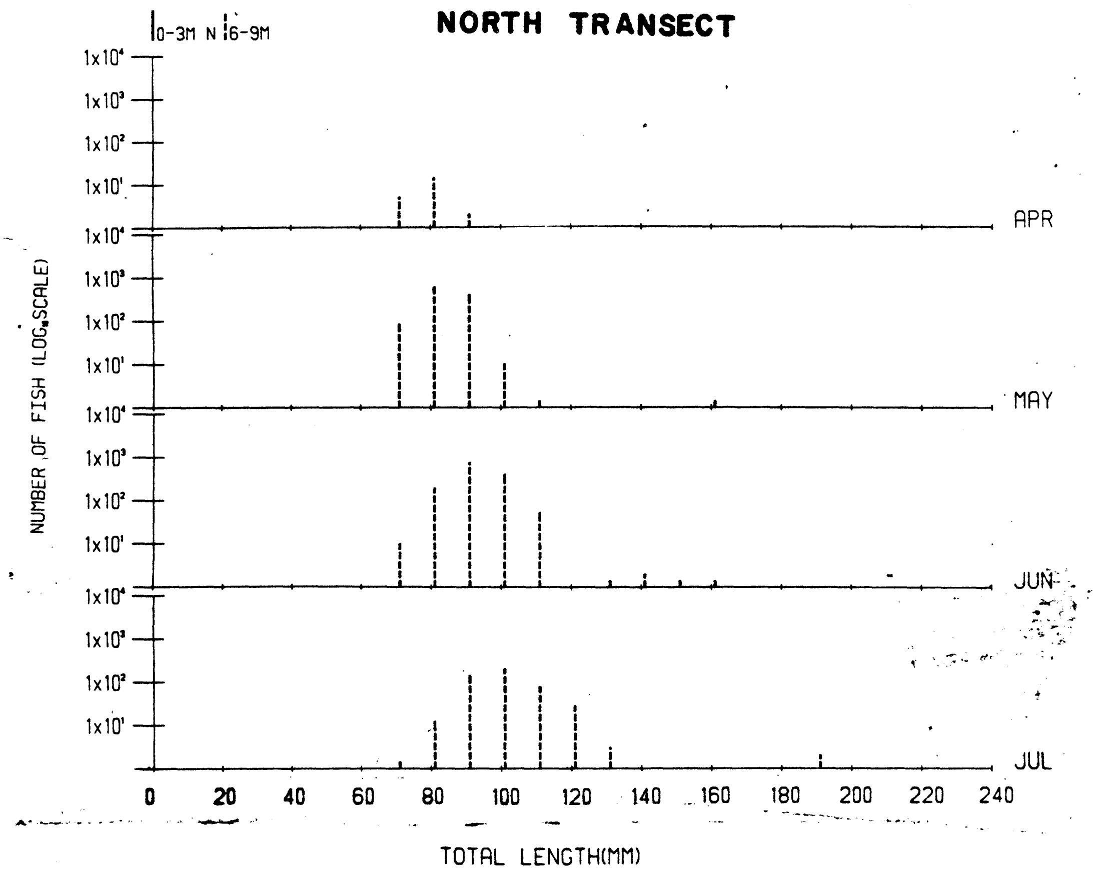
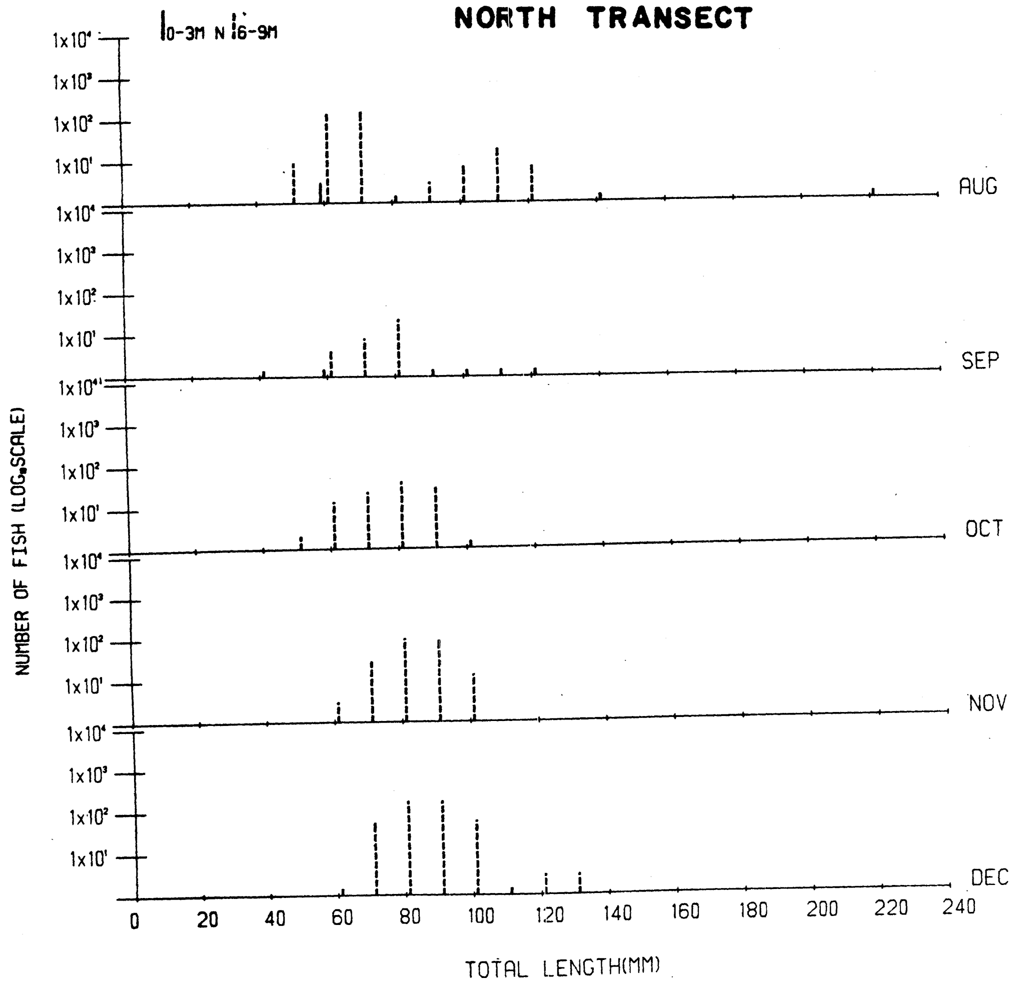


Fig. 30. Length-frequency histograms for unidentified Coregoninae collected during April - December 1981 at the north and south transects. Stations were combined into two groups for the north transect: beach and 3 m; 6 and 9 m and into three groups for the south transect: beach, 1.5 and 3 m; 6 and 9 m; and 12 m. Diel periods and gear types were pooled.



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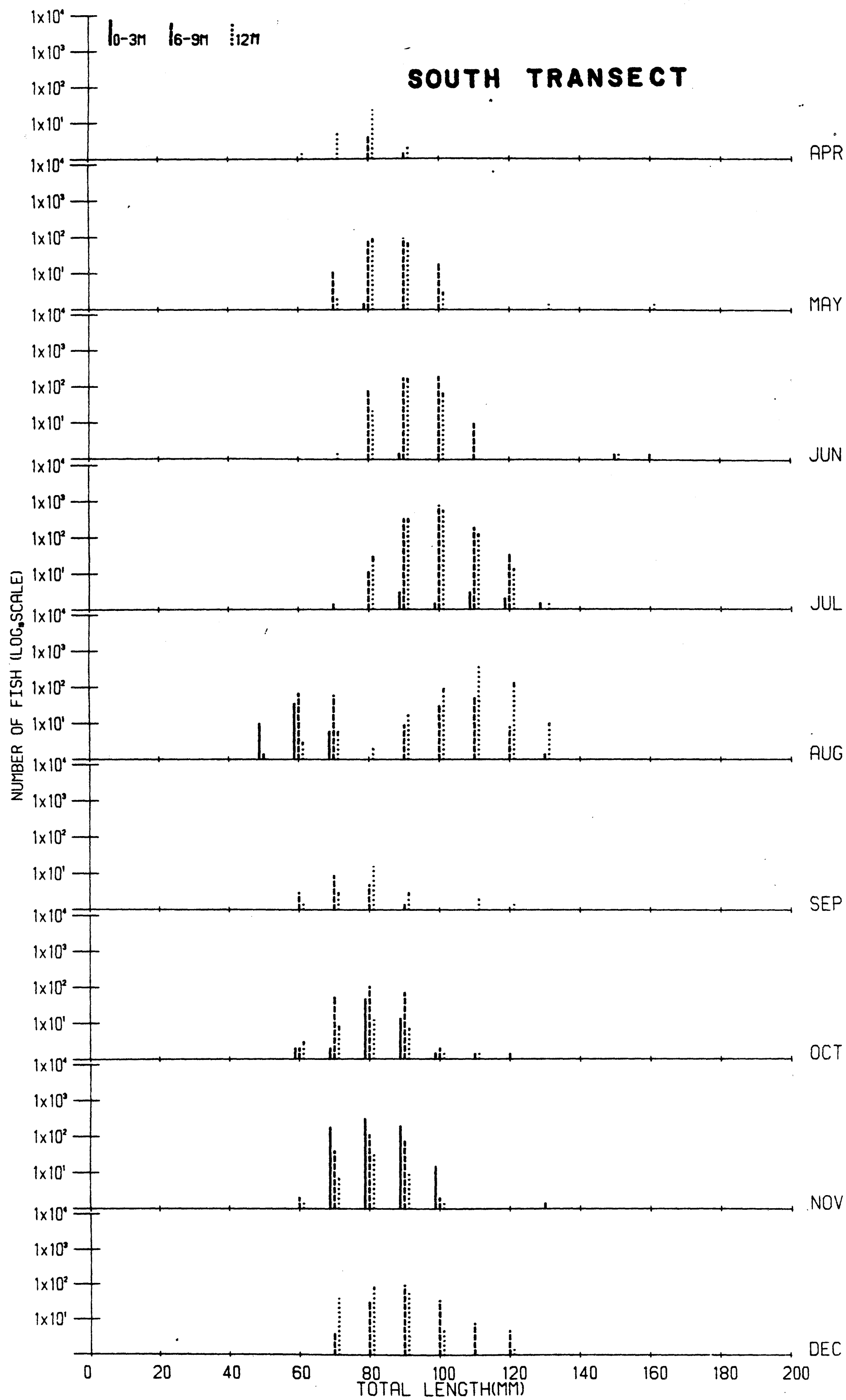


Fig. 30. Continued.

During 1981, the largest coregonine was in the 220-mm length interval, and only 13 fish longer than 135 mm were collected (Fig. 30). These adults were collected during spring and summer by bottom gill net and trawl, at water temperatures of 4 to 22 C and depths of 6 to 12 m. Gonads of adult unidentified Coregoninae were only slightly developed. Males and females were nearly equal in number. Most unidentified Coregoninae (all sizes) were collected at night.

Yellow Perch

Introduction--

Yellow perch was the fifth-most abundant species caught in adult sampling gear in 1981 (Table 32). During our 5-yr study (1977-1981), perch have been consistently between fourth and sixth in overall abundance. Seasonal distribution of yellow perch in 1981 was similar to that of other years. However, the total number of perch caught in adult sampling gear was considerably greater in 1981 (2,370) than in previous sampling years (1977-1980 range: 605-1,714) and the proportion of the catch according to life stage (YOY, yearling, adult) was unusual in 1981.

In Lake Michigan in the vicinity of the J. H. Campbell Plant, adult yellow perch overwinter at depths beyond our deepest sampling station of 15 m (Jude et al. 1981a). A few perch move into shallower water (predominantly between 6 and 15 m) during April, and more follow in May. Male perch (many with well developed gonads) are generally the first to come inshore where they congregate and await the arrival of females (Scott and Crossman 1973). Lake Michigan perch prefer to spawn over gravel, rocks or crevices in bottom substrate, generally at depths between 6 and 12 m (Dorr 1982). Riprap associated with the Campbell Plant intake and discharge structures provides suitable substrate for perch reproduction to depths of about 12 m. Construction activities during preoperational years may have discouraged perch spawning in the intake/discharge area as evidenced by mid-June collections of larval perch which were substantially less in 1978-1980 than in 1981. Perch spawning in Lake Michigan usually is concentrated over a 7 to 12-day period (Dorr 1982) and occurs during late May or early June near the Campbell Plant (Jude et al. 1981a). Similar spawning times have been reported for perch near the D. C. Cook Nuclear Power Plant at Bridgman, Michigan (Jude et al. 1979b) and near Ludington, Michigan (Brazo 1973). Eggs may hatch after 6-27 days depending on water temperature (Hokanson and Kleiner 1974; Mansueti 1964a). Norden (1961) and Dorr et al. (1976) reported hatching lengths for yellow perch to be from 5 to 6 mm, but smaller larvae (4.0 and 4.5 mm) were not unusual in Campbell Plant field samples.

Perch with hatching lengths between 5.5 and 6.0 mm had completely absorbed their yolks at 7.0 mm (after about 5 days) and teeth were evident in fish of 7.2 mm according to Mansueti (1964a). Larval perch swim well relative to most other larval fish of similar age, and exhibit notable ability to avoid larval fish sampling devices. The phenomenon of net avoidance by yellow perch and other species has been discussed and confirmed by many workers (Isaacs 1964; Faber 1967; Ward and Robinson 1974; Wells 1974). Few perch larvae exceeding lengths of 9 mm have been caught near the Campbell Plant. Wong (1972) considered perch to be demersal when they attained approximately 30 mm; they were pelagic prior to that size. Mansueti (1964a) observed that under laboratory conditions, newly hatched perch larvae must actively feed (generally on green colonial flagellates and small zooplankton) to supplement yolk-derived nutrients, and larvae that did not feed died after 7 days. Aquaria-held larvae engaged in feeding activities and appeared to be immediately vigorous swimmers upon hatching (Mansueti 1964a). Houde (1969) similarly documented active swimming by aquaria-held perch larvae under 6.5 mm, but discovered that swimming movements ceased when currents of 5.0 cm/s were introduced in a test apparatus; larvae less than 10-11 mm allowed themselves to be rolled along the length of the testing tube by the current.

Perch larvae that are collected in Lake Michigan before mid-June are generally considered to be fish that were spawned in April and May in warmer waters of inland lakes, rivers and streams (Wells 1973; Jude et al. 1981a). Such fish are believed to drift into Lake Michigan from their inland nursery grounds and be dispersed in Lake Michigan by lake currents. Houde (1969) suggests that limnetic larvae (such as yellow perch), in contrast with littoral or stream-inhabiting larvae, may depend mostly on drifting in lake currents for dispersal. Since alongshore currents are strongest closest to shore, most larvae collected before mid-June are found in water less than or equal to 3 m. Relatively warmer temperatures and greater food availability may also explain predominance of larvae in nearshore water.

Larvae--

Seasonal distribution--

April--A 6.5-mm perch larva was collected in the north transect beach zone on 15 April 1981 (Figs. 31 and 32). Size of the fish indicated that it had probably hatched in early April. Perch larvae had not previously been collected in April near the Campbell Plant, and were only rarely collected elsewhere; one larva was collected on 28 April 1973 near the D. C. Cook Nuclear Plant (Jude et al. 1979b). Temperature in nearshore water in 1981 (11.5 C) was not exceptional compared with preoperational years, but perhaps inland water sources were warm enough to allow earlier than usual perch spawning as was indicated by Units 1 and 2 entrainment data (see RESULTS AND DISCUSSION - Yellow Perch, Larvae - Entrainment). Estimated average density of perch larvae in April in the beach zone was 55/1000 m³ (Appendix 9).

May--Perch were collected from the beach zone out to the 12-m contour during early May. Highest densities came from beach stations at both north (312/1000 m³) and south (113/1000 m³) transects (Appendixes 9 and 10). Densities farther offshore ranged from 35/1000 m³ (12 m, south) to 95/1000 m³ (6 m, north) (Appendixes 9 and 10). Mean length of larvae from both transects was 6.6 mm (Fig. 32). Similar densities and sizes of perch larvae were collected during preoperational years. Water temperatures in 1981 ranged from 10.1 to 11.3 C at stations where perch larvae were found.

Early June--No perch were collected at the south transect in early June, but at the north transect, perch continued to be most concentrated (112/1000 m³) in the beach zone (Appendix 9, Fig. 31); whereas, larval perch densities were lower at 1.5- (25/1000 m³) and 6-m (23/1000 m³) contours (Appendix 9). Fish lengths ranged from 6.5 to 8.0 mm (Fig. 32), indicating that, as in April and May, fish collected in early June were produced in inland waters. Spawning in Lake Michigan had probably already commenced in late May, but at water temperatures recorded during early June (14.7-18.3 C), eggs would require about 8-10 days to hatch (Hokanson and Kleiner 1974). Densities and distribution of perch larvae in 1981 were similar to those of 1978, but were somewhat higher than those of other preoperational years. The variable densities and length frequencies of perch larvae collected in early June of different years were partly attributable to the relative timing of perch spawning in inland waters and in Lake Michigan. If spawning in inland waters occurred in early May (1977 and 1979), larvae were large enough by early June to avoid our nets; if spawning was delayed or continued into mid-May (1978, 1980 and 1981) larvae collected in early June included some perch from inland sources. Perch spawned in Lake Michigan were present in early June samples only when spawning had occurred by late May (1978 and 1979).

Mid-June--Perch larvae were collected in mid-June at densities up to 874/1000 m³ at the north transect, and up to 1547/1000 m³ at the south transect (Appendixes 9 and 10). Larvae were generally distributed throughout the water column at every sampling contour (beach to 15 m) during both day and night. Normally, few perch larvae are found deeper than 5.5 m (Clady 1976), but we collected many perch at considerably greater depths (e.g., 209 perch/1000 m³ at the 11-m stratum over the 12-m reference contour and 78 perch/1000 m³ in a sled tow at 15-m south). Indeed, larval perch were more widespread and occurred in higher mean densities at 12- and 15-m contours compared with

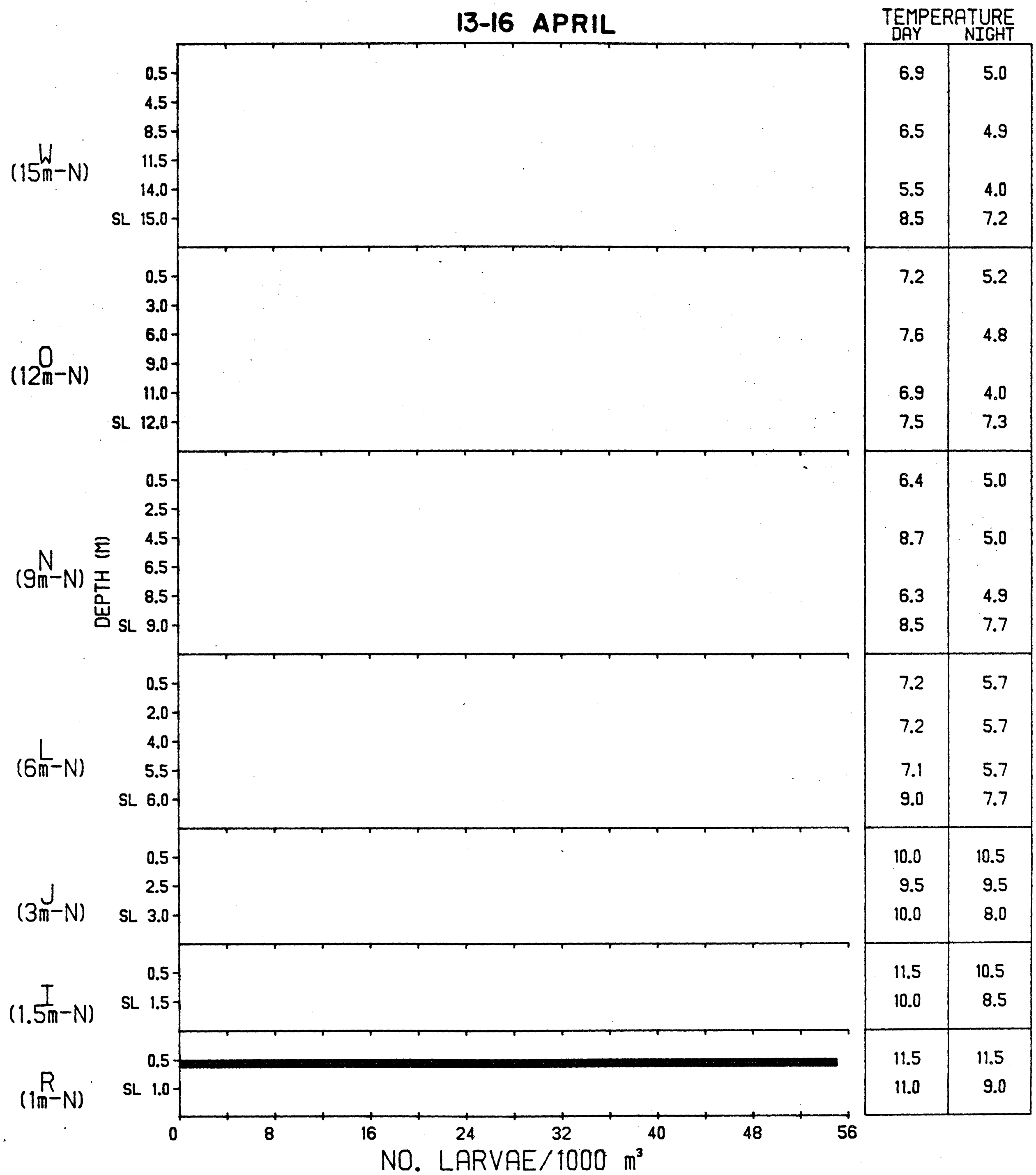
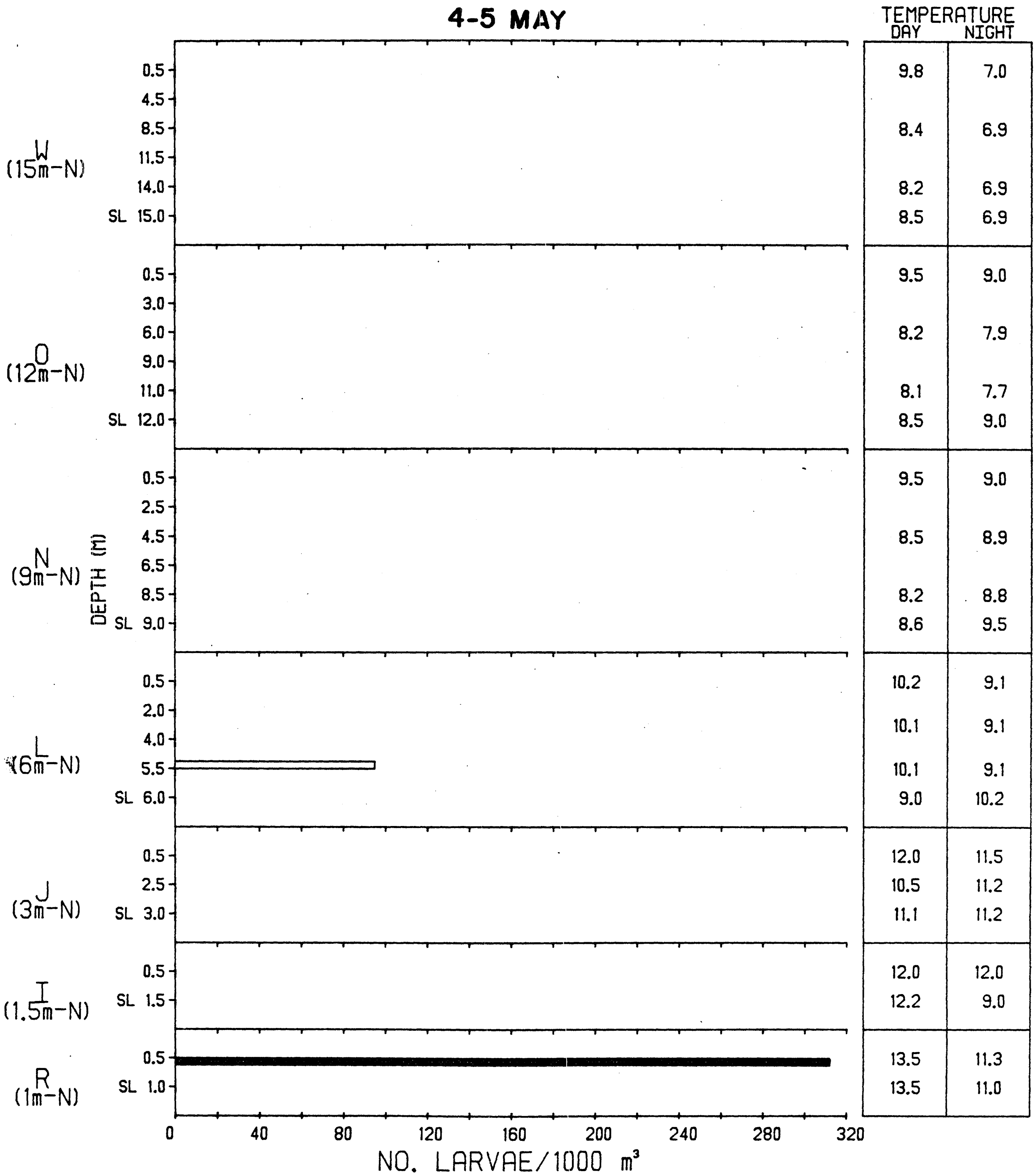


Fig. 31. Density of larval yellow perch (no./1000 m^3) at north and south transect stations near the J. H. Campbell Plant, eastern Lake Michigan, April-July 1981. □ = day, ■ = night, SL = sled.



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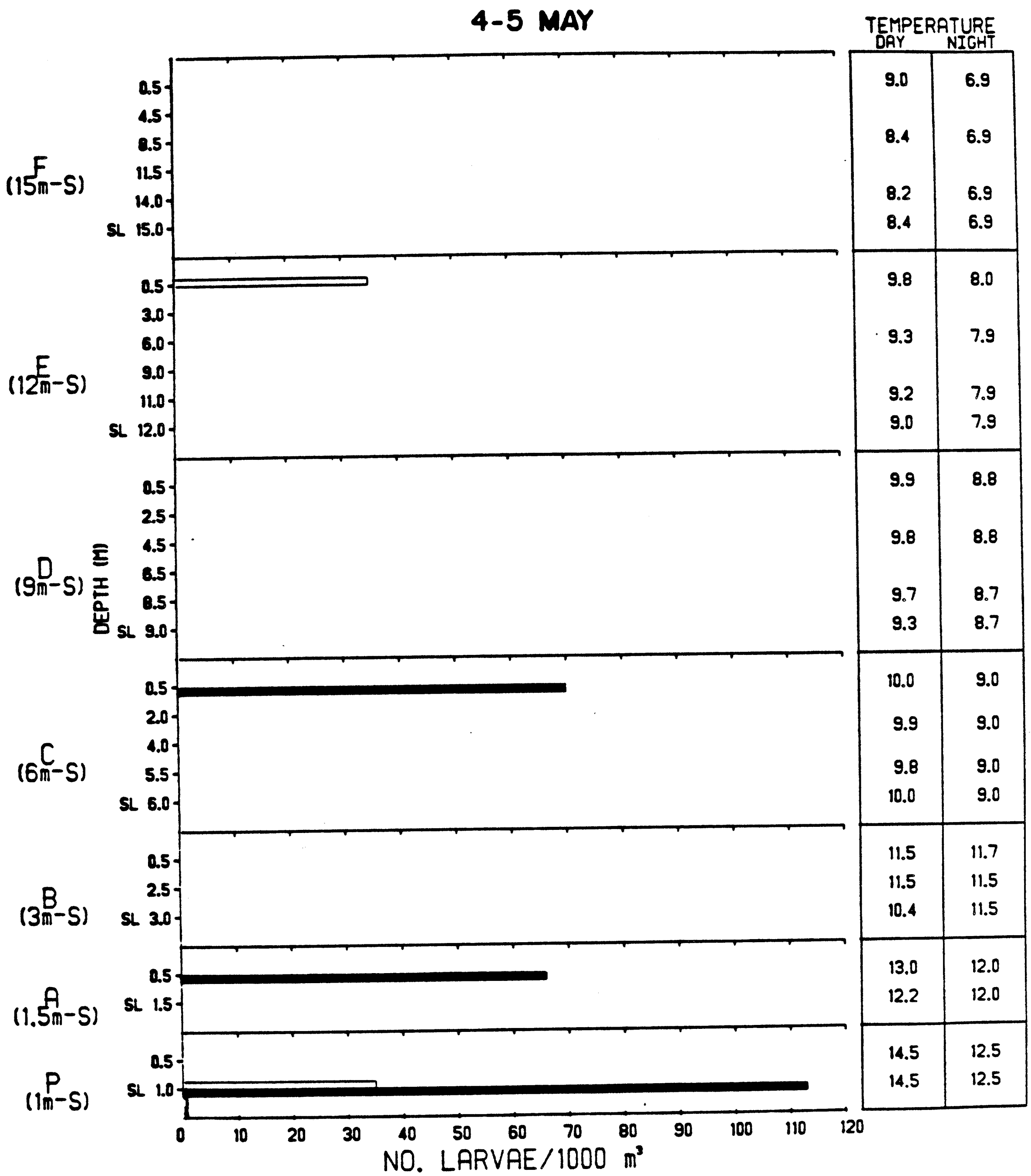

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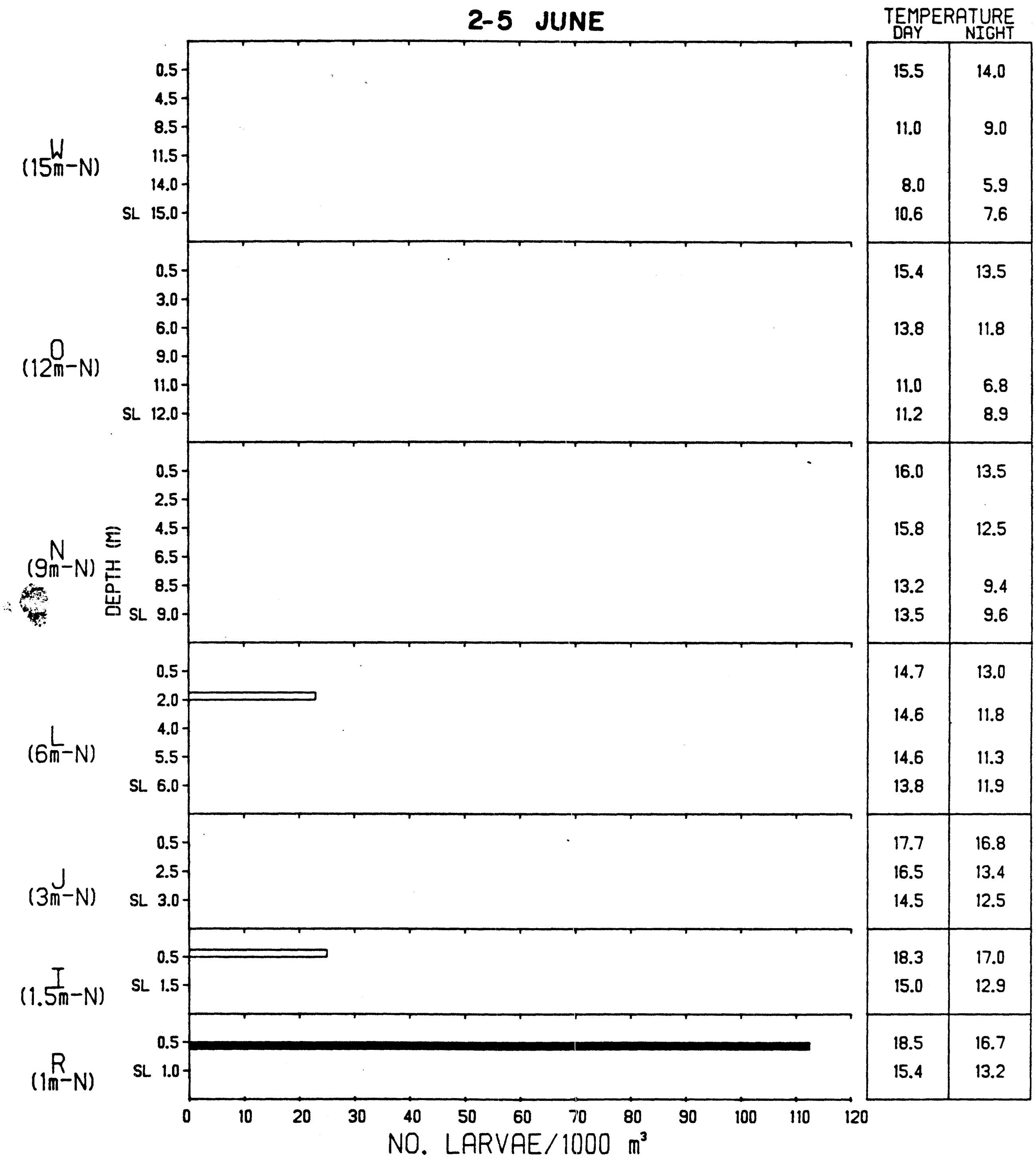

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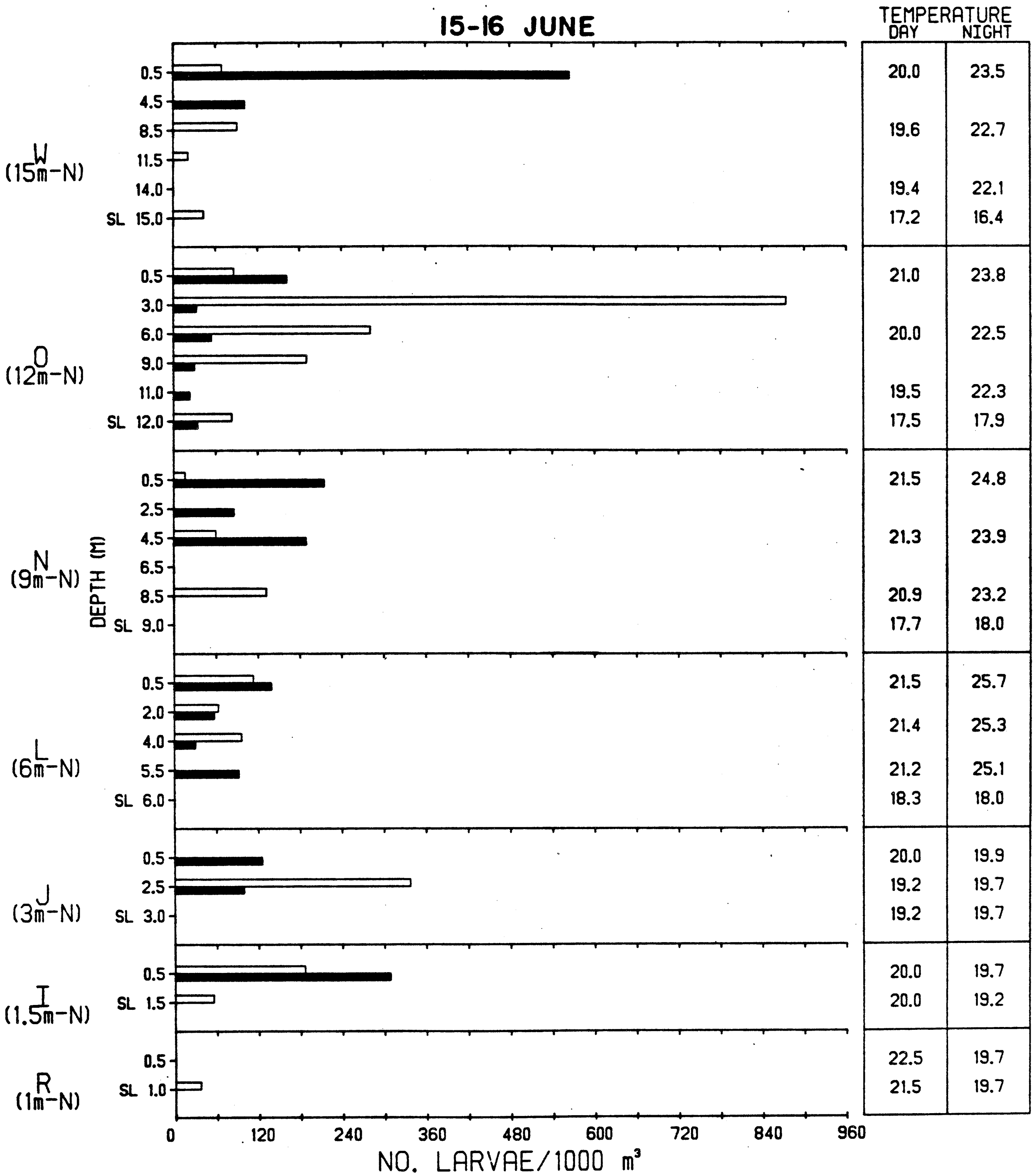

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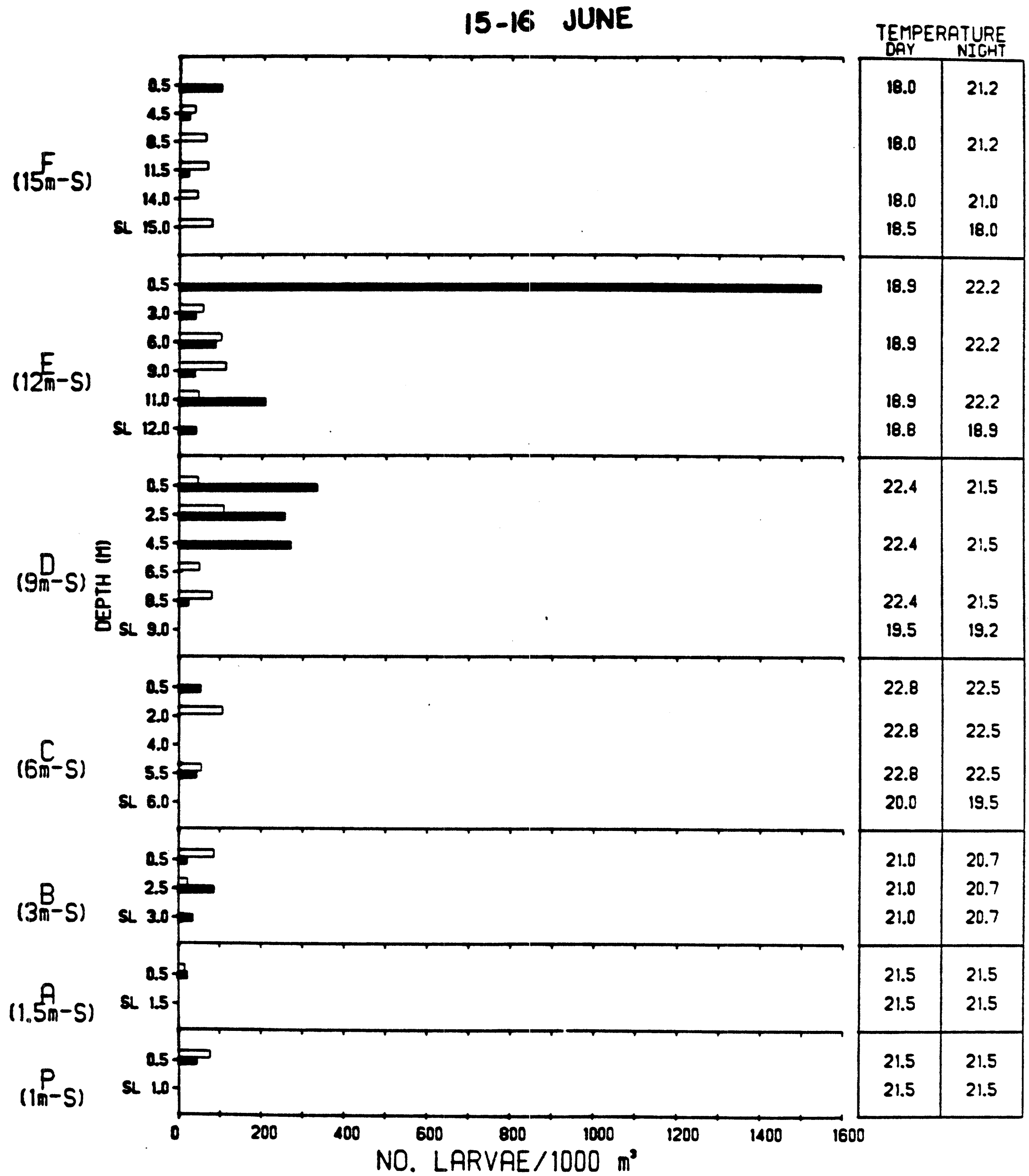

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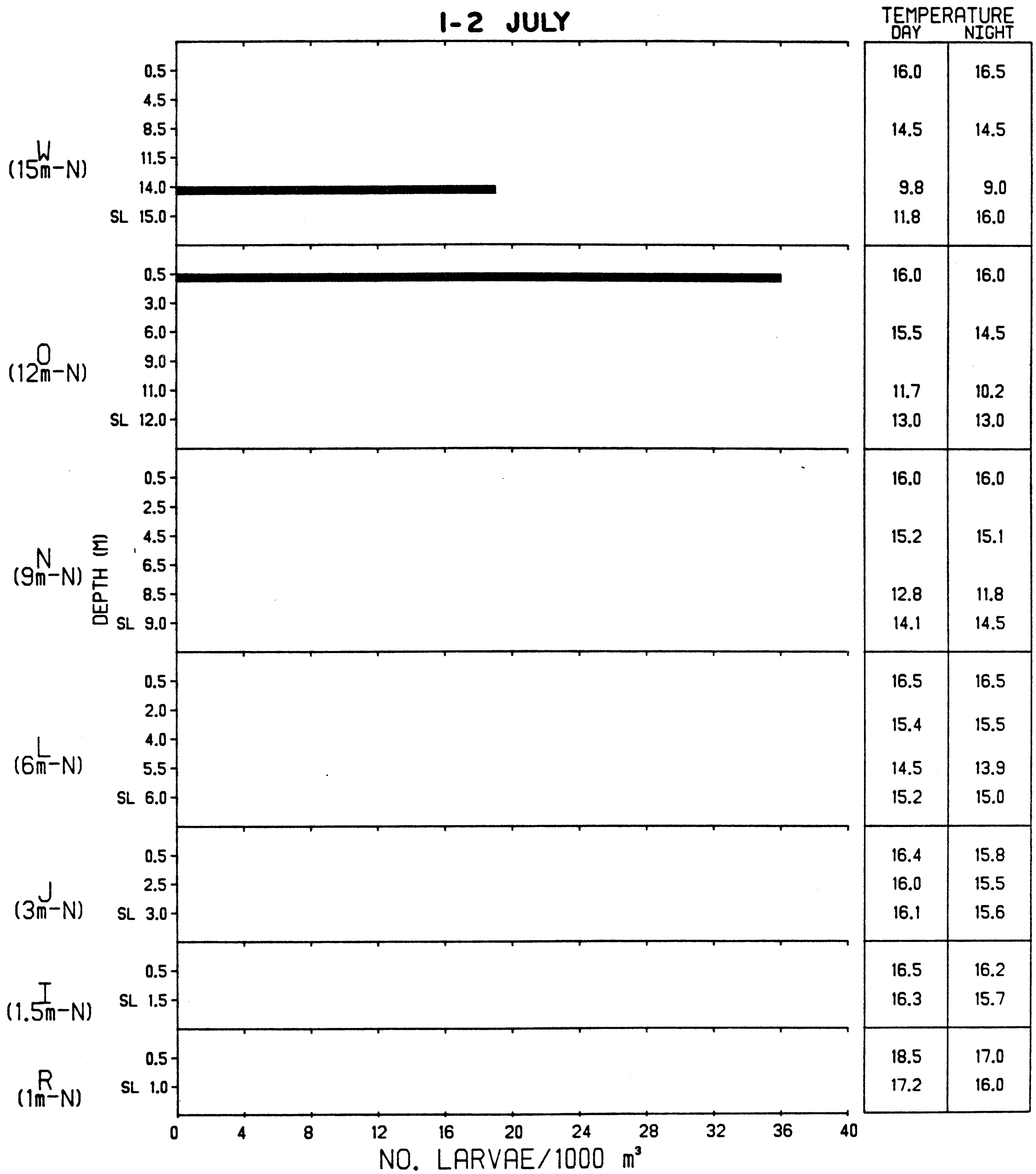

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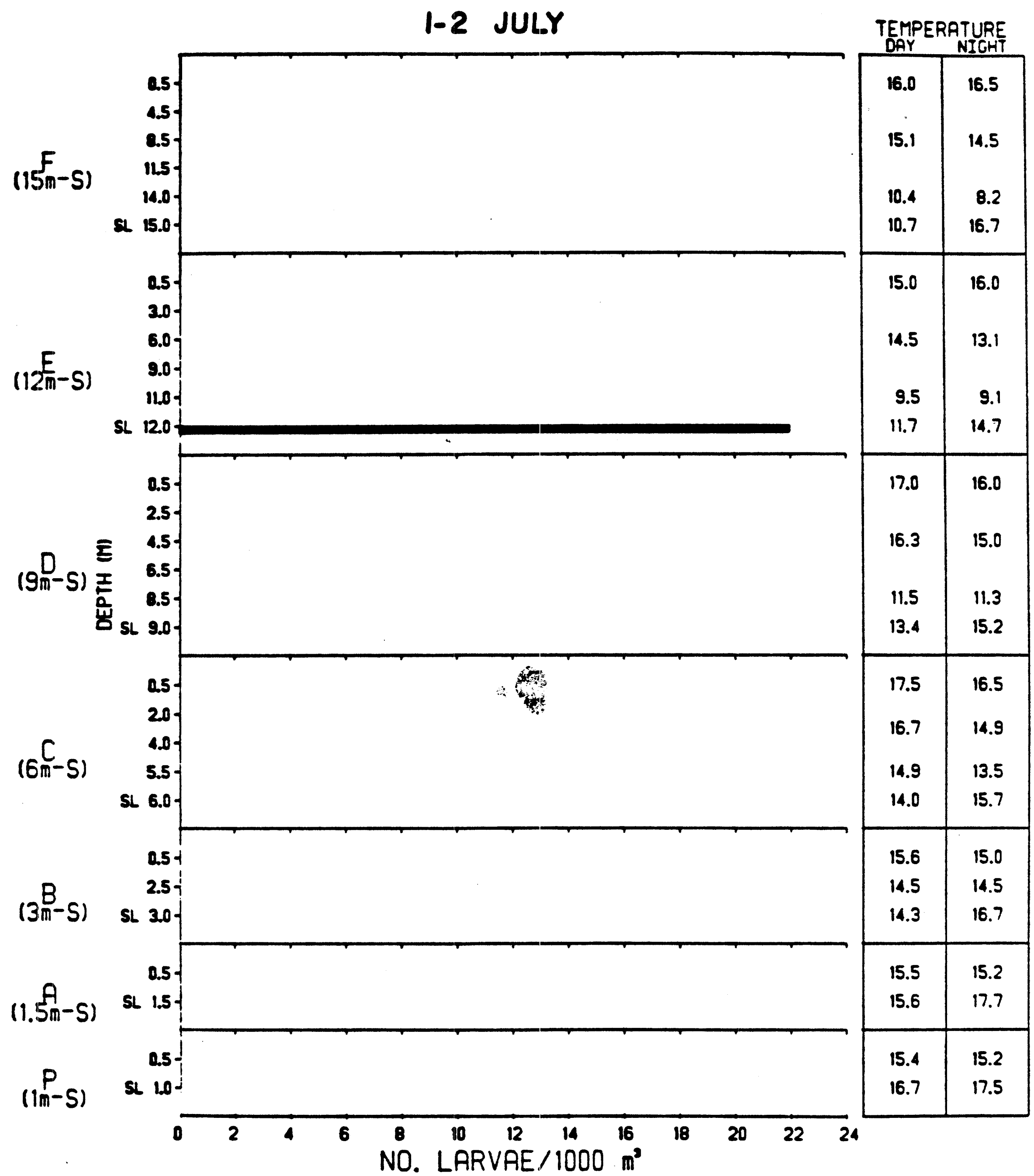

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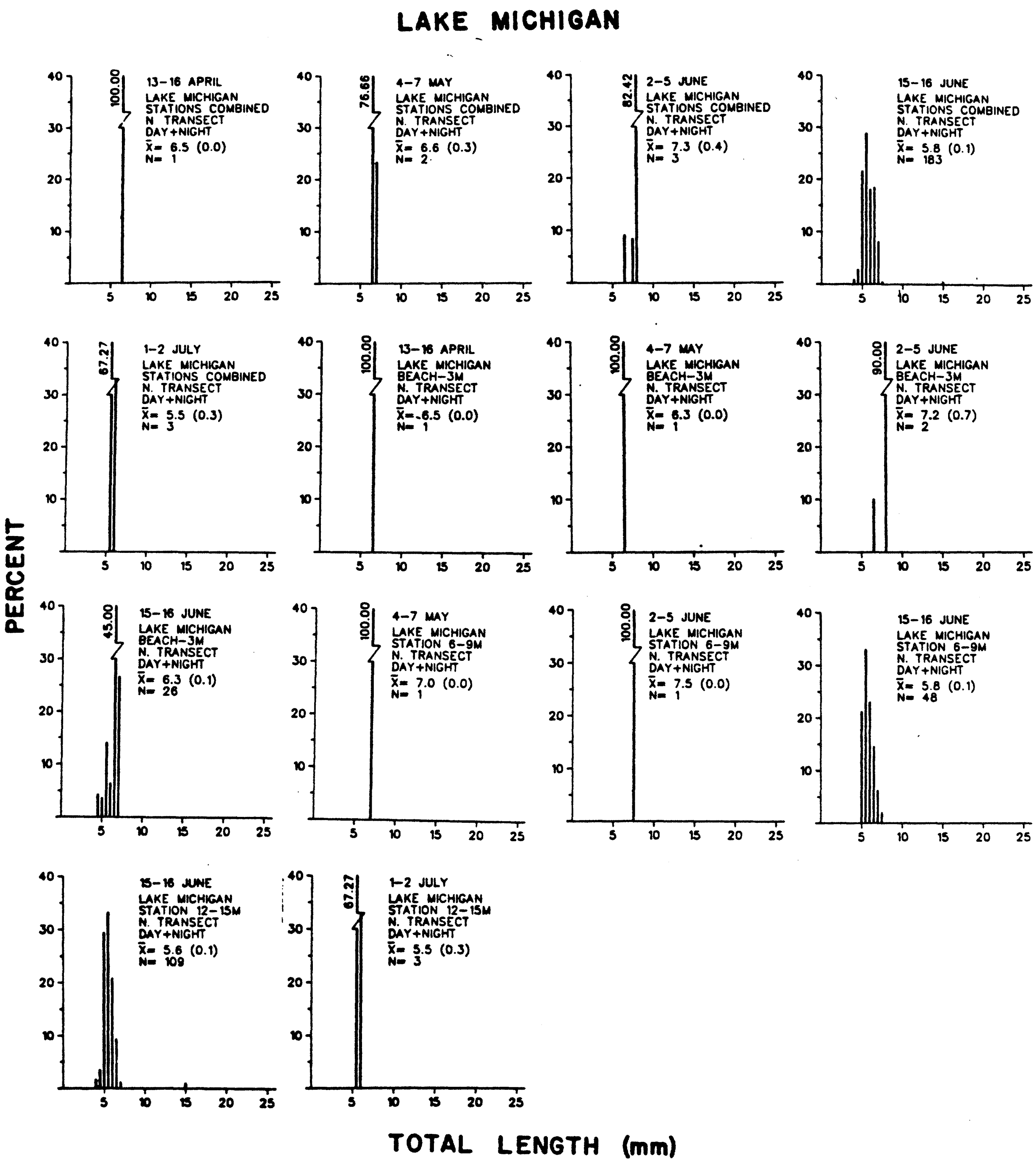
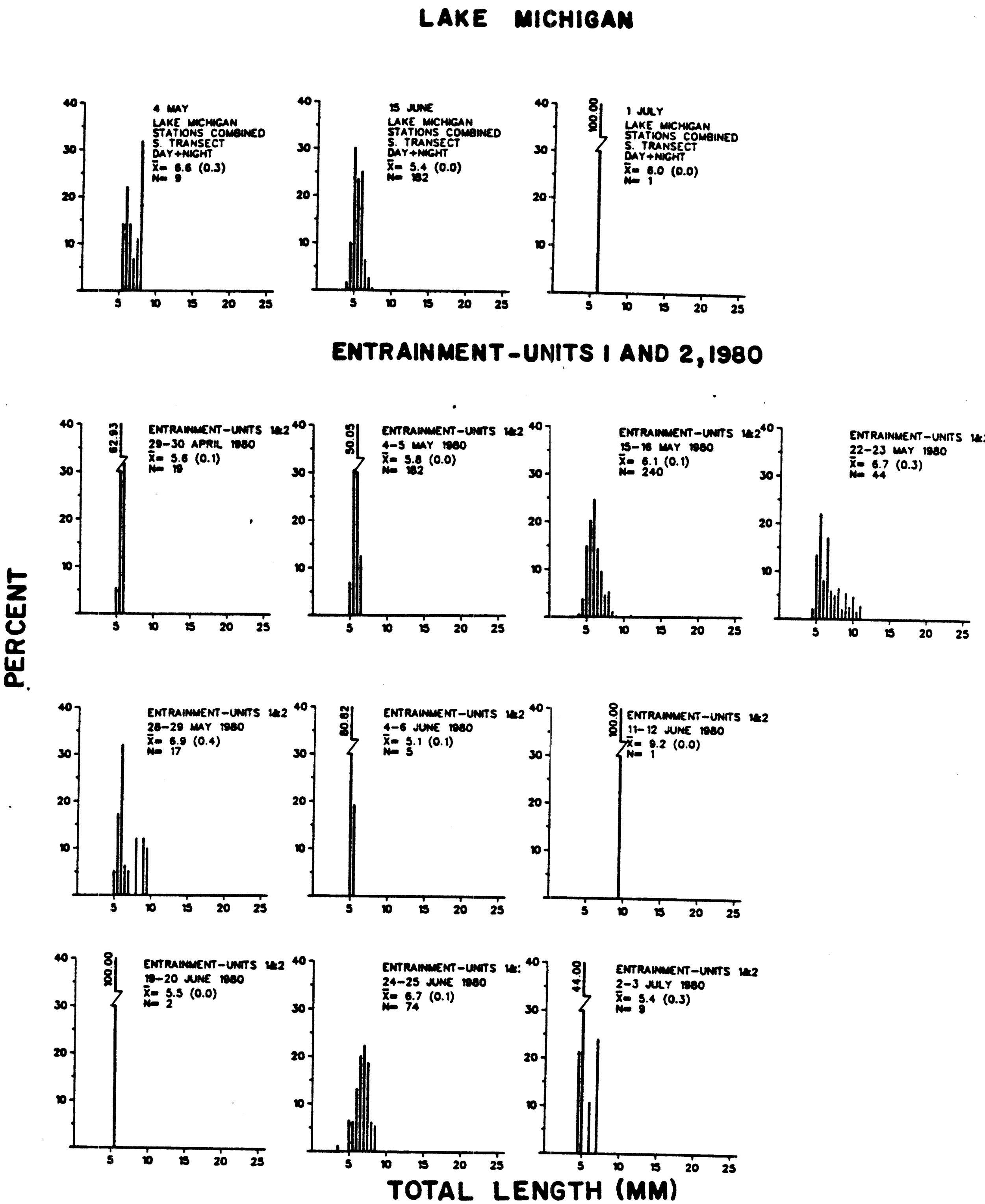


Fig. 32. Length-frequency histograms for larval yellow perch observed in field and entrainment samples collected during 1981 near the J. H. Campbell Plant, eastern Lake Michigan. Length-frequency histograms for yellow perch larvae entrained during 1980 were also included. All plankton net and sled tow samples were combined. $\bar{X}$ = mean, N = total number of larvae, standard error is given in parentheses.



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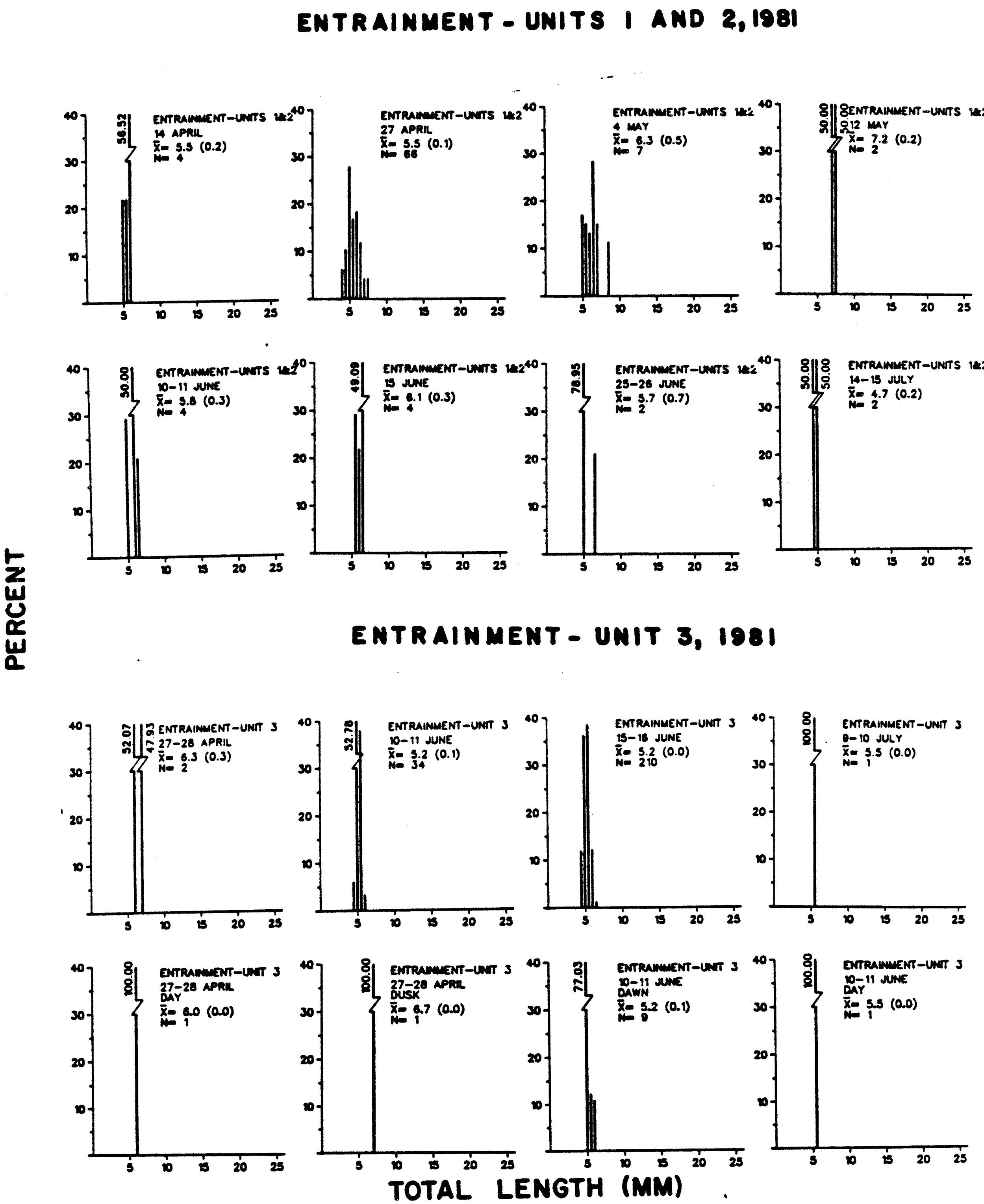

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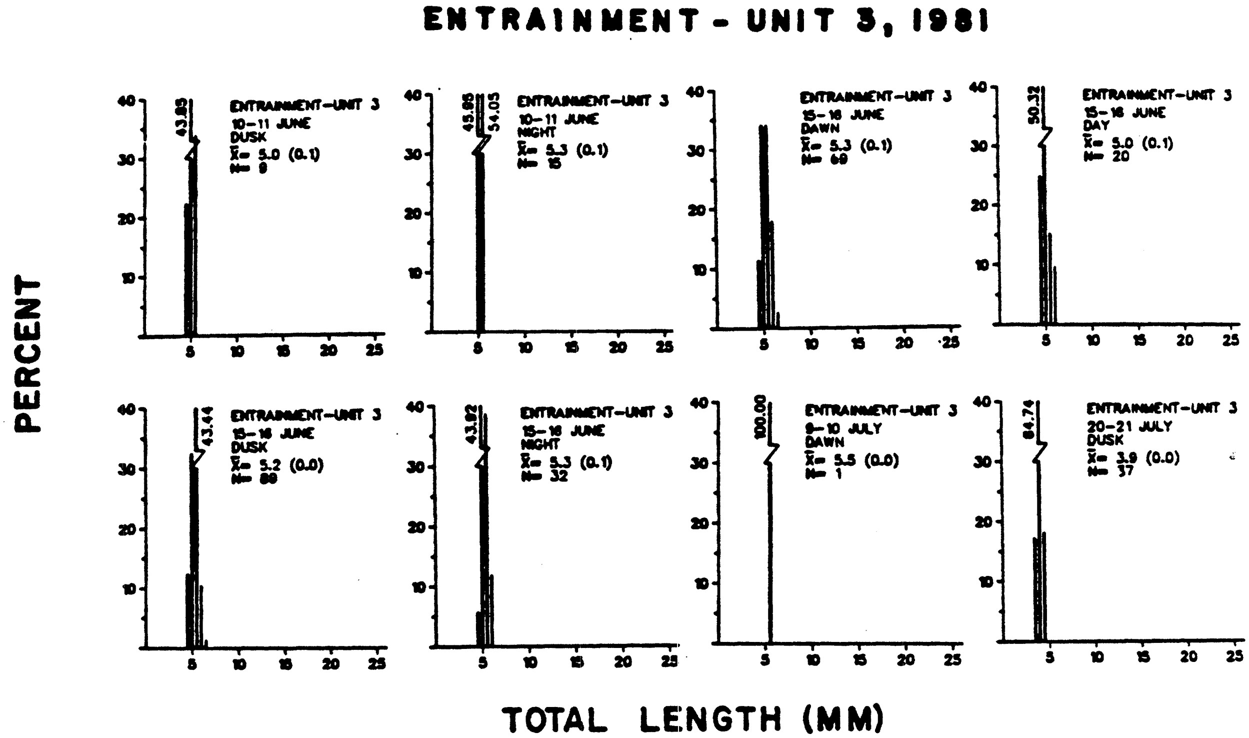

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shallower stations during 1981 (Appendixes 9 and 10). During preoperational years, abundance of larvae decreased with increasing distance from shore (Jude et al. 1981a). Perch at deeper stations in 1981 may have been more abundant because of availability of suitable spawning substrate in the north (to about 12 m), or winds and strong currents may have caused perch to shift to deeper water as was observed in Lake Erie (Turner 1920). Similar to what was found to occur with spottail shiner larvae during preoperational years, the mean length of larval perch decreased as sampling depth increased. At the north transect for example, perch caught between the beach and the 3-m contour had an overall mean length of 6.3 mm; at 6 and 9 m perch mean length was 5.8 mm and at deeper stations (12 and 15 m) mean fish length was 5.6 mm. Perhaps fish were larger in shallower water because they hatched earlier (spawned inland) or because more food was available to fish in the more productive nearshore zone. In addition, smaller larvae may be more susceptible to transport by currents. Predominance of small larvae may have inflated estimated densities of perch in deeper water relative to shallow water densities because smaller larvae are less able to avoid nets. Wong (1972) found that larval perch fed continuously, so presence of fish throughout the water column during both day and night is not surprising.

Overall densities of larval perch for mid-June 1981 were substantially greater than densities during preoperational years. As stated before, we believe this reflects in part the extensive use of riprap as a spawning ground. However, comparable densities of perch larvae at both north and south transects indicate that successful spawning in the vicinity of the Campbell Plant was not restricted to the riprap area, even though the possibility of transportation of larvae between transects by lake currents clouds this issue somewhat. Adult gonad condition data indicate that most spawning may indeed have occurred at the north transect (see RESULTS AND DISCUSSION, Yellow Perch, Adults). Water temperatures in mid-June 1981 (17.2-25.7 C) were appreciably higher than in other years and probably contributed to higher catches. Some newly hatched perch were collected in discharge samples in mid-June 1981, apparently indicating limited perch reproduction within the discharge canal or in Pigeon Lake. Field densities of perch larvae collected in mid-June may therefore have been augmented slightly by larvae originating from the discharge canal and being pumped into the open lake.

July--On 1 July 1981, yellow perch in low densities were captured at 12 m (22-36/1000 m^3) and 15 m (19/1000 m^3) (Appendixes 9 and 10). Most fish which were hatched in mid-June were probably large enough to avoid nets by the end of June. Furthermore, Ward and Robinson (1974) documented that in West Blue Lake, Manitoba (31 m maximum depth - 160 ha), yellow perch moved offshore soon after hatching and occupied the epilimnion throughout mid-lake; perch returned to the littoral zone around early August at sizes of about 30 mm. Jude et al. (1979b) inferred similar behavior for perch near the D. C. Cook Nuclear Plant, and our data from 1981 and preoperational years are also consistent with such a migration. Thus by July, most yellow perch larvae may have occupied water deeper than our deepest sampling station. Larval perch densities in July of preoperational years did not differ greatly among years or from those of 1981, and small differences probably reflect variations in time of major hatches.

Mean length of perch caught in July 1981 was 5.5 mm (Fig. 32). This suggests that some peripheral spawning activity may have extended into late June.

Entrainment--

Units 1 and 2, 1980--Yellow perch was the second most frequently entrained species at Units 1 and 2 in 1980 as an estimated 6.5 million larvae were collected (Table 25). Perch comprised 3.5% of the 1980 entrainment total. Entrainment of yellow perch larvae peaked in early to mid May. Mean length of fish collected during this peak period was about 6.0 mm (Fig. 32).

Units 1 and 2, 1981--Perch larvae represented 3.6% of the total number of fish larvae entrained at Units 1 and 2. Projected number of yellow perch entrained at Units 1 and 2 in 1981 (787,000) was 18 to 20 times less than in previous sampling years (excluding 1977 when only 7,450 perch larvae were entrained; however, entrainment sampling did not commence until July). Sampling was not performed during 1981 in Pigeon Lake (where the majority of perch larvae entrained at Units 1 and 2 originate), so reasons for a relatively low entrainment rate, related to the relative success of Pigeon Lake perch spawners, were not documented.

Peak entrainment of perch occurred in April 1981 (Appendix 12); whereas, most perch were entrained in May from 1978 to 1980. This was evidence that inland spawning of perch occurred earlier than usual in 1981.

Unit 3--Yellow perch were entrained at Unit 3 in greater numbers, (3.25 million), than any other species and represented nearly 32% of the total number of fish larvae entrained at the Unit 3 offshore intake during 1981 (Table 28). These losses were partially attributable to the extensive use of riprap (associated with intake structures) by spawning perch in 1981. Perch comprised a higher percentage of the total entrainment loss and more larvae were entrained at Unit 3 than at Units 1 and 2.

Considerably higher densities of Lake Michigan-spawned perch larvae were collected (especially at depths near intake structures and riprap) in 1981 compared with preoperational years (1977-1980). Temperatures favorable to perch reproduction occurred for prolonged periods in 1981 and probably contributed to perch reproductive success.

Other fish species undoubtedly utilized Campbell Plant riprap for spawning purposes, but they did not make as extensive use of the riprap at 11-m depths as perch apparently did. Furthermore, perch larvae were found throughout the water column during both day and night, making perch more susceptible to entrainment (since they had a higher chance of encountering intake screens) than species which were either concentrated near the surface, entirely demersal, crepuscular or generally less active.

During different dates when perch were entrained, different periods (day, dusk, night, dawn) accounted for greatest entrainment densities for any given sampling date (Appendix 14). Overall however, most larvae were entrained during the dusk period. Wong (1972) proposed that larval perch experience a combination of partial night blindness and low efficiency of scotopic vision after sunset and at night; this could make perch more susceptible to entrainment during periods of darkness. Wong additionally found that perch were less affected at dawn when they changed from scotopic to photic vision. In general, for any given sampling date larvae entrained during the day were smaller than those entrained at night, and larvae entrained at dusk or dawn were of a size somewhere in between (Fig. 32). This implies that larvae which were larger and better swimmers were able to avoid entrainment during the day when they could detect intake screens.

Entrained larvae were generally smaller than larvae collected in field samples at approximately corresponding dates (Fig. 32). Thus it appears that larvae remained susceptible to capture by field gear after they had reached sizes which enabled them to avoid entrainment.

Perch egg masses are gelatinous and rope-like and become lodged on rock substrate. Since offshore intake structures at the Campbell Plant are about 2 m off the bottom, entrainment of perch eggs is unlikely and we did not identify any in our samples.

April--Perch were entrained on 27 April 1981 during day (53/1000 m^3) and dusk (49/1000 m^3) sampling periods (Appendix 14, Fig. 33); larvae measured between 6.0 and 6.7 mm (Fig. 32). Field sampling dates on which perch larvae were collected and which were closest to the April entrainment date, were 15 April and 4-7 May. Perch of densities and sizes similar to those entrained were captured on both sampling dates. However, on 15 April, perch were apparently concentrated in the beach zone; whereas, in early May perch were found out to the 6-m contour as well as in the beach zone. Entrainment of perch in late April indicates distribution out to at least the 11-m contour. It appears therefore that perch in nearshore water in mid-April moved toward deeper water in subsequent weeks, just as was found by Ward and Robinson (1974) for perch in West Blue Lake, Manitoba. Mean length of fish entrained during April (6.3 mm) was greater than for any other date on which perch were entrained. Fish greater than 6 mm were generally able to avoid entrainment, but perhaps relatively cold water (10-11 C) and generally more turbid conditions during April inhibited swimming ability and made entrainment of relatively larger fish more likely.

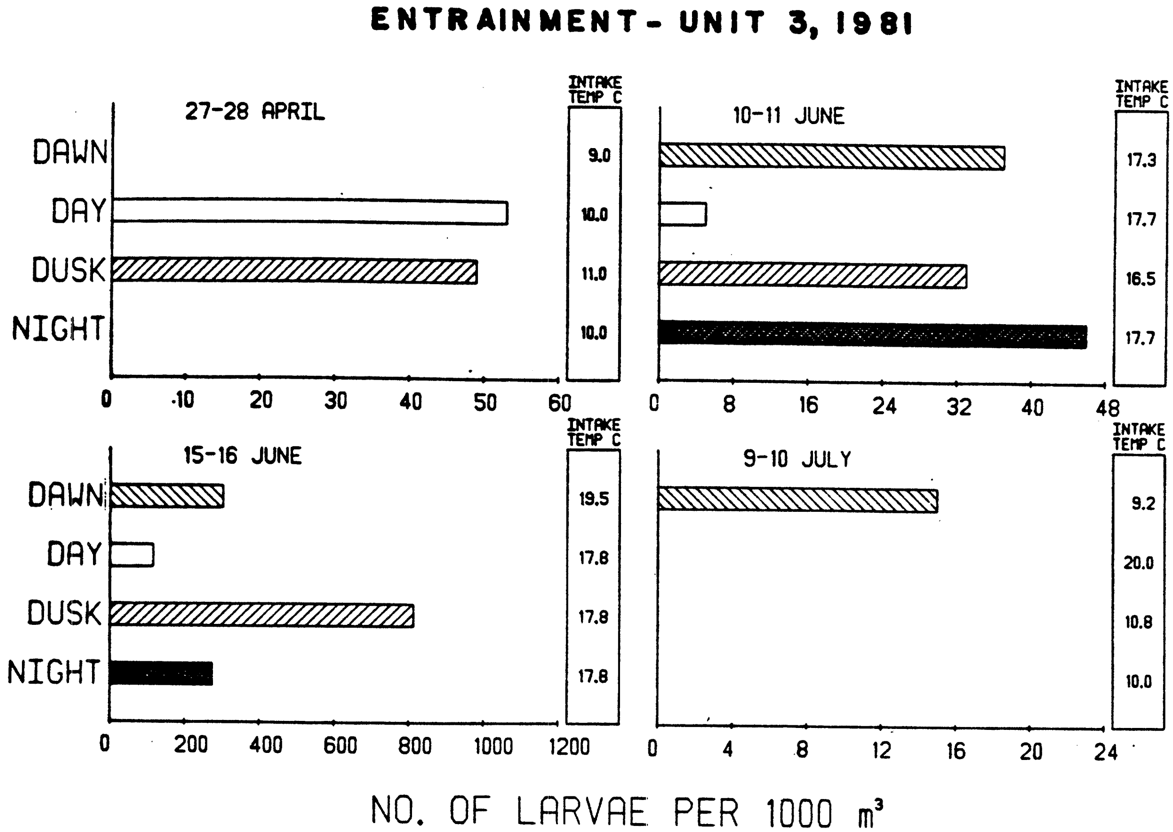


Fig. 33. Density of larval yellow perch (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at the J. H. Campbell Plant's Unit 3 during 1981.

May--No perch larvae were collected in May entrainment samples. However, 16,700 perch were projected to have been entrained during May (Table 28) based on entrainment samples collected in late April.

June--During sampling periods on 10-11 June, perch were entrained at dusk (33/1000 m^3), night (46/1000 m^3), dawn (37/1000 m^3) and day (5/1000 m^3) (Appendix 14, Fig. 33). All larvae were recently hatched (4.5-6.0 mm), but major Lake Michigan hatching had apparently not yet occurred. Field samples collected between 2 and 5 June contained yellow perch which were most highly concentrated in the beach zone, but densities at deeper contours were of similar magnitude as entrainment densities. However, mean length of field-collected larvae (7.3 mm) suggests that these fish were probably the last of the perch cohort spawned in inland waters that was still susceptible to our gear, while entrained larvae, with a mean length of 5.2 mm, probably marked the beginning of Lake Michigan-spawned perch.

Peak perch entrainment densities corresponded with peak perch field densities. Entrainment samples collected on 15-16 June contained perch in densities of 117/1000 m^3 (day), 813/1000 m^3 (dusk), 276/1000 m^3 (night) and 304/1000 m^3 (dawn) respectively (Appendix 14). Again entrained perch were newly hatched with a mean length of 5.2 mm (Fig. 32). Mean length of perch caught in field samples at the 9- and 12-m contours was 5.6 mm, while overall mean length for perch in mid-June field samples was 5.8 mm (Fig. 32). Field-collected perch were distributed through each sampling depth, but highest single-sample densities were found at the 12- and 15-m contours.

July--Entrainment sampling conducted at dawn on 10 July included one perch (5.5 mm) (Fig. 32) representing a density of 15/1000 m^3 (Appendix 14, Fig. 33). Perch densities determined from 1 July field samples were similarly low, and fish collected had a mean length of 5.5 mm. Perch were caught in the field at 12- and 15-m stations.

<u>24-h population and entrainment estimates</u>-- Population estimates for the number of yellow perch passing by the plant from shore to the 15-m depth contour during a 24-h period were generated and compared with 24-h entrainment estimates of yellow perch on 15-16 June. Both field and entrainment data for this date indicate that it was a time of peak perch abundance in Lake Michigan. The 24-h entrainment estimate (414,000) represents 1.7% of the 24-h, day-night population (24,600,000) estimated to be present in the near-plant vicinity (Table 31). The day-night population estimate was used because it was deemed more accurate than the estimate made from only night densities, i.e., day densities were greater than night densities on this particular date.

Most entrained perch were less than 6.0 mm, and no perch greater than 6.7 mm were entrained (Fig. 32). The Unit 3 offshore intakes create currents of 11.5-15.2 cm/s through-slot velocity according to engineering specifications (Consumers Power Company 1978). Perch larger than 6.7 mm, therefore, are apparently able to detect and react to lower velocity currents some distance away from screens and thereby prevent themselves from being drawn into stronger currents. Houde (1969) determined that perch less than 9.5 mm could not maintain themselves in current velocities of 3 cm/s. In general, after an initial period as newly hatched larvae when fish swam poorly, larval perch exhibited sustained swimming ability in currents of 3-4 larval lengths/s (Houde 1969). The effect of temperature on the swimming of perch larvae is inferred by Houde from tests on 20-25-mm smallmouth bass, whose swimming ability continued to increase as temperatures were raised to near the lethal limit.

Loss of perch larvae through entrainment is compensated to some degree by increased overall spawning potential for perch utilizing the riprap area. Natural survival rates for larval perch in Lake Michigan are not known and would help in evaluating entrainment losses. Early survival of perch (egg to 8 mm) in Oneida Lake, New York, varied from 1.6 to 18.4% (Clady and Hutchinson 1975). Certainly the smaller the larvae the higher the mortality rate, and since only small larvae are entrained, the population should be less affected than if larger larvae were entrained.

Young-of-the-Year--

Densities of larval perch observed in mid-June 1981 were greater than in any other sampling year (see RESULTS AND DISCUSSION, Yellow Perch, Larvae). However, this indication of perch-spawning success was not reflected in the number of YOY caught during months subsequent to spawning. YOY comprised only 7% of the 1981 yellow perch catch; whereas, from 1977 to 1980, YOY comprised 30-41% of the overall perch catch. Number of YOY caught in 1981 (167) was substantially less than in 1977 (414), 1978 (340), and 1980 (696), but was comparable to the number caught in 1979 (183). In 1979, the small number of YOY collected was attributed to an upwelling which occurred during July (Jude et al. 1981a). An upwelling also occurred in the vicinity of the Campbell Plant during July, 1981, and water temperatures remained relatively cool through our August sampling dates. Cool summer water temperatures apparently caused YOY to leave our sampling area and seek warmer water in other parts of the lake. Another possibility is that the disproportionate number of yearling perch (see RESULTS AND DISCUSSION, Yellow Perch, Yearlings), reduced larval perch numbers in 1981 by cannibalizing YOY perch and competing with them for food.

In 1981, YOY perch first appeared in August samples at sizes in the 30- to 70-mm length intervals; by December, YOY were in the 60- to 90-mm length intervals (Fig. 34; Appendix 7). Most YOY perch were caught in August (97); fewer were caught in September (26), October (16), November (0), and December (28). Thirty-four perch fry per 1000 m^3 were estimated from a single 39.5 mm fry caught in larval fish sampling gear in August (Appendix 15). YOY were caught predominantly at depths between 0 and 9 m from August through December, but a few were also caught at 12- and 15-m stations (Fig. 34). There did not appear to be obvious differences between catches from north and south transects (Fig. 34).

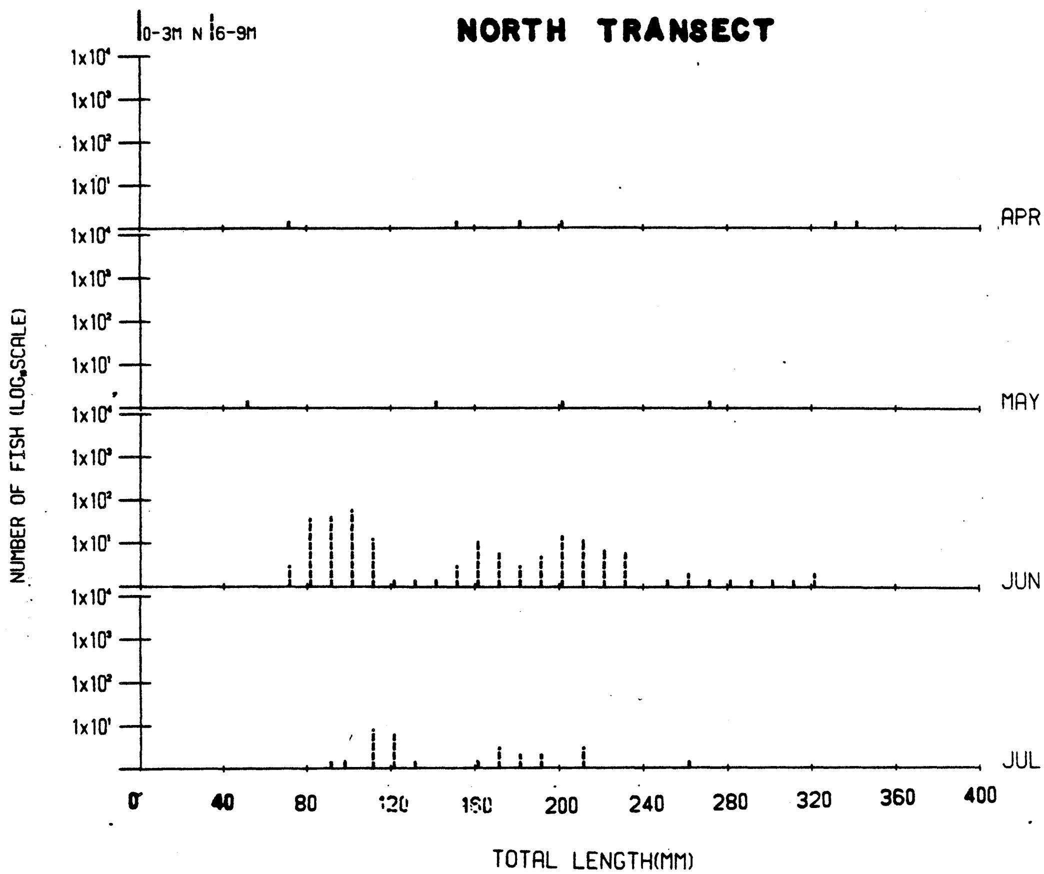
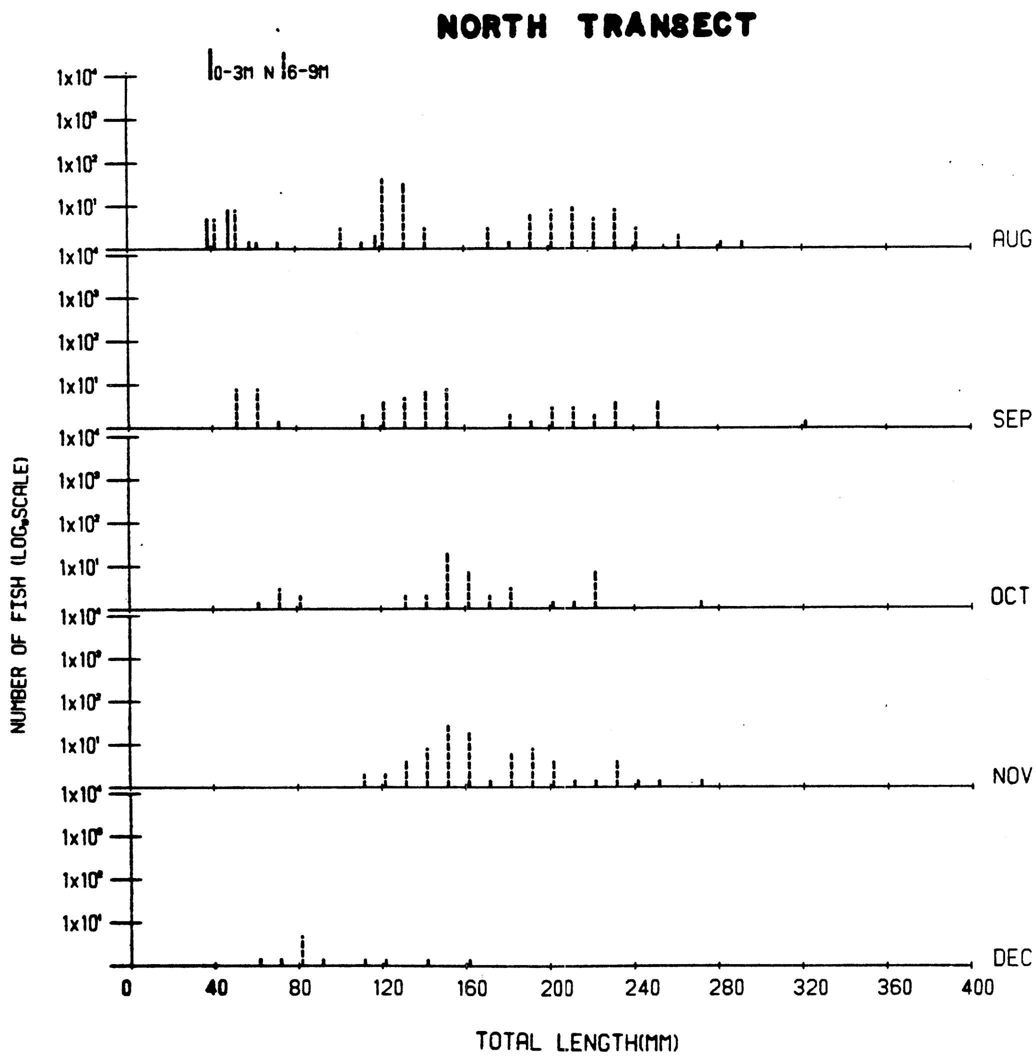


Fig. 34. Length-frequency histograms for yellow perch collected during April - December 1981 at the north and south transects. Stations were combined into two groups for the north transect: beach and 3 m; 6 and 9 m and into three groups for the south transect: beach, 1.5 and 3 m; 6 and 9 m; and 12 m. Diel periods and gear types were pooled.



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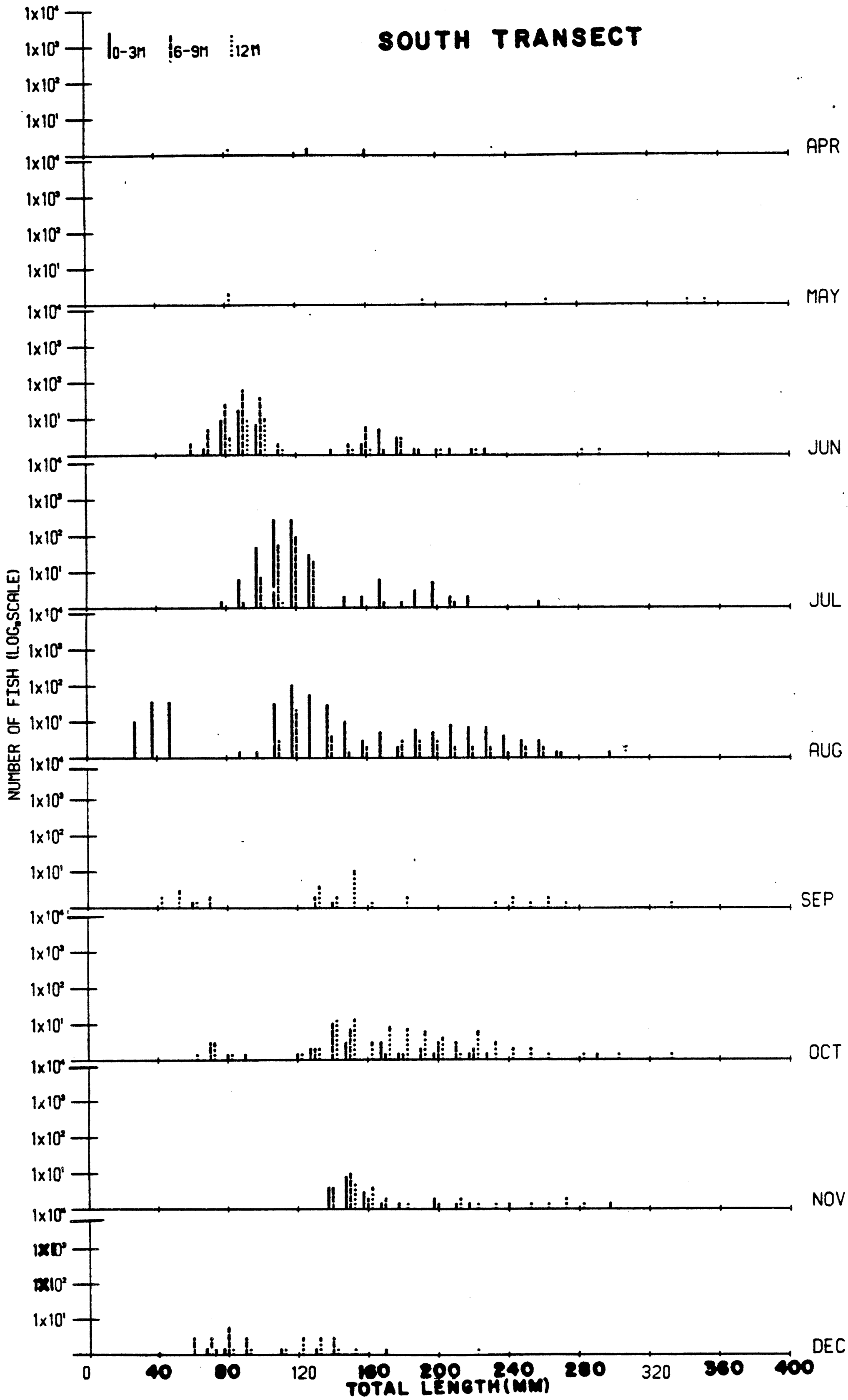

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Yearlings--

Number of yearling perch caught during 1981 was from 5 to 71 times greater than the number caught in other years. Yearlings dominated the perch catch in 1981 (75%); from 1977 to 1980 they comprised only 2-35% of the total number of perch caught. A large 1981 yearling catch was predicted from the number of YOY caught in 1980 (Jude et al. 1981a), but the preponderance of yearlings in the 1981 catch was not expected.

A few yearlings were captured in our sampling area in April and May, but most perch were in water deeper than 15 m during these months. Yearlings moved inshore at both transects in June and were caught in unprecedented numbers through August (Fig. 34). Yearling catches for June (350) and August (339) were larger than the total number of yearlings caught during the entire year in 1977, 1979, and 1980, and the catch for July, 1981 (804) surpassed totals for all other sampling years combined. Size range of yearlings in 1981 (66-84 mm in April and May; 86-174 mm in November and December--see Appendix 7) was similar to that of other years. From September to December, numbers of yearlings caught were less than during the mid-summer peak, but were generally greater than catches for the same months in previous years.

Adults--

During 1981, the catch of 434 adult yellow perch represented 18% of the total perch catch. Adult perch generally occupied water >15 m deep until June when inshore migration associated with spawning occurred. Peak spawning took place in early June as in other sampling years. From April to June, adults with well developed gonads were collected at north and south transects in approximately equal numbers. Also, densities of perch larvae were nearly parallel at both the plant and reference transects (see RESULTS AND DISCUSSION, Yellow Perch, Larvae). Some evidence indicated that spawning was concentrated at the north transect as 72% of the perch with spent gonads were caught there. However, because perch spawning probably peaked about 2 wk prior to our mid-June adult sampling date, some perch that were captured at the north transect may have moved over the riprap after having spawned elsewhere in the lake. Adults were captured in water depths $\leq$ 9 m through November, but a few perch had begun to move to deeper water during September (Fig. 34). By December, offshore migration by perch was nearly complete.

Diet of yellow perch varied seasonally in that alewives were predominant food items during June and July; whereas, the availability of rainbow smelt YOY was capitalized upon during August. Perch also consumed small numbers of several other fish species including johnny darter, slimy sculpin, spottail shiner, unidentified coregonine, and yellow perch. One perch captured in April had 20 sculpin eggs in its stomach.

Trout-perch

Introduction--

Trout-perch inhabit all the Great Lakes and a few of the larger inland lakes (Hubbs and Lagler 1958). In Lake Michigan this species occurs most commonly in shoal areas, but may range into water as deep as 94 m (House and Wells 1973).

Trout-perch was one of the most abundant fish species collected near the Campbell Plant during 1977 through 1981. Trout-perch comprised approximately 1.1% of the total adult and juvenile catch in Lake Michigan in 1977, slightly more than 2% both in 1978 and in 1979, about 3.5% in 1980 and 0.9% in 1981. Adult and yearling trout-perch apparently are benthic as almost all were caught in trawls from the lake bottom.

Although adults and juveniles were very common, trout-perch larvae were uncommon in the study area which may be partially explained by the prolonged spawning period and the relatively low fecundity of the species (Jude et al. 1981a). Furthermore, larval trout-perch are apparently demersal and not susceptible to the majority of our sampling efforts; 52 of the 63 trout-perch larvae (over 80%) captured in Lake Michigan from 1977 through 1981 were collected in sled tows.

In general, during the previous years of the study, a few adult trout-perch would move into the study area during April, presumably to spawn. It was not until May that a substantial trout-perch population was inshore and spawning activity was high. June was the peak spawning month for trout-perch in the vicinity of the plant for each of the years 1977 through 1980 and spawning activity remained high through July. Spawning activity apparently declined in August but did not cease; larvae data indicate that spawning may have extended into early September (Jude et al. 1981a). During late spring and throughout summer most adults and yearlings were collected in bottom trawls from 6 to 12 m at night and showed a movement toward deeper water with daylight. The vast majority of adults and yearlings were trawled at night. Adult and yearling trout-perch exhibited a wide range of tolerance to water temperature; no distinctive distributional patterns associated with temperature were noted (Jude et al. 1981a). In agreement with our conclusion on the lack of temperature preference by trout-perch were the scuba diver observations of a Georgian Bay study in which trout-perch behavior was unaffected by upwellings (Emery 1970). A substantial population of adult trout-perch remained in the study area into September but this population dispersed from the area during October through December. Most adults and yearlings had left the study area by November. A few (47) YOY trout-perch were collected in trawls from 1977 through 1980; all were caught from August to November between 6 and 15 m.

Larvae--

Seasonal distribution--Trout-perch larvae in Lake Michigan were caught from the beach to 15 m during years 1977 through 1981 with the majority caught from 6 to 15 m. Larvae were collected from April through September. Most were captured at night and by sleds.

During 1981, nine trout-perch larvae were collected during June to August in Lake Michigan from the beach to 12 m at the north transect. All but one larva were caught in sled tows. Six larvae were caught at night, while three were caught during the day indicating more net avoidance occurred during the day. Densities for strata where trout-perch were collected ranged from 26 to 125 larvae/1000 m^3 (Fig. 35). Water temperatures at which these nine larvae were collected ranged from 11.8 to 22.5 C. Six larvae (6-8 mm in length) were recently hatched. Trout-perch are about 5.5 to 6.0 mm at hatching (Jude et al. 1979b; Fish 1932). Three larger larvae were collected in early August in sled tows: a 9-mm specimen at the beach, a 10.0-mm larva at 1.5 m and a 16.5-mm specimen at 12 m (Fig. 36). A 40-mm yearling was collected in a night sled at 12 m in early August (Appendix 15).

At the south transect in 1981, trout-perch larvae were first collected in early July when one larva was captured in each of two plankton net tows at the 9- and 12-m stations (Fig. 35). In late July one larva was caught in a sled at the 9-m station; and in late August three trout-perch larvae were collected in each night sled tow sample from the beach and 1.5-m stations. One larva was also collected in a plankton net sample at the 9-m station. All larvae were recently hatched (4.5-7.0 mm in length) and all were collected at night. Densities ranged from 26 to 219 larvae/1000 m^3 and temperatures at which these larvae were caught ranged from 9.0 to 17.9 C.

The number of trout-perch larvae collected in the field at the north transect decreased from 23 larvae in 1980 to 9 larvae in 1981. Furthermore there was no apparent difference in catch or density of larvae between transects during 1981 (10 trout-perch larvae were collected at the south transect). However, numbers of larvae generally collected in the field were low enough so the conclusion that the riprap lost its attractiveness to trout-perch for spawning (and cover) from 1980 to 1981 was not warranted.

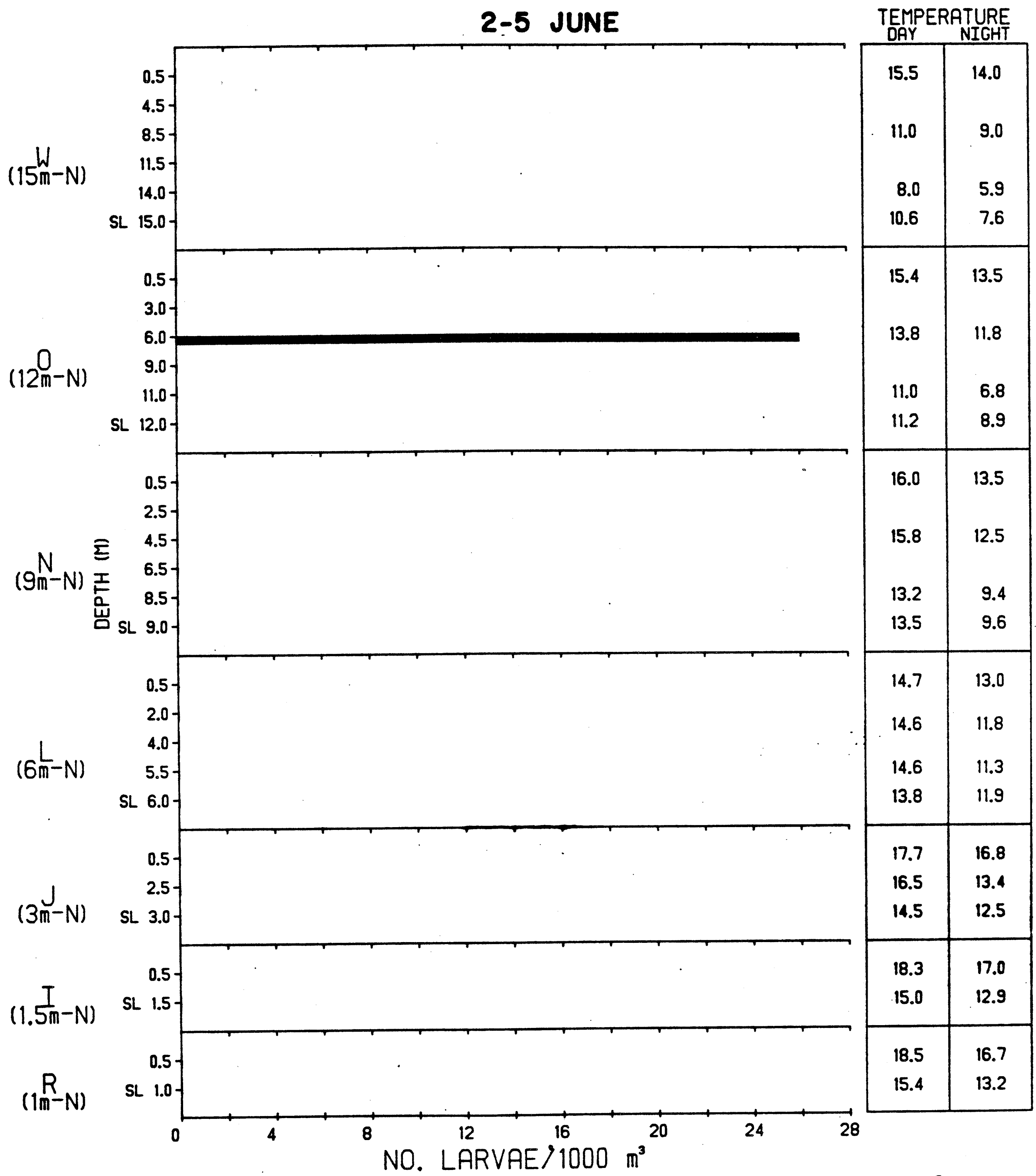
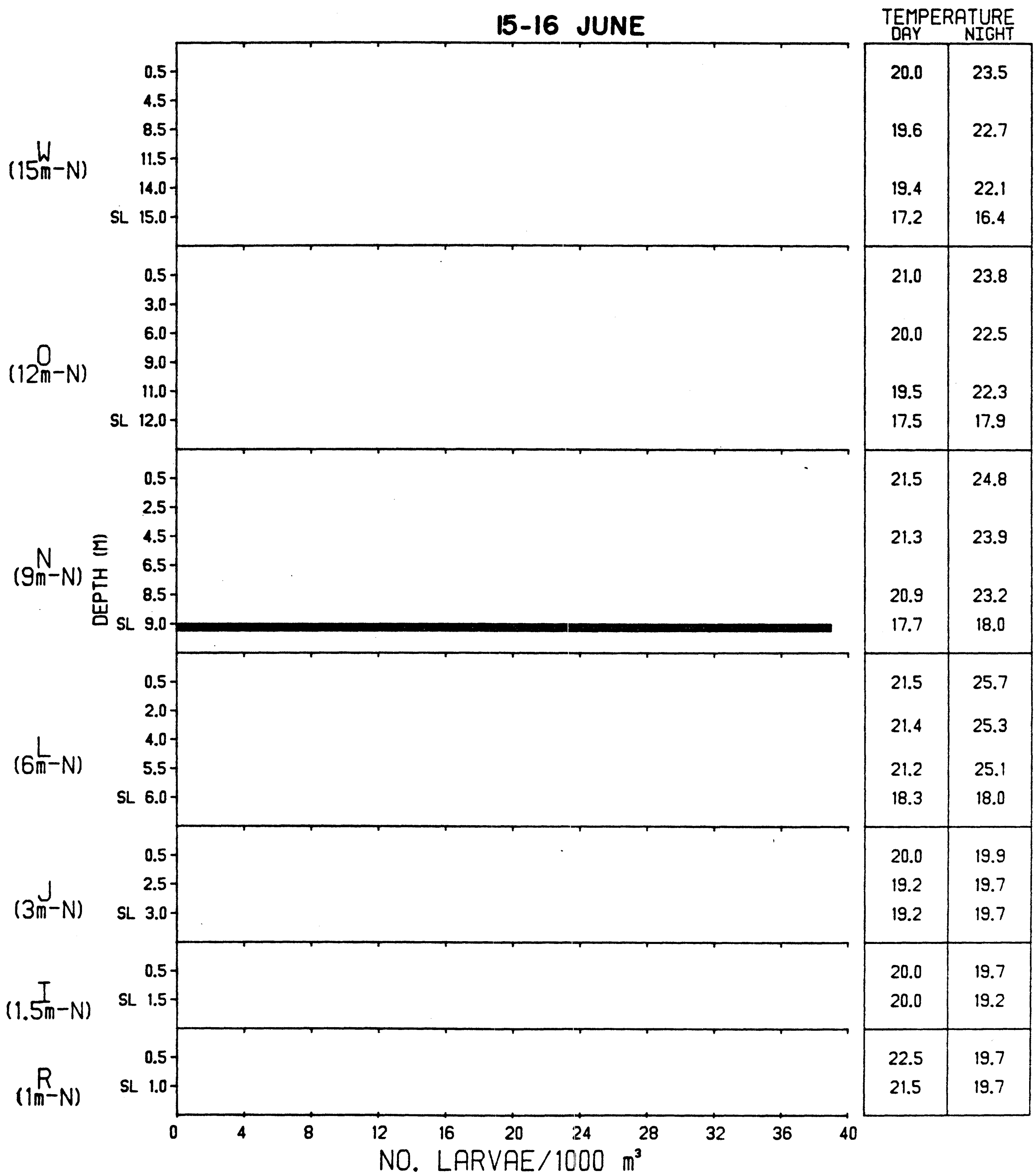


Fig. 35. Density of larval trout-perch (no./1000 m^3) at north and south transect stations near the J. H. Campbell Plant, eastern Lake Michigan, June, July and August 1981. □ = day, ■ = night, SL = sled.



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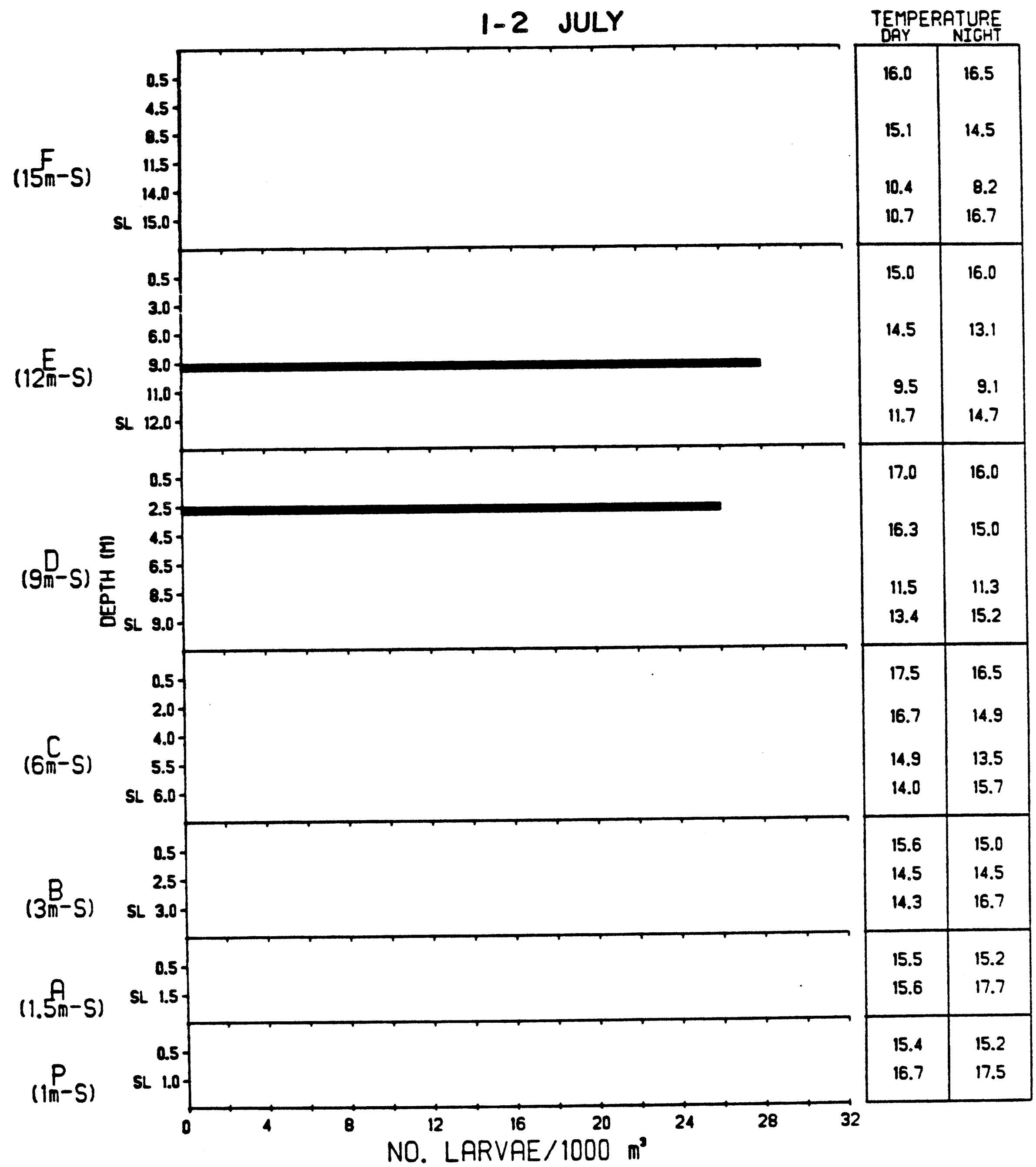

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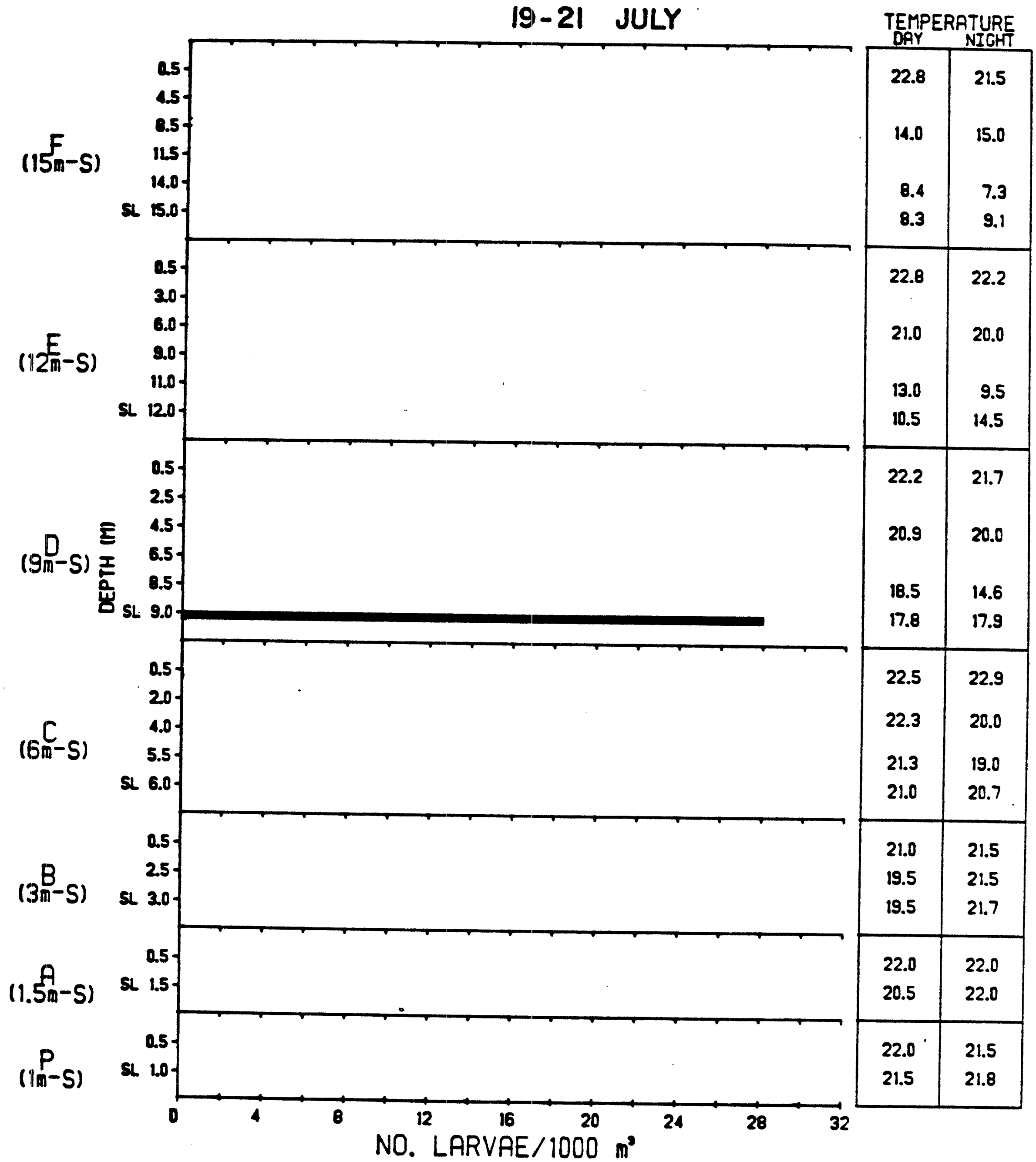

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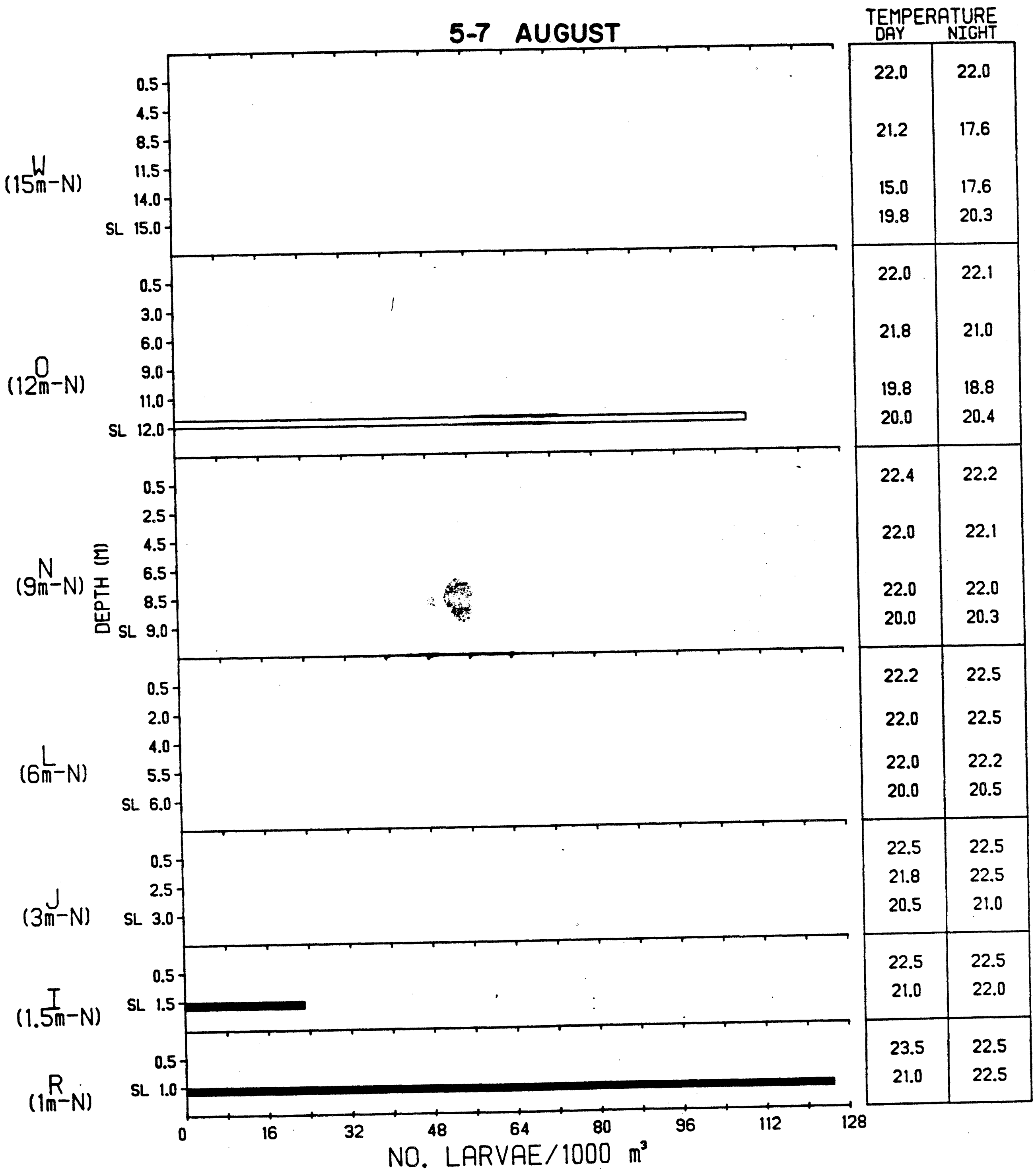

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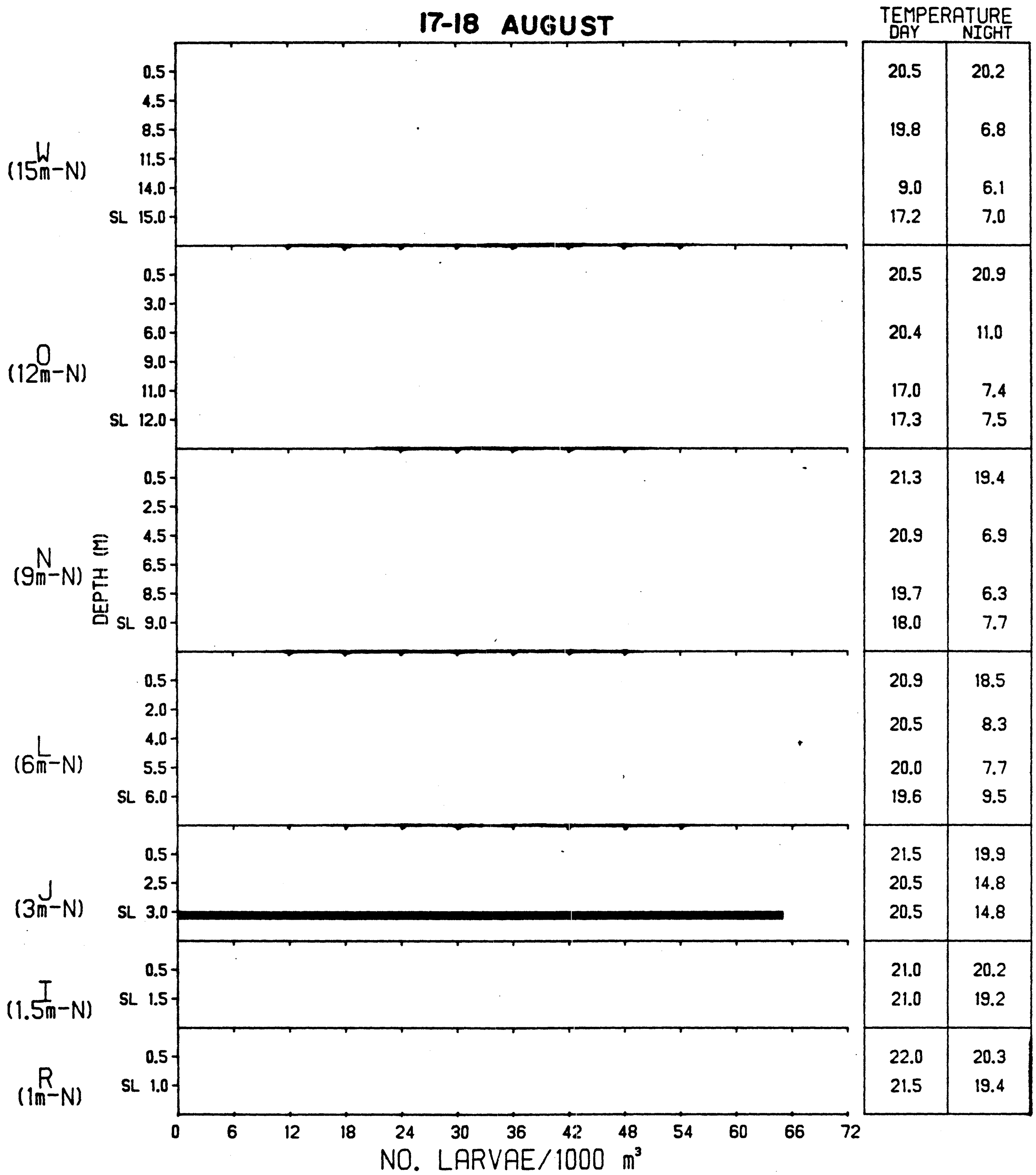

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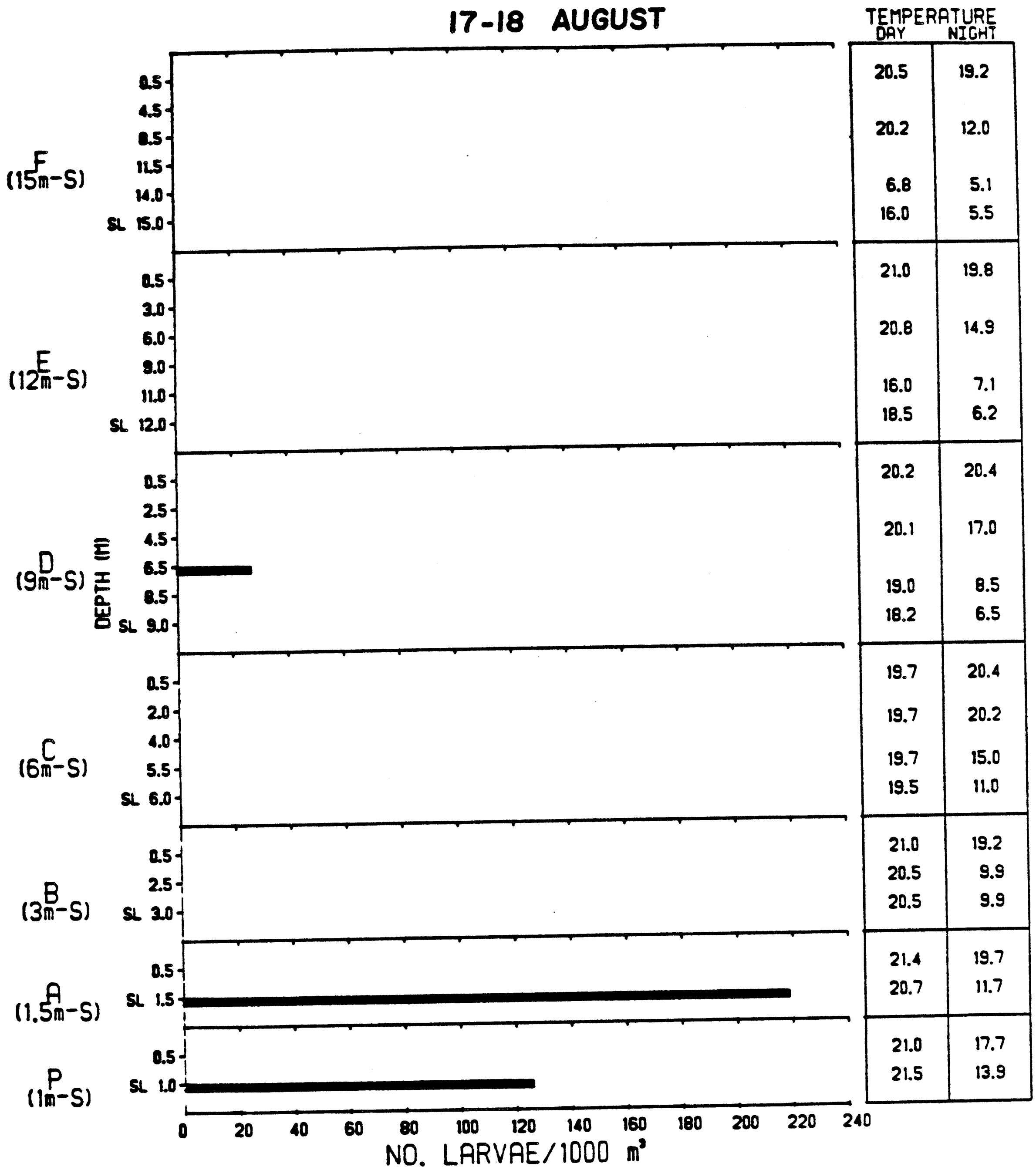

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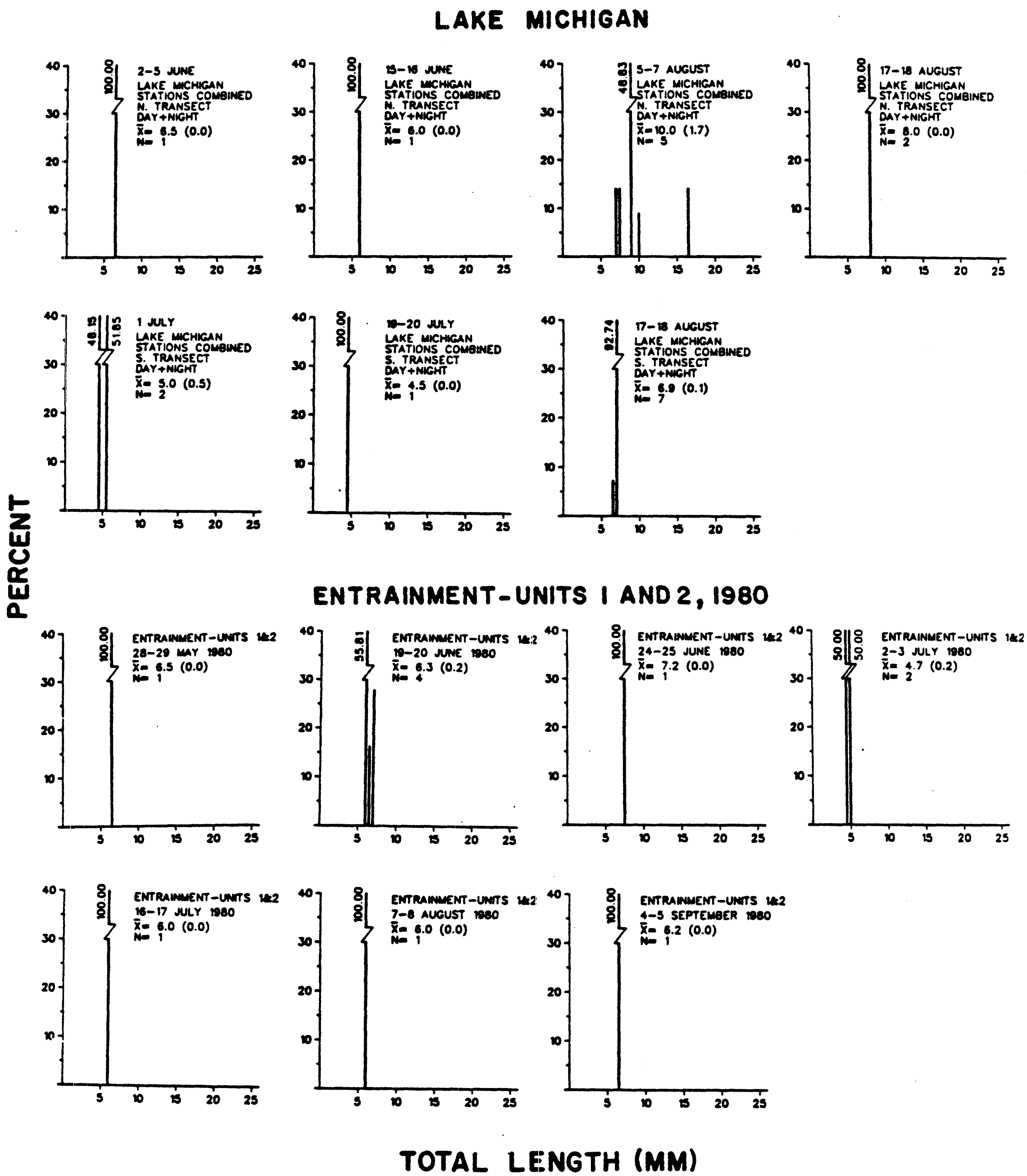


Fig. 36. Length-frequency histograms for larval trout-perch observed in field and entrainment samples collected during 1981 near the J. H. Campbell Plant, eastern Lake Michigan. Length-frequency histograms for trout-perch larvae entrained during 1980 were also included. All plankton net and sled tow samples were combined. $\bar{X}$ = mean, N = total number of larvae, standard error is given in parentheses.

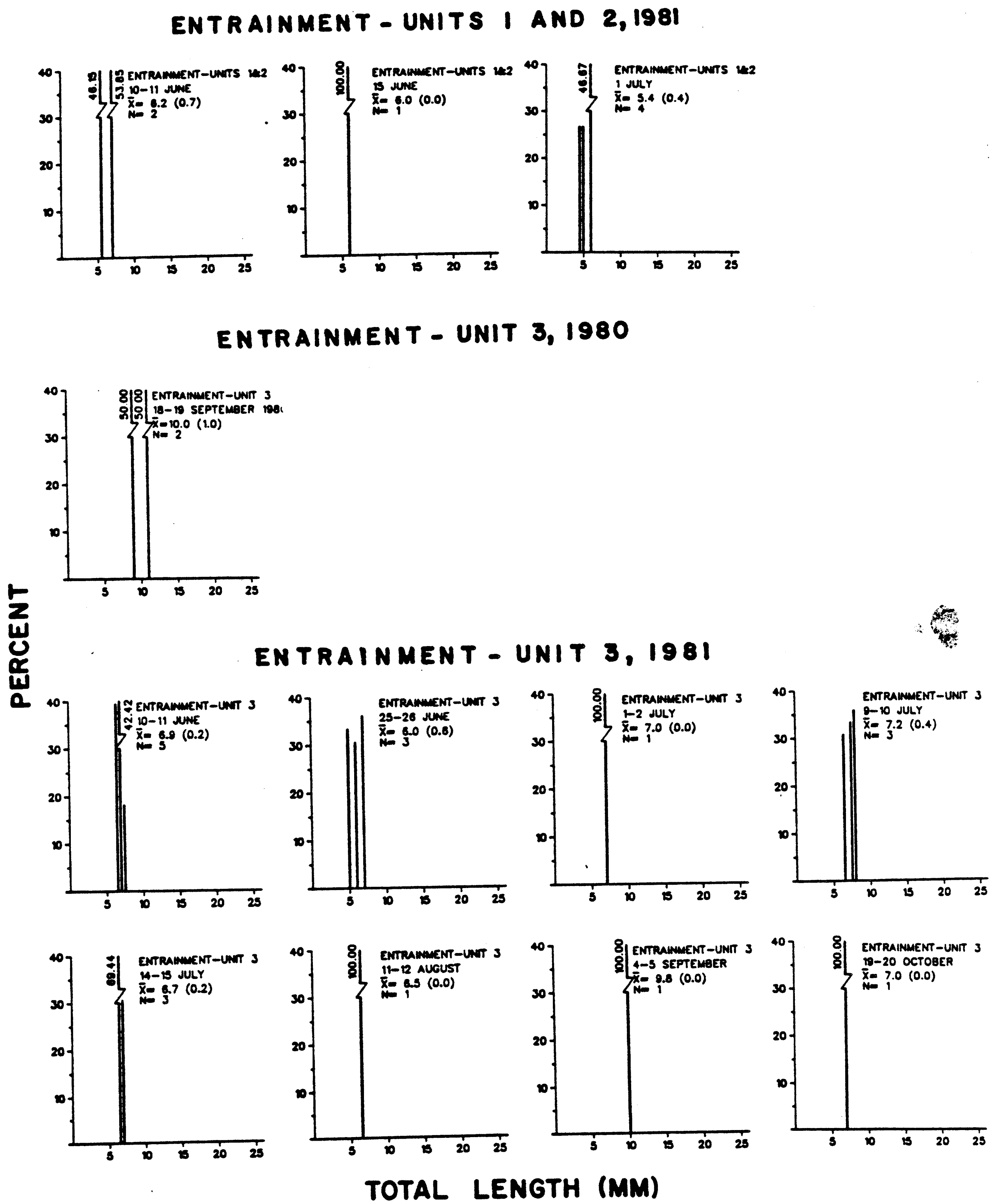


Fig. 36. Continued.

Entrainment--Eleven trout-perch, all newly hatched (4.5-7.2 mm in length), were counted in entrainment samples collected at Units 1 and 2 during 1980. Six larvae were from night samples, two from dawn and three from dusk samples; densities of these larvae ranged from 1 to 8/1000 m^3 (Appendix 11). Larvae were first collected in entrainment samples during late May and were collected intermittently from the end of May through September. The observed peak density was recorded during June and the estimate of trout-perch entrained during the month of June was highest of all the months sampled at Units 1 and 2 during 1980 (Appendix 11; Table 25). At Unit 3 sampling began in September during 1980 and during 18-19 September two larvae (9 and 11 mm in length) were collected. The estimated number of larvae entrained during 1980 at Unit 3 (49,600 larvae) was disproportionately high compared to number counted in samples due to relatively low volume of water sampled (Table 27).

During June through October 1981, 18 trout-perch larvae were collected in entrainment samples from Unit 3 (Fig. 37). All larvae were recently hatched (5.0 to 7.8 mm), except for a 9.8-mm larva recovered in a sample collected at dusk in early September. Average entrainment densities for diel periods when trout-perch larvae were collected ranged from 2 to 25 larvae/1000 m^3. Larvae were collected at water temperatures ranging from 7.3 to 22.3 C. Nine larvae were caught at night, six at dusk, one at dawn and only two during the day. It may be that trout-perch larvae are more active at night (dusk and dawn also) than during the day and are more likely to be entrained during the night than during the day. Most trout-perch larvae entrained at Unit 3 during 1981 were entrained during June and July (80,000 and 62,000 larvae, respectively); during August through October entrainment levels were considerably lower (Table 28). A 7.0-mm trout-perch larva was recovered from a 20 October entrainment sample (Fig. 36); this recently-hatched larva indicated that trout-perch spawning continued through early October during 1981. Entrainment occurred mainly during June and July in 1981 for all units of the plant, although this was not the case in previous years at Units 1 and 2. For example, in 1979 at Units 1 and 2 monthly entrainment rates were relatively steady from April through September, except in July when no trout-perch larvae were collected in entrainment samples. In 1978 trout-perch larvae were recovered from entrainment samples just in May and July, while during 1977 they were only found in June.

Trout-perch larvae were entrained at Units 1 and 2 during 1981 at night on 1 June (3 larvae/1000 m^3), 15 June (3/1000 m^3) and 1 July (7 larvae/1000 m^3). A total of seven larvae were identified in entrainment samples; all were newly hatched (4.5 to 7.0 mm in length). An estimated 30,000 trout-perch larvae were entrained during June and 18,600 larvae were entrained during

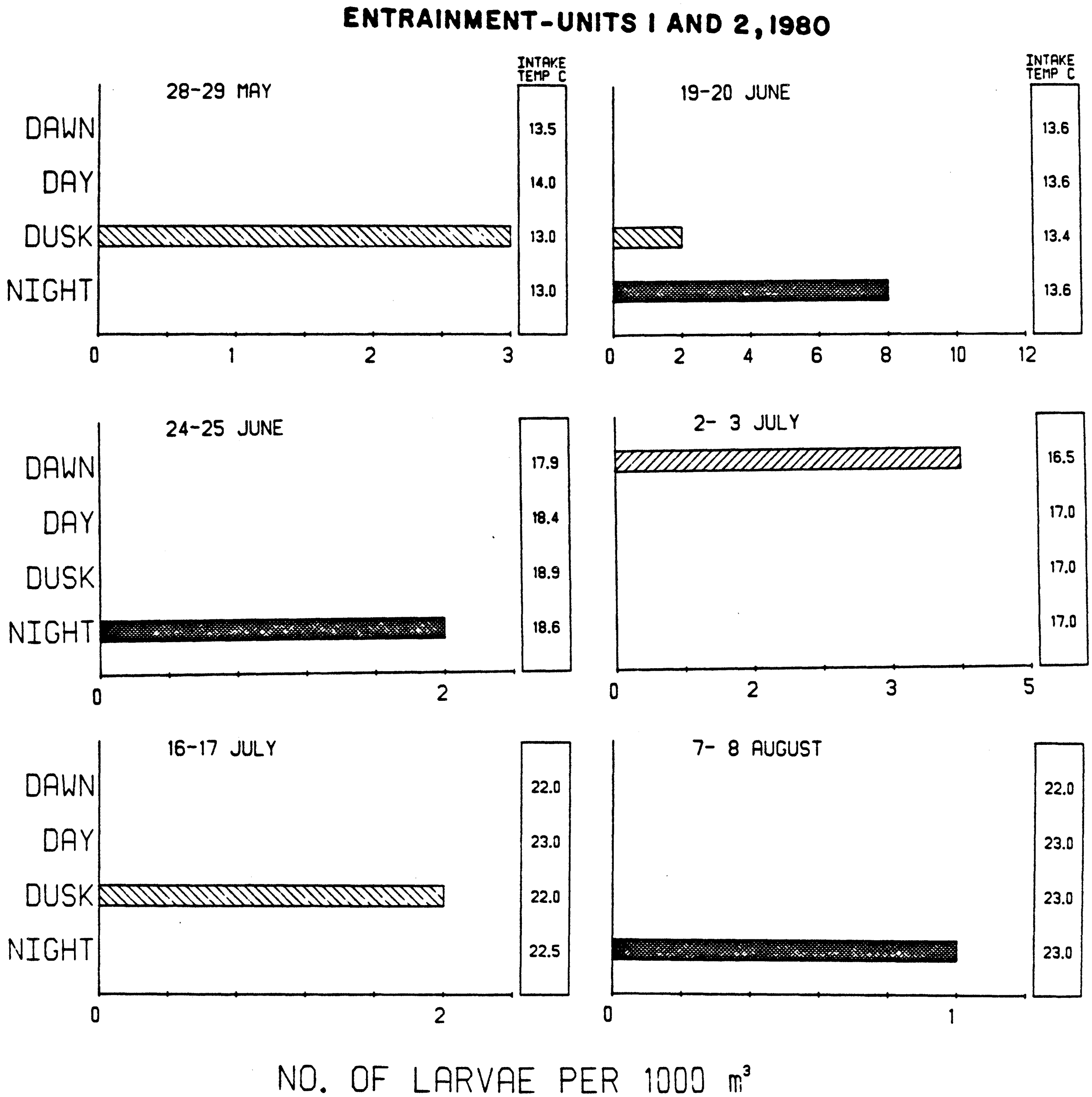


Fig. 37. Density of larval trout-perch (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at the J. H. Campbell Plant's Units 1 and 2 and Unit 3 during 1980 and 1981. Only day and night densities were shown for Units 1 and 2 during 1981.

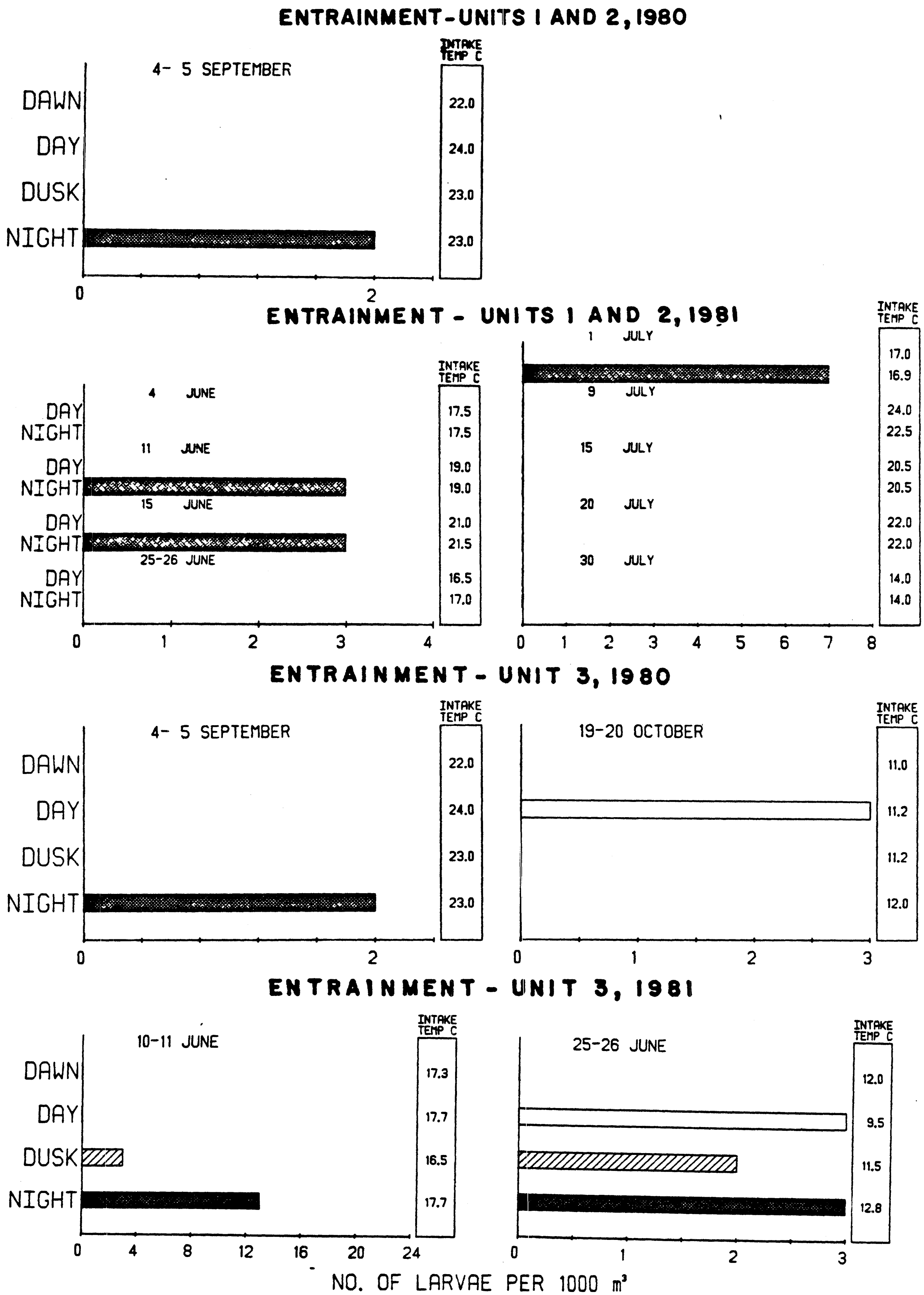


Fig. 37. Continued.

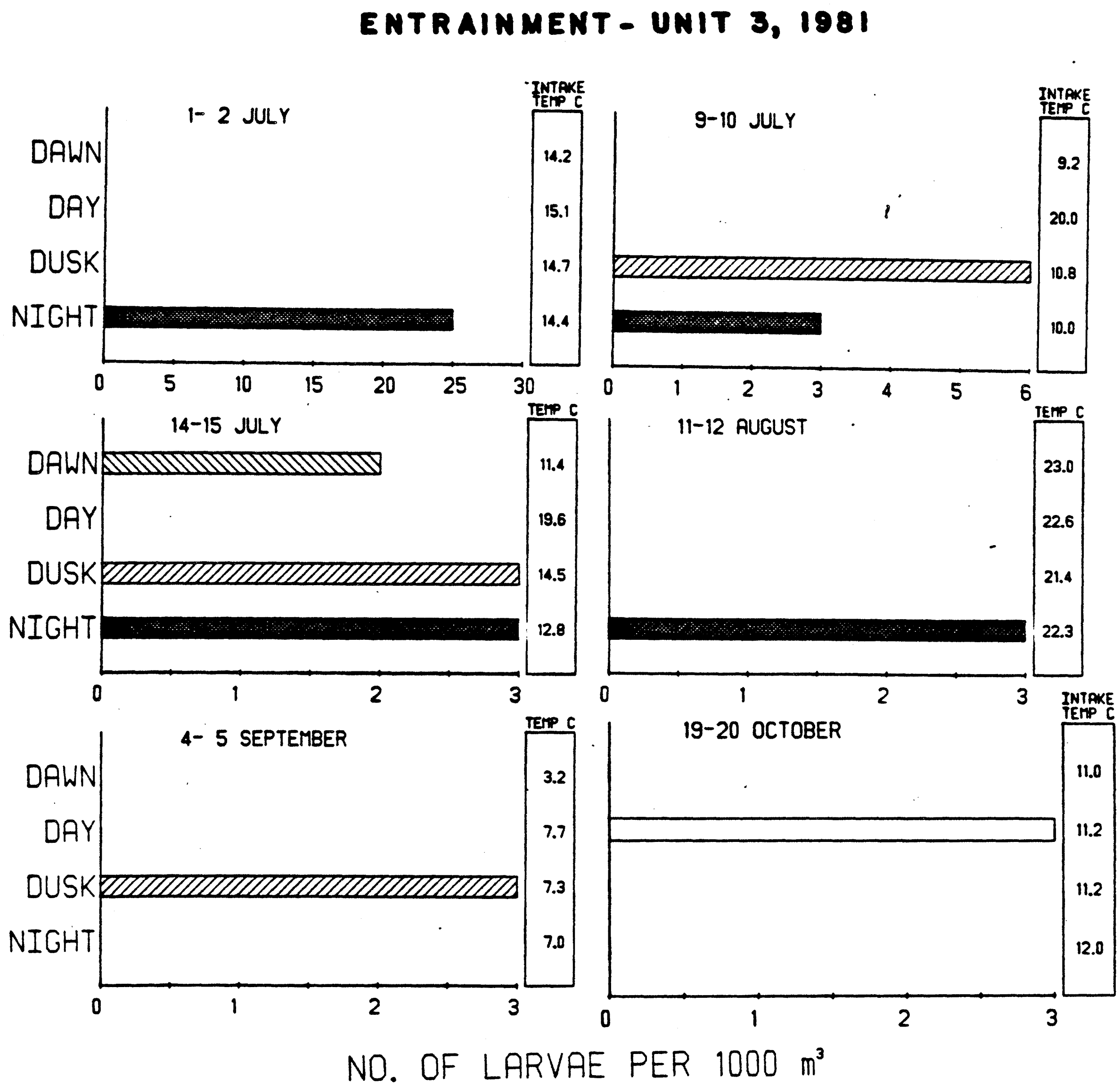


Fig. 37. Continued.

July (Table 26). Coincidentally, trout-perch larvae were also collected in entrainment samples at Unit 3 during 11 June and 1-2 July 1981.

Trout-perch larvae catches were infrequent and sparse enough not to warrant ANOVA for testing differences in densities between samples collected in Lake Michigan at the north transect (near the intake for Unit 3) and entrainment samples for Unit 3. Note that trout-perch were never collected simultaneously during any sampling period during 1981 in both Unit 3 entrainment and north transect field samples (Figs. 35 and 37). Most trout-perch larvae collected during 1981 in both entrainment and field samples were recently hatched (5-8 mm). Of the few larger larvae collected, more were collected in the field than were in entrainment samples. The aforementioned characteristics of length frequency were similar to those observed for years 1977 through 1980.

Entrainment of trout-perch larvae at Units 1 and 2 was relatively high during 1979 (86,500 larvae) compared with 1978 (4,690 larvae) and 1977 (7,450 larvae). This substantial increase may to due to attraction of trout-perch to the riprap (deposited in 1979), intake and discharge structures and currents produced by them. This area is apparently favorable to trout-perch for spawning, feeding and cover. During 1980, 23 larvae were recovered from field samples at the north transect and the riprap was suspected of attracting trout-perch to the plant area to spawn (Jude et al. 1981a). During 1980 and 1981 trout-perch entrainment at Units 1 and 2 was moderately high at an estimated 46,300 and 48,600 larvae, respectively. The annual entrainment total was expected to be relatively high for the Unit 3 intake during 1981 since the water would be drawn from the riprap area, to which trout-perch were probably attracted for spawning. The total was high as an estimated 145,000 trout-perch larvae were entrained by Unit 3 during 1981.

<u>24-h population and entrainment estimates</u>--As was stated previously, collection of trout-perch larvae in Unit 3 entrainment samples never coincided with collection of these larvae in Lake Michigan during 1981. This fact plus the uncommon occurrence of trout-perch larvae in the plant vicinity complicated the assessment of the entrainment loss in relation to the larval trout-perch population in the vicinity of the plant. Maximum number of larvae estimated in the plant vicinity was 423,000 (for early June), while peak entrainment for a 24-h sampling period (7,600 larvae) occurred in early July; 7,600 is 1.8% of 423,000 (Table 31). This percentage was fairly high compared with those of alewife, but not high compared with other less common species. Since larval trout-perch catch was sparse, the population estimates of larvae in Lake Michigan in the plant vicinity are probably not as accurate as those for more common species of larvae. Actual trout-perch densities at lake bottom strata may be underestimated since density of trout-perch larvae in the immediate area of the riprap was suspected to have been greater than the density sampled at north transect stations. Of the four sampling periods (two in June and two in August) when trout-perch larvae were collected at the north transect, no trout-perch were estimated entrained.

Young-of-the-Year--

Only one YOY trout-perch was captured during 1981; this was a specimen in the 40-mm length interval caught in a night trawl at station E (12 m, south) during September (Fig. 38). Previous YOY annual catches were not quite as sparse (ranging from 3 to 16 fish); however, note that trawling was not performed at station F (15 m, south) during 1981, although it was in earlier years, and this may account for the lower 1981 catch.

Yearlings--

Yearling trout-perch catch was unusually low in 1981 (only 30 fish compared to a range of 201 to 1175 fish annually for years 1977 through 1980) for reasons not clear. Perhaps the bulk of the yearlings remained in deeper water, not entering the study area; again note that the 15-m station was dropped from the sampling design for trawls during 1981. Additionally, the survival of YOY from 1980 may have been poor during the 1980-1981 winter. All the yearlings but one were caught in trawls between 6- and 12-m depths (Fig. 38); similarly, in previous years most yearlings were captured in trawls between the 6- and 12-m depths.

Adults--

The adult trout-perch catch data present some anomalies to the annual distribution pattern established by the data for previous years. Peak adult catch was observed during the spawning peak in June or in May just prior to peak spawning. However, in 1981 the May catch was low relative to catches from other months; furthermore, peak catch of adults was observed in October when 342 adults were collected. Most of these fish were recovered from a night trawl at station N (9 m, north) (Fig. 38). In previous years, adult catch for October ranged from 20 to 139 individuals. Total adult catch for 1981 was 1240 fish (during the three previous years, annual adult catch ranged from 1043 to 1694 fish), however catch was fairly low during June 1981, the peak spawning month for that year, as only 163 adults were caught. One other unusual feature of the 1981 data was the evidence for trout-perch spawning in October. In previous years trout-perch spawning usually extended from April to September but there was no indication of spawning in October. However, in 1981 one ripe-running female was captured in October and a recently-hatched trout-perch larva was collected in an entrainment sample. As observed in earlier years, most adults captured during 1981 occurred in night trawls between the 6- and 12-m depths.

The 1981 adult catch data were inconclusive as to whether the riprap and intake-discharge complex were attracting adults to spawn. Summing for the entire sampling year, considerably more adults were observed in trawls at the 6- and 9-m stations at the

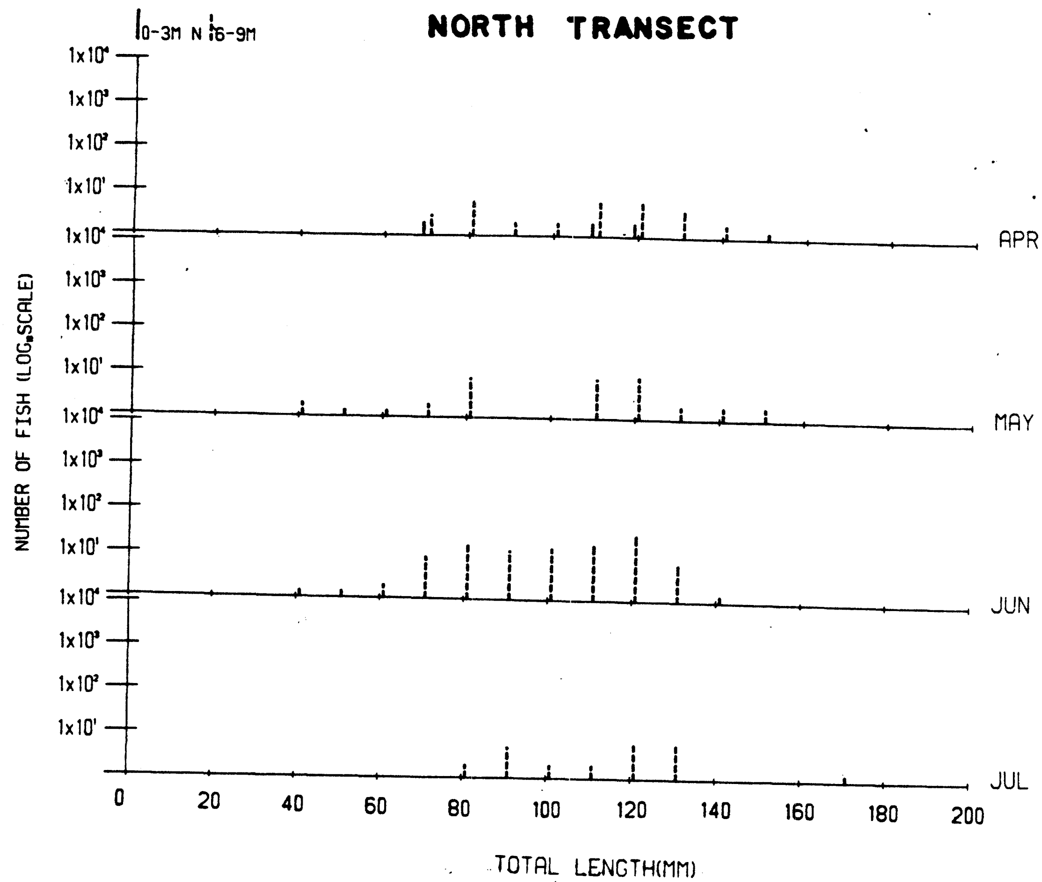


Fig. 38. Length-frequency histograms for trout-perch collected during April - December 1981 at the north and south transects. Stations were combined into two groups for the north transect: beach and 3 m; 6 and 9 m and into three groups for the south transect: beach, 1.5 and 3 m; 6 and 9 m; and 12 m. Diel periods and gear types were pooled.

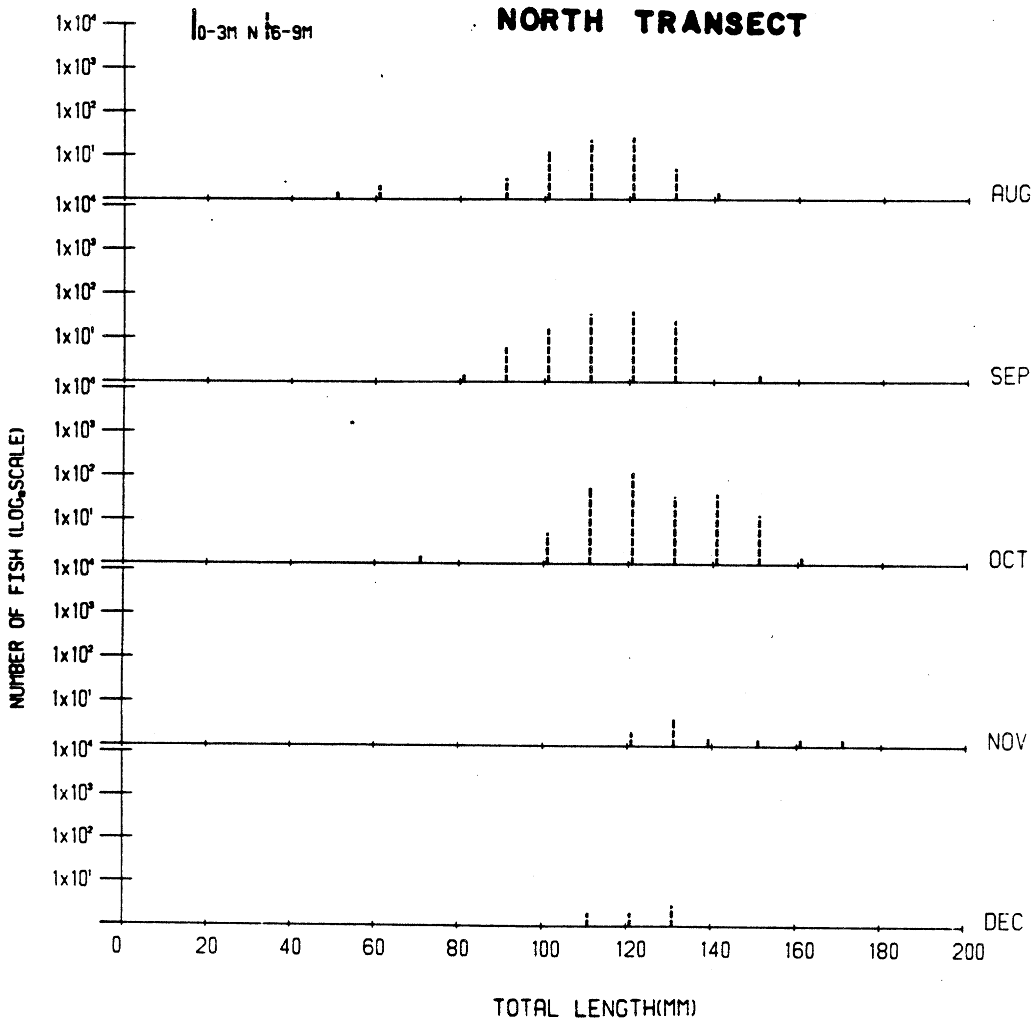
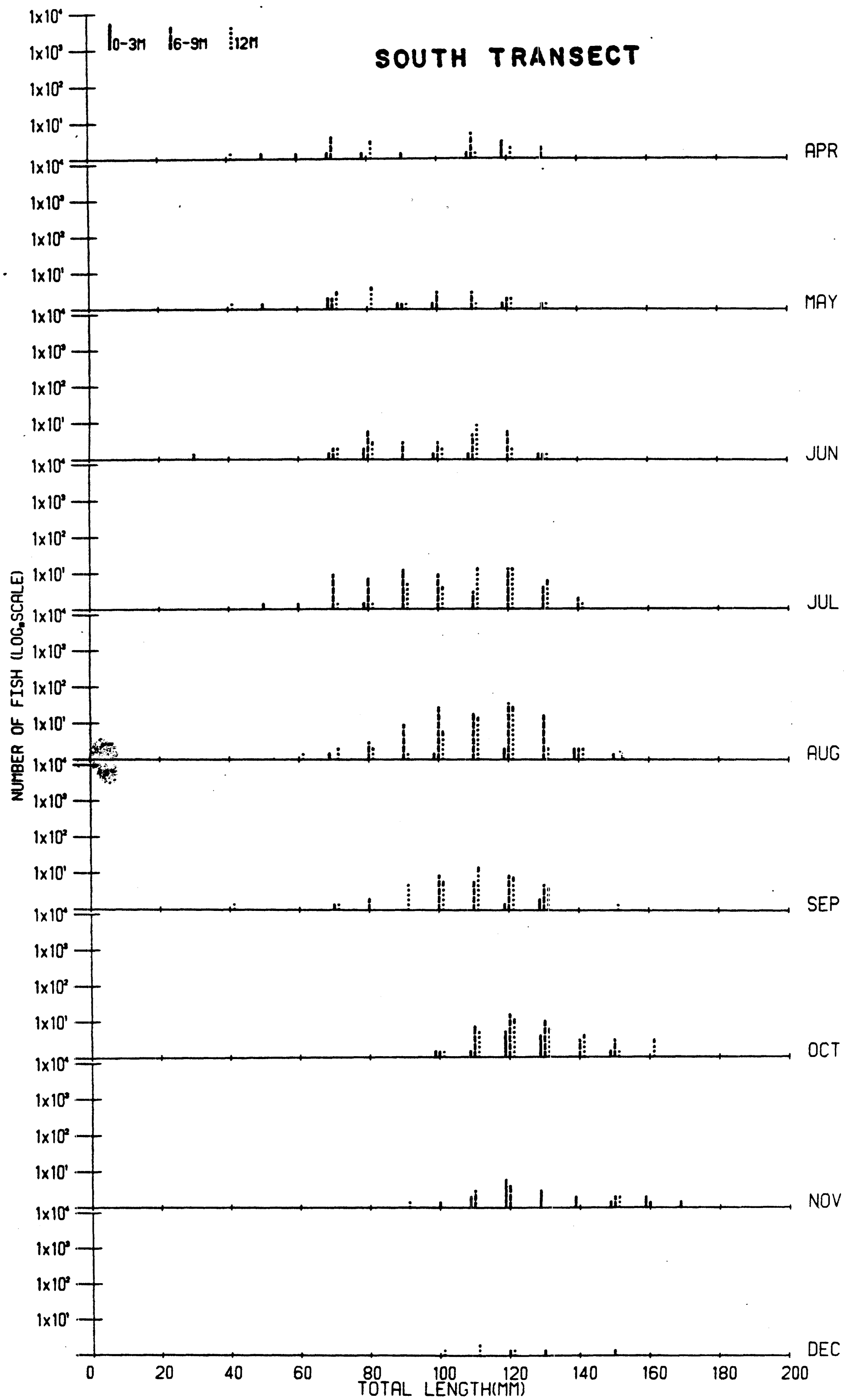


Fig. 38. Continued.


SOUTH TRANSECT
0-3M
6-9M
12M
NUMBER OF FISH (LOG SCALE)
1x10⁴
1x10³
1x10²
1x10¹
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
0
20
40
60
80
100
120
140
160
180
200
TOTAL LENGTH(MM)

north transect than at stations with matching depths at the south transect, but this was chiefly due to the unusually high trawl catch at station N (9 m, north) during October, a month of very limited spawning activity according to gonad data. The difference in adult trout-perch catch between transects for the 6- and 9-m depths during months of high spawning activity (June through August) was very slight.

LESS ABUNDANT SPECIES

Johnny Darter

Introduction--

The johnny darter inhabits a wide range of aquatic habitats, including lakes, rivers and streams. It has been recorded at a depth of 40 m in the Great Lakes (Scott and Crossman 1973) and is widespread in the Lake Michigan basin (Becker 1976). Johnny darters were the seventh-most abundant species collected during 1981, with 526 taken. They comprised 0.3% of the total catch, similar to their relative abundance in previous years.

During preoperational years in the Campbell Plant vicinity, adults appeared to spend winter months offshore and moved inshore in April or May (Jude et al. 1981a). Spawning took place from late May through July. Adults were most abundant at 6- and 9-m stations during these months. In 1980, a marked preference by johnny darters for the plant transect was noted, particularly in May, when 40 adult johnny darters were trawled at station L (6 m, north) in contrast to 6 at station C (6 m, south). Darter preference for the north transect is undoubtedly related to the riprap (associated with intake and discharge structures) which provides excellent darter habitat. Construction-related activities probably discouraged notable colonization of riprap by darters during 1978 and 1979. Prior to 1980, no substantial catch differences existed between transects.

Larvae--

Seasonal distribution--During preoperational years, collections of larval johnny darters increased from 1 larva in 1977 to 105 larvae in 1980 (Jude et al. 1981a). Thus distributional patterns were most evident in 1980. The earliest occurrence of johnny darter larvae in 1980 was in early June at 6 m. In late June, larvae were collected at beach station Q (south discharge). During July, johnny darter larvae occurred from 6 to 15 m. In June and July, north transect densities ranged from 20 to 87 larvae/1000 m³. By August, johnny darter larvae were only caught in night sled tows because their demersal habits had become established and they had apparently grown to sizes (>10 mm) at which net avoidance limited daytime capture. For example, a density of 1688 larvae/1000 m^3, highest for the year, was recorded for a sled tow during August 1980 at station N (9 m, north).

During 1981, seasonal distribution of johnny darter larvae was similar to that observed in 1980. First occurrence was in mid-June, at 6- to 15-m plant transect stations, throughout the water column (Fig. 39). Densities reached 56 larvae/1000 m^3 at 9 m, and larvae were 5.5 to 6.5 mm TL (Fig. 40). No johnny darter larvae were collected at the plant transect in July 1981, but a few appeared at reference transect stations 1-9 m in depth. July densities ranged from 22 to 141 larvae/1000 m^3 and larvae were 5.3-7.5 mm TL. In early August johnny darter larvae (6.0-7.5 mm) were again collected from 6 to 12 m in night sled tows at the plant transect, where densities were 29-202 larvae/1000 m^3. It should be noted that in both 1980 and 1981, johnny darter adults and larvae tended to be most abundant from the 6- to 12-m depth contours at the north transect, where the riprap associated with Campbell Plant intake and discharge structures is located.

Entrainment--Johnny darter larvae were entrained by Unit 3 from 10 June to 11 August, 1981. Estimated entrainment densities in June ranged from 2 to 60 larvae/1000 m^3 (Fig. 41) which were similar to plant transect densities (17-56/1000 m^3). During July, entrainment densities were 3-27 larvae/1000 m^3, while johnny darter larvae were collected only at the reference transect (densities 22-141/1000 m^3). August entrainment densities stayed low, 3-16/1000 m^3, while plant transect densities were higher, 25-202/1000 m^3. Density differences were attributed to growth of larvae and to behavior patterns associated with different-sized fish. Mean length of larvae tended to be smaller in Unit 3 entrainment samples than in field samples (Fig. 40). For example, during 5-7 August, mean length of entrained larvae was 5.9 mm, while field-caught larvae averaged 6.7 mm. Smaller larvae are poorer swimmers and are somewhat pelagic, while larger larvae can more easily resist intake currents or may be almost totally demersal, thus staying away from the Unit 3 intakes which are almost 3 m off bottom. In late summer, most larvae have grown large enough to be relatively invulnerable to entrainment, accounting for low densities observed in Unit 3 entrainment samples. In late August a 15.2-mm larva was collected at station N (9 m, north) (Fig. 40), but no johnny darter larvae were taken in entrainment samples.

During 1981, an estimated 304,000 johnny darter larvae were entrained by Unit 3 (Table 28). This is more than were entrained by Units 1 and 2, where an estimated 193,000 johnny darter larvae were entrained in 1981 (Table 26). However, Unit 3 intakes are located in an area where johnny darters are naturally more abundant than the area near the intake for Units 1 and 2.

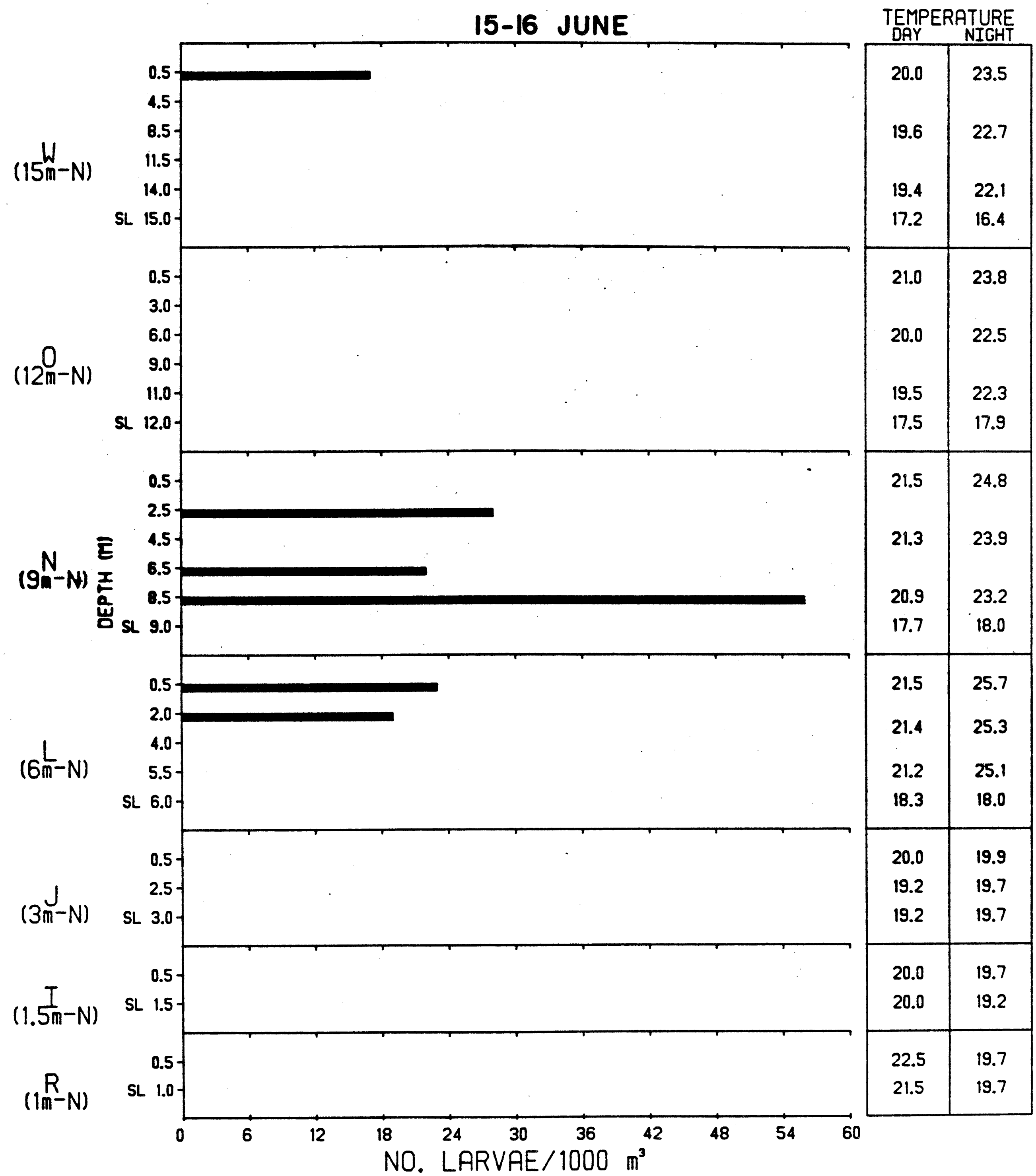
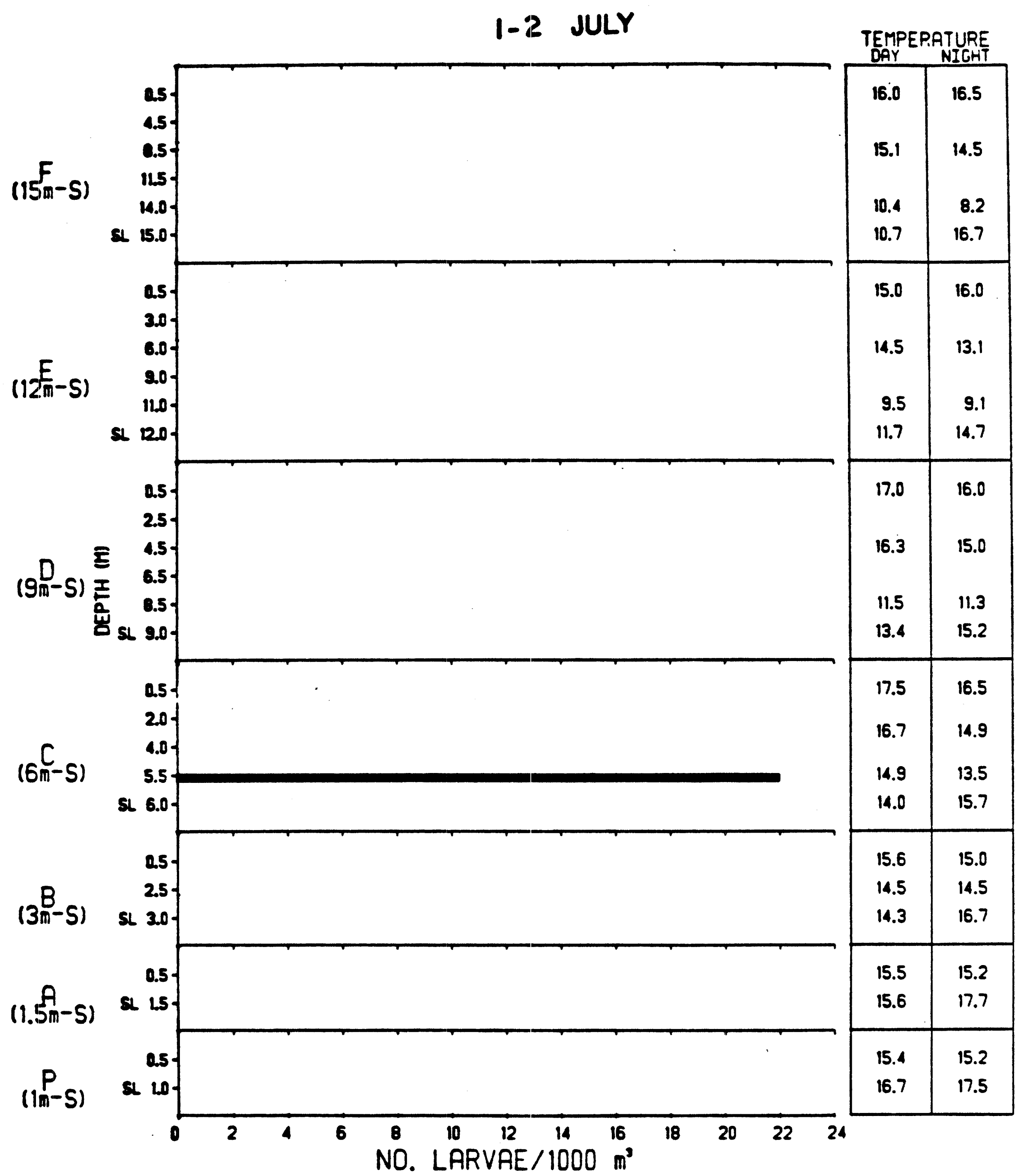


Fig. 39. Density of larval johnny darters (no./1000 m^3) at north and south transect stations near the J. H. Campbell Plant, eastern Lake Michigan, June, July and August 1981. ☐ = day, ■ = night, SL = sled.



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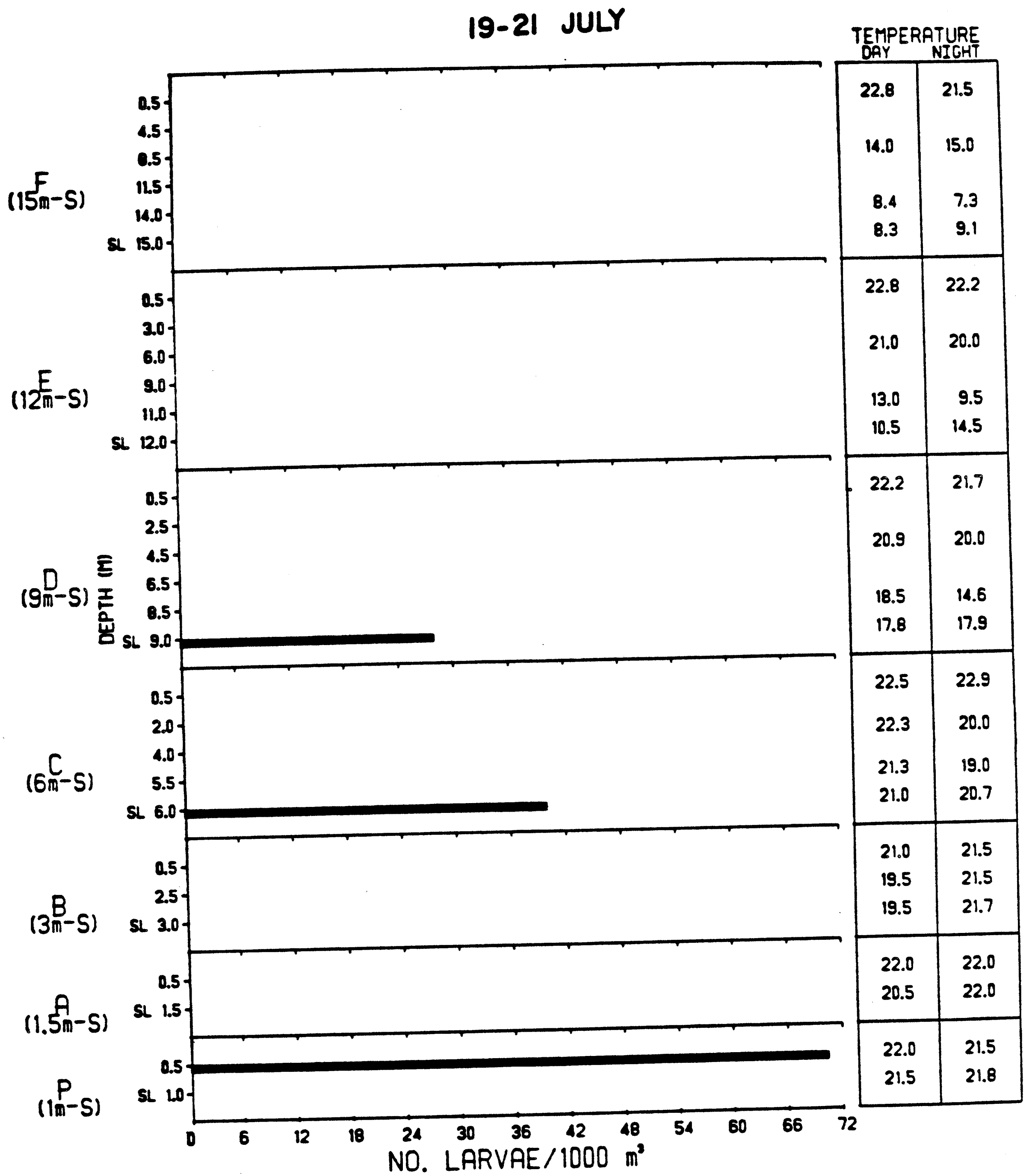

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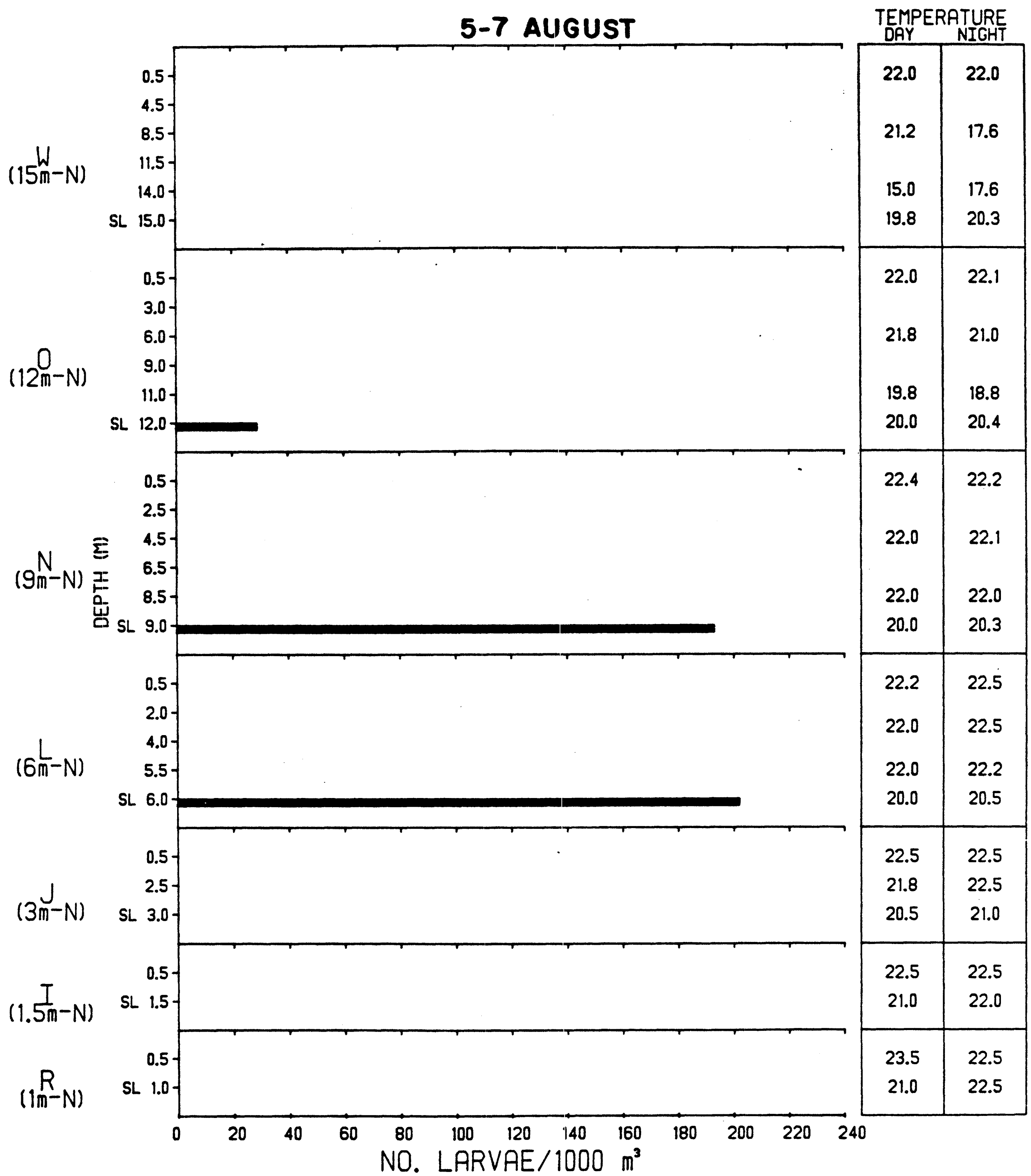
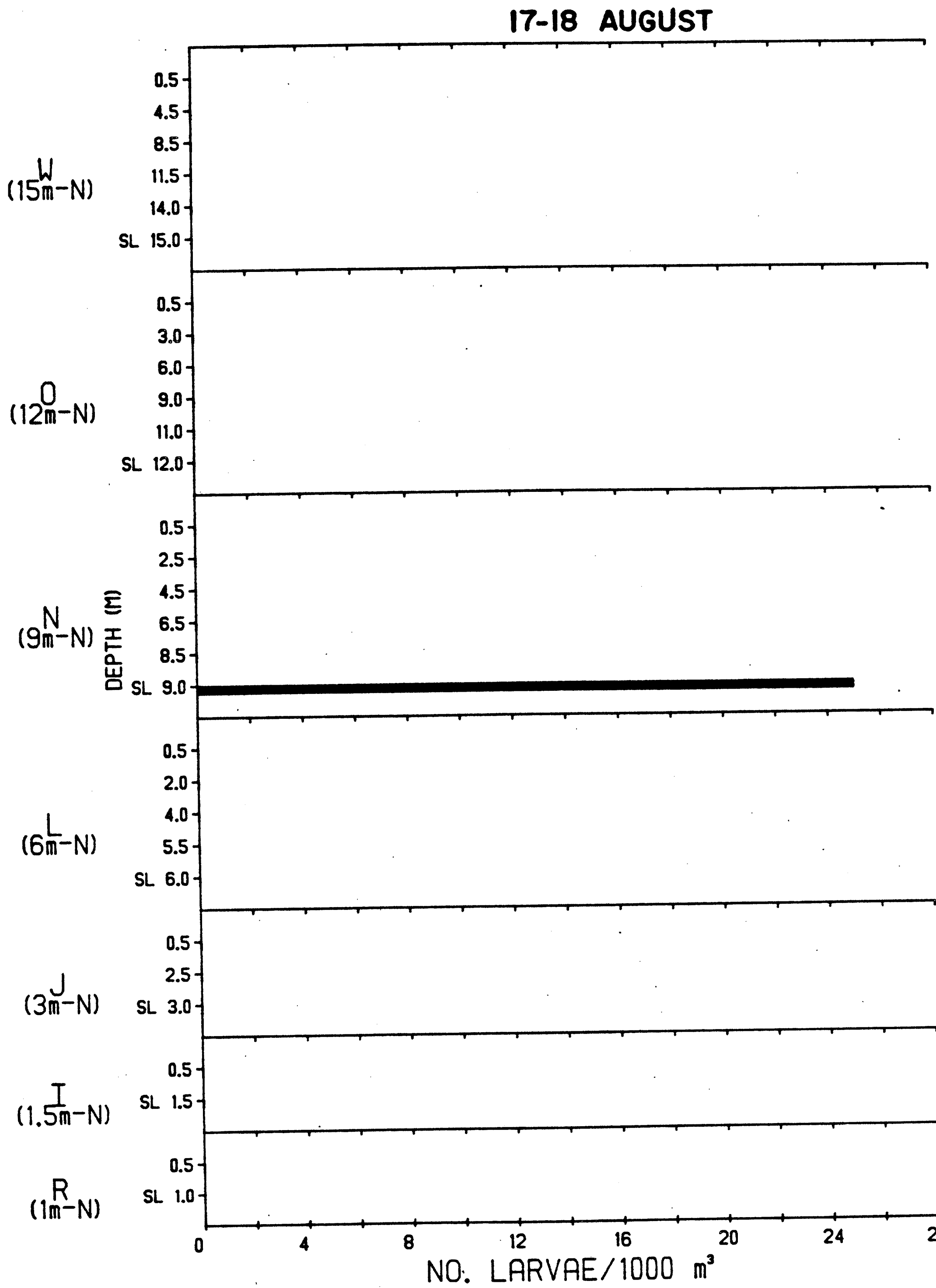


Fig. 39. Continued.



Station	TEMPERATURE DAY	TEMPERATURE NIGHT
W	20.5	20.2
	19.8	6.8
	9.0	6.1
	17.2	7.0
O	20.5	20.9
	20.4	11.0
	17.0	7.4
	17.3	7.5
N	21.3	19.4
	20.9	6.9
	19.7	6.3
	18.0	7.7
L	20.9	18.5
	20.5	8.3
	20.0	7.7
	19.6	9.5
J	21.5	19.9
	20.5	14.8
	20.5	14.8
I	21.0	20.2
	21.0	19.2
R	22.0	20.3
	21.5	19.4

Fig. 39. Continued.

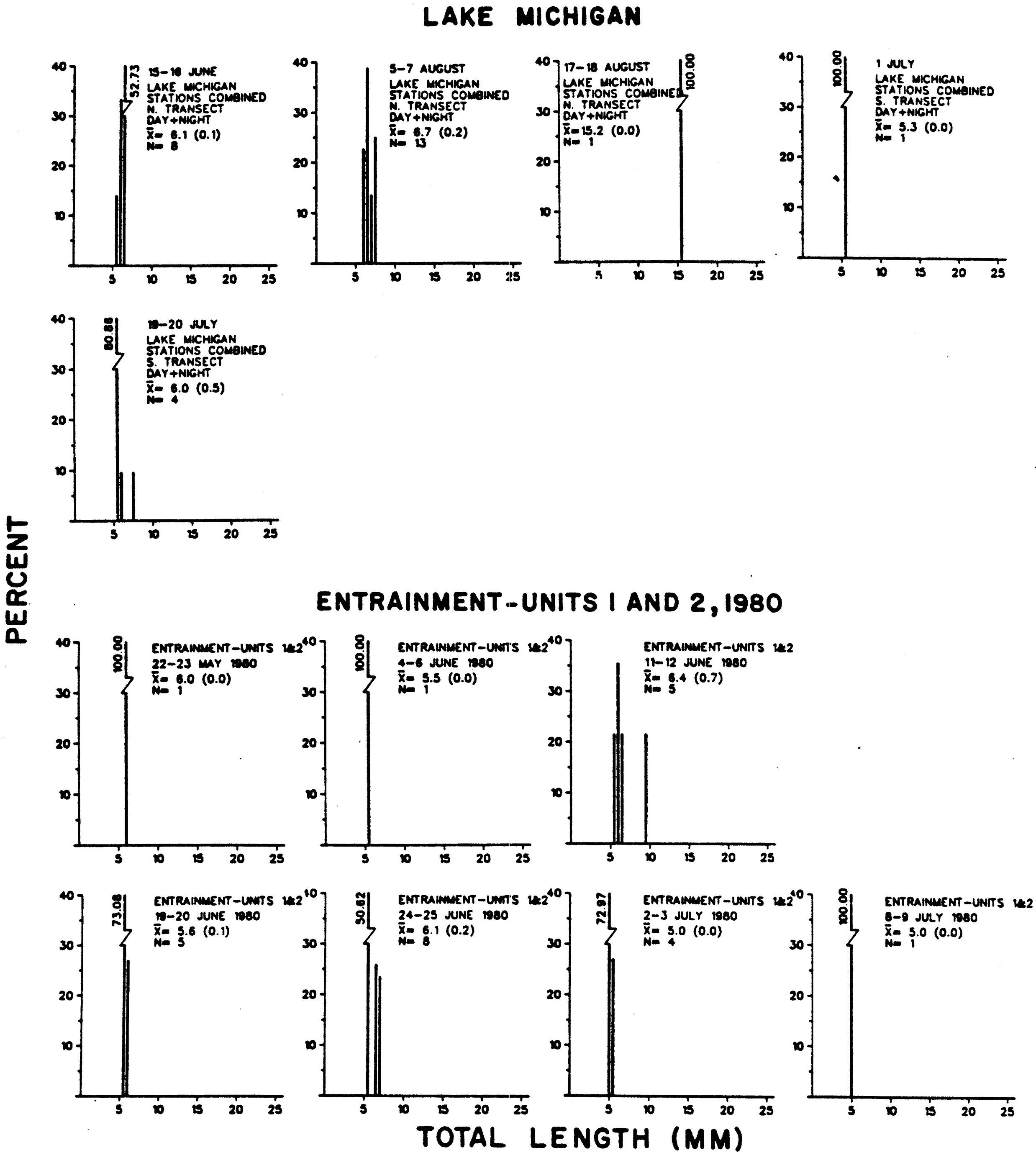


Fig. 40. Length-frequency histograms for larval johnny darters observed in field and entrainment samples collected during 1981 near the J. H. Campbell Plant, eastern Lake Michigan. Length-frequency histograms for johnny darter larvae entrained during 1980 were also included. All plankton net and sled tow samples were combined. $\bar{X}$ = mean, N = total number of larvae, standard error is given in parentheses.

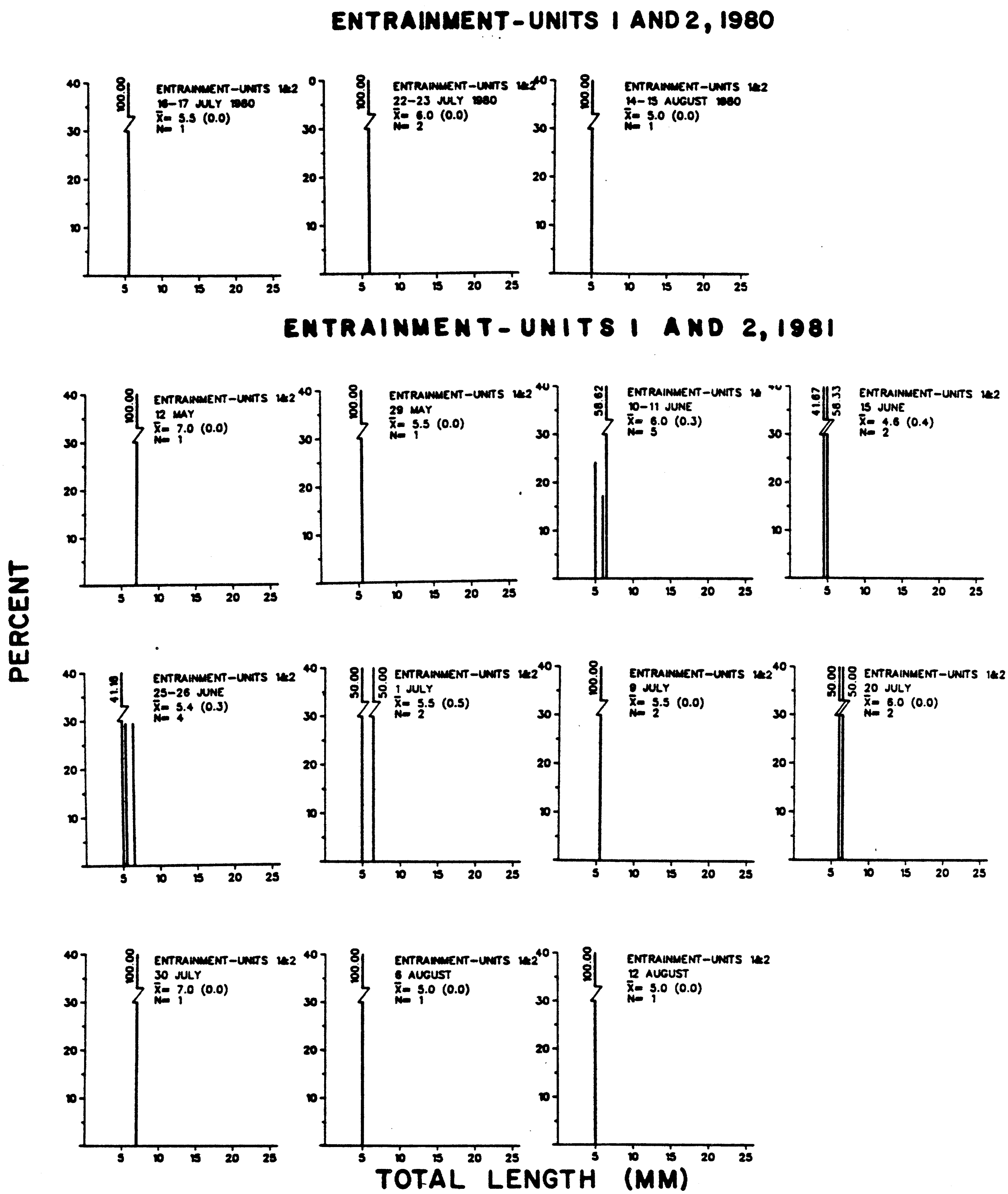


Fig. 40. Continued.

ENTRAINMENT - UNIT 3, 1981

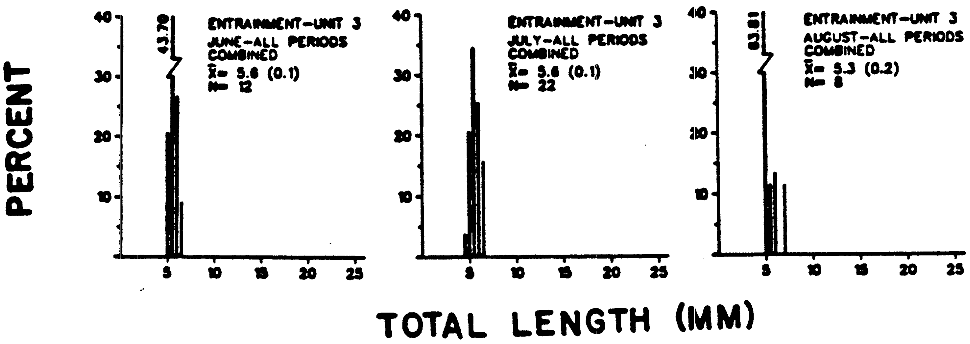


Fig. 40. Continued.

Units 1 and 2 entrainment loss data show an increase in abundance of larval johnny darters over the years 1977-1981 (Jude et al. 1980; Tables 25, 26). Densities in 1981 Units 1 and 2 entrainment samples were 1-13 johnny darter larvae/1000 m^3 (Fig. 41). Larvae were entrained from 12 May to 12 August, and ranged in size from 5.0 to 7.0 mm (Fig. 40). Mean length of larvae did not increase over time, rather, newly hatched larvae were entrained in all months, a pattern not uncommon among entrained larvae we have sampled.

During 1980, Units 1 and 2 entrained an estimated 160,000 johnny darter larvae (Table 25). Larvae were entrained from 22 May to 14 August (Appendix 11). Peak densities occurred in June (23 larvae/1000 m^3 - Fig. 41). Johnny darter larvae entrained during 1980 ranged in size from 5.0 to 9.5 mm. As in 1981, newly hatched larvae were entrained in all months (Fig. 40).

<u>24-h population and entrainment estimates</u>--Comparison of number of entrained johnny darter larvae with the estimated population in the vicinity of the Campbell Plant indicated Unit 3 entrainment will only minimally affect johnny darter populations. Based on night field samples for 15-16 June, an estimated 807,000 johnny darter larvae were in the vicinity of the plant and only 16,200 (2%) were estimated to have been entrained by Unit 3 in that 24-h period. For 1-2 July, 4100 larvae were estimated entrained in 24 h, but none were taken in field samples, possibly because cool water temperatures (9-16 C) during late June depressed spawning. For 6-7 August, the estimated field population was 264,000 and 2940 (1%) were estimated entrained. The estimated population was 13,500 on 17-18 August and none were

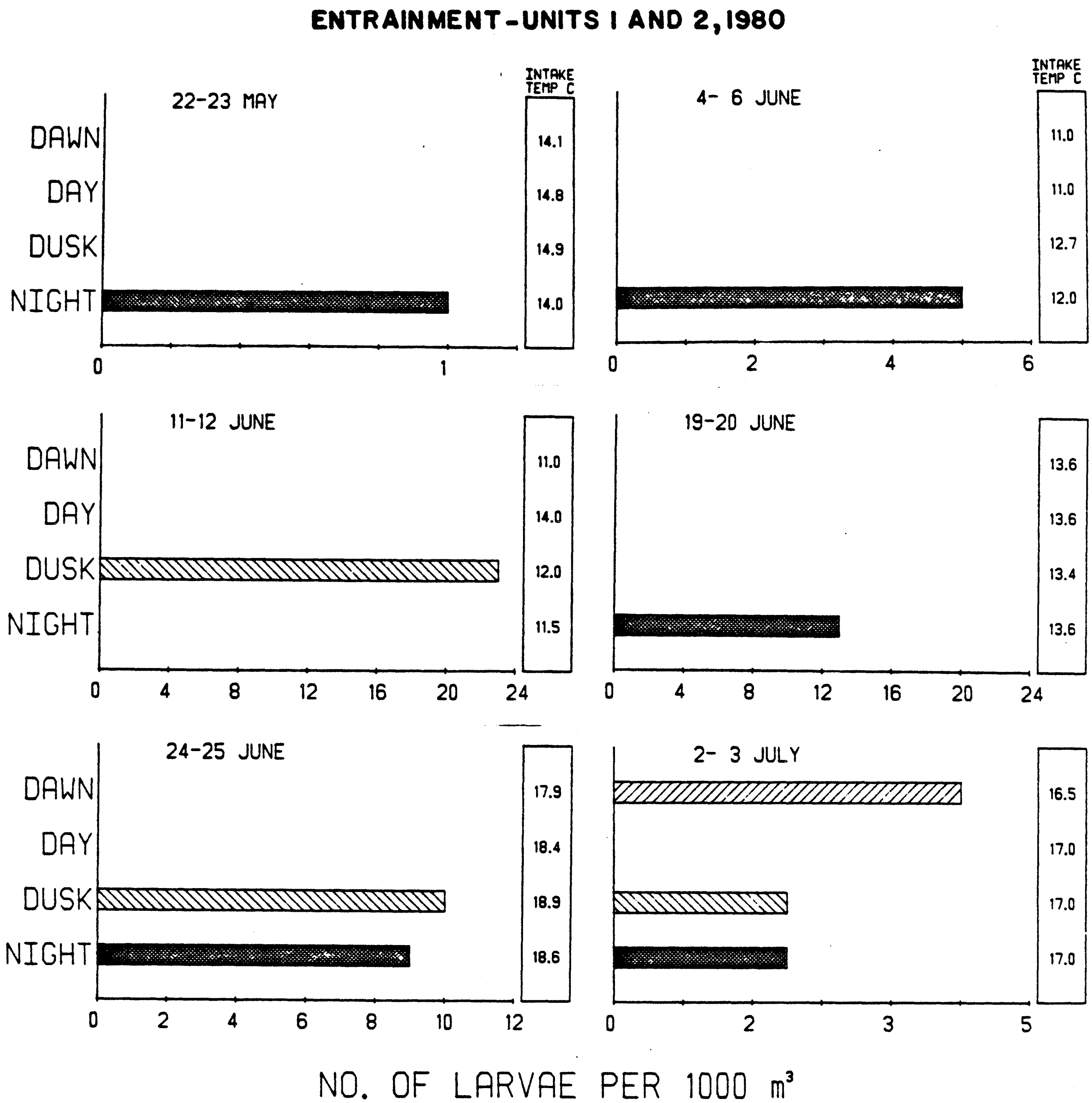


Fig. 41. Density of larval johnny darters (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at the J. H. Campbell Plant's Unit 3, eastern Lake Michigan, 1981.

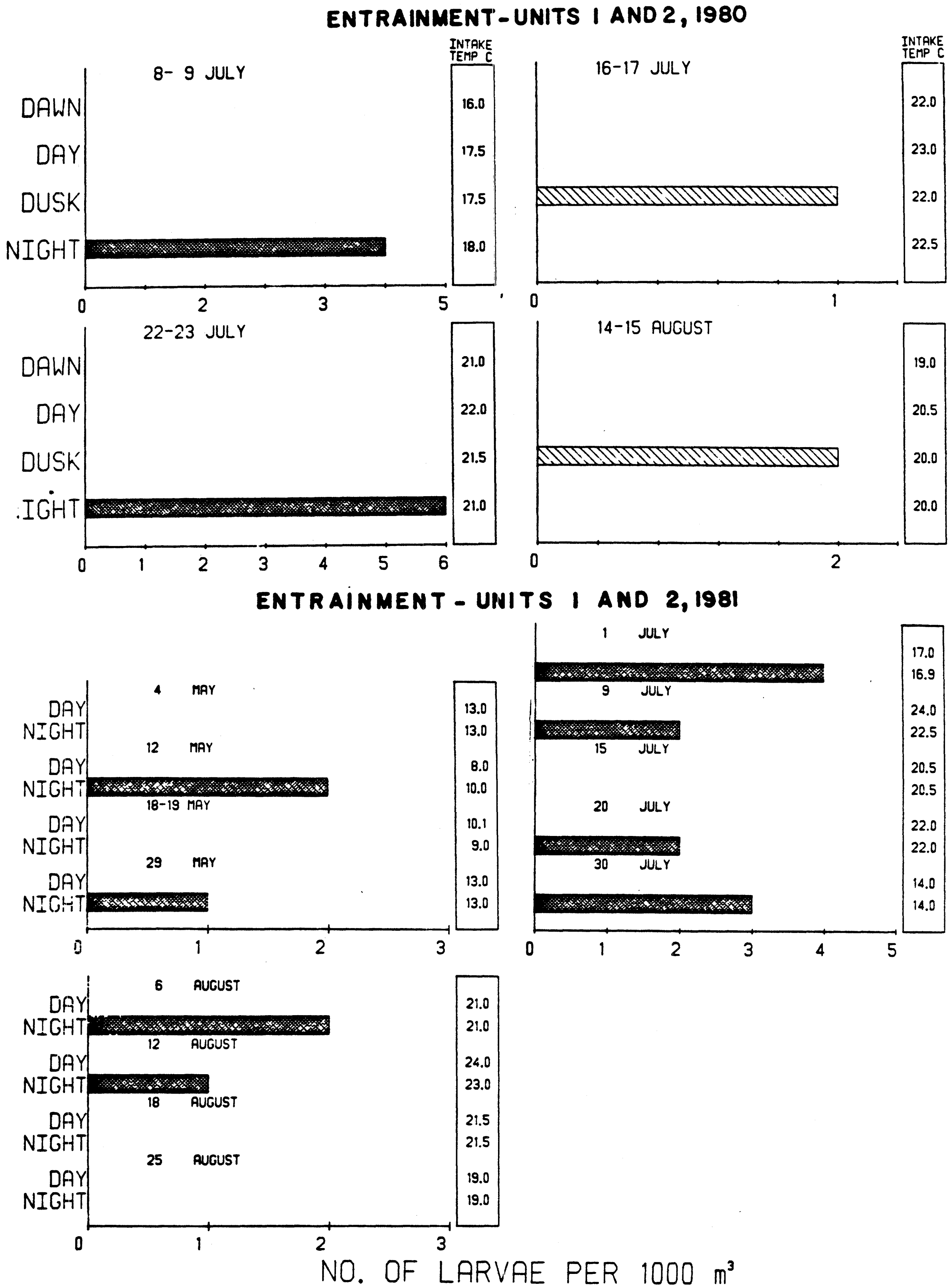


Fig. 41. Continued.

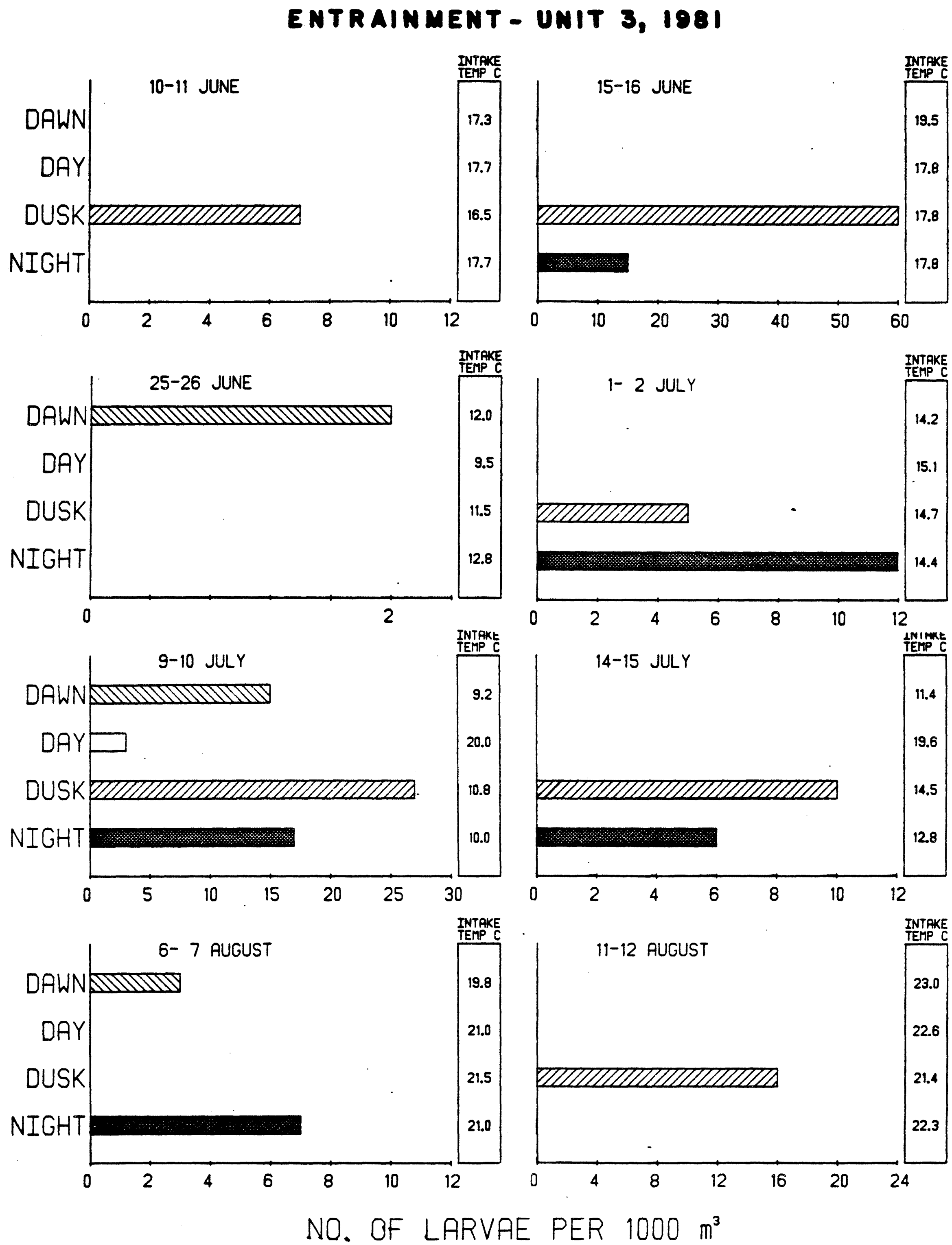


Fig. 41. Continued.

entrained. By late summer, population estimates were undoubtedly low due to growth of larvae and net avoidance; vulnerability to entrainment also decreased substantially.

The increase in abundance of johnny darter larvae from 1977 to 1980 and from 1980 to 1981 is most likely due to utilization of the Campbell Plant riprap for spawning. Scuba observations showed densities as high as 40 adult johnny darters/m² on the riprap (Jude et al. 1981a). Johnny darters prefer to spawn under rocks or other objects (Winn 1958). The riprap also provides foraging habitat. Thus local johnny darter populations may be increasing. However, despite attraction of adult johnny darters to the riprap to spawn, their larvae were not relatively abundant in entrainment samples when compared with other species such as slimy sculpin and ninespine stickleback. The estimated percentage of local Lake Michigan larvae populations entrained by Unit 3 was higher for slimy sculpin and ninespine stickleback (Table 31) than for johnny darter. Perhaps johnny darter larvae are more demersal at early stages, while sculpin and stickleback larvae are more pelagic and hence more susceptible to entrainment. Additionally, johnny darter larvae, due to their large pectoral fins, probably swim better than ninespine stickleback larvae. Thus darters may be able to resist intake currents or may move away from the riprap to forage. In view of the increased spawning habitat and protective cover for adults, johnny darter populations have probably benefited from addition of the riprap habitat more than they have been impacted by entrainment.

Juveniles and Adults--

Only three YOY johnny darters were collected during 1981. These YOY, 15-34 mm TL, were trawled during August and September at stations 6-12 m in depth. Yearling and adult johnny darters could not be distinguished by length. During 1981, as in preoperational years, adult johnny darters moved inshore during late spring and were most abundant at 6- to 9-m stations in summer. Spawning probably took place around these depths. Ripe-running and spent fish were collected May through August, indicating an extended spawning period. More johnny darters were collected in August than any other month. Offshore movement began after August, and more fish were collected at 9- to 12-m stations than 6-m stations during the fall, which was similar to findings in preoperational years. Water temperatures when johnny darters were collected ranged from 4 to 24 C, but most were taken at temperatures below 10 C.

During 1981, 165 males and 128 females were collected. All johnny darters captured were in trawl hauls. None were seined, indicating little use of the beach zone. Most were taken at night. Unlike 1980, catches were similar between transects in

1981. However, scuba observations conducted during 1981 showed johnny darters continued to utilize the Campbell Plant riprap. We believe that johnny darters concentrate on the riprap, and north transect catches have not necessarily reflected this.

White Sucker

Introduction--

During 1981 white sucker was the eighth-most abundant species in our collections, with 466 fish comprising 0.3% of the total catch. Relative importance during 1981 was similar to preoperational years (Jude et al. 1981a). White suckers were the fourth-most abundant species in bottom gill nets, 3.4% of the total catch.

Larvae--

In our study area, white suckers usually spawn during April in streams. Most young stay in streams up to 1 yr, causing larvae to be rare in our samples. During 1981 no sucker larvae were collected in Lake Michigan field samples or Unit 3 entrainment samples. On 27 April 1981, three unidentified catostomid larvae were collected in Units 1 and 2 entrainment samples, resulting in an estimated 17,000 catostomid larvae entrained for the entire year (Table 26). These three larvae were most likely white suckers, the most abundant species of Catostomidae in the study area. Intake water temperature on 27 April was 8.0 C. The larvae were 12.0-19.0 mm TL.

Young-of-the-Year and Yearlings--

Data from Koehler (1978) were used to separate YOY and yearling white suckers. Only one YOY (100 mm in September) was collected in 1981. It was captured by seine, as were YOY during preoperational years. Several juveniles, ranging from 90 mm in June to 250 mm in fall, were probably yearlings. The 90-mm individual was trawled at 3 m, and the rest (200-250 mm) were gillnetted in September and October at depths of 3-9 m. Water temperatures when YOY and yearlings were collected ranged from 6 to 22 C, which were similar to temperatures at which adults were collected. Generally YOY inhabited shallower water than yearlings or adults.

Adults--

Nearly all adult white suckers were collected by bottom gill net. Generally throughout the year, white suckers were more abundant from 1.5 to 6 m than from 9 to 12 m. Most were 370 to

460 mm TL, but white suckers ranged up to 614 mm TL (Appendix 7). More were collected at night than during the day, most markedly at 1.5- to 3-m stations.

During preoperational years, no white suckers were collected in April because they had migrated to streams to spawn. During April 1981, 25 white suckers were collected, 14 of them with spent gonads. Possibly spawning occurred earlier in 1981 than in 1977-1980. From April to July 1981, abundance increased irregularly. Peak catch of white suckers was in August, when 175 were collected at water temperatures from 6 to 13.5 C. During the 5 yr of our study, peak catch of white suckers was always during August or September. August catch varied inversely with water temperature (Jude et al. 1981a). Adults apparently move inshore when water temperatures begin to cool in late summer or fall, or when upwellings occur. Later in the fall, abundance tapered off, probably due to offshore movement.

White suckers with well developed gonads were collected from August to November 1981. More males (233) were collected than females (208). Water temperatures when adult white suckers were captured ranged from 4 to 22 C. Mean lengths tended to be greater at cooler water temperatures.

Preoperational data (1977-1980) showed five times as many white suckers were collected at reference transect station C (6 m, south) as at plant transect station L (6 m, north). During 1981, the trend continued as 108 white suckers were gillnetted at station C and 59 at station D (9 m, south) contrasted to 25 at station L and 17 at station N (9 m, north). Water temperatures were not consistently higher at the north transect. However, at times the south transect was a few degrees cooler, and suckers may have preferred the cooler waters. Construction activity ceased by 1981 and was not a factor in sucker distribution, as it was thought to have been for 1977-1980. At the D. C. Cook Nuclear Plant, as at Campbell, white suckers tended to be more numerous at the reference transect than the plant transect (Great Lakes Research Division, unpublished data).

Lake Trout

Introduction--

Lake trout are naturally occurring and widely distributed throughout northern North America. Southern Lake Michigan marks the southern-most extension of this species' natural range although they have been widely introduced (Scott and Crossman 1973). While anglers have found this species to be abundant in nearshore waters of Lake Michigan during spring and fall, scientific evidence indicates that little or no natural reproduction is occurring. All of the lake trout occurring in Lake Michigan since the late 1960s are believed to have been the result of annual stocking efforts initiated in 1965 because of a population crash during the 1930s and 1940s due to lamprey predation and overfishing.

The occurrence of 61 lake trout larvae in our 1980 samples (Jude et al. 1981a, 1981b) documented the first evidence of successful natural reproduction by lake trout in southern Lake Michigan since stocking began. Fertilized lake trout eggs were found on the riprap covering the intake and discharge pipes during fall 1980; however, no larvae or fry were collected the following spring in 1981. Lake trout eggs were collected from the riprap again in fall 1981 and 1982.

Juveniles--

As in previous sampling years, juvenile lake trout (21 fish, 110-276 mm) occurred sporadically throughout the 1981 sampling season. Greatest numbers were collected in May (seven fish) and June (seven fish) with the remainder in July (five fish) and August (two fish). Unlike adults, juvenile lake trout do not congregate in nearshore areas during the fall, apparently remaining offshore in deeper water during this time.

Adults--

Of the 262 lake trout collected in 1981, 241 (92%) were adults (395-914 mm). Annual catches in preceding years were 201, 258, 222 and 513 in 1977, 1978, 1979 and 1980 respectively, of which 92% of the total were adults (Jude et al. 1981a). All but one of the adult lake trout caught in 1981 were taken by gillnetting, and 90% of all lake trout were collected at night.

Lake trout were collected during all months sampling was performed in 1981, April through December. Furthermore, lake trout have been collected during every month sampling was performed since June 1977 except for December 1978 and July 1980. While greatest numbers of lake trout generally are observed in the fall and to a lesser extent in the spring, large catches have occurred during summer months. For example 54 lake trout were collected in August 1981, 22 in July 1979 and 56 in July 1977. These occurrences have been coincident with either cold water upwelling or intrusion of the thermocline within our sampling area, producing favorable water temperatures for this species.

Congregation of lake trout in the fall around nearshore spawning grounds has produced seasonal high catches in all 5 yr of sampling, including 1981. Greatest monthly catches of lake trout have occurred consistently in October. This is also the month when fish in spawning condition first appear. Substantial differences in abundance of lake trout between transects were not evident in spite of the predicted attraction of lake trout to the riprap adjacent to north transect sampling stations. Catches for stations C (6 m, south), D (9 m, south), L (6 m, north), U (6 m, north) and N (9 m, north) were 28, 4, 43, 19 and 3 for October 1981, respectively, and 3, 0, 5, 1 and 2 for November 1981.

Analysis of lake trout for stomach contents revealed the occurrence of fish in the stomachs of 94% of those examined from spring catches (April and May), 33% from summer catches (June through August) and 4% from fall catches (September through December). Alewives comprised 80% and 68% of the identifiable fish in stomachs of spring- and summer-caught lake trout respectively. Other species found in lake trout stomachs during these periods were smelt and sculpins. Gizzard shad was the only species identified in the stomachs of fall-caught fish. The infrequency of food in stomachs of lake trout collected in the fall is consistent with observations from previous sampling years and appears to be a characteristic of lake trout while in spawning or near spawning condition.

Examination of lake trout for lamprey scars revealed an overall decline in the frequency of attacks from 1977 through 1981. Seventeen percent of 220 fish examined in 1981 had lamprey scars. This value along with the 27%, 36%, 24% and 23% observed in 1977, 1978, 1979 and 1980 respectively substantiates a downward trend (Jude et al. 1978, 1979a, 1980, 1981a). Low lamprey attack activity within our study area is evidenced by the occurrence of fresh lamprey wounds on only 2.5% of the lake trout examined. Equally low occurrences of fresh lamprey wounds were found in previous sampling years.

Longnose Sucker

Introduction--

Longnose sucker was the tenth-most abundant species collected in juvenile and adult fish sampling gear during 1981, comprising 0.1% of the total catch (Table 32). Most longnose suckers were collected by bottom gill net; they were the seventh-most abundant species in that gear and comprised 1.3% of the gill net catch. As with white suckers, longnose suckers spawn in streams in early spring, so we do not often collect their larvae.

Young-of-the-Year and Yearlings--

YOY and yearling longnose suckers were separated using data from Koehler (1978). YOY in our study were collected from July to December 1981. During July and August, YOY were 65 to 124 mm TL (Appendix 7), and 17 were collected in seines and trawls at stations 1-3 m in depth. During September through December, a few YOY were trawled (one was gillnetted) at stations 6-9 m in depth; fish had grown to 135-184 mm TL by this time. These fish were longer than YOY in preoperational years (35-124 mm), probably reflecting an earlier spawning period in 1981.

A few yearling longnose suckers were gillnetted and trawled during 1981 at stations 6-12 m in depth. They were 165-264 mm TL. YOY and yearling fish data for 1981 show longnose suckers inhabiting the nearshore zone during their first summer, then moving to somewhat deeper waters (6-12 m) during the fall and for their second year of life. Preoperational data showed a similar pattern (Jude et al. 1981a).

Adults--

During 1978-1980 longnose suckers were scarce in April samples (1 to 9 fish), most likely because they were in streams to spawn. However, in April 1981, 39 longnose suckers were collected, 37 of them with spent gonads, indicating spawning occurred earlier than usual. White suckers also spawned early in 1981. Generally, adult longnose suckers were most abundant at station C (6 m, south). No seasonal movement patterns were observed during 1981. Water temperatures when longnose suckers were collected ranged from 2 to 24 C, but most were taken at 6-12 C.

Longnose suckers ranged in size up to 594 mm, but most were 400-500 mm. More were collected at night than during the day, especially at shallow stations (1-3 m). More males were collected than females (95 males, 80 females).

Like white suckers, longnose suckers were more abundant at the south transect than the north transect during all 5 yr of our study. During 1981, 53 longnose suckers were gillnetted at station C (6 m, south) and 30 at station D (9 m, south) in contrast to 12 at station L (6 m, north) and 11 at station N (9 m, north). A small, inconsistent water temperature difference between transects may have caused suckers to prefer the reference transect (see RESULTS AND DISCUSSION - White Sucker).

Round Whitefish

During 1981, 134 round whitefish were collected near the Campbell Plant, continuing the increase in abundance documented during preoperational years (Jude et al. 1981a). During 1977 only 8 were collected, while 10 were taken in 1978, 44 in 1979 and 115 in 1980. During each of the preoperational years, several YOY or yearling round whitefish were collected, but 1981 collections included no YOY and only one yearling, which was trawled in May at station C (6 m, south). Round whitefish larvae could not be distinguished from other coregonine larvae (see RESULTS AND DISCUSSION-Unidentified Coregoninae). Round whitefish collected by trawl ranged in size from 135 to 404 mm, while those in bottom gill nets were 195 to 514 mm. Most were collected at night.

As in past years, round whitefish were collected from April to December at all stations where trawling or gillnetting was conducted. Most were collected in the fall, and very few were taken during summer (Appendix 7). There was a tendency for greater abundance at deeper stations. Round whitefish were probably offshore in cool water during summer, and moved inshore to spawn during fall. Water temperatures when adults were captured were 4-22 C, in contrast to 1977-1980 when only immatures were collected at temperatures >16 C. During September 1981, unusually warm water temperatures (20-23 C) occurred during our sampling. Round whitefish adults may have begun to move inshore for spawning despite the warm water. Round whitefish with well developed gonads were found from August to December, most commonly in October. Two spent fish were collected in October, indicating spawning had begun then. By December most had moved offshore. During 1981, 60 males and 59 females were collected. Immature fish and those with only slight gonad development in the fall appeared to move with mature fish.

Round whitefish with identifiable food in their stomachs most often had eaten chironomid larvae. Snails were also frequently found, and a few fish had eaten caddisfly and dipteran larvae and beetles. During August one fish had eaten fish eggs, probably those of alewife or spottail shiner due to the season. During past years a number of round whitefish were found to have consumed lake trout eggs, but during 1981 none were found with salmonid eggs in their stomachs. Lake trout apparently had spawned on the riprap at the Campbell Plant intake in past years (1979-1980), and in 1980 round whitefish were more abundant at the plant transect. Preoperational construction activities increased turbidity (thus decreasing net avoidance) and stirred food organisms into the water column, possibly attracting round whitefish. During 1981, however, abundance of round whitefish was similar between north and south transects. Absence of construction activity and fewer spawning lake trout during fall 1981 may have caused fewer food organisms to be available at the plant transect than in preoperational years.

Slimy Sculpin

Introduction--

Slimy sculpins are bottom-dwelling members of the family Cottidae. In southern Lake Michigan this species has been found to inhabit depths up to 155 m but attain highest densities between 22 and 73 m (Wells 1968). Inshore residence by slimy sculpin is relatively infrequent and appears to be strongly influenced by temperature and spawning habits. Greatest numbers of mature sculpins in the nearshore zone of southeastern Lake Michigan observed by Jude et al. (1979b, 1981a) occurred during April and May. Gonad condition data indicate most of these fish were in spawning condition. Individuals with spent gonads began to appear in May suggesting that this month represents the onset of the spawning period. In New York waters slimy sculpins were reported to begin spawning in spring when water temperatures reached 5 C in Cayuga Lake and 10 C in spring streams (Koster 1936). Water temperatures during our May 1981 collections of mature sculpins ranged from 5.5 to 7.2 C at depth of capture.

Larvae--

Seasonal distribution--Slimy sculpin larvae have occurred sporadically over the 5 yr of sampling in Lake Michigan near the J. H. Campbell Plant. In general, they have occurred with greater frequency and in greater densities in years since deposition of riprap covering the intake pipe (1979-1981) than in years prior (1977-1978) (Jude et al. 1981a). Relatively low densities of larvae overall make transect comparisons difficult; however, in 1981, there appeared to be substantially greater numbers of slimy sculpin larvae at plant transect stations (14) than at our reference stations (3 - Fig. 42). If sampling were to be performed directly over the riprap rather than the plant transect stations, an even greater disparity in larvae abundance would have likely been observed.

Slimy sculpin larvae first appeared in nearshore waters in late spring from May to July. The newly hatched larva is robust, usually 6-6.5 mm in length, with well developed hypurals and pectoral fins (Heufelder and Auer 1980). Laboratory observations and the common occurrence of this species in lotic systems suggest that young larvae possess good swimming ability. Like adults, yolk-sac larvae maintain a demersal existence, remaining close to the protected nest area until the time of complete yolk absorption. Remaining close to a protected area often affords protection from conventional sampling gear and explains the absence of newly hatched larvae in our samples. Once the yolk has been absorbed the larvae appear less restricted to benthic habitats. Slimy sculpin larvae collected during early June 1981 at both plant and reference transects ranged in length from 7 to

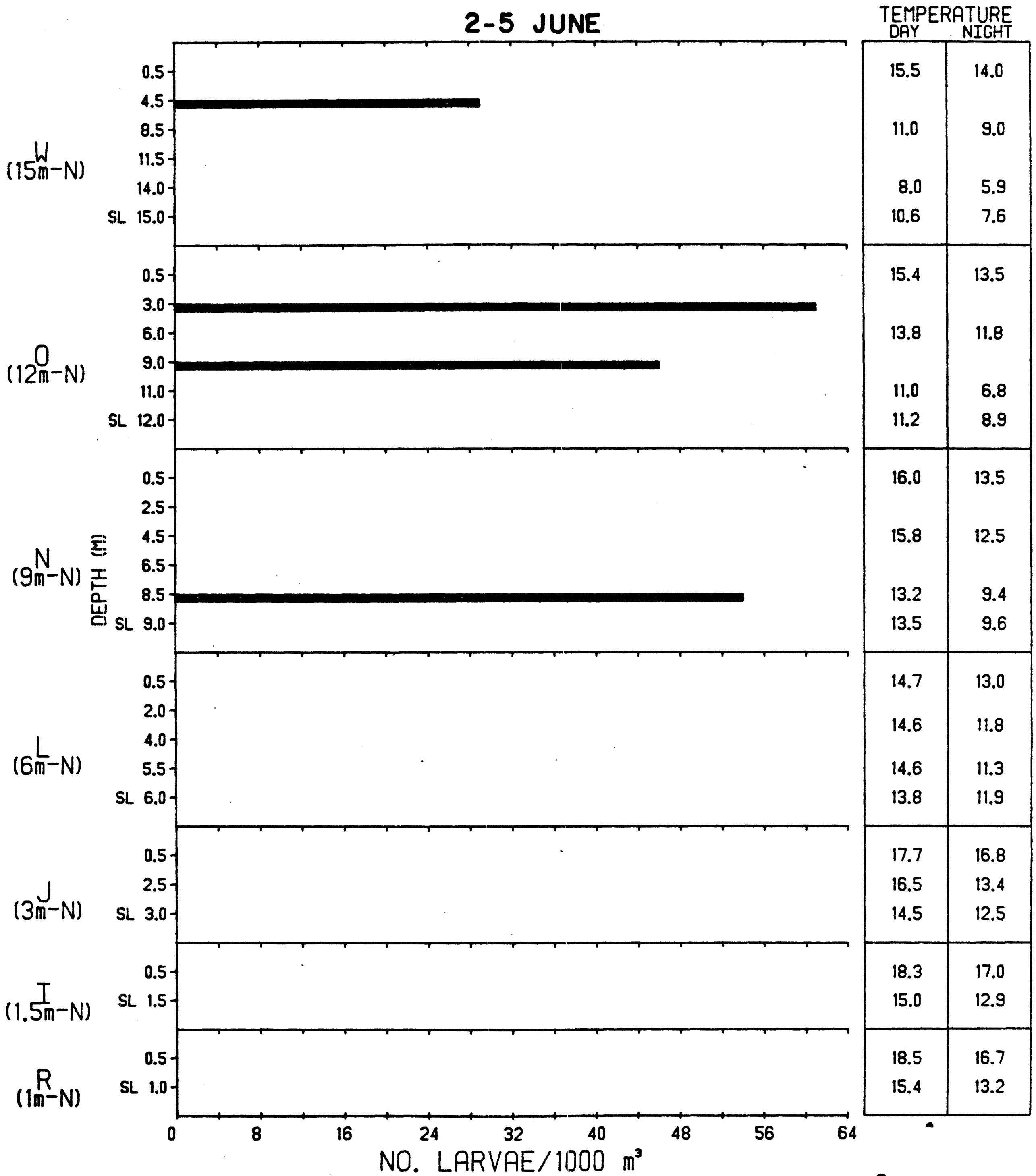
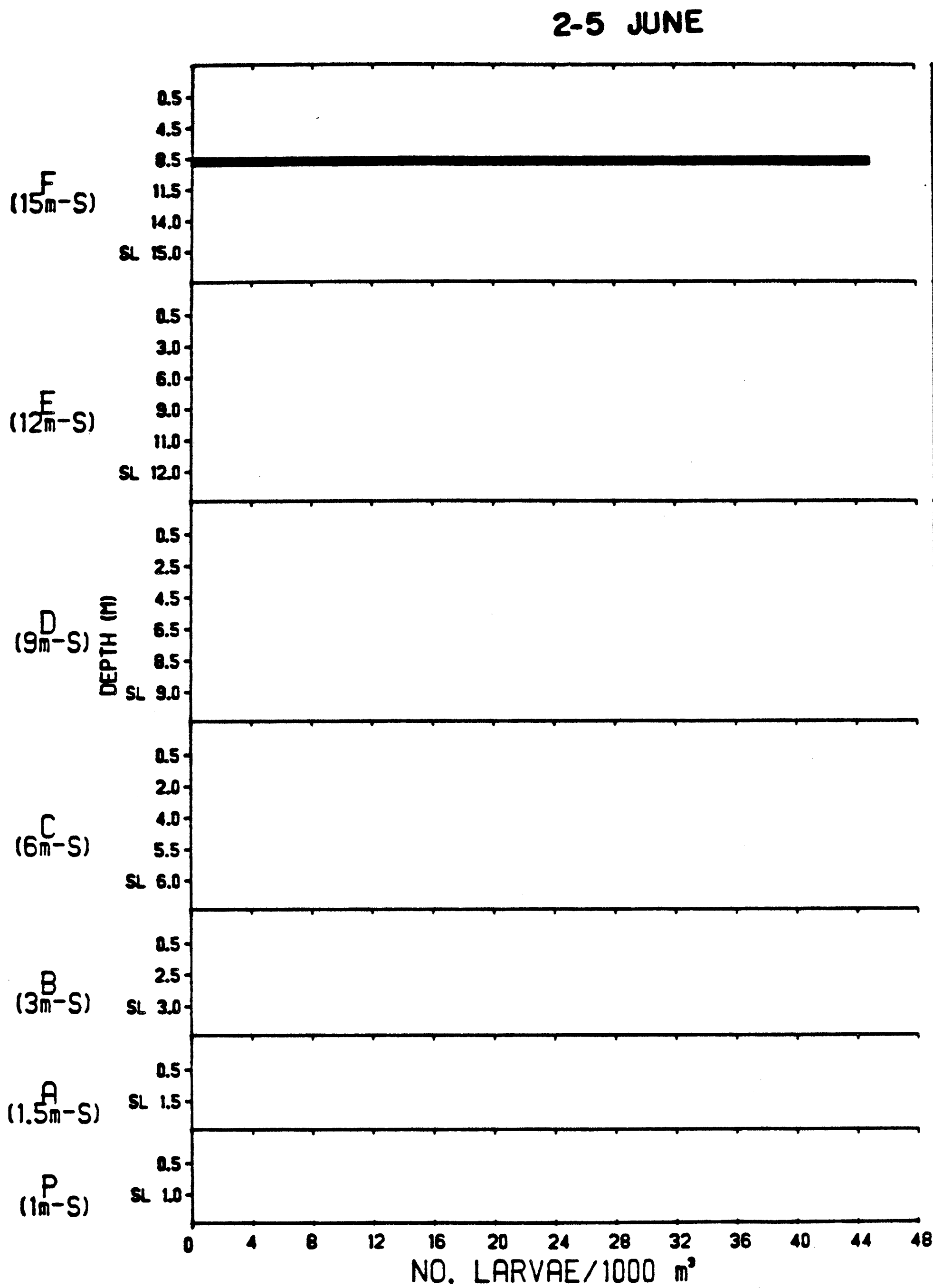


Fig. 42. Density of larval slimy sculpins (no./1000 m^3) at north and south transect stations near the J. H. Campbell Plant, eastern Lake Michigan, June and August 1981. □ = day, ■ = night, SL = sled.



TEMPERATURE DAY	TEMPERATURE NIGHT
15.5	14.0
10.3	7.3
7.5	5.8
9.7	8.2
15.0	14.0
12.0	10.5
11.4	6.9
11.6	10.1
15.2	14.0
12.6	12.1
11.1	9.0
12.2	10.6
14.8	13.5
13.0	11.8
13.0	11.5
14.5	12.2
17.2	16.3
15.7	13.5
14.5	12.2
17.5	16.2
14.7	13.2
19.2	16.6
15.4	13.4

Fig. 42. Continued.

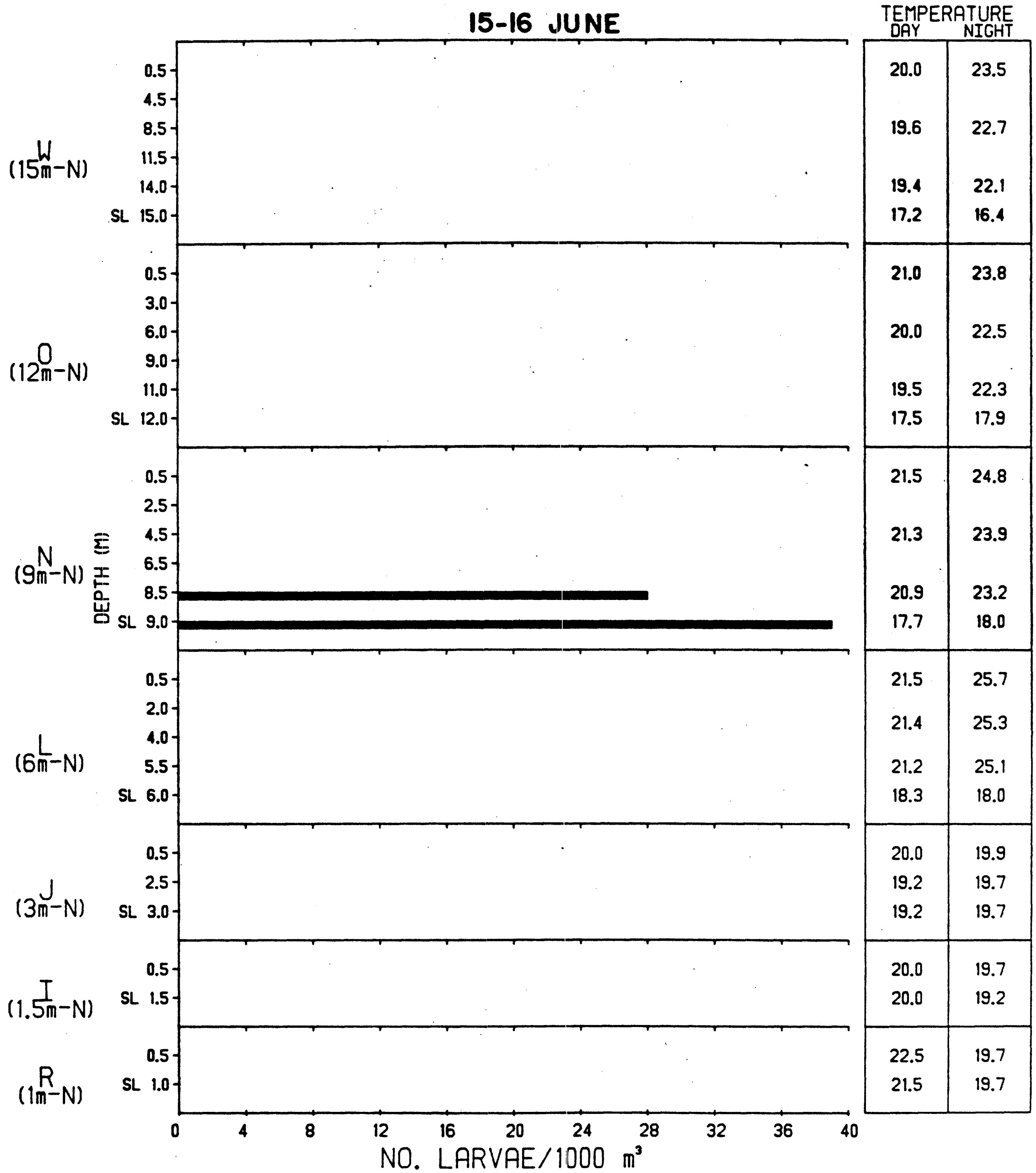


Fig. 42. Continued.

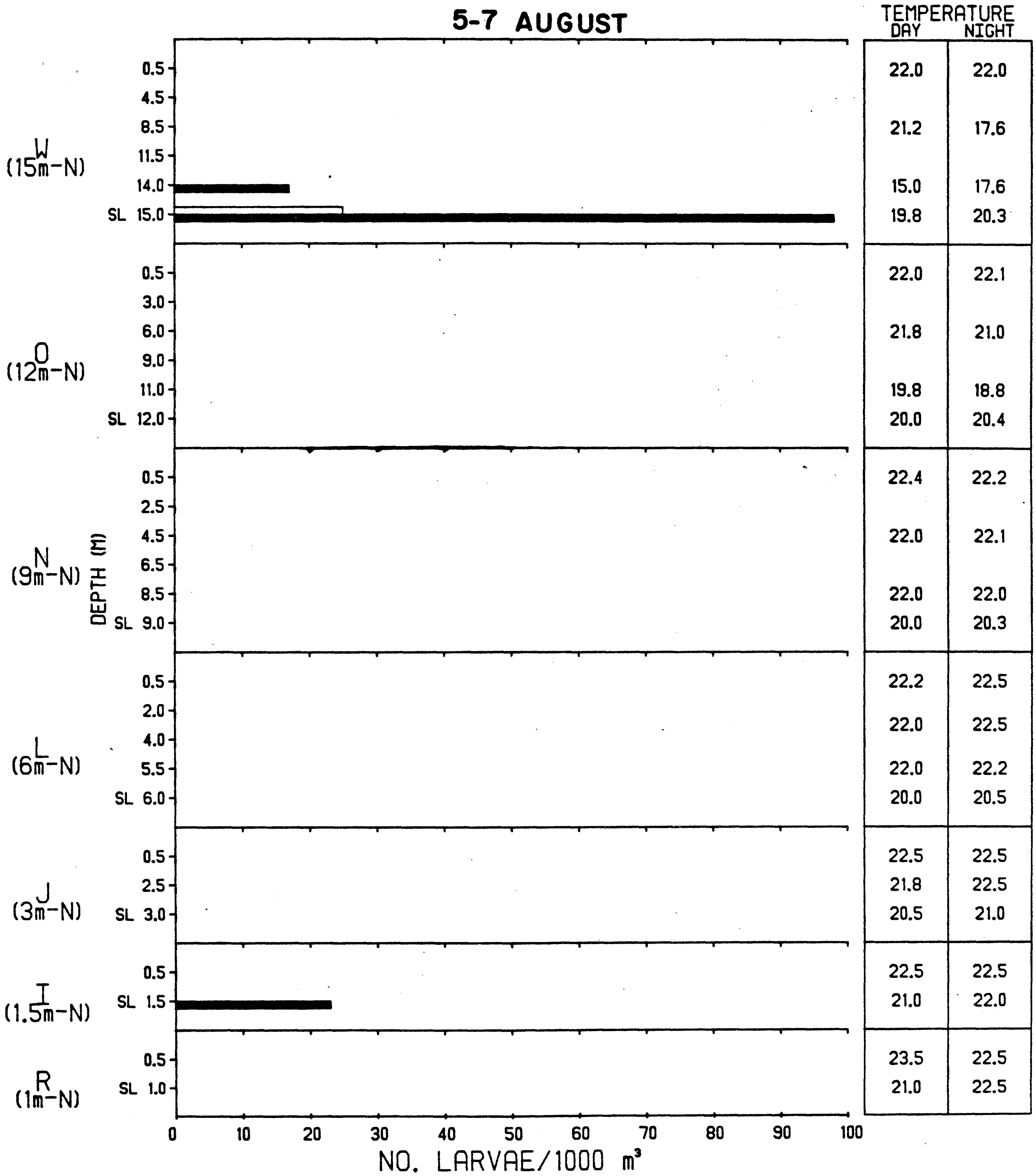
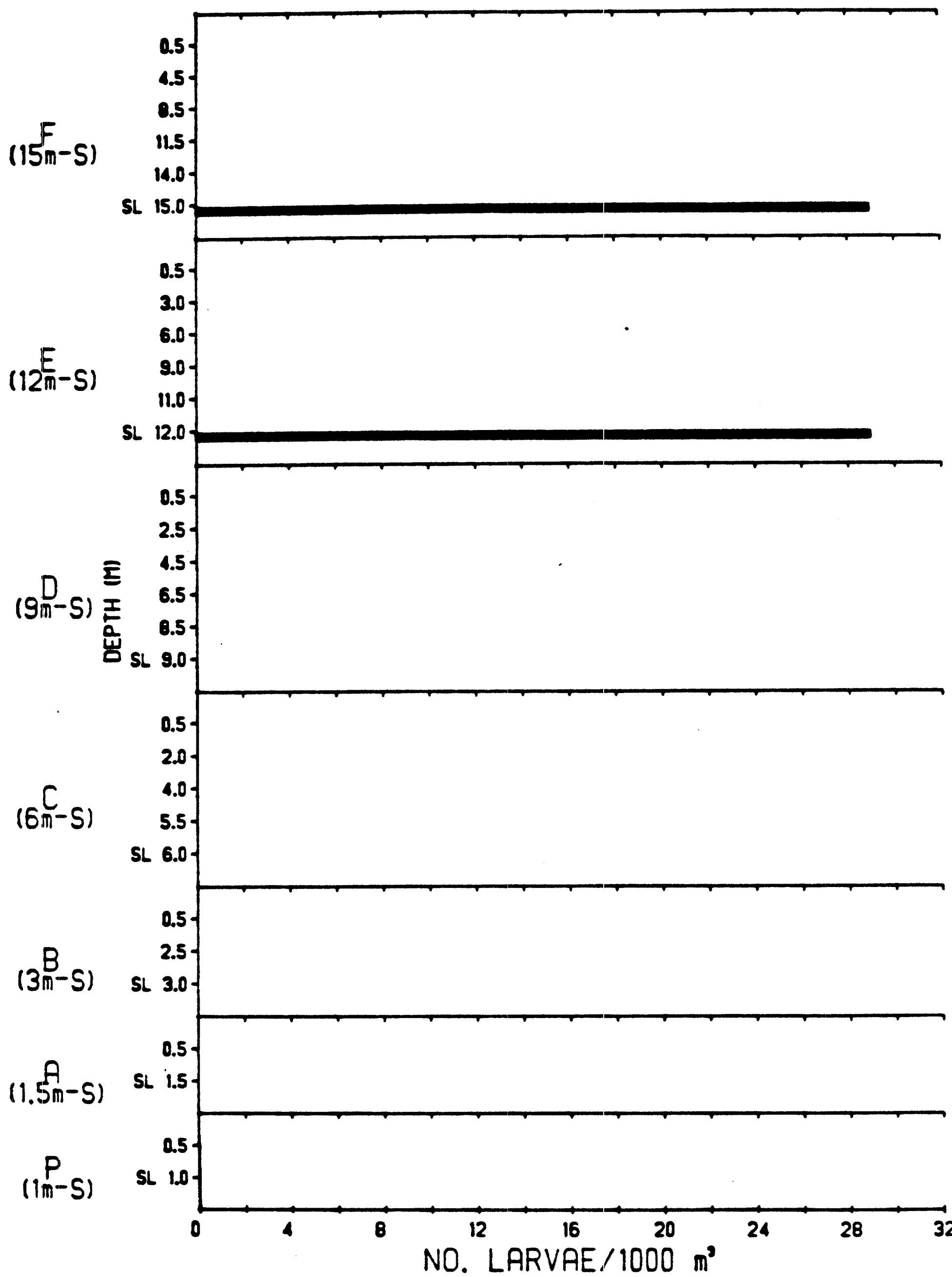


Fig. 42. Continued.

5-7 AUGUST



TEMPERATURE DAY	TEMPERATURE NIGHT
22.0	22.2
21.0	21.5
16.9	17.4
21.4	17.8
22.0	22.2
21.9	21.8
21.9	17.8
21.2	19.0
22.6	22.2
22.3	22.0
22.2	22.0
21.6	20.6
22.6	22.0
22.3	22.0
22.3	22.0
21.6	21.0
22.5	21.3
22.5	20.9
21.9	20.9
23.0	21.3
22.2	21.0
23.0	21.3
22.8	21.3

Fig. 42. Continued.

10 mm and were found at intermediate depths within the water column, which also led to many this size being entrained (Figs. 42, 43). Early-occurring pelagic sculpin larvae were also evident during 1979 and 1980 (Jude et al. 1980, 1981a) in our study area. The vast majority of sculpin larvae were found at depth contours of 9 m or greater which was characteristic of all sampling years when very young larvae were collected (1979-1981). Densities of larvae during this period (no. of larvae/1000 m^3) ranged from 17 to 42 in 1979, 15 to 40 in 1980 and 28 to 61 in 1981. No slimy sculpin larvae were collected in 1978 and the earliest occurring larvae may not have been susceptible to capture in 1977 since our sampling did not begin until late June.

Timing of the first appearance of slimy sculpin larvae in our study area was affected mainly by water temperature. No doubt, onset of spawning activity as well as the incubation period of eggs and subsequent duration of the yolk-sac stage are all temperature mediated. It is interesting to note that water temperatures at time of capture of the earliest occurring larvae were inversely related to the timing of first occurrence such that water temperatures were highest in years when larvae appeared earliest in the season. In 1979 when larvae (9-14 mm) were first collected in early July, water temperatures ranged from 5.7 to 8.0 C. In 1980 water temperatures of 13.8-14.7 C were recorded in late June when larvae (7-9 mm) first appeared. The earliest occurrence of larvae (7-10 mm) in the 5 yr of field sampling was in early June 1981 when water temperatures had reached 13.5 C.

By mid-June 1981 slimy sculpin larvae collected in the study area were 10 to 12 mm in length and appeared to resume a more benthic existence (Figs. 42, 43). Densities of 28 and 39 larvae per 1000 m^3 were estimated at the 8.5- and 9.0-m strata of station N (9 m, north) respectively (Appendix 9). The next and final occurrence of sculpin larvae during 1981 was in August when water temperatures in excess of 20 C were recorded (Fig. 12). Again, larvae were concentrated at or near the bottom (Fig. 42). However, greatest densities were found farther offshore [12-98 larvae/1000 m^3 at station W (15 m, north), 28 larvae/1000 m^3 at both E (12 m, south) and F (15 m, south)] in August than in June. Similarly August marked the final occurrence of larvae in the study area in both 1979 and 1980, and they were generally found at greater depths than in previous months. The absence of larvae following August may be the result of offshore movement or possibly that larvae have grown to a length beyond 24.5 mm when larvae are designated fry (see METHODS - DEFINITION OF TERMS). Lengths of larvae collected in early August ranged from 12.5 to 24 mm suggesting that both explanations may be plausible.

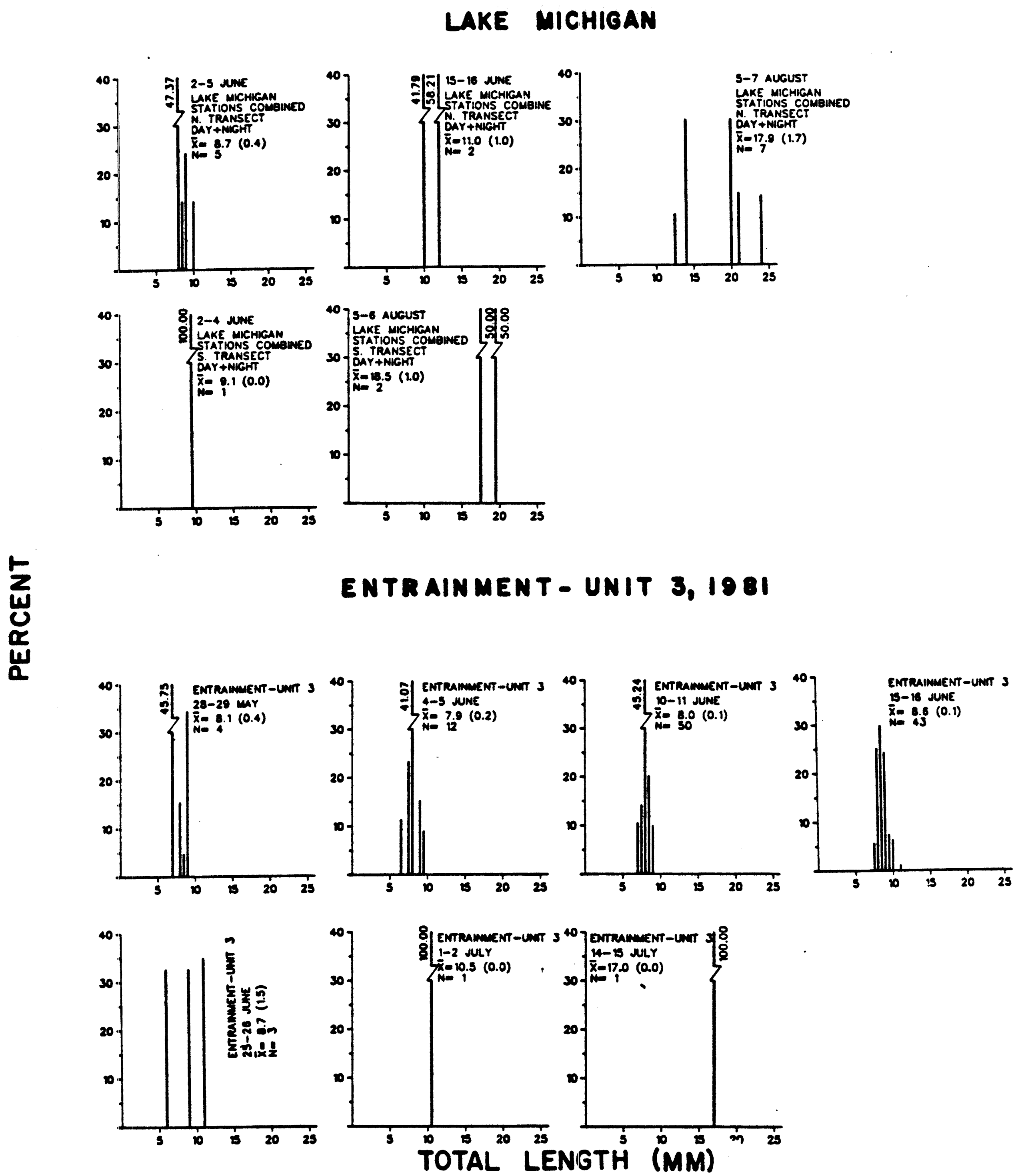


Fig. 43. Length-frequency histograms for larval slimy sculpins observed in field and Unit 3 entrainment samples collected during 1981 near the J. H. Campbell Plant, eastern Lake Michigan. All plankton net and sled tow samples were combined. $\bar{X}$ = mean, N = total number of larvae, standard error is given in parentheses.

During our 5 yr of sampling in the vicinity of the J. H. Campbell Plant 40 fish larvae samples contained slimy sculpin larvae. All but three of those samples were taken at night which suggests either daytime net avoidance or a diurnal association of larvae with protective bottom cover such as riprap, which renders them invulnerable to our sampling gear during the day.

Entrainment--Until operation of Unit 3, slimy sculpin larvae were rarely entrained by the J. H. Campbell Plant. During the first 2 yr of preoperational sampling (1977-1978) no slimy sculpin larvae were collected in entrainment samples for Units 1 and 2 (Jude et al. 1980). In 1979 an estimated 3790 slimy sculpins were entrained based on one occurrence of 2 larvae/1000 m^3 in mid-June. During the first complete year of operation (1981), Unit 3 entrained an estimated 1.24 million slimy sculpin larvae (Table 28). This total was sufficiently high to rank *Cottus cognatus* as the fourth-most abundant species entrained, comprising 12.1% of the total.

As previously mentioned, highest densities of sculpin larvae in field samples were generally found at the 9- to 15-m stations. Given the infrequent occurrence of slimy sculpin larvae in Lake Michigan at stations less than 9 m in depth, it is understandable why few have been entrained by Units 1 and 2 since the inflowing cooling water from Lake Michigan is drawn from approximately the 6-m contour. Location of the Unit 3 intake structures at the 11-m contour places them within the zone of high larval slimy sculpin abundance.

A 9.0-mm slimy sculpin larva was found in a 12 June, 1980 entrainment sample, resulting in an estimated 6,420 larvae entrained by Units 1 and 2 for 1980. An unidentified cottid larva, probably also slimy sculpin, was taken during the same sampling period with an estimated 1,910 entrained during 1980 (Table 25, Appendix 11). No slimy sculpin or unidentified cottid larvae were found in Units 1 and 2 entrainment samples from 1981.

Ninety-six percent of the slimy sculpin larvae entrained by Unit 3 in 1981 were less than 10 mm TL; entrainment occurred primarily in June. First occurring in the last week of May, sculpin larvae were entrained with increasing frequency during the first 2 wk of June. Seasonal peak densities were attained during the third week of June with 202 and 147 larvae per 1000 m^3 for dusk and night diel periods respectively (Fig. 44). Length-frequency histograms (Fig. 43) indicate a slight increase in the mean length of larvae over this period from 7.9 to 8.6 mm. Densities declined sharply at the end of June (10 larvae/1000 m^3) and early July (12 larvae/1000 m^3). These larvae ranged in length from 6.5 to 10.5 mm indicating the presence of recently hatched larvae and an extension of the spawning season beyond that inferred from field larvae data. The last occurrence of entrained slimy sculpin larvae was in mid-July when a 16.5-m individual was captured at night at a density of 12 larvae/1000 m^3.

Coincident mid-water occurrence of 7- to 10-mm slimy sculpin larvae at 9-15-m stations during early June with high entrainment densities during that period suggests that location of the intake risers within the water column (1 to 3 m above the bottom) makes them ideally located for entraining larvae in this size range. Larvae of this size, at or near the point of complete yolk absorption, appear less benthic than newly hatched (6-6.5 m) or larger larvae (>10 mm). These vertically migrating larvae may be attracted to the structures as cover, to protect them from potential predation by fish such as alewives and juvenile yellow perch. The reasons why larval sculpins, which lack a swim bladder and sensitive buoyancy control, leave the protective cover of bottom substrate for a mid-water existence are poorly understood but may very likely be related to feeding activity. Periphytic growth observed on the intake screens and possible high concentrations of potential food items may further serve to attract slimy sculpin larvae. Considering the relatively low through-screen velocity of the inflowing cooling water it seems likely that larval sculpins possessing good swimming ability could be actively moving in and out of the screens over the course of time during foraging and escape activity.

Larval slimy sculpins were rarely entrained during the day (Fig. 44). Highest entrainment densities were attained at dusk and night diel periods with frequent occurrences at dawn. The near absence of day-entrained larvae reinforces the contention that larval slimy sculpins are exhibiting a diel activity pattern. Unlike field larvae observations, net avoidance would not be a plausible explanation for infrequent daytime occurrence if larvae are assumed to be swimming freely in and out of the intake screens.

<u>24-h population and entrainment estimates</u>-- Projected estimates of total numbers of slimy sculpin larvae passing by the intake screen over a 24-h period vs. numbers of larvae entrained over the same periods (Table 31) indicate an overwhelming effect of Unit 3, which entrained 212% of the standing crop of slimy sculpin larvae during times of peak abundance (15-16 June). However, for this species, these data may be misleading. Population values based on north transect field larvae densities probably grossly underestimate the number of larvae that are actually present in the vicinity of the intake structure. Highest densities of slimy sculpin larvae probably occur in the immediate vicinity of the riprap given the relatively high entrainment densities and association of spawners and larvae with bottom structures, such as rocks and debris. North transect sampling stations appear sufficiently distant from the riprap to

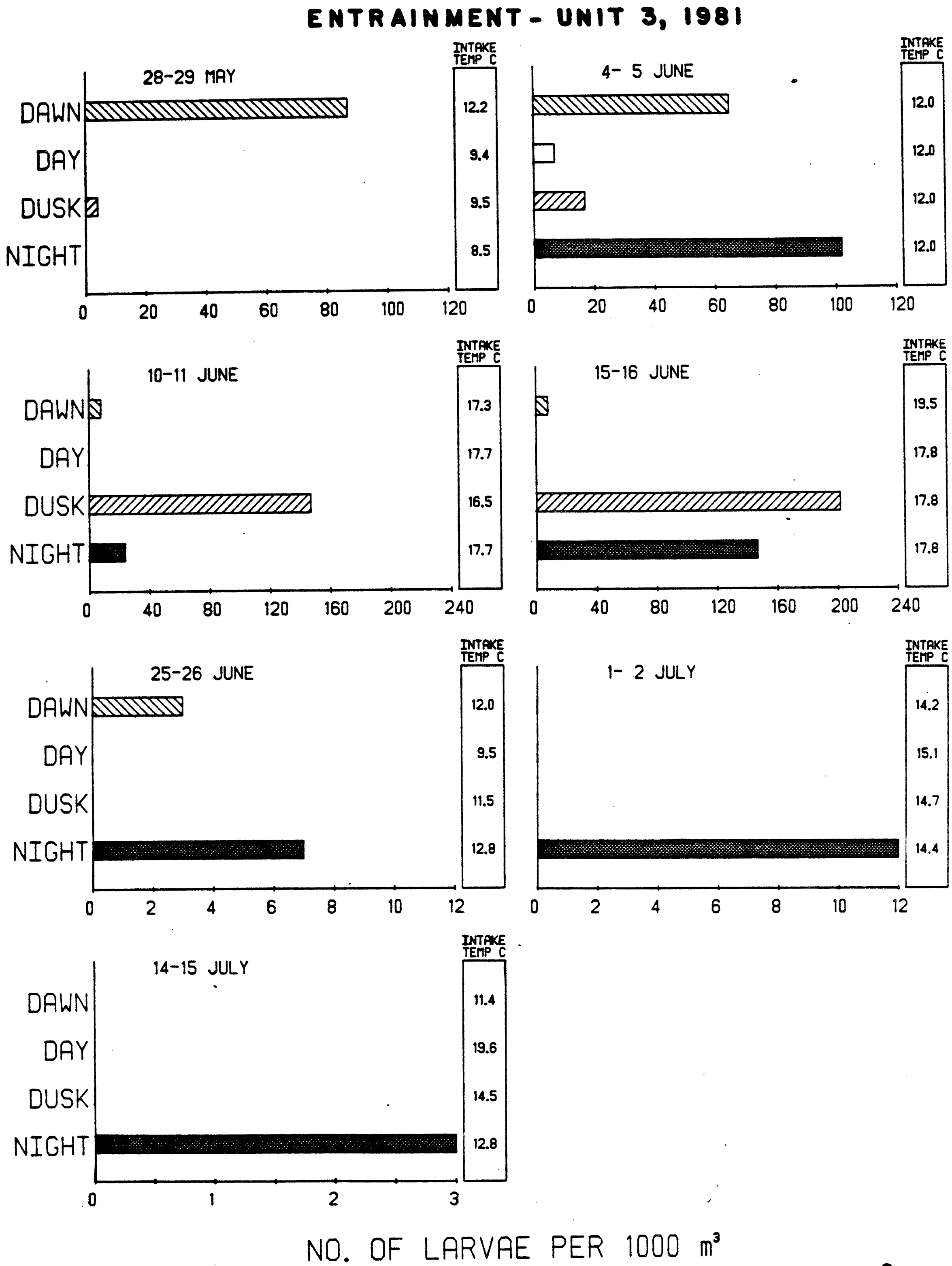


Fig. 44. Density of larval slimy sculpins (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at the J. H. Campbell Plant's Unit 3, eastern Lake Michigan, 1981.

be strongly influenced by high densities most likely occurring there. No sampling for field larvae was performed directly over the riprap at contours of 9 m or greater.

The potential for entrainment of slimy sculpin larvae in future years will likely be a function of the nature and rate at which the Campbell riprap is colonized. Similar studies of riprap colonization associated with offshore water intakes at the D. C. Cook Nuclear Power Plant, southeastern Lake Michigan (1973-1979) have indicated a rapid increase in abundance of certain reef colonizers on newly laid riprap followed by several years of gradual decline and eventual stabilization of population densities (J. Dorr, unpublished data, Univ. of Mich., Great Lakes Research Division, Ann Arbor, Mich.). Early macroinvertebrate colonizers such as crayfish and snails appeared to reach peak densities within 1 yr of reef implantation. Snail abundance, however, dropped off sharply the next year, further declining the following year to an eventual level of stabilization; whereas, crayfish declined in abundance more gradually over a 4-yr period from nearly 1000 observed to less than 100. Vertebrate colonizers such as johnny darters and sculpins responded less rapidly to the presence of new structure with greatest numbers occurring 1 to 2 yr after deposition of the riprap. Johnny darter abundance decreased abruptly over the following 2 yr and appeared to taper off a year or two later. Numbers of sculpins also declined sharply in the year following peak abundance but appeared to reach a level of stabilization the following year. As observed at the J. H. Campbell Plant, greatest numbers of sculpins occurred during the spawning season, in April and May, suggesting that similar trends in abundance of sculpin larvae from year to year may be expected.

Processes similar to those at Cook are undoubtedly occurring on the Campbell reef; however, the greater depth at which it is located may cause it to age more slowly. If so, then 1981 entrainment densities of slimy sculpin larvae, occurring 2 yr after completion of the Campbell intake structures and final deposition of riprap, are most likely well below densities expected to occur over the next few years. The rate of riprap colonization will determine the time at which maximum densities are reached. A period of diminishing abundance of adult and larval slimy sculpins would follow in ensuing years leading eventually (3-6 yr) to stable levels most likely less than or equal to 1981 levels.

The average size of riprap boulders is larger for the Campbell reef than for Cook. Thus, interstitial spaces are larger, and the Campbell riprap may not be as good cover for organisms such as crayfish and sculpins as the Cook riprap. Possibly sculpin populations will not become as dense at Campbell as at Cook.

Adults--

Over the 5 yr of sampling near the J. H. Campbell Plant we observed greatest abundances of slimy sculpins in the early spring and late fall. Of the 134 sculpins collected in 1981, 79 occurred in April and May, 49 in December and the remaining 6 occurred from June through October (Appendix 7). Ninety-three percent of the sculpins sampled were collected at night, with seventy-four percent occurring at deeper stations (9-15 m). Differences in abundance between north (plant) and south (reference) stations were slight (48 at south transect stations C, 6 m, and D, 9 m, and 43 at north transect stations L, 6 m, and N, 9 m). However, diver observations combined with a general knowledge of the association of sculpins with bottom structures such as rocks and debris suggested that numbers of sculpins inhabiting the riprap greatly exceeded those on the adjacent sand substrate where our north plant transect stations are located. Therefore, it is expected that there is a greater abundance of slimy sculpins in the plant-influenced area (including the riprap) than in the reference area, 4.8 km south of the plant.

The occurrence of slimy sculpins in nearshore areas in the spring most likely represents a small percentage of the overall spawning population in the region. Data of Wells (1968) suggest most spawning occurs between 31 m and 73 m. Known to deposit egg masses on the undersides of rocks and large pieces of debris (Koster 1936), slimy sculpins on the nearshore fringe of the population would likely be attracted to riprap covering the intake and discharge pipes. Diver observations verified this contention with the collection of an egg mass on 18 June 1980 (water temperature 10 C) which was attached to a small piece of riprap, 2-5 cm in diameter (Jude et al. 1981a). A similar occurrence was reported by Jude et al. (1979b) when a slimy sculpin egg mass was collected from the riprap covering the offshore intake structure at the D. C. Cook Nuclear Power Plant, southeastern Lake Michigan.

The low numbers of slimy sculpins occurring in our study area during summer months, and their recurrence in December, were most likely due to the suitability of inshore water temperatures. Laboratory studies suggest the preferred temperature for this species ranges from 9 to 12 C depending upon acclimation temperature (Otto and Rice 1977). However, field observations of Rottiers (1965) indicate a preferred water temperature of 6 C and Wells (1968) reported that this species was most frequently collected at temperatures of 4-5 C.

Gizzard Shad

Introduction--

Gizzard shad spawning takes place from April to July (Bodola 1966; Smith 1979) in sloughs, ponds, lakes or large rivers (Miller 1960). Near the Campbell Plant there was apparently no gizzard shad spawning activity in Lake Michigan, Pigeon Lake or Pigeon River. Data collected during 1977-1980 suggested gizzard shad spawn in the discharge canal; spawning probably also occurs in the Grand River (Jude et al. 1979a).

Larvae--

Seasonal distribution--During 1977-1980 larval gizzard shad occurred in the study area from May to July in densities up to 175 larvae/1000 m^3. During 1981 gizzard shad larvae were relatively scarce, being caught only during June at 6, 9 and 12 m (north) and at 15 m (south). Densities ranged from 27 to 56 larvae/1000 m^3 (Appendixes 9 and 10). All gizzard shad larvae from the plant transect were recently hatched (2.5 to 3.5 mm); whereas, a single larva captured at the reference transect measured 6.5 mm. These larvae may have been carried by currents from the discharge canal or from the Grand River.

Entrainment--

Units 1 and 2, 1980 and 1981--Gizzard shad larvae were entrained at low densities (2-8 fish/1000 m^3) during late May and early June 1980 (Appendix 11). From these densities, 27,700 larvae were estimated to have been entrained (Table 27). No gizzard shad were found in Units 1 and 2 entrainment samples in 1981.

Unit 3--At Unit 3 intakes, gizzard shad were entrained during 20-21 July and 6-7 August at a mean density of approximately 1 larva/1000 m^3 (Appendix 14). Entrained gizzard shad larvae (3 and 4 mm) were approximately the same size range as those collected in Lake Michigan during June and probably had similar origins (i.e., the discharge canal or the Grand River).

Young-of-the-Year, Yearlings, and Adults--

Gizzard shad were caught during 1981 in numbers, patterns, and at temperatures similar to other years. YOY were present in our sampling area from August through October (Appendix 7), and were collected in small numbers (1-24 fish), mostly in seine and trawl hauls.

Yearling (~50-130 mm) and adult (~140-690 mm) gizzard shad were collected from April through November, generally at temperatures exceeding 10 C. Monthly catches ranged from 1 fish in April to 34 fish in September (Appendix 7). Most yearling and adult gizzard shad were captured in gill nets at depths of 6 m or less. Of the few adult shad collected with well developed gonads, two were caught in May and four were caught in June. None of the shad that we captured during 1981 had spent gonads, again indicating that adult gizzard shad do not spawn in Lake Michigan in the vicinity of the Campbell Plant.

Chinook Salmon

In general, chinook salmon catch in 1981 (76 fish) was typical of catches during the past 2 sampling years. Catches at north and south transects were similar.

Chinook smolts (~70-180 mm) were collected in May (1 fish), June (27 fish), July (4 fish) and August (6 fish) (Appendix 7). Smolts were found most often at water temperatures of about 19 C, and were most susceptible to capture in seine and trawl hauls. Jack (~200-400 mm) and adult (~430-940 mm) chinook salmon were caught sporadically from April to November at temperatures ranging from 7 to 21 C. All jacks and adults were captured in gill nets, and 87% were caught at night. Adults with well developed gonads were present in our sampling area during August and September.

Stomach contents of immature chinook included terrestrial insects, amphipods and a small alewife. Diet of adult salmon consisted mostly of alewives (75-200 mm), but smelt and unidentified (partially digested) fish were also found in adult chinook stomachs.

Coho Salmon

Sixty coho salmon were collected during 1981. From 1977 to 1980, 18 to 75 coho were sampled.

Catch in 1981 included 32 coho smolts (~130-170 mm), all of which were seined in May (Appendix 7). The beach zone apparently was preferred because of food availability. Smolt stomachs contained a variety of terrestrial insects and some small fish (alewife and smelt). Smolts occupied water temperatures between 9 and 13 C, and most (91%) were caught at night.

Adult coho (~400-640 mm) were captured sporadically throughout our sampling season; highest catches occurred in April (7 fish), May (13 fish), and November (5 fish). Adults were caught in both surface and bottom gill nets, mostly at night (Appendix 7). Large coho appeared to prefer cool water temperatures (7-11 C). Coho were found with both adult and YOY alewives in their stomachs.

Only two adults, one of each sex, contained well developed gonads. Both fish were caught in September.

Brown Trout

Brown trout catch in 1981 was concentrated (78%) during April and May, but a few fish were caught in other months through November. Most browns (93%) were caught in water $\leq$ 6 m. In total, 2 juveniles (~110-160 mm) and 44 adults (~260-720 mm) were caught in approximately equal numbers during day and night sampling (Appendix 7). During other sampling years, from 49 to 114 brown trout were collected (Jude et al. 1981a).

Predominance of brown trout in the spring was probably related to water temperature and food availability. Brown trout were caught mostly at water temperatures between 7 and 11 C, although a few individuals were caught at higher temperatures up to 21 C. Brown trout were voracious piscivores, foraging mostly on alewives. Sculpins and smelt were occasionally consumed. One 685-mm female had 19 alewives, from 60 to 140 mm in length, and 5 other unidentified (half-digested) fish in its gut. Many other brown trout contained from 5 to 15 fish in their stomachs.

Brown trout spawning occurs during fall in Lake Michigan near the Campbell Plant (Jude et al. 1981a). A few browns collected in 1981 had well developed gonads in September.

Emerald Shiner

Introduction--

The emerald shiner is a pelagic species characterized by extreme fluctuations in abundance (Scott and Crossman 1973). In Lake Michigan emerald shiner populations have declined drastically since the 1950s, coincident with the increase in alewife populations (Wells and McLain 1972). During 1981, we collected 32 emerald shiners, down from 247 in 1980. However, our catches during 1977-1979 ranged from 1 to 50 emerald shiners. Our catch is unpredictable due to schooling behavior and movements and may or may not reflect population levels. Emerald shiners in the vicinity of the Campbell Plant spawn during June and July, probably in Pigeon Lake (Jude et al. 1981a). Adults move offshore after spawning, return to the beach zone of Lake Michigan in autumn, then overwinter offshore.

Larvae--

During 1977-1980, newly hatched emerald shiner larvae were collected most frequently at relatively shallow north transect stations (1-9 m); highest densities were at beach stations. Older larvae and juveniles were sometimes collected out to 15-m stations.

In 1981 emerald shiner larvae were collected in field samples only at beach station R (north discharge) in early July. Density was 132 larvae/1000 m^3. Emerald shiner larvae were rare in 1981 compared with 1979 and 1980, although they were never abundant during preoperational years. Changes in abundance of larvae in our samples were probably due to patchy distribution and natural population fluctuations. No emerald shiner larvae were collected in Unit 3 entrainment samples.

Emerald shiner larvae were found in 1981 Units 1 and 2 entrainment samples only on 1 July, at a density of only 4 larvae/1000 m^3. During 1980, emerald shiner larvae were found in entrainment samples on 12 June, 17 July and 15 August, at densities of 2-3 larvae/1000 m^3. An estimated 15,400 emerald shiner larvae were entrained by Units 1 and 2 during 1981, compared with none in 1977, 9830 in 1978, 321,000 in 1979 and 13,200 in 1980 (Jude et al. 1980; Tables 25, 26). Difficulty in identifying emerald shiner larvae may cause these estimates to be low, as some emerald shiner larvae may have been called spottail shiners.

Juveniles and Adults--

Age-groups of emerald shiners were separated using data from Flittner (1964), Fuchs (1967) and our study (Jude et al. 1981a). As in preoperational years, emerald shiner YOY, yearlings and adults were collected only by seine, mostly at plant transect beach station R. Eighteen emerald shiners (which were probably YOY), ranging in length from approximately 25 to 44 mm, were seined during September and October. Two YOY, 25.5 and 34.0 mm TL, were found in Units 1 and 2 entrainment samples during October and November. The rest of our 1981 catch may have been yearlings. Two fish collected in April were 25-54 mm TL. Yearling or adult emerald shiners collected from August to October were 45-84 mm TL, and all had either immature or only slightly developed gonads. During 1977-1980, we collected emerald shiners up to 104 mm TL.

Water temperatures when emerald shiners were collected during 1981 were 8-22 C. As during preoperational years, emerald shiner abundance appeared to be related more to season than to water temperature. Although catch fluctuated considerably over the 5 yr, a pattern was discernible: occasionally yearlings were taken during spring, and YOY, yearlings and adults were taken during late summer and fall. The pelagic habit, schooling behavior and inshore-offshore movements of emerald shiners are probably responsible for yearly fluctuations in catch and zero catch in Lake Michigan during summer. When emerald shiners are offshore, they are in the upper water column so our bottom trawl would not capture them. Successful spawning probably takes place in Pigeon Lake and other inland waters (Jude et al. 1981a).

Ninespine Stickleback

Introduction--

The ninespine stickleback is common in the Great Lakes basin (Scott and Crossman 1973), but is not as abundant in southeastern Lake Michigan as it is farther north (Wells 1968). Adults overwinter in deep water and usually move inshore in May, then spawn from June through August (Jude et al. 1981a).

During 1977-1980, ninespine sticklebacks comprised 0.1-0.5% of our catches. From 133 to 414 were collected each year (Jude et al. 1981a). However, in 1981 only 32 ninespine sticklebacks were collected, comprising only 0.02% of the total catch. During 1981, spawning of sticklebacks appeared to be earlier than usual, and offshore movement may have decreased catches. Slimy sculpins, which prefer rocky areas as sticklebacks are believed to, were slightly less numerous in our 1981 catches (134) than in 1980 catches (163). Low catches of sticklebacks may have been caused by riprap which attracted them to such an extent that few were captured at north transect sampling stations.

Larvae--

Seasonal distribution--During our preoperational study, spawning took place in 12- to 15-m water (probably also deeper) as newly hatched larvae were only collected at these depths. Older larvae and fry were collected at all depths sampled (1-15 m), indicating dispersal after leaving nests. Both larvae and adults appeared to prefer bottom strata. Ninespine stickleback larvae increased in abundance near the J. H. Campbell Plant during preoperational years (Jude et al. 1981a), but decreased in 1981. Apparently spawning sticklebacks were attracted to the riprap which was deposited from 1978 to 1980. In 1981, only three stickleback larvae were collected in field samples, in mid-June at stations L (6 m, north) and C (6 m, south) and in early August at station A (1.5 m, south). These larvae were not newly hatched, and the ones collected at the reference transect were larger (12-17.5 mm TL) than the larva at the plant transect (8 mm).

Entrainment--In 1981 ninespine stickleback larvae were entrained from 15 June through 17 August. Densities were lower, 3-12 larvae/1000 m^3, than field densities of 28-40/1000 m^3. Larvae entrained were 7-15 mm TL, not newly hatched (Fig. 45).

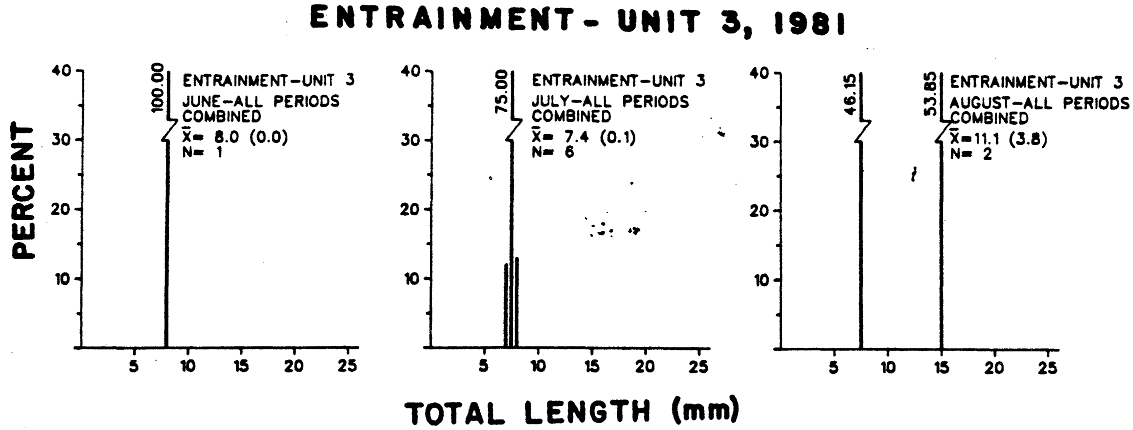


Fig. 45. Length-frequency histograms for larval ninespine sticklebacks observed in Unit 3 entrainment samples collected during 1981 near the J. H. Campbell Plant, eastern Lake Michigan. X̄ = mean, N = total number of larvae, standard error is given in parentheses.

Extrapolating 1981 entrainment sampling data for the entire year showed an estimated 68,000 ninespine stickleback larvae were entrained by Unit 3. Units 1 and 2 entrained fewer stickleback larvae: none in 1977, 1979, 1980 or 1981 and an estimated 16,500 in 1978 (Jude et al. 1980; Tables 25, 26). However, abundance in Unit 3 entrainment samples was not due to the arrangement or location of intake screens; rather, the Unit 3 riprap attracted ninespine sticklebacks to the area of the intakes, where larvae were entrained. Presumably this local concentration would not affect the main Lake Michigan population of ninespine sticklebacks, since they prefer spawning in deeper water than the 11-m intake depth (Jude et al. 1981a). Additionally, riprap periphyton and fauna provide a food source better than that provided by sand substrate.

24-h population and entrainment estimates--Based on 15-16 June 1981 collections of ninespine stickleback larvae (night data only), 48,200 larvae were estimated to be in the vicinity of the Campbell Plant (Table 31). During this 24-h period, an estimated 4,400 ninespine stickleback larvae were entrained, representing

9% of the proximate population. However, this comparison ignores utilization of riprap for spawning which would concentrate stickleback larvae around that area. There were probably greater densities of larvae around the riprap than over sandy substrate at the north transect. In 1977 to 1978, before the present intake and discharge structures and riprap were in place, fewer stickleback larvae were collected, indicating spawning was not concentrated and was mostly taking place in deeper water. By 1980 larvae were collected frequently and it was speculated that spawning occurred on the riprap because of a concentration of sticklebacks there. Data from 1981 show ninespine stickleback larvae appeared more frequently in entrainment samples than in field samples, although entrainment densities were low. Frequency of stickleback entrainment indicates the local population of ninespine sticklebacks may have been attracted to the riprap, built nests and spawned there more than over sandy substrate at the north transect. During 1981, no newly hatched larvae were collected in field or entrainment samples, in contrast to previous years. This suggests riprap provides good nesting habitat where larvae are protected from entrainment and currents. After yolk absorption, larvae became free-swimming and dispersed. At that time some larvae in the intake area moved up in the water column and became vulnerable to entrainment. This would explain the difference between entrainment and field collections.

Adults--

During 1981, no YOY ninespine sticklebacks were collected in adult and juvenile fish sampling gear. Yearling sticklebacks could not be distinguished from older ones by size, and yearlings may spawn (Jones and Hynes 1950); therefore, yearlings were considered together with adults in this report.

During 1981, adult ninespine sticklebacks were collected from May to July, mostly at deeper stations (9-12 m); most were trawled. For the first time during our study, one was collected in a bottom gill net. Fish with ripe-running or spent gonads appeared May through July instead of June through August as in preoperational years, indicating early spawning in 1981. Twenty-three females and three males were collected during 1981, which was similar to the unbalanced sex ratio seen in preoperational years (Jude et al. 1981a).

Due to the preference of ninespine sticklebacks for deeper waters, many were often collected at station F (15 m, south) during 1977-1980. During 1981 we did not trawl at station F. That, in combination with attraction to the riprap, early spawning and subsequent offshore migration, may have accounted for the large decrease in stickleback abundance in our 1981 collections. Sticklebacks were not seen on the riprap by scuba divers, however, these fish are small and may stay down in the rock crevices. Distribution of larvae indicates adults must have spawned on the riprap.

Rainbow Trout

Eighteen rainbow trout were captured during 1981 sampling. Catch data indicated that 11 C was the most favored water temperature, although some rainbows were caught in water ranging from 7 to 23 C. Rainbow trout appeared in samples from April through November, with greatest catches occurring during spring and fall (Appendix 7). Breakdown of catch according to gear type was as follows: bottom gill nets--six fish; surface gill nets--eight fish; seines--four fish. From 8 to 26 rainbows were caught during other sampling years (Jude et al. 1981a).

Only two immature (∽110-150 mm) rainbow trout were collected, one each in June and July. In general, adult fish (∽240-790 mm) had slight to moderate gonadal development in spring and well developed gonads in fall. Catch data from 1979 indicated that spring-spawning rainbows also may occur in the study area (Jude et al. 1981a). Food items of rainbow trout caught in 1981 included alewives, rainbow smelt, and terrestrial insects.

Common Carp

Introduction--

The carp is a native of Asia, widely introduced and naturalized in North America. Although common in inland waters such as Pigeon Lake, carp are not collected frequently in Lake Michigan near the Campbell Plant. Some carp larvae in Lake Michigan originate in inland waters and drift to the lake (Jude et al. 1981a), while others are known to originate from spawnings in the vicinity of the D. C. Cook Nuclear Plant warm-water discharge in southeastern Lake Michigan (Jude et al. 1979b). Absence of YOY and yearling carp from Lake Michigan signifies inland waters such as Pigeon Lake serve as nursery areas. During 1977-1979 a few immature carp were collected in Pigeon Lake. Each year of our study, a few adult carp were collected in Lake Michigan.

Larvae--

Seasonal distribution--During preoperational years, 1977-1980, carp larvae were collected from Lake Michigan from mid-May through September. Occurrence of larvae was, however, discontinuous and sporadic, indicating spawning at different times by several populations (Jude et al. 1981a). In 1977-1978, when the Campbell Plant discharge was onshore, carp larvae were most abundant at north transect stations 1-3 m in depth. When the offshore discharge structure was completed in 1979, carp larvae began to be more abundant at deeper stations (6-15 m). This pattern indicates that the Campbell Plant discharge system and Pigeon Lake were major sources for carp spawning and larvae production in our study area. It is likely that carp spawned both in the discharge canal and in the thermal plume in Lake Michigan.

Few carp larvae were collected during 1981 in field samples. Carp larvae were captured in Lake Michigan only in mid-June at station W (15 m, north). Densities were low, 17-19 larvae/1000 m^3. Larvae were 5.5-6.0 mm TL.

Entrainment--Unit 3 entrainment samples yielded carp larvae on 11 June and 9 July; densities were 3-12 larvae/1000 m^3. An estimated 30,700 carp larvae were entrained by Unit 3 for the entire year. Units 1 and 2, in contrast, entrained an estimated 1.5 million carp larvae in 1978, 11.2 million in 1979, 2.65 million in 1980 and 3.35 million in 1981. These larvae originated from the Pigeon Lake system which is much more productive than Lake Michigan in terms of carp populations (Jude et al. 1980). A spawning population of carp inhabits the intake canal of Units 1 and 2, which causes many carp larvae to be entrained by these units, in addition to those produced in Pigeon Lake. Carp was the third-most abundant species in 1981 entrainment samples from Units 1 and 2, comprising 15.1% of the total estimated loss (Table 26). During 1980, carp was the fourth-most abundant species entrained by Units 1 and 2 (1.4% of total - Table 25). During 1981, densities ranged up to almost 200 larvae/1000 m^3, peaking in mid-July; in 1980, peak density was 440 larvae/1000 m^3 on 3 July. Carp larvae were entrained by Units 1 and 2 from 29 May to 25 August 1981, and from 22 May to 15 August 1980. Most carp larvae were from entrainment samples collected at night. All carp larvae in Unit 3 entrainment samples were newly hatched ($\leq$ 6 mm TL), but samples from Units 1 and 2 included larger larvae, up to 15.5 mm during 1981. Newly hatched larvae continued to appear in entrainment samples from Units 1 and 2 through mid-August in both 1980 and 1981. Intake water temperatures at Units 1 and 2 were 13-23 C when carp larvae were entrained in 1981, and 11-23 C in 1980.

Discharge canal samples provided more insight into carp populations. Carp larvae were more abundant in discharge canal samples than in either Lake Michigan or Unit 3 intake samples (discharge canal densities were 6-322 larvae/1000 m^3). Also, carp larvae were more abundant in discharge canal samples than any other species. A spawning population of carp inhabits the discharge canal, which was shown by the presence of carp larvae in discharge samples and capture of seven adult carp by gill nets set in the canal. Scarcity (compared with carp) of more abundant species such as larval alewife and spottail shiner in discharge samples suggests that either most larvae are dead when discharged from the plant, so do not reach the discharge pumps, or if they survive, do not grow and successfully spawn in the canal. The higher thermal tolerance of carp permits them to spawn, and their larvae to survive, at higher temperatures than other species common to our study area (Pitt et al. 1956; Reutter and Herdendorf 1974).

Adults--

No YOY or yearling carp were collected in the plant vicinity during 1981, just as none were collected during 1977-1980. Lake Michigan is not a favorable nursery area for carp. However, 15 adult carp were collected during 1981, similar to our catches in previous years. Fourteen were gillnetted, and one was trawled. Ten were collected in September and October, in contrast to preoperational years, when catch was relatively constant through the sampling season. Carp were collected at 1.5- to 6-m stations at the reference transect and 6- and 9-m stations at the plant transect. As in preoperational years, carp appeared to prefer inshore waters, although none were seined during 1981, probably because they easily avoided our seine. During both 1980 and 1981, several carp were collected at station N (9 m, north) which may indicate carp extend their range offshore somewhat due to the presence of the riprap and/or warmer waters from the Campbell Plant discharge.

Seven male carp and eight females, with slightly to well developed gonads, were collected during 1981. Fish with the most highly developed gonads appeared from April to June. Carp we collected ranged in size from 585 to 784 mm, and water temperatures were 6 to 22 C.

Lake Whitefish

Only 13 lake whitefish were collected near the Campbell Plant during 1981, down from 75 in 1980. No YOY or yearling lake whitefish were captured during 1981. Most lake whitefish were taken in bottom gill nets. Fish captured in gill nets ranged from 215 to 674 mm TL. One fish in the 700-mm length interval was trawled. Five males and four females were collected, with slightly to well developed gonads. Water temperatures at times of collection ranged from 4 to 20 C. All were taken April through August.

There was no noticeable pattern of depth distribution. No lake whitefish were collected during the fall. They were also absent during fall of preoperational years (Jude et al. 1981a), indicating most may spawn elsewhere (see RESULTS AND DISCUSSION - Unidentified Coregoninae, Larvae). During the summer most lake whitefish inhabit deeper water than we sample (Van Oosten et al. 1946).

During 1981 all lake whitefish were collected at night. Amphipods, snails, and chironomid larvae were observed in lake whitefish stomachs.

Shorthead Redhorse

The shorthead redhorse inhabits lakes more commonly than other redhorses (Becker 1976). During 1981, we collected 13 shorthead redhorses, equaling our catch for 1977-1980 combined. The seasonal distribution pattern was similar to that observed in 1977-1980, as shorthead redhorses were collected from June to October, most at nearshore stations but a few out to 9 m. All were taken in bottom gill nets during the 5 yr. Shorthead redhorses collected during 1981 ranged in size from 365 to 514 mm. Seven females and three males were observed, none in spawning condition. Water temperatures when shorthead redhorses were collected were 10-22 C.

Silver Redhorse

The silver redhorse primarily inhabits rivers (Becker 1976). Silver redhorses collected during 1981 in the Campbell Plant vicinity were similar in abundance, distribution and season of occurrence to those taken during preoperational years. All 12 were collected by bottom gill net, most at 1.5- and 3-m stations, but a few as deep as 9 m. Silver redhorses were collected from August to November. Six males and six females were captured, ranging in size from 485 to 614 mm. None were ripe-running or spent. Water temperatures were 8-22 C.

Burbot

Introduction--

The burbot inhabits deep waters of lakes, coming inshore to spawn during midwinter (Scott and Crossman 1973). Adult burbot were infrequently collected at the Campbell Plant, as we did not sample deep enough water or sample during midwinter. Burbot larvae were collected more often than adults over the 5 yr. Winter impingement sampling and Units 1 and 2 entrainment indicate burbot spawn in Pigeon Lake (Jude et al. 1980, 1981a).

Larvae--

No burbot larvae were found in Lake Michigan collections during 1981, unlike preoperational years, when burbot larvae usually appeared from April to June (Mansfield et al. in press). During 1978-1980 newly hatched larvae occurred at densities of hundreds/1000 m^3 at beach stations (Jude et al. 1981a). There were no burbot larvae in Unit 3 entrainment samples, probably because burbot larvae are more abundant in the beach zone than at the intake depth, and apparently not many burbot spawned in Lake Michigan in the vicinity of the plant during 1981.

Units 1 and 2 entrained burbot larvae from 9 April to 4 May 1981 and 15 to 23 May 1980. Densities were low in samples from both years, 1-6 larvae/1000 m^3. Larvae were newly hatched (3.0-4.5 mm TL). An estimated 54,000 burbot larvae were entrained by Units 1 and 2 during 1981. Yearly entrainment of burbot larvae fluctuated greatly during our study, with 1.56 million estimated entrained during 1978, only 810 in 1979 and 15,900 in 1980. Presence of burbot larvae in Units 1 and 2 entrainment samples in 1981, while none were found in field samples, indicates nearly all spawning that year was in Pigeon Lake or Pigeon River.

Adults--

No YOY or yearling burbot were collected in the plant vicinity during 1981. However, more adults were taken during 1981 (12) than all preoperational years put together (6). Two were taken during spring, the rest during fall. Eleven were collected by bottom gill net, and one was trawled. All were collected at the plant transect, in contrast to previous years, when burbot were collected at the reference transect as well. Burbot may be attracted to the riprap; one was seen there by scuba divers.

Burbot collected during 1981 ranged from 335 to 524 mm TL. Most burbot were collected at cool water temperatures, 8-14 C. Six males and six females were taken, most with slight or moderate gonad development.

Walleye

Ten walleyes were collected in Lake Michigan during 1981, all in the fall (Appendix 7). All were caught at night in bottom gill nets when water temperatures were between 9 and 13 C.

Walleyes were caught at 1.5-, 3-, and 6-m stations, and were found at both north and south transects in October. During November, walleyes were captured only at the north transect in water from 6 to 9 m deep. Captured fish were between 255 and 574 mm in length and generally had moderately or well developed gonads. Alewives and rainbow smelt were found in walleye stomachs.

During previous sampling years, walleyes were collected in Lake Michigan only in 1978 (seven YOY) and 1980 (three adults). Adult walleyes may be attracted to the Campbell riprap to forage (Jude et al. 1981a).

Bluntnose Minnow

The bluntnose minnow is common in inland waters (Becker 1976), including Pigeon Lake (Jude et al. 1981a), but was not frequently collected in Lake Michigan during our study. Fifteen were collected during 1978, four during 1979 and five during 1981. Most were collected by seine and two by trawl during our study, indicating use of the beach zone but usually not open water. Bluntnose minnows were collected during April, September and October 1981. All were immature or sex could not be determined. Bluntnose minnows taken in 1981 were 25-64 mm in length. Water temperatures at times of collection were 6-20 C. No bluntnose minnow larvae or YOY were collected during 1981.

Channel Catfish

Channel catfish were rare in our Lake Michigan samples taken from 1977 to 1981. Catch in any given year never exceeded 10 fish. Catfish we collected are believed to have migrated into Lake Michigan from large river systems (Jude et al. 1981a). This migration has usually occurred around August in the vicinity of the Campbell Plant.

Five channel catfish were caught during 1981 (Appendix 7). One YOY (70-mm length interval) was collected in a trawl haul (6 m, south) in September. Water temperature the night of capture was 23 C. Four adult catfish (∽450-580 mm) were gillnetted in water 6 m or less in depth. Adults were captured in June, August and September at water temperatures ranging from 17 to 21 C. All but one adult were collected at night.

Catfish with well developed gonads were caught in June (one male) and September (one female); a female that had recently spawned was caught in September. No catfish with well developed or spent gonads had been caught during previous sampling years.

Quillback

Quillbacks inhabit several tributaries of Lake Michigan near the Campbell Plant (Becker 1976), including the plant discharge canal. From inland waters, quillbacks occasionally move into Lake Michigan, where we collected six during 1977-1980 and four during 1981. Quillbacks were gillnetted during April, June and August 1981 at stations 1.5-9 m in depth. Two males and two females were collected, including a spent female taken in August, indicating summer spawning. In late April 1978, a quillback larva was collected, probably originating from the discharge canal (Jude et al. 1981a). Individual quillbacks may spawn at widely differing times in our study area, most likely triggered by water temperature.

Quillbacks collected during 1981 were 405-444 mm in length. Water temperatures when quillbacks were taken were 8-20 C.

Freshwater Drum

Three freshwater drums (201-342 mm) were caught in night bottom gill nets set in October 1981 (Appendix 7). Drums were taken at both transects (one fish at 6 m, north, and two fish at 3 m, south). All three drums had slightly developed gonads. Only one fish had food in its stomach. Water temperature when drums were captured was 11 C.

The freshwater drum is rare in Lake Michigan near the Campbell Plant; only two specimens were collected from 1977 to 1980 (Jude et al. 1981a). Their occasional appearance in Pigeon Lake and Units 1 and 2 impingement samples (Jude et al. 1979a) indicated that a small population of freshwater drums may inhabit the Pigeon Lake area. As would be expected from the low density of adults, no larval drums were collected in the area of the plant.

Deepwater Sculpin

Introduction--

The deepwater sculpin is distributed from approximately 50 to 200 m in Lake Michigan (Deason 1939). Adults were seldom collected during our study; however, larvae were collected with some regularity. Because of their pelagic existence, deepwater sculpin larvae tend to drift or swim inshore (Jude et al. 1981a; Mansfield et al. in press). In addition, during winter some adults may move inshore to spawn, but this has not been documented. Times when larvae were collected indicate spawning occurred from early winter to early spring (Jude et al. 1981a).

Larvae--

Seasonal distribution--Deepwater sculpin larvae were collected from February through August during the preoperational study (Jude et al. 1981a). Peaks of occurrence were usually from March through early May, according to Units 1 and 2 entrainment sampling. In 1981 deepwater sculpin larvae were collected in field samples only on 18-19 May, which was later than usual. Presumably temperature controls time of hatching, and currents may affect temperature at the incubation site and patterns of dispersal. This complexity makes it difficult to predict times of abundance.

During our study, 1977-1981, larvae were generally more abundant at 12-15 m than nearshore, although they were collected as shallow as 3 m. In contrast to the demersal habits of adult sculpins, sculpin larvae are pelagic. Deepwater sculpin larvae occurred throughout the water column, including one collected in 1981 at the surface stratum of station N (9 m, north) (Fig. 46). During 1981, more deepwater sculpin larvae were collected at the plant transect than the reference transect.

Deepwater sculpin larvae collected in July or August were somewhat larger (18-20 mm) than those collected during spring (8-16 mm); summer occurrences were always during cold-water upwellings. Thus larvae collected in summer were not newly hatched, and inhabited deep, cool water most of the time. Deepwater sculpin larvae were scarce in the inshore zone after spring, which we attribute to offshore dispersal by currents or an active attempt by larvae to inhabit deep water.

Entrainment--Deepwater sculpin larvae were taken in Unit 3 entrainment samples only on 18 May. The density of larvae was 15/1000 m^3, compared with values ranging from 11 to 173/1000 m^3 during 5 yr of field sampling. Lengths of larvae entrained (8-10 mm) were similar to those observed in 1981 field samples on that date (Fig. 47). Unit 3 entrained an estimated 39,200 deepwater sculpin larvae during 1981 (Table 28).

Units 1 and 2 entrained an estimated 227,000 deepwater sculpin larvae during 1978, 166,000 during 1979 (Jude et al. 1980) and 62,600 during 1980 (Table 25). However, during 1981, no deepwater sculpin larvae were found in Units 1 and 2 entrainment samples, eliminating direct comparison between Units 1 and 2 and Unit 3. This hinders prediction as to whether many deepwater sculpin larvae would be entrained by Unit 3 in subsequent years. Because deepwater sculpins do not spawn in Pigeon Lake, larvae entrained by Units 1 and 2 originated in Lake Michigan. Unit 3 might be expected to entrain more larvae because its intake is closer to spawning sites of deepwater sculpins.

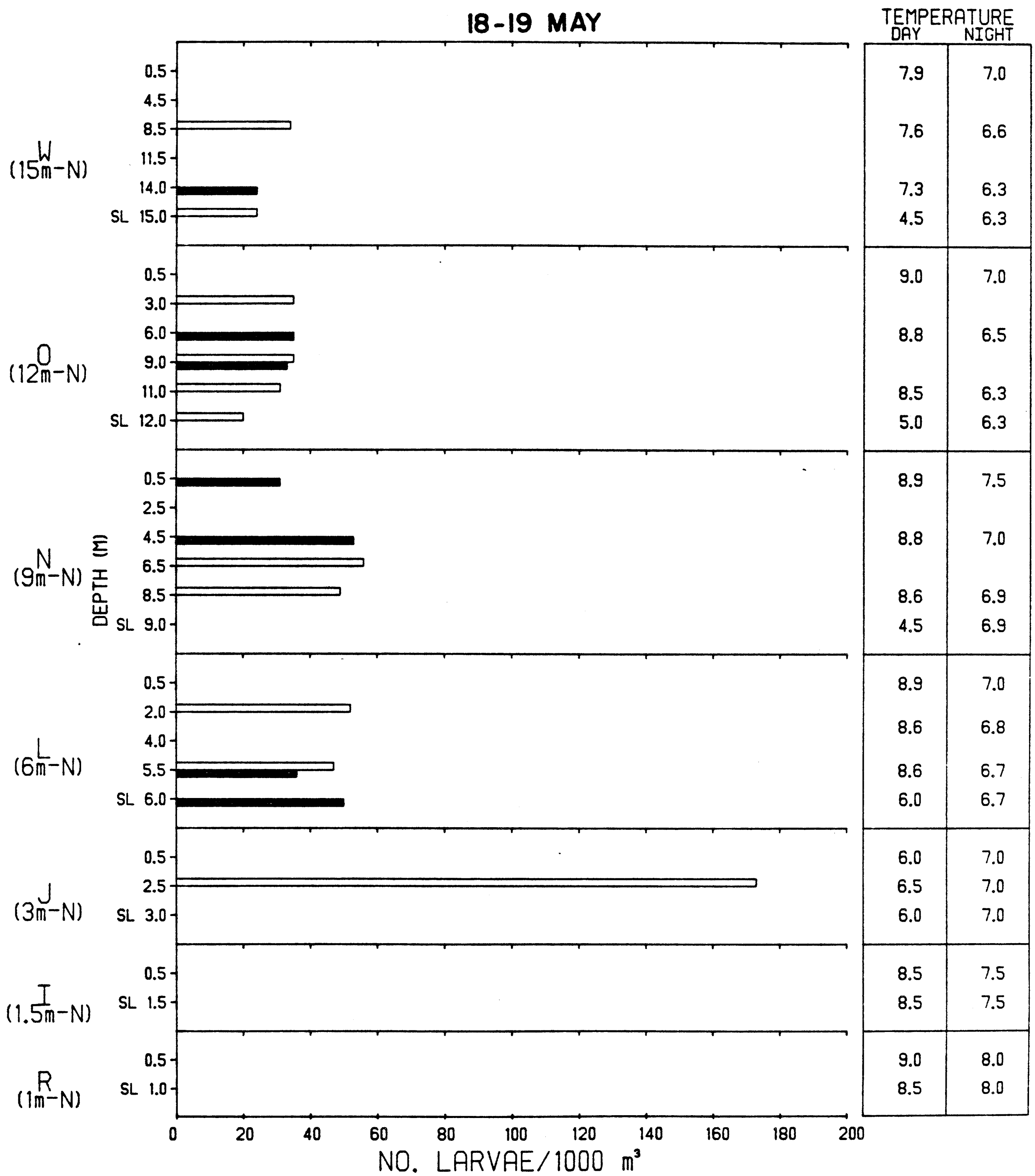


Fig. 46. Density of larval deepwater sculpins (no./1000 m³) at north and south transect stations near the J. H. Campbell Plant, eastern Lake Michigan, 18-19 May 1981. □ = day, ■ = night, SL = sled.

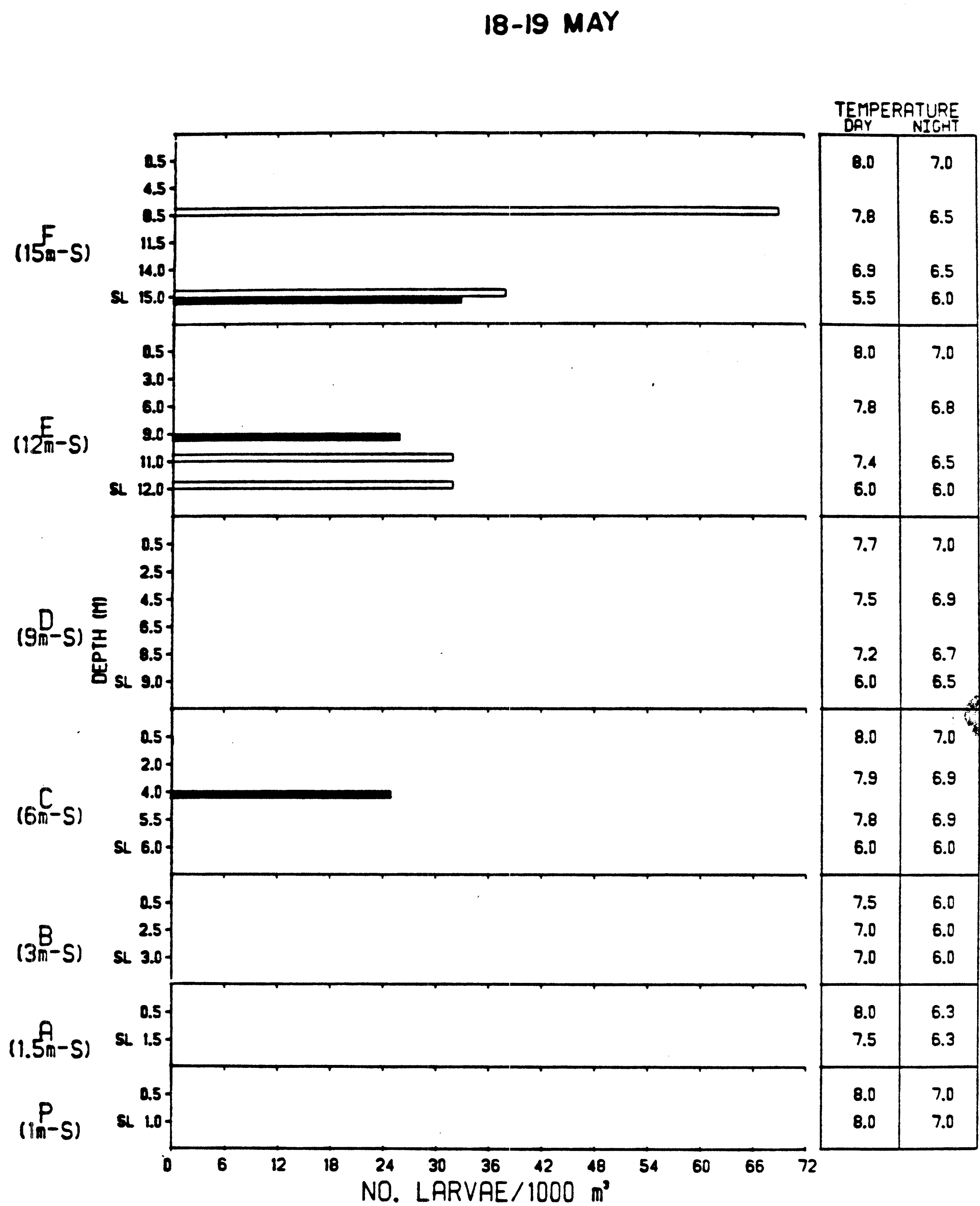


Fig. 46. Continued.

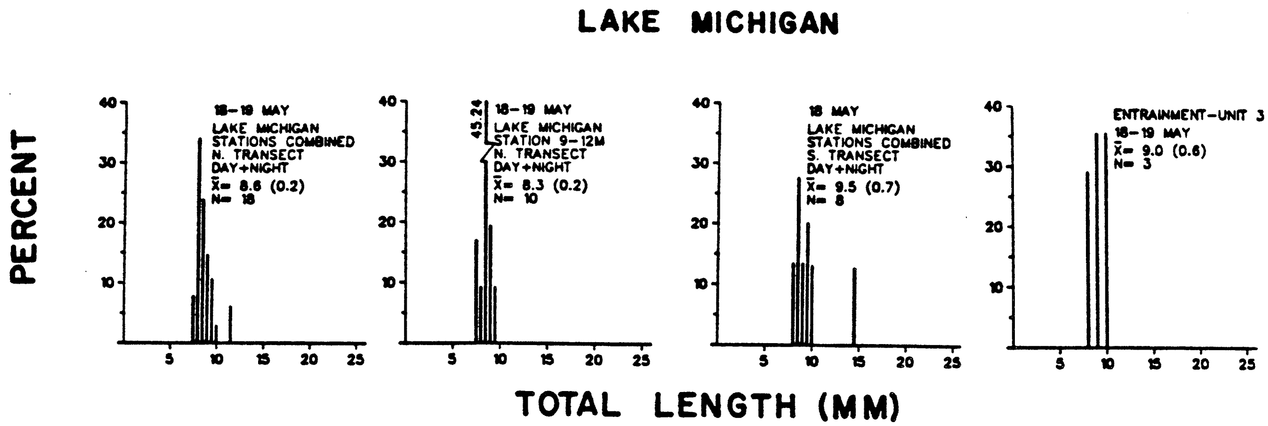


Fig. 47. Length-frequency histograms for larval deepwater sculpins observed in field and Unit 3 entrainment samples collected during 1981 near the J. H. Campbell Plant, eastern Lake Michigan. All plankton net and sled tow samples were combined. $\bar{X}$ = mean, N = total number of larvae, standard error is given in parentheses.

Deepwater sculpin larvae in 1980 Units 1 and 2 entrainment samples were 10.4 to 16.5 mm in length. All were taken in dawn samples on 30 April, at a mean density of 19 larvae/1000 m³.

<u>24-h population and entrainment estimate</u>--Estimated total number of larvae entrained on 18-19 May by Unit 3 was 4900 for the 24-h period. Based on night field samples, an estimated 2,490,000 larvae were in the vicinity of the Campbell Plant; only 0.2% of this estimated population was entrained. This percentage does not accurately reflect the even smaller impact of entrainment on the whole lake's sculpin population, since we believe the major distribution of larval deepwater sculpins is at depths exceeding 15 m. The small percentage of larvae entrained additionally suggests deepwater sculpins either do not utilize the riprap as spawning habitat (thus are not concentrated in the riprap area), or their larvae are easily able to resist the slow intake current. The closely related fourhorn sculpin

(*Myoxocephalus quadricornis*) builds nests on sandy bottoms in marine waters (Westin 1970); perhaps deepwater sculpins also prefer sandy substrate for spawning.

Adults--

Very few deepwater sculpins were collected in adult and juvenile fish sampling gear during our study, due to their preference for deeper waters than those we sampled. Two adults were trawled during 1981, in August and November at 6-m stations L (north) and C (south) respectively. Both were males with slight gonad development. Water temperatures were 8-11 C when they were collected; an upwelling occurred during August. During the preoperational study, 1977-1980, only two deepwater sculpins were collected. However, supplemental trawling during May 1981 at 80 and 100 m off the Campbell Plant yielded dozens of adult deepwater sculpins, demonstrating their abundance offshore (M. Evans, personal communication, Great Lakes Research Division, Univ. of Mich., Ann Arbor, Mich.).

Golden Redhorse

Golden redhorse was the least common redhorse collected during our study. During 1981, two golden redhorses were gillnetted, one at station A (1.5 m, south) in October and one at station L (6 m, north) in June. Water temperatures were 10.5 and 17.2 C respectively. These data are within the ranges of depth, season and temperature for golden redhorses collected during 1977-1980. Both fish were females, and the one taken during June was reabsorbing eggs. Two female golden redhorses collected during July 1979 were also reabsorbing eggs.

Mottled Sculpin

One mottled sculpin larva, 7.8 mm TL, was found in a 11 June 1980 entrainment sample from Units 1 and 2 (Table 25, Appendix 11). In April 1981, one mottled sculpin measuring 90 mm was caught at 9 m, south in a trawl (Appendix 7). Water temperature was 7 C. Mottled sculpin were rare (0-5 specimens caught) in Lake Michigan samples during preoperational years 1977-1980 (Jude et al. 1981a).

Chestnut Lamprey

A single chestnut lamprey (253 mm) was trawled at night in October 1981 at 6 m, north (Appendix 7). Water temperature was 11 C. The chestnut lamprey is largely stream living (Scott and Crossman 1973). The female captured, which had moderately developed gonads, was the first chestnut lamprey we caught in Lake Michigan during 5 yr of sampling. Most nets are ineffective for sampling lamprey, so its status in the area of the Campbell Plant is unknown. Chestnut lampreys occurred rarely in Units 1 and 2 impingement samples (Consumers Power Company 1975; Jude et al. 1979a).

Bluegill

Bluegill is a common species in Pigeon Lake. Bluegills were occasionally caught in Lake Michigan during 1977-1980. During 1981 a 30-mm juvenile bluegill was seined at beach station P on the south transect during October. This specimen and other bluegills found in Lake Michigan during 1977-1980 probably originated from Pigeon Lake.

Unidentified *Lepomis* spp.

Bluegill and pumpkinseed were the most common species of sunfish caught in Pigeon Lake during 1977-1979. Green sunfish and warmouth were scarce in the study area, suggesting that most unidentified *Lepomis* spp. larvae we collected were bluegill or pumpkinseed. Sunfish spawn from late May to August (Carlander 1969). *Lepomis* larvae generally occurred in entrainment samples at Units 1 and 2 from late June or early July to August during 1977-1979. During 1980 we first collected *Lepomis* larvae during mid-May (Appendix 11), suggesting that spawning of sunfish took place earlier in 1980 than 1977-1979 in our study area. Entrainment of *Lepomis* larvae was low during May 1980. Highest entrainment density at Units 1 and 2 (16 larvae/1000 m^3) occurred during early June. Larval *Lepomis* continued to occur in Units 1 and 2 entrainment samples during late June, July and early August at densities of 1 to 5 larvae/1000 m^3 (Appendix 11). *Lepomis* larvae entrained during May and June were small (4-6 mm) (Fig. 48). In July and August entrained *Lepomis* larvae ranged from 4 to 9.5 mm, most being less than 7 mm.

During 1981 *Lepomis* larvae were first entrained during 11 June at a density of 1 larva/1000 m^3. They continued to occur at low densities during July and August (Appendix 12). *Lepomis* larvae entrained during 1981 were 4-5.5 mm (Fig. 48). Estimated entrainment losses of *Lepomis* larvae were 239,000 in 1980 and 63,600 in 1981 (Tables 25, 26).

Lepomis larvae hatch at 2.2-3.23 mm (Morgan 1951; Mansueti 1964b; Anjard 1974). During 1977-1981 larvae entrained ranged from 4 to 9.5 mm. Most newly hatched larvae in Pigeon Lake probably remained in shallow nursery areas which are outside the influence of intake currents. *Lepomis* larvae were common in

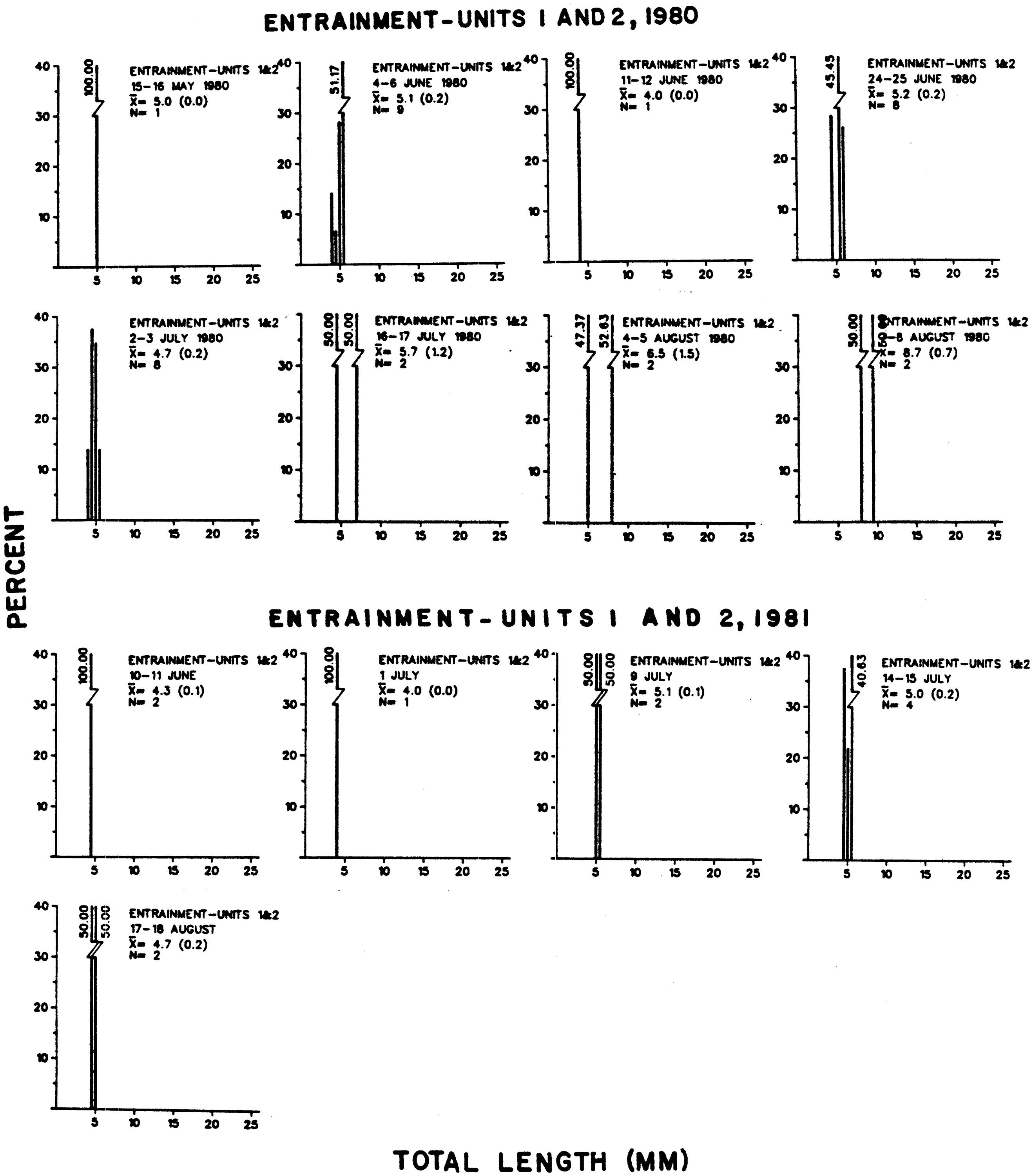


Fig. 48. Length-frequency histograms for larval *Lepomis* observed in entrainment samples at the J. H. Campbell Plant's Units 1 and 2, eastern Lake Michigan during 1980 and 1981. $\bar{X}$ = mean, N = total number of larvae, standard error given in parentheses.

Pigeon Lake during 1977-1979 (Jude et al. 1980). Entrainment of larval *Lepomis* was generally low during 1977-1981 probably because this species remained in the shallow water after their dispersal from the nests. No *Lepomis* larvae were entrained at the Unit 3 intake.

A few centrarchid larvae, approximately 5 mm, were observed in entrainment samples at Units 1 and 2 during late June 1980 and 1981 (Appendixes 11 and 12). These larvae were too damaged to be identified beyond the family level.

Unidentified *Pomoxis* spp.

Black crappie is a common species in Pigeon Lake. White crappie was reported to occur in Pigeon Lake (Consumers Power Company 1975), but had never been caught in the study area during 1977-1981. These data suggested that most unidentified *Pomoxis* spp. larvae we collected were black crappie larvae.

In 1980 *Pomoxis* larvae were first entrained by Units 1 and 2 during mid-May at a density of 3 larvae/1000 m^3 (Appendix 11). *Pomoxis* larvae occurred at slightly higher densities (15-20 larvae/1000 m^3) during 23 and 29 May 1980. Entrainment of *Pomoxis* larvae peaked during early June in 1980 (50 larvae/1000 m^3) and declined sharply during late June and early July when densities of 1-5 larvae/1000 m^3 were observed (Appendix 11). In 1980 no *Pomoxis* larvae were entrained at Units 1 and 2 after mid-July. An estimated 1.02 million *Pomoxis* larvae were entrained during 1980 (Table 25).

In 1981 *Pomoxis* larvae were first observed in entrainment samples at Units 1 and 2 during late May at a density of 3 larvae/1000 m^3. Entrainment of *Pomoxis* larvae continued at low densities (Appendix 12) from late May to mid-June 1981. No *Pomoxis* larvae were entrained after 15 June in 1981. Units 1 and 2 entrained an estimated 103,000 *Pomoxis* larvae during 1981 (Table 26).

Pomoxis larvae were generally common in Pigeon Lake during May and early June (Jude et al. 1980). Peak entrainment densities were 120 larvae/1000 m^3 during early June in 1978 and 355 larvae/1000 m^3 during May in 1979. Lower densities observed in entrainment samples at Units 1 and 2 during 1980 and 1981 may be due to lower spawning intensity in Pigeon Lake.

Pomoxis larvae were 2-2.36 mm when first hatched (Siefert 1969). Entrained *Pomoxis* larvae were 4 to 8.5 mm during 1980 and 4 to 9 mm during 1981, most being between 4 and 5 mm (Fig. 49). A similar size range was observed for *Pomoxis* larvae entrained during 1978-1979. Newly hatched larvae were probably not entrained because they remained near the bottom of the nest and were therefore not vulnerable to being drawn into intake currents. *Pomoxis* larvae larger than than 9 mm were scarce in entrainment samples because they were able to avoid the intake current. No *Pomoxis* larvae were found in Unit 3 entrainment samples, probably because crappies are rarely found in Lake Michigan.

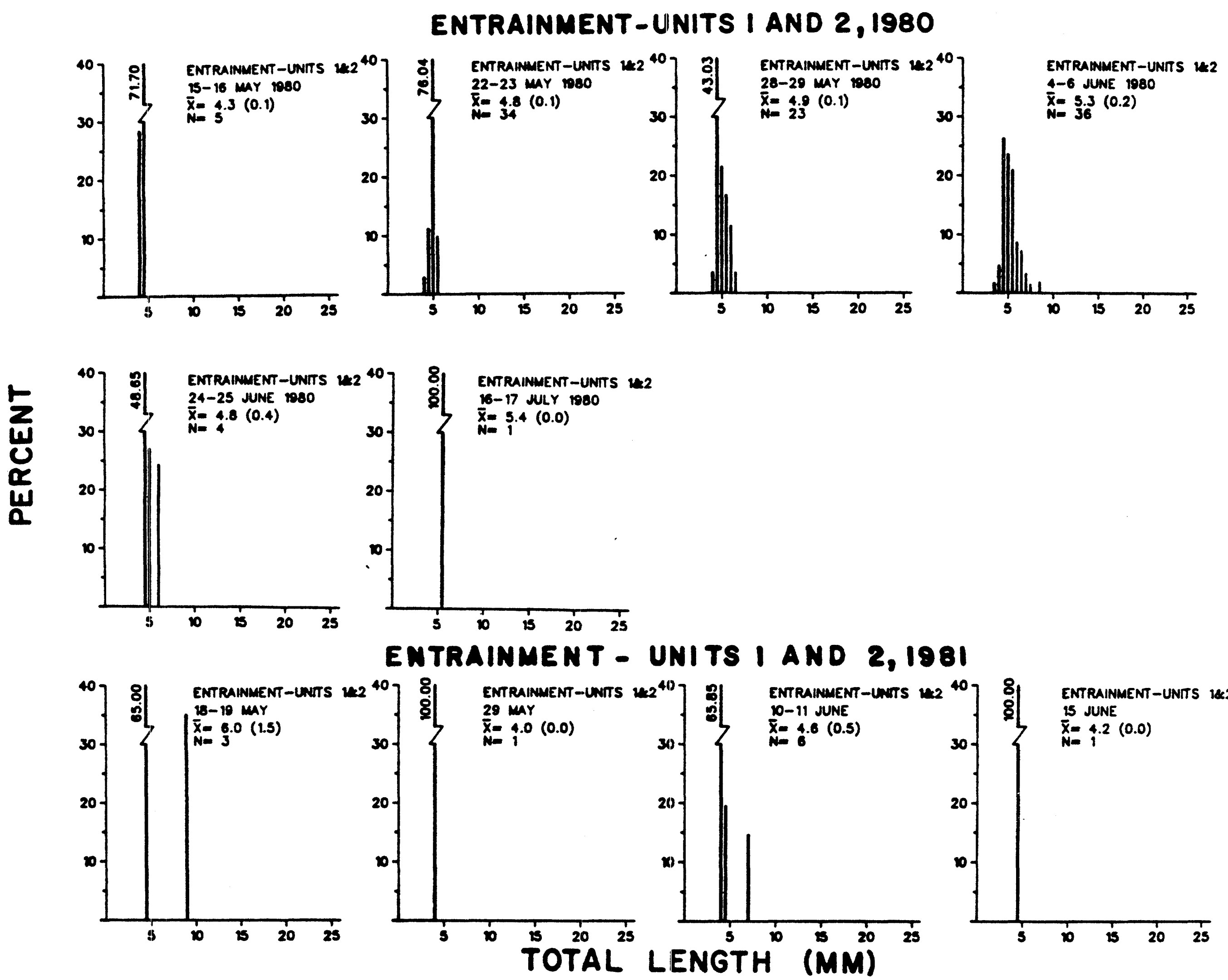


Fig. 49. Length-frequency histograms for larval *Pomoxis* observed in entrainment samples at the J. H. Campbell Plant's Units 1 and 2, eastern Lake Michigan during 1980 and 1981. $\bar{X}$ = mean, N = total number of larvae, standard error given in parentheses.

Lake Sturgeon

The lake sturgeon has suffered the most abrupt decline of any species in Lake Michigan (Wells and McLain 1973). This species is rare in the vicinity of the Campbell Plant. One 487-mm specimen was captured in a night trawl haul in August 1981 (Appendix 7). It was returned unharmed to the lake. Water temperature at the site of capture (9 m, south) was 9 C. Two lake sturgeons were collected during other sampling years, one in July 1977 and one in May 1979 (Jude et al. 1981a).

Fathead Minnow

Fathead minnows were rarely collected in Lake Michigan during our study. During August 1981, one immature was seined at beach station P (south reference) at a water temperature of 17.7 C. Two fathead minnows, 35.0-35.2 mm, were taken in a sled tow during April, also at station P. A number of fathead minnows, 33-45 mm, were found in Units 1 and 2 entrainment samples during late March and April 1981 (Appendix 17). Such entrainment of fry has not happened in previous years, and fathead minnows are not particularly common in Pigeon Lake, so we surmise that most were bait minnows released by fishermen.

Golden Shiner

Golden shiner is a common species in Pigeon Lake. Larval golden shiners were collected in low numbers in Pigeon Lake during 1977-1979 (Jude et al. 1980). Larval golden shiner were however, not found in entrainment samples during 1977-1979 and 1981. One golden shiner larva (23.5 mm) occurred in Units 1 and 2 entrainment samples at dusk during late May 1980.

Brook Silverside

Adult and juvenile brook silversides were common in Pigeon Lake during 1977-1979 (Jude et al. 1980). Larvae of this species were caught in low numbers every year during 1977-1979. They were however, scarce in entrainment samples. One brook silverside larva was entrained at Units 1 and 2 in July each year during 1979-1981. Larvae were newly hatched (approximately 5 mm). No brook silverside larvae were entrained in 1977 and 1978.

Largemouth Bass

Largemouth bass is common in Pigeon Lake. During 1977-1979 largemouth bass larvae were caught in low numbers in Pigeon Lake, but were never found in Lake Michigan (Jude et al. 1978, 1979a and 1980). One largemouth bass larva (9.5 mm) was collected during 17-18 August 1981 at the north transect (6-m station L). This larva was probably carried by current from the discharge canal. No largemouth bass larvae were found in Unit 3 entrainment samples.

Damaged Larvae

During the course of sample collection there are a number of factors which may result in damaged larvae. In field samples the primary cause of damage is abrasion, which occurs when sand and other debris grind against specimens during net tows and subsequent sample processing. With few notable exceptions, highest densities of damaged larvae occurred in sled tow samples and at beach and 1.5-m stations. These areas have the greatest turbulence which causes suspended sand and debris to be in highest occurrence in the samples where they exhibit maximum abrasive effects. Another source of damaged larvae may be those larvae which died prior to our sampling and exhibit varying degrees of decomposition, often making them impossible to distinguish from larvae which were subjected to abrasion.

Unlike damaged field larvae which were generally a result of sampling techniques and subsequent handling, damaged larvae occurring in entrainment samples were most likely disfigured prior to sampling. Damage incurred as a result of entrainment by Unit 3, however, should contribute relatively little to the overall abundance of damaged larvae since entrained larvae are sampled prior to passage through the plant. As in field samples, larvae which had died and were partially decomposed prior to entrainment would be expected to contribute to damaged larvae totals.

When damage occurred to a larva, all practical methods were employed to identify the larva to species. In some instances, however, elimination of body parts or obscuring of pigmentation patterns precluded larva identification. When larvae were damaged beyond recognition, we speculated as to their identity based on the identity of larvae caught coincidentally in the same or adjacent samples.

In 1981, 0.8 and 1.2% of the larvae collected at north and south transects, respectively, were classified as damaged. The percentage of damaged larvae observed in Lake Michigan was 2.3%

in 1978 and 0.5% in 1979. In general, highest densities of damaged larvae occurred during periods of greatest larval fish abundance.

In order to determine the potential influence of damaged larvae on the abundance of identified larvae in the same sample, damaged larvae were proportioned among species of co-occurring larvae. Using the information in Tables 40-43, densities of damaged larvae were assigned to a particular species based on the presence of that species in the same or adjacent samples and what percentage of the entrainment sample that species represented. Only species whose length-frequency distribution for that particular sampling period overlapped with lengths of damaged larvae (Fig. 50) were assigned damaged larvae.

Of the 25 north transect samples containing damaged larvae in 1981, 9 would require adjustments of more than 15% if damaged larvae were proportionally assigned to species. In four of these samples damaged larvae were the only larvae present, but occurred in densities below 35 larvae/1000 m^3. On the south transect 11 of the 30 samples containing damaged larvae would require adjustment of more than 15%. Damaged larvae were the only larvae present in one of these 30 samples. As was concluded by Jude et al. (1981a), regarding the 4 yr of preoperational sampling, such adjustments in larvae abundance, if made, would not have affected our results or conclusions about any known species of larval fish in the area. Most damaged larvae found at north and south transect stations were small (5 mm or less).

During 1980 damaged larvae represented 0.9% (210 of 22,795) of all larvae collected at Units 1 and 2. A higher percentage of damaged larvae (4% of all larvae collected) was observed in entrainment samples collected at Units 1 and 2 during 1981. Damaged larvae accounted for 5.5 and 4.5% of all larvae found in entrainment samples in 1977 and 1978 respectively. Low percentage of damaged larvae observed in 1980 may be due to the extreme abundance of newly hatched alewife larvae which were relatively easier to identify than other larval fish species when damaged.

Of the 1008 larvae collected in Unit 3 entrainment samples during 1981, 4.3% (43 larvae) were damaged. This value appears surprisingly high, for reasons previously explained, compared with percentages of damaged larvae occurring in Units 1 and 2 samples. Either Unit 3 entrainment, up to the point of our sampling, is more rigorous than expected or more damaged larvae occurring in the field are being entrained. The latter is most likely because larvae in poor condition, or dead, would not resist intake currents.

Table 40. Densities of all species of larvae in samples containing damaged larvae from north and south transect stations at the J. H. Campbell Plant, eastern Lake Michigan, 1981. Species of co-occurring larvae are given in parentheses. See Table 24 for species codes.

Date	Station	Depth stratum	Density of damaged larvae (no./1000 m³)	Density of co-occurring larvae (no./1000 m³)
				North transect
5-18-81	O	6.0	35	35(FS)
6-15-81	I	1.5	55	55(YP), 611(SP), 498(AL)
6-15-81	I	0.5	185	308(YP), 3022(SP), 1293(AL)
6-15-81	J	2.5	298	99(YP), 957(SP), 1358(AL)
6-15-81	N	6.5	25	50(SM), 127(AL)
6-15-81	N	8.5	88	132(YP), 92(AL)
6-15-81	O	9.0	63	190(YP), 695(AL)
6-15-81	W	0.5	17	17(JD), 17(SM), 17(CP), 565(YP), 1404(AL)
6-16-81	W	11.5	19	19(XC), 19(CP), 39(SM), 40(SP), 449(AL)
7-01-81	R	1.0	103	722(AL)
7-01-81	R	1.0	54	1137(SP), 108(AL)
7-01-81	J	0.5	40	80(SP), 81(AL)
7-01-81	J	3.0	31	none
7-01-81	N	9.0	32	32(SM), 65(SP), 64(AL)
7-20-81	J	2.5	71	1441(SP), 781(AL)
7-20-81	L	0.5	15	none
7-20-81	L	4.0	9	127(AL)
7-20-81	N	4.5	16	none
7-19-81	W	15.0	19	19(AL)
8-06-81	R	0.5	206	1031(AL)
8-07-81	N	6.5	19	469(AL)
8-17-81	I	1.5	292	373(SP), 6973(AL)
8-17-81	J	3.0	32	64(SP), 515(AL)
8-18-81	L	4.0	14	345(AL)
8-17-81	N	2.5	14	none
				South transect
5-04-81	P	0.5	128	128(SM)

Table 40. Continued.

Date	Station	Depth stratum	Density of damaged larvae (no./1000 m^3)	Density of co-occurring larvae (no./1000 m^3)
			South transect	
6-04-81	C	0.5	24	none
6-04-81	E	6.0	25	25(AL), 77(SM)
6-04-81	F	8.5	37	75(SM)
6-15-81	P	1.0	40	100(AL), 200(SM)
6-15-81	A	1.5	37	296(AL)
6-15-81	B	3.0	35	70(AL)
6-15-81	B	2.5	22	798(AL), 22(SP), 88(YP)
6-15-81	C	4.0	68	414(AL)
6-15-81	C	0.5	27	744(AL), 109(SP), 55(YP)
6-15-81	C	2.0	27	1330(AL)
6-15-81	D	8.5	40	81(AL)
6-15-81	D	9.0	45	90(AL)
6-15-81	D	0.5	104	685(AL), 335(YP)
6-15-81	D	6.5	60	842(AL), 60(SM)
6-15-81	E	6.0	25	209(AL), 102(YP)
6-15-81	E	6.0	29	972(AL), 88(YP)
6-15-81	F	4.5	17	686(AL), 34(YP)
6-15-81	F	14.0	21	1224(AL), 42(YP)
7-01-81	P	1.0	34	865(AL), 69(YP)
7-01-81	B	3.0	23	23(SP), 23(SM)
7-01-81	C	6.0	25	125(AL)
7-01-81	E	9.0	28	58(AL), 28(TP)
7-20-81	P	0.5	141	282(AL), 141(SP), 141(JD)
7-19-81	A	1.5	26	706(SP)
7-20-81	F	8.5	14	42(AL)
7-20-81	F	0.5	15	15(AL)
8-06-81	C	0.5	14	72(AL)
8-06-81	C	2.0	24	146(AL), 11(SP)
8-06-81	B	3.0	52	886(AL), 522(AL)

Table 41. Densities of all species of larvae in samples containing damaged larvae from Units 1 and 2 discharges, J. H. Campbell Plant, eastern Lake Michigan, 1980. Species of co-occurring larvae are given in parentheses. See Table 24 for species codes.

Date	Diel period	Density of damaged larvae (no./1000 m^3)	Density of co-occurring larvae (no./1000 m^3)
5-05-80	Dawn	4	155(YP)
5-05-80	Day	13	612(YP)
5-16-80	Dawn	5	287(YP), 78(SM), 2(XL)
5-15-80	Day	10	13(PM), 3(BR), 170(YP), 37(SM)
5-15-80	Night	8	188(YP), 51(SM), 3(BR)
5-23-80	Dawn	11	25(YP), 21(SM), 14(PM)
5-23-80	Day	8	18(YP), 6(SM), 26(PM), 2(GS), 2(BR)
5-22-80	Dusk	5	2(CP), 25(YP), 3(SM), 22(PM), 2(GL), 2(BR)
5-22-80	Night	10	36(YP), 2(SP), 10(SM), 15(PM), 1(JD)
5-29-80	Night	2	8(CP), 9(YP), 11(SM), 18(PM)
6-05-80	Dawn	17	14(XL), 81(PM), 18(GS), 17(CT)
6-04-80	Dusk	11	11(CP), 31(XL), 11(PM)
6-19-80	Dawn	2	20(AL), 22(SP), 6(SM)
6-24-80	Dawn	8	38(AL), 5(CP), 33(YP), 36(SP), 22(SM), 11(XL), 4(PM), 3(CT)
6-24-80	Day	13	9(AL), 5(CP), 18(YP), 10(SP), 3(XL)
6-24-80	Dusk	25	21(AL), 5(CP), 42(YP), 19(SP), 12(SM) 2(XL), 10(JD)
6-25-80	Night	54	37(AL), 126(CP), 95(YP), 221(SP), 22(SM), 5(XL), 4(PM), 9(JD)
7-03-80	Dawn	60	2808(AL), 14(CP), 12(YP), 97(SP), 2(SM), 7(XL), 4(JD)
7-02-80	Dusk	18	1335(AL), 119(CP), 81(SP), 6(SM), 2(JD)
7-03-80	Night	103	1540(AL), 443(CP), 2(YP), 45(SP), 2(SM), 8(XL), 2(JD)
7-08-80	Dawn	9	5586(AL), 321(SP)
7-08-80	Dusk	26	2791(AL), 21(SP)

Table 41. Continued.

Date	Diel period	Density of damaged larvae (no./1000 m^3)	Density of co-occurring larvae (no./1000 m^3)
7-09-80	Night	50	5178(AL), 274(SP), 4(JD)
7-17-80	Dawn	29	1639(AL), 109(CP), 3(ES), 3(SV)
7-16-80	Day	4	667(AL), 10(CP), 17(SP)
7-11-80	Dusk	7	1327(AL), 26(SP), 1(JD), 2(TP)
7-17-80	Night	28	2164(AL), 2(CP), 7(XL), 1(PM)
7-23-80	Dawn	18	934(AL), 143(SP)
7-22-80	Day	3	1187(AL), 10(CP), 14(SP)
7-22-80	Dusk	14	2596(AL), 3(CP), 14(SP)
8-05-80	Dawn	2	778(AL), 14(SP), 2(XL)
8-08-80	Night	3	1405(AL), 19(SP), 3(XL), 1(TP)
8-14-80	Day	6	119(AL), 2(CP), 4(SP)
8-14-80	Dusk	10	181(AL), 4(CP), 2(SP), 2(JD)
8-15-80	Night	2	307(AL), 3(CP), 5(SP)
8-21-80	Day	2	23(AL), 2(SP)
8-21-80	Dusk	2	77(AL)
8-27-80	Dawn	2	11(AL)
9-04-80	Night	2	12(AL), 2(TP)

Table 42. Densities of all species of larvae in samples containing damaged larvae from the Units 1 and 2 discharges, J. H. Campbell Plant, eastern Lake Michigan, 1981. Species of co-occurring larvae are given in parentheses. See Table 24 for species codes.

Date	Diel period	Density of damaged larvae (no./1000 m³)	Density of co-occurring larvae (no./1000 m³)
3-28-81	Night	2	none
4-29-81	Night	3	52(YP), 1(BR)
5-12-81	Night	2	2(JD)
5-19-81	Night	1	11(SM), 1(PM)
5-29-81	Day	2	2(PM)
5-29-81	Night	1	1(CP), 1(JD)
6-04-81	Night	2	22(CP)
6-11-81	Day	16	2(AL), 6(SP), 4(SM), 132(CP), 4(PM)
6-11-81	Night	13	9(AL), 18(SP), 6(YP), 21(SM), 80(CP) 7(JD), 6(PM), 2(XL)
6-15-81	Day	16	95(AL), 3(SP), 7(YP), 6(SM), 3(CT)
6-15-81	Night	22	268(AL), 54(SP), 6(YP), 53(SM), 65(CP) 9(JD), 3(PM), 3(TP)
6-26-81	Day	7	7(AL), 2(SP), 1(YP), 10(CP)
6-26-81	Night	42	94(AL), 330(SP), 3(YP), 19(SM), 79(CP)
7-01-81	Night	8	54(AL), 120(SP), 9(SM), 89(CP), 4(JD) 7(TP), 4(ES)
7-09-81	Day	1	101(AL), 1(SP)
7-09-81	Night	10	189(AL), 416(SP), 1(SM), 2(CP), 2(JD), 2(XL)
7-15-81	Day	7	51(AL), 2(SP), 4(YP), 1(XL)
7-15-81	Night	24	57(AL), 78(SP), 197(CP), 6(XL)
7-20-81	Night	1	7(AL), 19(SP), 47(CP), 2(JD)
8-06-81	Night	2	23(AL), 6(SP), 2(JD)
8-12-81	Day	4	82(AL), 2(SP)
8-12-81	Night	8	232(AL), 23(SP), 4(CP), 1(JD)
8-18-81	Night	40	1544(AL), 79(SP), 15(CP), 5(XL)
8-25-81	Night	1	10(AL), 6(SP), 1(CP)
9-24-81	Day	1	none

Table 43. Densities of all species of larvae in samples containing damaged larvae from the Unit 3 intake, J. H. Campbell Plant, eastern Lake Michigan, 1981. Species of co-occurring larvae are given in parentheses. See Table 24 for species codes.

Date	Diel period	Density of damaged larvae (no./1000 m^3)	Density of co-occurring larvae (no./1000 m^3)
6-11-81	Dawn	4	37(YP), 8(SM), 8(SS), 4(AL)
6-10-81	Dusk	21	147(SS), 93(SP), 33(YP), 14(AL), 7(JD), 3(SM), 3(TP)
6-11-81	Night	6	168(SP), 46(YP), 24(SS), 13(TP), 12(CP), 9(SM), 3(AL)
6-16-81	Dawn	30	351(AL), 304(YP), 72(SP), 8(SS)
6-15-81	Day	24	117(YP), 69(AL)
6-15-81	Dusk	120	813(YP), 202(SS), 162(AL), 67(SP), 60(JD), 9(SM)
6-15-81	Night	36	306(AL), 276(YP), 147(SS), 59(SP), 40(SM), 15(JD), 9(NS)
6-26-81	Dawn	3	16(AL), 6(SP), 3(SS), 2(JD)
6-26-81	Night	3	23(SP), 7(SS), 3(TP)
7-02-81	Night	25	35(AL), 25(TP), 12(SP), 12(JD), 12(SS)
7-09-81	Night	3	24(SP), 22(AL), 17(JD), 6(NS), 3(TP)
7-20-81	Dusk	4	146(AL), 4(GS)

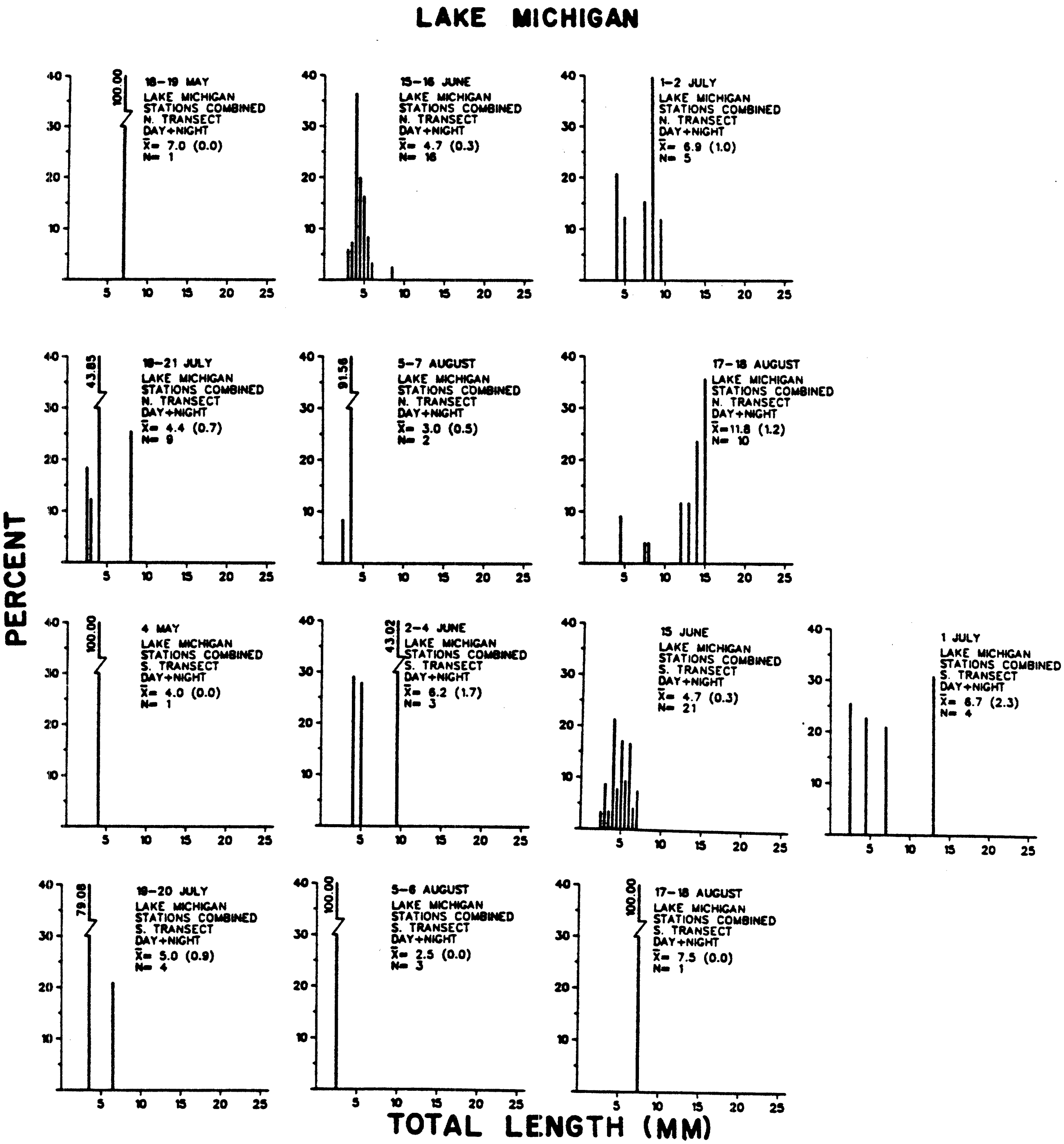
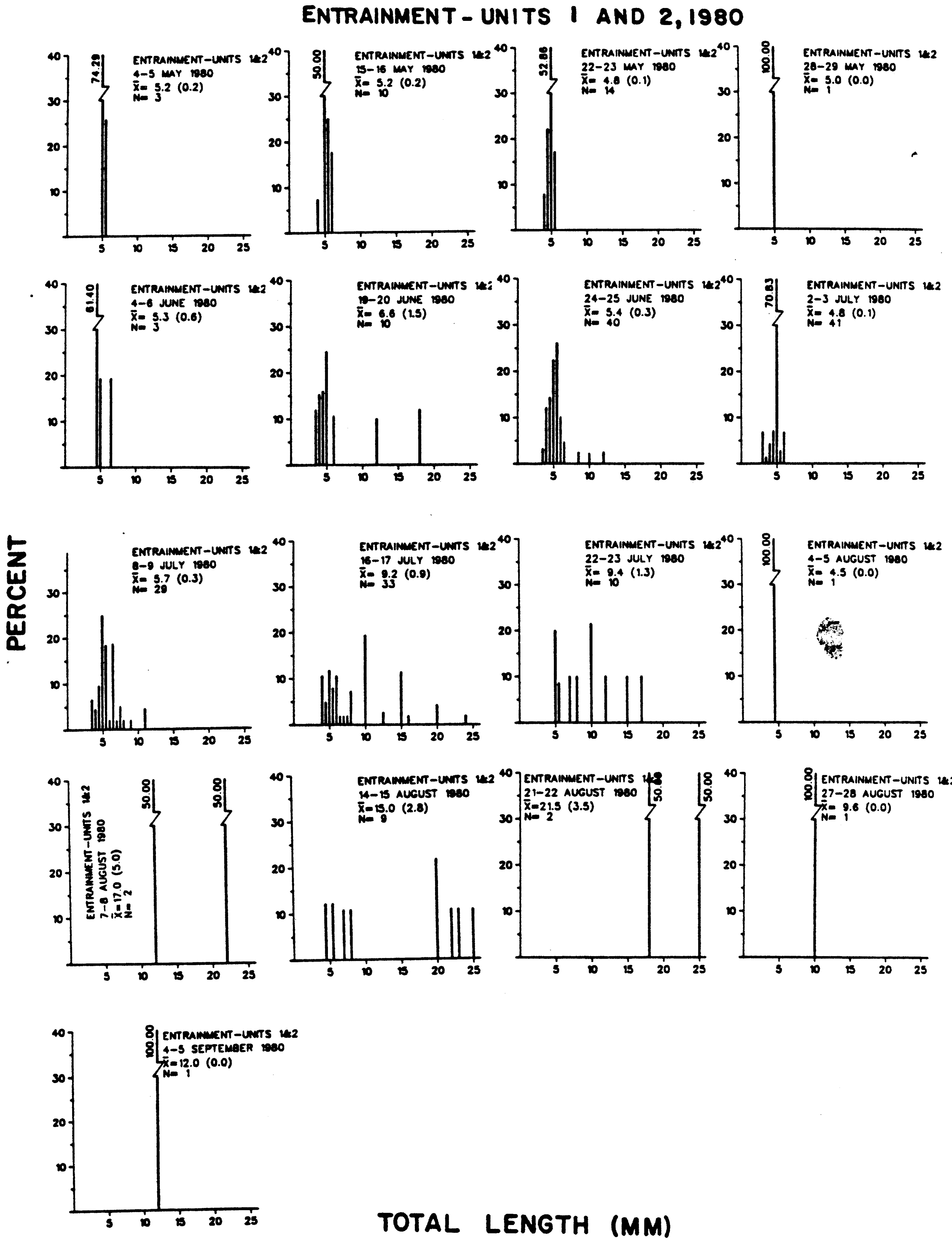


Fig. 50. Length-frequency histograms for damaged larvae observed in field and entrainment samples collected during 1981 near the J. H. Campbell Plant, eastern Lake Michigan. All plankton net and sled tow samples were combined. Length-frequency histograms for damaged larvae entrained during 1980 were also included. X̄ = mean, N = total number of larvae, standard error is given in parenthesis.

ENTRAINMENT - UNITS 1 AND 2, 1980



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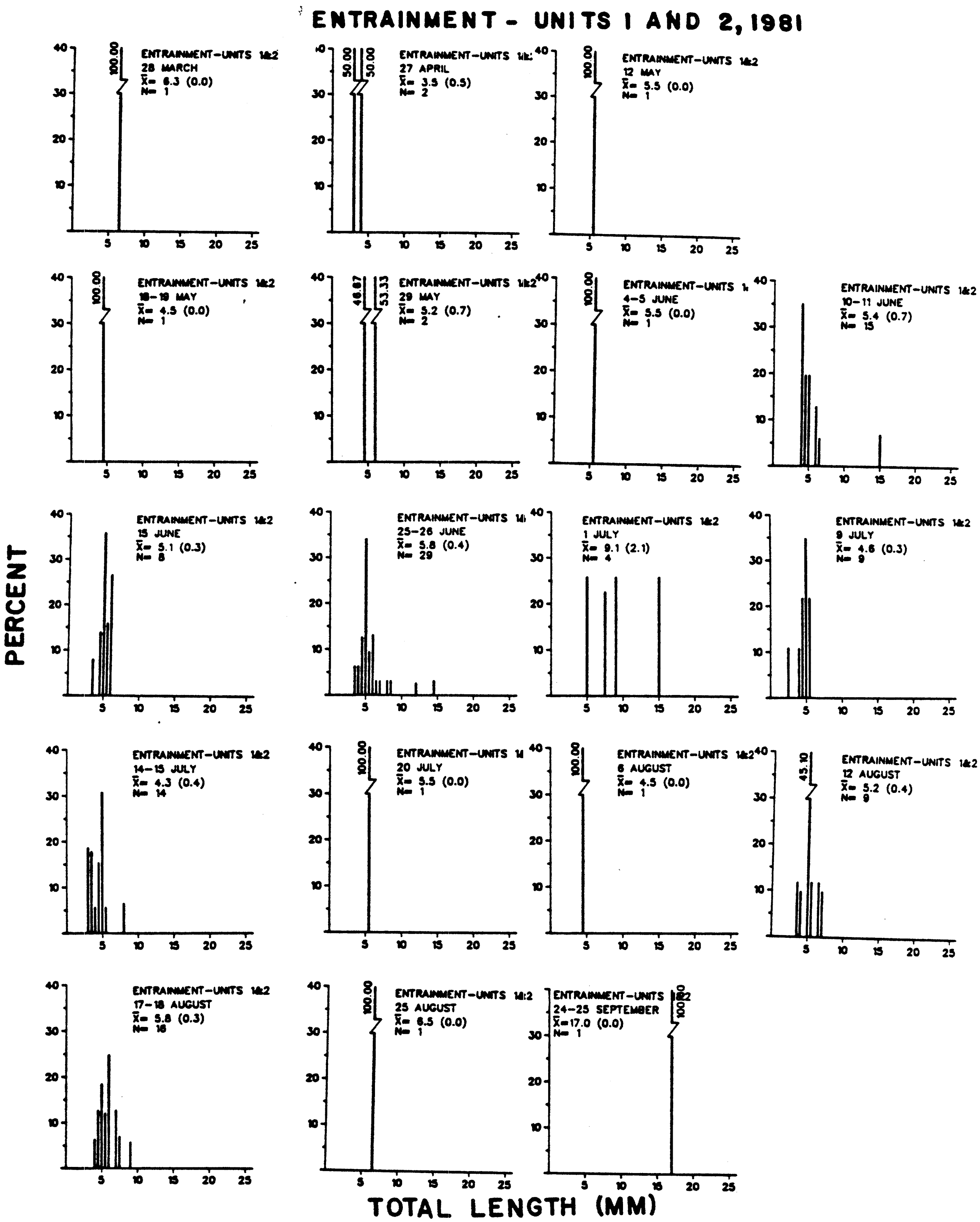

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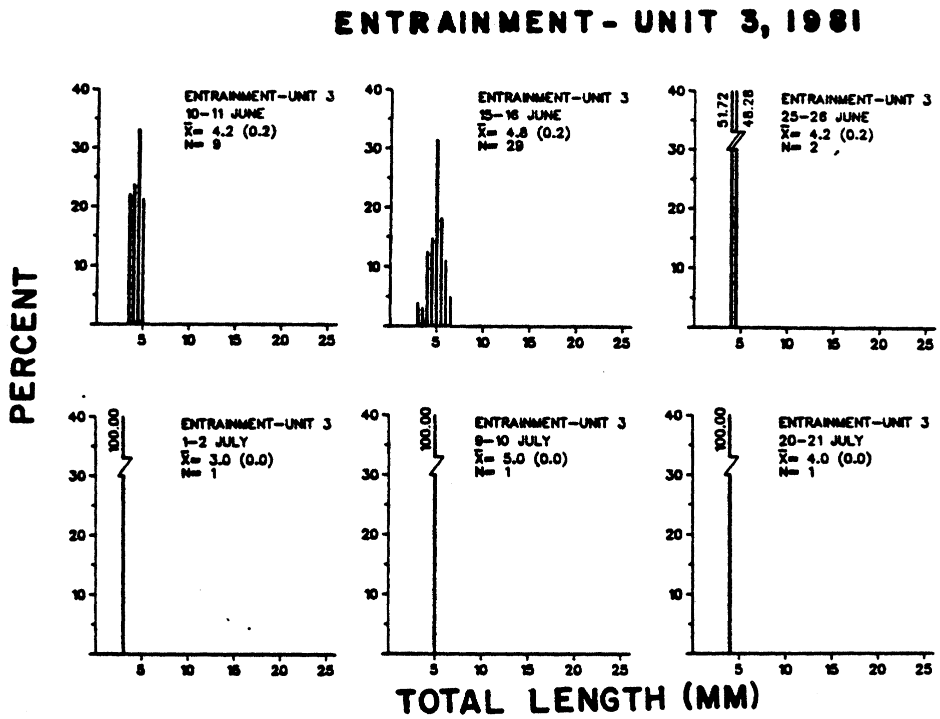


Fig. 50. Continued.

Densities of damaged larvae were generally low. Entrainment samples collected at Units 1 and 2 contained 2 to 103 damaged larvae/1000 m^3 during 1980 and 1 to 42 damaged larvae/1000 m^3 during 1981. Only a few samples from 1980 and 1981 had more than 40 damaged larvae/1000 m^3 (Tables 41 and 42). Highest densities of damaged larvae in Units 1 and 2 entrainment samples were observed from mid-June to mid-July in 1980 and during mid-June and mid-August in 1981 (Tables 41 and 42). Most damaged larvae occurred at Units 1 and 2 when alewife and spottail shiner larvae were most abundant.

Densities of damaged larvae in entrainment samples collected at Unit 3 were also low with 11 of the 12 occurrences being less than 40 larvae/1000 m^3. Using the same technique that was applied to field larvae samples, the percent contribution of damaged larvae to densities of identified larvae, in the same samples, was also low; less than 15%, in 92% of the samples. The highest densities of damaged larvae in Unit 3 entrainment samples occurred in mid-June (Fig. 51) when alewives and yellow perch were the most abundant species in entrainment samples (Table 28).

All damaged larvae from Unit 3 samples were small, with most less than or equal to 5 mm (Fig. 50). A substantial number of damaged larvae larger than 5 mm, however, occurred in Units 1 and 2 entrainment samples during 1980 and 1981.

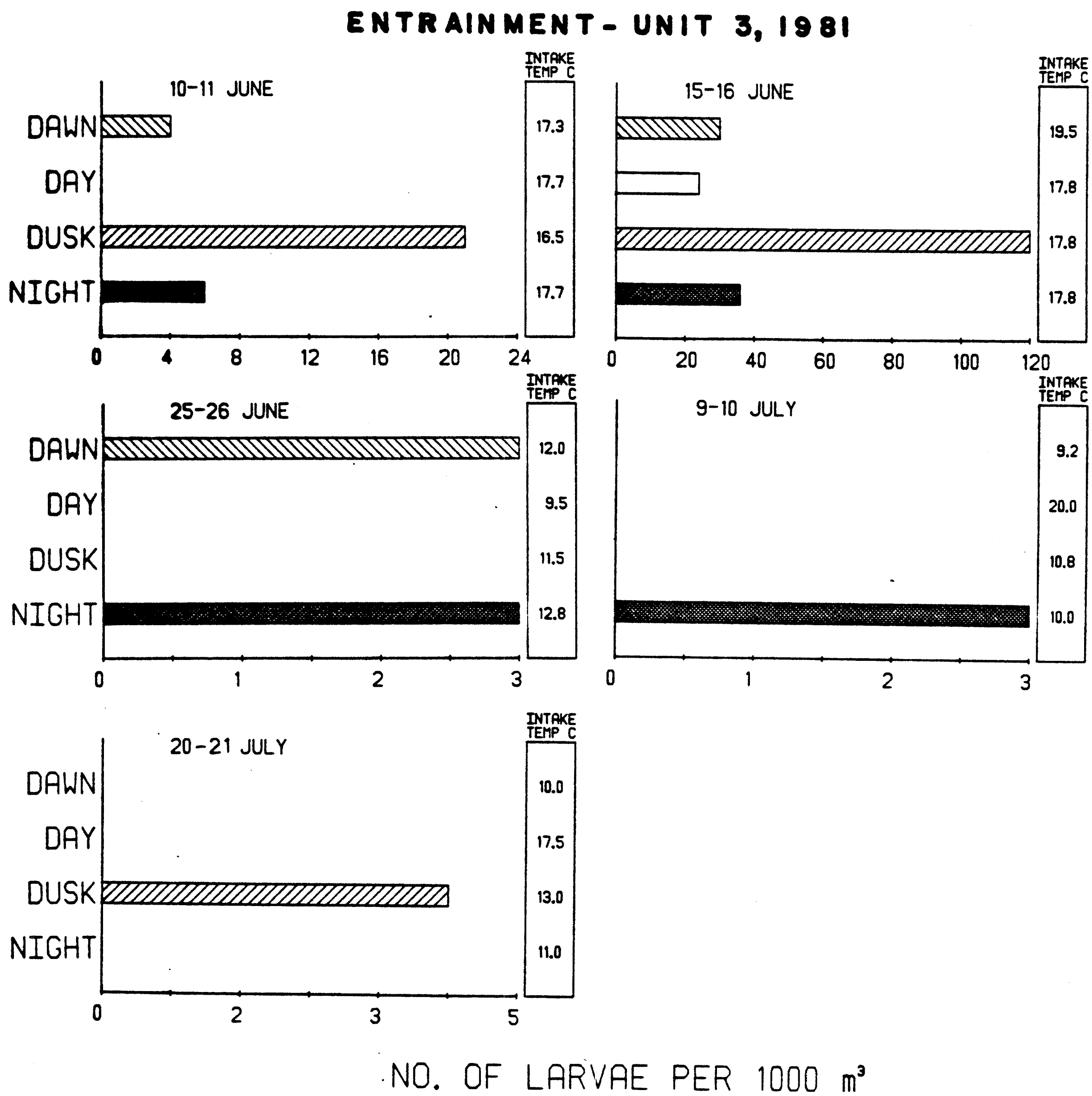


Fig. 51. Density of damaged larvae (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at Unit 3 of the J. H. Campbell Plant, eastern Lake Michigan, 1981.

FISH EGGS

Introduction

Most fish eggs collected in our samples were nondescript in appearance and similar in diameter, thus were not identified to the species level. However, based on biology of indigenous species, we speculated on their identity. We feel that the majority of fish eggs in our samples were those of alewives and spottail shiners. Evidence for this contention is that alewife larvae and spottail shiner larvae comprised the vast majority of larvae collected in our samples. Additional species which are thought to spawn in the study area are yellow perch, trout-perch, rainbow smelt, emerald shiner, burbot, slimy sculpin, ninespine stickleback, johnny darter, white sucker, longnose sucker, gizzard shad, lake trout and coregonines. Since slimy sculpins and ninespine sticklebacks lay their adhesive eggs within nests and johnny darters lay their adhesive eggs on the bottom of submerged objects, it was unlikely that we sampled the eggs of these species. White suckers and longnose suckers were more apt to spawn in streams and also have comparatively larger eggs which would facilitate identification. Trout-perch eggs are large and contain an oil globule which would aid in distinguishing them from alewife or spottail shiner. Burbot eggs are considered to occur in the study area in late winter or early spring (Jude et al. 1981a). However, most eggs counted in our samples were collected in late spring and in summer and thus were not burbot eggs. Eggs of emerald shiners have a large perivitelline space which would enable them to be identified. Eggs of yellow perch and smelt are highly characteristic and could be easily recognized. Lake trout and coregonine eggs are large (>5 mm and 3 mm respectively). Gizzard shad eggs could possibly be in our samples, but spawning adults have not been observed in the study area, except for the discharge canal.

Additional evidence, circumstantial though it may be, supporting the argument that most fish eggs collected were from alewives and spottail shiners, was provided by a few samples with larvae collected (and preserved) in the act of emerging from their eggs. These samples contained a relatively high number of eggs and were predominated by recently hatched alewife larvae or by recently hatched spottail shiner larvae; the few larvae in the act of breaking out of their eggs were clearly identified as the predominant species of larvae in that sample (either alewives or spottail shiners).

Statistically higher densities of fish eggs were sampled by the benthic sled than by the plankton net. Using ANOVA and the Wilcoxon signed ranks test, it has been shown that the mean density for the sled tow was significantly higher than the mean density for the plankton net tow performed closest to bottom for each of the years 1978 through 1980.

Seasonal Distribution

At the north transect during 1981, fish eggs were first collected during the early May sampling period (Fig. 52). Egg densities ranged from 25 to 564/1000 m^3 in day sleds at 1- and 1.5-m stations and a night sled at the 12-m station. These eggs may be the result of spawning activity in the Units 1 and 2 intake canal; eggs may have passed through the plant and were then discharged into the lake, as was suspected in previous years 1977-1980 (Jude et al. 1981a). Another possibility is that a few alewives or spottail shiners were spawning in the vicinity of the discharge in Lake Michigan. Spawning and subsequent egg dispersal may have been influenced by water flow, temperature and the riprap. Relatively low densities of fish eggs were observed at the beach to 3-m station at the south transect in early May (Fig. 52); these eggs may have been the result of low spawning activity in Lake Michigan or were discharged into the lake from inland sources. A few of these eggs collected in early May at both transects were stalked, indicating spawning by rainbow smelt in the general vicinity.

Eggs were next collected during early June when they were recovered in a night sled tow sample at station R (north, beach), a day sled at station P (south, beach) and a night sled at station E (12 m, south) (Fig. 52). This early June density was relatively low and the eggs collected were the result of some early spawning, possibly in Lake Michigan, by a few individuals, most likely alewives or spottail shiners.

In mid-June relatively high densities of eggs were observed at both transects (Fig. 52). In general, substantially higher densities were observed at night, and eggs were more concentrated from the beach to 9 m. Eggs were recovered from samples throughout the water column (from surface to lake bottom), but in general, the highest densities were found in sled tows rather than in plankton net tows. Alewife larvae, like fish eggs, were concentrated from the beach to 9 m during the mid-June sampling period (Fig. 14). Almost all alewife larvae collected at this time were recently hatched (Fig. 15); also highest densities of alewife larvae at both transects were observed at this time. Spottail shiner larvae (almost all newly hatched) occurred in relatively high densities during mid-June but were very concentrated between the beach and 3 m (Fig. 23). Thus data suggest that most eggs collected from 6 to 9 m were alewife eggs, while both alewife and spottail shiner eggs probably comprised eggs collected from the beach to 3 m. During 1977 through 1979 almost all eggs sampled were found from the beach to 3 m.

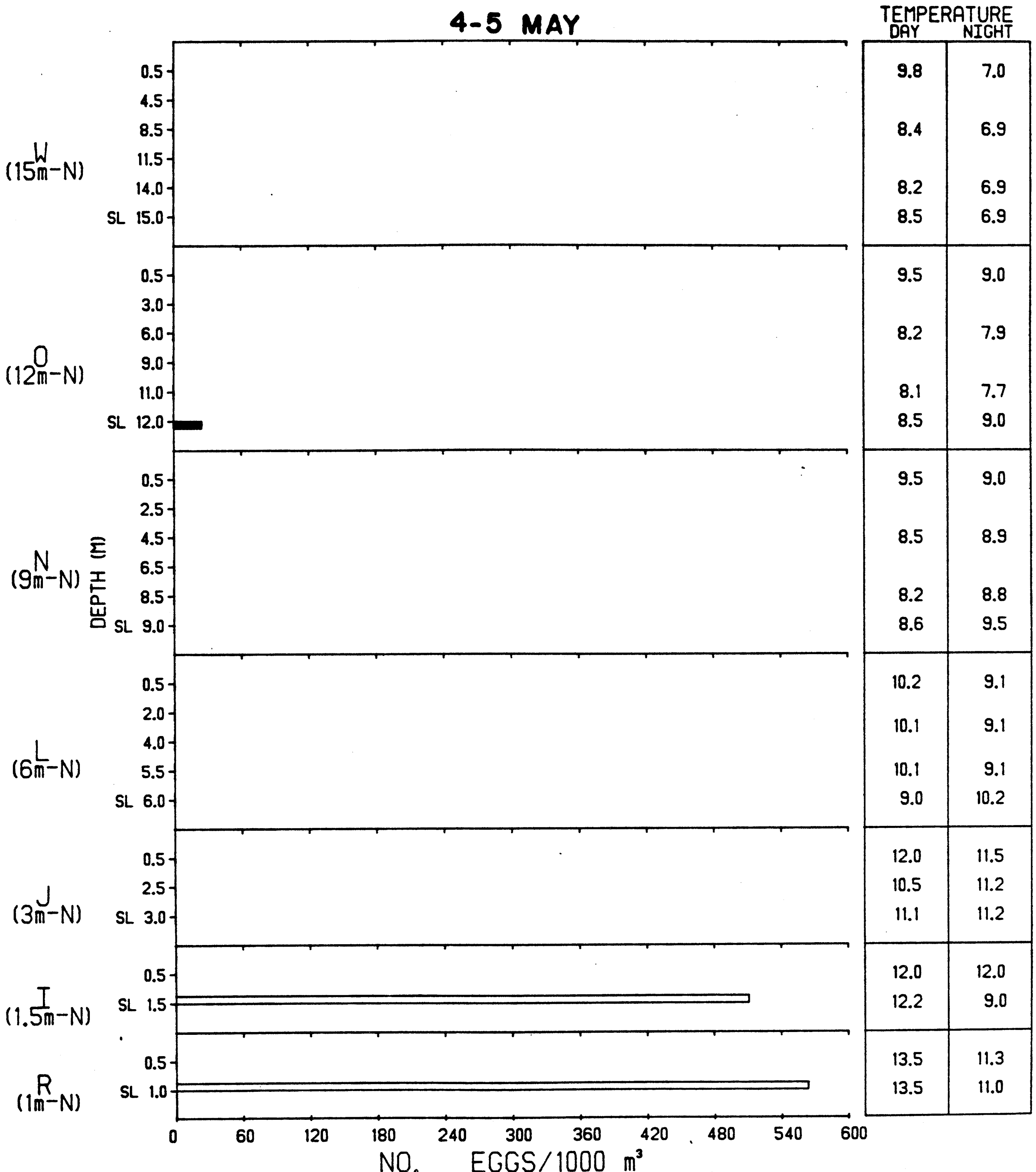
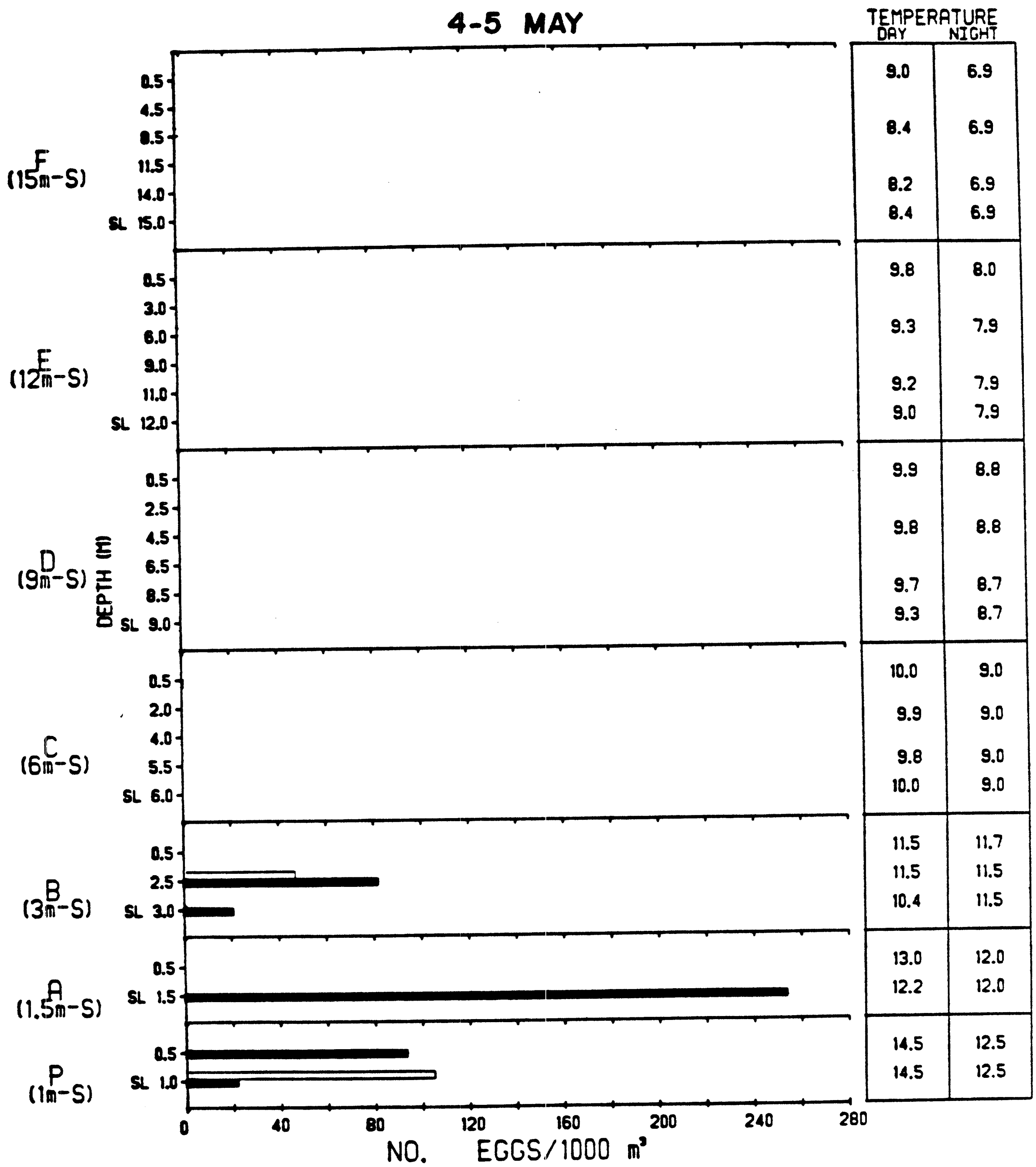


Fig. 52. Density of fish eggs (no./1000 m^3) at north and south transect stations near the J. H. Campbell Plant, eastern Lake Michigan, May-September 1981. □ = day, ■ = night, SL = sled.



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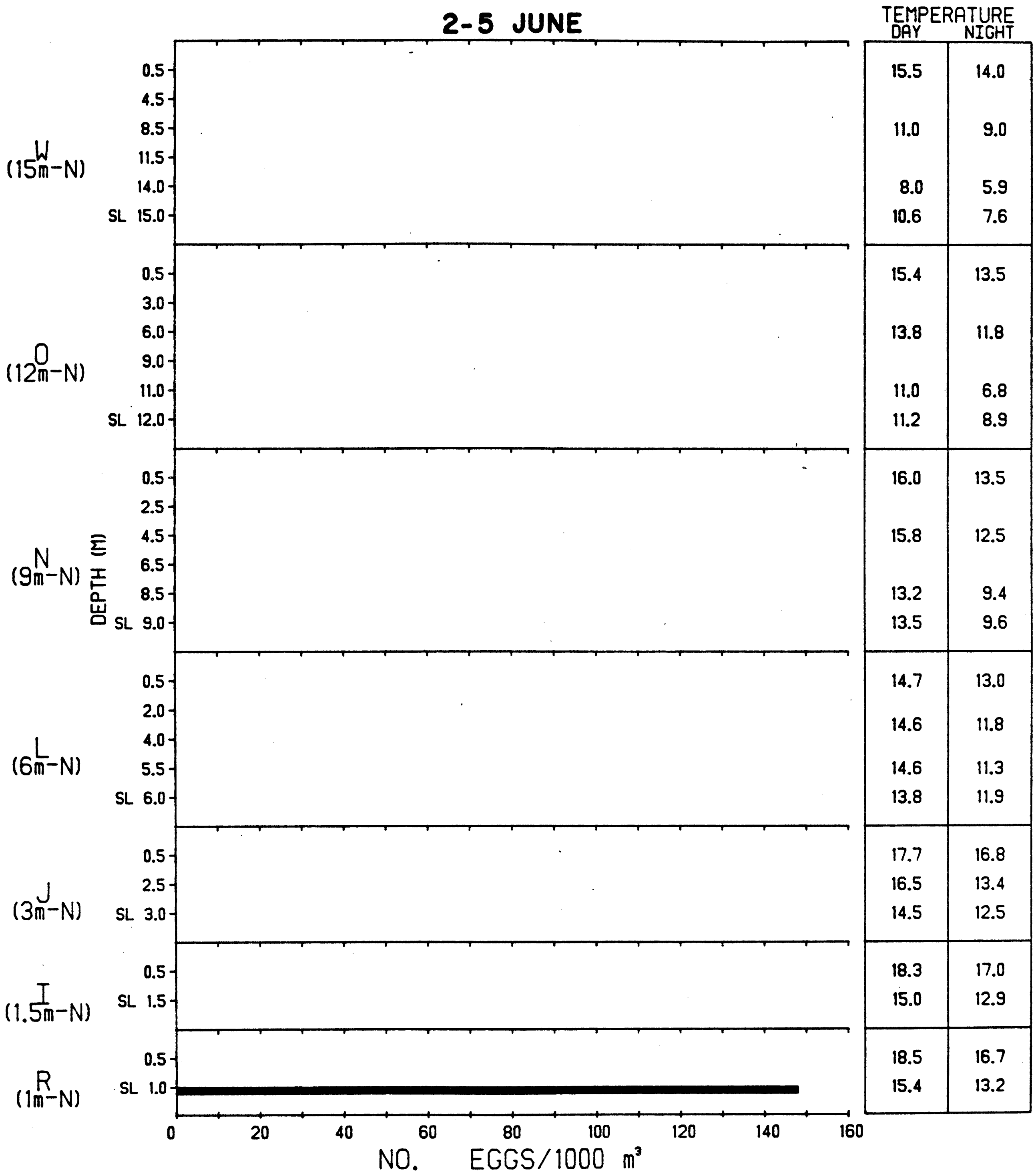
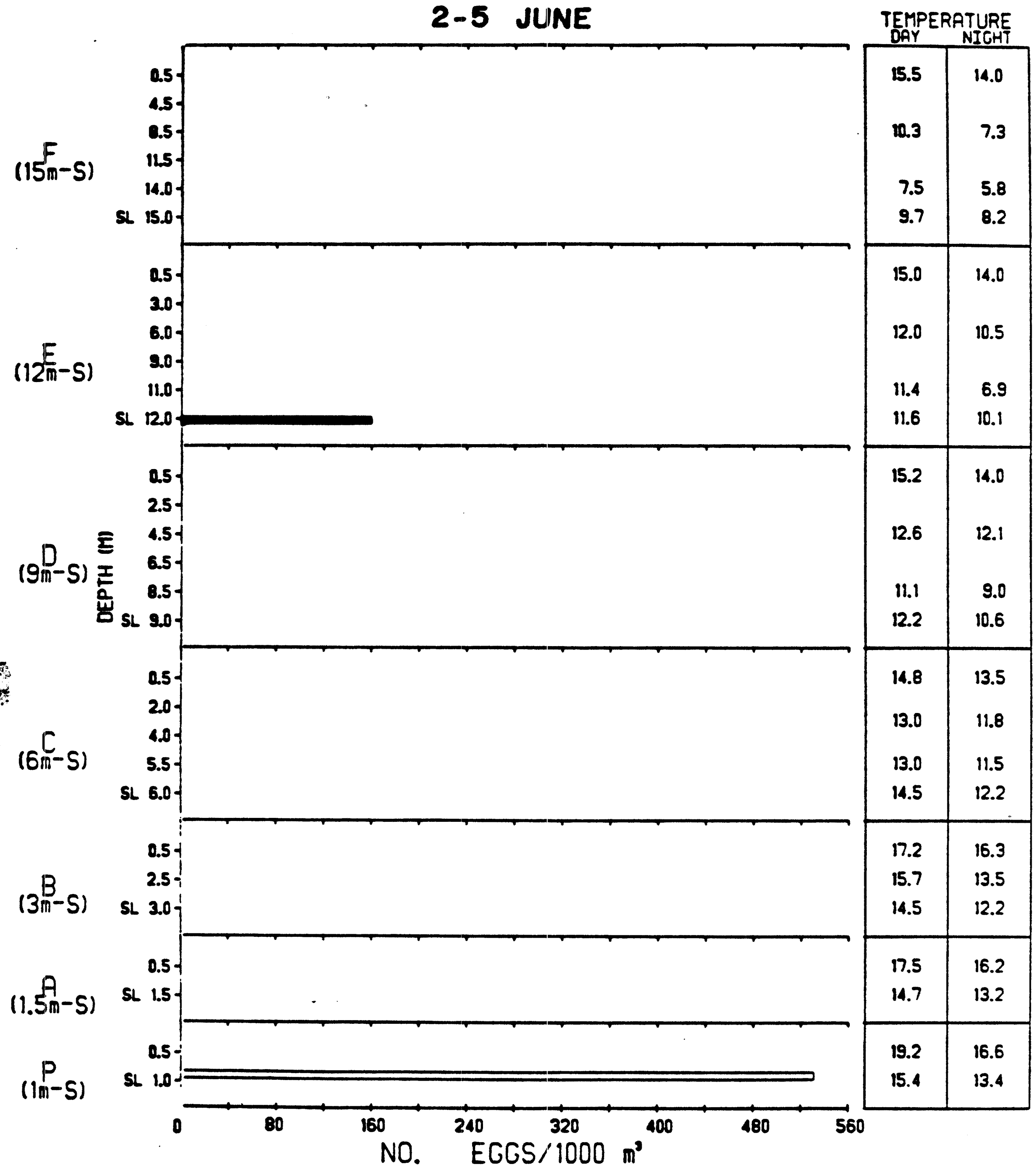


Fig. 52. Continued.



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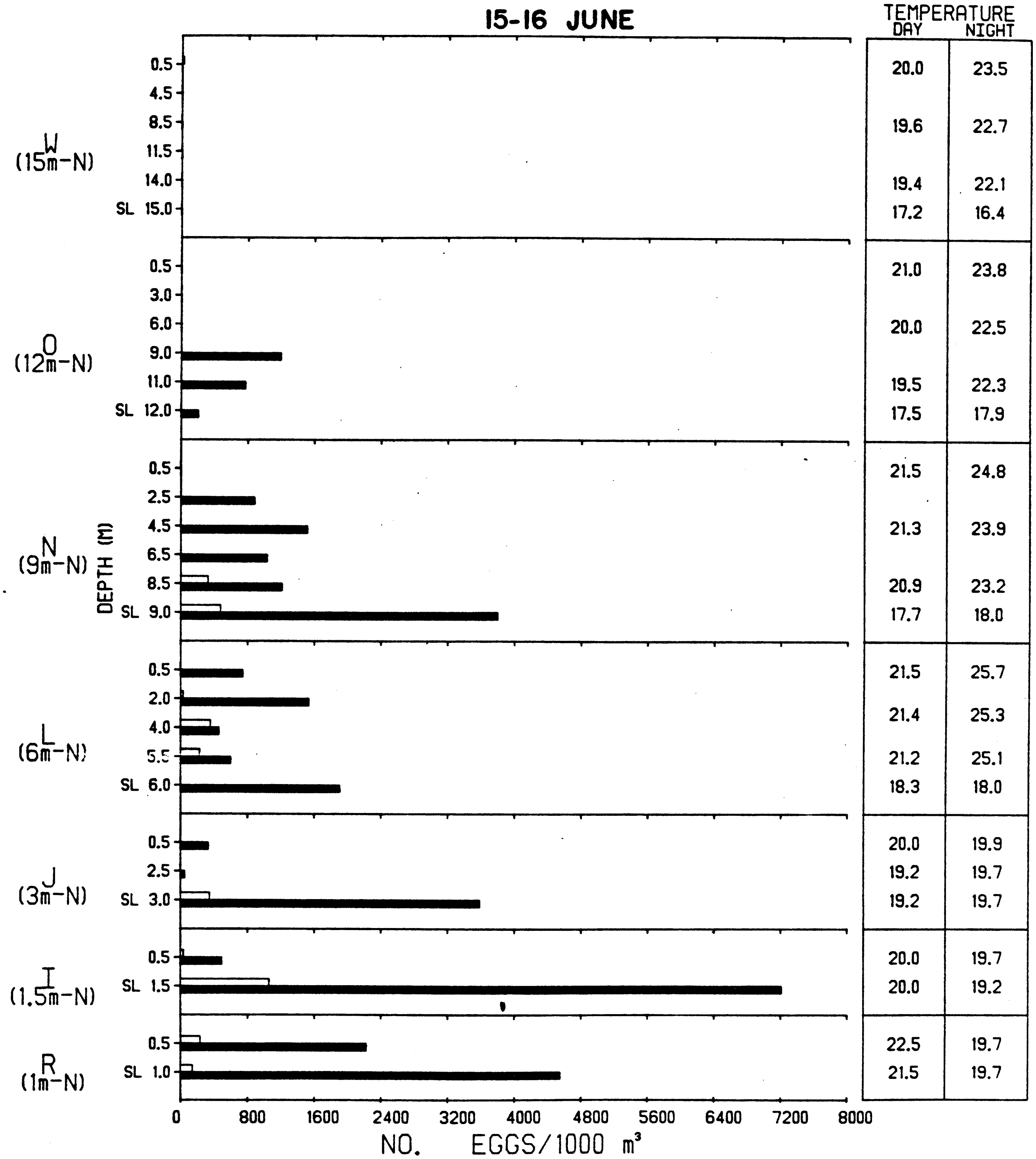

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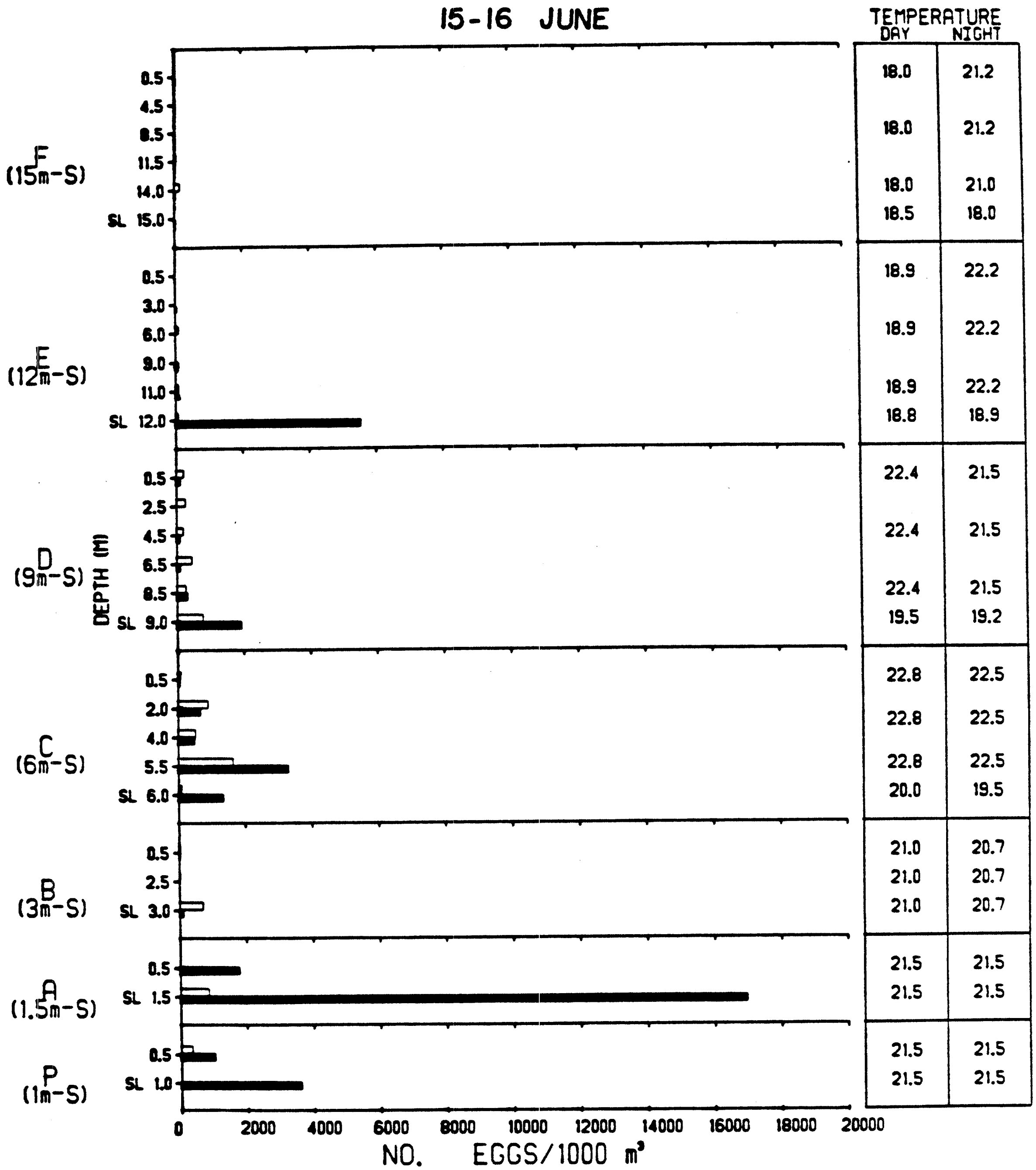

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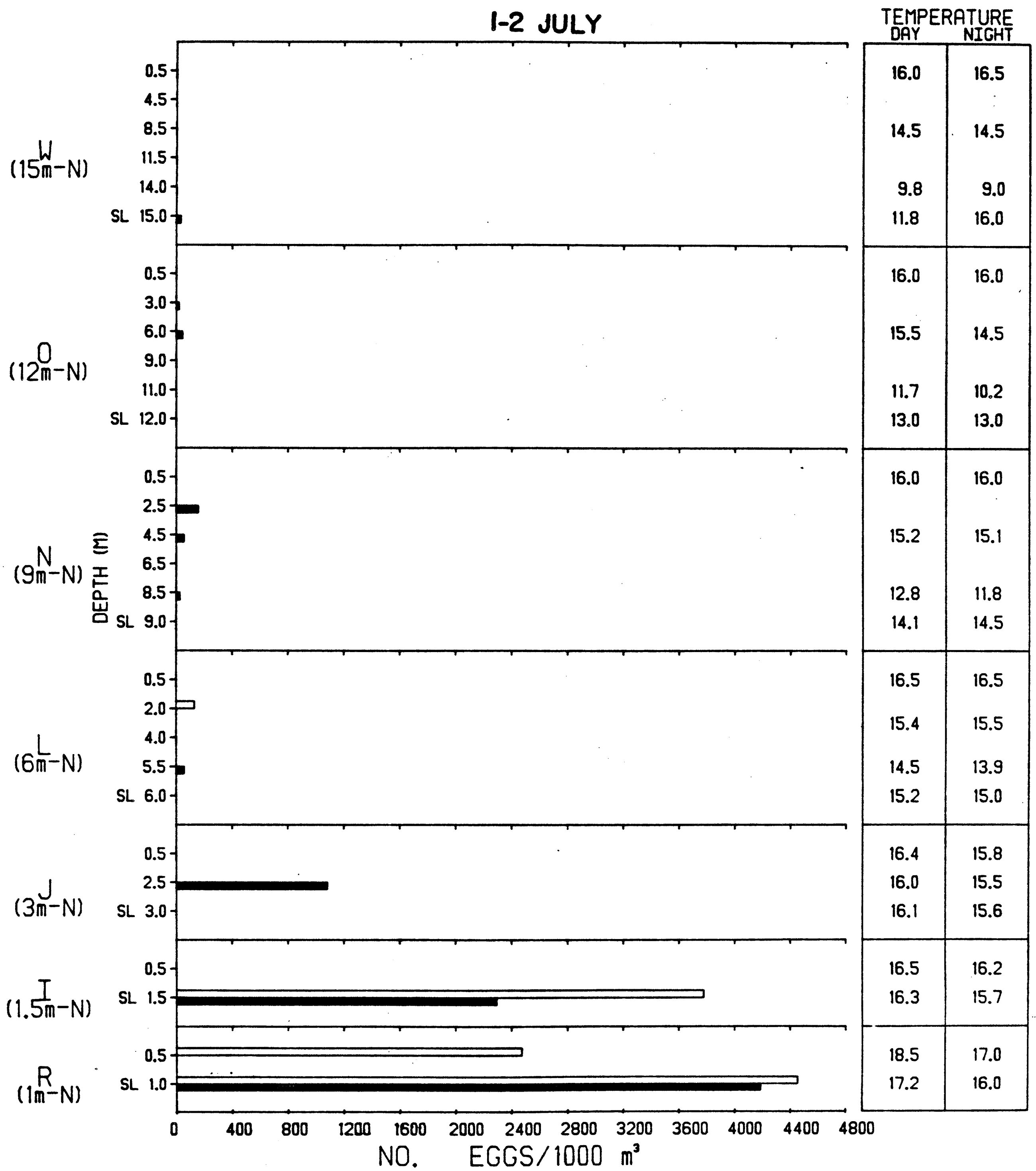

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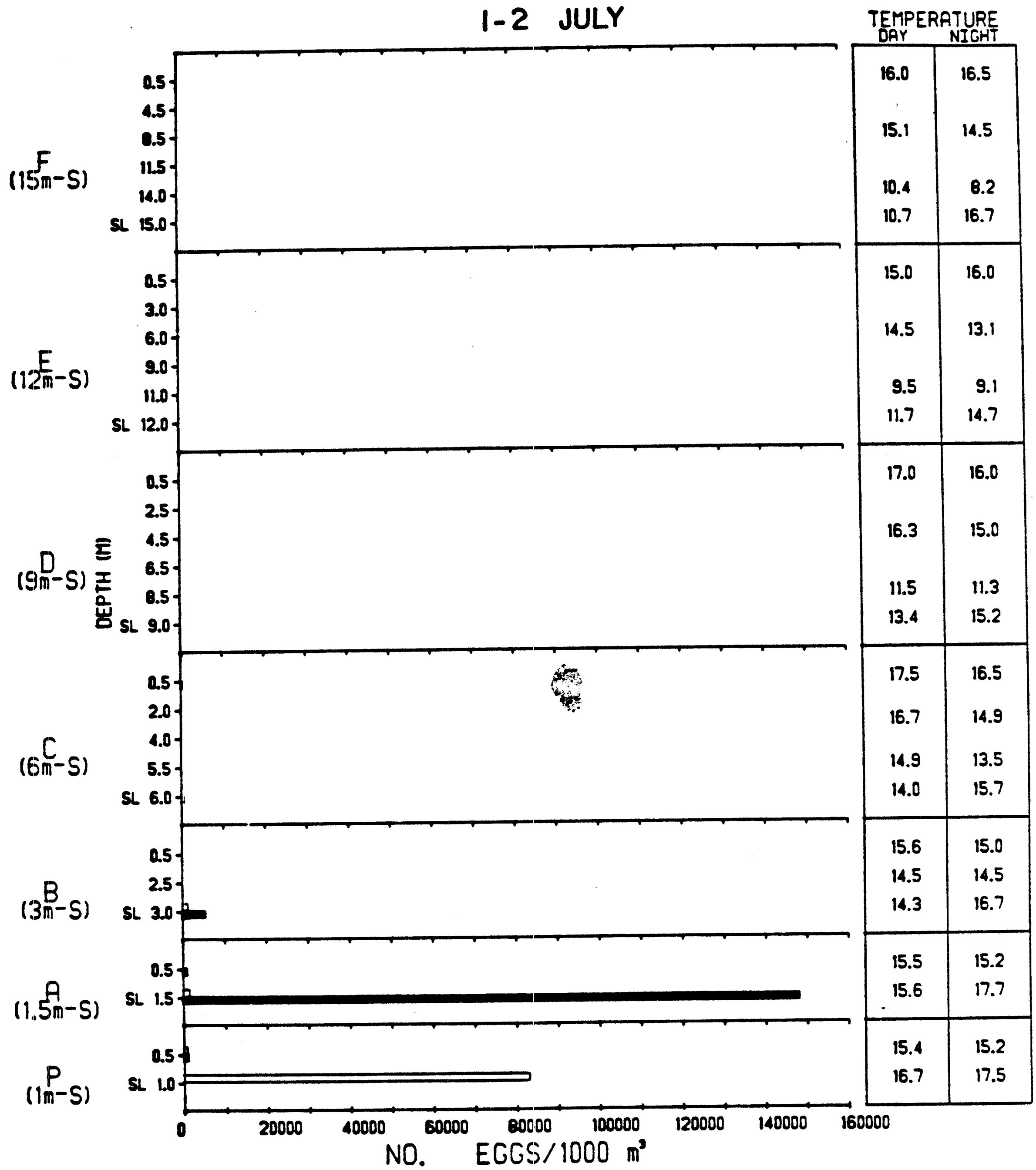

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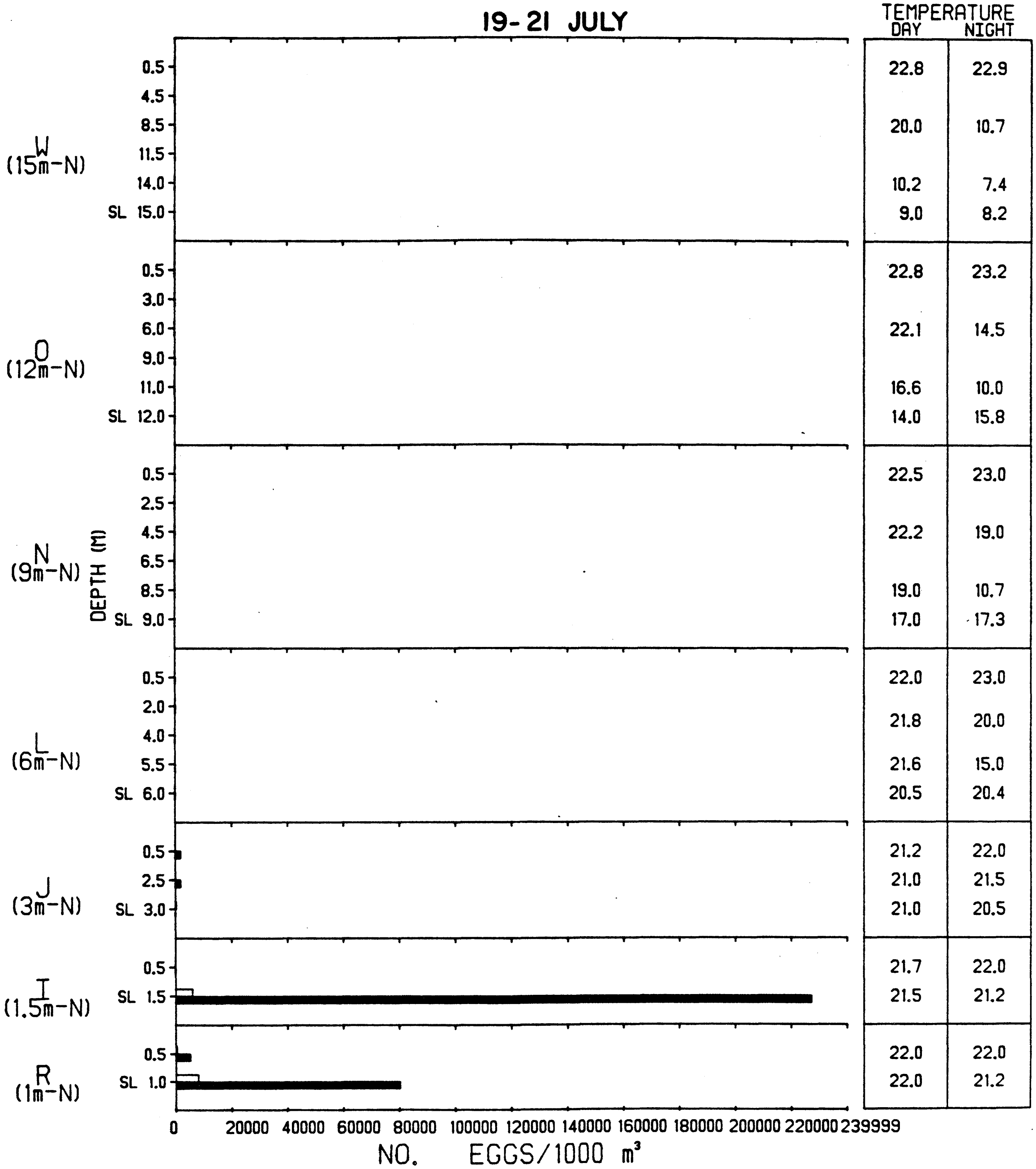

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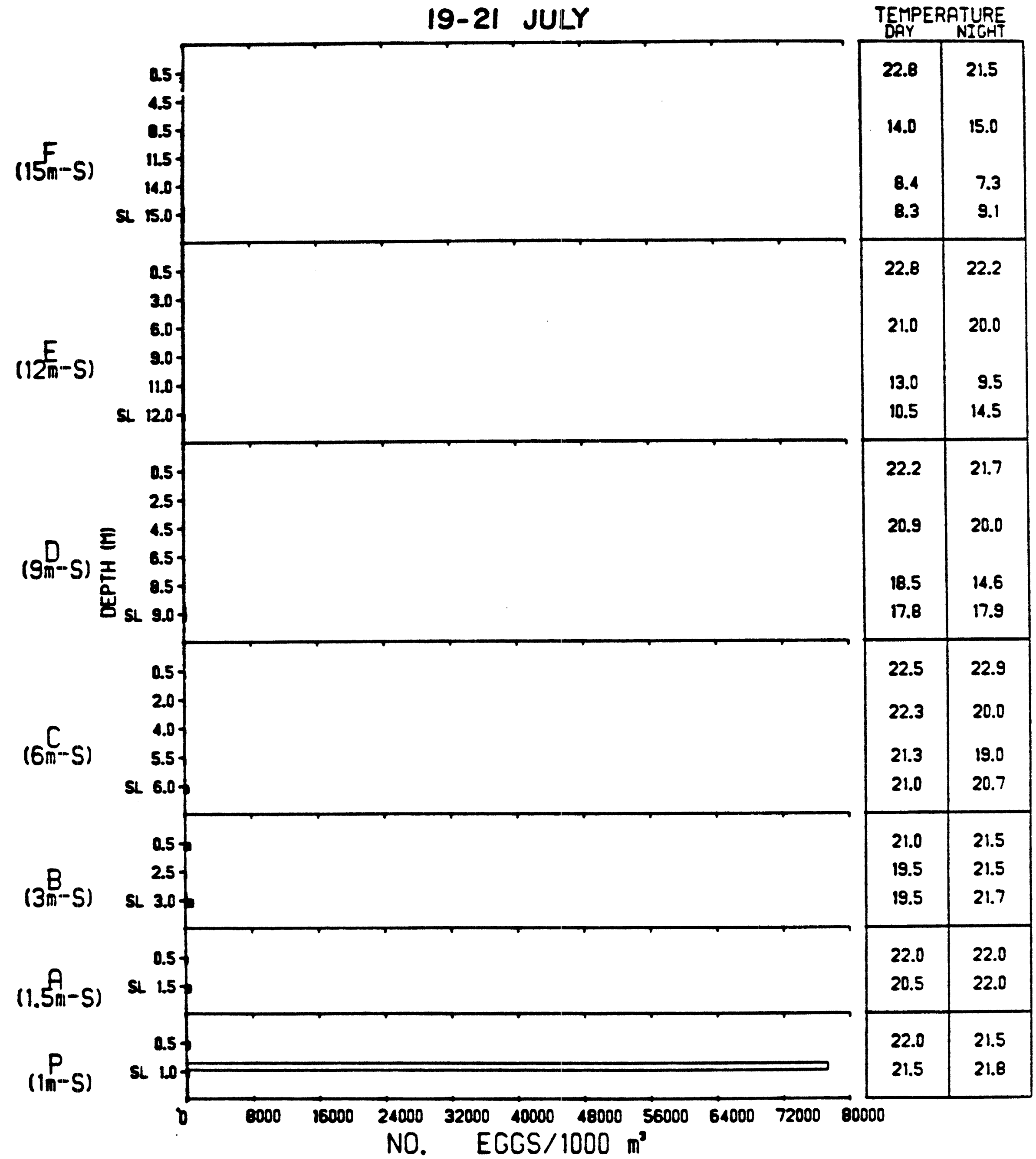

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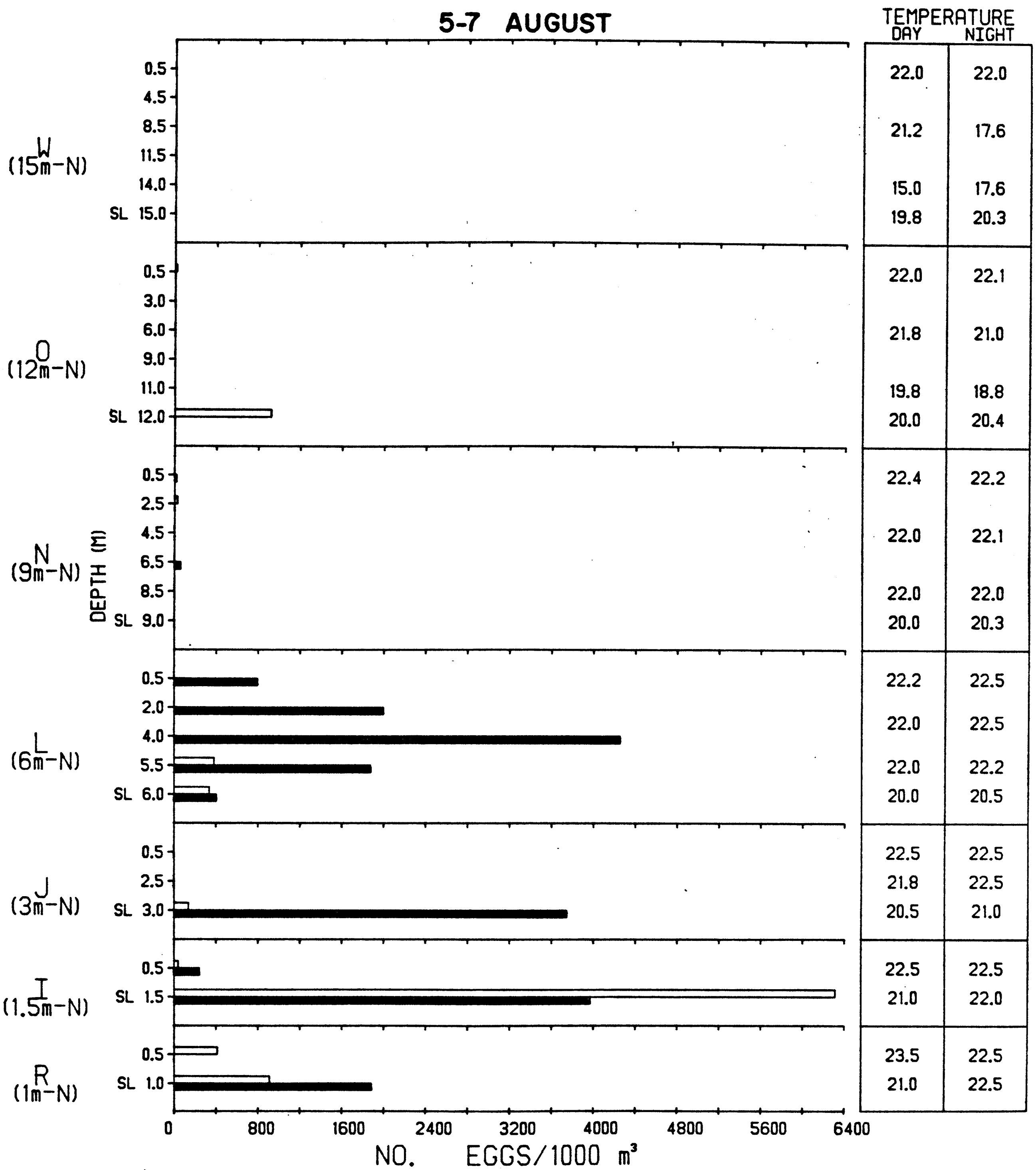

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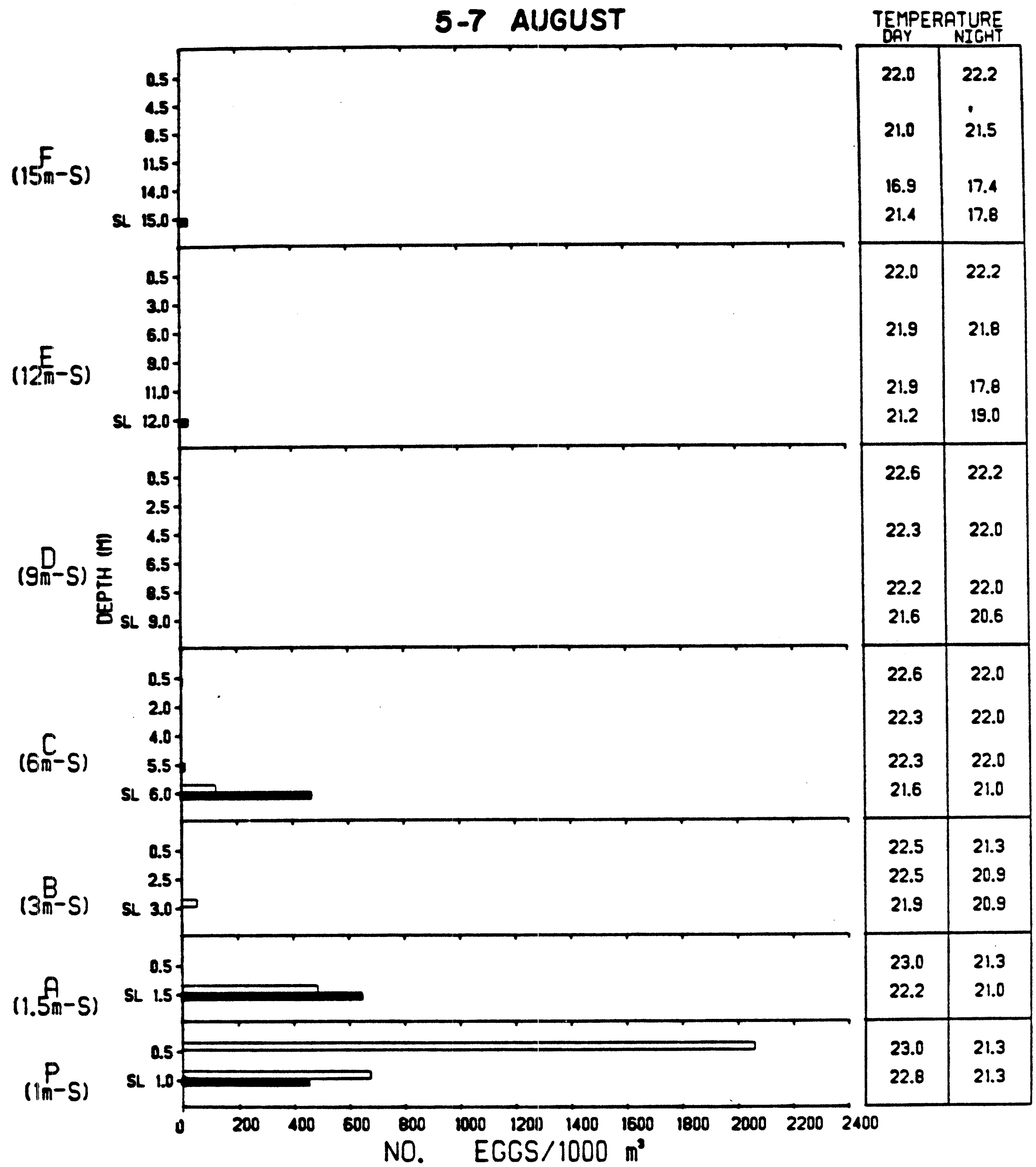

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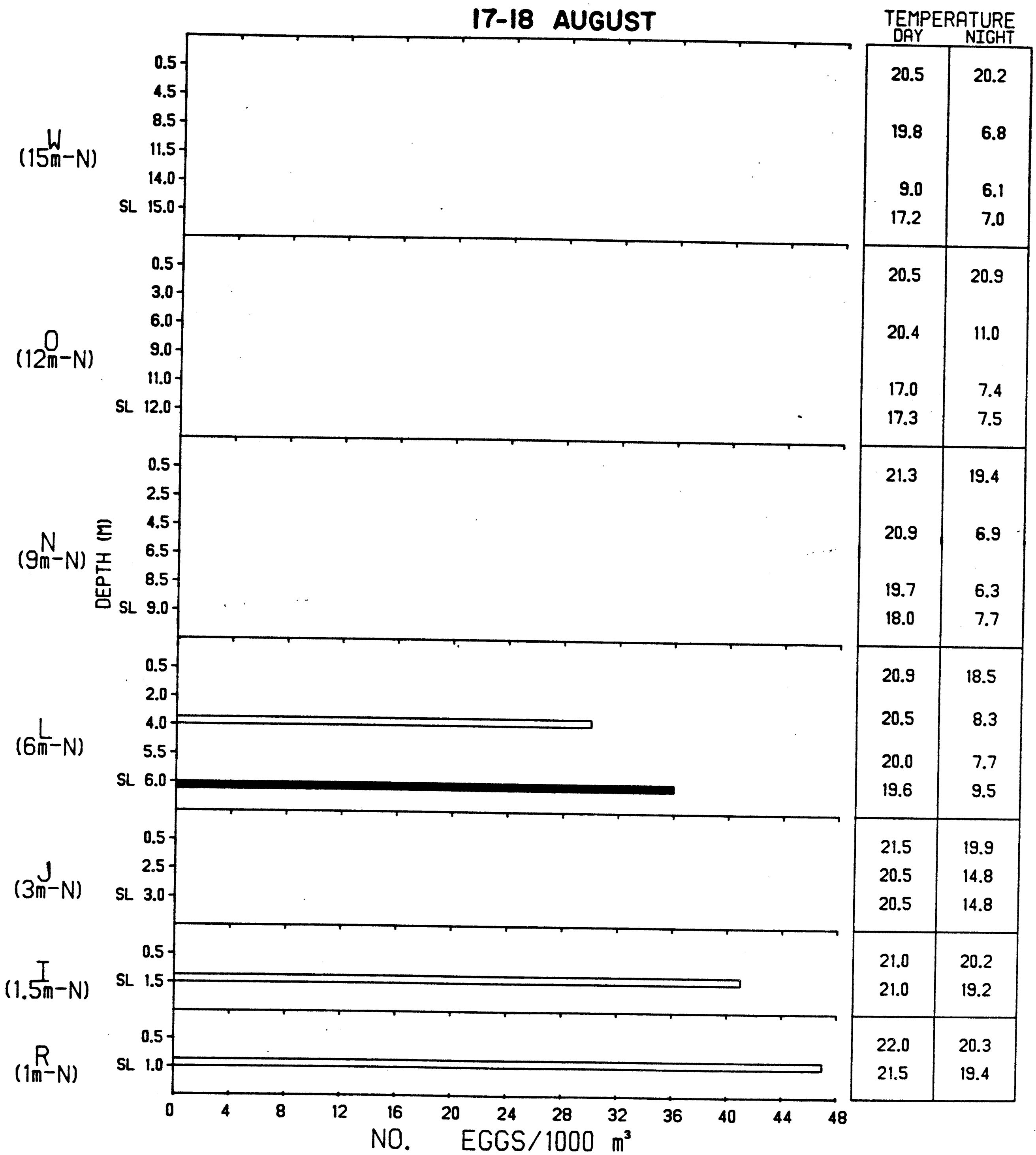
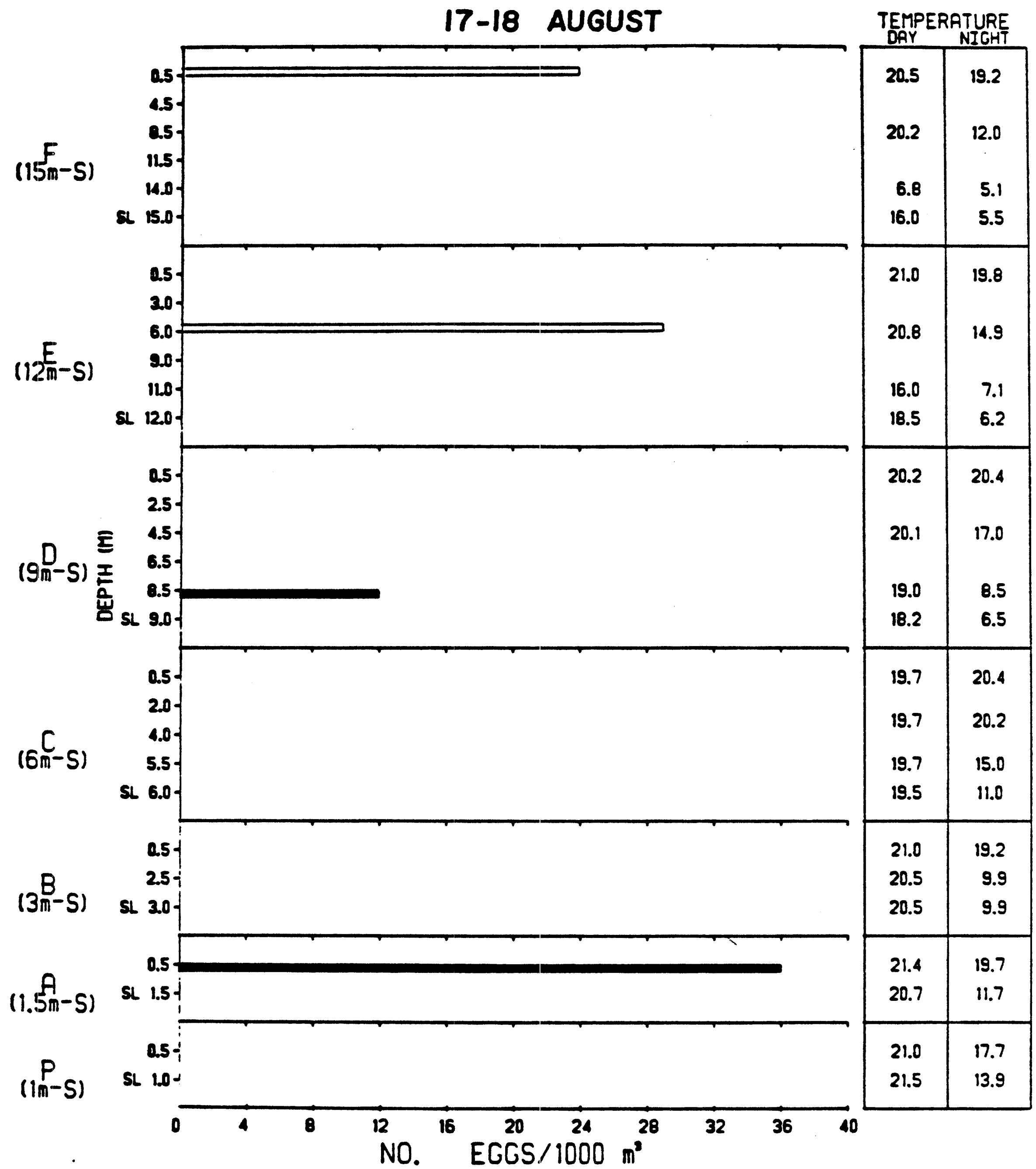


Fig. 52. Continued.



Station	Depth (m)	Day	Night
F (15m-S)	0.5	20.5	19.2
	8.5	20.2	12.0
	14.0	6.8	5.1
	SL 15.0	16.0	5.5
E (12m-S)	0.5	21.0	19.8
	6.0	20.8	14.9
	11.0	16.0	7.1
	SL 12.0	18.5	6.2
D (9m-S)	0.5	20.2	20.4
	4.5	20.1	17.0
	8.5	19.0	8.5
	SL 9.0	18.2	6.5
C (6m-S)	0.5	19.7	20.4
	2.0–4.0	19.7	20.2
	5.5	19.7	15.0
	SL 6.0	19.5	11.0
B (3m-S)	0.5	21.0	19.2
	2.5	20.5	9.9
	SL 3.0	20.5	9.9
A (1.5m-S)	0.5	21.4	19.7
	SL 1.5	20.7	11.7
P (1m-S)	0.5	21.0	17.7
	SL 1.0	21.5	13.9

Fig. 52. Continued.

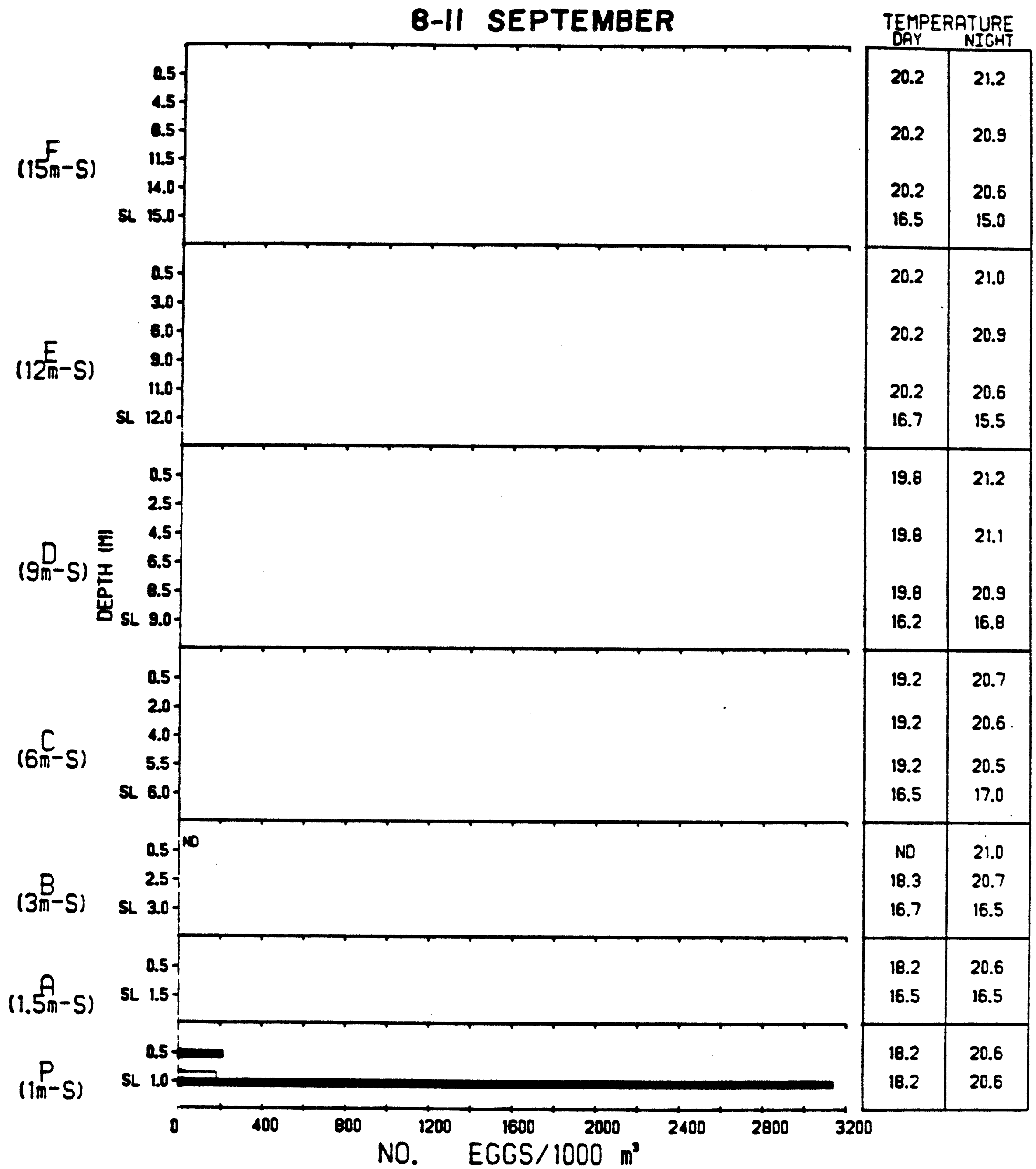


Fig. 52. Continued.

However, relatively high egg densities were observed at 6- and 9-m depths at the north transect during 1980 (Jude et al. 1981a). Again during 1981 (in mid-June and early August) relatively high egg densities were recorded at 6- and 9-m depths at the north transect. The warm-water discharge and the riprap probably encouraged more spawning in the vicinity of the 6- and 9-m stations at the north transect. Note that eggs and larvae from the discharge canal may have been transported offshore by the discharge system. Also in 1980, unlike 1981, relatively high densities of spottail shiner larvae were observed at the 6- and 9-m depth contours at the north transect. The pattern of higher densities at the 6- and 9-m stations in 1980 and 1981 than at these same stations in years 1977 through 1979, was also observed for the south transect. This phenomenon may somehow be related to the switch from onshore to an offshore discharge; this switch occurred between the 1979 and 1980 field sampling seasons.

Considerable egg deposition was indicated in early July 1981; most eggs were collected from the beach to 3 m (Fig. 52). In general, day densities were higher than night densities at the north transect; whereas, at the south transect the highest densities recorded for this sampling period were for the day sled at the beach and the night sled at the 1.5-m station (Fig. 52); indeed, these were the highest densities of fish eggs observed at the south transect for the sampling year. Sampling was performed during an upwelling with decreased water temperatures at night, so spawning was probably interrupted somewhat during early July sampling. Furthermore this concentrated nearshore (beach to 3 m) distribution of fish eggs may have been partially due to the upwelling.

The highest observed egg densities of 1981 for the north transect occurred during the late July sampling period with night sled tow densities of over 80,000 and 227,000/1000 m^3 for beach and 1.5-m stations, respectively (Fig. 52). Indeed eggs were chiefly concentrated in the beach to 1.5-m depth contour region for both transects (Fig. 52). This distribution is well matched by the late July one for spottail shiner larvae. A substantial portion of the spottail shiner larvae in these samples were recently hatched (Fig. 24). Therefore, a considerable portion of these eggs were probably those of spottail shiners.

During early August fish eggs were collected chiefly from the beach to the 6-m depth contour at the north transect (Fig. 52). Densities were higher at night in general, although highest density was for a day sled at the 1.5-m station. The distribution pattern exhibited by fish eggs was quite similar to that for alewife larvae (most of which were newly hatched), suggesting a good percentage of these eggs were alewife eggs. Densities of fish eggs in early August at the south transect, with the exception of the beach station, were substantially less than those corresponding densities at the north transect (Fig. 52). Reasons for the transect difference during this sampling period and no differences during the other sampling times were not clear.

In late August egg densities were relatively low at both transects. No eggs were collected in September field sampling at the north transect, although alewife spawning may have continued through late August and early September based on alewife larvae data. Eggs were recovered from the beach station at the south transect during September (Fig. 52).

During years 1977 through 1980 the density of fish eggs at the north transect was significantly greater than that at the south transect (Jude et al. 1981a). However, in 1981 no overall difference between the densities of fish eggs for both transects was detected using the Wilcoxon signed ranks test (see METHODS-STATISTICS, Wilcoxon Test). Indeed, the fish egg densities matched each other fairly closely between the two transects throughout the sampling year, with the exception of early August. Entrainment data indicated that fish eggs were concentrated in the immediate area of the intake-discharge complex. Perhaps the operation of the Unit 3 intake during 1981 affected the distribution of fish eggs such that eggs were most dense in the immediate vicinity of the riprap and intake and discharge structures but density declined rapidly from the intake structure area, causing densities at the north transect sampling area to be similar to those for the south transect. To keep the lack of a density difference between transects during 1981 in perspective, it must be pointed out that 1981 was a relatively poor year for fish egg abundance in general. Densities of fish eggs observed in field and Units 1 and 2 entrainment samples were considerably higher in years 1978 through 1980 than in 1981, most likely due to frequent upwellings during 1981.

Entrainment

Units 1 and 2, 1980--

Fish eggs in low densities were entrained during mid-February 1980 at Units 1 and 2 (Fig. 53). These eggs were probably those of burbot, which are known to spawn in winter. The next eggs collected in entrainment samples were in early May and were probably the result of early spawning in Lake Michigan or Pigeon Lake; egg densities were low. The first observation of substantial entrainment of fish eggs was for 5-6 June when over 900,000 eggs were estimated entrained and on 19-20 June when over 500,000 eggs were estimated entrained (Appendix 11). Most of these eggs were believed to be alewife and spottail shiner eggs. Night densities were relatively high during these sampling periods, although not the highest for the 24-h periods. Observed peak entrainment of fish eggs occurred on 24-25 June when over 37 million eggs were estimated entrained for the 24-h period. Judging from the densities of fish larvae for this sampling period and the subsequent period (2-3 July), a considerable portion of these eggs were carp eggs; however, most were probably alewife and spottail shiner eggs (Appendix 11). A secondary peak was recorded for 8-9 July when over 11 million eggs were estimated entrained during the 24-h period; almost all of these eggs were alewife and spottail shiner eggs. Fish eggs were last recovered from entrainment samples performed on 16-17 July. From 24-25 June to this time the night entrainment density of eggs was roughly at least one order of magnitude greater than the next highest density for the diel periods sampled (Fig. 53).

Units 1 and 2, 1981--

First record of fish eggs at Units 1 and 2 during 1981 was for 22-23 April, probably the result of limited, early spawning inland or in Lake Michigan (Fig. 53). Fish eggs were entrained sporadically and in low densities during late April through the end of May at Units 1 and 2 (Fig. 53). During 4-5 June, substantial egg entrainment occurred with an estimated 116,000 entrained. Maximum 24-h entrainment of fish eggs at Units 1 and 2 during 1981 was recorded on 11 June when over 1.1 million eggs were estimated entrained; coincidentally, egg entrainment peaked for Unit 3 at over 9 million eggs (Appendixes 12, 14). A secondary entrainment peak was observed in early July; on 1 July an estimated 838,134 eggs were entrained at Units 1 and 2. At Unit 3 this secondary peak extended through the first 2 wk of July, while at Units 1 and 2, relatively few eggs were entrained on 9 July and 15 July (Appendixes 12, 14; Fig. 53). Eggs at Units 1 and 2 were next collected during 6 August; density of eggs was low (Fig. 53). No fish eggs were collected again at Units 1 and 2 until 27 October when a low density (4/1000 m^3) was recorded.

Unit 3--

No eggs were collected at Unit 3 during 1981; few were expected since collection began in September. In Unit 3 entrainment sampling during 1981, eggs were first collected in mid-March (Fig. 53). These eggs were probably those of burbot, as were the eggs collected in late March (Jude et al. 1981a). Eggs were not collected in Unit 3 entrainment samples again until the latter half of April and were observed in relatively low densities from just after mid-April until mid-May (Fig. 53). These eggs probably were spawned in the discharge canal or the intake canal of Units 1 and 2 and were carried offshore into Lake Michigan by the discharge system. A few fish may have spawned in Lake Michigan in the area of the discharge also. Eggs were not collected in Unit 3 entrainment samples again until early June

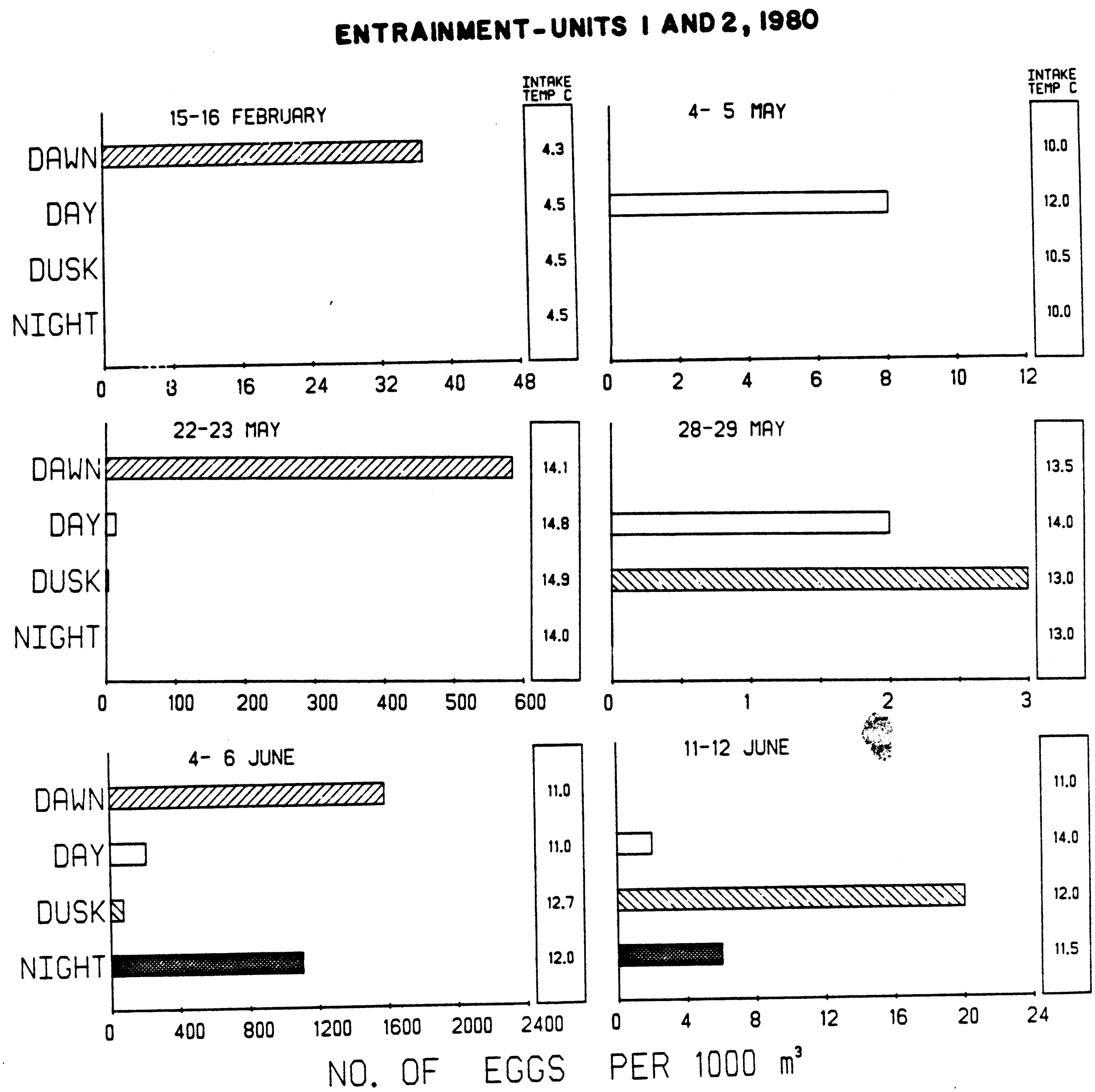
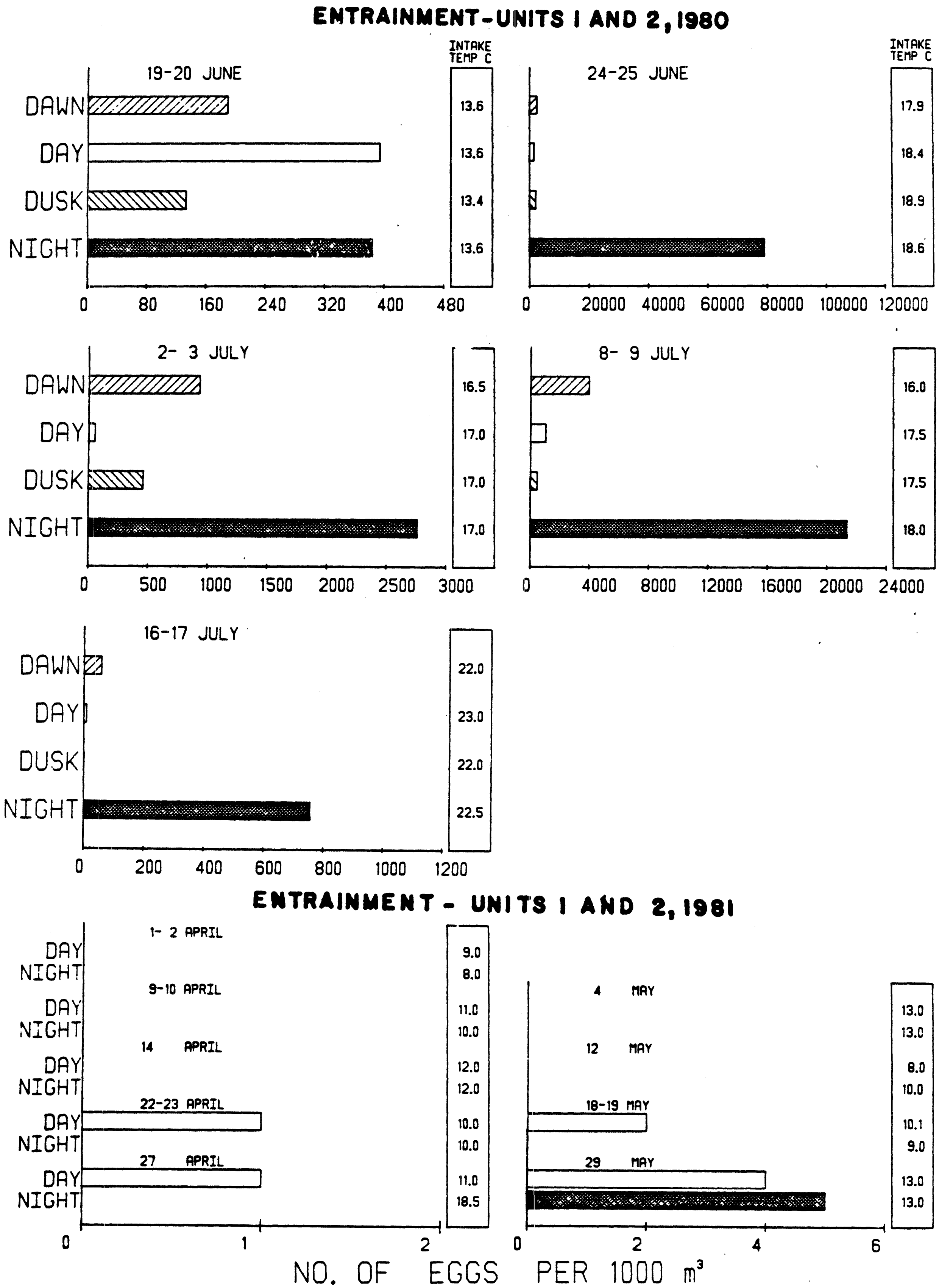


Fig. 53. Density of fish eggs (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at Units 1 and 2 and Unit 3 of the J. H. Campbell Plant, during 1980 and 1981. Only day and night densities were shown for Units 1 and 2 during 1981.



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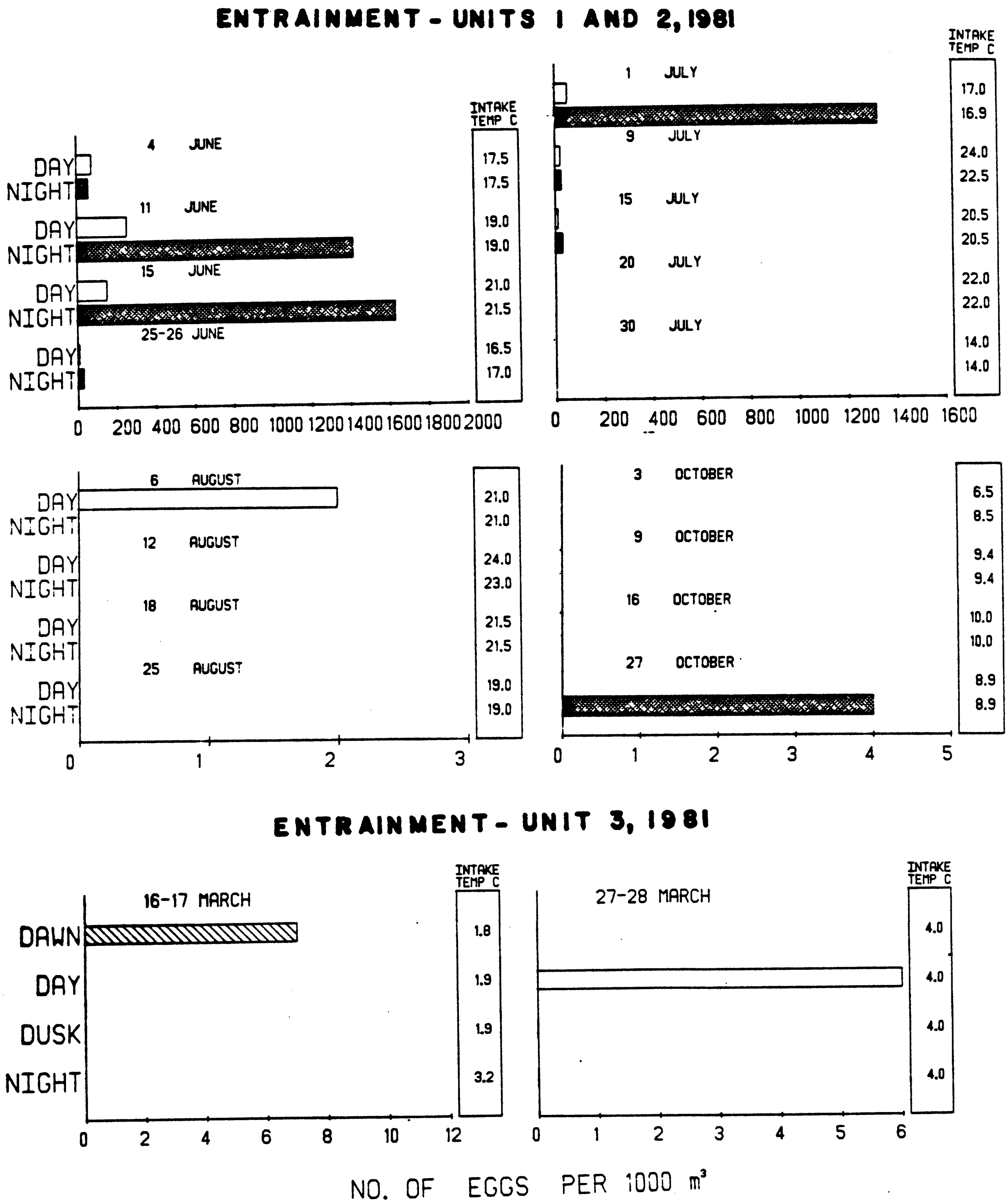

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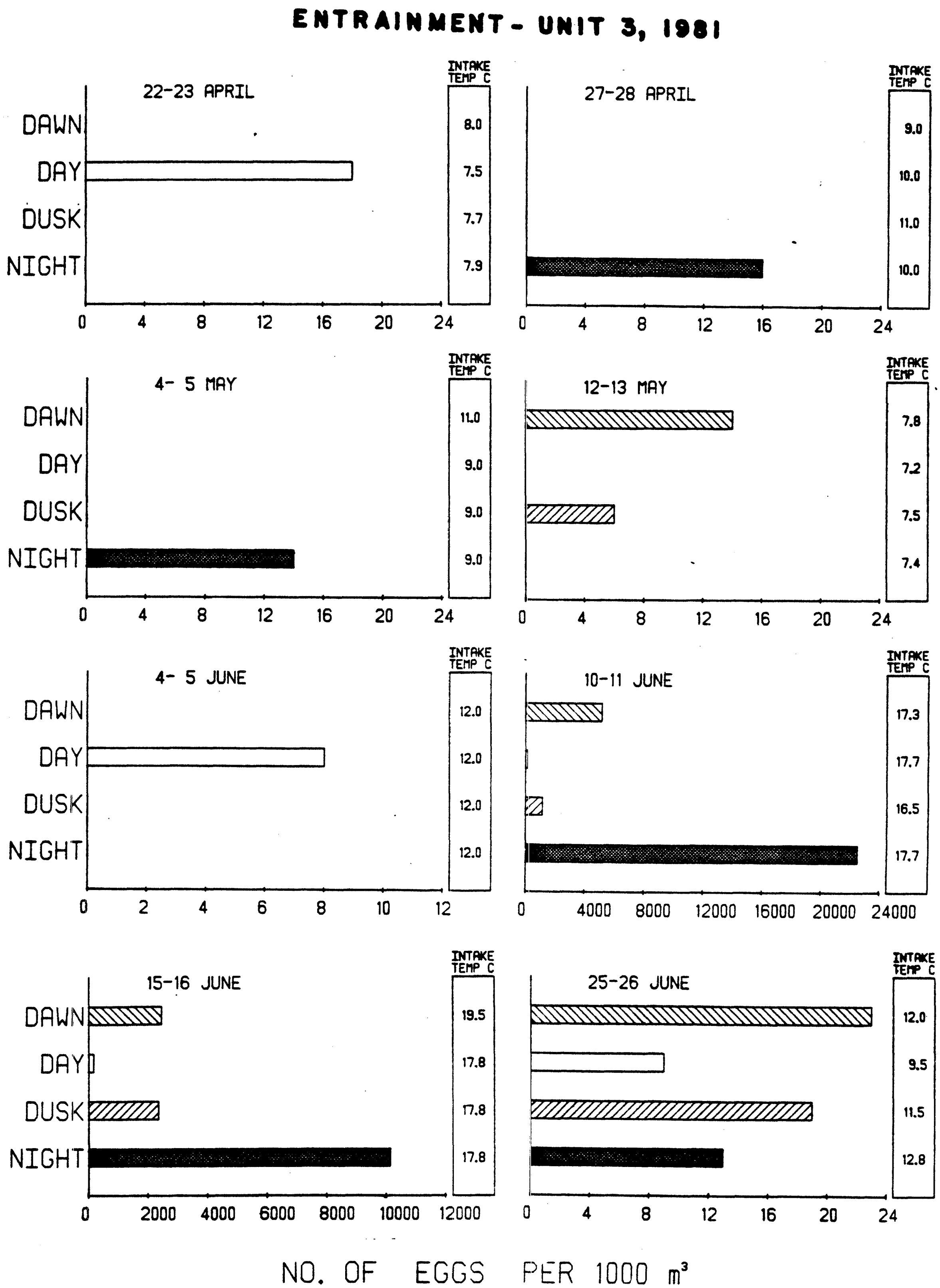

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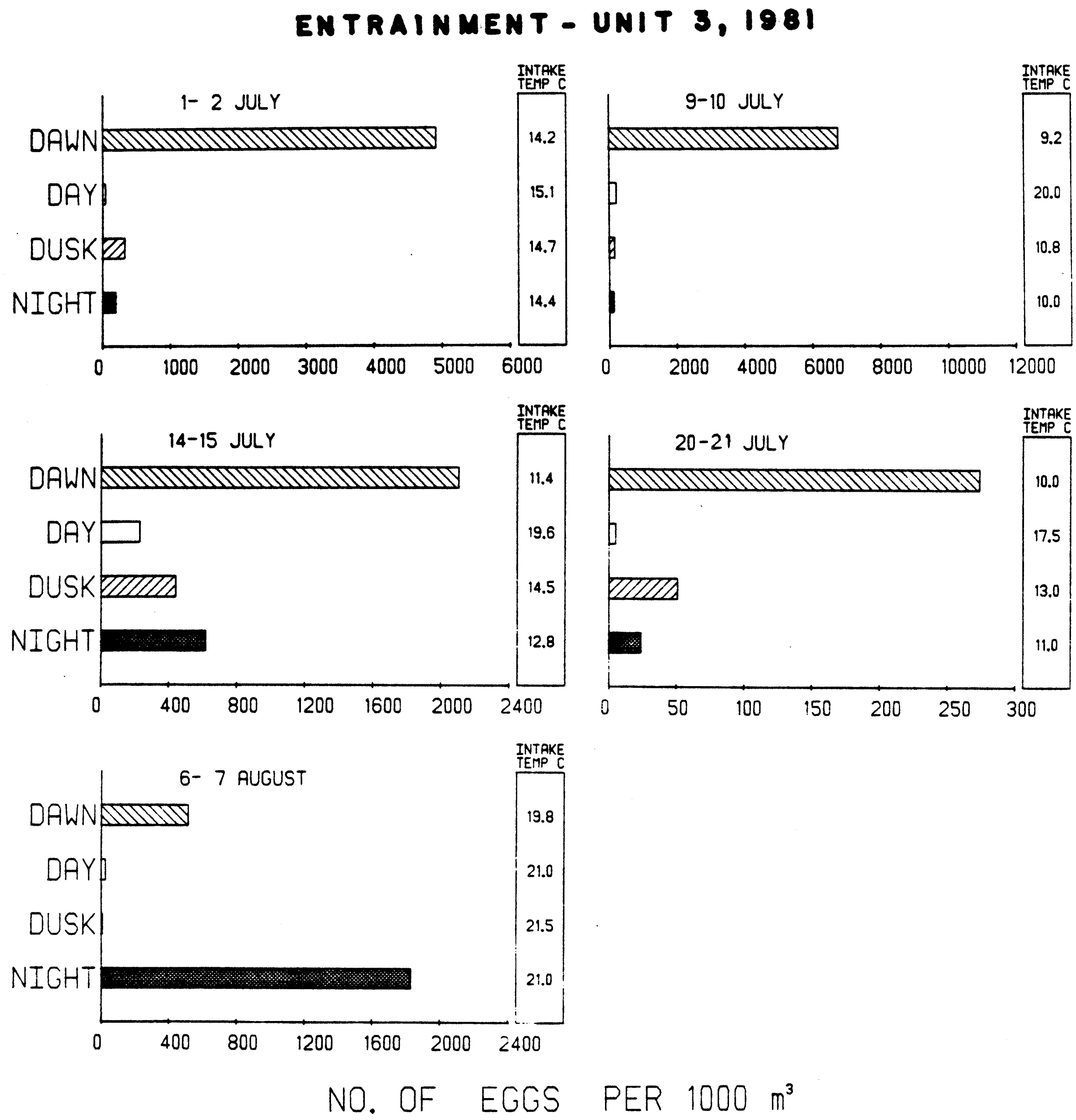


Fig. 53. Continued.

when they were found in low densities. Then during the 10-11 June sampling period peak densities of eggs were recorded, up to 22,512/1000 m^3 at night (Fig. 53). Densities remained relatively high through the 15-16 June period (169-10,137/1000 m^3); field densities were also high during the 15-16 June period even at the 9- and 12-m depth contours where up to 3797 eggs/1000 m^3 were found. The intake structure is located between these two depth contours. Highest densities were observed at night. These high egg entrainment densities occurred at the same time peak alewife spawning was observed in the field.

Egg entrainment densities were also relatively high (over 4000 eggs/1000 m^3 for dawn on 1-2 July and over 6000 eggs/1000 m^3 for the night on 9-10 July) during the 1-2 July and 9-10 July sampling periods. In general, night densities were higher than day densities; however, dawn densities during July were substantially higher than those for any of the other diel periods. Note that July sampling was marked by concurrent upwellings. During the 20-21 July sampling period the highest north transect egg densities of 1981 were observed. However, entrainment densities were relatively low for this sampling period. This may be explained by the field distribution for the 20-21 July sampling period; low densities were observed at the 9- and 12-m depth contours (intake structures are located at about the 11-m contour).

Moderately high entrainment densities (about 1800 eggs/1000 m^3 at night) were observed during early August, during which time a secondary spawning peak for alewives was occurring. Night densities were highest of the diel period densities. Eggs were found only twice in entrainment samples after early August; once for the 9-10 October sampling period and again for 5-6 November (Fig. 53). Speculation on the identity of these eggs entrained in early October is difficult since this time of the year was too late for most species of fish to spawn but early for burbot; whereas those entrained in November were probably burbot eggs as burbot spawning has been reported to occur as early as November (Scott and Crossman 1973).

Overall, the seasonal pattern of entrainment of fish eggs was similar between Units 1 and 2 and Unit 3 during 1981. For the most part, however, the density of fish eggs entrained at Unit 3 was higher than the coincident density at Units 1 and 2. In general, higher densities were observed at night at Units 1 and 2 than during the day, particularly during peak sampling dates (11 June, 15 June, and 1 July) (Fig. 53).

Comparing field and Unit 3 entrainment densities of 1981, we found the mean density of entrained eggs was significantly higher than the density for the field (see RESULTS AND DISCUSSION - STATISTICS). This difference was most pronounced during the 15-16 June sampling period, when the spawning peak for alewives was observed in Lake Michigan. Apparently egg densities in the immediate area of the intake structures were higher than densities at north transect sampling stations. Alewives may have been attracted to the riprap, discharge plume, currents or even the intake structure itself to spawn, thus accounting for higher densities observed in entrainment samples than in field samples. Eggs may have been broadcasted over the intake screens themselves; similar behavior was observed in a study by Zeitoun et al. (1981). Eggs discharged into Lake Michigan (from fish spawning in the Units 1 and 2 intake canal or the discharge canal) may also have contributed to the apparently higher egg densities in the immediate vicinity of the intake structure.

Night entrainment densities were usually higher than day densities for Unit 3 during 1981. This difference in densities between times of day was also found for entrainment estimates at the D. C. Cook Plant, southeastern Lake Michigan (M. Perrone, personal communication, Great Lakes Res. Div., Univ. Mich., Ann Arbor, Mich.). This pattern was also observed for Units 1 and 2 entrainment at the Campbell Plant for years 1978 and 1979. Scott and Crossman (1973) reported that alewives, very likely the major contributor to fish eggs in the area of the plant, spawn at night. Eggs apparently require some time to water harden and sink. Thus eggs are high in the water column (and in greatest number) at night and are more susceptible to entrainment then. Reasons for the high dawn densities during July 1981 were not clear. Perhaps upwellings during the sampling periods affected the behavior of spawning alewives or possibly even the sinking rate of eggs.

For fish eggs sampled in the field, there was no consistent pattern observed for density according to time of day. During 1979 the day mean density was significantly greater than the night mean density. However, during 1980 there was no apparent difference between day and night densities; while in 1981, for the north transect, night densities were, in general, higher than day densities. Note field sampling includes sled tows, unlike entrainment sampling. Perhaps the switch from onshore to offshore discharge (during 1980) affected the rates at which fish eggs eventually reached lake bottom.

Note that fish egg abundance based on 1977 data was not directly comparable to abundance for other years because of the lower total effort and timing of the effort used in 1977 compared to later years. During 1977 employment of the sled, the more effective gear for field sampling of fish eggs, did not begin until July; but June was usually the month of peak abundance for eggs. Likewise, entrainment sampling did not start until July 1977.

During 1981 from January through December, 107 million fish eggs were estimated entrained by Unit 3 of the Campbell Plant (Table 28). This estimate is the same order of magnitude as that for Units 1 and 2 of the Campbell Plant for the entire year of 1978 (163 million fish eggs). Most of the fish eggs (about 87 million) entrained by Unit 3 were entrained in June. Again, most of these eggs were probably alewife or spottail shiner eggs. During 1979 an estimated 3.25 billion eggs were entrained by Units 1 and 2. The difference between the 1979 entrainment estimate and that for Unit 3 in 1981 (or 1978 estimate) was mainly attributed to high carp egg production in the intake canal for Units 1 and 2 during 1979 (Jude et al. 1980). During 1980, the combination of relatively few upwellings and considerable carp egg production in the intake canal probably led to a moderately high entrainment year for Units 1 and 2, when an estimated 336 million eggs were entrained (Table 25). High carp spawning activity was not observed in the area of the Unit 3 intakes during 1981. The 1981 annual entrainment total of fish eggs at Units 1 and 2 was relatively low (an estimated 20.6 million) probably because of interruption of spawning due to frequent upwellings (Table 26). Note that fish eggs may not be damaged by passage through the plant (Schubel 1975); this should be considered in evaluating the impact of fish egg entrainment on fish populations in the plant vicinity (Jude et al. 1979b).

The argument that eggs were concentrated in the immediate area of the intake and discharge complex is supported not only by the ANOVA testing results but also by: (1) the consistently greater densities of fish eggs at Unit 3 than coincident densities at Units 1 and 2 throughout 1981 and (2) despite the apparent poor year for egg production in 1981 for the Campbell Plant vicinity, the Unit 3 annual entrainment total of fish eggs (over 107 million) was the same order of magnitude as years 1977, 1978 and 1980 for Units 1 and 2. This concentration of fish eggs is undoubtedly due to attraction of fish (alewives and spottail shiners included) to spawn in the immediate area of the intake and discharge structures as well as due to the discharge of fish eggs offshore (at the 6-m contour). Evaluation of the impact of the offshore intake and discharge system on fish egg entrainment would be more meaningful during a year of greater abundance of fish eggs. Most likely during a year of relatively high fish egg production, annual entrainment of fish eggs at Unit 3 would be greater than that of Units 1 and 2, unless a large "spike" of carp eggs, produced by carp spawning in the intake canal for Units 1 and 2, was to be entrained, as was the case in 1979. The 11-m depth contour, where the offshore intake is situated, is normally an area of relatively low fish egg abundance as most fish eggs are usually deposited between the beach and 3-m depth contours. However, the attractive influence of the intake and discharge structures and accompanying riprap and the offshore discharge of eggs appear to have more than negated the effect of locating the the intake in an area that is normally low in fish egg abundance. Note that the Unit 3 intake location may have circumvented the problem of unusually high egg entrainment due to high carp spawning activity. The intake canal for Units 1 and 2, with its patches of dense aquatic vegetation, appears to be more ideal carp spawning habitat than the riprap area of the intake-discharge complex.

24-h Population and Entrainment Estimates

The estimated number of fish eggs entrained at Unit 3 for a 24-h sampling period during 1981 usually comprised a relatively high percentage (up to 32%) of the number of fish eggs estimated for the vicinity of the Campbell Plant, compared with this same percentage for taxons of fish larvae (Table 31). The number of fish eggs for the Campbell Plant vicinity was probably underestimated for each sampling period. Fish egg deposition appeared to be concentrated in the immediate riprap and discharge area, an area not sampled aside from actual entrainment sampling. Numbers of fish eggs in the plant vicinity were relatively high for the mid-June through early August sampling periods with a peak in the 20-21 July period. Note the entrainment of fish eggs was relatively low for this period, presumably because fish eggs were almost all concentrated from the beach to the 1.5-m depth contour in Lake Michigan where they were not susceptible to entrainment.

DIVER OBSERVATIONS

Introduction

Artificial reefs are used throughout the world to increase the fisheries production potential of barren or relatively unproductive areas. In southeastern Lake Michigan, with the exception of a few natural reefs, the nearshore area is primarily a sand bottom habitat hosting a limited number of recreationally important species at relatively low densities. The diversification of this habitat by the addition of artificial structures increases the number of species and density of fish and other aquatic biota (Dorr and Miller 1975; Dorr and Jude 1980).

The earliest use of artificial reefs was recorded by the Japanese in efforts to improve commercial fishing (Steimile and Stone 1973). Douglas Lake in northern Michigan was the site of some of the first experiments with artificial shelters in fresh water in this country (Rodenheffer 1939). Studies in marine and fresh waters have shown not only that artificial reefs concentrate fish and increase biological productivity of an area, but peak species abundance and diversity of colonizing organisms occurs during the first few years after the reef is constructed.

In conjunction with our monitoring the environmental effects of the J. H. Campbell Plant's cooling water intakes and discharges, we assessed the colonization and utilization of the riprap by invertebrates, periphyton and fish. We also monitored impingement of fish on the screens, and biofouling problems were documented. These observations provided a confirmatory link between our field sampling and the actual fish species (their behavior and distribution) that inhabited the area around the intake structures. These observations were also important in providing information on spawning substrate, which fish species were attracted to the riprap and information on certain benthic organisms that concentrated on the riprap.

Invertebrates

Numbers of attached invertebrates (*Hydra*, bryozoans and freshwater sponge) increased noticeably between 1980 and 1981. *Hydra* were extremely numerous on the intake screens as well as on the riprap. The length of *Hydra* colonies reached 1.5 mm by October 1980 and 2.5 mm by August 1981. Lack of heavy algal growth, especially *Cladophora*, may facilitate the growth of *Hydra*. Dorr and Jude (1980) observed tremendous numbers of *Hydra* at the D. C. Cook Plant on the sides and undersides of riprap, where algal growth was reduced.

Bryozoa did not appear until 1981 and were especially abundant on the intake screens with some colonies covering an area of 0.5 m^2. Numbers of bryozoans on the riprap were low in comparison with colonies on the screens. The colonization of the intake screens by bryozoans could result in the screens becoming clogged and reducing the flow of intake water to the plant. Bryozoans were most abundant in May and July with a reduction in colony size and numbers observed in August.

Freshwater sponges, which were uncommon in 1980, became very numerous in 1981. They were most abundant on the sides of the intake risers with some colonies over 1 m^2 in size. Growth of sponge colonies may also be facilitated by the limited algal growth in the intake area.

Unattached invertebrates increased dramatically in number during 1981. Isopods (*Asellus* sp.), which were not observed during 1980, were extremely abundant in 1981. During day dives concentrations of *Asellus* sp. 1-2 m^2 in size were observed on the surfaces of some rocks. Numbers of snails also increased greatly in 1981. A few *Valvata* were observed on the sides of rocks in 1980, but disappeared in 1981 when large numbers of *Lymnaea* appeared on the sides of the intake risers and rocks. Densities as high as 300/m^2 were noted. Many juvenile and immature individuals were observed. Sphaeriidae (fingernail clams) shells were numerous on the sand transects, but absent from the riprap.

No crayfish were observed during 1980 or 1981 at the Campbell riprap. During the same period, crayfish were also absent from the Muskegon reef, which is about 32 km north of the Campbell Plant (Biener 1982). Dorr and Miller (1975) observed increasing numbers of crayfish at the Cook Plant riprap during its first 2 yr after construction. A difference in the size of the rocks used at the Campbell and Cook Plants may explain the lack of crayfish at the Campbell Plant. The larger rocks at Campbell and Muskegon may not provide small enough spaces for crayfish to inhabit in order to avoid predation by fish such as sculpins and perch.

Periphyton

During 1980 and 1981, 46 taxa of periphyton were observed at the Campbell reef. In 1980, 2 green algae, 2 blue-green algae and 14 diatoms were collected (Table 44). An increase in the number of taxa was observed in 1981 with 3 green algae and 29 species of diatoms collected. *Cladophora* appeared for the first time in 1981. During the first 2 yr after the Cook Plant reef was built, similar numbers of taxa were collected (Table 44), but a thick and luxuriant growth of *Cladophora* was beginning to appear in the second year at the Cook Plant (Dorr and Miller 1975).

The Campbell reef is rather depauperate in periphytic growth in contrast to the Cook reef. The increased depth of the Campbell reef (11.5 m vs. 9.1 m at Cook) may be responsible for the sparse growth of *Cladophora* at Campbell. Small clumps of unknown loose algae (3 to 25 mm in diameter) were found on the sand transects.

Fish

Eleven species of fish were observed during 1981 and listed in descending order of abundance were: alewife, yellow perch, rainbow smelt, spottail shiner, johnny darter, slimy sculpin, burbot, white sucker, logperch, lake trout and trout-perch. Slimy sculpin was the most frequently observed fish (measured as presence or absence, not as numbers of fish). Because of the vast number of intersticial spaces among the rocks in the reef and the cryptozoic nature of slimy sculpins, the low numbers observed do not reflect the actual population present. Slimy sculpins are most likely the most abundant year-round residents of the reef. Johnny darters were the second-most frequently observed fish on the reef and were more numerous than in 1980. For the same reasons as discussed for slimy sculpin, johnny darter numbers are probably greater than the numbers indicated by our observations. The highest densities of alewife, yellow perch and spottail shiner were noted during June-August when water

Table 44. Algae observed in qualitative analysis of periphyton collected in southeastern Lake Michigan during 1974 diving operations at the D. C. Cook Nuclear Plant (Dorr and Miller 1975) and 1980 through 1981 at the J. H. Campbell Plant.

	Campbell		Cook
Taxon	1980	1981	1974
Green Algae			
Cladophora sp.		X	X
Scenedesmus sp.	X	X	
Scenedesmus quadricauda v. *longispina*		X	
Scenedesmus quadricauda	X		X
Closteriopsis sp.			X
Oocystis sp.			X
Pediastrum tetras			X
Pediastrum duplex			X
Spirogyra sp.			X
Ulothrix sp.			X
Blue-green Algae			
Oscillatoria sp.	X		X
Gomphosphaeria lacustris	X		
Diatoms			
Amphipleura pellucida		X	
Amphora ovalis			X
Amphora sp.	X	X	
Asterionella formosa		X	X
Cocconeis sp.			X
Cymatopleura solea			X
Cyclotella ocellata		X	
Cymbella sp.		X	
Diatoma tenue v. *elongatum*			X
Diatoma tenue		X	X
Fragilaria crotonensis	X	X	X
Gomphonema sp.	X		X
Gyrosigma sp.			
Melosira granulata	X	X	X
Melosira varians		X	
Melosira sp.			X
Navicula sp.	X	X	X

Table 44. Continued.

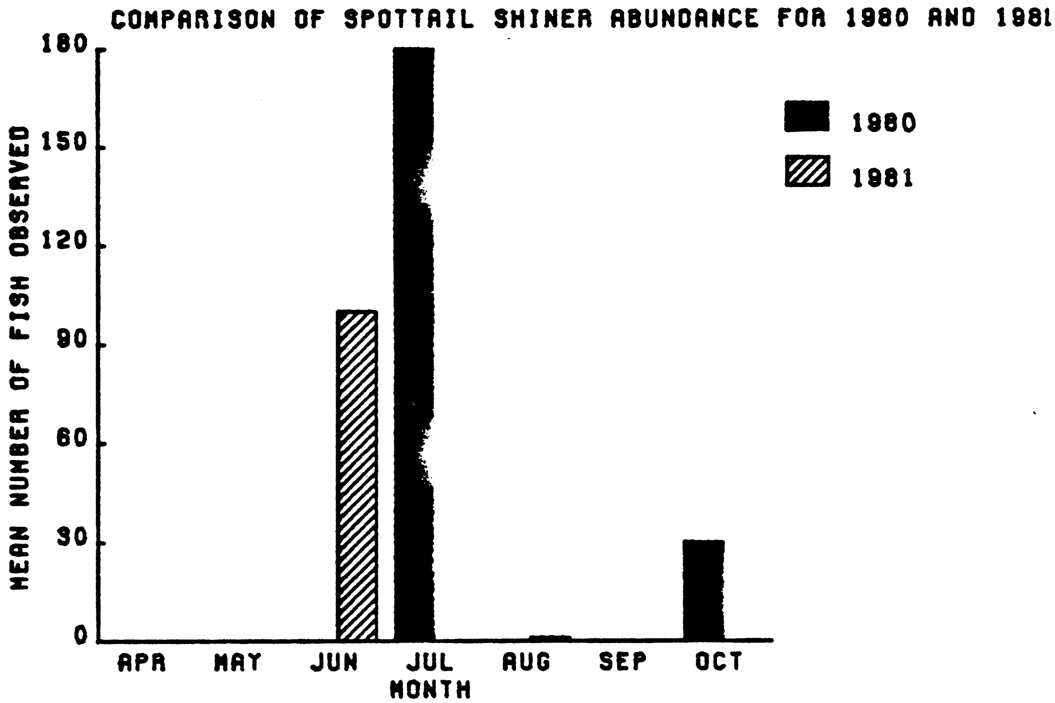
Taxon	Campbell 1980	Campbell 1981	Cook 1974
Diatoms continued.			
Nitzschia sp.	X	X	X
Rhizosolenia eriensis			X
Rhoicosphenia curvata			
Stephanodiscus niagarae		X	X
Stephanodiscus minutus			
Stephanodiscus tenuis		X	
Stephanodiscus sp.	X	X	X
Cymbella ventricosa			
Surirella angusta			X
Surirella ovata v. *pinnata*			
Synedra ulna	X	X	
Synedra sp.	X	X	
Tabellaria fenestrata		X	X
Cymbella triangulata		X	
Cyclotella meneghiniana		X	
Navicula tripunctata		X	
Gomphonema olivaceum		X	
Meridion circulare		X	
Fragilaria intermedia v. *fallax*		X	
Cyclotella comta	X	X	
Stephanodiscus binderanus		X	
Nitzschia romana		X	
Synedra ostenfeldii		X	
Caloneis sp.		X	
Neidium dubium		X	
Anomoeoneis vitrea		X	
Surirella sp.		X	
Cocconeis placentula v. *euglypta*		X	
Rhizosolenia gracilis		X	
Melosira islandica	X	X	
Cyclotella sp.	X		
Stephanodiscus alpinus	X		
Tabellaria fenestrata v. *intermedia*	X		

temperatures were warm. Field samples in the area near the reef indicated that alewife, yellow perch and spottail shiner were abundant in the study area during June-August.

Although large numbers of alewife were observed while diving on the reef, they were usually observed nearer the surface while divers were descending to the riprap or returning to the surface. Some very large schools, mostly juvenile and YOY fish, were observed during July and August over the riprap (Fig. 54), but the largest school was observed at the sand transect during August (Fig. 54). These data seem to indicate that the reef may not serve to attract alewives to the degree that it does demersal species such as sculpins, yellow perch and johnny darters, although vertical structures such as the intake risers are probably more attractive than the riprap to pelagic fish. The flow of water created by the intake risers may increase the amount of potential food available to alewives, but whether it contains a greater amount of prey than the water transported by natural currents in the area is not known.

Yellow perch exhibited the greatest increase in numbers of individuals and frequency of observation from 1980 to 1981 (Fig. 55). During August 1981 schools of 5 to 35 individuals, 100-300 mm in length, were observed hovering between the bottoms and the tops of the intake risers. At night they were observed resting on the rocks. Yellow perch were observed only during July and August 1980, while in 1981 they were observed during all months of the study, except May. During dives on the riprap in April and May 1982, sightings of yellow perch were frequent, although no quantitative data were recorded. The increased observations of yellow perch seem to indicate that the Campbell reef could become an important yellow perch habitat. Dorr (1982) documented a preference by yellow perch in Lake Michigan for rocky substrates. Although no egg masses were observed, it is quite certain (from Dorr 1982 and high yellow perch entrainment rates) that the Campbell reef has become a spawning ground for yellow perch. The perch sighted during April and May 1982 were large adults, suggesting that a spawning aggregation was beginning to assemble.

Rainbow smelt were not observed in the reef area during 1980 but were observed in all months except June and July in 1981. Trawl catches of smelt in 1981 demonstrated trends similar to the diver observations. Almost no smelt were trawled in June 1981, and largest trawl catches were taken in August and September. Dive observations of smelt showed peak abundance in August and September and no fish observed in June or July. YOY fish were the predominate age-group observed during dives and found in trawl catches. Smelt exhibited a behavior similar to alewife; they were usually found in mid-water and not among the rocks. Smelt were often observed at the rock/sand interface and were observed almost exclusively at night.



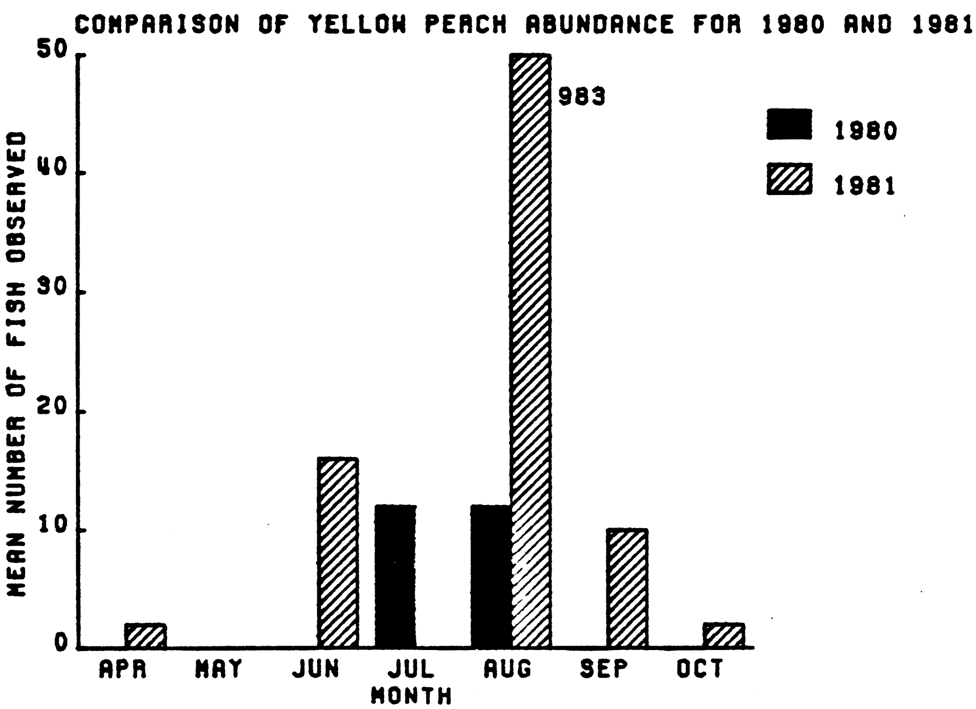
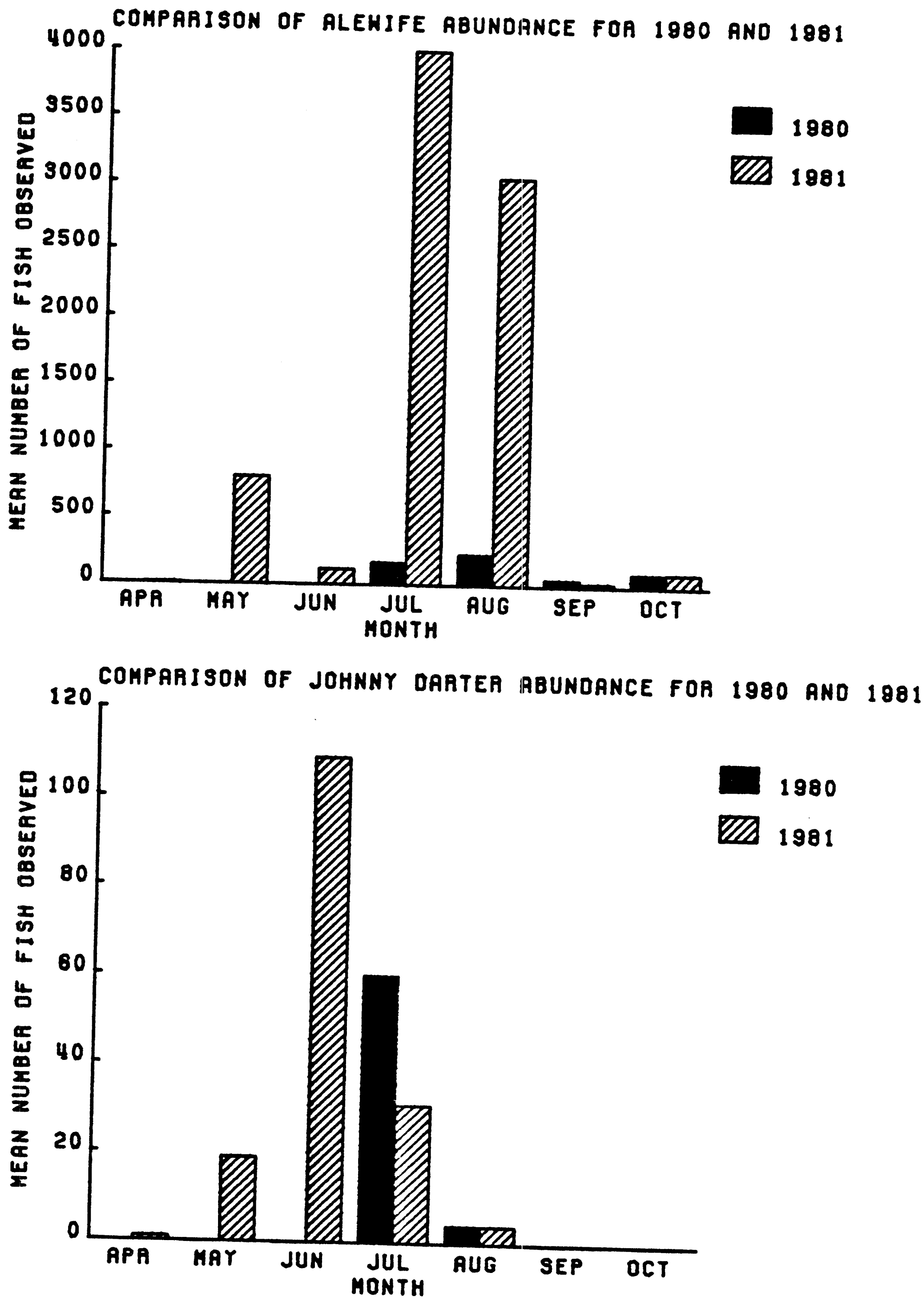


Fig. 54. Numbers of spottail shiner, yellow perch, alewife, johnny darter and rainbow smelt observed monthly by scuba divers during 1980 and 1981 on the J. H. Campbell riprap.



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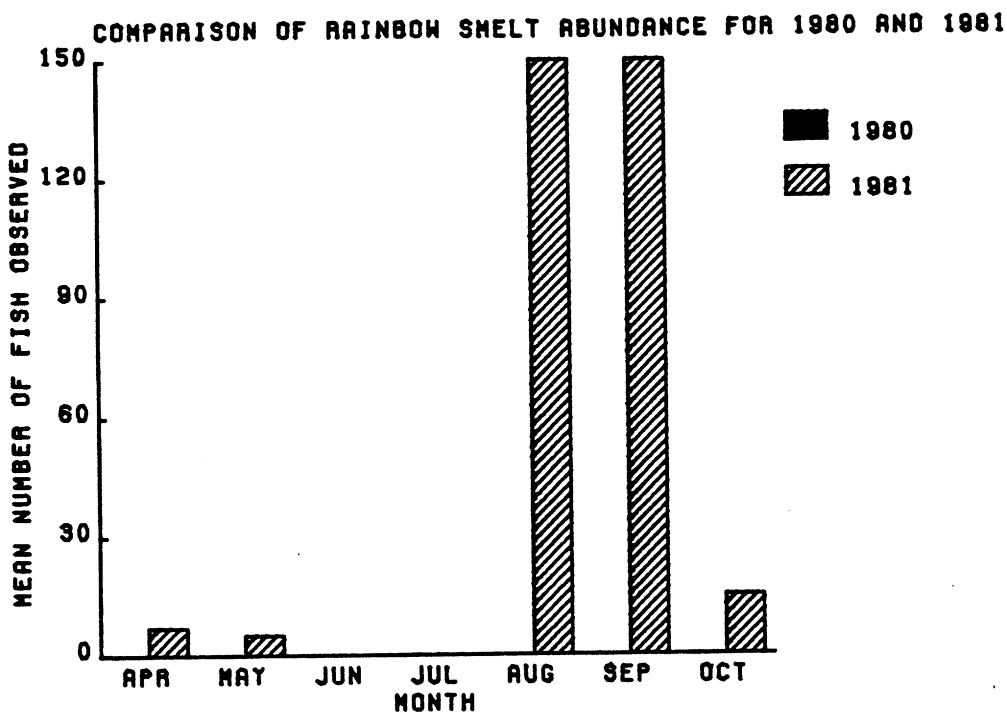

Fig. 54. Continued.

Although spottail shiners ranked third in field collections by all gear types in 1981, they were observed infrequently in the reef area. During July, adult spottails were observed resting on top of the wedge-wire screens. Dorr and Miller (1975) observed spawning by this species over the Cook Plant intake structures which were covered by a luxuriant growth of *Cladophora*. It is felt by Dorr (personal communication, Great Lakes Research Division, University of Michigan, Ann Arbor, MI) that the *Cladophora* was mostly responsible for the observed spawning activity. With a reduction in the *Cladophora* substrate, spottail spawning was never again observed at the Cook Plant. Because of the limited numbers of spottails observed on the Campbell Plant reef, despite field samples showing this species to be abundant in the area, we concluded that spottails were not a significant component of the reef fauna. They were always observed at least 3 m above the rocks and never observed feeding. Although some spawning may occur, data from Dorr and Miller (1975) suggest that the Campbell reef will have little or no impact upon the life history and ecology of spottail shiners in the study area.

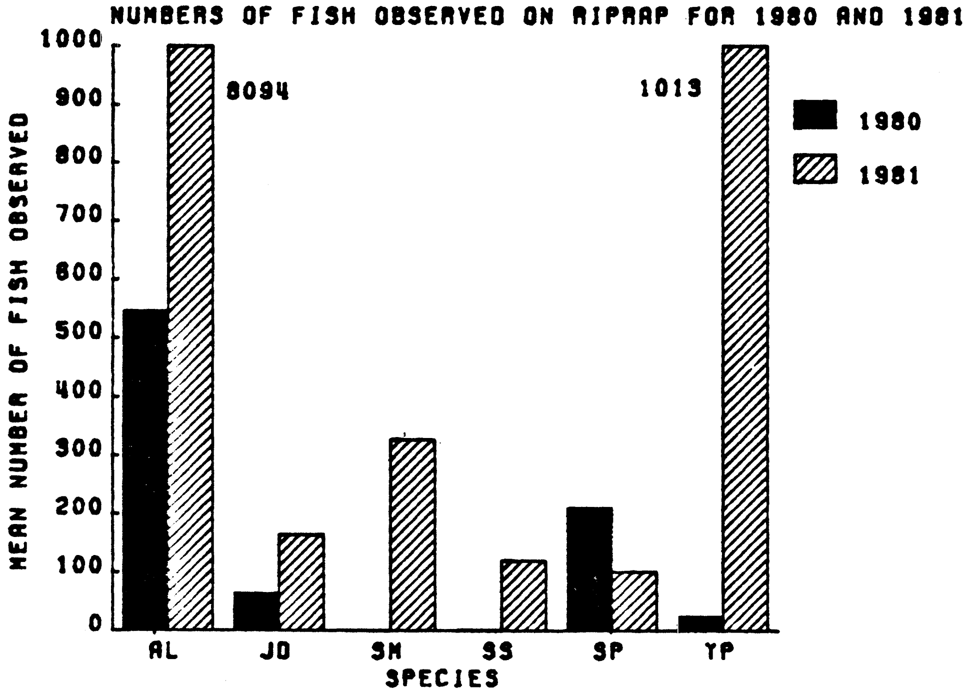

Fig. 55. Total numbers (pooled over month and diel period) of the six most abundant species of fish observed on the J. H. Campbell intake riprap during 1980 and 1981.

Although never observed in high numbers during standard series dives (Fig. 54), slimy sculpin and johnny darter are probably the most abundant members of the Campbell reef fish fauna. Due to the extremely large number of interstices and the cryptozoic nature of these fish, visual observations do not accurately reflect their true numbers. Sampling with emergent fry traps in April and May of 1981 revealed densities of slimy sculpins over $10/m^2$ although very few were observed visually. Johnny darters were also collected in the fry traps, but in lesser numbers than sculpins.

Numbers of fish observed on the reef were always higher than encountered in the sand bottom control transects, with the exception of an enormous school of YOY and juvenile alewives observed in mid-water on the south reference transect on one occasion. Trout-perch and johnny darters were sometimes observed at the sand/rock interface. With the exception of yellow perch, fish were observed in greater numbers and exhibited higher activity levels at night than during the day. Yellow perch numbers were usually similar for both diel periods. If perch were observed during the day, they were most often present at night resting on rocks. Perch had a higher level of activity during the daylight period.

Biofouling

During 1981 a substantial increase in biofouling of the wedge-wire intake screens was detected at the Campbell Plant. From April to September an escalating accumulation of organic matter on the screens was noted. Attached algae, invertebrates, flocculent organic detritus and sediment were present in varying amounts. Among the periphyton were 21 species of attached algae which are indicative of eutrophic conditions (e.g., *Asterionella formosa*, *Cladophora* sp., *Oscillatoria* sp., *Aphanizomenon* sp.). Invertebrates included bryozoans (*Pectinatella magnifica*, *Cristatella mucedo*, *Lophopodella carteri*), *Hydra* and freshwater sponges.

Periphyton density (resulting in clogging of screen pores) was variable by screen. Some screens had only small patches of growth while others had very large patches (nearly 0.5 m^2) on both upper and bottom portions of the screens. Sponges increased dramatically both in size and abundance between May and September. Sponge growth was most common on the base of the risers, rather than on the screens themselves, so screen obstruction by sponges would not be a problem.

Peak height of periphyton on the screens was usually less than 25 mm. During the season, growth seemed to be minimal in terms of height, but colony size increased to cover more surface area. Maximum coverage was observed in early September with a decrease in late September and October.

Periphytic growth on the riprap was minimal in contrast to that observed on the intake risers. Most likely the 3-m difference in depth was responsible for the sparse growth on the riprap.

Impingement and Intake Observations

Divers inspected at least 14 screens, 28 when possible, during each of a total of 16 dives performed between 27 April and 22 October 1981 (see METHODS - SCUBA OBSERVATIONS for details). Fish species observed on the screens, riprap or in the general area around the intakes were also recorded by divers, to identify how many of which species were utilizing the new habitat afforded by the offshore intake structures. Divers observed several fish species in the riprap or in the water column near intake structures. These species included alewife (in schools with fish numbering in the thousands during mid- to late summer), burbot, gizzard shad, johnny darter, logperch, rainbow smelt, slimy sculpin, spottail shiner, trout-perch, unidentified Coregoninae and yellow perch.

Diver observations determined that no fish were impinged on intake screens during the periods observed. The closest approximation to impingement was retention on screens of already dead alewives (70-150 mm) during June (31 fish) and October (1 fish). The 31 fish retained in June were believed to have been part of an alewife die-off which occurred in June and which was observed at both plant and reference transects near the J. H. Campbell Plant. Dead alewives were observed in June at the surface (approximate density: 10-15 fish/m²) and on the beach, and were collected in seine hauls (up to 100 fish/haul). Dead alewives were similarly observed during June in southeastern Lake Michigan near the D. C. Cook Nuclear Plant (unpublished data, Great Lakes Research Division), so the phenomenon was not strictly localized. Alewives retained on Campbell intake screens, therefore, were believed to have been already dead fish which were drifting with lake currents and which happened to pass close enough to the screens to have become retained. Because no other fish were observed impinged during diver observations, it is assumed that the single alewife retained in October was also a fish which had died prior to being impinged and was carried close to the intakes by lake currents.

To judge the strength of intake currents around screens, divers held and released dead alewives at various distances from the screens. A 75-mm alewife was drawn gradually back onto the screen if its distance from the screen was less than or equal to about 30 cm. At distances greater than 30 cm, lake currents had a greater influence on the fish than intake currents, and the fish was carried away from the intake structures. Thus it appears that a dead fish drifting with lake currents would have to pass quite close before it would become influenced by Campbell intake currents.

On two occasions, different species of live fish were observed directly on intake screens and did not appear to be influenced by intake currents. In April, 30 slimy sculpins (85-150 mm) were observed on various screens; 2 johnny darters (70-90 mm) were similarly seen in July. Sculpins and darters are known to be attracted to benthic structures and it was clear that they were not impinged. When divers approached too near, fish would swim to another portion of the screen or would swim away to hide themselves in the riprap. Swimming did not appear to be inhibited even for the smallest of the fish observed. Other fish species were also observed on intake screens [three trout-perch (75-110 mm) and an abundance of spottail shiners (100-140 mm) in June; two rainbow smelt (50 mm) in October], but these observations were made during periods when no offshore pumping was taking place, and presumably no intake current was influencing fish behavior.

Additional evidence of fish being able to resist intake currents comes from observations of many gizzard shad (200-340 mm) and one large carp (500 mm) on the inside of intake cylinders. These fish must have swum against the intake current for the full length of the offshore conduit; they maintained their positions inside the screens by swimming against the current.

Other species which were apparently unaffected by water intakes included those species collected in our standardized sampling. Species which were gillnetted or trawled at the 9-m contour of the plant transect in the general area of the intakes included brown trout, common carp, chinook salmon, lake trout, lake whitefish, longnose sucker, ninespine stickleback, quillback, round whitefish, shorthead redhorse, walleye and white sucker.

At the D. C. Cook Nuclear Power Plant in southeastern Lake Michigan (intakes at 9 m), alewife, rainbow smelt, spottail shiner and yellow perch were the species most frequently impinged; their combined weight from January through September 1981 was 13,627 kg (unpublished data, Great Lakes Research Division). These same species were abundant near the Campbell intake structures and the absence of any impingement indicates that the location and design of the Campbell intakes are extremely effective at preventing fish impingement.

Additional Observations

Slimy sculpin eggs were found on the surface of a piece of riprap in June 1981; they hatched shortly after transport to the surface. Larvae were identified as slimy sculpins. Several unidentified Coregoninae larvae were collected from emergent fry traps set in May 1982, which provided evidence that lake whitefish or round whitefish spawned on the reef. Lake trout eggs were collected during 1980, 1981 and 1982 on the reef, and Jude et al. (1981a) collected lake trout fry in the vicinity of the Campbell Plant providing evidence of successful incubation of lake trout eggs on the reef.

Schooling behavior was observed for rainbow smelt, alewives and yellow perch. Smelt were rarely observed during the day, while at night schools of 5-15 individuals were observed about 1-4 m above the reef. Smelt seemed very sensitive to divers' lights and would dart away when divers approached within 1 m. Adult smelt were never observed on the reef. Yellow perch were observed in schools hovering over the intake risers and large rocks during the day, while at night individuals settled to the bottom of the reef as schools dissipated. At night yellow perch seemed to be in a dormant state. Dive lights elicited no response from them and it was possible to touch or grab them while they were illuminated by divers' lights. Alewives darted away when a light was within 1 m of a fish. During the day alewives did not dart away from divers, but did not allow them to approach too near. When descending through schools of alewives the fish moved away at a very controlled rate as opposed to the flight behavior observed at night.

The seasonal trend in biological activity on the reef closely paralleled the trends in fish distribution described by Jude et al. (1978, 1979a, 1980) for the portion of Lake Michigan surrounding the Campbell reef. There was an increase in the number and kind of fish observed in late spring (May through early June) which reached a peak during summer months. Numbers of fish observed decreased beginning in the fall (late September to late October) with minimal activity by December.

Presence of the riprap field in the vicinity of the Campbell Plant has created a rough bottom habitat atypical of Lake Michigan. The artificial reef that has been formed has increased surface area for attachment and shelter of potential fish-food organisms and has also served as a spawning habitat and shelter for fish. The riprap at Campbell will result in an increased density and diversity of fish and invertebrates when compared with the adjacent sand area.

GENERAL SUMMARY AND CONCLUSIONS

INTRODUCTION

Operational studies were conducted during 1981 to comply with regulations requiring monitoring of the new Unit 3 wedge-wire screened intakes placed in 11 m of water in offshore Lake Michigan. Main emphasis was placed on securing information on impingement of juvenile and adult fish and entrainment of fish eggs and larvae at the Unit 3 intake. To accomplish this, we conducted scuba diver observations to investigate the extent of impingement of fish on the screens and to document colonization of the screens and riprap by plants and animals. In addition, an encompassing sampling program was instituted to provide background data on larval fish distribution, abundance and densities in Lake Michigan from which population estimates in the immediate vicinity of the plant were made. These data were then used for comparisons of abundance, species composition and length-frequency distributions between entrained larvae and those found in the field. Data were also gathered on juvenile and adult fish distribution and abundance in the study area to provide ancillary data on spawning, dominant fish in the plant vicinity and which species and sizes were in the proximity of the intakes.

STATISTICAL TESTS

Significantly higher densities of fish eggs were entrained than were found in the field, which we attributed to attraction of spawning fish, mainly alewife, to the vertical habitat provided by the intake risers. Egg densities for entrainment samples were higher at night than during the day, which corresponds with known nocturnal spawning by the alewife. For alewife larvae, significantly higher densities were measured in the field than in entrained water. This was unique among the species tested, as all other comparisons resulted in no differences, or higher densities being found in entrainment samples. The reason for the higher alewife densities in field compared with entrainment samples was probably that alewife larvae, even newly hatched individuals, exhibited some avoidance of the intakes. As alewife larvae grew larger their susceptibility to entrainment decreased substantially. For yellow perch, higher densities of larvae were entrained than were observed in the field. Attraction of adult yellow perch to the intake riprap base for spawning resulted in newly hatched perch larvae being susceptible over a short period (until they reached 6.0-6.7 mm) to entrainment by Unit 3. Slimy sculpins also were entrained in higher densities than were found in adjacent Lake Michigan. Slimy sculpins are known to be attracted to riprap for spawning, as they lay their eggs on the undersides of rocks.

Divers collected sculpin eggs from the riprap; the eggs hatched after being moved. Again, the increased nocturnal movements of sculpins resulted in more being entrained at night than during the day. For the remaining three species tested, spottail shiner, rainbow smelt and johnny darter, no significant difference was detected between entrainment and field mean larval fish densities.

FIELD LARVAE DISTRIBUTION OVERVIEW

Alewife and spottail shiner were the most abundant larvae in field samples during 1981, as in prior years 1977-1980. Alewives were widespread throughout the study area during times of elevated temperatures (>15 C), but were more restricted to nearshore areas during upwellings. Spottail shiners were found in water ≤3 m deep and were strongly demersal. Mean densities of larvae (all species) were generally lower in 1981 than in most preoperational years, which was a reflection of low water temperatures caused by frequent upwellings in 1981. During 1980, a time of few upwellings, larvae were substantially more abundant and widespread than any other year studied. The low abundance of larvae in the area during 1981 resulted in low numbers of larvae being entrained at Units 1, 2 and 3.

Few larvae were collected in April, May and early June. Species collected then were unidentified Coregoninae, yellow perch, rainbow smelt and deepwater sculpin. Alewife and spottail shiner spawning commenced in mid-June and yellow perch larvae were widespread at this time. Species diversity was greatest in mid-June. Alewife, spottail shiner and a few trout-perch were the species most often collected during remaining months.

ENTRAINMENT SUMMARY

For 1981, 10.2 million fish larvae were entrained at Unit 3. During 1977-1980, 18 to 21 larval fish species were collected in the field. In 1981, only 15 species were observed on the north transect and of these only 11 were observed in Unit 3 entrainment samples. Yellow perch (31.8% of total) and alewife (29.2% of total) were the two most often entrained larval fish. From January to March, no larvae were entrained; in April, the only species entrained was yellow perch. In May, deepwater sculpin, slimy sculpin, and yellow perch were entrained. June was the month of maximum entrainment losses when 8.25 million larvae, over 80% of the total, were estimated entrained by Unit 3. Yellow perch was the major species entrained (36.2% of the total for the month) followed by alewife, smelt, spottail shiner and slimy sculpin. In July entrainment losses were low compared with June, probably as a result of larvae produced in June growing large enough to avoid intakes and the detrimental effect of upwellings on reproduction during this month. In August-September, alewives and spottail shiners were dominant species in entrainment samples, but rates were very low compared with earlier months.

Entrainment losses at Units 1 and 2 ranged from 69.9 million to 77.7 million from 1977 to 1979. In 1980, a substantially warmer year than any other studied, Units 1 and 2 entrained 186 million larvae, almost three times more than former annual losses. In 1981, another year of frequent upwellings, reproduction was so depressed that entrainment rates at Units 1 and 2 were the lowest recorded during the 5 yr, only 22.2 million. This contrasted with 10.2 million entrained at Unit 3. The species composition of larvae entrained by Units 1 and 2 was dominated by alewife (33.5-90.5% of total larvae entrained during 1977-1981) and spottail shiner (2.6-14.4%). Yellow perch (2.1-20.9% of the total), carp and smelt were the next most-often entrained larvae at Units 1 and 2. This contrasted with Unit 3, where yellow perch was the dominant species, followed by alewife, spottail shiner, slimy sculpin and rainbow smelt. This is a dramatic species shift, which was strongly influenced by increased spawning on the riprap by yellow perch, slimy sculpin, johnny darter and ninespine stickleback. Deepwater sculpin was seldom entrained at Units 1 and 2, but was entrained more often at Unit 3, because of the more offshore placement of the intakes in 11-m water, where this species is more abundant than near shore. The percentage of the total comprised by spottail shiner and smelt remained approximately the same at Units 1 and 2 as at Unit 3.

24-H POPULATION AND ENTRAINMENT COMPARISONS

Measured populations of larvae in the vicinity of the plant during a 24-h period were compared with the entrainment estimate for that species for the same time interval. Average percentage of the population estimate comprised by the corresponding entrainment estimate was low for alewife (0 to 0.53%), while the average percentage was highest for slimy sculpin (over 100%). For slimy sculpin, johnny darter and ninespine stickleback, and possibly yellow perch, our ambient populations are believed to be underestimated because of concentrated spawning and residence of larvae in the immediate vicinity of the riprap, an area not sampled by our field tows.

TOTAL CATCH OF JUVENILE AND ADULT FISH

In 1981, 36 species of juvenile and adult fish were collected in Lake Michigan near the Campbell Plant. Alewife dominated the total catch (41%), followed by rainbow smelt (40%), spottail shiner (8%), unidentified Coregoninae (6%) and yellow perch (1%). Unidentified Coregoninae have become more abundant in each succeeding year of the study, a reflection of banning commercial harvest and decline or stabilization of alewife populations.

ALEWIFE

Alewife was the most abundant larval fish species observed in the field during summer months, but they were only the second-most abundant fish entrained at Unit 3; yellow perch was the larval fish most often entrained. During 1981, almost 3 million larval alewives were entrained at Unit 3 (29.2% of the total), the most during June (2.3 million). Highest densities were usually entrained during dusk, dawn or night periods. To compare entrainment losses with ambient field population estimates in the vicinity of the plant during a 24-h period, we calculated the number of larvae in the body of water from shore to 15 m which passed by the plant in 24 h. We then calculated the percentage of this population estimate that entrainment losses comprised on each sampling date. For alewives, the highest percentage was only 0.53. A comparison of the densities of larvae and of length-frequency distributions in the field and entrainment samples gave insight into how selective the Unit 3 wedge-wire screens were. An ANOVA showed that densities of entrained larvae were significantly lower than corresponding field densities measured on the same date. Length-frequency data further indicated that only the small, newly hatched alewife larvae were being entrained. During mid-June, mostly newly hatched larvae were present in field samples, yet densities of larvae entrained were less than ambient densities suggesting some avoidance of the wedge-wire screens occurred by fish in this size interval. Later in the year, it was clear that size-selective entrainment was occurring as the whole range of larvae were present in the field (5-25 mm), yet mostly newly hatched larvae along with small numbers of larvae up to 12.5 mm were entrained. A noticeable reduction in entrainment vulnerability occurred after larvae attained a size of 5.0 mm.

Entrainment at Units 1 and 2 was dominated by alewife larvae from 1977 to 1981. Percentages comprised by alewife ranged from 33.5 to 90.5. Because alewife was the dominant species, fluctuations in Units 1 and 2 entrainment over the 5-yr study were primarily due to fluctuations in alewife larvae abundance resulting from water temperature effects on alewife spawning.

Adult and juvenile alewives were the most often collected fish in 1981; total catch was substantially higher than any previous year's catch. A large portion of the alewife catch was comprised of yearlings, which are usually rare in our catches because of their more offshore residence.

YELLOW PERCH

Yellow perch were unexpectedly the most abundant larval fish species entrained at the Unit 3 intake during 1981; almost 3.25 million (31.8% of the total) larvae passed through the pipe. At Units 1 and 2 in 1980, a year of warm inshore water temperatures, 6.49 million perch larvae were entrained. In 1981, when upwellings characterized the year, only 787,000 perch larvae were entrained at Units 1 and 2. Yellow perch occur in Lake Michigan usually in two cohorts, one in early spring (April-May) from eggs spawned in inland and connecting waters and one in June from reproduction occurring in Lake Michigan proper.

Because of predominant alongshore currents, the early cohort of yellow perch is usually concentrated near shore ($\leq$ 3 m) and away from the influence of the 11-m deep intakes. Later, in June, yellow perch larvae derived from Lake Michigan spawners are more widespread and thus more susceptible to entrainment through the Unit 3 screens. In addition, there was evidence that increased numbers of spawners and increased utilization of the riprap as spawning habitat (inferred from higher densities of larvae), caused more larval perch to be present in the vicinity of the intakes which ultimately resulted in over 3.2 million fish being entrained at Unit 3. Of this total, 3.03 million were entrained during June when peak Lake Michigan larval perch densities were observed. Apparently this concentration of spawners in the area was substantial, as 1981 field densities in June were the highest recorded during our 5-yr study. Highest entrainment rates were recorded at dusk. Lengths of larvae entrained were generally smaller than comparable perch collected in the field, again confirming the trend of entrainment of the newly hatched, smaller members of the larval perch cohorts and avoidance of the intakes by larger perch. Most entrained perch were 6 mm, and none any larger than 6.7 mm were entrained. Statistical analyses revealed that significantly higher densities of perch larvae were found in entrainment samples than were present in the field near the intakes. We attributed this difference again to the concentration of spawning perch and newly hatched perch on the riprap around the intakes, which caused higher densities to be recorded in our entrainment samples. In addition, we calculated a population estimate for yellow perch in the vicinity of the plant and found that entrainment losses on 15-16 June (peak larval perch abundance) were only 1.68% (414,000 perch) of the total estimated population in the vicinity of the plant (24.6 million). Juvenile and adult yellow perch were ranked fifth in our field catches in the plant area, comprising 1% of the catch. Catches were similar to those obtained in prior years.

SPOTTAIL SHINER

Spottail shiners are a bottom-oriented minnow (third-most abundant fish in adult and juvenile fish collections), whose spawning activity and nursery area are usually confined to the 3-m to shore area of Lake Michigan in the vicinity of the plant. Some incidental spawning, however, is suspected to have occurred on the riprap surrounding the discharge and intake structures which may have increased entrainment susceptibility of larvae. Most larvae found at depths greater than 3 m were small, newly hatched larvae that probably drifted from the inshore zone. Peak spawning occurred during June and July with maximum densities recorded during July. Entrainment losses for spottail shiner during 1981 at Unit 3 totalled 1,310,000 (12.8% of the total) with 851,000 being entrained during June. Fewer entrainment losses were recorded in May and July-August. All larvae entrained were less than 7 mm, with most around 5 mm, the size at hatching. Field samples, particularly those collected later in the year, contained larvae up to 25 mm, showing again the highly selective nature of the Unit 3 screens which entrained only the smallest larvae present in the cohort. Spottail shiner larvae entrainment at Units 1 and 2 was 4.8 million in 1980 and 4.9 million in 1981, which contrasts with 1.3 million entrained at Unit 3 in 1981. In 1981, densities of larvae in field and entrainment samples were not significantly different. Numbers of spottails lost to entrainment were slight when compared with estimates of the total number of larvae in the plant vicinity. The highest ratio of spottail larvae entrained to those present in the area was only 2.11 percent during 6-7 August when 6720 larvae were entrained from an estimated 319,000 present in the plant area. At other times these percentages were $\leq$ 2 percent. Placement of the intake screens in 11-m-deep water away from nearshore concentrations of larvae and 2.3 m off the bottom (greatest densities of spottail larvae occurred in bottom strata) has significantly reduced the potential impact of Unit 3 on spottail shiners. In addition, obvious avoidance of the intakes by larger larvae ensures that the more important (in terms of the overall spottail population) large larvae, which have survived the higher mortality experienced by smaller larvae, are not affected by the plant. Abundance and distribution of adult and juvenile spottail shiners during 1981 were similar to patterns displayed in preoperational years.

RAINBOW SMELT

Smelt spawn in spring when waters are around 10 C, usually sometime in April or May. Most spawning occurs in the nearshore area, although some deepwater spawning does occur. Larvae hatch at about 5 mm, are most concentrated nearshore right after hatching, then become more widespread in the study area. They are commonly found from 6 to 15 m from June through September. Entrainment rates are dependent on the distribution and densities of smelt near the 11-m contour of the study site. Smelt larvae were entrained in only 2 mo at Unit 3. During May 105,000 were entrained while during June another 191,000 passed through the Unit 3 intake system. Smelt represented only 2.9 percent of the total number of larvae entrained. From analysis of our data we found that densities and sizes of smelt in the field were comparable to those entrained at Unit 3, which was contrary to results observed for perch and alewives. For example most smelt larvae entrained during June were 10.5 to 21 mm TL showing that relatively large larvae were entrained. In addition, they occupy water in the region of the intake structures for a good part of their early life history. Fry 35-42 mm were found in entrainment samples during August and September. Entrainment of smelt at Units 1 and 2 was 649,000 in 1980 and 784,000 in 1981, which compares with the 296,000 entrained at Unit 3 in 1981. Our comparisons of field population estimates with the number of larvae entrained during the same period showed that relatively small percentages (0-3.7%) of the field population were impacted.

Annual catches of juvenile and adult smelt in the study area increased from 12,903 in 1977 to 62,533 in 1981. YOY made up the major portion of the total catches. Adults occurred mostly during the spawning season.

UNIDENTIFIED COREGONINAE

Each year of the study, the number of unidentified Coregoninae caught has increased. Larvae, probably round or lake whitefish, were collected in the beach zone during spring 1981, as in previous years. None were entrained at Unit 3 because of their primarily nearshore distribution, but 4230 were estimated entrained at Units 1 and 2 during 1980 and 1.41 million during 1981. Larvae believed to be bloaters were collected rarely at our deeper stations during summer, but none were found in entrainment samples. Most adult and juvenile unidentified Coregoninae were believed to be bloaters and were taken in trawls. Most taken from August through December were YOY, and most taken April through July were yearlings. YOY were generally collected at shallower depths than older fish. Although YOY and yearlings were more abundant than previous years, fewer adults were collected during 1981 than during 1979 or 1980. Also in contrast to previous years, similar numbers of unidentified Coregoninae were taken at each transect. We attributed these two differences to construction activity, which increased turbidity (decreasing net avoidance) and stirred up food organisms, attracting fish.

TROUT-PERCH

Though trout-perch juveniles and adults were among the five most abundant fish collected in the plant vicinity, larvae were relatively uncommon. Apparently the prolonged spawning period (April-September), low fecundity of adults and the demersal behavior of larvae resulted in larvae appearing infrequently in our gear. Over 80% of the 63 trout-perch caught from 1977 to 1981 in Lake Michigan appeared in sled samples. Only 17 larval trout-perch were entrained by Unit 3 in 1981; all were recently hatched (5-7.8 mm) except one 9.8-mm specimen. Most were entrained during dusk, night and dawn. Major entrainment of trout-perch occurred in June (68,500) and July (62,700) with lesser quantities entrained during August-September. Trout-perch entrainment at Units 1 and 2 was as follows: 1977 - 7,450; 1978 - 4,690; 1979 - 86,500; 1980 - 46,300 and 1981 - 48,600. Entrainment rate at Unit 3 in 1981 was substantially higher (145,000) than was observed at Units 1 and 2. Attraction of trout-perch to the riprap is the suspected cause of high entrainment rates.

YOY and yearling trout-perch catches were lower than in previous years, in part because trawling was not performed at 15 m in 1981. Peak catch of adults occurred in October, unlike 1977-1980 when the peak was in May or June, just prior to peak spawning. A ripe-running trout-perch and a recently hatched larva provided evidence for October spawning, extending our documentation of their spawning period to April-October.

SLIMY SCULPIN

Slimy sculpins are demersal fish which have been found to thrive in rocky substrates such as that found around the Campbell intake and discharge system. Sculpins usually spawn in April and May and deposit their eggs on the undersides of rocks or similar objects. The population in the vicinity of the plant represents the fringes of a population which resides in deeper water beyond the study area. Most adults migrate to deeper and colder water during summer months. Sculpin larvae have occurred in higher densities and frequencies since deposition of the riprap, although compared to other larvae, numbers caught were relatively low. More larvae were found at deeper offshore stations than those closer to shore. In 5 yr of sampling only 40 samples (37 at night) contained larvae. Slimy sculpins, though rare in field samples, were comparatively abundant (ranked fourth) in entrainment samples as 1.24 million (12.1% of total) were estimated lost in 1981 at Unit 3. Location of the intake structures at 11 m placed them within the zone of greatest field abundance of slimy sculpin larvae. Of those larvae entrained, 96% were <10 mm TL and most were entrained during June. It appeared that larvae around 7-10 mm (near the end of yolk absorption) were less benthic, and therefore more susceptible to entrainment by the intake structures, which are located within the water column (2 m above the bottom), than were smaller and larger larvae. Most entrainment occurred at dusk, night and dawn periods when adults and, apparently, larvae are most active. Entrainment of slimy sculpin larvae always comprised less than 1% of the total entrainment loss at Units 1 and 2 during 1977-1981, probably due to the more nearshore withdrawal of water (6 m) where slimy sculpins are less abundant. Slimy sculpin larvae were entrained with greater frequency by Unit 3 and comprised a much higher percentage (12.1%) of the total entrainment loss than at Units 1 and 2. Attraction of slimy sculpins to the riprap is believed responsible for the increased slimy sculpin entrainment rate at Unit 3 relative to Units 1 and 2. This attraction was also the cause of the significantly higher densities of entrained larvae at Unit 3 when they were compared with ambient densities in the vicinity of the plant. A comparison of field estimates of population abundance with entrainment estimates showed that on 15-16 June more than twice as many larvae (212%) were entrained as were calculated present in the Campbell Plant vicinity. However, we feel this is due to the overwhelming effect of colonization and spawning on the riprap and low abundance elsewhere (off the riprap area).

JOHNNY DARTER

Johnny darters, like sculpins, are demersal, lay their eggs under objects and prefer rocky habitat. As evidence of this, one larva was collected in 1977, while increases through the years occurred such that 105 were caught in 1980. In both 1980 and 1981, adults and larvae tended to be most abundant at 6 to 12 m. Divers noted densities of adults in the riprap as high as $40/m^2$. Darters were entrained from 10 June to 11 August when 304,000 larvae (2.98% of the total) were estimated to be lost at the Unit 3 intake in 1981. Density comparisons between the field and entrainment samples varied; in June they were similar, in July more were caught in the field and in August field densities were higher than entrainment densities. Mean length of larvae tended to be shorter in entrainment samples when compared with field-caught larvae, suggesting avoidance of the Unit 3 intakes by the probably more demersal longer and older larvae. In 1980, 160,000 johnny darters were entrained at Units 1 and 2; in 1981 over

190,000 were estimated entrained. Field estimates of populations of darters compared with those entrained showed low percentages ($\leq$ 2%) of larvae impacted by entrainment.

LESS ABUNDANT SPECIES

A number of larval fish species were collected infrequently in the field and in entrainment samples. Deepwater sculpin larvae are uncommon in the vicinity of the plant, but enough were collected to establish that they are pelagic larvae with major populations in deep water (>50 m). Spawning occurs over a prolonged period from early winter to early spring. Deepwater sculpin larvae were entrained on 18 May at a density of 15/1000 m^3 which was comparable to densities of 11-173/1000 m^3 measured in the field over the past 5 yr. Lengths of larvae entrained (8-10 mm) were similar to those collected in the field on that date. Unit 3 entrained an estimated 39,200 deepwater sculpin larvae during 1981, while none were entrained by Units 1 and 2 in 1981. In 1980, Units 1 and 2 entrained 62,600 larvae.

Ninespine stickleback larvae were entrained from 15 June through 17 August; densities were low and larvae ranged from 7 to 15 mm TL. During 1981 68,000 larvae were entrained by Unit 3. Ninespine stickleback larvae were relatively rare in larval fish samples from 1977-1979. Beginning in 1980-1981 more were observed in field and entrainment samples, as apparently more adults utilized the riprap for spawning. In previous years spawning was believed to be more concentrated in deeper offshore waters.

Common carp larvae were relatively rare in Lake Michigan, only occurring in late June at the 15-m station. Entrainment losses at Unit 3 for the year were 35,000 with most being newly hatched larvae $\leq$ 6 mm. Entrainment losses at Units 1 and 2 were very high in some years (over 11 million in 1979), but levels were reduced in 1980 (2.65 million) and 1981 (3.35 million).

Gizzard shad was another species which was entrained at the Unit 3 intakes in low quantities (5420). A number of species (unidentified Coregoninae, emerald shiner, largemouth bass) were collected in the field, but not entrained.

FISH EGGS

Fish eggs reached maximum densities in field samples in June-July, with highest densities in late July sled tows. Most eggs were believed to be those of alewife and spottail shiner. Significantly higher densities were recorded in entrainment samples than field samples, which was attributed to the attractive influence of the intake riprap and risers to spawning alewives. Night densities for entrainment samples were higher than corresponding day densities. Unit 3 egg entrainment in 1981 was 107 million. Units 1 and 2 entrained 336 million eggs and 20.6 million eggs in 1980 and 1981, respectively.

DIVER OBSERVATIONS

Hydra, bryozoans and freshwater sponges were the dominant colonizers on the Unit 3 intake screens and risers. The deep water (11 m) apparently inhibited algal growth and favored these invertebrates. Isopods (*Asellus* sp.) were observed in high densities in the riprap, as well as a few snails (*Lymnaea* sp.). No crayfish were observed. Periphyton growth was sparse compared to other areas, but *Cladophora* was noted in low abundance on riprap collected in 1981. Eleven species of fish were observed, and spawning by lake trout, unidentified Coregoninae and slimy sculpin was documented. Slimy sculpins, johnny darters, trout-perch, spottail shiners and rainbow smelt were observed resting on top of the wedge-wire screens.

IMPINGEMENT

Results of our scuba diver work showed that no fish were impinged on the intake screens. Many live fish were observed directly on top of the screens and they seemed unaffected by the low through-slot current velocities.

BIOFOULING

From April to September 1981, an escalating accumulation of organic matter was observed on the Unit 3 wedge-wire screens. Invertebrates (freshwater sponges, bryozoans and *Hydra*), attached algae (including some *Cladophora*), flocculent organic detritus and sediment were present in varying amounts. Some screens had only small patches, while others had very large patches, up to 0.5 m^2 on both upper and lower parts of the screens. Maximum coverage was observed in early September with a decrease recorded in late September-October. Periphyton growth on the riprap was minimal in contrast to that observed on the wedge-wire screens.

OVERVIEW

The placement of the Unit 3 intake at the 11-m contour in Lake Michigan was based on previously collected data which showed this depth was an area of low abundance of larvae during most times of the year for most species. The potential effects of this decision were realized and evaluated in terms of entrainment and impingement losses, creation of new habitat, colonization of that habitat and operational success of the wedge-wire screens themselves, i.e., biofouling and resistance to storm-generated ice or tree damage. Estimated entrainment losses of larvae at Unit 3 in 1981 totaled 10.2 million, which when compared with potential populations of larvae in the vicinity of the plant, represented a minimal impact on respective populations. For most species, newly hatched, or small larvae of a particular cohort, were entrained with greater frequency than larger larvae which appeared to successfully avoid the wedge-wire screens. Since the smallest larvae usually experience the highest mortality rate, their entrainment represents less of a loss than if larger, older larvae were removed from their respective populations. Most entrainment occurred during the non-daylight periods, evidence that larvae were able to visually detect and avoid the screens. The most frequently entrained larvae were yellow perch, which was somewhat surprising; apparently the riprap extended optimal spawning habitat out to the 11-12-m contours which resulted in perch larvae being susceptible to entrainment by the Unit 3 intake.

Statistical analyses (ANOVA) showed that alewife larvae densities were significantly higher in field samples than in entrainment samples. This is evidence that even newly hatched alewife larvae are exhibiting an avoidance reaction to the wedge-wire screen intakes. Data from later on in the alewife spawning season showed only larvae up to 10 mm in length were entrained when larvae up to 25 mm were present in the field. Densities of entrained spottail shiner larvae were not significantly different from those in the field; however, the ANOVA utilized tows from four strata nearest the intake, not the 1-3-m depths where spottail larvae were most abundant. The fact that fish egg, yellow perch, and slimy sculpin densities were significantly higher in entrainment samples than in the four north transect field tows used to represent ambient field densities is undoubtedly due to attraction of fish to the riprap for spawning. For rainbow smelt, johnny darter and damaged larvae, there was no significant difference between densities in field samples and entrainment samples.

The Unit 3 screens completely prevented any impingement of fish according to our scuba divers who surveyed the screens regularly during 1981. Some fish which were presumed dead prior to their impingement were observed on the screens.

Another consideration in evaluating the new screens is the creation of new habitat by the structures and associated riprap which have been documented as attracting invertebrates and fish by providing cover and food. Lake trout, slimy sculpin and unidentified Coregoninae were documented as spawning in and around the riprap since its deposition began in 1978. Several other species, including johnny darter, yellow perch, ninespine stickleback and trout-perch, were also believed to prefer rocky areas for spawning, as larvae of these species were found in entrainment samples with greater frequency than they were found in field samples.

Lastly, the screens were shown to exhibit considerable biofouling, with up to 60% of some screens being covered with *Hydra*, bryozoans, freshwater sponges and various algal species, including *Cladophora*. No damage to the screens by ice or storms was noted by scuba divers during 1981, although the winter of 1980-1981 was relatively mild.

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INDEX TO FISH SPECIES

APPENDIXES

ADULT, JUVENILE AND LARVAL FISH POPULATIONS IN THE VICINITY OF THE JAMES H. CAMPBELL POWER PLANT, 1981, WITH SPECIAL REFERENCE TO THE EFFECTIVENESS OF WEDGE-WIRE INTAKE SCREENS IN REDUCING ENTRAINMENT AND IMPINGEMENT OF FISH

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APPENDIXES

Appendix 1. Alphabetical listing of code letters and common names of all fish species and species groups captured in Lake Michigan near the J. H. Campbell Plant, 1977 to 1981.

Code	Common name	Code	Common name
AL	Alewife	MA	Silver Redhorse
BC	Black Crappie	MM	Central Mudminnow
BG	Bluegill	MS	Mottled Sculpin
BM	Bluntnose Minnow	NP	Northern Pike
BL	Bloater	NS	Ninespine Stickleback
BR	Burbot	PM	Unidentified *Pomoxis* spp.
BT	Brown Trout	PP	Fathead Minnow
CC	Channel Catfish	PS	Pumpkinseed
CH	Chinook Salmon	QL	Quillback
CM	Coho Salmon	RT	Rainbow Trout
CP	Common Carp	RW	Round Whitefish
ES	Emerald Shiner	SB	Smallmouth Bass
FD	Freshwater Drum	SM	Rainbow Smelt
FS	Deepwater Sculpin	SP	Spottail Shiner
GF	Goldfish	SR	Shorthead Redhorse
GL	Golden Shiner	SS	Slimy Sculpin
GN	Green Sunfish	SV	Brook Silverside
GR	Golden Redhorse	TP	Trout-perch
GS	Gizzard Shad	UC	Unidentified Cottidae
JD	Johnny Darter	WL	Walleye
LD	Longnose Dace	WS	White Sucker
LG	Lake Sturgeon	XC	Unidentified Coregoninae
LH	Lake Herring	XG	Unidentified Stickleback
LP	Logperch	XL	Unidentified *Lepomis* spp.
LS	Longnose Sucker	XM	Unidentified Cyprinidae
LT	Lake Trout	XP	Damaged Larvae
LW	Lake Whitefish	XS	Unidentified Catostomidae
XX	Unidentified Pisces	YB	Yellow Bullhead
YP	Yellow Perch		

Appendix 2. Meteorological and limnological parameters measured during gillnetting, April to November 1981 near the J. H. Campbell Plant, eastern Lake Michigan. *=surface gill net.

STARTING DATE	TIME START	TIME FINISH	STATION	TEMPERATURE (C) SURFACE	TEMPERATURE (C) FISH DEPTH	WIND DIR. FROM	WIND SPEED (MPH)	WAVES DIR. FROM	WAVES HEIGHT (m)	WEATHER	SECCHI (m)
4-13-81	0920	1900	A	9.1	8.4	SE	10-15	SE	0-0.3	CLEAR	1.75
4-14-81	1910	0720	A	9.0	8.5	NW	5-10	W	0.6-1.0	CLEAR	-
4-13-81	0930	1855	B	8.0	7.6	SE	10-15	SE	0-0.3	CLEAR	1.5
4-14-81	1915	0715	B	8.5	8.0	NW	5-10	W	0.6-1.0	CLEAR	-
4-13-81	0940	1840	C	7.6	7.5	SE	10-15	SE	0-0.3	CLEAR	1.75
4-14-81	1925	0700	C	8.5	8.0	NW	10-15	W	0.6-1.0	CLEAR	-
4-13-81	0945	1845	C*	7.6	7.6	SE	10-15	SE	0-0.3	CLEAR	1.75
4-14-81	1930	0708	C*	8.5	8.5	NW	10-15	W	0.6-1.0	CLEAR	-
4-13-81	0945	1835	D	7.6	7.2	SE	10-15	SE	0-0.3	CLEAR	2.0
4-14-81	1935	0645	D	8.0	7.5	NW	10-15	W	0.6-1.0	CLEAR	-
4-13-81	0950	1825	E	7.4	7.0	SE	10-15	SE	0-0.3	CLEAR	2.0
4-14-81	1942	0630	E	8.0	6.8	NW	10-15	W	0.6-1.0	CLEAR	-
4-13-81	0855	1905	L	10.0	9.0	SE	5-10	SE	0-0.3	CLEAR	1.75
4-14-81	1920	0625	L	8.0	7.5	NW	10-15	NW	0.6-1.0	CLEAR	-
4-13-81	0850	1858	L*	10.0	10.0	SE	5-10	SE	0-0.3	CLEAR	1.75
4-14-81	1915	0640	L*	8.0	8.0	NW	10-15	NW	0.6-1.0	CLEAR	-
4-13-81	0905	1910	N	9.5	9.0	SE	5-10	SE	0-0.3	CLEAR	1.75
4-14-81	1935	0625	N	8.0	7.5	NW	10-15	NW	0.6-1.0	CLEAR	-
4-13-81	0830	1850	U	9.0	9.0	SE	5-10	SE	0-0.3	CLEAR	1.75
4-14-81	1930	0700	U	8.0	7.5	NW	10-15	NW	0.6-1.0	CLEAR	-
4-13-81	0835	1855	U*	9.0	9.0	SE	5-10	SE	0-0.3	CLEAR	1.75
4-14-81	1925	0655	U*	8.0	8.0	NW	10-15	NW	0.6-1.0	CLEAR	-
5-18-81	0645	1940	A	6.7	6.5	NE	0-5	NW	0-0.3	CLEAR	1.25
5-18-81	1940	0625	A	8.0	7.5	NE	10-15	NW	0.3-0.6	OVERCAST	-
5-18-81	0650	1920	B	6.5	6.2	NE	0-5	NW	0-0.3	CLEAR	1.75
5-18-81	1920	0620	B	7.5	7.0	NE	10-15	NW	0.3-0.6	OVERCAST	-
5-18-81	0710	1905	C	6.3	6.4	NE	0-5	NW	0-0.3	CLEAR	2.25
5-18-81	1905	0635	C	7.0	6.0	NE	10-15	NW	0.3-0.6	OVERCAST	-
5-18-81	0720	1900	C*	6.3	6.3	NE	0-5	NW	0-0.3	CLEAR	2.5
5-18-81	1900	0610	C*	7.0	7.0	NE	10-15	NW	0.3-0.6	OVERCAST	-
5-18-81	0730	1840	D	6.4	6.4	NE	0-5	NW	0-0.3	CLEAR	2.5
5-18-81	1840	0650	D	6.5	6.0	NE	10-15	NW	0.3-0.6	OVERCAST	-
5-18-81	0740	1835	E	6.5	6.0	NE	0-5	NW	0-0.3	CLEAR	2.5
5-18-81	1835	0545	E	6.0	5.5	NE	10-15	NW	0.3-0.6	OVERCAST	-
5-18-81	0820	1910	L	6.4	6.4	NE	0-5	NW	0-0.3	CLEAR	2.0
5-18-81	1920	0600	L	6.5	6.0	NE	10-15	NW	0.3-0.6	OVERCAST	-
5-18-81	0830	1900	L*	6.4	6.4	NE	0-5	NW	0-0.3	CLEAR	2.0
5-18-81	1910	0605	L*	6.5	6.5	NE	10-15	NW	0.3-0.6	OVERCAST	-
5-18-81	0840	1830	N	6.3	6.0	NE	0-5	NW	0-0.3	CLEAR	2.5
5-18-81	1850	0615	N	5.5	4.5	NE	10-15	NW	0.3-0.6	OVERCAST	-
5-18-81	0810	1840	U	6.4	6.4	NE	0-5	NW	0-0.3	CLEAR	2.0
5-18-81	1855	0550	U	6.4	6.4	NE	15-20	NW	0.3-0.6	OVERCAST	-
5-18-81	0800	1850	U*	6.4	6.4	NE	0-5	NW	0-0.3	CLEAR	2.0
5-18-81	1850	0540	U*	6.4	6.4	NE	15-20	NW	0.3-0.6	OVERCAST	-
6-16-81	0905	1905	A	18.6	19.0	SW	15-20	WSW	0.6-1.0	OVERCAST	1.0
6-16-81	2125	0625	A	19.0	19.0	W	20-25	W	0.3-0.6	PT.CLOUDY	-

Appendix 2. Continued.

STARTING DATE	TIME		STATION	TEMPERATURE (C)		WIND		WAVES		WEATHER	SECCHI (m)
	START	FINISH		SURFACE	FISH DEPTH	DIR. FROM	SPEED (MPH)	DIR. FROM	HEIGHT (m)		
6-16-81	0900	1900	B	18.6	18.2	SW	15-20	WSW	0.6-1.0	OVERCAST	1.5
6-16-81	2130	0635	B	19.0	19.0	W	20-25	W	0.6-1.0	PT.CLOUDY	-
6-16-81	0850	1855	C	19.5	19.5	SW	15-20	WSW	0.6-1.0	OVERCAST	1.75
6-16-81	2140	0645	C	19.0	19.0	SW	10-15	SW	0.6-1.0	PT.CLOUDY	-
6-16-81	0855	1845	C*	19.5	19.5	SW	15-20	WSW	0.6-1.0	OVERCAST	1.75
6-16-81	2150	0650	C*	19.0	19.0	SW	10-15	SW	0.6-1.0	PT.CLOUDY	-
6-16-81	0840	1840	D	19.0	19.0	SW	15-20	WSW	0.6-1.0	OVERCAST	2.0
6-16-81	2135	0700	D	18.0	18.0	SW	10-15	SW	0.6-1.0	PT.CLOUDY	-
6-16-81	0830	1830	E	19.0	19.0	SW	15-20	WSW	0.6-1.0	RAIN	3.75
6-16-81	2125	0710	E	17.8	17.8	SW	10-15	SW	0.6-1.0	PT.CLOUDY	-
6-16-81	0840	1830	L	17.5	16.8	SW	15-20	SW	0.6-1.0	OVERCAST	2.5
6-16-81	2030	0650	L	18.0	17.2	W	20-25	W	0.3-0.6	PT.CLOUDY	-
6-16-81	0835	1820	L*	17.5	17.5	SW	15-20	SW	0.6-1.0	OVERCAST	2.5
6-16-81	1917	0640	L*	18.0	18.0	W	20-25	W	0.3-0.6	PT.CLOUDY	-
6-16-81	0905	1900	N	17.0	16.0	SW	15-20	SW	0.6-1.0	OVERCAST	3.0
6-16-81	2020	0705	N	18.5	17.8	W	15-20	W	0.3-0.6	PT.CLOUDY	-
6-16-81	0855	1850	U	17.8	17.5	SW	15-20	SW	0.6-1.0	OVERCAST	2.0
6-16-81	2025	0700	U	18.0	17.2	W	20-25	W	0.3-0.6	PT.CLOUDY	-
6-16-81	0845	1845	U*	17.8	17.8	SW	15-20	SW	0.6-1.0	OVERCAST	2.0
6-16-81	1844	0625	U*	18.2	18.0	W	20-25	W	0.3-0.6	PT.CLOUDY	-
7-20-81	0745	1740	A	20.5	20.1	VAR	0-5	VAR	0-0.3	FOG	BOTTOM
7-20-81	1740	0540	A	22.0	22.0	NW	10-15	NW	0-0.3	RAIN	-
7-20-81	0750	1750	B	20.5	20.5	VAR	0-5	VAR	0-0.3	FOG	BOTTOM
7-20-81	2000	0550	B	21.0	21.0	WNW	0-5	WNW	0.3-0.6	OVERCAST	-
7-20-81	0800	1800	C	20.0	15.2	VAR	0-5	VAR	0-0.3	FOG	6.0
7-20-81	1950	0600	C	20.5	18.0	WNW	0-5	WNW	0.3-0.6	OVERCAST	-
7-20-81	0805	1805	C*	20.0	20.0	VAR	0-5	VAR	0-0.3	FOG	6.0
7-20-81	1805	0610	C*	20.5	20.5	NW	5-10	NW	0-0.3	RAIN	-
7-20-81	0810	1940	D	19.5	8.5	VAR	0-5	VAR	0-0.3	FOG	8.25
7-20-81	1940	0625	D	21.0	13.0	WNW	0-5	WNW	0.3-0.6	OVERCAST	-
7-20-81	0815	1930	E	20.5	6.2	VAR	0-5	VAR	0-0.3	FOG	6.5
7-20-81	1930	0635	E	21.0	8.0	WNW	0-5	WNW	0.3-0.6	OVERCAST	-
7-20-81	0755	1730	L	20.8	9.3	ENE	5-10	CALM	CALM	OVERCAST	5.25
7-20-81	1940	0625	L	21.2	17.4	NW	5-10	NW	0-0.3	RAIN	-
7-20-81	0750	1745	L*	20.8	20.8	ENE	5-10	CALM	CALM	OVERCAST	5.25
7-20-81	1745	0550	L*	21.2	21.2	NW	5-10	NW	0-0.3	RAIN	-
7-20-81	0820	1800	N	20.7	9.4	ENE	5-10	CALM	CALM	OVERCAST	7.25
7-20-81	1955	0620	N	21.0	17.0	NW	5-10	NW	0-0.3	RAIN	-
7-20-81	0815	1755	U	20.7	15.0	ENE	5-10	CALM	CALM	OVERCAST	6.0
7-20-81	1945	0610	U	21.2	17.4	NW	5-10	NW	0-0.3	RAIN	-
7-20-81	0810	1750	U*	20.7	20.7	ENE	5-10	CALM	CALM	OVERCAST	6.0
7-20-81	1750	0600	U*	21.2	21.2	NW	5-10	NW	0-0.3	RAIN	-
8-17-81	0745	1945	A	19.8	19.4	E	0-5	NW	0-0.3	CLEAR	1.5
8-18-81	2040	0600	A	17.5	13.5	NE	5-10	NW	0.3-0.6	CLEAR	-
8-17-81	0800	1940	B	19.8	19.5	E	0-5	NW	0-0.3	CLEAR	1.3
8-18-81	2035	0610	B	15.6	10.2	NE	5-10	NW	0.3-0.6	CLEAR	-
8-17-81	0810	1935	C	20.1	16.3	E	0-5	NW	0-0.3	CLEAR	2.0
8-18-81	2030	0615	C	16.7	8.3	NE	5-10	NW	0.6-1.0	CLEAR	-

Appendix 2. Continued.

STARTING DATE	TIME		STATION	TEMPERATURE (C)		WIND		WAVES		WEATHER	SECCHI (m)
	START	FINISH		SURFACE	FISH DEPTH	DIR. FROM	SPEED (MPH)	DIR. FROM	HEIGHT (m)		
8-17-81	0815	1925	C*	20.1	20.1	E	0-5	NW	0-0.3	CLEAR	2.0
8-18-81	2015	0625	C*	16.7	16.7	NE	5-10	NW	0.3-0.6	CLEAR	-
8-17-81	0825	1915	D	20.2	12.1	E	0-5	NW	0-0.3	CLEAR	2.0
8-18-81	2020	0630	D	16.5	7.7	NE	5-10	NW	0.3-0.6	CLEAR	-
8-17-81	0830	1900	E	20.7	8.7	E	0-5	NW	0-0.3	CLEAR	2.5
8-18-81	2015	0640	E	17.7	6.2	NE	10-15	NW	0.6-1.0	CLEAR	-
8-17-81	0905	1820	L	20.7	17.7	E	5-10	NW	0-0.3	CLEAR	2.0
8-18-81	1920	0630	L	19.0	10.0	N	15-20	NW	0.6-1.0	CLEAR	-
8-17-81	0910	1830	L*	20.7	20.7	E	5-10	NW	0-0.3	CLEAR	2.0
8-18-81	1920	0600	L*	19.0	19.0	N	15-20	NW	0.6-1.0	CLEAR	-
8-17-81	0855	1905	N	20.8	16.3	E	5-10	NW	0-0.3	CLEAR	2.0
8-18-81	1945	0705	N	18.7	7.5	N	15-20	NW	0.6-1.0	CLEAR	-
8-17-81	0915	1850	U	20.7	19.6	E	5-10	NW	0-0.3	CLEAR	2.0
8-18-81	1940	0640	U	18.5	9.5	N	15-20	NW	0.6-1.0	CLEAR	-
8-17-81	0920	1840	U*	20.7	20.7	E	5-10	NW	0-0.3	CLEAR	2.0
8-18-81	1935	0650	U*	18.5	18.5	N	15-20	NW	0.6-1.0	CLEAR	-
9-09-81	0730	1740	A	16.8	16.7	SW	0-5	NW	0-0.3	CLEAR	BOTTOM
9-10-81	1900	0640	A	20.6	20.6	SW	0-5	SW	0.6-1.0	OVERCAST	-
9-09-81	0735	1745	B	17.0	16.0	SW	0-5	NW	0-0.3	CLEAR	2.7
9-10-81	1855	0645	B	21.0	20.7	SW	0-5	SW	0.6-1.0	OVERCAST	-
9-09-81	0750	1800	C	17.0	16.3	SW	0-5	NW	0-0.3	CLEAR	2.7
9-10-81	1850	0650	C	21.2	20.8	SW	0-5	SW	0.6-1.0	OVERCAST	-
9-09-81	0745	1750	C*	17.0	17.0	SW	0-5	NW	0-0.3	CLEAR	2.7
9-10-81	1845	0655	C*	21.2	21.2	SW	0-5	SW	0.6-1.0	OVERCAST	-
9-09-81	0755	1805	D	18.4	16.7	SW	0-5	NW	0-0.3	CLEAR	3.7
9-10-81	1835	0705	D	21.0	20.5	SW	0-5	SW	0.6-1.0	OVERCAST	-
9-09-81	0830	1820	E	19.0	16.8	SW	0-5	NW	0-0.3	CLEAR	4.0
9-10-81	1830	0715	E	21.1	20.3	SW	0-5	SW	0.6-1.0	OVERCAST	-
9-09-81	0725	1805	L	17.5	17.0	SW	5-10	NW	0-0.3	CLEAR	4.0
9-10-81	1826	0715	L	20.3	20.0	SW	0-5	SW	0.6-1.0	OVERCAST	-
9-09-81	0730	1755	L*	17.5	17.5	SW	5-10	NW	0-0.3	CLEAR	4.0
9-10-81	1815	0710	L*	20.3	20.3	SW	0-5	SW	0.6-1.0	OVERCAST	-
9-09-81	0745	1730	N	17.5	16.0	SW	5-10	W	0-0.3	CLEAR	4.5
9-10-81	1845	0655	N	20.7	20.4	SW	0-5	SW	0.6-1.0	OVERCAST	-
9-09-81	0735	1740	U	17.5	17.0	SW	5-10	NW	0-0.3	CLEAR	4.0
9-10-81	1830	0630	U	20.3	20.0	SW	0-5	SW	0.6-1.0	OVERCAST	-
9-09-81	0740	1735	U*	17.5	17.5	SW	5-10	NW	0-0.3	CLEAR	4.0
9-10-81	1835	0640	U*	20.3	20.3	SW	0-5	SW	0.6-1.0	OVERCAST	-
10-21-81	1135	1810	A	10.0	10.0	NE	5-10	NE	0-0.3	OVERCAST	1.0
10-20-81	1815	0735	A	10.5	10.5	VAR	0-5	SW	0.3-0.6	PT.CLOUDY	-
10-21-81	1125	1805	B	10.5	10.5	NE	5-10	NE	0-0.3	OVERCAST	1.5
10-20-81	1825	0740	B	10.0	10.0	VAR	0-5	SW	0.3-0.6	PT.CLOUDY	-
10-21-81	1130	1800	C	11.0	10.5	NE	5-10	NE	0-0.3	OVERCAST	1.5
10-20-81	1830	0750	C	10.5	10.5	N	5-10	VAR	0.3-0.6	PT.CLOUDY	-
10-21-81	1120	1755	C*	11.0	11.0	NE	5-10	NE	0-0.3	OVERCAST	1.5
10-20-81	1852	0800	C*	10.5	10.5	N	5-10	VAR	0.3-0.6	PT.CLOUDY	-
10-21-81	1115	1750	D	11.0	11.0	NE	5-10	NE	0-0.3	OVERCAST	2.0
10-20-81	1845	0810	D	10.5	10.0	N	5-10	VAR	0.3-0.6	PT.CLOUDY	-

Appendix 2. Continued.

STARTING DATE	TIME START	TIME FINISH	STATION	TEMPERATURE (C) SURFACE	TEMPERATURE (C) FISH DEPTH	WIND DIR. FROM	WIND SPEED (MPH)	WAVES DIR. FROM	WAVES HEIGHT (m)	WEATHER	SECCHI (m)
10-21-81	1107	1745	E	11.5	11.0	NE	5-10	NE	0-0.3	OVERCAST	2.0
10-20-81	1855	0820	E	10.5	10.0	NE	10-15	VAR	0.3-0.6	PT.CLOUDY	-
10-21-81	0955	1635	L	11.5	11.0	NE	5-10	NE	0-0.3	OVERCAST	2.0
10-20-81	1850	0730	L	10.3	9.8	N	5-10	W	0.6-1.0	PT.CLOUDY	-
10-21-81	0950	1640	L*	11.5	11.5	NE	5-10	NE	0-0.3	OVERCAST	2.0
10-20-81	1845	0735	L*	10.3	10.3	N	5-10	W	0.6-1.0	PT.CLOUDY	-
10-21-81	1020	1705	N	11.5	11.0	NE	5-10	NE	0-0.3	OVERCAST	2.0
10-20-81	1818	0725	N	11.0	10.5	N	5-10	W	0.6-1.0	PT.CLOUDY	-
10-21-81	1000	1700	U	11.5	11.0	NE	5-10	NE	0-0.3	OVERCAST	2.0
10-20-81	1825	0730	U	10.5	10.5	N	5-10	W	0.6-1.0	PT.CLOUDY	-
10-21-81	1010	1650	U*	11.5	11.5	NE	5-10	NE	0-0.3	OVERCAST	2.0
10-20-81	1830	0740	U*	10.5	10.5	N	5-10	W	0.6-1.0	PT.CLOUDY	-
11-03-81	1045	1705	A	10.7	10.7	SE	10-15	SW	0-0.3	CLEAR	BOTTOM
11-02-81	1800	0725	A	11.2	11.2	NE	10-15	NW	0.3-0.6	PT.CLOUDY	-
11-03-81	1040	1710	B	11.0	10.5	SE	10-15	SW	0-0.3	CLEAR	2.5
11-02-81	1755	0730	B	11.0	11.0	NE	10-15	NW	0.3-0.6	PT.CLOUDY	-
11-03-81	1030	1725	C	10.7	10.5	SE	10-15	SW	0-0.3	CLEAR	3.5
11-02-81	1750	0745	C	10.9	10.9	NE	10-15	NW	0.3-0.6	PT.CLOUDY	-
11-03-81	1035	1715	C*	10.7	10.7	SE	10-15	SW	0-0.3	CLEAR	3.5
11-02-81	1745	0735	C*	10.9	10.9	NE	10-15	NW	0.3-0.6	PT.CLOUDY	-
11-03-81	1025	1625	D	11.0	9.8	SE	10-15	SW	0-0.3	CLEAR	4.0
11-02-81	1735	0745	D	11.0	10.4	NE	10-15	NW	0.3-0.6	PT.CLOUDY	-
11-03-81	1015	1620	E	11.0	9.5	SE	10-15	SW	0-0.3	CLEAR	4.0
11-02-81	1725	0755	E	11.1	10.3	NE	10-15	NW	0.3-0.6	PT.CLOUDY	-
11-03-81	0935	1600	L	10.5	10.5	SE	10-15	SW	0-0.3	CLEAR	4.25
11-02-81	1645	0630	L	11.5	11.5	N	5-10	N	0-0.3	PT.CLOUDY	-
11-03-81	0940	1605	L*	10.5	10.5	SE	10-15	SW	0-0.3	CLEAR	4.25
11-02-81	1640	0635	L*	11.5	11.5	N	5-10	N	0-0.3	PT.CLOUDY	-
11-03-81	1000	1615	N	11.0	10.5	SE	10-15	SW	0-0.3	CLEAR	4.25
11-02-81	1650	0620	N	12.5	12.0	N	5-10	N	0-0.3	PT.CLOUDY	-
11-03-81	0950	1645	U	10.5	10.5	SE	10-15	SW	0-0.3	CLEAR	4.5
11-02-81	1630	0645	U	11.5	11.5	N	5-10	N	0-0.3	PT.CLOUDY	-
11-03-81	0945	1640	U*	10.5	10.5	SE	10-15	SW	0-0.3	CLEAR	4.5
11-02-81	1635	0650	U*	11.5	11.5	N	5-10	N	0-0.3	PT.CLOUDY	-

Appendix 3. Meteorological and limnological parameters measured during seining, April to November 1981 near the J. H. Campbell Plant, eastern Lake Michigan.

STARTING DATE	START TIME	STATION	TEMPERATURE C		WIND		WAVES		WEATHER
			SURFACE	FISH DEPTH	DIR. FROM	SPEED (MPH)	DIR. FROM	HT (m)	
4-13-81	1715	P	10.5	10.5	SW	0-5	SW	0-0.3	CLEAR
4-13-81	2039	P	9.0	9.0	SE	0-5	SE	0-0.3	CLEAR
4-13-81	1800	R	11.0	11.0	SW	0-5	SW	0-0.3	CLEAR
4-13-81	2110	R	9.0	9.0	SE	0-5	SE	0-0.3	RAIN
5-19-81	1515	P	12.0	12.0	NW	10-15	NW	0.3-0.6	CLEAR
5-19-81	2055	P	9.5	9.5	NW	0-5	NW	0.3-0.6	CLEAR
5-19-81	1545	R	12.5	12.5	NW	10-15	NW	0.3-0.6	CLEAR
5-19-81	2130	R	10.5	10.5	NW	0-5	NW	0.3-0.6	CLEAR
6-16-81	1408	P	19.4	19.4	SW	15-20	SW	0.6-1.0	PT.CLOUDY
6-16-81	2310	P	18.5	18.5	W	10-15	W	0.6-1.0	CLEAR
6-16-81	1445	R	19.5	19.5	SW	15-20	SW	0.6-1.0	PT.CLOUDY
6-16-81	2350	R	18.3	18.3	W	10-15	W	0.6-1.0	CLEAR
7-20-81	1330	P	22.0	22.0	NE	0-5	NE	0-0.3	OVERCAST
7-19-81	2020	P	22.5	22.5	SW	0-5	SW	0-0.3	OVERCAST
7-20-81	1410	R	22.0	22.0	NE	0-5	NE	0-0.3	OVERCAST
7-19-81	2150	R	22.5	22.5	SW	0-5	SW	0-0.3	OVERCAST
8-18-81	1220	P	17.7	17.7	NW	0-5	NW	0-0.3	CLEAR
8-18-81	2020	P	18.5	18.5	N	0-5	NW	0.3-0.6	CLEAR
8-18-81	1248	R	20.2	20.2	NW	0-5	NW	0-0.3	CLEAR
8-18-81	2058	R	19.5	19.5	N	0-5	NW	0.3-0.6	CLEAR
9-08-81	1425	P	16.0	16.0	NW	10-15	NW	0.6-1.0	CLEAR
9-08-81	2200	P	15.0	15.0	N	5-10	NW	0.6-1.0	PT.CLOUDY
9-08-81	1505	R	15.0	15.0	NW	10-15	NW	0.6-1.0	PT.CLOUDY
9-08-81	2240	R	14.0	14.0	NW	5-10	NW	0.3-0.6	PT.CLOUDY
10-22-81	0900	P	8.0	8.0	SW	0-5	SW	0-0.3	OVERCAST
10-19-81	1917	P	9.5	9.5	SW	25+	SW	1-2	CLEAR
10-22-81	0945	R	8.4	8.4	SW	0-5	SW	0-0.3	OVERCAST
10-19-81	1950	R	9.5	9.5	SW	25+	SW	1-2	CLEAR
11-02-81	1400	P	13.0	13.0	N	0-5	NW	0-0.3	PT.CLOUDY
11-02-81	1830	P	12.0	12.0	E	0-5	NW	0-0.3	PT.CLOUDY
11-02-81	1427	R	13.0	13.0	N	0-5	NW	0-0.3	PT.CLOUDY
11-02-81	1900	R	12.0	12.0	E	0-5	NW	0-0.3	PT.CLOUDY

Appendix 4. Meteorological and limnological parameters measured during trawling, April to December 1981 near the J. H. Campbell Plant, eastern Lake Michigan.

STARTING DATE	TIME START	TIME FINISH	STATION	TEMPERATURE C SURFACE	TEMPERATURE C FISH DEPTH	WIND DIR. FROM	WIND SPEED (MPH)	WAVES DIR. FROM	WAVES HEIGHT (m)	WEATHER	SECCHI (m)
4-15-81	0820	0830	B	8.0	7.5	E	0-5	CALM	CALM	CLEAR	1.0
4-15-81	0255	0305	B	6.8	6.8	WSW	0-5	WSW	0-0.3	CLEAR	-
4-15-81	0856	0906	C	7.3	7.3	E	0-5	CALM	CALM	CLEAR	1.6
4-15-81	0212	0222	C	6.0	6.0	WSW	5-10	WSW	0-0.3	CLEAR	-
4-15-81	0932	0942	D	7.2	7.2	E	0-5	CALM	CALM	CLEAR	1.1
4-15-81	0127	0137	D	6.0	6.0	WSW	0-5	WSW	0.3-0.6	CLEAR	-
4-15-81	1015	1025	E	7.0	6.7	E	0-5	CALM	CALM	CLEAR	1.2
4-15-81	0045	0055	E	6.0	6.0	WSW	0-5	WSW	0.3-0.6	CLEAR	-
4-15-81	1150	1200	L	7.2	6.0	W	0-5	W	0-0.3	CLEAR	1.2
4-14-81	2315	2325	L	7.0	6.0	WSW	0-5	VAR	0-0.3	CLEAR	-
4-14-81	1110	1120	N	7.0	6.0	W	0-5	W	0-0.3	CLEAR	1.0
4-14-81	2357	0007	N	7.0	7.0	WSW	0-5	VAR	0-0.3	CLEAR	-
5-19-81	1804	1814	B	7.5	7.0	NNW	10-15	NW	0.6-1.0	CLEAR	2.0
5-19-81	2224	2234	B	5.5	5.0	VAR	0-5	NW	0.3-0.6	CLEAR	-
5-19-81	1726	1736	C	6.5	6.5	NNW	10-15	NW	0.6-1.0	CLEAR	3.0
5-19-81	2147	2157	C	5.5	5.5	VAR	0-5	NW	0.3-0.6	CLEAR	-
5-19-81	1646	1656	D	6.0	5.5	NNW	10-15	NW	0.6-1.0	CLEAR	3.5
5-19-81	2106	2116	D	6.5	6.5	VAR	0-5	NW	0.3-0.6	CLEAR	-
5-19-81	1603	1613	E	6.5	6.0	NNW	10-15	NW	0.6-1.0	CLEAR	3.5
5-19-81	2027	2037	E	4.5	5.0	VAR	0-5	NW	0.6-1.0	CLEAR	-
5-19-81	1430	1440	L	8.0	8.0	NNW	10-15	NW	0.6-1.0	PT.CLOUDY	2.5
5-20-81	0010	0020	L	6.0	6.0	VAR	0-5	NW	0.3-0.6	CLEAR	-
5-19-81	1510	1520	N	6.5	6.0	NNW	10-15	NW	0.6-1.0	PT.CLOUDY	2.8
5-19-81	2315	2325	N	5.0	5.0	VAR	0-5	NW	0.3-0.6	CLEAR	-
6-16-81	1845	1855	B	19.5	19.5	WSW	15-20	SSW	0.6-1.0	PT.CLOUDY	1.5
6-16-81	2245	2255	B	20.1	20.0	W	15-20	W	0.6-1.0	CLEAR	-
6-16-81	1805	1815	C	19.5	19.5	WSW	15-20	WSW	1-2	OVERCAST	1.5
6-16-81	2210	2220	C	19.9	20.1	W	15-20	W	0.6-1.0	CLEAR	-
6-16-81	1730	1740	D	19.0	18.8	WSW	15-20	WSW	0.6-1.0	OVERCAST	2.0
6-16-81	2135	2145	D	19.0	18.5	W	15-20	W	0.6-1.0	OVERCAST	-
6-16-81	1650	1700	E	18.8	18.2	SW	15-20	WSW	0.6-1.0	PT.CLOUDY	4.0
6-16-81	2055	2105	E	19.0	18.5	W	15-20	W	0.6-1.0	OVERCAST	-
6-16-81	1513	1523	L	21.3	21.4	SW	15-20	WSW	0.6-1.0	OVERCAST	2.5
6-17-81	0020	0030	L	19.9	19.9	W	15-20	W	0.6-1.0	CLEAR	-
6-16-81	1550	1600	N	20.3	20.1	WSW	15-20	WSW	0.6-1.0	PT.CLOUDY	3.0
6-16-81	2345	2355	N	20.0	20.0	W	15-20	W	0.6-1.0	CLEAR	-
7-22-81	1822	1832	B	7.9	6.7	NW	5-10	NW	0-0.3	CLEAR	2.0
7-22-81	2253	2303	B	6.2	5.9	VAR	0-5	NW	0-0.3	CLEAR	-
7-22-81	1744	1754	C	7.3	5.7	NW	5-10	NW	0-0.3	CLEAR	2.75
7-22-81	2218	2228	C	6.7	5.7	NW	0-5	NW	0-0.3	CLEAR	-
7-22-81	1705	1715	D	9.2	5.3	NW	0-5	NW	0-0.3	CLEAR	2.5
7-22-81	2140	2150	D	6.4	5.2	NW	0-5	NW	0-0.3	CLEAR	-

Appendix 4. Continued.

STARTING DATE	TIME		STATION	TEMPERATURE C		WIND		WAVES		WEATHER	SECCHI (m)
	START	FINISH		SURFACE	FISH DEPTH	DIR. FROM	SPEED (MPH)	DIR. FROM	HEIGHT (m)		
7-22-81	1623	1633	E	10.2	5.3	NW	0-5	NW	0-0.3	CLEAR	3.0
7-22-81	2100	2110	E	6.5	4.9	NW	0-5	NW	0-0.3	CLEAR	-
7-22-81	1450	1500	L	8.2	5.7	NW	0-5	NW	0-0.3	CLEAR	1.75
7-23-81	0042	0052	L	8.0	5.3	VAR	0-5	NW	0-0.3	CLEAR	-
7-22-81	1529	1539	N	8.8	5.7	NW	0-5	NW	0-0.3	CLEAR	2.25
7-22-81	2350	0000	N	6.9	5.3	VAR	0-5	NW	0-0.3	CLEAR	-
8-18-81	2215	2225	B	13.5	8.0	NE	5-10	NE	0-0.3	CLEAR	-
8-18-81	1804	1814	C	12.2	9.0	NW	5-10	NW	0-0.3	CLEAR	1.75
8-18-81	2133	2143	C	14.6	7.5	NW	5-10	NW	0-0.3	CLEAR	-
8-18-81	1724	1734	D	12.2	6.8	NW	0-5	NW	0-0.3	CLEAR	1.90
8-18-81	2053	2103	D	16.9	6.6	NW	5-10	NW	0.3-0.6	CLEAR	-
8-18-81	1627	1637	E	11.8	7.0	NW	5-10	NW	0.3-0.6	CLEAR	2.0
8-18-81	2011	2021	E	16.0	6.5	NW	5-10	NW	0.3-0.6	CLEAR	-
8-18-81	1420	1430	L	18.5	18.0	NW	5-10	NW	0-0.3	CLEAR	2.5
8-18-81	2353	0003	L	13.3	8.0	NE	5-10	NW	0-0.3	CLEAR	-
8-18-81	1537	1547	N	12.0	11.8	NW	5-10	NW	0-0.3	CLEAR	2.75
8-18-81	2314	2324	N	14.2	6.7	NE	5-10	NW	0.3-0.6	CLEAR	-
9-10-81	1745	1755	C	20.5	20.0	SW	5-10	SW	0.3-0.6	CLEAR	4.0
9-11-81	2040	2050	C	21.5	21.5	SSW	15-20	SW	1-2	CLEAR	-
9-10-81	1704	1714	D	20.5	20.0	SW	5-10	SW	0.6-1.0	CLEAR	4.25
9-11-81	2000	2010	D	21.5	21.5	SSW	15-20	SW	1-2	CLEAR	-
9-10-81	1618	1628	E	21.0	20.0	SW	5-10	SW	1-2	CLEAR	3.75
9-11-81	1915	1925	E	23.0	22.5	SSW	15-20	SW	1-2	CLEAR	-
9-10-81	1425	1435	L	18.5	18.5	SW	10-15	SW	1-2	CLEAR	3.5
9-11-81	2220	2230	L	23.0	23.0	SSW	15-20	SW	1-2	CLEAR	-
9-10-81	1509	1519	N	20.5	18.5	SW	10-15	SW	1-2	CLEAR	4.5
9-11-81	2140	2150	N	22.5	22.5	SSW	15-20	SW	1-2	PT.CLOUDY	-
10-21-81	1449	1459	B	11.0	11.0	NE	15-20	N	0.3-0.6	RAIN	1.5
10-21-81	1408	1418	C	11.6	11.6	E	15-20	E	0.3-0.6	RAIN	2.0
10-20-81	2037	2047	C	11.5	11.5	NE	10-15	NE	0.3-0.6	OVERCAST	-
10-21-81	1329	1339	D	11.6	11.6	E	10-15	NE	0-0.3	RAIN	2.0
10-20-81	1959	2009	D	12.2	12.2	NE	10-15	NE	0.3-0.6	OVERCAST	-
10-21-81	1252	1302	E	11.2	11.2	E	10-15	E	0-0.3	RAIN	2.1
10-20-81	1916	1926	E	12.0	12.0	NE	10-15	SW	0.6-1.0	OVERCAST	-
10-21-81	1622	1632	L	11.3	11.3	E	10-15	NW	0-0.3	RAIN	1.9
10-20-81	2207	2217	L	11.1	11.1	E	5-10	N	0-0.3	PT.CLOUDY	-
10-21-81	1541	1551	N	11.6	11.6	NE	10-15	NW	0.3-0.6	RAIN	2.0
10-20-81	2129	2139	N	11.1	11.1	E	5-10	N	0-0.3	PT.CLOUDY	-

Appendix 4. Continued.

STARTING DATE	TIME		STATION	TEMPERATURE C		WIND		WAVES		WEATHER	SECCHI (m)
	START	FINISH		SURFACE	FISH DEPTH	DIR. FROM	SPEED (MPH)	DIR. FROM	HEIGHT (m)		
11-04-81	1607	1617	B	11.8	11.6	E	0-5	CALM	CALM	PT.CLOUDY	3.0
11-04-81	1945	1955	B	11.5	11.5	E	0-5	CALM	CALM	PT.CLOUDY	-
11-04-81	1531	1541	C	11.4	11.4	E	0-5	CALM	CALM	PT.CLOUDY	4.0
11-04-81	1910	1920	C	11.3	11.0	E	0-5	CALM	CALM	PT.CLOUDY	-
11-04-81	1455	1505	D	11.6	10.6	E	0-5	CALM	CALM	PT.CLOUDY	4.0
11-04-81	1834	1844	D	11.4	10.2	E	0-5	CALM	CALM	PT.CLOUDY	-
11-04-81	1415	1425	E	11.8	9.3	VAR	0-5	CALM	CALM	PT.CLOUDY	4.0
11-04-81	1800	1810	E	11.7	9.5	E	0-5	CALM	CALM	CLEAR	-
11-04-81	1250	1300	L	11.7	10.8	E	0-5	CALM	CALM	CLEAR	4.0
11-04-81	2110	2120	L	11.5	10.5	SE	10-15	CALM	CALM	PT.CLOUDY	-
11-04-81	1323	1333	N	11.8	10.8	SE	10-15	CALM	CALM	CLEAR	3.5
11-04-81	2035	2045	N	11.5	10.5	SE	5-10	CALM	CALM	PT.CLOUDY	-
12-03-81	1550	1600	B	3.0	3.0	VAR	0-5	SW	0.6-1.0	OVERCAST	1.0
12-03-81	1955	2050	B	3.0	3.0	E	0-5	SW	0.3-0.6	OVERCAST	-
12-03-81	1515	1525	C	3.5	3.5	SW	0-5	SW	0.6-1.0	PT.CLOUDY	1.75
12-03-81	1915	1925	C	4.0	3.5	E	0-5	SW	0.3-0.6	OVERCAST	-
12-03-81	1435	1445	D	4.8	4.0	SW	0-5	SW	0.6-1.0	OVERCAST	2.0
12-03-81	1840	1850	D	4.0	4.0	E	0-5	SW	0.3-0.6	OVERCAST	-
12-03-81	1355	1405	E	4.9	4.6	SW	0-5	SW	0.6-1.0	OVERCAST	2.0
12-03-81	1755	1805	E	4.5	4.2	E	0-5	SW	0.3-0.6	OVERCAST	-
12-03-81	1200	1210	L	4.0	4.0	SW	0-5	SW	0.6-1.0	PT.CLOUDY	2.0
12-03-81	2130	2140	L	3.5	4.0	SE	0-5	SW	0.3-0.6	OVERCAST	-
12-03-81	1234	1244	N	5.8	4.8	SW	0-5	SW	0.6-1.0	PT.CLOUDY	2.0
12-03-81	2050	2100	N	3.9	3.2	SE	0-5	SW	0.3-0.6	OVERCAST	-

Appendix 5. Meteorological and limnological parameters measured during fish larvae sampling by plankton net, April to September 1981 near the J. H. Campbell Plant, eastern Lake Michigan.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
4-15-81	1455	A	D	1.0	0.5	10.2	W	0-5	W	0-0.3	CLEAR
					1.0	10.2					
					1.5	10.2					
4-15-81	2049	A	N	-	0.5	9.5	VAR	0-5	VAR	0-0.3	CLEAR
					1.0	9.2					
					1.5	8.0					
4-15-81	1446	B	D	1.0	0.5	9.5	W	0-5	W	0-0.3	CLEAR
					1.5	9.5					
					3.0	9.5					
4-15-81	2026	B	N	-	0.5	9.0	VAR	0-5	VAR	0-0.3	CLEAR
					1.5	8.7					
					3.0	8.0					
4-15-81	1751	C	D	1.6	0.5	7.0	CALM	CALM	W	0-0.1	CLEAR
					2.0	6.9					
					4.0	6.8					
					5.5	6.7					
4-15-81	2016	C	N	-	0.5	7.8	VAR	0-5	VAR	0-0.3	CLEAR
					2.0	7.8					
					4.0	7.8					
					5.5	7.8					
4-15-81	1715	D	D	1.1	0.5	8.0	W	0-5	W	0-0.3	CLEAR
					2.5	7.8					
					4.5	7.6					
					6.5	7.5					
					8.5	7.2					
4-15-81	2040	D	N	-	0.5	7.3	S	0-5	VAR	0-0.1	CLEAR
					2.5	7.3					
					4.5	7.2					
					6.5	6.9					
					8.5	6.2					
4-15-81	1644	E	D	1.2	0.5	7.5	W	0-5	W	0.3	CLEAR
					3.0	7.4					
					6.0	7.3					
					9.0	7.2					
					11.0	7.0					
4-15-81	2111	E	N	-	0.5	6.5	S	10-15	VAR	0.1	CLEAR
					3.0	6.4					
					6.0	6.0					
					9.0	5.5					
					11.0	5.1					
4-15-81	1608	F	D	1.9	0.5	7.3	W	0-5	W	0.3	CLEAR
					4.5	7.2					
					8.5	7.1					
					11.5	6.9					
					14.0	6.5					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
4-15-81	2149	F	N	-	0.5	6.0	SSE	10-15	VAR	0.1	CLEAR
					4.5	5.9					
					8.5	5.0					
					11.5	4.6					
					14.0	4.1					
4-15-81	1605	I	D	1.0	0.5	11.5	W	5-10	NW	0.3-0.6	CLEAR
					1.0	11.5					
					1.5	11.5					
4-15-81	2020	I	N	-	0.5	10.5	VAR	5-10	SW	0-0.3	CLEAR
					1.0	10.5					
					1.5	10.0					
4-15-81	1605	J	D	1.0	0.5	10.0	W	5-10	NW	0.3-0.6	CLEAR
					1.5	10.0					
					3.0	9.5					
4-15-81	2030	J	N	-	0.5	10.5	VAR	5-10	SW	0-0.3	CLEAR
					1.5	10.0					
					3.0	9.5					
4-15-81	1310	L	D	1.2	0.5	7.2	NW	5-10	NW	0.6	CLEAR
					2.0	7.2					
					4.0	7.2					
					5.5	7.1					
4-16-81	0021	L	N	-	0.5	5.7	SSW	15-20	SW	0.6	CLEAR
					2.0	5.7					
					4.0	5.7					
					5.5	5.7					
4-15-81	1332	N	D	1.0	0.5	6.5	NW	5-10	NW	0.6	CLEAR
					2.5	6.5					
					4.5	6.5					
					6.5	6.5					
					8.5	6.5					
4-15-81	2343	N	N	-	0.5	5.0	SSW	15-20	SW	0.6	CLEAR
					2.5	5.0					
					4.5	5.0					
					6.5	5.0					
					8.5	4.9					
4-15-81	1441	O	D	1.6	0.5	7.2	NW	5-10	NW	0.6	CLEAR
					3.0	7.2					
					6.0	7.0					
					9.0	6.9					
					11.0	6.9					
4-15-81	2311	O	N	-	0.5	5.2	SSW	15-20	SW	0.3	CLEAR
					3.0	5.2					
					6.0	4.8					
					9.0	3.5					
					11.0	3.5					
4-15-81	1540	P	D	BOTTOM	SURFACE	10.2	WSW	5-10	W	0-0.3	CLEAR
					MID-DEPTH	10.2					
					BOTTOM	10.2					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
4-15-81	2107	P	N	-	SURFACE	9.5	VAR	0-5	VAR	0-0.3	CLEAR
					MID-DEPTH	9.5					
					BOTTOM	9.5					
4-15-81	1430	R	D	BOTTOM	SURFACE	11.5	W	5-10	W	0.3-0.6	CLEAR
					MID-DEPTH	11.5					
					BOTTOM	11.5					
4-15-81	2100	R	N	-	SURFACE	11.5	VAR	5-10	W	0-0.3	CLEAR
					MID-DEPTH	11.0					
					BOTTOM	11.0					
4-15-81	1519	W	D	1.5	0.5	6.9	NW	5-10	NW	0.6	CLEAR
					4.5	6.6					
					8.5	6.5					
					11.5	5.8					
					14.0	5.5					
4-15-81	2233	W	N	-	0.5	5.0	E	15-20	S	0-0.3	CLEAR
					4.5	4.9					
					8.5	4.9					
					11.5	3.7					
					14.0	3.4					
5-04-81	1540	A	D	1.5	0.5	13.0	SW	10-15	SW	0-0.5	PT.CLOUDY
					1.0	12.0					
					1.5	11.5					
5-04-81	2236	A	N	-	0.5	12.0	SW	10-15	SW	0.5-1.0	RAIN
					1.0	12.0					
					1.5	12.0					
5-04-81	1528	B	D	1.5	0.5	11.5	SW	10-15	SW	0-0.5	PT.CLOUDY
					1.5	11.5					
					3.0	11.5					
5-04-81	2140	B	N	-	0.5	11.7	SW	10-15	SW	0.5-1.0	RAIN
					1.5	11.7					
					3.0	11.5					
5-04-81	1657	C	D	2.25	0.5	10.0	VAR	0-5	SW	0.3	PT.CLOUDY
					2.0	9.9					
					4.0	9.9					
					5.5	9.8					
5-04-81	2008	C	N	-	0.5	9.0	S	15-20	SW	0.6	OVERCAST
					2.0	9.0					
					4.0	9.0					
					5.5	9.0					
5-04-81	1623	D	D	2.25	0.5	9.9	VAR	0-5	SW	0.3	PT.CLOUDY
					2.5	9.9					
					4.5	9.8					
					6.5	9.8					
					8.5	9.7					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
5-04-81	2047	D	N	-	0.5	8.8	S	15-20	SW	0.6	OVERCAST
					2.5	8.8					
					4.5	8.8					
					6.5	8.7					
					8.5	8.7					
5-04-81	1550	E	D	2.5	0.5	9.8	VAR	0-5	SW	0.3-0.6	PT.CLOUDY
					3.0	9.5					
					6.0	9.3					
					9.0	9.2					
					11.0	9.2					
5-04-81	2117	E	N	-	0.5	8.0	S	15-20	SW	0.6	RAIN
					3.0	7.9					
					6.0	7.9					
					9.0	7.9					
					11.0	7.9					
5-04-81	1510	F	D	3.0	0.5	9.0	VAR	0-5	SW	0.3-0.6	CLEAR
					4.5	8.7					
					8.5	8.4					
					11.5	8.3					
					14.0	8.2					
5-04-81	2200	F	N	-	0.5	6.9	S	15-20	SW	0.6	RAIN
					4.5	6.9					
					8.5	6.9					
					11.5	6.9					
					14.0	6.9					
5-04-81	1652	I	D	1.25	0.5	12.0	SW	5-10	SW	0-0.3	OVERCAST
					1.0	12.0					
					1.5	11.5					
5-05-81	0055	I	N	-	0.5	12.0	SW	5-10	SW	0.3-0.6	OVERCAST
					1.0	12.0					
					1.5	12.0					
5-04-81	1644	J	D	1.5	0.5	12.0	SW	5-10	SW	0-0.3	OVERCAST
					1.5	11.0					
					3.0	10.5					
5-05-81	0030	J	N	-	0.5	11.5	SW	5-10	SW	0.3-0.6	OVERCAST
					1.5	11.2					
					3.0	11.2					
5-04-81	1245	L	D	1.75	0.5	10.2	SSE	10-15	SW	0.3-0.6	CLEAR
					2.0	10.2					
					4.0	10.1					
					5.5	10.1					
5-05-81	0038	L	N	-	0.5	9.1	S	10-15	SW	0.6-1.0	OVERCAST
					2.0	9.1					
					4.0	9.1					
					5.5	9.1					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
5-04-81	1309	N	D	2.5	0.5	9.5	SSE	10-15	SW	0.3-0.6	CLEAR
					2.5	9.1					
					4.5	8.5					
					6.5	8.2					
					8.5	8.2					
5-05-81	0001	N	N	-	0.5	9.0	S	10-15	SW	0.6-1.0	OVERCAST
					2.5	8.9					
					4.5	8.9					
					6.5	8.8					
					8.5	8.8					
5-04-81	1344	O	D	2.0	0.5	9.5	VAR	0-5	SW	0.3-0.6	CLEAR
					3.0	8.4					
					6.0	8.2					
					9.0	8.1					
					11.0	8.1					
5-04-81	2324	O	N	-	0.5	9.0	S	10-15	SW	0.3-0.6	OVERCAST
					3.0	8.7					
					6.0	7.9					
					9.0	7.8					
					11.0	7.7					
5-04-81	1600	P	D	BOTTOM	SURFACE	14.5	SW	10-15	SW	0-0.5	PT.CLOUDY
					MID-DEPTH	14.5					
					BOTTOM	14.5					
5-04-81	2315	P	N	-	SURFACE	12.5	SW	10-15	SW	0.5-1.0	OVERCAST
					MID-DEPTH	12.5					
					BOTTOM	12.5					
5-04-81	1704	R	D	BOTTOM	SURFACE	13.5	SW	5-10	SW	0-0.3	OVERCAST
					MID-DEPTH	13.5					
					BOTTOM	13.5					
5-04-81	2230	R	N	-	SURFACE	11.3	SW	5-10	SW	0.3-0.6	OVERCAST
					MID-DEPTH	11.2					
					BOTTOM	11.0					
5-04-81	1422	W	D	3.0	0.5	9.8	VAR	0-5	SW	0.3-0.6	CLEAR
					4.5	9.0					
					8.5	8.4					
					11.5	8.3					
					14.0	8.2					
5-04-81	2245	W	N	-	0.5	7.0	S	10-15	SW	0.6-1.0	OVERCAST
					4.5	6.9					
					8.5	6.9					
					11.5	6.9					
					14.0	9.9					
5-18-81	1543	A	D	1.5	0.5	8.0	NE	5-10	NE	0-1	CLEAR
					1.0	8.0					
					1.5	7.5					
5-18-81	2231	A	N	-	0.5	6.3	NE	0-5	NW	0-0.5	HAZE
					1.0	6.3					
					1.5	6.3					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
5-18-81	1513	B	D	1.8	0.5	7.5	NE	5-10	NE	0-1	CLEAR
					2.5	6.5					
					3.0	6.0					
5-18-81	2206	B	N	-	0.5	6.0	NE	0-5	NW	0-0.5	HAZE
					2.5	6.0					
					3.0	6.0					
5-18-81	1726	C	D	2.7	0.5	8.0	SW	10-15	NE	0-0.3	CLEAR
					2.0	8.0					
					4.0	7.9					
					5.5	7.8					
5-18-81	2018	C	N	-	0.5	7.0	VAR	0-5	NW	0-0.7	PT.CLOUDY
					2.0	7.0					
					4.0	6.9					
					5.5	6.9					
5-18-81	1652	D	D	2.8	0.5	7.7	E	15-20	NE	0-0.3	CLEAR
					2.5	7.7					
					4.5	7.5					
					6.5	7.3					
					8.5	7.2					
5-18-81	2042	D	N	-	0.5	7.0	VAR	0-5	NW	0.3-0.6	PT.CLOUDY
					2.5	7.0					
					4.5	6.9					
					6.5	6.7					
					8.5	6.7					
5-18-81	1622	E	D	2.6	0.5	8.0	E	20-30	NE	1	CLEAR
					3.0	7.9					
					6.0	7.8					
					9.0	7.4					
					11.0	7.4					
5-18-81	2118	E	N	-	0.5	7.0	VAR	0-5	NW	0.7	PT.CLOUDY
					3.0	7.0					
					6.0	6.8					
					9.0	6.5					
					11.0	6.5					
5-18-81	1544	F	D	2.9	0.5	8.0	NE	15-20	E	0-0.2	CLEAR
					4.5	7.9					
					8.5	7.8					
					11.5	7.4					
					14.0	6.9					
5-18-81	2151	F	N	-	0.5	7.0	VAR	0-5	NW	0-0.6	PT.CLOUDY
					4.5	6.9					
					8.5	6.5					
					11.5	6.5					
					14.0	6.5					
5-18-81	1510	I	D	1.0	0.5	8.5	NE	15-20	NE	0-0.2	CLEAR
					1.0	8.5					
					1.5	8.5					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
5-18-81	2350	I	N	-	0.5	7.5	E	5-10	NW	0.3-1	OVERCAST
					1.0	7.5					
					1.5	7.5					
5-18-81	1445	J	D	2.0	0.5	6.0	NE	15-20	NE	0-0.2	CLEAR
					2.5	6.5					
					3.0	7.0					
5-18-81	2320	J	N	-	0.5	7.0	E	5-10	NW	0.3-1	OVERCAST
					2.5	7.0					
					3.0	7.0					
5-18-81	1327	L	D	2.5	0.5	8.9	ENE	20	NE	0-0.2	PT.CLOUDY
					2.0	8.8					
					4.0	8.6					
					5.5	8.6					
5-19-81	0022	L	N	-	0.5	7.0	VAR	0-5	VAR	0-0.3	PT.CLOUDY
					2.0	6.9					
					4.0	6.8					
					5.5	6.7					
5-18-81	1348	N	D	2.75	0.5	8.9	NE	25+	NE	0-0.2	PT.CLOUDY
					2.5	8.8					
					4.5	8.8					
					6.5	8.7					
					8.5	8.6					
5-18-81	2348	N	N	-	0.5	7.5	N	5	VAR	0-0.6	PT.CLOUDY
					2.5	7.3					
					4.5	7.0					
					6.5	6.9					
					8.5	6.9					
5-18-81	1423	O	D	2.75	0.5	9.0	NE	15	NE	0-0.3	PT.CLOUDY
					3.0	9.0					
					6.0	8.8					
					9.0	8.6					
					11.0	8.5					
5-18-81	2318	O	N	-	0.5	7.0	N	10	NW	0.3-0.6	PT.CLOUDY
					3.0	6.9					
					6.0	6.5					
					9.0	6.4					
					11.0	6.3					
5-18-81	1440	P	D	0.5	SURFACE	8.0	NE	0-5	NE	0-1	CLEAR
					MID-DEPTH	8.0					
					BOTTOM	8.0					
5-18-81	2245	P	N	-	SURFACE	6.3	NE	0-5	NW	0-0.2	HAZE
					MID-DEPTH	6.3					
					BOTTOM	6.3					
5-18-81	1525	R	D	0.5	SURFACE	9.0	NE	15-20	NE	0-0.2	CLEAR
					MID-DEPTH	9.0					
					BOTTOM	8.5					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
5-18-81	0005	R	N	-	SURFACE	8.0	E	5-10	NW	0.3-1	OVERCAST
					MID-DEPTH	8.0					
					BOTTOM	8.0					
5-18-81	1500	W	D	2.75	0.5	7.9	NE	20	NE	0-0.2	CLEAR
					4.5	7.8					
					8.5	7.6					
					11.5	7.4					
					14.0	7.3					
5-18-81	2240	W	N	-	0.5	7.0	N	10-15	NW	0.3-0.6	PT.CLOUDY
					4.5	7.0					
					8.5	6.6					
					11.5	6.3					
					14.0	6.3					
6-04-81	1644	A	D	BOTTOM	0.5	17.5	NW	5-10	NW	0.3-0.6	CLEAR
					1.0	16.7					
					1.5	16.2					
6-04-81	2207	A	N	-	0.5	16.2	NW	0-5	NW	0-0.3	CLEAR
					1.0	15.5					
					1.5	13.9					
6-04-81	1624	B	D	2.25	0.5	17.2	NW	5-10	NW	0.3-0.6	CLEAR
					1.5	16.2					
					3.0	15.7					
6-04-81	2140	B	N	-	0.5	16.3	NW	0-5	NW	0-0.3	CLEAR
					1.5	14.5					
					3.0	13.5					
6-04-81	1758	C	D	3.0	0.5	14.8	NW	0-5	NW	0.3-0.6	CLEAR
					2.0	13.8					
					4.0	13.0					
					5.5	13.0					
6-04-81	2117	C	N	-	0.5	13.5	VAR	0-5	N	0.3	CLEAR
					2.0	12.8					
					4.0	11.8					
					5.5	11.8					
6-04-81	1723	D	D	3.0	0.5	15.2	NW	0-5	NW	0.3-0.6	CLEAR
					2.5	14.0					
					4.5	12.6					
					6.5	11.3					
					8.5	11.1					
6-04-81	2144	D	N	-	0.5	14.0	VAR	0-5	N	0.3	CLEAR
					2.5	13.7					
					4.5	12.1					
					6.5	11.0					
					8.5	11.0					
6-04-81	1648	E	D	2.75	0.5	15.0	NW	0-5	NW	0.6	CLEAR
					3.0	14.4					
					6.0	12.0					
					9.0	11.7					
					11.0	11.7					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
6-04-81	2111	E	N	-	0.5	14.0	VAR	0-5	NNW	0.3-0.6	HAZE
					3.0	13.7					
					6.0	10.5					
					9.0	7.8					
					11.0	6.9					
6-04-81	1611	F	D	3.5	0.5	15.5	NW	5-10	NW	0.6	CLEAR
					4.5	13.7					
					8.5	10.3					
					11.5	8.5					
					14.0	7.5					
6-04-81	2056	F	N	-	0.5	14.0	VAR	0-5	NNW	0.3-0.6	HAZE
					4.5	12.0					
					8.5	7.3					
					11.5	6.1					
					14.0	5.8					
6-04-81	1757	I	D	1.0	0.5	18.3	NW	5-10	NW	0.3-0.6	FOG
					1.0	17.3					
					1.5	17.2					
6-04-81	2337	I	N	-	0.5	17.0	NW	0-5	NW	0-0.3	CLEAR
					1.0	14.9					
					1.5	14.3					
6-04-81	1742	J	D	2.25	0.5	17.7	NW	5-10	NW	0.3-0.6	FOG
					1.5	16.5					
					3.0	15.5					
6-04-81	2307	J	N	-	0.5	16.8	NW	0-5	NW	0-0.3	CLEAR
					1.5	13.4					
					3.0	13.4					
6-04-81	1349	L	D	2.8	0.5	14.7	NW	10-15	NW	0.3-0.6	OVERCAST
					2.0	14.7					
					4.0	14.6					
					5.5	14.6					
6-05-81	0044	L	N	-	0.5	13.0	CALM	0-5	CALM	CALM	CLEAR
					2.0	12.5					
					4.0	11.8					
					5.5	11.8					
6-04-81	1413	N	D	2.9	0.5	16.0	NW	10-15	NW	0.3-0.6	OVERCAST
					2.5	16.0					
					4.5	15.8					
					6.5	14.5					
					8.5	14.5					
6-05-81	0010	N	N	-	0.5	13.5	CALM	CALM	CALM	CALM	CLEAR
					2.5	13.4					
					4.5	12.5					
					6.5	11.2					
					8.5	11.2					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
6-04-81	1449	O	D	3.0	0.5	15.4	NW	10-15	NW	0.3-0.6	OVERCAST
					3.0	15.3					
					6.0	13.8					
					9.0	11.3					
					11.0	11.0					
6-04-81	2335	O	N	-	0.5	13.5	CALM	CALM	CALM	CALM	CLEAR
					3.0	13.5					
					6.0	11.8					
					9.0	8.9					
					11.0	8.9					
6-04-81	1715	P	D	BOTTOM	SURFACE	19.2	NW	5-10	NW	0.3-0.6	CLEAR
					MID-DEPTH	19.2					
					BOTTOM	19.0					
6-04-81	2242	P	N	-	SURFACE	16.6	NW	0-5	NW	0-0.3	CLEAR
					MID-DEPTH	16.4					
					BOTTOM	15.0					
6-04-81	1815	R	D	BOTTOM	SURFACE	18.5	NW	5-10	NW	0.3	CLEAR
					MID-DEPTH	17.7					
					BOTTOM	17.6					
6-04-81	2343	R	N	-	SURFACE	16.7	NW	0-5	NW	0-0.3	CLEAR
					MID-DEPTH	16.6					
					BOTTOM	15.0					
6-04-81	1525	W	D	2.75	0.5	15.5	NW	10-15	NW	0.3-0.6	PT.CLOUDY
					4.5	15.4					
					8.5	11.0					
					11.5	9.4					
					14.0	8.0					
6-04-81	2259	W	N	-	0.5	14.0	VAR	0-5	VAR	0-0.1	CLEAR
					4.5	13.5					
					8.5	9.0					
					11.5	7.0					
					14.0	5.9					
6-15-81	1621	A	D	1.0	0.5	21.5	SW	15-20	SW	0.6-1.0	PT.CLOUDY
					1.0	21.5					
					1.5	21.5					
6-15-81	2313	A	N	-	0.5	21.5	W	5-10	W	0.3-0.6	PT.CLOUDY
					1.0	21.5					
					1.5	21.5					
6-15-81	1604	B	D	1.0	0.5	21.0	SW	15-20	SW	0.6-1.0	PT.CLOUDY
					1.5	21.0					
					3.0	21.0					
6-15-81	2256	B	N	-	0.5	20.7	W	5-10	W	0.3-0.6	PT.CLOUDY
					1.5	20.7					
					3.0	20.7					
6-15-81	1908	C	D	1.5	0.5	22.8	SW	20-25	SW	1.0-2.0	CLEAR
					2.0	22.8					
					4.0	22.8					
					5.5	22.8					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
6-15-81	2129	C	N	-	0.5	22.5	SW	10-15	SW	1.0	PT.CLOUDY
					2.0	22.5					
					4.0	22.5					
					5.5	22.5					
6-15-81	1827	D	D	2.5	0.5	22.4	SW	20-25	SW	1.0-2.0	CLEAR
					2.5	22.4					
					4.5	22.4					
					6.5	22.4					
					8.5	22.4					
6-15-81	2157	D	N	-	0.5	21.5	SW	5-10	SW	1.0-1.5	CLEAR
					2.5	21.5					
					4.5	21.5					
					6.5	21.5					
					8.5	21.5					
6-15-81	1750	E	D	2.5	0.5	18.9	SW	25	SW	1.5	CLEAR
					3.0	18.9					
					6.0	18.9					
					9.0	18.9					
					11.0	18.9					
6-15-81	2232	E	N	-	0.5	22.2	SW	5-10	SW	1.0-1.5	CLEAR
					3.0	22.2					
					6.0	22.2					
					9.0	22.2					
					11.0	22.2					
6-15-81	1703	F	D	3.0	0.5	18.0	SW	20-25	SW	1.0-2.0	CLEAR
					4.5	18.0					
					8.5	18.0					
					11.5	18.0					
					14.0	18.0					
6-15-81	2313	F	N	-	0.5	21.2	SW	15-20	SW	1.0-1.5	CLEAR
					4.5	21.2					
					8.5	21.2					
					11.5	21.1					
					14.0	21.0					
6-15-81	1538	I	D	0.5	0.5	20.0	S	10-15	SSW	0.3-0.6	OVERCAST
					1.0	20.0					
					1.5	20.0					
6-15-81	2220	I	N	-	0.5	19.7	SW	5-10	SW	0.3-0.6	PT.CLOUDY
					1.0	19.7					
					1.5	19.2					
6-15-81	1526	J	D	1.5	0.5	20.0	S	10-15	SSW	0.3-0.6	OVERCAST
					1.5	19.5					
					3.0	19.2					
6-15-81	2233	J	N	-	0.5	19.9	SW	5-10	SW	0.3-0.6	PT.CLOUDY
					1.5	19.7					
					3.0	19.7					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
6-15-81	1414	L	D	2.5	0.5	21.5	S	15-20	SW	0.6-1.0	PT.CLOUDY
					2.0	21.4					
					4.0	21.3					
					5.5	21.2					
6-16-81	0151	L	N	-	0.5	25.7	SW	15-20	SW	0.3-0.6	PT.CLOUDY
					2.0	25.7					
					4.0	25.3					
					5.5	25.1					
6-15-81	1444	N	D	2.5	0.5	21.5	S	15-20	SW	0.3-0.6	PT.CLOUDY
					2.5	21.4					
					4.5	21.3					
					6.5	21.1					
					8.5	20.9					
6-16-81	0114	N	N	-	0.5	24.8	SW	15-20	SW	0.6	OVERCAST
					2.5	24.7					
					4.5	23.9					
					6.5	23.7					
					8.5	23.2					
6-15-81	1517	O	D	3.0	0.5	21.0	SW	15-20	SW	0.6-1.0	RAIN
					3.0	20.5					
					6.0	20.0					
					9.0	19.5					
					11.0	19.5					
6-16-81	0036	O	N	-	0.5	23.8	SW	15-20	SW	0.3-0.6	OVERCAST
					3.0	23.5					
					6.0	22.5					
					9.0	22.4					
					11.0	22.3					
6-15-81	1631	P	D	1.0	SURFACE	21.5	SW	15-20	SW	0.3-0.6	RAIN
					MID-DEPTH	21.5					
					BOTTOM	21.5					
6-15-81	2328	P	N	-	SURFACE	21.5	W	5-10	W	0.3-0.6	PT.CLOUDY
					MID-DEPTH	21.5					
					BOTTOM	21.5					
6-15-81	1548	R	D	BOTTOM	SURFACE	22.5	SW	20-25	SW	1.0-1.5	RAIN
					MID-DEPTH	22.5					
					BOTTOM	22.5					
6-15-81	2151	R	N	-	SURFACE	19.7	SW	5-10	SW	0.3-0.6	RAIN
					MID-DEPTH	19.7					
					BOTTOM	19.7					
6-15-81	1548	W	D	3.5	0.5	20.0	SSW	20-25	SW	1.0-1.5	OVERCAST
					4.5	20.0					
					8.5	19.6					
					11.5	19.5					
					14.0	19.4					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
6-15-81	2356	W	N	-	0.5	23.5	SW	15-20	SW	0.3-0.6	RAIN
					4.5	23.0					
					8.5	22.7					
					11.5	22.3					
					14.0	22.1					
7-01-81	1706	A	D	BOTTOM	0.5	15.5	E	0-5	NW	0-0.3	OVERCAST
					1.0	15.5					
					1.5	15.0					
7-01-81	2205	A	N	-	0.5	15.2	E	0-5	NW	0-0.3	OVERCAST
					1.0	15.0					
					1.5	14.5					
7-01-81	1641	B	D	2.5	0.5	15.6	E	0-5	NW	0-0.5	OVERCAST
					1.5	14.7					
					3.0	14.5					
7-01-81	2140	B	N	-	0.5	15.0	E	0-5	NW	0-0.3	OVERCAST
					1.5	14.7					
					3.0	14.5					
7-01-81	1735	C	D	3.5	0.5	17.5	NE	10-15	NW	0.3	OVERCAST
					2.0	17.4					
					4.0	16.7					
					5.5	14.9					
7-01-81	2220	C	N	-	0.5	16.5	E	10-15	NW	0-0.3	OVERCAST
					2.0	16.4					
					4.0	14.9					
					5.5	13.5					
7-01-81	1706	D	D	4.5	0.5	17.0	NE	10-15	NW	0.3	OVERCAST
					2.5	16.9					
					4.5	16.3					
					6.5	15.0					
					8.5	11.5					
7-01-81	2150	D	N	-	0.5	16.0	E	10-15	NW	0-0.3	OVERCAST
					2.5	15.9					
					4.5	15.0					
					6.5	13.0					
					8.5	11.3					
7-01-81	1630	E	D	4.0	0.5	15.0	NE	10-15	NW	0.3-0.6	OVERCAST
					3.0	14.9					
					6.0	14.5					
					9.0	12.5					
					11.0	9.5					
7-01-81	2115	E	N	-	0.5	16.0	NE	10-15	NW	0-0.3	OVERCAST
					3.0	16.0					
					6.0	13.1					
					9.0	11.6					
					11.0	9.1					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
7-01-81	1600	F	D	5.5	0.5	16.0	NE	10-15	NW	0.3	OVERCAST
					4.5	15.6					
					8.5	15.1					
					11.5	13.9					
					14.0	10.4					
7-01-81	2102	F	N	-	0.5	16.5	E	10-15	NW	0-0.3	OVERCAST
					4.5	16.5					
					8.5	14.5					
					11.5	12.0					
					14.0	8.2					
7-01-81	1720	I	D	BOTTOM	0.5	16.5	E	5-10	NW	0.3-0.6	OVERCAST
					1.0	16.6					
					1.5	16.8					
7-01-81	2204	I	N	-	0.5	16.2	ENE	5-10	CALM	CALM	OVERCAST
					1.0	16.2					
					1.5	16.2					
7-01-81	1712	J	D	3.0	0.5	16.4	E	5-10	NW	0.3-0.6	OVERCAST
					1.5	16.2					
					3.0	16.0					
7-01-81	2137	J	N	-	0.5	15.8	ENE	5-10	CALM	CALM	OVERCAST
					1.5	15.5					
					3.0	15.8					
7-01-81	1340	L	D	4.0	0.5	16.5	NE	10-15	NW	0.3	CLEAR
					2.0	16.4					
					4.0	15.4					
					5.5	14.5					
7-02-81	0035	L	N	-	0.5	16.5	E	10-15	NW	0.1	OVERCAST
					2.0	16.3					
					4.0	15.5					
					5.5	13.9					
7-01-81	1403	N	D	4.0	0.5	16.0	NE	10-15	NW	0.3	CLEAR
					2.5	15.5					
					4.5	15.2					
					6.5	14.6					
					8.5	12.8					
7-02-81	0005	N	N	-	0.5	16.0	E	10-15	NW	0-0.3	OVERCAST
					2.5	15.8					
					4.5	15.1					
					6.5	13.8					
					8.5	11.8					
7-01-81	1440	O	D	4.5	0.5	16.0	NE	10-15	NW	0.3	OVERCAST
					3.0	15.7					
					6.0	15.5					
					9.0	14.2					
					11.0	11.7					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
7-01-81	2333	O	N	-	0.5	16.0	E	10-15	NW	0-0.3	OVERCAST
					3.0	15.9					
					6.0	14.5					
					9.0	12.8					
					11.0	10.2					
7-01-81	1720	P	D	BOTTOM	SURFACE	15.4	E	0-5	NW	0-0.3	OVERCAST
					MID-DEPTH	15.4					
					BOTTOM	16.2					
7-01-81	2215	P	N	-	SURFACE	15.2	E	0-5	NW	0-0.3	OVERCAST
					MID-DEPTH	15.0					
					BOTTOM	14.9					
7-01-81	1734	R	D	BOTTOM	SURFACE	18.5	E	5-10	NW	0.3-0.6	OVERCAST
					MID-DEPTH	17.0					
					BOTTOM	16.0					
7-01-81	2217	R	N	-	SURFACE	17.0	ENE	5-10	CALM	CALM	OVERCAST
					MID-DEPTH	16.8					
					BOTTOM	16.8					
7-01-81	1510	W	D	6.0	0.5	16.0	NE	10-15	NW	0.3	PT.CLOUDY
					4.5	15.8					
					8.5	14.5					
					11.5	12.1					
					14.0	9.8					
7-01-81	2300	W	N	-	0.5	16.5	E	10-15	NW	0-0.3	OVERCAST
					4.5	16.4					
					8.5	14.5					
					11.5	12.8					
					14.0	9.0					
7-20-81	1320	A	D	BOTTOM	0.5	22.0	NW	5-10	NW	0-0.3	FOG
					1.0	22.0					
					1.5	20.5					
7-20-81	2220	A	N	-	0.5	22.0	WNW	10-15	WNW	1.0-1.5	FOG
					1.0	22.0					
					1.5	22.0					
7-20-81	1335	B	D	BOTTOM	0.5	21.0	NW	5-10	NW	0-0.3	FOG
					1.5	21.0					
					3.0	19.5					
7-20-81	2210	B	N	-	0.5	21.5	WNW	10-15	WNW	1.0-1.5	FOG
					1.5	21.5					
					3.0	21.5					
7-20-81	1806	C	D	BOTTOM	0.5	22.5	NW	5-10	NW	0.6-1.0	RAIN
					2.0	22.4					
					4.0	22.3					
					5.5	21.3					
7-20-81	2235	C	N	-	0.5	22.9	NW	5-10	NW	0.6-1.0	OVERCAST
					2.0	22.5					
					4.0	20.0					
					5.0	19.0					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
7-20-81	1733	D	D	5.5	0.5	22.2	NW	5-10	NW	0.3-0.6	OVERCAST
					2.5	22.0					
					4.5	20.9					
					6.5	20.2					
					8.5	18.5					
7-20-81	2157	D	N	-	0.5	21.7	NW	5-10	NW	0.6-1.0	OVERCAST
					2.5	21.6					
					4.5	20.0					
					6.5	17.5					
					8.5	14.6					
7-20-81	1655	E	D	6.5	0.5	22.8	NW	5-10	NW	0.3-0.6	OVERCAST
					3.0	22.2					
					6.0	21.0					
					9.0	17.5					
					11.0	13.0					
7-20-81	2125	E	N	-	0.5	22.2	NW	5-10	NW	0.6-1.0	OVERCAST
					3.0	22.2					
					6.0	20.0					
					9.0	11.5					
					11.0	9.5					
7-20-81	1618	F	D	7.0	0.5	22.8	NW	5-10	NW	0.3-0.6	HAZE
					4.5	22.3					
					8.5	14.0					
					11.5	11.8					
					14.0	8.4					
7-20-81	2045	F	N	-	0.5	21.5	NW	10-15	NW	0.6-1.0	OVERCAST
					4.5	21.4					
					8.5	15.0					
					11.5	7.6					
					14.0	7.3					
7-20-81	1432	I	D	BOTTOM	0.5	21.7	NW	5-10	NW	0-0.3	FOG
					1.0	21.7					
					1.5	21.5					
7-20-81	2214	I	N	-	0.5	22.0	NE	10-15	NE	0.6-1.0	OVERCAST
					1.0	21.5					
					1.5	21.0					
7-20-81	1408	J	D	BOTTOM	0.5	21.2	NW	5-10	NW	0-0.3	FOG
					1.5	21.2					
					3.0	21.0					
7-20-81	2235	J	N	-	0.5	22.0	NE	10-15	NE	0.6-1.0	OVERCAST
					1.5	22.0					
					3.0	22.0					
7-20-81	1339	L	D	BOTTOM	0.5	22.0	NW	5-10	NW	0.3-0.6	OVERCAST
					2.0	22.0					
					4.0	21.8					
					5.5	21.6					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
7-21-81	0105	L	N	-	0.5	23.0	N	5-10	NW	0.6-1.0	FOG
					2.0	22.8					
					4.0	20.0					
					5.5	15.0					
7-20-81	1408	N	D	8.0	0.5	22.5	NW	5-10	NW	0.3-0.6	OVERCAST
					2.5	22.4					
					4.5	22.2					
					6.5	21.0					
					8.5	19.0					
7-21-81	0029	N	N	-	0.5	23.0	N	5-10	NW	0.6-1.0	FOG
					2.5	22.9					
					4.5	19.0					
					6.5	13.0					
					8.5	10.7					
7-20-81	1448	O	D	9.0	0.5	22.8	NW	5-10	NW	0.3-0.6	OVERCAST
					3.0	22.6					
					6.0	22.1					
					9.0	19.5					
					11.0	16.6					
7-20-81	2355	O	N	-	0.5	23.2	N	5-10	NW	0.6-1.0	FOG
					3.0	22.8					
					6.0	14.5					
					9.0	11.0					
					11.0	10.0					
7-20-81	1300	P	D	BOTTOM	SURFACE	22.0	NW	5-10	NW	0-0.3	FOG
					MID-DEPTH	21.5					
					BOTTOM	21.5					
7-20-81	2330	P	N	-	SURFACE	21.5	WNW	10-15	WNW	1.0-1.5	FOG
					MID-DEPTH	21.5					
					BOTTOM	21.5					
7-20-81	1445	R	D	BOTTOM	SURFACE	22.0	NW	5-10	NW	0-0.3	FOG
					MID-DEPTH	22.0					
					BOTTOM	22.0					
7-20-81	2315	R	N	-	SURFACE	22.0	NE	10-15	NE	0.6-1.0	FOG
					MID-DEPTH	22.0					
					BOTTOM	22.0					
7-20-81	1530	W	D	9.5	0.5	22.8	NW	5-10	NW	0.3-0.6	OVERCAST
					4.5	22.2					
					8.5	20.0					
					11.5	15.5					
					14.0	10.2					
7-20-81	2314	W	N	-	0.5	22.9	NW	5-10	NW	0.6-1.0	FOG
					4.5	22.8					
					8.5	10.7					
					11.5	9.0					
					14.0	7.4					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
8-06-81	1538	A	D	BOTTOM	0.5	23.0	W	5-10	W	0-0.5	PT.CLOUDY
					1.0	22.7					
					1.5	22.7					
8-05-81	2106	A	N	-	0.5	21.3	E	0-5	CALM	CALM	OVERCAST
					1.0	21.3					
					1.5	21.0					
8-06-81	1521	B	D	BOTTOM	0.5	21.3	W	5-10	W	0-0.5	PT.CLOUDY
					1.5	21.0					
					3.0	20.9					
8-05-81	2052	B	N	-	0.5	22.5	E	0-5	CALM	CALM	OVERCAST
					1.5	22.5					
					3.0	22.5					
8-06-81	1749	C	D	5.0	0.5	22.6	SW	0-5	CALM	CALM	CLEAR
					2.0	22.3					
					4.0	22.3					
					5.5	22.3					
8-06-81	2033	C	N	-	0.5	22.0	SE	5-10	S	0-0.3	PT.CLOUDY
					2.0	22.0					
					4.0	22.0					
					5.5	22.0					
8-06-81	1717	D	D	4.5	0.5	22.6	SW	0-5	CALM	CALM	PT.CLOUDY
					2.5	22.3					
					4.5	22.3					
					6.5	22.3					
					8.5	22.2					
8-06-81	2046	D	N	-	0.5	22.2	S	5-10	S	0-0.3	PT.CLOUDY
					2.5	22.0					
					4.5	22.0					
					6.5	22.0					
					8.5	22.0					
8-06-81	1643	E	D	4.5	0.5	22.0	W	0-5	SW	0-0.3	PT.CLOUDY
					3.0	21.9					
					6.0	21.9					
					9.0	21.9					
					11.0	21.9					
8-06-81	2128	E	N	-	0.5	22.2	S	5-10	S	0-0.3	PT.CLOUDY
					3.0	21.8					
					6.0	21.8					
					9.0	21.8					
					11.0	17.8					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
8-06-81	1600	F	D	4.2	0.5	22.0	WSW	0-5	SW	0-0.3	PT.CLOUDY
					4.5	21.0					
					8.5	21.0					
					11.5	21.0					
					14.0	16.9					
8-06-81	2203	F	N	-	0.5	22.2	SSE	10-15	S	0-0.3	PT.CLOUDY
					4.5	21.5					
					8.5	21.5					
					11.5	21.5					
					14.0	17.4					
8-06-81	1626	I	D	BOTTOM	0.5	22.5	W	5-10	W	0-0.5	PT.CLOUDY
					1.0	22.5					
					1.5	22.7					
8-05-81	2205	I	N	-	0.5	22.5	E	0-5	CALM	CALM	OVERCAST
					1.0	22.5					
					1.5	22.5					
8-06-81	1600	J	D	BOTTOM	0.5	22.5	W	5-10	W	0-0.5	PT.CLOUDY
					1.5	22.2					
					3.0	21.8					
8-05-81	2148	J	N	-	0.5	22.5	E	0-5	CALM	CALM	OVERCAST
					1.5	22.5					
					3.0	22.5					
8-06-81	1336	L	D	4.0	0.5	22.2	SW	0-5	SW	0.3	PT.CLOUDY
					2.0	22.0					
					4.0	22.0					
					5.5	22.0					
8-07-81	0036	L	N	-	0.5	22.5	SW	15-20	S	0.6	OVERCAST
					2.0	22.5					
					4.0	22.2					
					5.5	22.7					
8-06-81	1400	N	D	4.0	0.5	22.4	SW	0-5	SW	0.3	PT.CLOUDY
					2.5	22.0					
					4.5	22.0					
					6.5	22.0					
					8.5	22.0					
8-07-81	0006	N	N	-	0.5	22.2	SW	15-20	S	0.3	OVERCAST
					2.5	22.1					
					4.5	22.1					
					6.5	22.1					
					8.5	22.0					
8-06-81	1437	O	D	4.5	0.5	22.0	SW	0-5	SW	0.3	PT.CLOUDY
					3.0	21.8					
					6.0	21.8					
					9.0	21.8					
					11.0	19.8					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
8-06-81	2327	O	N	-	0.5	22.1	S	10-15	S	0.3	PT.CLOUDY
					3.0	21.0					
					6.0	21.0					
					9.0	21.0					
					11.0	18.8					
8-06-81	1540	P	D	BOTTOM	SURFACE	23.5	W	5-10	W	0-0.5	PT.CLOUDY
					MID-DEPTH	23.4					
					BOTTOM	23.3					
8-05-81	2120	P	N	-	SURFACE	21.3	E	0-5	CALM	CALM	OVERCAST
					MID-DEPTH	21.3					
					BOTTOM	21.3					
8-06-81	1625	R	D	BOTTOM	SURFACE	23.5	W	5-10	W	0-0.5	PT.CLOUDY
					MID-DEPTH	23.5					
					BOTTOM	23.5					
8-05-81	2245	R	N	-	SURFACE	22.5	E	0-5	CALM	CALM	OVERCAST
					MID-DEPTH	22.5					
					BOTTOM	22.5					
8-06-81	1513	W	D	4.0	0.5	22.0	SW	5-10	SW	0.3	PT.CLOUDY
					4.5	21.2					
					8.5	21.2					
					11.5	21.2					
					14.0	15.0					
8-06-81	2249	W	N	-	0.5	22.0	S	5-10	S	0-0.3	PT.CLOUDY
					4.5	21.8					
					8.5	21.8					
					11.5	21.8					
					14.0	17.6					
8-17-81	1443	A	D	BOTTOM	0.5	21.4	NW	10-15	NW	0.3-0.6	CLEAR
					1.0	21.2					
					1.5	20.7					
8-18-81	0102	A	N	-	0.5	19.7	N	0-5	CALM	CALM	CLEAR
					1.0	19.2					
					1.5	11.7					
8-17-81	1419	B	D	1.5	0.5	21.0	NW	10-15	NW	0.3-0.6	CLEAR
					1.5	20.7					
					3.0	20.5					
8-18-81	0031	B	N	-	0.5	19.2	N	0-5	CALM	CALM	CLEAR
					1.5	10.2					
					3.0	9.9					
8-17-81	1778	C	D	2.25	0.5	19.7	NNE	15-20	NW	1.0-1.5	CLEAR
					2.0	19.7					
					4.0	19.7					
					5.5	19.7					
8-17-81	2145	C	N	-	0.5	20.4	NE	5-10	NW	0.3-0.6	CLEAR
					2.0	20.4					
					4.0	20.2					
					5.5	15.0					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
8-17-81	1645	D	D	2.25	0.5	20.2	NNE	15-20	NW	1.0-1.5	CLEAR
					2.5	20.2					
					4.5	20.1					
					6.5	20.0					
					8.5	19.0					
8-17-81	2110	D	N	-	0.5	20.4	NE	15-20	N	0.6-1.0	CLEAR
					2.5	20.4					
					4.5	17.0					
					6.5	8.8					
					8.5	8.5					
8-17-81	1609	E	D	2.75	0.5	21.0	NW	15-20	NW	1.5	CLEAR
					3.0	21.0					
					6.0	20.8					
					9.0	19.9					
					11.0	16.0					
8-17-81	2040	E	N	-	0.5	19.8	N	15-20	N	0.6-1.0	CLEAR
					3.0	19.8					
					6.0	14.9					
					9.0	7.2					
					11.0	7.1					
8-17-81	1536	F	D	3.5	0.5	20.5	NW	15-20	NW	1.0-1.5	CLEAR
					4.5	20.4					
					8.5	20.2					
					11.5	18.5					
					14.0	6.8					
8-17-81	2023	F	N	-	0.5	19.2	N	20-25	NW	1.0-1.5	CLEAR
					4.5	19.1					
					8.5	12.0					
					11.5	5.1					
					14.0	5.1					
8-17-81	1516	I	D	1.2	0.5	21.0	NW	5-10	NW	0.3-0.6	CLEAR
					1.0	21.0					
					1.5	21.0					
8-18-81	0040	I	N	-	0.5	20.2	N	0-5	CALM	CALM	CLEAR
					1.0	19.7					
					1.5	19.2					
8-17-81	1528	J	D	1.4	0.5	21.5	NW	5-10	NW	0.3-0.6	CLEAR
					1.5	21.0					
					3.0	20.5					
8-18-81	0017	J	N	-	0.5	19.9	N	0-5	CALM	CALM	CLEAR
					1.5	15.3					
					3.0	14.8					
8-17-81	1320	L	D	3.0	0.5	20.9	NW	5-10	NW	0.3-0.6	CLEAR
					2.0	20.9					
					4.0	20.5					
					5.5	20.0					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
8-18-81	0004	L	N	-	0.5	18.5	NE	5-10	NW	0-0.3	CLEAR
					2.0	18.5					
					4.0	8.3					
					5.5	7.7					
8-17-81	1355	N	D	3.0	0.5	21.3	NW	5-10	NW	0.3-0.6	CLEAR
					2.5	21.3					
					4.5	20.9					
					6.5	20.5					
					8.5	19.7					
8-17-81	2322	N	N	-	0.5	19.4	NE	5-10	NW	0-0.3	CLEAR
					2.5	19.4					
					4.8	6.9					
					6.5	6.4					
					8.5	6.3					
8-17-81	1423	O	D	2.5	0.5	20.5	NW	15-20	NW	0.6-1.0	CLEAR
					3.0	20.5					
					6.0	20.4					
					9.0	19.7					
					11.0	17.0					
8-17-81	2252	O	N	-	0.5	20.9	NE	5-10	NW	0.3-0.6	CLEAR
					3.0	20.8					
					6.0	11.0					
					9.0	7.4					
					11.0	7.4					
8-17-81	1457	P	D	BOTTOM	SURFACE	21.0	NW	10-15	NW	0.3-0.6	CLEAR
					MID-DEPTH	21.2					
					BOTTOM	21.5					
8-18-81	0120	P	N	-	SURFACE	17.7	N	0-5	CALM	CALM	CLEAR
					MID-DEPTH	14.5					
					BOTTOM	13.9					
8-17-81	1500	R	D	BOTTOM	SURFACE	22.0	NW	5-10	NW	0.3-0.6	CLEAR
					MID-DEPTH	22.0					
					BOTTOM	21.5					
8-18-81	0108	R	N	-	SURFACE	20.3	N	0-5	CALM	CALM	CLEAR
					MID-DEPTH	20.0					
					BOTTOM	19.4					
8-17-81	1457	W	D	3.5	0.5	20.5	NW	15-20	NW	1.0-1.5	CLEAR
					4.5	20.4					
					8.5	19.8					
					11.5	17.9					
					14.0	9.0					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
8-17-81	2216	W	N	-	0.5	20.2	NE	5-10	NW	0.3-0.6	CLEAR
					4.5	20.0					
					8.5	6.8					
					11.5	6.1					
					14.0	6.1					
9-09-81	1635	A	D	BOTTOM	0.5	18.2	W	10-15	SW	1.0-1.5	CLEAR
					1.0	18.2					
					1.5	18.2					
9-10-81	2012	A	N	-	0.5	20.6	CALM	CALM	W	0-0.3	CLEAR
					1.0	20.6					
					1.5	20.6					
9-09-81	1625	B	D	2.5	0.5	18.2	W	10-15	SW	1.0-1.5	CLEAR
					1.5	18.3					
					3.0	18.3					
9-10-81	1955	B	N	-	0.5	21.0	CALM	CALM	W	0-0.3	CLEAR
					1.5	20.8					
					3.0	20.7					
9-09-81	1908	C	D	3.0	0.5	19.2	SW	15-20	SW	1.5	CLEAR
					2.0	19.2					
					4.0	19.2					
					5.5	19.2					
9-10-81	2200	C	N	-	0.5	20.7	SW	0-5	SW	0-0.3	CLEAR
					2.0	20.7					
					4.0	20.6					
					5.5	20.5					
9-09-81	1834	D	D	4.0	0.5	19.8	SW	15-20	SW	1.5	CLEAR
					2.5	19.8					
					4.5	19.8					
					6.5	19.8					
					8.5	19.8					
9-10-81	2125	D	N	-	0.5	21.2	SW	0-5	SW	0-0.3	CLEAR
					2.5	21.2					
					4.5	21.1					
					6.5	21.0					
					8.5	20.9					
9-09-81	1802	E	D	3.0	0.5	20.2	SW	15-20	SW	1.5	CLEAR
					3.0	20.2					
					6.0	20.2					
					9.0	20.2					
					11.0	20.2					
9-10-81	2057	E	N	-	0.5	21.0	SW	0-5	SW	0-0.3	CLEAR
					3.0	21.0					
					6.0	20.9					
					9.0	20.7					
					11.0	20.6					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
9-09-81	1724	F	D	4.0	0.5	20.2	SW	15-20	SW	1.5	CLEAR
					4.5	20.2					
					8.5	20.2					
					11.5	20.2					
					14.0	20.2					
9-10-81	2017	F	N	-	0.5	21.2	SW	0-5	SW	0-0.3	CLEAR
					4.5	21.2					
					8.5	20.9					
					11.5	20.7					
					14.0	20.6					
9-09-81	1544	I	D	BOTTOM	0.5	18.0	SW	10-15	SW	1.0-1.5	CLEAR
					1.0	18.0					
					1.5	18.0					
9-10-81	2047	I	N	-	0.5	20.6	SW	0-5	SW	0.3-1.0	CLEAR
					1.0	20.5					
					1.5	20.7					
9-09-81	1522	J	D	2.0	0.5	18.0	SW	10-15	SW	1.0-1.5	CLEAR
					1.5	18.0					
					3.0	18.0					
9-10-81	2005	J	N	-	0.5	20.8	SW	0-5	SW	0.3-1.0	CLEAR
					1.5	20.7					
					3.0	20.3					
9-09-81	1442	L	D	3.0	0.5	18.5	SW	15-20	SW	1.0	CLEAR
					2.0	18.5					
					4.0	18.5					
					5.5	18.3					
9-11-81	0017	L	N	-	0.5	20.3	SW	0-5	SW	0.3	CLEAR
					2.0	20.3					
					4.0	20.2					
					5.5	20.0					
9-09-81	1510	N	D	3.0	0.5	19.5	SW	15-20	SW	1.0	CLEAR
					2.5	19.3					
					4.5	19.0					
					6.5	18.8					
					8.5	18.6					
9-10-81	2341	N	N	-	0.5	20.7	SW	0-5	SW	0.3	CLEAR
					2.5	20.6					
					4.5	20.5					
					6.5	20.5					
					8.5	20.4					
9-09-81	1544	O	D	3.0	0.5	19.7	SW	15-20	SW	1.0	CLEAR
					3.0	19.6					
					6.0	19.4					
					9.0	19.2					
					11.0	19.2					

Appendix 5. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc (m)	Depth (m)	Temperature (C)	WIND Dir. From	WIND Speed (MPH)	WAVES Dir. From	WAVES Height (m)	Weather
9-10-81	2311	O	N	-	0.5	20.6	SW	0-5	SW	0-0.3	CLEAR
					3.0	20.6					
					6.0	20.2					
					9.0	20.2					
					11.0	20.2					
9-09-81	1630	P	D	BOTTOM	SURFACE	18.2	W	10-15	SW	1.0-1.5	CLEAR
					MID-DEPTH	18.2					
					BOTTOM	18.2					
9-10-81	2025	P	N	-	SURFACE	20.6	CALM	CALM	W	0-0.3	CLEAR
					MID-DEPTH	20.6					
					BOTTOM	20.6					
9-09-81	1700	R	D	BOTTOM	SURFACE	18.0	SW	10-15	SW	1.0-1.5	CLEAR
					MID-DEPTH	18.0					
					BOTTOM	18.0					
9-10-81	2035	R	N	-	SURFACE	20.6	SW	0-5	SW	0.3-1.0	CLEAR
					MID-DEPTH	20.6					
					BOTTOM	20.6					
9-09-81	1623	W	D	3.0	0.5	19.9	SSW	15-20	SW	1.0	CLEAR
					4.5	19.8					
					8.5	19.6					
					11.5	19.5					
					14.0	19.4					
9-10-81	2235	W	N	-	0.5	20.6	SW	0-5	SSW	0-0.3	CLEAR
					4.5	20.4					
					8.5	20.3					
					11.5	20.2					
					14.0	20.1					

Appendix 6. Meteorological and limnological parameters measured during fish larvae sampling by benthic sled, April to September 1981 near the J. H. Campbell Plant, eastern Lake Michigan.

					Temperature (C)			Wind		Waves		
Starting Date	Starting Time	Station	Diel Period	Secchi Disc	Surface	Mid-Depth	Bottom	Direction	Speed	Direction	Height	Weather
4-13-81	1726	A	D	BOTTOM	9.1	8.6	8.4	SE	10-15	SSE	0-0.3	CLEAR
4-13-81	2140	A	N	-	8.2	8.0	7.8	SE	10-15	SE	0-0.3	RAIN
4-13-81	1734	B	D	1.75	8.0	8.0	7.6	SE	10-15	SSE	0-0.3	CLEAR
4-13-81	2151	B	N	-	8.0	8.0	7.5	SE	10-15	SE	0-0.3	RAIN
4-13-81	1744	C	D	2.0	7.6	7.8	7.5	SE	10-15	SSE	0-0.3	CLEAR
4-13-81	2203	C	N	-	8.0	8.0	7.9	SE	10-15	SE	0-0.3	RAIN
4-13-81	1754	D	D	2.0	7.6	7.3	7.2	SE	10-15	SSE	0-0.3	CLEAR
4-13-81	2113	D	N	-	7.7	7.5	7.1	SE	10-15	SE	0-0.3	RAIN
4-13-81	1802	E	D	2.0	7.4	7.5	7.0	SE	10-15	SSE	0-0.3	CLEAR
4-13-81	2100	E	N	-	7.6	7.2	6.8	SE	10-15	SE	0-0.3	RAIN
4-13-81	1813	F	D	2.0	7.0	6.5	5.9	SE	10-15	SSE	0-0.3	CLEAR
4-13-81	2045	F	N	-	7.0	7.0	6.0	SE	10-15	SE	0-0.3	RAIN
4-13-81	1821	I	D	1.0	10.5	10.0	10.0	SE	5-10	SE	0.1	CLEAR
4-13-81	2146	I	N	-	8.7	8.7	8.5	E	10-15	E	0-0.5	RAIN
4-13-81	1811	J	D	1.0	10.0	10.0	10.0	SE	5-10	SE	0.1	CLEAR
4-13-81	2134	J	N	-	8.3	8.1	8.0	E	10-15	E	0-0.5	RAIN
4-13-81	1758	L	D	1.2	10.0	9.5	9.0	SE	5-10	SE	0.1	CLEAR
4-13-81	2122	L	N	-	8.3	8.2	7.7	E	10-15	E	0-0.5	RAIN
4-13-81	1746	N	D	1.6	9.5	9.5	8.5	SE	5-10	SE	0.1	CLEAR
4-13-81	2104	N	N	-	7.8	7.8	7.7	E	10-15	E	0-0.5	RAIN
4-13-81	1734	O	D	1.6	10.0	9.0	7.5	SE	5-10	SE	0.1	CLEAR
4-13-81	2052	O	N	-	9.0	7.9	7.3	E	10-15	E	0-0.5	OVERCAST
4-13-81	1718	P	D	BOTTOM	9.1	8.6	8.4	SE	10-15	SSE	0-0.3	CLEAR
4-13-81	2127	P	N	-	9.0	8.9	8.8	SE	10-15	SE	0-0.3	RAIN
4-13-81	1830	R	D	BOTTOM	11.0	11.0	11.0	SE	5-10	SE	0.1	CLEAR
4-13-81	2211	R	N	-	9.0	9.0	9.0	E	10-15	E	0-0.5	OVERCAST
4-13-81	1720	W	D	1.5	10.0	9.5	8.5	SE	5-10	SE	0.1	CLEAR
4-13-81	2037	W	N	-	7.8	7.4	7.2	E	10-15	E	0-0.5	OVERCAST
5-04-81	1755	A	D	BOTTOM	12.5	12.3	12.2	SW	0-5	SW	0.5	OVERCAST
5-04-81	2250	A	N	-	12.0	12.0	12.0	SW	10-15	SW	0.5-1.0	RAIN
5-04-81	1744	B	D	1.5	11.7	10.5	10.4	SW	0-5	SW	0.5	OVERCAST
5-04-81	2200	B	N	-	11.7	11.7	11.5	SW	10-15	SW	0.5-1.0	RAIN
5-04-81	1724	C	D	2.0	10.2	10.2	10.0	SW	0-5	SW	0.5	OVERCAST
5-04-81	2126	C	N	-	10.5	10.5	10.5	SW	10-15	SW	0.5-1.0	RAIN
5-04-81	1721	D	D	2.0	9.5	9.5	9.3	SW	0-5	SW	0.5	OVERCAST
5-04-81	2111	D	N	-	10.2	10.2	10.0	SW	10-15	SW	0.5-1.0	RAIN
5-04-81	1709	E	D	2.5	9.3	9.0	9.0	SW	0-5	SW	0.5	OVERCAST
5-04-81	2055	E	N	-	9.5	9.2	9.0	SW	10-15	SW	0.5-1.0	RAIN
5-04-81	1657	F	D	3.0	8.9	8.6	8.4	SW	0-5	SW	0.5	OVERCAST
5-04-81	2040	F	N	-	8.7	8.5	8.5	SW	10-15	SW	0.5-1.0	RAIN
5-04-81	1640	I	D	1.25	13.0	12.5	12.2	SW	15-20	SW	0.5	CLEAR
5-07-81	2133	I	N	-	9.3	9.2	9.0	VAR	0-5	NW	0-1.0	CLEAR
5-04-81	1630	J	D	1.5	11.4	11.2	11.1	SW	15-20	SW	0.5	CLEAR
5-05-81	0030	J	N	-	11.5	11.2	11.2	SW	5-10	SW	0.5-1.0	OVERCAST
5-04-81	1615	L	D	2.0	10.2	9.6	9.0	SW	15-20	SW	0.5	CLEAR
5-05-81	0010	L	N	-	10.6	10.4	10.2	SW	5-10	SW	0.5-1.0	OVERCAST

Appendix 6. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc	Temperature (C) Surface	Mid-Depth	Bottom	Wind Direction	Wind Speed	Waves Direction	Waves Height	Weather
5-04-81	1600	N	D	2.5	9.8	9.2	8.6	SW	15-20	SW	0.5	CLEAR
5-05-81	0010	N	N	-	9.5	9.5	9.5	SW	5-10	SW	0.5-1.0	OVERCAST
5-04-81	1545	O	D	2.5	10.4	9.0	8.5	SW	15-20	SW	0.5	CLEAR
5-05-81	2350	O	N	-	10.0	9.7	9.0	SW	5-10	SW	0.5-1.0	OVERCAST
5-04-81	1600	P	D	BOTTOM	14.5	14.5	14.5	SW	10-15	SW	0-0.5	PT.CLOUDY
5-04-81	2315	P	N	-	12.5	12.5	12.5	SW	10-15	SW	0.5-1.0	RAIN
5-04-81	1704	R	D	BOTTOM	13.5	13.5	13.5	SW	10-15	SW	0-0.5	PT.CLOUDY
5-07-81	2208	R	N	-	11.3	11.2	11.0	VAR	0-5	NW	0-1.0	CLEAR
5-04-81	1530	W	D	2.0	10.7	9.5	8.5	SW	15-20	SW	0.5	CLEAR
5-05-81	0005	W	N	-	7.0	6.9	6.9	SW	5-10	SW	0.5-1.0	OVERCAST
5-18-81	1448	A	D	1.5	8.0	8.0	7.5	NE	10-15	NE	0.3	CLEAR
5-18-81	2231	A	N	-	6.3	6.3	6.3	NE	0-5	NW	0-0.3	OVERCAST
5-18-81	1426	B	D	1.8	7.5	7.5	7.0	NE	10-15	NE	0.3	CLEAR
5-18-81	2206	B	N	-	6.0	6.0	6.0	NE	0-5	NW	0-0.3	OVERCAST
5-18-81	1415	C	D	2.3	7.0	6.5	6.0	NE	10-15	NE	0.3	CLEAR
5-18-81	2157	C	N	-	5.3	5.6	6.0	NE	0-5	NW	0-0.3	OVERCAST
5-18-81	1404	D	D	2.3	6.5	6.0	6.0	NE	10-15	NE	0.3	CLEAR
5-18-81	2146	D	N	-	6.5	6.5	6.5	NE	0-5	NW	0-0.3	OVERCAST
5-18-81	1351	E	D	2.5	6.0	6.0	5.5	NE	10-15	NE	0.3	CLEAR
5-18-81	2136	E	N	-	6.5	6.0	6.0	NE	0-5	NW	0-0.3	OVERCAST
5-18-81	1336	F	D	2.5	7.0	6.5	6.0	NE	10-15	NE	0.3	CLEAR
5-18-81	2124	F	N	-	6.5	6.5	6.0	NE	0-5	NW	0-0.3	OVERCAST
5-18-81	1510	I	D	1.0	8.5	8.5	8.5	E	15-20	NE	0.3-0.6	CLEAR
5-18-81	2350	I	N	-	7.5	7.5	7.5	E	10-15	NW	0.3-1.0	OVERCAST
5-18-81	1445	J	D	2.0	7.0	6.5	6.0	E	15-20	NE	0.3-0.6	CLEAR
5-18-81	2320	J	N	-	7.0	7.0	7.0	E	10-15	NW	0.3-1.0	OVERCAST
5-18-81	1430	L	D	2.0	6.5	6.0	6.0	E	15-20	NE	0.3-0.6	CLEAR
5-18-81	2305	L	N	-	7.0	6.9	6.7	E	10-15	NW	0.3-1.0	OVERCAST
5-18-81	1415	N	D	2.25	5.5	5.0	4.5	E	15-20	NE	0.3-0.6	CLEAR
5-18-81	2255	N	N	-	7.5	7.0	6.9	E	10-15	NW	0.3-1.0	OVERCAST
5-18-81	1400	O	D	2.5	5.5	5.0	5.0	E	15-20	NE	0.3-0.6	CLEAR
5-18-81	2245	O	N	-	7.0	6.5	6.3	E	10-15	NW	0.3-1.0	OVERCAST
5-18-81	1503	P	D	BOTTOM	8.0	8.0	8.0	NE	10-15	NE	0.3	CLEAR
5-18-81	2242	P	N	-	7.0	7.0	7.0	NE	0-5	NW	0-0.3	OVERCAST
5-18-81	1525	R	D	BOTTOM	9.0	9.0	8.5	E	15-20	NE	0.3-0.6	CLEAR
5-19-81	0005	R	N	-	8.0	8.0	8.0	E	10-15	NW	0.3-1.0	OVERCAST
5-18-81	1345	W	D	2.5	5.5	5.0	4.5	E	15-20	NE	0.3-0.6	CLEAR
5-18-81	2230	W	N	-	7.0	6.6	6.3	E	10-15	NW	0.3-1.0	OVERCAST
6-03-81	1510	A	D	BOTTOM	15.6	15.2	14.7	W	0-5	CALM	CALM	CLEAR
6-02-81	2258	A	N	-	13.5	13.2	13.2	SE	0-5	CALM	CALM	FOG
6-03-81	1455	B	D	2.5	15.0	14.6	14.5	W	0-5	CALM	CALM	CLEAR
6-02-81	2242	B	N	-	14.2	12.8	12.2	SE	0-5	CALM	CALM	FOG
6-03-81	1442	C	D	3.0	15.2	14.8	14.5	W	0-5	CALM	CALM	CLEAR
6-02-81	2230	C	N	-	12.3	12.1	12.2	SE	0-5	CALM	CALM	FOG
6-03-81	1428	D	D	3.25	14.5	14.0	12.2	W	0-5	CALM	CALM	CLEAR
6-02-81	2205	D	N	-	12.8	11.5	10.6	SE	0-5	CALM	CALM	FOG
6-03-81	1410	E	D	3.25	14.9	13.6	11.6	W	0-5	CALM	CALM	CLEAR
6-02-81	2143	E	N	-	12.0	11.4	10.1	SE	0-5	CALM	CALM	FOG

Appendix 6. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc	Temperature (C) Surface	Mid-Depth	Bottom	Wind Direction	Speed	Waves Direction	Height	Weather
6-03-81	1355	F	D	3.25	15.0	12.6	9.7	W	0-5	CALM	CALM	CLEAR
6-02-81	2124	F	N	-	12.7	11.2	8.2	SE	0-5	CALM	CALM	FOG
6-03-81	1654	I	D	BOTTOM	16.2	15.2	15.0	W	0-5	CALM	CALM	PT.CLOUDY
6-03-81	0117	I	N	-	13.1	13.0	12.9	SE	5-10	CALM	CALM	OVERCAST
6-03-81	1641	J	D	3.0	15.5	14.7	14.5	W	0-5	CALM	CALM	PT.CLOUDY
6-03-81	0058	J	N	-	12.7	12.7	12.5	SE	5-10	CALM	CALM	OVERCAST
6-03-81	1627	L	D	3.25	15.3	14.2	13.8	W	0-5	CALM	CALM	PT.CLOUDY
6-03-81	0047	L	N	-	12.9	12.0	11.9	SE	5-10	CALM	CALM	OVERCAST
6-03-81	1614	N	D	3.0	16.2	14.3	13.5	W	0-5	CALM	CALM	PT.CLOUDY
6-03-81	0031	N	N	-	12.6	10.6	9.6	SE	5-10	CALM	CALM	OVERCAST
6-03-81	1600	O	D	2.75	15.5	13.2	11.2	W	0-5	CALM	CALM	PT.CLOUDY
6-03-81	0015	O	N	-	12.8	10.3	8.9	SE	5-10	CALM	CALM	OVERCAST
6-03-81	1522	P	D	BOTTOM	15.8	15.7	15.4	W	0-5	CALM	CALM	CLEAR
6-02-81	2213	P	N	-	13.6	13.3	13.4	SE	0-5	CALM	CALM	FOG
6-03-81	1707	R	D	BOTTOM	15.8	15.7	15.4	W	0-5	CALM	CALM	PT.CLOUDY
6-03-81	0140	R	N	-	13.2	13.2	13.2	SE	5-10	CALM	CALM	OVERCAST
6-03-81	1546	W	D	3.0	15.0	13.1	10.6	W	0-5	CALM	CALM	PT.CLOUDY
6-03-81	0005	W	N	-	12.0	11.4	7.6	SE	5-10	CALM	CALM	OVERCAST
6-15-81	1621	A	D	1.0	21.5	21.5	21.5	SW	15-20	SW	0.6-1.0	PT.CLOUDY
6-15-81	2313	A	N	-	21.5	21.5	21.5	WSW	5-10	SW	0.3-0.6	PT.CLOUDY
6-15-81	1604	B	D	1.0	21.0	21.0	21.0	SW	15-20	SW	0.6-1.0	PT.CLOUDY
6-15-81	2256	B	N	-	20.7	20.7	20.7	WSW	5-10	SW	0.3-0.6	PT.CLOUDY
6-15-81	1552	C	D	1.5	20.3	20.0	20.0	SW	15-20	SW	0.6-1.0	PT.CLOUDY
6-15-81	2236	C	N	-	19.8	19.5	19.5	WSW	5-10	SW	0.3-0.6	PT.CLOUDY
6-15-81	1541	D	D	2.0	19.5	19.5	19.5	SW	15-20	SW	0.6-1.0	PT.CLOUDY
6-15-81	2223	D	N	-	19.5	19.3	19.2	WSW	5-10	SW	0.3-0.6	PT.CLOUDY
6-15-81	1528	E	D	3.0	19.2	18.8	18.8	SW	15-20	SW	0.6-1.0	PT.CLOUDY
6-15-81	2210	E	N	-	18.9	18.9	18.9	WSW	5-10	SW	0.3-0.6	PT.CLOUDY
6-15-81	1511	F	D	3.0	18.5	18.5	18.5	SW	15-20	SW	0.6-1.0	PT.CLOUDY
6-15-81	2156	F	N	-	18.0	18.0	18.0	WSW	5-10	SW	0.3-0.6	PT.CLOUDY
6-15-81	1538	I	D	1.5	20.0	20.0	20.0	S	10-15	SSW	0.3-0.6	PT.CLOUDY
6-15-81	2220	I	N	-	19.7	19.7	19.2	SW	5-10	SW	0.3-0.6	RAIN
6-15-81	1513	J	D	1.5	19.5	19.5	19.2	S	10-15	SSW	0.3-0.6	PT.CLOUDY
6-15-81	2233	J	N	-	19.9	19.7	19.7	SW	5-10	SW	0.3-0.6	RAIN
6-15-81	1459	L	D	2.5	18.8	18.6	18.3	S	10-15	SSW	0.3-0.6	PT.CLOUDY
6-15-81	2302	L	N	-	18.7	18.5	18.0	SW	5-10	SW	0.3-0.6	RAIN
6-15-81	1446	N	D	2.5	18.4	18.4	17.7	S	10-15	SSW	0.3-0.6	PT.CLOUDY
6-15-81	2312	N	N	-	18.7	18.5	18.0	SW	5-10	SW	0.3-0.6	RAIN
6-15-81	1434	O	D	2.5	18.4	17.8	17.5	S	10-15	SSW	0.3-0.6	PT.CLOUDY
6-15-81	2330	O	N	-	18.7	18.0	17.9	SW	5-10	SW	0.3-0.6	RAIN
6-15-81	1631	P	D	BOTTOM	21.5	21.5	21.5	SW	15-20	SW	0.6-1.0	PT.CLOUDY
6-15-81	2328	P	N	-	21.5	21.5	21.5	WSW	5-10	SW	0.3-0.6	PT.CLOUDY
6-15-81	1553	R	D	BOTTOM	21.5	21.5	21.5	S	10-15	SSW	0.3-0.6	PT.CLOUDY
6-15-81	2151	R	N	-	19.7	19.7	19.7	SW	5-10	SW	0.3-0.6	RAIN
6-15-81	1421	W	D	3.5	17.3	17.2	17.2	S	10-15	SSW	0.3-0.6	PT.CLOUDY
6-15-81	2345	W	N	-	19.7	16.9	16.4	SW	5-10	SW	0.3-0.6	RAIN
7-01-81	1325	A	D	BOTTOM	16.4	15.6	15.6	NE	5-10	NW	0-0.3	PT.CLOUDY
7-01-81	0110	A	N	-	17.7	17.7	17.7	E	15-20	NW	0.3-0.6	PT.CLOUDY

Appendix 6. Continued.

					Temperature (C)			Wind		Waves		
Starting Date	Starting Time	Station	Diel Period	Secchi Disc	Surface	Mid-Depth	Bottom	Direc-tion	Speed	Direc-tion	Height	Weather
7-01-81	1315	B	D	BOTTOM	15.3	14.3	14.3	NE	5-10	NW	0-0.3	PT.CLOUDY
7-01-81	0100	B	N	-	17.2	17.0	16.7	E	15-20	NW	0.3-0.6	PT.CLOUDY
7-01-81	1300	C	D	3.0	15.8	14.8	14.0	NE	5-10	NW	0-0.3	PT.CLOUDY
7-01-81	0050	C	N	-	17.0	16.7	15.7	E	15-20	NW	0.3-0.6	PT.CLOUDY
7-01-81	1245	D	D	3.5	15.9	15.0	13.4	NE	5-10	NW	0-0.3	PT.CLOUDY
7-01-81	0035	D	N	-	17.2	16.7	15.2	E	15-20	NW	0.3-0.6	PT.CLOUDY
7-01-81	1230	E	D	4.0	16.1	15.4	11.7	NE	5-10	NW	0-0.3	PT.CLOUDY
7-01-81	0025	E	N	-	17.2	16.3	14.7	E	15-20	NW	0.3-0.6	PT.CLOUDY
7-01-81	1220	F	D	5.0	16.7	15.4	10.7	NE	5-10	NW	0-0.3	PT.CLOUDY
7-01-81	0010	F	N	-	17.8	17.5	16.7	E	15-20	NW	0.3-0.6	PT.CLOUDY
7-01-81	1326	I	D	BOTTOM	17.4	16.8	16.3	ENE	0-5	NE	0-0.1	CLEAR
7-01-81	0127	I	N	-	16.0	15.7	15.7	E	5-10	NW	0.3-0.6	CLEAR
7-01-81	1314	J	D	3.0	18.0	16.5	16.1	ENE	0-5	NE	0-0.1	CLEAR
7-01-81	0114	J	N	-	16.5	15.5	15.6	E	5-10	NW	0.3-0.6	CLEAR
7-01-81	1303	L	D	3.75	17.7	15.9	15.2	ENE	0-5	NE	0-0.1	CLEAR
7-01-81	0102	L	N	-	16.5	15.0	15.0	E	5-10	NW	0.3-0.6	CLEAR
7-01-81	1251	N	D	4.0	17.4	16.7	14.1	ENE	0-5	NE	0-0.1	CLEAR
7-01-81	0048	N	N	-	16.8	15.0	14.5	E	5-10	NW	0.3-0.6	CLEAR
7-01-81	1240	O	D	5.0	17.1	15.6	13.0	ENE	0-5	NE	0-0.1	CLEAR
7-01-81	0035	O	N	-	17.0	15.0	13.0	E	5-10	NW	0.3-0.6	CLEAR
7-01-81	1339	P	D	BOTTOM	17.3	16.3	16.7	NE	5-10	NW	0-0.3	PT.CLOUDY
7-01-81	0120	P	N	-	17.5	17.5	17.5	E	15-20	NW	0.3-0.6	PT.CLOUDY
7-01-81	1336	R	D	BOTTOM	18.5	17.3	17.2	ENE	0-5	NE	0-0.1	CLEAR
7-01-81	0140	R	N	-	16.0	16.0	16.0	E	5-10	NW	0.3-0.6	CLEAR
7-01-81	1227	W	D	5.5	17.2	16.2	11.8	ENE	0-5	NE	0-0.1	CLEAR
7-01-81	0015	W	N	-	18.2	17.2	16.0	E	5-10	NW	0.3-0.6	CLEAR
7-20-81	1320	A	D	BOTTOM	22.0	22.0	20.5	NW	5-10	NW	0-0.3	FOG
7-19-81	2245	A	N	-	22.1	22.1	22.0	CALM	CALM	SW	0.3-0.6	PT.CLOUDY
7-20-81	1346	B	D	BOTTOM	21.0	21.0	19.5	NW	5-10	NW	0-0.3	FOG
7-19-81	2230	B	N	-	22.0	21.8	21.7	CALM	CALM	SW	0.3-0.6	PT.CLOUDY
7-20-81	1358	C	D	5.5	22.5	22.4	21.0	NW	5-10	NW	0-0.3	FOG
7-19-81	2213	C	N	-	21.8	21.4	20.7	CALM	CALM	SW	0.3-0.6	PT.CLOUDY
7-20-81	1412	D	D	7.5	22.2	20.9	17.8	NW	5-10	NW	0-0.3	FOG
7-19-81	2145	D	N	-	21.6	21.3	17.9	CALM	CALM	SW	0.3-0.6	PT.CLOUDY
7-20-81	1425	E	D	7.0	22.8	21.0	10.5	NW	5-10	NW	0-0.3	FOG
7-19-81	2130	E	N	-	21.7	21.2	14.5	CALM	CALM	SW	0.3-0.6	PT.CLOUDY
7-20-81	1441	F	D	5.5	22.8	14.0	8.3	NW	5-10	NW	0-0.3	FOG
7-19-81	2110	F	N	-	21.6	21.3	19.1	CALM	CALM	SW	0.3-0.6	OVERCAST
7-20-81	1432	I	D	BOTTOM	21.7	21.7	21.5	NW	5-10	NW	0-0.3	FOG
7-19-81	2230	I	N	-	21.2	21.2	21.2	SE	5-10	CALM	CALM	OVERCAST
7-20-81	1408	J	D	BOTTOM	21.2	21.2	21.0	NW	5-10	NW	0-0.3	FOG
7-19-81	2215	J	N	-	21.8	21.5	20.5	SE	5-10	CALM	CALM	OVERCAST
7-20-81	1355	L	D	BOTTOM	21.0	20.8	20.5	NW	5-10	NW	0-0.3	FOG
7-19-81	2205	L	N	-	22.1	21.3	20.4	SE	5-10	CALM	CALM	OVERCAST
7-20-81	1345	N	D	7.5	21.0	19.5	17.0	NW	5-10	NW	0-0.3	FOG
7-19-81	2150	N	N	-	20.7	20.5	17.3	SE	5-10	CALM	CALM	OVERCAST
7-20-81	1330	O	D	7.5	21.0	20.2	14.0	NW	5-10	NW	0-0.3	FOG
7-19-81	2135	O	N	-	20.7	20.5	15.8	SE	5-10	CALM	CALM	OVERCAST

Appendix 6. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc	Temperature (C) Surface	Mid-Depth	Bottom	Wind Direction	Speed	Waves Direction	Height	Weather
7-20-81	1300	P	D	BOTTOM	22.0	21.5	21.5	NW	5-10	NW	0-0.3	FOG
7-19-81	2310	P	N	-	22.2	21.8	21.8	CALM	CALM	SW	0.3-0.6	PT.CLOUDY
7-20-81	1445	R	D	BOTTOM	22.0	22.0	22.0	NW	5-10	NW	0-0.3	FOG
7-19-81	2250	R	N	-	21.2	21.2	21.2	SE	5-10	CALM	CALM	OVERCAST
7-20-81	1315	W	D	9.0	20.5	20.0	9.0	NW	5-10	NW	0-0.3	FOG
7-19-81	2110	W	N	-	20.5	20.0	8.2	SE	5-10	CALM	CALM	OVERCAST
8-05-81	1605	A	D	BOTTOM	22.8	22.6	22.2	NW	5-10	NW	0.3	OVERCAST
8-05-81	2106	A	N	-	21.3	21.3	21.0	E	0-5	CALM	CALM	PT.CLOUDY
8-05-81	1555	B	D	BOTTOM	22.3	22.2	21.9	NW	5-10	NW	0.3	OVERCAST
8-05-81	2052	B	N	-	21.3	21.0	20.9	E	0-5	CALM	CALM	PT.CLOUDY
8-05-81	1544	C	D	4.0	22.3	21.8	21.6	NW	5-10	NW	0.3	OVERCAST
8-05-81	2134	C	N	-	21.3	21.0	20.8	E	0-5	CALM	CALM	PT.CLOUDY
8-05-81	1533	D	D	4.0	22.4	21.8	21.6	NW	5-10	NW	0.3	OVERCAST
8-05-81	2122	D	N	-	21.3	21.0	20.6	E	0-5	CALM	CALM	PT.CLOUDY
8-05-81	1519	E	D	3.5	22.4	21.7	21.2	NW	5-10	NW	0.3	OVERCAST
8-05-81	2110	E	N	-	21.3	20.2	19.0	E	0-5	CALM	CALM	PT.CLOUDY
8-05-81	1504	F	D	4.0	22.6	21.8	21.4	NW	5-10	NW	0.3	OVERCAST
8-05-81	2052	F	N	-	21.3	20.5	17.8	E	0-5	CALM	CALM	PT.CLOUDY
8-05-81	1739	I	D	BOTTOM	21.5	21.5	21.0	NW	5-10	NW	0.3	PT.CLOUDY
8-05-81	2205	I	N	-	22.0	22.0	22.0	SE	0-5	NW	0-0.3	RAIN
8-05-81	1728	J	D	3.5	21.0	20.5	20.5	NW	5-10	NW	0.3	PT.CLOUDY
8-05-81	2148	J	N	-	21.0	21.0	21.0	SE	0-5	NW	0-0.3	RAIN
8-05-81	1717	L	D	3.5	21.0	20.5	20.0	NW	5-10	NW	0.3	PT.CLOUDY
8-05-81	2256	L	N	-	21.3	20.6	20.5	SE	0-5	NW	0-0.3	RAIN
8-05-81	1704	N	D	3.5	21.4	21.0	20.0	NW	5-10	NW	0.3	PT.CLOUDY
8-05-81	2242	N	N	-	21.3	20.9	20.3	SE	0-5	NW	0-0.3	RAIN
8-05-81	1652	O	D	4.0	21.4	20.8	20.0	NW	5-10	NW	0.3	PT.CLOUDY
8-05-81	2228	O	N	-	21.3	20.8	20.4	SE	0-5	NW	0-0.3	RAIN
8-05-81	1616	P	D	BOTTOM	22.9	22.9	22.8	NW	5-10	NW	0.3	OVERCAST
8-05-81	2120	P	N	-	21.3	21.3	21.3	E	0-5	CALM	CALM	PT.CLOUDY
8-05-81	1751	R	D	BOTTOM	21.3	21.3	21.0	NW	5-10	NW	0.3	PT.CLOUDY
8-05-81	2235	R	N	-	22.5	22.5	22.5	SE	0-5	NW	0-0.3	RAIN
8-05-81	1636	W	D	4.0	21.0	20.5	19.8	NW	5-10	NW	0.3	PT.CLOUDY
8-05-81	2212	W	N	-	21.3	21.0	20.3	SE	0-5	NW	0-0.3	RAIN
8-17-81	1443	A	D	BOTTOM	21.4	21.2	20.7	NW	10-15	NW	0.3-0.6	CLEAR
8-18-81	0102	A	N	-	19.7	19.2	11.7	NW	10-15	NW	0.3-0.6	CLEAR
8-17-81	1419	B	D	1.5	21.0	20.7	20.5	NW	10-15	NW	0.3-0.6	CLEAR
8-18-81	0031	B	N	-	19.2	10.2	9.9	NW	10-15	NW	0.3-0.6	CLEAR
8-17-81	1406	C	D	1.75	20.7	20.7	19.5	NW	10-15	NW	0.3-0.6	CLEAR
8-18-81	0016	C	N	-	20.2	16.5	11.0	NW	10-15	NW	0.3-0.6	CLEAR
8-17-81	1355	D	D	2.0	20.8	20.5	18.2	NW	10-15	NW	0.3-0.6	CLEAR
8-18-81	0002	D	N	-	20.2	16.5	11.0	NW	10-15	NW	0.3-0.6	CLEAR
8-17-81	1342	E	D	2.5	21.5	20.7	18.5	NW	10-15	NW	0.3-0.6	CLEAR
8-17-81	2345	E	N	-	20.2	16.0	6.2	NW	10-15	NW	0.3-0.6	CLEAR
8-17-81	1326	F	D	2.75	21.7	21.0	16.0	NW	10-15	NW	0.3-0.6	CLEAR
8-17-81	2325	F	N	-	20.2	6.0	5.5	NW	10-15	NW	0.3-0.6	CLEAR
8-17-81	1421	I	D	1.2	21.5	21.0	21.0	N	10-15	NW	0.3-0.6	CLEAR
8-18-81	0040	I	N	-	20.2	19.7	19.2	N	10-15	N	0.3-0.6	CLEAR

Appendix 6. Continued.

Starting Date	Starting Time	Station	Diel Period	Secchi Disc	Temperature (C) Surface	Temperature (C) Mid-Depth	Temperature (C) Bottom	Wind Direction	Wind Speed	Waves Direction	Waves Height	Weather
8-17-81	1410	J	D	1.4	21.5	21.0	20.5	N	10-15	NW	0.3-0.6	CLEAR
8-18-81	0017	J	N	-	19.9	15.3	14.8	N	10-15	N	0.3-0.6	CLEAR
8-17-81	1358	L	D	2.1	21.4	21.6	19.6	N	10-15	NW	0.3-0.6	CLEAR
8-18-81	0003	L	N	-	20.0	9.8	9.5	N	10-15	N	0.3-0.6	CLEAR
8-17-81	1343	N	D	2.6	21.4	20.5	18.0	N	10-15	NW	0.3-0.6	CLEAR
8-17-81	2348	N	N	-	20.5	9.5	7.7	N	10-15	N	0.3-0.6	CLEAR
8-17-81	1334	O	D	2.8	21.5	21.0	17.3	N	10-15	NW	0.3-0.6	CLEAR
8-17-81	2333	O	N	-	20.5	20.5	7.5	N	10-15	N	0.3-0.6	CLEAR
8-17-81	1457	P	D	BOTTOM	21.0	21.2	21.5	NW	10-15	NW	0.3-0.6	CLEAR
8-18-81	0125	P	N	-	17.7	14.5	13.9	NW	10-15	NW	0.3-0.6	CLEAR
8-17-81	1434	R	D	BOTTOM	22.0	22.0	21.5	N	10-15	NW	0.3-0.6	CLEAR
8-18-81	0053	R	N	-	20.3	20.0	19.4	N	10-15	N	0.3-0.6	CLEAR
8-17-81	1318	W	D	3.0	21.8	22.3	17.2	N	10-15	NW	0.3-0.6	CLEAR
8-17-81	2315	W	N	-	20.5	20.5	7.0	N	10-15	N	0.3-0.6	CLEAR
9-08-81	1610	A	D	BOTTOM	16.9	16.8	16.5	NW	10-15	NW	1.0	PT.CLOUDY
9-08-81	2150	A	N	-	17.0	16.7	16.5	NE	10-15	NW	1.0	PT.CLOUDY
9-08-81	1556	B	D	1.9	17.3	17.3	16.7	NW	10-15	NW	1.0	PT.CLOUDY
9-08-81	2140	B	N	-	17.0	16.9	16.5	NE	10-15	NW	1.0	PT.CLOUDY
9-08-81	1531	C	D	3.5	17.4	17.2	16.5	NW	10-15	NW	1.0	PT.CLOUDY
9-08-81	2123	C	N	-	17.9	17.5	17.0	NE	10-15	NW	1.0	PT.CLOUDY
9-08-81	1514	D	D	3.7	17.6	17.3	16.2	NW	10-15	NW	1.0	PT.CLOUDY
9-08-81	2107	D	N	-	17.9	17.5	16.8	NE	10-15	NW	1.0	PT.CLOUDY
9-08-81	1458	E	D	3.2	17.3	17.3	16.7	NW	10-15	NW	1.0	PT.CLOUDY
9-08-81	2049	E	N	-	17.5	17.0	15.5	NE	10-15	NW	1.0	PT.CLOUDY
9-08-81	1440	F	D	3.0	17.7	17.0	16.5	NW	10-15	NW	1.0	PT.CLOUDY
9-08-81	2029	F	N	-	17.7	17.5	15.0	NE	10-15	NW	1.0	PT.CLOUDY
9-08-81	1535	I	D	BOTTOM	15.0	15.0	14.8	NW	10-15	NW	1.0-1.3	CLEAR
9-08-81	2149	I	N	-	15.0	15.0	15.0	NW	10-15	NW	0.6	PT.CLOUDY
9-08-81	1523	J	D	2.5	15.2	15.2	15.2	NW	10-15	NW	1.0-1.3	CLEAR
9-08-81	2136	J	N	-	16.0	15.6	15.6	NW	10-15	NW	0.6	PT.CLOUDY
9-08-81	1511	L	D	3.0	15.5	15.0	14.0	NW	10-15	NW	1.0-1.3	CLEAR
9-08-81	2123	L	N	-	16.2	16.2	15.2	NW	10-15	NW	0.6	PT.CLOUDY
9-08-81	1458	N	D	4.5	16.0	15.0	13.5	NW	10-15	NW	1.0-1.3	CLEAR
9-08-81	2054	N	N	-	17.0	16.5	15.5	NW	10-15	NW	0.6	PT.CLOUDY
9-08-81	1445	O	D	3.3	16.0	15.5	14.0	NW	10-15	NW	1.0-1.3	CLEAR
9-08-81	2040	O	N	-	16.5	16.3	15.5	NW	10-15	NW	0.6	PT.CLOUDY
9-08-81	1700	P	D	BOTTOM	18.2	18.2	18.2	NW	10-15	NW	1.0	PT.CLOUDY
9-10-81	2025	P	N	-	20.6	20.6	20.6	NE	10-15	NW	1.0	PT.CLOUDY
9-08-81	1551	R	D	BOTTOM	14.8	14.8	14.8	NW	10-15	NW	1.0-1.3	CLEAR
9-08-81	2201	R	N	-	14.8	14.8	14.8	NW	10-15	NW	0.6	PT.CLOUDY
9-08-81	1432	W	D	4.8	16.0	15.0	15.0	NW	10-15	NW	1.0-1.3	CLEAR
9-08-81	2021	W	N	-	17.0	16.5	15.5	NW	10-15	NW	0.6	PT.CLOUDY

Appendix 7. Monthly length-frequency distributions of species caught from April to December 1981 in the J. H. Campbell Plant study area, eastern Lake Michigan. Catches from all gear were pooled. Length intervals represent the mid-point of a 10-mm length group.

ALEWIFE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
20	0	0	0	0	0	0	7	0	0	0	0	1	0	0	0	0	0	0	7	1
30	0	0	0	0	0	0	4	0	5205	83	8	11	2	0	0	0	0	0	5219	94
40	0	0	0	0	0	0	0	0	1448	106	10	41	305	2	89	33	0	0	1852	182
50	0	0	0	0	0	0	0	0	48	30	69	227	715	3	7608	2908	0	5	8440	3173
60	1	0	23	29	1	0	0	0	12	0	50	121	91	1	11853	7412	1	6	12032	7569
70	35	24	464	923	68	22	2	1	3	3	30	26	3	0	1497	2085	0	2	2102	3086
80	51	50	817	2693	231	241	98	0	7	3	18	8	2	1	62	253	0	0	1286	3249
90	31	42	680	2375	121	313	392	0	37	8	12	2	0	0	0	0	0	0	1273	2740
100	24	17	261	581	11	79	1075	2	20	84	58	38	2	0	0	0	0	0	1451	801
110	1	38	103	168	9	30	250	4	77	138	28	51	11	0	0	2	0	1	479	432
120	32	82	124	402	8	25	47	6	50	42	1	8	14	0	0	0	0	1	276	566
130	171	67	71	248	21	29	128	22	14	2	0	0	5	0	0	1	0	0	410	369
140	53	43	28	82	10	16	113	10	4	2	1	0	2	0	0	0	0	0	211	153
150	34	63	11	49	14	38	65	4	8	3	0	1	1	0	0	1	0	0	133	159
160	98	274	2	142	45	290	76	114	18	9	0	1	2	2	0	0	0	0	241	832
170	157	347	1	120	114	630	174	195	34	15	0	0	1	0	0	0	0	0	481	1307
180	144	190	2	102	98	501	275	146	16	10	1	0	0	1	0	0	0	0	536	950
190	151	143	0	35	33	108	302	19	12	2	0	0	0	0	0	0	0	1	498	308
200	50	171	3	44	4	35	147	3	0	1	0	0	0	1	0	0	0	0	204	255
210	0	77	1	44	4	46	11	13	0	1	0	0	0	0	0	0	0	0	16	181
220	0	16	0	15	1	19	4	5	0	0	0	0	0	0	0	0	0	0	5	55
230	0	0	0	0	1	0	2	1	0	0	0	0	0	0	0	0	0	0	3	1
TOTALS	1033	1644	2591	8052	794	2422	3172	545	7013	542	286	536	1156	11	21109	12695	1	16	37155	26463

BLUNTNOSE MINNOW

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
40	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
50	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
60	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TOTALS	0	2	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	1	4

Appendix 7. Continued.

BROWN TROUT

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
110	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
160	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
260	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
300	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
310	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
390	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
410	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
440	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
450	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
470	1	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
480	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
490	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
500	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
510	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	3
520	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
530	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
540	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
550	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
570	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
580	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
600	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
610	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	1
620	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
680	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
690	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2
700	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0
720	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	2	7	16	11	1	1	1	0	0	1	1	2	0	0	0	3	0	0	21	25

BURBOT

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
340	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	3
350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
360	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
410	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
460	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
490	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
520	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
TOTALS	0	0	0	1	0	1	0	0	0	0	0	0	0	2	0	8	0	0	0	12

Appendix 7. Continued.

CHANNEL CATFISH

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
70	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
450	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
510	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
570	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
580	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	1	0	0	0	1	1	2	0	0	0	0	0	0	1	4

CHINOOK SALMON

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
70	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
80	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	2	1
90	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0
100	0	0	0	0	5	8	0	0	0	0	0	0	0	0	0	0	0	0	5	8
120	0	0	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0	0	5
130	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
150	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
160	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
170	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
180	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
200	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	3
220	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
270	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
280	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
290	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	5
300	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
320	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
340	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
370	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
380	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
400	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
430	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
450	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
470	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
540	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
550	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
690	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
730	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
780	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
790	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
800	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
830	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
840	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
900	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
910	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
940	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TOTALS	0	12	1	2	15	10	1	9	1	12	1	7	0	0	0	5	0	0	19	57

COHO SALMON

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
130	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
140	0	0	2	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9
150	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13
160	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
170	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
400	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
430	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
450	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
460	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
490	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
500	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
510	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
520	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
530	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
540	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
550	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
560	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3
570	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
580	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
590	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
640	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TOTALS	1	6	4	41	0	0	0	0	1	0	0	2	0	0	0	5	0	0	6	54

COMMON CARP

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
590	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
600	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
610	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
640	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
650	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
660	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
680	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	2
690	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
700	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
710	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
730	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
780	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	1	1	0	0	0	2	0	1	0	0	0	6	0	4	0	0	0	0	1	14

Appendix 7. Continued.

DEEPWATER SCULPIN

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
140	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	2

EMERALD SHINER

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
30	1	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	4	0
40	0	0	0	0	0	0	0	0	0	0	13	1	1	0	0	0	0	0	14	1
50	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	2	2
60	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
70	0	0	0	0	0	0	0	0	5	0	0	1	0	0	0	0	0	0	5	1
80	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
TOTALS	1	1	0	0	0	0	0	0	7	1	17	2	2	1	0	0	0	0	27	5

FRESHWATER DRUM

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
200	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
330	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
340	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3

Appendix 7. Continued.

GIZZARD SHAD

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
50	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
60	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
70	0	0	0	0	0	0	0	0	0	0	1	1	2	0	0	0	0	0	3	1
80	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
90	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
100	0	0	0	0	0	0	0	0	0	0	1	1	0	3	0	0	0	0	1	4
110	0	0	0	0	0	0	0	0	0	0	1	1	0	7	0	0	0	0	1	8
120	0	0	0	0	0	0	0	0	0	1	0	1	1	4	0	0	0	0	1	6
130	0	0	0	0	0	0	0	0	0	0	0	1	1	2	0	0	0	0	1	3
140	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	3
180	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
290	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
310	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
320	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
340	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
350	0	0	0	0	0	0	0	0	1	1	0	4	0	0	0	0	0	0	1	5
360	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5
370	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	3
380	0	0	0	0	0	0	0	1	0	0	0	5	0	0	0	1	0	0	0	7
390	0	0	0	0	0	0	0	0	0	0	0	3	0	1	0	1	0	0	0	5
400	0	0	0	0	0	0	0	1	0	0	0	4	0	0	0	1	0	0	0	6
410	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	1	2
420	0	0	0	0	0	1	0	1	0	0	1	2	0	0	0	3	0	0	1	7
430	0	0	0	0	0	3	0	1	1	0	0	0	0	0	0	5	0	0	1	9
440	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	3
450	0	0	0	0	0	1	0	0	0	2	0	1	0	0	0	0	0	0	0	4
460	0	0	0	1	0	4	2	1	0	3	0	0	0	0	0	2	0	0	2	11
470	0	0	0	0	0	1	0	3	0	1	0	1	0	1	0	2	0	0	0	9
480	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	2	1
490	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
500	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
510	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
690	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
TOTALS	0	1	2	2	1	14	3	9	2	10	6	37	6	24	0	18	0	0	20	115

GOLDEN REDHORSE

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
540	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
560	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
TOTALS	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	2

JOHNNY DARTER

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
20	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
30	0	0	0	0	0	5	0	0	0	1	0	1	0	0	0	0	0	0	0	7
40	1	6	1	21	3	38	0	7	0	7	0	0	0	1	0	0	0	0	5	80
50	2	7	4	32	2	37	2	38	3	53	0	8	0	2	0	0	0	0	13	177
60	2	8	0	15	0	5	1	5	9	78	5	34	1	2	0	5	0	4	18	156
70	3	8	1	9	0	2	0	1	1	15	2	12	1	2	0	3	1	0	9	52
80	2	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	3	2
TOTALS	10	29	6	78	5	87	3	51	13	155	7	55	3	7	0	8	1	5	48	475

LAKE TROUT

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
110	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
120	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1
130	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	2
140	0	0	0	3	2	2	0	1	0	0	0	0	0	0	0	0	0	0	2	6
150	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	2
170	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	2	1
220	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
440	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
510	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
520	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
540	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
560	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1
570	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
580	0	1	0	0	0	0	0	0	0	2	0	0	1	3	0	1	0	0	1	7
590	0	0	0	0	0	0	0	0	0	1	0	1	0	3	0	1	0	0	0	6
600	0	2	0	0	0	0	0	0	0	2	1	0	2	4	0	0	0	1	3	9
610	0	0	0	0	0	0	0	1	0	0	0	0	1	10	0	0	0	0	1	11
620	0	0	0	0	0	0	0	0	0	1	0	1	1	6	0	0	0	0	1	8
630	0	0	0	0	0	0	0	1	0	3	0	1	0	5	0	0	0	0	0	10
640	0	1	0	0	0	0	0	0	0	1	1	0	0	9	0	0	0	0	1	11
650	0	1	0	0	0	0	0	0	0	7	0	0	0	12	0	1	0	0	0	21
660	0	2	0	2	0	0	0	0	0	2	0	0	1	10	0	0	0	0	1	16
670	0	0	0	0	0	0	0	1	0	4	1	0	2	5	0	0	0	0	3	10
680	0	1	0	0	0	0	0	0	0	3	0	1	1	4	0	0	0	0	1	9
690	0	3	0	1	0	0	0	1	0	2	0	0	0	8	0	3	0	0	0	18
700	0	1	0	1	0	0	0	0	0	4	0	0	1	7	0	2	0	0	1	15
710	0	0	0	0	0	0	0	0	0	5	1	0	0	8	0	0	0	0	1	13
720	0	1	0	1	0	0	0	0	0	2	0	1	0	4	0	0	0	0	0	9
730	0	0	0	0	0	0	0	0	0	3	0	1	0	5	0	2	0	0	0	11
740	0	0	0	0	0	0	0	0	0	1	0	1	1	4	1	1	0	0	2	7
750	0	0	0	1	0	0	0	0	0	2	0	0	0	2	0	1	0	0	0	6
760	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	2
770	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	3
780	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	0	0	4
790	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0	4
800	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
830	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
850	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
860	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
910	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
TOTALS	0	14	0	13	3	4	4	5	0	54	4	8	15	119	1	17	0	1	27	235

LAKE WHITEFISH

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
220	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
250	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
270	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
310	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
380	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
490	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
520	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
580	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
600	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
610	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
670	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
700	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	3	0	3	0	0	0	5	0	2	0	0	0	0	0	0	0	0	0	13

Appendix 7. Continued.

LONGNOSE SUCKER

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
70	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
80	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	1	4
90	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4
100	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	3
110	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
120	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
140	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
150	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
170	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
180	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
210	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2	0
230	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
240	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
260	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2
280	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	2
290	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2
300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
310	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
320	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2
330	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3
340	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
350	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
360	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
380	0	0	0	3	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	5
390	0	0	0	0	0	1	0	0	1	2	0	1	0	1	0	0	0	0	1	5
400	0	0	0	2	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	5
410	0	0	0	3	0	1	0	1	0	3	1	0	0	0	0	1	0	0	1	9
420	0	1	0	3	0	3	0	2	0	0	0	1	0	0	0	0	0	0	0	10
430	1	0	0	1	0	0	1	0	1	5	0	0	0	1	0	0	0	0	3	7
440	0	0	0	2	0	0	0	1	0	3	0	0	0	1	0	0	0	0	0	7
450	3	1	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0	0	3	6
460	1	1	0	3	0	1	0	0	0	2	0	2	0	1	0	1	0	0	1	11
470	2	1	0	2	0	0	1	1	0	2	0	1	0	0	0	4	0	0	3	11
480	1	1	0	1	0	1	0	0	0	0	0	0	0	1	0	4	0	0	1	8
490	2	2	0	2	0	0	0	0	0	1	0	0	1	0	0	2	0	0	3	7
500	1	2	0	0	0	0	0	1	0	1	0	0	0	0	0	2	0	0	1	6
510	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	3
520	3	3	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	3	5
530	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
540	0	3	0	1	0	1	0	0	0	0	0	1	0	0	0	2	0	0	0	8
550	2	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	2	3
560	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	5	0	0	1	5
570	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1	7
580	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	4
590	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
TOTALS	18	21	0	28	0	14	3	27	3	32	4	11	1	6	0	34	0	2	29	175

Appendix 7. Continued.

NINESPINE STICKLEBACK

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
50	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3
60	0	0	1	4	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	6
70	0	0	3	8	1	1	0	4	0	0	0	0	0	0	0	0	0	0	4	13
80	0	0	0	2	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	4
TOTALS	0	0	4	16	1	2	1	8	0	0	0	0	0	0	0	0	0	0	6	26

QUILLBACK

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
410	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
420	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
430	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
440	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	1	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	3	1

RAINBOW SMELT

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
20	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
30	0	0	0	0	0	0	2	32	84	181	113	75	1	1	0	11	0	0	200	300
40	1	0	1	0	0	0	1	7	910	4932	2003	1160	69	45	330	125	8	16	3323	6285
50	390	210	398	426	0	0	28	12	202	800	643	350	426	105	2403	2601	316	652	4806	5156
60	2217	1791	1231	3631	4	1	413	555	30	88	66	22	126	107	2977	2383	342	753	7406	9331
70	2740	2230	2461	4190	4	1	802	1216	97	316	4	0	6	12	32	116	31	58	6177	8139
80	822	847	611	1769	1	0	1709	1354	201	245	5	3	3	1	1	2	1	0	3354	4221
90	119	138	108	265	0	0	1039	322	193	53	6	0	6	2	0	0	0	0	1471	780
100	25	23	12	45	0	0	200	62	62	10	19	5	14	6	0	0	0	0	332	151
110	24	6	2	3	0	0	59	2	56	5	33	2	31	9	0	0	0	1	205	28
120	49	17	2	3	0	0	16	0	25	1	33	4	40	5	0	1	2	0	167	31
130	17	20	3	3	0	0	9	1	10	2	12	1	28	7	2	6	1	0	82	40
140	12	55	0	2	0	0	10	0	19	8	13	0	23	1	0	14	0	0	77	80
150	1	32	0	4	0	0	0	0	8	41	5	1	9	3	2	29	2	0	27	110
160	2	23	0	1	0	0	2	2	10	15	2	0	4	2	1	32	0	0	21	75
170	1	16	1	2	0	0	0	1	2	11	0	1	4	3	0	16	0	0	8	50
180	1	18	0	1	0	0	0	1	1	1	0	0	2	0	0	13	0	1	4	35
190	0	4	0	0	0	0	0	1	0	2	0	0	0	0	0	4	0	0	0	11
200	0	8	0	0	0	0	0	0	0	2	0	0	1	0	0	3	0	0	1	13
210	0	14	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	16
220	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	6
230	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	6
240	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	3
250	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
260	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
280	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	6421	5466	4830	10345	9	2	4290	3569	1912	6714	2957	1624	793	309	5748	5360	703	1481	27663	34870

Appendix 7. Continued.

RAINBOW TROUT

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
110	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
150	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
240	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
450	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	2	0	0	1	3
480	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
500	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
530	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
580	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
600	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
610	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
620	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
710	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
790	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	2	1	1	1	0	0	2	0	0	0	2	1	3	0	5	0	0	3	15

ROUND WHITEFISH

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
140	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
160	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
180	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
200	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
210	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3
220	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	1
230	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
250	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1
260	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1
270	0	0	1	1	0	0	0	0	0	0	0	1	2	0	0	0	0	0	3	2
280	0	1	0	0	0	0	0	0	0	2	0	0	0	0	1	1	0	0	1	4
300	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	1	3
310	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	3	1
320	0	1	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	2	3
330	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	0	0	2	3
340	0	3	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	4
350	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	2
360	0	1	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	2	3
370	0	0	0	0	0	0	0	0	0	0	1	3	3	1	0	0	0	0	4	4
380	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	2	0	0	0	5
390	0	1	0	0	0	0	0	0	0	0	0	1	4	7	0	3	0	0	4	12
400	0	1	0	1	0	0	0	0	0	2	0	1	1	1	0	3	1	0	2	9
410	0	0	0	0	0	0	0	0	0	0	1	2	1	2	0	1	0	0	2	5
420	0	1	0	0	0	0	0	0	0	1	1	2	1	0	0	2	0	0	2	6
430	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	3
440	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	3
450	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
460	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	0	0	4
470	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
480	0	1	0	0	0	0	0	0	0	2	0	1	1	0	0	1	0	0	1	5
490	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	1	2
500	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
510	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
TOTALS	0	15	1	4	1	0	1	3	0	15	4	21	26	18	2	22	1	0	36	98

Appendix 7. Continued.

SHORTHEAD REDHORSE

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
370	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
410	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
430	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	1	2
440	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
450	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
460	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
480	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
490	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
500	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
510	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	2	2	0	0	1	0	0	5	0	3	0	0	0	0	3	10

SILVER REDHORSE

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
490	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
520	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
540	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
560	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	2
570	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
590	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
600	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	2
610	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	2
TOTALS	0	0	0	0	0	0	0	0	2	5	0	2	0	2	0	1	0	0	2	10

SLIMY SCULPIN

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
30	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
40	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
50	0	1	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4
60	0	12	0	2	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	16
70	0	19	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	22
80	2	20	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12	2	33
90	2	14	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	22	3	38
100	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	2	9
110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
130	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
TOTALS	4	67	0	8	0	1	0	1	0	0	0	1	1	2	0	0	4	45	9	125

Appendix 7. Continued.

SPOTTAIL SHINER

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
10	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	14	0
20	0	0	0	0	0	0	29	0	18	0	0	0	0	0	0	0	0	0	47	0
30	0	0	0	0	0	0	1	0	146	10	0	1	0	4	4	0	0	0	151	15
40	2	8	0	4	0	0	0	0	109	14	72	29	3	1	1	1	0	2	187	59
50	16	44	5	35	22	53	1	1	6	2	68	123	29	10	6	14	0	12	153	294
60	7	36	1	32	11	31	4	5	8	19	173	183	31	4	1	13	1	9	237	332
70	1	12	0	0	6	17	2	19	1	7	47	94	23	8	0	4	1	3	81	164
80	0	5	0	1	2	3	0	1	1	41	36	57	25	2	0	0	0	4	64	114
90	1	19	0	7	46	22	0	1	1	14	35	137	188	2	0	4	0	21	271	227
100	1	35	7	91	137	234	1	21	7	12	5	64	164	15	0	3	0	12	322	487
110	7	196	26	483	849	1689	0	366	53	125	36	272	94	73	0	21	1	12	1066	3237
120	5	117	26	502	589	2067	3	517	73	131	24	393	151	111	0	34	1	30	872	3902
130	0	29	1	65	69	183	0	43	9	35	7	67	52	19	0	7	1	6	139	454
140	0	0	0	9	8	13	0	5	0	0	0	0	4	2	0	0	0	0	12	29
160	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
170	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
180	1	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	1	5
200	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
210	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
TOTALS	47	501	66	1229	1739	4317	55	979	432	410	503	1420	764	251	12	101	5	111	3623	9319

TROUT-PERCH

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
40	0	1	0	3	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2	4
50	0	1	0	2	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	6
60	0	1	0	1	1	1	0	1	0	3	0	0	0	0	0	0	0	0	1	7
70	0	10	0	9	4	10	3	7	0	3	2	0	1	0	0	0	0	0	10	39
80	5	5	1	11	9	19	1	10	0	5	2	1	0	0	0	0	0	0	18	51
90	1	2	0	3	9	7	5	17	0	13	7	4	0	0	0	1	0	0	22	47
100	0	2	0	4	10	11	2	13	0	46	16	15	7	1	0	1	0	1	35	94
110	2	13	0	12	5	28	0	18	5	49	32	23	52	14	0	5	0	4	96	166
120	1	12	0	14	18	21	2	30	13	77	23	34	113	34	0	12	0	4	170	238
130	2	4	0	4	4	6	2	14	2	21	13	22	34	20	0	7	0	4	57	102
140	1	1	0	2	0	1	0	3	0	7	0	0	37	8	0	3	0	0	38	25
150	1	0	0	2	0	0	0	0	0	1	0	2	15	3	0	6	0	1	16	15
160	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	4	0	0	1	7
170	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	3
TOTALS	13	52	1	67	61	106	15	115	20	226	96	101	260	83	0	41	0	14	466	805

Appendix 7. Continued.

UNIDENTIFIED COREGONINAE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
40	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
50	0	0	0	0	0	0	0	0	6	14	0	0	2	0	0	0	0	0	8	14
60	1	0	0	0	0	0	0	0	9	228	6	3	16	4	6	0	0	1	38	236
70	8	2	10	85	9	2	0	2	3	212	16	4	78	6	32	222	50	48	206	583
80	37	3	63	698	204	92	35	17	0	3	39	5	185	14	145	400	132	157	840	1389
90	4	1	68	488	769	345	402	359	4	25	5	0	105	10	65	299	135	193	1557	1720
100	0	0	17	14	439	232	492	954	15	112	1	0	3	2	7	24	20	80	994	1418
110	0	0	0	1	53	10	97	275	180	252	3	0	1	1	0	0	5	4	339	543
120	0	0	0	0	0	0	9	65	76	70	2	0	1	0	0	0	4	5	92	140
130	0	0	0	1	1	0	4	1	7	4	0	0	0	0	0	1	0	3	12	10
140	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0
150	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	2	1
160	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
190	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
220	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
TOTALS	50	6	158	1289	1481	682	1039	1675	301	921	73	12	391	37	255	946	346	491	4094	6059

WALLEYE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
260	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
390	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
520	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
530	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
560	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
570	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	2
TOTALS	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	4	0	0	0	10

Appendix 7. Continued.

WHITE SUCKER

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
90	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
100	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
200	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
230	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2
240	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	2	1
250	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	1
260	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
280	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	3
300	0	0	0	0	0	1	0	0	1	1	1	2	0	0	0	1	0	0	2	5
310	0	0	0	1	0	0	0	0	0	1	1	3	0	0	0	0	0	0	1	5
320	0	1	0	0	0	0	0	2	2	1	0	1	0	1	0	0	0	0	2	6
330	0	0	0	0	0	1	1	1	2	1	0	0	0	0	0	0	0	0	3	3
340	0	1	0	1	0	1	1	4	2	6	0	1	1	0	0	0	0	0	4	14
350	0	1	0	3	1	4	0	7	1	2	0	2	0	0	0	1	0	0	2	20
360	0	2	0	0	0	2	0	5	3	1	0	3	0	0	0	0	0	0	3	13
370	0	1	0	0	0	1	1	2	2	6	1	3	0	2	0	0	0	0	4	15
380	0	1	0	1	1	4	1	1	2	5	0	3	0	2	0	0	0	0	4	17
390	1	1	0	3	0	1	0	9	3	4	0	3	0	1	0	2	0	0	4	24
400	1	2	0	1	0	1	2	3	5	10	0	7	0	3	0	1	0	0	8	28
410	0	1	1	4	0	1	0	7	4	3	0	4	0	1	0	2	0	0	5	23
420	0	0	0	2	0	0	0	4	2	10	0	3	0	2	0	3	0	0	2	24
430	0	0	0	0	0	1	0	6	1	14	0	5	0	0	0	1	0	0	1	27
440	0	0	0	3	0	1	0	2	2	7	0	5	1	1	0	2	0	0	3	21
450	0	0	0	1	0	2	1	3	1	10	0	1	0	3	0	3	0	0	2	23
460	1	2	0	3	0	0	1	3	3	6	0	4	0	1	0	1	0	0	5	20
470	0	2	0	1	0	0	0	1	0	9	0	2	0	1	0	0	0	0	0	16
480	0	0	0	0	0	1	1	3	4	5	2	3	0	0	0	1	0	0	7	13
490	0	0	0	2	0	0	1	0	0	11	0	2	0	0	0	0	0	0	1	15
500	0	2	0	1	0	0	0	1	1	4	0	0	0	0	0	3	0	0	1	11
510	1	1	0	2	0	0	1	0	0	3	0	2	0	0	0	0	0	0	2	8
520	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	3
530	1	0	0	1	0	0	0	1	1	3	1	1	0	1	0	0	0	0	3	7
540	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	2
550	0	0	0	1	0	0	0	1	0	3	0	0	0	0	0	1	0	0	0	6
560	0	0	0	0	0	1	0	1	0	2	0	0	0	0	0	1	0	0	0	5
570	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
580	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
590	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2
600	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
610	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
TOTALS	6	19	1	32	2	27	11	70	42	133	9	65	2	23	0	24	0	0	73	393

Appendix 7. Continued.

YELLOW PERCH

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
30	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	10
40	0	0	0	0	0	0	0	0	11	29	1	1	0	0	0	0	0	0	12	30
50	0	0	0	1	0	0	0	0	8	36	5	6	0	0	0	0	0	0	13	43
60	0	0	0	0	0	2	0	0	1	1	2	8	1	1	0	0	0	4	4	16
70	0	1	0	0	6	3	0	0	1	0	0	3	8	1	0	0	1	5	16	13
80	0	1	0	2	45	30	1	0	0	0	0	0	4	0	0	0	2	11	52	44
90	0	0	0	0	69	61	0	8	0	1	0	0	1	0	0	0	0	5	70	75
100	0	0	0	0	80	37	13	41	3	1	0	0	0	0	0	0	0	0	96	79
110	0	0	0	0	11	5	206	122	6	29	2	0	0	0	0	2	0	3	225	161
120	0	0	0	0	0	1	262	102	61	105	4	0	2	0	0	2	0	4	329	214
130	0	1	0	0	0	1	35	14	31	55	10	1	5	3	0	4	0	4	81	83
140	0	0	0	1	1	1	0	0	4	32	9	1	14	10	0	16	1	4	29	65
150	0	1	0	0	3	3	1	1	3	8	18	1	24	18	3	47	0	1	52	80
160	1	0	0	0	11	9	1	2	2	3	1	0	7	3	0	27	0	1	23	45
170	0	0	0	0	7	5	2	8	2	6	0	0	3	11	0	4	0	1	14	35
180	0	1	0	0	8	1	1	2	3	3	3	1	3	9	0	8	0	0	18	25
190	0	0	0	1	3	4	0	5	10	5	1	0	3	5	0	8	0	0	17	28
200	0	1	0	1	4	13	0	5	9	7	2	1	7	2	0	7	0	0	22	37
210	0	0	0	0	2	11	1	5	12	7	3	0	0	5	0	4	0	0	18	32
220	0	0	0	0	3	6	0	2	6	8	2	0	8	8	0	3	0	1	19	28
230	0	0	0	0	1	6	0	0	7	10	5	0	1	3	0	5	0	0	14	24
240	0	0	0	0	0	0	0	0	6	2	2	0	0	2	0	2	0	0	8	6
250	0	0	0	0	0	1	0	0	2	3	5	0	0	2	0	2	0	0	7	8
260	0	0	0	1	0	2	0	2	3	4	2	0	0	1	0	1	0	0	5	11
270	0	0	0	1	0	1	0	0	1	1	1	0	0	1	0	3	0	0	2	7
280	0	0	0	0	0	2	0	0	0	1	0	0	0	1	0	1	0	0	0	5
290	0	0	0	0	0	2	0	0	0	1	0	0	0	1	0	0	0	0	0	4
300	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	1	0	0	0	4
310	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
320	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	3
330	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	3
340	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
350	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
360	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
370	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TOTALS	1	8	0	10	254	212	523	319	192	369	78	26	91	89	3	147	4	44	1146	1224

Appendix 8. Monthly length-frequency distributions of the most abundant species caught during April-December 1981 in Lake Michigan near the J. H. Campbell Plant. Distributions were segregated by gear type. Length intervals given represent the mid-point of a 10-mm length group.

ALEWIFE

SEINES

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
20	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	7	0
30	0	0	0	0	0	0	4	0	5205	83	1	2	0	0	0	0	0	0	5210	85
40	0	0	0	0	0	0	0	0	1447	106	1	2	0	0	1	19	0	0	1449	127
50	0	0	0	0	0	0	0	0	48	30	0	0	0	0	1	55	0	0	49	85
60	0	0	12	21	0	0	0	0	0	0	0	0	0	0	0	69	0	0	12	90
70	0	2	108	264	0	0	1	0	0	3	0	0	0	0	0	2	0	0	109	271
80	0	4	364	676	0	1	0	0	0	3	0	0	0	0	0	2	0	0	364	686
90	1	1	260	526	0	0	0	0	0	6	0	0	0	0	0	0	0	0	261	533
100	0	2	110	235	0	1	0	0	0	8	0	0	0	0	0	0	0	0	110	246
110	0	0	26	39	0	0	0	0	0	7	0	0	0	0	0	0	0	0	26	46
120	0	0	16	53	0	1	0	1	0	0	0	0	0	0	0	0	0	0	16	55
130	0	0	20	35	0	3	0	8	0	1	0	0	0	0	0	0	0	0	20	47
140	0	0	4	13	0	2	0	5	0	1	0	0	0	0	0	0	0	0	4	21
150	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
160	0	0	0	1	0	7	0	1	0	0	0	0	0	0	0	0	0	0	0	9
170	0	0	0	1	0	13	0	1	0	0	0	0	0	0	0	0	0	0	0	15
180	0	1	0	0	1	22	0	2	0	0	0	0	0	0	0	0	0	0	1	25
190	0	0	0	0	0	22	0	2	0	0	0	0	0	0	0	0	0	0	0	24
200	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3
210	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	1	10	920	1864	1	78	12	20	6700	248	2	4	0	0	2	147	0	0	7638	2371

TRAWLS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
20	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
30	0	0	0	0	0	0	0	0	0	0	7	9	2	0	0	0	0	0	9	9
40	0	0	0	0	0	0	0	0	1	0	9	39	305	2	88	14	0	0	403	55
50	0	0	0	0	0	0	0	0	0	0	69	227	715	3	7607	2853	0	5	8391	3088
60	1	0	11	8	1	0	0	0	12	0	50	121	91	1	11853	7343	1	6	12020	7479
70	35	22	356	659	68	22	1	1	3	0	30	26	3	0	1497	2083	0	2	1993	2815
80	51	46	453	2017	231	240	98	0	7	0	18	7	2	1	62	251	0	0	922	2562
90	30	41	420	1848	121	313	392	0	37	0	12	1	0	0	0	0	0	0	1012	2203
100	24	10	151	345	11	71	1075	0	6	0	58	5	2	0	0	0	0	0	1327	431
110	1	11	75	102	9	13	246	0	57	0	27	5	11	0	0	0	0	1	426	132
120	32	39	105	286	8	11	43	0	36	0	1	1	14	0	0	0	0	1	239	338
130	171	54	51	199	18	14	122	0	12	0	0	0	5	0	0	0	0	0	379	267
140	52	30	24	69	10	14	112	0	4	1	0	0	2	0	0	0	0	0	204	114
150	34	26	9	30	5	10	64	0	1	0	0	0	1	0	0	0	0	0	114	66
160	90	71	1	49	1	23	68	0	3	2	0	0	2	0	0	0	0	0	165	145
170	148	90	0	42	4	18	154	0	3	2	0	0	1	0	0	0	0	0	310	152
180	140	116	1	67	13	32	239	0	4	0	0	0	0	0	0	0	0	0	397	215
190	150	64	0	22	1	15	282	1	2	0	0	0	0	0	0	0	0	1	435	103
200	48	24	1	16	0	4	145	0	0	0	0	0	0	0	0	0	0	0	194	44
210	0	3	0	2	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10	5
220	0	1	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3	2
230	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0
TOTALS	1007	648	1658	5762	501	800	3056	2	188	5	281	442	1156	7	21107	12544	1	16	28955	20226

Appendix 8. Continued.

ALEWIFE

BOTTOM GILL NETS

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
80	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
90	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	3
100	0	5	0	1	0	0	0	1	14	29	0	12	0	0	0	0	0	0	14	48
110	0	26	2	20	0	2	4	1	20	33	1	14	0	0	0	2	0	0	27	98
120	0	42	3	42	0	8	4	4	14	2	0	1	0	0	0	0	0	0	21	99
130	0	13	0	9	3	8	6	14	2	0	0	0	0	0	0	1	0	0	11	45
140	1	13	0	0	0	0	1	5	0	0	1	0	0	0	0	0	0	0	3	18
150	0	33	2	11	9	26	1	2	7	0	0	1	0	0	0	1	0	0	19	74
160	8	195	1	66	44	183	8	105	15	5	0	1	0	1	0	0	0	0	76	556
170	9	251	1	49	110	443	20	174	31	6	0	0	0	0	0	0	0	0	171	923
180	4	71	1	21	84	313	36	126	12	5	1	0	0	1	0	0	0	0	138	537
190	1	74	0	9	32	47	20	14	10	1	0	0	0	0	0	0	0	0	63	145
200	2	141	2	21	4	27	2	3	0	1	0	0	0	0	0	0	0	0	10	193
210	0	72	1	31	4	43	1	13	0	0	0	0	0	0	0	0	0	0	6	159
220	0	15	0	8	1	19	1	5	0	0	0	0	0	0	0	0	0	0	2	47
230	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
TOTALS	25	951	13	289	292	1119	104	468	125	83	3	31	0	2	0	4	0	0	562	2947

SURFACE GILL NETS

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
90	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
100	0	0	0	0	0	7	0	1	0	47	0	21	0	0	0	0	0	0	0	76
110	0	1	0	7	0	15	0	3	0	98	0	32	0	0	0	0	0	0	0	156
120	0	1	0	21	0	5	0	1	0	40	0	6	0	0	0	0	0	0	0	74
1[illegible]0	0	0	0	5	0	4	0	0	0	1	0	0	0	0	0	0	0	0	0	10
150	0	4	0	8	0	0	0	2	0	3	0	0	0	0	0	0	0	0	0	17
160	0	8	0	26	0	77	0	8	0	2	0	0	0	1	0	0	0	0	0	122
170	0	6	0	28	0	156	0	20	0	7	0	0	0	0	0	0	0	0	0	217
180	0	2	0	14	0	134	0	18	0	5	0	0	0	0	0	0	0	0	0	173
190	0	5	0	4	0	24	0	2	0	1	0	0	0	0	0	0	0	0	0	36
200	0	6	0	7	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	15
210	0	2	0	11	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	16
220	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
TOTALS	0	35	0	137	0	425	0	55	0	206	0	59	0	2	0	0	0	0	0	919

Appendix 8. Continued.

RAINBOW SMELT

SEINES

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
20	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
30	0	0	0	0	0	0	0	0	2	9	0	6	0	0	0	0	0	0	2	15
40	0	0	0	0	0	0	0	0	3	844	7	157	1	0	0	6	0	0	11	1007
50	0	3	1	0	0	0	0	0	0	365	0	14	0	1	1	4	0	0	2	387
60	0	11	0	27	0	0	0	0	0	43	0	0	0	0	0	5	0	0	0	86
70	0	20	0	551	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	571
80	0	9	0	164	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	173
90	0	4	0	22	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	28
100	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	7
110	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	4
120	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
130	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
140	0	4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	5
150	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	5
160	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
170	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	60	1	764	0	0	0	0	6	1277	7	177	1	1	1	16	0	0	16	2295

TRAWLS

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
30	0	0	0	0	0	0	2	32	82	172	113	69	1	1	0	11	0	0	198	285
40	1	0	1	0	0	0	1	7	906	4088	1996	1003	68	45	330	119	8	16	3311	5278
50	390	207	397	426	0	0	28	12	202	435	643	336	426	104	2402	2597	316	652	4804	4769
60	2217	1780	1231	3604	4	1	413	555	30	45	66	22	126	107	2977	2378	342	753	7406	9245
70	2740	2210	2461	3639	4	1	802	1216	97	316	4	0	6	12	32	116	31	58	6177	7568
80	822	838	611	1605	1	0	1709	1354	201	245	5	3	3	1	1	2	1	0	3354	4048
90	119	134	108	243	0	0	1039	322	193	51	6	0	6	2	0	0	0	0	1471	752
100	25	23	12	45	0	0	200	62	62	3	19	5	14	6	0	0	0	0	332	144
110	24	6	2	3	0	0	59	2	53	1	33	2	31	7	0	0	0	1	202	22
120	49	15	2	3	0	0	16	0	25	0	32	3	40	5	0	1	2	0	166	27
130	17	7	3	3	0	0	9	0	9	1	12	1	28	7	2	4	1	0	81	23
140	9	3	0	1	0	0	10	0	19	0	13	0	21	0	0	6	0	0	72	10
150	1	0	0	2	0	0	0	0	6	1	4	0	4	1	0	1	2	0	17	5
160	2	1	0	1	0	0	0	0	5	0	2	0	2	0	0	4	0	0	11	6
170	1	1	0	0	0	0	0	0	2	0	0	1	2	1	0	2	0	0	5	5
180	1	1	0	1	0	0	0	1	0	0	0	0	1	0	0	4	0	1	2	8
200	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
TOTALS	6418	5226	4828	9576	9	2	4288	3563	1892	5358	2948	1445	780	299	5744	5245	703	1481	27610	32195

Appendix 8. Continued.

RAINBOW SMELT

BOTTOM GILL NETS

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
40	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
110	0	0	0	0	0	0	0	0	3	0	0	0	0	2	0	0	0	0	3	2
120	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	2
130	0	8	0	0	0	0	0	1	1	1	0	0	0	0	0	2	0	0	1	12
140	3	43	0	1	0	0	0	0	0	7	0	0	2	1	0	8	0	0	5	60
150	0	26	0	1	0	0	0	0	2	31	1	1	5	2	2	27	0	0	10	88
160	0	17	0	0	0	0	2	2	5	11	0	0	2	0	1	28	0	0	10	58
170	0	14	1	2	0	0	0	1	0	8	0	0	2	2	0	14	0	0	3	41
180	0	17	0	0	0	0	0	0	1	1	0	0	1	0	0	9	0	0	2	27
190	0	4	0	0	0	0	0	1	0	2	0	0	0	0	0	4	0	0	0	11
200	0	8	0	0	0	0	0	0	0	2	0	0	0	0	0	3	0	0	0	13
210	0	14	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	16
220	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	5
230	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	6
240	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	3
250	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
260	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
280	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	3	165	1	4	0	0	2	6	14	64	2	2	12	7	3	99	0	0	37	347

SURFACE GILL NETS

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
130	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
140	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
150	0	3	0	1	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	12
160	0	2	0	0	0	0	0	0	0	4	0	0	0	2	0	0	0	0	0	8
170	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3
220	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	15	0	1	0	0	0	0	0	15	0	0	0	2	0	0	0	0	0	33

Appendix 8. Continued.

SPOTTAIL SHINER

SEINES

LENGTH INTERVAL	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
10	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	14	0
20	0	0	0	0	0	0	29	0	18	0	0	0	0	0	0	0	0	0	47	0
30	0	0	0	0	0	0	1	0	146	10	0	1	0	0	4	0	0	0	151	11
40	0	1	0	0	0	0	0	0	109	10	3	1	1	0	1	1	0	0	114	13
50	0	6	0	0	1	0	1	0	6	2	1	1	1	0	5	7	0	0	15	16
60	0	3	0	0	1	0	4	0	8	19	2	1	0	0	1	5	0	0	16	28
70	0	0	0	0	1	0	1	4	1	7	0	1	0	0	0	2	0	0	3	14
80	0	1	0	0	1	0	0	0	1	14	0	0	0	0	0	0	0	0	2	15
90	0	3	0	0	4	0	0	0	1	6	0	0	0	0	0	3	0	0	5	12
100	0	3	0	1	7	0	0	0	1	5	0	0	0	0	0	0	0	0	8	9
110	0	17	0	3	15	2	0	11	1	8	0	0	0	0	0	3	0	0	16	44
120	0	8	0	1	9	2	0	2	0	7	0	0	0	1	0	2	0	0	9	23
130	0	0	0	1	1	1	0	2	0	3	0	0	0	0	0	0	0	0	1	7
TOTALS	0	42	0	6	40	5	50	19	292	91	6	5	2	1	11	23	0	0	401	192

TRAWLS

LENGTH INTERVAL	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	4
40	2	7	0	4	0	0	0	0	0	4	69	28	2	1	0	0	0	2	73	46
50	16	38	5	35	21	53	0	1	0	0	67	122	28	10	1	7	0	12	138	278
60	7	33	1	32	10	31	0	5	0	0	171	182	31	4	0	8	1	9	221	304
70	1	12	0	0	5	17	1	15	0	0	47	93	23	8	0	2	1	3	78	150
80	0	4	0	1	1	3	0	1	0	27	36	57	25	2	0	0	0	4	62	99
90	1	16	0	7	42	22	0	0	0	8	35	137	188	2	0	1	0	21	266	214
100	1	28	0	55	81	171	0	15	0	7	4	53	160	6	0	1	0	12	246	348
110	5	48	8	233	338	569	0	60	0	60	33	196	72	11	0	1	1	12	457	1190
120	3	15	8	258	193	357	1	74	0	43	21	262	108	23	0	3	1	30	335	1065
130	0	5	0	37	43	80	0	11	0	15	2	47	40	8	0	0	1	6	86	209
140	0	0	0	6	8	11	0	1	0	0	0	0	4	1	0	0	0	0	12	19
TOTALS	36	206	22	668	742	1314	2	183	0	164	485	1177	681	80	1	23	5	111	1974	3926

Appendix 8. Continued.

SPOTTAIL SHINER

BOTTOM GILL NETS

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
90	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
100	0	4	7	35	49	63	1	3	6	0	1	11	4	9	0	2	0	0	68	127
110	2	131	18	247	496	1116	0	226	52	57	3	76	22	62	0	17	0	0	593	1932
120	2	94	18	243	386	1706	2	355	73	81	3	131	43	87	0	29	0	0	527	2726
130	0	24	1	27	25	102	0	30	9	17	5	20	12	11	0	7	0	0	52	238
140	0	0	0	3	0	2	0	4	0	0	0	0	0	1	0	0	0	0	0	10
160	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
170	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
180	1	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	1	5
200	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
210	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
TOTALS	11	253	44	555	956	2994	3	619	140	155	12	238	81	170	0	55	0	0	1247	5039

SURFACE GILL NETS

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
100	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3
110	0	0	0	0	0	2	0	69	0	0	0	0	0	0	0	0	0	0	0	71
120	0	0	0	0	1	2	0	86	0	0	0	0	0	0	0	0	0	0	1	88
TOTALS	0	0	0	0	1	4	0	158	0	0	0	0	0	0	0	0	0	0	1	162

Appendix 8. Continued.

UNIDENTIFIED COREGONINAE

SEINES

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
50	0	0	0	0	0	0	0	0	6	4	0	0	0	0	0	0	0	0	6	4
60	0	0	0	0	0	0	0	0	9	27	1	0	0	0	0	0	0	0	10	27
70	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	3	3
TOTALS	0	0	0	0	0	0	0	0	18	34	1	0	0	0	0	0	0	0	19	34

TRAWLS

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
40	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
50	0	0	0	0	0	0	0	0	0	10	0	0	2	0	0	0	0	0	2	10
60	1	0	0	0	0	0	0	0	0	201	5	3	16	4	6	0	0	1	28	209
70	8	2	10	85	9	2	0	2	0	209	16	4	78	6	32	222	50	48	203	580
80	37	3	63	698	204	92	35	17	0	3	39	5	185	14	145	400	132	157	840	1389
90	4	1	68	488	769	345	402	359	4	24	5	0	105	10	65	299	135	193	1557	1719
100	0	0	17	14	439	232	492	954	15	112	1	0	3	2	7	24	20	80	994	1418
110	0	0	0	1	53	10	96	271	179	252	3	0	1	1	0	0	5	4	337	539
120	0	0	0	0	0	0	6	58	76	66	2	0	1	0	0	0	4	5	89	129
130	0	0	0	1	1	0	1	1	6	2	0	0	0	0	0	1	0	3	8	8
140	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0
150	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	2	1
160	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
TOTALS	50	6	158	1289	1481	682	1032	1662	281	879	72	12	391	37	255	946	346	491	4066	6004

BOTTOM GILL NETS

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
90	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
110	0	0	0	0	0	0	1	4	1	0	0	0	0	0	0	0	0	0	2	4
120	0	0	0	0	0	0	3	7	0	4	0	0	0	0	0	0	0	0	3	11
130	0	0	0	0	0	0	3	0	1	2	0	0	0	0	0	0	0	0	4	2
190	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
220	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	7	13	2	8	0	0	0	0	0	0	0	0	9	21

Appendix 8. Continued.

YELLOW PERCH

SEINES

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
40	0	0	0	0	0	0	0	0	11	4	0	0	0	0	0	0	0	0	11	4
50	0	0	0	0	0	0	0	0	6	4	0	0	0	0	0	0	0	0	6	4
60	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
100	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
120	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
TOTALS	0	0	0	0	0	0	0	1	17	11	0	0	0	0	0	0	0	0	17	12

TRAWLS

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
30	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	10
40	0	0	0	0	0	0	0	0	0	25	1	1	0	0	0	0	0	0	1	26
50	0	0	0	1	0	0	0	0	2	32	5	6	0	0	0	0	0	0	7	39
60	0	0	0	0	0	2	0	0	1	0	2	8	1	1	0	0	0	4	4	15
70	0	1	0	0	6	3	0	0	0	0	0	3	8	1	0	0	1	5	15	13
80	0	1	0	2	45	30	1	0	0	0	0	0	4	0	0	0	2	11	52	44
90	0	0	0	0	62	59	0	8	0	0	0	0	1	0	0	0	0	5	63	72
100	0	0	0	0	41	29	11	39	0	1	0	0	0	0	0	0	0	0	52	69
110	0	0	0	0	4	1	16	97	0	21	0	0	0	0	0	0	0	3	20	122
120	0	0	0	0	0	0	9	65	0	90	0	0	0	0	0	1	0	4	9	160
130	0	1	0	0	0	0	0	6	0	47	0	1	1	1	0	0	0	4	1	60
140	0	0	0	0	0	0	0	0	0	11	0	0	1	1	0	0	1	4	2	16
150	0	0	0	0	0	1	1	1	0	0	0	0	1	2	0	1	0	1	2	6
160	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	1	1	4
170	0	0	0	0	0	0	1	4	0	2	0	0	0	1	0	0	0	1	1	8
180	0	0	0	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0	1	3
190	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
200	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	3
210	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	4
220	0	0	0	0	1	0	0	1	0	3	0	0	1	0	0	0	0	1	2	5
230	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
260	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	2
280	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	3	0	3	160	128	40	227	3	250	8	19	18	8	0	3	4	44	233	685

Appendix 8. Continued.

BOTTOM GILL NETS

YELLOW PERCH

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
70	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
90	0	0	0	0	7	2	0	0	0	1	0	0	0	0	0	0	0	0	7	3
100	0	0	0	0	39	8	2	1	3	0	0	0	0	0	0	0	0	0	44	9
110	0	0	0	0	7	4	190	25	6	8	2	0	0	0	0	2	0	0	205	39
120	0	0	0	0	0	1	253	37	61	13	4	0	2	0	0	1	0	0	320	52
130	0	0	0	0	0	1	35	8	31	8	10	0	4	2	0	4	0	0	80	23
140	0	0	0	1	1	1	0	0	4	21	9	1	13	9	0	16	0	0	27	49
150	0	1	0	0	3	2	0	0	3	8	18	1	23	16	3	46	0	0	50	74
160	1	0	0	0	11	8	0	1	2	3	1	0	7	3	0	26	0	0	22	41
170	0	0	0	0	7	5	1	4	2	4	0	0	3	10	0	4	0	0	13	27
180	0	1	0	0	7	1	1	1	3	2	3	1	3	8	0	8	0	0	17	22
190	0	0	0	1	3	4	0	5	10	4	1	0	3	5	0	8	0	0	17	27
200	0	1	0	1	4	12	0	3	9	7	2	1	7	2	0	7	0	0	22	34
210	0	0	0	0	2	11	1	4	12	4	3	0	0	5	0	4	0	0	18	28
220	0	0	0	0	2	6	0	1	6	5	2	0	7	8	0	3	0	0	17	23
230	0	0	0	0	1	6	0	0	7	8	5	0	1	3	0	5	0	0	14	22
240	0	0	0	0	0	0	0	0	6	2	2	0	0	2	0	2	0	0	8	6
250	0	0	0	0	0	1	0	0	2	3	5	0	0	2	0	2	0	0	7	8
260	0	0	0	1	0	2	0	1	3	3	2	0	0	1	0	1	0	0	5	9
270	0	0	0	1	0	1	0	0	1	1	1	0	0	1	0	3	0	0	2	7
280	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	1	0	0	0	4
290	0	0	0	0	0	2	0	0	0	1	0	0	0	1	0	0	0	0	0	4
300	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	1	0	0	0	4
310	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
320	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	3
330	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	3
340	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
350	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
360	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
370	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TOTALS	1	5	0	7	94	84	483	91	172	108	70	7	73	81	3	144	0	0	896	527

Appendix 8. Continued.

TROUT-PERCH

SEINES

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
70	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
80	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
110	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
120	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
TOTALS	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	10

TRAWLS

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
30	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
40	0	1	0	3	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2	4
50	0	1	0	2	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	6
60	0	1	0	1	1	1	0	1	0	3	0	0	0	0	0	0	0	0	1	7
70	0	7	0	9	4	10	3	7	0	3	2	0	1	0	0	0	0	0	10	36
80	5	4	1	11	9	19	1	10	0	5	2	1	0	0	0	0	0	0	18	50
90	1	2	0	3	9	7	5	17	0	13	7	4	0	0	0	1	0	0	22	47
100	0	2	0	4	10	10	2	12	0	46	16	12	7	1	0	1	0	1	35	69
110	1	7	0	9	5	21	0	17	3	43	32	15	46	7	0	2	0	4	87	125
120	1	4	0	11	15	17	2	20	4	68	21	14	104	13	0	2	0	4	147	153
130	2	3	0	4	4	4	1	9	0	21	13	6	32	15	0	1	0	4	52	67
140	1	1	0	2	0	1	0	3	0	7	0	0	36	5	0	1	0	0	37	20
150	1	0	0	2	0	0	0	0	0	1	0	2	15	0	0	3	0	1	16	9
160	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1
TOTALS	12	33	1	61	58	92	14	97	7	211	94	54	242	41	0	12	0	14	428	615

BOTTOM GILL NETS

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
100	0	0	0	0	0	1	0	1	0	0	0	3	0	0	0	0	0	0	0	5
110	1	4	0	3	0	7	0	1	2	6	0	8	6	7	0	3	0	0	9	39
120	0	5	0	3	3	4	0	10	9	9	2	20	9	21	0	10	0	0	23	82
130	0	1	0	0	0	2	1	5	2	0	0	16	2	5	0	6	0	0	5	35
140	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	1	0	0	1	4
150	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0	6
160	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0	6
170	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	3
TOTALS	1	10	0	6	3	14	1	18	13	15	2	47	18	42	0	28	0	0	38	180

Appendix 8. Continued.

SEINES — BLUEGILL

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
30	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1

TRAWLS — CHESTNUT LAMPREY

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
250	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1

SEINES — FATHEAD MINNOW

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
50	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
TOTALS	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0

TRAWLS — LAKE STURGEON

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
490	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1

TRAWLS — MOTTLED SCULPIN

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
90	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Appendix 9. Number of fish larvae and eggs per 1000 m^3 for north transect stations in Lake Michigan (Fig. 1) near the J. H. Campbell Plant, eastern Lake Michigan, April to September 1981. D = day, N = night, * = sled tow. See Appendix 1 for species code identification.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	NUMBER OF LARVAE PER 1000 M^3: AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
4-15-81	D	R	0.5	11.5										208			208	0
4-15-81	D	R	0.5	11.5													0	0
4-13-81	D	R*	1.0	11.0													0	0
4-15-81	N	R	0.5	11.5				110						220			330	0
4-15-81	N	R	0.5	11.5													0	0
4-13-81	N	R*	1.0	9.0													0	0
4-15-81	D	I	0.5	11.5													0	0
4-13-81	D	I*	1.5	10.0													0	0
4-15-81	N	I	0.5	10.5										43			43	0
4-13-81	N	I*	1.5	8.5													0	0
4-15-81	D	J	0.5	10.0													0	0
4-15-81	D	J	2.5	9.5													0	0
4-13-81	D	J*	3.0	10.0													0	0
4-15-81	N	J	0.5	10.5													0	0
4-15-81	N	J	2.5	9.5													0	0
4-13-81	N	J*	3.0	8.0										22			22	0
4-15-81	D	L	0.5	7.2													0	0
4-15-81	D	L	2.0	7.2													0	0
4-15-81	D	L	4.0	7.2													0	0
4-15-81	D	L	5.5	7.1													0	0
4-13-81	D	L*	6.0	9.0													0	0
4-16-81	N	L	0.5	5.7													0	0
4-16-81	N	L	2.0	5.7													0	0
4-16-81	N	L	4.0	5.7													0	0
4-16-81	N	L	5.5	5.7													0	0
4-13-81	N	L*	6.0	7.7													0	0
4-15-81	D	N	0.5	6.4													0	0
4-15-81	D	N	2.5	6.4													0	0
4-16-81	D	N	4.5	8.7													0	0
4-15-81	D	N	6.5	6.4													0	0
4-15-81	D	N	8.5	6.3													0	0
4-13-81	D	N*	9.0	8.5													0	0
4-15-81	N	N	0.5	5.0													0	0
4-15-81	N	N	2.5	5.0													0	0
4-15-81	N	N	4.5	5.0													0	0
4-15-81	N	N	6.5	5.0													0	0
4-16-81	N	N	8.5	4.9													0	0
4-13-81	N	N*	9.0	7.7													0	0

Appendix 9. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	NUMBER OF LARVAE PER 1000 M³: AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
4-15-81	D	O	0.5	7.2													0	0
4-16-81	D	O	3.0	7.6													0	0
4-16-81	D	O	6.0	7.6													0	0
4-15-81	D	O	9.0	7.0													0	0
4-15-81	D	O	11.0	6.9													0	0
4-13-81	D	O*	12.0	7.5													0	0
4-15-81	N	O	0.5	5.2													0	0
4-15-81	N	O	3.0	5.2													0	0
4-15-81	N	O	6.0	4.8													0	0
4-15-81	N	O	9.0	4.0													0	0
4-15-81	N	O	11.0	4.0													0	0
4-13-81	N	O*	12.0	7.3													0	0
4-15-81	D	W	0.5	6.9													0	0
4-15-81	D	W	4.5	6.6													0	0
4-15-81	D	W	8.5	6.5													0	0
4-15-81	D	W	11.5	5.8													0	0
4-15-81	D	W	14.0	5.5													0	0
4-13-81	D	W*	15.0	8.5													0	0
4-15-81	N	W	0.5	5.0													0	0
4-15-81	N	W	4.5	4.9													0	0
4-15-81	N	W	8.5	4.9													0	0
4-15-81	N	W	11.5	4.0													0	0
4-15-81	N	W	14.0	4.0													0	0
4-13-81	N	W*	15.0	7.2													0	0
4-27-81	D	L	0.5	10.0													0	0
4-27-81	N	L	0.5	10.0													0	0
4-27-81	D	N	0.5	12.0													0	0
4-27-81	D	N	4.5	9.8													0	0
4-27-81	D	N	8.5	8.5													0	0
4-27-81	N	N	0.5	12.0													0	0
4-27-81	N	N	4.5	9.8													0	0
4-27-81	N	N	8.5	8.5													0	0

Appendix 9. Continued.

DATE	DIEL PERIOD	STA- TION	DEPTH (M)	TEMP. C	NUMBER OF LARVAE PER 1000 M³: AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
5-04-81	D	R	0.5	13.5			1025										1025	0
5-04-81	D	R	0.5	13.5			952										952	0
5-04-81	D	R*	1.0	13.5													0	564
5-07-81	N	R	0.5	11.3			312	312									624	0
5-07-81	N	R*	1.0	11.0													0	0
5-04-81	D	I	0.5	12.0			155										155	0
5-04-81	D	I*	1.5	12.2													0	511
5-05-81	N	I	0.5	12.0			174										174	0
5-07-81	N	I*	1.5	9.0													0	0
5-04-81	D	J	0.5	12.0													0	0
5-04-81	D	J	2.5	10.5			42										42	0
5-04-81	D	J*	3.0	11.1													0	0
5-05-81	N	J	0.5	11.5													0	0
5-05-81	N	J	2.5	11.2													0	0
5-05-81	N	J*	3.0	11.2													0	0
5-04-81	D	L	0.5	10.2													0	0
5-04-81	D	L	2.0	10.2													0	0
5-04-81	D	L	4.0	10.1													0	0
5-04-81	D	L	5.5	10.1				95									95	0
5-04-81	D	L*	6.0	9.0													0	0
5-05-81	N	L	0.5	9.1													0	0
5-05-81	N	L	2.0	9.1													0	0
5-05-81	N	L	4.0	9.1													0	0
5-05-81	N	L	5.5	9.1													0	0
5-05-81	N	L*	6.0	10.2													0	0
5-04-81	D	N	0.5	9.5													0	0
5-04-81	D	N	2.5	9.1			61										61	0
5-04-81	D	N	4.5	8.5													0	0
5-04-81	D	N	6.5	8.2													0	0
5-04-81	D	N	8.5	8.2													0	0
5-04-81	D	N*	9.0	8.6													0	0
5-05-81	N	N	0.5	9.0													0	0
5-05-81	N	N	2.5	8.9													0	0
5-05-81	N	N	4.5	8.9													0	0
5-05-81	N	N	6.5	8.8													0	0
5-05-81	N	N	8.5	8.8													0	0
5-05-81	N	N*	9.0	9.5													0	0

Appendix 9. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
5-04-81	D	O	0.5	9.5													0	0
5-04-81	D	O	3.0	8.4													0	0
5-04-81	D	O	6.0	8.2													0	0
5-04-81	D	O	9.0	8.1													0	0
5-04-81	D	O	11.0	8.1													0	0
5-04-81	D	O*	12.0	8.5													0	0
5-04-81	N	O	0.5	9.0													0	0
5-04-81	N	O	3.0	8.7													0	0
5-04-81	N	O	6.0	7.9													0	0
5-04-81	N	O	9.0	7.8													0	0
5-04-81	N	O	11.0	7.7													0	0
5-04-81	N	O*	12.0	9.0													0	25
5-04-81	D	W	0.5	9.8													0	0
5-04-81	D	W	4.5	9.0													0	0
5-04-81	D	W	8.5	8.4													0	0
5-04-81	D	W	11.5	8.3													0	0
5-04-81	D	W	14.0	8.2													0	0
5-04-81	D	W*	15.0	8.5													0	0
5-04-81	N	W	0.5	7.0													0	0
5-04-81	N	W	4.5	6.9													0	0
5-04-81	N	W	8.5	6.9													0	0
5-04-81	N	W	11.5	6.9													0	0
5-04-81	N	W	14.0	6.9													0	0
5-05-81	N	W*	15.0	6.9													0	0
5-18-81	D	R	0.5	9.0													0	0
5-18-81	D	R	0.5	9.0													0	0
5-18-81	D	R*	1.0	8.5													0	0
5-18-81	N	R	0.5	8.0													0	0
5-18-81	N	R	0.5	8.0													0	0
5-18-81	N	R*	1.0	8.0													0	0
5-18-81	D	I	0.5	8.5													0	0
5-18-81	D	I*	1.5	8.5													0	0
5-18-81	N	I	0.5	7 5													0	0
5-18-81	N	I*	1.5	7.5													0	0

Appendix 9. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
5-18-81	D	J	0.5	6.0													0	0
5-18-81	D	J	2.5	6.5							173						173	0
5-18-81	D	J*	3.0	6.0													0	0
5-18-81	N	J	0.5	7.0													0	0
5-18-81	N	J	2.5	7.0													0	0
5-18-81	N	J*	3.0	7.0													0	0
5-18-81	D	L	0.5	8.9													0	0
5-18-81	D	L	2.0	8.8							52						52	0
5-18-81	D	L	4.0	8.6													0	0
5-18-81	D	L	5.5	8.6							47						47	0
5-18-81	D	L*	6.0	6.0													0	0
5-19-81	N	L	0.5	7.0													0	0
5-19-81	N	L	2.0	6.9													0	0
5-19-81	N	L	4.0	6.8													0	0
5-19-81	N	L	5.5	6.7							36						36	0
5-18-81	N	L*	6.0	6.7							50						50	0
5-18-81	D	N	0.5	8.9													0	0
5-18-81	D	N	2.5	8.8													0	0
5-18-81	D	N	4.5	8.8													0	0
5-18-81	D	N	6.5	8.7							56						56	0
5-18-81	D	N	8.5	8.6			49				49						98	0
5-18-81	D	N*	9.0	4.5													0	0
5-18-81	N	N	0.5	7.5							31						31	0
5-18-81	N	N	2.5	7.3													0	0
5-18-81	N	N	4.5	7.0							53						53	0
5-19-81	N	N	6.5	6.9													0	0
5-19-81	N	N	8.5	6.9													0	0
5-18-81	N	N*	9.0	6.9													0	0
5-18-81	D	O	0.5	9.0													0	0
5-18-81	D	O	3.0	9.0							35						35	0
5-18-81	D	O	6.0	8.8													0	0
5-18-81	D	O	9.0	8.6							35						35	0
5-18-81	D	O	11.0	8.5							31						31	0
5-18-81	D	O*	12.0	5.0							20						20	0
5-18-81	N	O	0.5	7.0													0	0
5-18-81	N	O	3.0	6.9													0	0
5-18-81	N	O	6.0	6.5						35	35						70	0
5-18-81	N	O	9.0	6.4							33						33	0
5-18-81	N	O	11.0	6.3													0	0
5-18-81	N	O*	12.0	6.3													0	0

Appendix 9. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	NUMBER OF LARVAE PER 1000 M³ AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
5-18-81	D	W	0.5	7.9													0	0
5-18-81	D	W	4.5	7.8													0	0
5-18-81	D	W	8.5	7.6							34						34	0
5-18-81	D	W	11.5	7.4													0	0
5-18-81	D	W	14.0	7.3													0	0
5-18-81	D	W*	15.0	4.5							24						24	0
5-18-81	N	W	0.5	7.0													0	0
5-18-81	N	W	4.5	7.0													0	0
5-18-81	N	W	8.5	6.6													0	0
5-18-81	N	W	11.5	6.3													0	0
5-18-81	N	W	14.0	6.3							24						24	0
5-18-81	N	W*	15.0	6.3													0	0
6-04-81	D	R	0.5	18.5													0	0
6-04-81	D	R	0.5	18.5													0	0
6-03-81	D	R*	1.0	15.4													0	0
6-04-81	N	R	0.5	16.7				225									225	0
6-04-81	N	R	0.5	16.7													0	0
6-04-81	N	R*	1.0	13.2													0	148
6-04-81	D	I	0.5	18.3				25									25	0
6-04-81	D	I*	1.5	15.0													0	0
6-04-81	N	I	0.5	17.0													0	0
6-02-81	N	I*	1.5	12.9													0	0
6-04-81	D	J	0.5	17.7													0	0
6-04-81	D	J	2.5	16.5													0	0
6-03-81	D	J*	3.0	14.5													0	0
6-04-81	N	J	0.5	16.8													0	0
6-04-81	N	J	2.5	13.4													0	0
6-02-81	N	J*	3.0	12.5													0	0
6-04-81	D	L	0.5	14.7													0	0
6-04-81	D	L	2.0	14.7				23									23	0
6-04-81	D	L	4.0	14.6			21										21	0
6-04-81	D	L	5.5	14.6			26										26	0
6-03-81	D	L*	6.0	13.8			31										31	0
6-05-81	N	L	0.5	13.0			25										25	0
6-05-81	N	L	2.0	12.5													0	0
6-05-81	N	L	4.0	11.8													0	0
6-05-81	N	L	5.5	11.3													0	0
6-03-81	N	L*	6.0	11.9													0	0

Appendix 9. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
6-04-81	D	N	0.5	16.0													0	0
6-04-81	D	N	2.5	16.0													0	0
6-04-81	D	N	4.5	15.8			64										64	0
6-04-81	D	N	6.5	14.5			39										39	0
6-04-81	D	N	8.5	13.2			26										26	0
6-03-81	D	N*	9.0	13.5													0	0
6-05-81	N	N	0.5	13.5			16										16	0
6-05-81	N	N	2.5	13.4			23										23	0
6-05-81	N	N	4.5	12.5													0	0
6-05-81	N	N	6.5	11.2													0	0
6-05-81	N	N	8.5	9.4								54					54	0
6-02-81	N	N*	9.0	9.6													0	0
6-04-81	D	O	0.5	15.4													0	0
6-04-81	D	O	3.0	15.3													0	0
6-04-81	D	O	6.0	13.8													0	0
6-05-81	D	O	9.0	11.3													0	0
6-04-81	D	O	11.0	11.0													0	0
6-03-81	D	O*	12.0	11.2													0	0
6-04-81	N	O	0.5	13.5			22										22	0
6-04-81	N	O	3.0	13.5			61					61					122	0
6-04-81	N	O	6.0	11.8			80						26				106	0
6-04-81	N	O	9.0	8.9								46					46	0
6-04-81	N	O	11.0	6.8													0	0
6-02-81	N	O*	12.0	8.9													0	0
6-04-81	D	W	0.5	15.5													0	0
6-04-81	D	W	4.5	15.4													0	0
6-04-81	D	W	8.5	11.0													0	0
6-04-81	D	W	11.5	9.4													0	0
6-04-81	D	W	14.0	8.0													0	0
6-03-81	D	W*	15.0	10.6													0	0
6-04-81	N	W	0.5	14.0													0	0
6-04-81	N	W	4.5	13.5								29					29	0
6-04-81	N	W	8.5	9.0													0	0
6-04-81	N	W	11.5	7.0													0	0
6-04-81	N	W	14.0	5.9													0	0
6-02-81	N	W*	15.0	7.6													0	0

Appendix 9. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	NUMBER OF LARVAE PER 1000 M³ AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
6-15-81	D	R	0.5	22.5	363	486											849	364
6-15-81	D	R	0.5	22.5		112											112	112
6-15-81	D	R*	1.0	21.5	686	252		36									974	144
6-15-81	N	R	0.5	19.7	78	2665											2743	2274
6-15-81	N	R	0.5	19.7	816	3536											4352	2176
6-15-81	N	R*	1.0	19.7	443	2323											2766	4550
6-15-81	D	I	0.5	20.0	259			186									445	37
6-15-81	D	I*	1.5	20.0	498	611		55		55							1219	1059
6-15-81	N	I	0.5	19.7	1293	3022		308		185							4808	493
6-15-81	N	I*	1.5	19.2	522	1200											1722	7214
6-15-81	D	J	0.5	20.0	619												619	0
6-15-81	D	J	2.5	19.2	829			337									1166	0
6-15-81	D	J*	3.0	19.2	153	76											229	349
6-15-81	N	J	0.5	19.9	290	166		125									581	333
6-15-81	N	J	2.5	19.7	1358	957		99		298							2712	50
6-15-81	N	J*	3.0	19.7		1791											1791	3584
6-15-81	D	L	0.5	21.5	519	22		113									654	0
6-15-81	D	L	2.0	21.4	1051			63									1114	31
6-15-81	D	L	4.0	21.4	1664			96									1760	359
6-15-81	D	L	5.5	21.2	226												226	230
6-15-81	D	L*	6.0	18.3	495												495	0
6-16-81	N	L	0.5	25.7	1184	46	233	139	23								1625	745
6-16-81	N	L	2.0	25.7	1990	19		57	19								2085	1535
6-15-81	N	L	4.0	25.3	519	60		30									609	459
6-16-81	N	L	5.5	25.1	2467	347	123	92								NS: 30	3059	601
6-15-81	N	L*	6.0	18.0	192	38											230	1910
6-15-81	D	N	0.5	21.5				16									16	0
6-15-81	D	N	2.5	21.4			32										32	0
6-15-81	D	N	4.5	21.3	684			60									744	0
6-15-81	D	N	6.5	21.1	127		50			25							202	0
6-15-81	D	N	8.5	20.9	92			132		88							312	328
6-15-81	D	N*	9.0	17.7	94												94	479
6-15-81	N	N	0.5	24.8	1233	26		215									1474	0
6-16-81	N	N	2.5	24.7	518	99		86	28								731	883
6-16-81	N	N	4.5	23.9	974	48	47	189									1258	1517
6-16-81	N	N	6.5	23.7	845	89			22								956	1033
6-16-81	N	N	8.5	23.2	2871	88	170		56			28			56		3269	1214
6-15-81	N	N*	9.0	18.0	156	78	156					39	39				468	3797

Appendix 9. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
6-15-81	D	O	0.5	21.0	42			86									128	0
6-15-81	D	O	3.0	20.5	256			874									1130	0
6-16-81	D	O	6.0	20.0	888		25	281									1194	0
6-15-81	D	O	9.0	19.5	695			190		63							948	0
6-15-81	D	O	11.0	19.5	1366	32											1398	0
6-15-81	D	O*	12.0	17.5	82		27	83							27		219	0
6-16-81	N	O	0.5	23.8	813			162									975	0
6-16-81	N	O	3.0	23.5	238		33	33									304	0
6-16-81	N	O	6.0	22.5	386		27	54							27		494	0
6-16-81	N	O	9.0	22.4	1417			30									1447	1192
6-15-81	N	O	11.0	22.3	1038		71	23									1132	767
6-15-81	N	O*	12.0	17.9	136			34									170	205
6-15-81	D	W	0.5	20.0	51	17		69									137	17
6-15-81	D	W	4.5	20.0	58	29											87	0
6-15-81	D	W	8.5	19.6	23			91									114	0
6-15-81	D	W	11.5	19.5	112			21									133	0
6-15-81	D	W	14.0	19.4	32												32	0
6-15-81	D	W*	15.0	17.2	172			43									215	0
6-15-81	N	W	0.5	23.5	1404		17	565	17	17						CP: 17	2037	0
6-15-81	N	W	4.5	23.0	741			102									843	0
6-16-81	N	W	8.5	22.7	2105		18										2123	0
6-16-81	N	W	11.5	22.3	449	40	39			19				19		CP: 19	585	0
6-16-81	N	W	14.0	22.1													0	0
6-15-81	N	W*	15.0	16.4	170	34	102										306	0
7-01-81	D	R	0.5	18.5	414												414	4761
7-01-81	D	R	0.5	18.5													0	189
7-01-81	D	R*	1.0	17.2	722					103							825	4455
7-01-81	N	R	0.5	17.0	1162	1162											2324	0
7-01-81	N	R	0.5	17.0	264	793										ES: 264	1321	0
7-01-81	N	R*	1.0	16.0	108	1137				54							1299	4187
7-01-81	D	I	0.5	16.5	560												560	0
7-01-81	D	I*	1.5	16.3	1161	581											1742	3779
7-01-81	N	I	0.5	16.2	43	130											173	0
7-01-81	N	I*	1.5	15.7	52	520	104										676	2293

Appendix 9. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
7-01-81	D	J	0.5	16.4													0	0
7-01-81	D	J	2.5	16.0	45												45	0
7-01-81	D	J*	3.0	16.1	88												88	0
7-01-81	N	J	0.5	15.8	81	80				40							201	0
7-01-81	N	J	2.5	15.5	83	83											166	1083
7-01-81	N	J*	3.0	15.6						31							31	0
7-01-81	D	L	0.5	16.5													0	0
7-01-81	D	L	2.0	16.4													0	131
7-01-81	D	L	4.0	15.4	21												21	0
7-01-81	D	L	5.5	14.5													0	0
7-01-81	D	L*	6.0	15.2													0	0
7-02-81	N	L	0.5	16.5	22	22											44	0
7-02-81	N	L	2.0	16.3													0	0
7-02-81	N	L	4.0	15.5													0	0
7-02-81	N	L	5.5	13.9	28												28	57
7-01-81	N	L*	6.0	15.0	34												34	0
7-01-81	D	N	0.5	16.0													0	0
7-01-81	D	N	2.5	15.5													0	0
7-01-81	D	N	4.5	15.2													0	0
7-01-81	D	N	6.5	14.6													0	0
7-01-81	D	N	8.5	12.8													0	0
7-01-81	D	N*	9.0	14.1													0	0
7-02-81	N	N	0.5	16.0	57	38											95	0
7-02-81	N	N	2.5	15.8	57												57	159
7-02-81	N	N	4.5	15.1		28											28	56
7-02-81	N	N	6.5	13.8													0	0
7-02-81	N	N	8.5	11.8													0	26
7-01-81	N	N*	9.0	14.5	64	65	32			32							193	0
7-01-81	D	O	0.5	16.0													0	0
7-01-81	D	O	3.0	15.7													0	0
7-01-81	D	O	6.0	15.5													0	0
7-01-81	D	O	9.0	14.2													0	0
7-01-81	D	O	11.0	11.7													0	0
7-01-81	D	O*	12.0	13.0	100												100	0
7-01-81	N	O	0.5	16.0	18	18		36									72	0
7-01-81	N	O	3.0	15.9	18		18										36	18
7-01-81	N	O	6.0	14.5	22												22	44
7-01-81	N	O	9.0	12.8													0	0
7-01-81	N	O	11.0	10.2													0	0
7-01-81	N	O*	12.0	13.0													0	0

Appendix 9. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
7-01-81	D	W	0.5	16.0													0	0
7-01-81	D	W	4.5	15.8													0	0
7-01-81	D	W	8.5	14.5	21		41										62	0
7-01-81	D	W	11.5	12.1	24												24	0
7-01-81	D	W	14.0	9.8													0	0
7-01-81	D	W*	15.0	11.8													0	0
7-01-81	N	W	0.5	16.5													0	0
7-01-81	N	W	4.5	16.4	38												38	0
7-01-81	N	W	8.5	14.5													0	0
7-01-81	N	W	11.5	12.8													0	0
7-01-81	N	W	14.0	9.0	20			19									39	0
7-01-81	N	W*	15.0	16.0	32												32	32
7-20-81	D	R	0.5	22.0	404												404	0
7-20-81	D	R	0.5	22.0	208												208	625
7-20-81	D	R*	1.0	22.0	220	220											440	8036
7-20-81	N	R	0.5	22.0	81	162											243	1788
7-20-81	N	R	0.5	22.0	1386	1109											2495	8333
7-19-81	N	R*	1.0	21.2		14684											14684	80179
7-20-81	D	I	0.5	21.7	141												141	0
7-20-81	D	I*	1.5	21.5	917												917	5980
7-20-81	N	I	0.5	22.0	349	39											388	0
7-19-81	N	I*	1.5	21.2	632	33617											34249	227167
7-20-81	D	J	0.5	21.2	69												69	0
7-20-81	D	J	2.5	21.0	207												207	0
7-20-81	D	J*	3.0	21.0	266												266	314
7-20-81	N	J	0.5	22.0	758	366											1124	1863
7-20-81	N	J	2.5	21.5	781	1441				71							2293	1791
7-19-81	N	J*	3.0	20.5	1247												1247	0
7-20-81	D	L	0.5	22.0						15							15	0
7-20-81	D	L	2.0	22.0													0	0
7-20-81	D	L	4.0	21.8	127					9							136	0
7-20-81	D	L	5.5	21.6	470												470	0
7-20-81	D	L*	6.0	20.5	66												66	0
7-21-81	N	L	0.5	23.0	3221	16											3237	0
7-21-81	N	L	2.0	22.8	4844	9											4853	59
7-21-81	N	L	4.0	20.0	5391												5391	0
7-21-81	N	L	5.5	15.0	1170	26											1196	0
7-19-81	N	L*	6.0	20.4	310												310	0

Appendix 9. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	NUMBER OF LARVAE PER 1000 M^3 AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
7-20-81	D	N	0.5	22.5	14												14	0
7-20-81	D	N	2.5	22.4	45												45	0
7-20-81	D	N	4.5	22.2						16							16	0
7-20-81	D	N	6.5	21.0	16												16	0
7-20-81	D	N	8.5	19.0	30												30	0
7-20-81	D	N*	9.0	17.0													0	0
7-21-81	N	N	0.5	23.0	373												373	0
7-21-81	N	N	2.5	22.9	240												240	0
7-21-81	N	N	4.5	19.0	80	20											100	0
7-21-81	N	N	6.5	13.0	14												14	0
7-21-81	N	N	8.5	10.7	40												40	0
7-19-81	N	N*	9.0	17.3	95	19											114	0
7-20-81	D	O	0.5	22.8													0	0
7-20-81	D	O	3.0	22.6													0	0
7-20-81	D	O	6.0	22.1	8												8	0
7-20-81	D	O	9.0	19.5	14												14	0
7-20-81	D	O	11.0	16.6													0	0
7-20-81	D	O*	12.0	14.0	195												195	65
7-20-81	N	O	0.5	23.2	17												17	0
7-20-81	N	O	3.0	22.8		14											14	15
7-21-81	N	O	6.0	14.5													0	0
7-21-81	N	O	9.0	11.0													0	114
7-21-81	N	O	11.0	10.0													0	0
7-19-81	N	O*	12.0	15.8	27	55											82	0
7-20-81	D	W	0.5	22.8													0	0
7-20-81	D	W	4.5	22.2	15												15	0
7-20-81	D	W	8.5	20.0													0	0
7-20-81	D	W	11.5	15.5	14												14	0
7-20-81	D	W	14.0	10.2													0	0
7-20-81	D	W*	15.0	9.0													0	28
7-20-81	N	W	0.5	22.9	19												19	0
7-20-81	N	W	4.5	22.8	21												21	0
7-20-81	N	W	8.5	10.7													0	0
7-20-81	N	W	11.5	9.0	20												20	0
7-20-81	N	W	14.0	7.4													0	0
7-19-81	N	W*	15.0	8.2	19					19							38	19

Appendix 9. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	NUMBER OF LARVAE PER 1000 M^3: AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
8-06-81	D	R	0.5	23.5	621												621	207
8-06-81	D	R	0.5	23.5	1031					206							1237	619
8-05-81	D	R*	1.0	21.0	778	43											821	911
8-05-81	N	R	0.5	22.5	2288	254											2542	0
8-05-81	N	R	0.5	22.5	215												215	0
8-05-81	N	R*	1.0	22.5		500							125				625	1885
8-06-81	D	I	0.5	22.5	394	82											476	41
8-05-81	D	I*	1.5	21.0	432	252											684	6314
8-05-81	N	I	0.5	22.5	275	34											309	242
8-05-81	N	I*	1.5	22.0	92	253						23	23				391	3969
8-06-81	D	J	0.5	22.5													0	0
8-06-81	D	J	2.5	21.8	225												225	0
8-05-81	D	J*	3.0	20.5													0	138
8-05-81	N	J	0.5	22.5	743												743	0
8-05-81	N	J	2.5	22.5	324												324	0
8-05-81	N	J*	3.0	21.0	51	25											76	3745
8-06-81	D	L	0.5	22.2													0	0
8-06-81	D	L	2.0	22.0	28												28	0
8-06-81	D	L	4.0	22.0													0	0
8-06-81	D	L	5.5	22.0	75												75	382
8-05-81	D	L*	6.0	20.0													0	335
8-07-81	N	L	0.5	22.5	855												855	796
8-07-81	N	L	2.0	22.5	931												931	1996
8-07-81	N	L	4.0	22.5	2237												2237	4253
8-07-81	N	L	5.5	22.2	1188												1188	1876
8-05-81	N	L*	6.0	20.5	28				202								230	404
8-06-81	D	N	0.5	22.4													0	0
8-06-81	D	N	2.5	22.0	14												14	29
8-06-81	D	N	4.5	22.0													0	0
8-06-81	D	N	6.5	22.0	31												31	0
8-06-81	D	N	8.5	22.0													0	0
8-05-81	D	N*	9.0	20.0													0	0
8-07-81	N	N	0.5	22.2	90												90	18
8-07-81	N	N	2.5	22.1	15												15	0
8-07-81	N	N	4.5	22.1	19												19	0
8-07-81	N	N	6.5	22.1	469					19							488	59
8-07-81	N	N	8.5	22.0	212												212	0
8-05-81	N	N*	9.0	20.3					193								193	0

Appendix 9. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	NUMBER OF LARVAE PER 1000 M^3: AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
8-06-81	D	O	0.5	22.0													0	16
8-06-81	D	O	3.0	21.8	12												12	0
8-06-81	D	O	6.0	21.8	112												112	0
8-06-81	D	O	9.0	21.8													0	0
8-06-81	D	O	11.0	19.8													0	0
8-05-81	D	O*	12.0	20.0	36	36							110				182	920
8-06-81	N	O	0.5	22.1	26												26	0
8-06-81	N	O	3.0	21.0	20												20	0
8-06-81	N	O	6.0	21.0	38												38	0
8-06-81	N	O	9.0	18.8	16												16	0
8-06-81	N	O	11.0	18.8	14												14	0
8-05-81	N	O*	12.0	20.4					29								29	0
8-06-81	D	W	0.5	22.0													0	0
8-06-81	D	W	4.5	21.2													0	0
8-06-81	D	W	8.5	21.2													0	0
8-06-81	D	W	11.5	15.0													0	0
8-06-81	D	W	14.0	15.0													0	0
8-05-81	D	W*	15.0	19.8								25					25	0
8-06-81	N	W	0.5	22.0	57												57	0
8-06-81	N	W	4.5	21.8	12												12	0
8-06-81	N	W	8.5	17.6	14												14	0
8-06-81	N	W	11.5	17.6													0	0
8-06-81	N	W	14.0	17.6								17					17	0
8-05-81	N	W*	15.0	20.3								98					98	0
8-17-81	D	R	0.5	22.0													0	0
8-17-81	D	R	0.5	22.0													0	0
8-17-81	D	R*	1.0	21.5	659	94											753	47
8-18-81	N	R	0.5	20.3	273	273											546	0
8-18-81	N	R	0.5	20.3													0	0
8-18-81	N	R*	1.0	19.4	378	2340											2718	0
8-17-81	D	I	0.5	21.0	103												103	0
8-17-81	D	I*	1.5	21.0	6973	373				292							7638	41
8-18-81	N	I	0.5	20.2	506												506	0
8-18-81	N	I*	1.5	19.2	34	68											102	0

Appendix 9. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	NUMBER OF LARVAE PER 1000 M^3: AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
8-17-81	D	J	0.5	21.5	27												27	0
8-17-81	D	J	2.5	20.5	813												813	0
8-17-81	D	J*	3.0	20.5	515	64				32							611	0
8-18-81	N	J	0.5	19.9	677												677	0
8-18-81	N	J	2.5	14.8	934	16											950	0
8-18-81	N	J*	3.0	14.8	64	32							65				161	0
8-17-81	D	L	0.5	20.9													0	0
8-17-81	D	L	2.0	20.9	68												68	0
8-17-81	D	L	4.0	20.5	225												225	30
8-17-81	D	L	5.5	20.0	24												24	0
8-17-81	D	L*	6.0	19.6	274	34											308	0
8-18-81	N	L	0.5	18.5	145												145	0
8-18-81	N	L	2.0	18.5	285											LB: 14	299	0
8-18-81	N	L	4.0	8.3	345					14							359	0
8-18-81	N	L	5.5	7.7	45												45	0
8-18-81	N	L*	6.0	9.5													0	36
8-17-81	D	N	0.5	21.3													0	0
8-17-81	D	N	2.5	21.3						14							14	0
8-17-81	D	N	4.5	20.9	36												36	0
8-17-81	D	N	6.5	20.5													0	0
8-17-81	D	N	8.5	19.7	26												26	0
8-17-81	D	N*	9.0	18.0													0	0
8-17-81	N	N	0.5	19.4		15											15	0
8-17-81	N	N	2.5	19.4	163												163	0
8-17-81	N	N	4.5	6.9	150												150	0
8-17-81	N	N	6.5	6.4													0	0
8-17-81	N	N	8.5	6.3													0	0
8-17-81	N	N*	9.0	7.7					25								25	0
8-17-81	D	O	0.5	20.5													0	0
8-17-81	D	O	3.0	20.5	15												15	0
8-17-81	D	O	6.0	20.4													0	0
8-17-81	D	O	9.0	19.7													0	0
8-17-81	D	O	11.0	17.0													0	0
8-17-81	D	O*	12.0	17.3	22												22	0
8-17-81	N	O	0.5	20.9	51												51	0
8-17-81	N	O	3.0	20.8	64												64	0
8-17-81	N	O	6.0	11.0	36												36	0
8-17-81	N	O	9.0	7.4													0	0
8-17-81	N	O	11.0	7.4													0	0
8-17-81	N	O*	12.0	7.5													0	0

Appendix 9. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	NUMBER OF LARVAE PER 1000 M³ AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
8-17-81	D	W	0.5	20.5													0	0
8-17-81	D	W	4.5	20.4													0	0
8-17-81	D	W	8.5	19.8	27												27	0
8-17-81	D	W	11.5	17.9													0	0
8-17-81	D	W	14.0	9.0	12												12	0
8-17-81	D	W*	15.0	17.2													0	0
8-17-81	N	W	0.5	20.2	36												36	0
8-17-81	N	W	4.5	20.0													0	0
8-17-81	N	W	8.5	6.8													0	0
8-17-81	N	W	11.5	6.1													0	0
8-17-81	N	W	14.0	6.1													0	0
8-17-81	N	W*	15.0	7.0													0	0
9-09-81	D	R	0.5	18.0													0	0
9-09-81	D	R	0.5	18.0													0	0
9-08-81	D	R*	1.0	14.8	38												38	0
9-10-81	N	R	0.5	20.6													0	0
9-10-81	N	R	0.5	20.6													0	0
9-08-81	N	R*	1.0	14.8													0	0
9-09-81	D	I	0.5	18.0													0	0
9-08-81	D	I*	1.5	14.8	58	58											116	0
9-10-81	N	I	0.5	20.6													0	0
9-08-81	N	I*	1.5	15.0		33											33	0
9-09-81	D	J	0.5	18.0													0	0
9-09-81	D	J	2.5	18.0													0	0
9-08-81	D	J*	3.0	15.2													0	0
9-10-81	N	J	0.5	20.8													0	0
9-10-81	N	J	2.5	20.3													0	0
9-08-81	N	J*	3.0	15.6													0	0
9-09-81	D	L	0.5	18.5													0	0
9-09-81	D	L	2.0	18.5													0	0
9-09-81	D	L	4.0	18.5													0	0
9-09-81	D	L	5.5	18.3													0	0
9-08-81	D	L*	6.0	14.0													0	0
9-11-81	N	L	0.5	20.3													0	0
9-11-81	N	L	2.0	20.3	81												81	0
9-11-81	N	L	4.0	20.2	15												15	0
9-11-81	N	L	5.5	20.0													0	0
9-08-81	N	L*	6.0	15.2													0	0

Appendix 9. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	JD	XP	FS	SS	TP	XC	GS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
9-09-81	D	N	0.5	19.5													0	0
9-09-81	D	N	2.5	19.3													0	0
9-09-81	D	N	4.5	19.0													0	0
9-09-81	D	N	6.5	18.8													0	0
9-09-81	D	N	8.5	18.6													0	0
9-08-81	D	N*	9.0	13.5													0	0
9-10-81	N	N	0.5	20.7													0	0
9-10-81	N	N	2.5	20.6													0	0
9-10-81	N	N	4.5	20.5	28												28	0
9-10-81	N	N	6.5	20.5													0	0
9-11-81	N	N	8.5	20.4													0	0
9-08-81	N	N*	9.0	15.5	19												19	0
9-09-81	D	O	0.5	19.7													0	0
9-09-81	D	O	3.0	19.6													0	0
9-09-81	D	O	6.0	19.4													0	0
9-09-81	D	O	9.0	19.2													0	0
9-09-81	D	O	11.0	19.2													0	0
9-08-81	D	O*	12.0	14.0													0	0
9-10-81	N	O	0.5	20.6													0	0
9-10-81	N	O	3.0	20.6													0	0
9-10-81	N	O	6.0	20.2	15												15	0
9-10-81	N	O	9.0	20.2	17												17	0
9-10-81	N	O	11.0	20.2	16												16	0
9-08-81	N	O*	12.0	15.5													0	0
9-09-81	D	W	0.5	19.9													0	0
9-09-81	D	W	4.5	19.8													0	0
9-09-81	D	W	8.5	19.6													0	0
9-09-81	D	W	11.5	19.5													0	0
9-09-81	D	W	14.0	19.4													0	0
9-08-81	D	W*	15.0	15.0													0	0
9-10-81	N	W	0.5	20.6													0	0
9-10-81	N	W	4.5	20.4													0	0
9-10-81	N	W	8.5	20.3													0	0
9-10-81	N	W	11.5	20.2													0	0
9-10-81	N	W	14.0	20.1													0	0
9-08-81	N	W*	15.0	15.5													0	0

Appendix 10. Number of fish larvae and eggs per 1000 m^3 for south transect stations in Lake Michigan (Fig. 1) near the J. H. Campbell Plant, eastern Lake Michigan, April to September 1981. D = day, N = night, * = sled tow. See Appendix 1 for species code identification.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
4-15-81	D	P	0.5	10.2								1075					1075	0
4-15-81	D	P	0.5	10.2								430					430	0
4-13-81	D	P*	1.0	8.4													0	0
4-15-81	N	P	0.5	9.5													0	0
4-15-81	N	P	0.5	9.5								310					310	0
4-13-81	N	P*	1.0	8.8													0	0
4-15-81	D	A	0.5	10.2													0	0
4-13-81	D	A*	1.5	8.4													0	0
4-15-81	N	A	0.5	9.5								330					330	0
4-13-81	N	A*	1.5	7.8													0	0
4-15-81	D	B	0.5	9.5													0	0
4-15-81	D	B	2.5	9.5													0	0
4-13-81	D	B*	3.0	7.6													0	0
4-15-81	N	B	0.5	9.0								143					143	0
4-15-81	N	B	2.5	8.0													0	0
4-13-81	N	B*	3.0	7.5													0	0
4-15-81	D	C	0.5	7.0													0	0
4-15-81	D	C	2.0	6.9								43					43	0
4-15-81	D	C	4.0	6.8													0	0
4-15-81	D	C	5.5	6.7													0	0
4-13-81	D	C*	6.0	7.5													0	0
4-15-81	N	C	0.5	7.8													0	0
4-15-81	N	C	2.0	7.8													0	0
4-15-81	N	C	4.0	7.8								33					33	0
4-15-81	N	C	5.5	7.8													0	0
4-13-81	N	C*	6.0	7.9													0	0
4-15-81	D	D	0.5	8.0								34					34	0
4-15-81	D	D	2.5	7.8													0	0
4-15-81	D	D	4.5	7.6													0	0
4-15-81	D	D	6.5	7.5													0	0
4-15-81	D	D	8.5	7.2													0	0
4-13-81	D	D*	9.0	7.2													0	0
4-15-81	N	D	0.5	7.3													0	0
4-15-81	N	D	2.5	7.3													0	0
4-15-81	N	D	4.5	7.2													0	0
4-15-81	N	D	6.5	6.9													0	0
4-15-81	N	D	8.5	6.2													0	0
4-13-81	N	D*	9.0	7.1													0	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
4-15-81	D	E	0.5	7.5													0	0
4-15-81	D	E	3.0	7.4													0	0
4-15-81	D	E	6.0	7.3													0	0
4-15-81	D	E	9.0	7.2													0	0
4-15-81	D	E	11.0	7.0													0	0
4-13-81	D	E*	12.0	7.0													0	0
4-15-81	N	E	0.5	6.5													0	0
4-15-81	N	E	3.0	6.4													0	0
4-15-81	N	E	6.0	6.0													0	0
4-15-81	N	E	9.0	5.5													0	0
4-15-81	N	E	11.0	5.1													0	0
4-13-81	N	E*	12.0	6.8													0	0
4-15-81	D	F	0.5	7.3													0	0
4-15-81	D	F	4.5	7.2													0	0
4-15-81	D	F	8.5	7.1													0	0
4-15-81	D	F	11.5	6.9													0	0
4-15-81	D	F	14.0	6.5													0	0
4-13-81	D	F*	15.0	5.9													0	0
4-15-81	N	F	0.5	6.0								28					28	0
4-15-81	N	F	4.5	5.9													0	0
4-15-81	N	F	8.5	5.0													0	0
4-15-81	N	F	11.5	4.6													0	0
4-15-81	N	F	14.0	4.1													0	0
4-13-81	N	F*	15.0	6.0													0	0
5-04-81	D	P	0.5	14.5				128		128							256	0
5-04-81	D	P	0.5	14.5				879									879	0
5-04-81	D	P*	1.0	14.5			35	210									245	105
5-04-81	N	P	0.5	12.5				3529									3529	0
5-04-81	N	P	0.5	12.5				3755									3755	187
5-04-81	N	P*	1.0	12.5			113	454									567	22
5-04-81	D	A	0.5	13.0													0	0
5-04-81	D	A*	1.5	12.2													0	0
5-04-81	N	A	0.5	12.0			66	66									132	0
5-04-81	N	A*	1.5	12.0													0	254

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
5-04-81	D	B	0.5	11.5													0	0
5-04-81	D	B	2.5	11.5													0	47
5-04-81	D	B*	3.0	10.4													0	0
5-04-81	N	B	0.5	11.7				103									103	0
5-04-81	N	B	2.5	11.5													0	82
5-04-81	N	B*	3.0	11.5				21									21	21
5-04-81	D	C	0.5	10.0													0	0
5-04-81	D	C	2.0	9.9													0	0
5-04-81	D	C	4.0	9.9													0	0
5-04-81	D	C	5.5	9.8													0	0
5-04-81	D	C*	6.0	10.0													0	0
5-04-81	N	C	0.5	9.0			70										70	0
5-04-81	N	C	2.0	9.0													0	0
5-04-81	N	C	4.0	9.0													0	0
5-04-81	N	C	5.5	9.0													0	0
5-04-81	N	C*	6.0	9.0													0	0
5-04-81	D	D	0.5	9.9													0	0
5-04-81	D	D	2.5	9.9													0	0
5-04-81	D	D	4.5	9.8													0	0
5-04-81	D	D	6.5	9.8													0	0
5-04-81	D	D	8.5	9.7													0	0
5-04-81	D	D*	9.0	9.3													0	0
5-04-81	N	D	0.5	8.8													0	0
5-04-81	N	D	2.5	8.8													0	0
5-04-81	N	D	4.5	8.8													0	0
5-04-81	N	D	6.5	8.7													0	0
5-04-81	N	D	8.5	8.7													0	0
5-04-81	N	D*	9.0	8.7													0	0
5-04-81	D	E	0.5	9.8			35										35	0
5-04-81	D	E	3.0	9.5													0	0
5-04-81	D	E	6.0	9.3													0	0
5-04-81	D	E	9.0	9.2													0	0
5-04-81	D	E	11.0	9.2													0	0
5-04-81	D	E*	12.0	9.0													0	0
5-04-81	N	E	0.5	8.0													0	0
5-04-81	N	E	3.0	7.9													0	0
5-04-81	N	E	6.0	7.9													0	0
5-04-81	N	E	9.0	7.9													0	0
5-04-81	N	E	11.0	7.9													0	0
5-04-81	N	E*	12.0	7.9													0	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
5-04-81	D	F	0.5	9.0													0	0
5-04-81	D	F	4.5	8.7													0	0
5-04-81	D	F	8.5	8.4													0	0
5-04-81	D	F	11.5	8.3													0	0
5-04-81	D	F	14.0	8.2													0	0
5-04-81	D	F*	15.0	8.4													0	0
5-04-81	N	F	0.5	6.9													0	0
5-04-81	N	F	4.5	6.9													0	0
5-04-81	N	F	8.5	6.9													0	0
5-04-81	N	F	11.5	6.9													0	0
5-04-81	N	F	14.0	6.9													0	0
5-04-81	N	F*	15.0	6.9													0	0
5-18-81	D	P	0.5	8.0													0	0
5-18-81	D	P	0.5	8.0													0	0
5-18-81	D	P*	1.0	8.0													0	0
5-18-81	N	P	0.5	7.0				272									272	0
5-18-81	N	P	0.5	7.0													0	0
5-18-81	N	P*	1.0	7.0													0	0
5-18-81	D	A	0.5	8.0													0	0
5-18-81	D	A*	1.5	7.5													0	0
5-18-81	N	A	0.5	6.3													0	0
5-18-81	N	A*	1.5	6.3													0	0
5-18-81	D	B	0.5	7.5													0	0
5-18-81	D	B	2.5	7.0													0	0
5-18-81	D	B*	3.0	7.0													0	0
5-18-81	N	B	0.5	6.0													0	0
5-18-81	N	B	2.5	6.0													0	0
5-18-81	N	B*	3.0	6.0													0	0
5-18-81	D	C	0.5	8.0													0	0
5-18-81	D	C	2.0	8.0													0	0
5-18-81	D	C	4.0	7.9													0	0
5-18-81	D	C	5.5	7.8													0	0
5-18-81	D	C*	6.0	6.0													0	0
5-18-81	N	C	0.5	7.0													0	0
5-18-81	N	C	2.0	7.0													0	0
5-18-81	N	C	4.0	6.9							25						25	0
5-18-81	N	C	5.5	6.9													0	0
5-18-81	N	C*	6.0	6.0													0	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
5-18-81	D	D	0.5	7.7													0	0
5-18-81	D	D	2.5	7.7													0	0
5-18-81	D	D	4.5	7.5													0	0
5-18-81	D	D	6.5	7.3													0	0
5-18-81	D	D	8.5	7.2													0	0
5-18-81	D	D*	9.0	6.0													0	0
5-18-81	N	D	0.5	7.0													0	0
5-18-81	N	D	2.5	7.0													0	0
5-18-81	N	D	4.5	6.9													0	0
5-18-81	N	D	6.5	6.7													0	0
5-18-81	N	D	8.5	6.7													0	0
5-18-81	N	D*	9.0	6.5													0	0
5-18-81	D	E	0.5	8.0													0	0
5-18-81	D	E	3.0	7.9													0	0
5-18-81	D	E	6.0	7.8													0	0
5-18-81	D	E	9.0	7.4													0	0
5-18-81	D	E	11.0	7.4							32						32	0
5-18-81	D	E*	12.0	6.0							32						32	0
5-18-81	N	E	0.5	7.0													0	0
5-18-81	N	E	3.0	7.0													0	0
5-18-81	N	E	6.0	6.8													0	0
5-18-81	N	E	9.0	6.5							26						26	0
5-18-81	N	E	11.0	6.5													0	0
5-18-81	N	E*	12.0	6.0													0	0
5-18-81	D	F	0.5	8.0													0	0
5-18-81	D	F	4.5	7.9													0	0
5-18-81	D	F	8.5	7.8							69						69	0
5-18-81	D	F	11.5	7.4													0	0
5-18-81	D	F	14.0	6.9													0	0
5-18-81	D	F*	15.0	5.5							38						38	0
5-18-81	N	F	0.5	7.0													0	0
5-18-81	N	F	4.5	6.9													0	0
5-18-81	N	F	8.5	6.5													0	0
5-18-81	N	F	11.5	6.5				26									26	0
5-18-81	N	F	14.0	6.5													0	0
5-18-81	N	F*	15.0	6.0							33						33	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
6-04-81	D	P	0.5	19.2													0	0
6-04-81	D	P	0.5	19.2													0	0
6-03-81	D	P*	1.0	15.4													0	531
6-04-81	N	P	0.5	16.6													0	0
6-04-81	N	P	0.5	16.6													0	0
6-02-81	N	P*	1.0	13.4													0	0
6-04-81	D	A	0.5	17.5													0	0
6-03-81	D	A*	1.5	14.7													0	0
6-04-81	N	A	0.5	16.2													0	0
6-02-81	N	A*	1.5	13.2													0	0
6-04-81	D	B	0.5	17.2													0	0
6-04-81	D	B	2.5	15.7													0	0
6-03-81	D	B*	3.0	14.5													0	0
6-04-81	N	B	0.5	16.3													0	0
6-04-81	N	B	2.5	13.5													0	0
6-02-81	N	B*	3.0	12.2													0	0
6-04-81	D	C	0.5	14.8													0	0
6-04-81	D	C	2.0	13.8													0	0
6-04-81	D	C	4.0	13.0													0	0
6-04-81	D	C	5.5	13.0													0	0
6-03-81	D	C*	6.0	14.5								26					26	0
6-04-81	N	C	0.5	13.5						24							24	0
6-04-81	N	C	2.0	12.8													0	0
6-04-81	N	C	4.0	11.8													0	0
6-04-81	N	C	5.5	11.5													0	0
6-02-81	N	C*	6.0	12.2													0	0
6-04-81	D	D	0.5	15.2													0	0
6-04-81	D	D	2.5	16.0				85									85	0
6-04-81	D	D	4.5	12.6				48									48	0
6-04-81	D	D	6.5	11.3													0	0
6-04-81	D	D	8.5	11.1				53									53	0
6-03-81	D	D*	9.0	12.2				23									23	0
6-04-81	N	D	0.5	14.0													0	0
6-04-81	N	D	2.5	13.7				23									23	0
6-04-81	N	D	4.5	12.1													0	0
6-04-81	N	D	6.5	11.0													0	0
6-04-81	N	D	8.5	9.0													0	0
6-02-81	N	D*	9.0	10.6													0	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
6-04-81	D	E	0.5	15.0													0	0
6-04-81	D	E	3.0	14.4													0	0
6-04-81	D	E	6.0	12.0	25			77		25							127	0
6-04-81	D	E	9.0	11.7													0	0
6-04-81	D	E	11.0	11.4													0	0
6-03-81	D	E*	12.0	11.6				26									26	0
6-04-81	N	E	0.5	14.0													0	0
6-04-81	N	E	3.0	13.7													0	0
6-04-81	N	E	6.0	10.5													0	0
6-04-81	N	E	9.0	7.8													0	0
6-04-81	N	E	11.0	6.9													0	0
6-02-81	N	E*	12.0	10.1													0	160
6-04-81	D	F	0.5	15.5													0	0
6-04-81	D	F	4.5	13.7				110									110	0
6-04-81	D	F	8.5	10.3				75		37							112	0
6-04-81	D	F	11.5	8.5													0	0
6-04-81	D	F	14.0	7.5													0	0
6-03-81	D	F*	15.0	9.7													0	0
6-04-81	N	F	0.5	14.0													0	0
6-04-81	N	F	4.5	12.0													0	0
6-04-81	N	F	8.5	7.3				45					45			GS: 45	135	0
6-04-81	N	F	11.5	6.1				51									51	0
6-04-81	N	F	14.0	5.8													0	0
6-02-81	N	F*	15.0	8.2				55									55	0
6-15-81	D	P	0.5	21.5	950												950	380
6-15-81	D	P	0.5	21.5	155		155										310	310
6-15-81	D	P*	1.0	21.5	108	36											144	0
6-15-81	N	P	0.5	21.5	2151	477											2628	878
6-15-81	N	P	0.5	21.5	1732	728	91										2551	1187
6-15-81	N	P*	1.0	21.5	120	200				40							360	3631
6-15-81	D	A	0.5	21.5	350		16										366	0
6-15-81	D	A*	1.5	21.5	296					37							333	855
6-15-81	N	A	0.5	21.5	396	22	22										440	1790
6-15-81	N	A*	1.5	21.5	84	505											589	16966

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
						NUMBER OF LARVAE PER 1000 M³												
6-15-81	D	B	0.5	21.0	377		87										464	29
6-15-81	D	B	2.5	21.0	1936		23										1959	23
6-15-81	D	B*	3.0	21.0	70					35							105	707
6-15-81	N	B	0.5	20.7	949	66	22										1037	22
6-15-81	N	B	2.5	20.7	798	22	88			22							930	0
6-15-81	N	B*	3.0	20.7	219	72	36										327	110
6-15-81	D	C	0.5	22.8	171	24											195	73
6-15-81	D	C	2.0	22.8	946		107										1053	894
6-15-81	D	C	4.0	22.8	414					68							482	522
6-15-81	D	C	5.5	22.8	373	28	56								28		485	1640
6-15-81	D	C*	6.0	20.0	76												76	76
6-15-81	N	C	0.5	22.5	744	109	55			27							935	55
6-15-81	N	C	2.0	22.5	1330					27							1357	679
6-15-81	N	C	4.0	22.5	439			27									466	499
6-15-81	N	C	5.5	22.5	322		45	22									389	3303
6-15-81	N	C*	6.0	19.5	168												168	1350
6-15-81	D	D	0.5	22.4	70		47										117	213
6-15-81	D	D	2.5	22.4	256	36	109	36									437	257
6-15-81	D	D	4.5	22.4	31												31	190
6-15-81	D	D	6.5	22.4	204		50	25									279	440
6-15-81	D	D	8.5	22.4	129		81			40							250	259
6-15-81	D	D*	9.0	19.5	90					45							135	770
6-15-81	N	D	0.5	21.5	625		335			104							1064	104
6-15-81	N	D	2.5	21.5	668		257	21									946	21
6-15-81	N	D	4.5	21.5	1144	21	272	20									1457	84
6-15-81	N	D	6.5	21.5	842			60		60							962	93
6-15-81	N	D	8.5	21.5	962	26	25	25									1038	312
6-15-81	N	D*	9.0	19.2	130			52									182	1934
6-15-81	D	E	0.5	18.9	276												276	0
6-15-81	D	E	3.0	18.9	366		57										423	0
6-15-81	D	E	6.0	18.9	209		102			25							336	78
6-15-81	D	E	9.0	18.9	289		113										402	0
6-15-81	D	E	11.0	18.9	225		48	24									297	75
6-15-81	D	E*	12.0	18.8		27											27	27
6-15-81	N	E	0.5	22.2	920		1547										2467	0
6-15-81	N	E	3.0	22.2	700		39										739	20
6-15-81	N	E	6.0	22.2	972		88			29							1089	0
6-15-81	N	E	9.0	22.2	1360	20	38	19									1437	40
6-15-81	N	E	11.0	22.2	1182	27	209	78									1496	27
6-15-81	N	E*	12.0	18.9		42	42										84	5558

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
6-15-81	D	F	0.5	18.0	91												91	0
6-15-81	D	F	4.5	18.0	686		34			17							737	0
6-15-81	D	F	8.5	18.0	2295	31	62										2388	0
6-15-81	D	F	11.5	18.0	3187		66										3253	23
6-15-81	D	F	14.0	18.0	1224		42			21							1287	133
6-15-81	D	F*	15.0	18.5	261		78										339	0
6-15-81	N	F	0.5	21.2	1129		99					19					1247	19
6-15-81	N	F	4.5	21.2	2430		21										2451	0
6-15-81	N	F	8.5	21.2	2084												2084	0
6-15-81	N	F	11.5	21.1	3465		20	20									3505	0
6-15-81	N	F	14.0	21.0	802			18				18					838	0
6-15-81	N	F*	15.0	18.0	320							21					341	0
7-01-81	D	P	0.5	15.4	2860	286											3146	0
7-01-81	D	P	0.5	15.4	21903												21903	1428
7-01-81	D	P*	1.0	16.7	1131	141											1272	82949
7-01-81	N	P	0.5	15.2	6846												6846	360
7-01-81	N	P	0.5	15.2	20738	2221											22959	1481
7-01-81	N	P*	1.0	17.5	34	865		69		34							1002	0
7-01-81	D	A	0.5	15.5	545												545	45
7-01-81	D	A*	1.5	15.6	996	43											1039	1345
7-01-81	N	A	0.5	15.2	5625												5625	865
7-01-81	N	A*	1.5	17.7		2774		86									2860	148169
7-01-81	D	B	0.5	15.6	529												529	0
7-01-81	D	B	2.5	14.5	508												508	0
7-01-81	D	B*	3.0	14.3	834												834	1171
7-01-81	N	B	0.5	15.0	2074	122											2196	0
7-01-81	N	B	2.5	14.5	384												384	0
7-01-81	N	B*	3.0	16.7		23		23		23							69	5501
7-01-81	D	C	0.5	17.5	76												76	0
7-01-81	D	C	2.0	17.4													0	0
7-01-81	D	C	4.0	16.7	24												24	0
7-01-81	D	C	5.5	14.9													0	0
7-01-81	D	C*	6.0	14.0	36												36	292
7-01-81	N	C	0.5	16.5	19												19	0
7-01-81	N	C	2.0	16.4	26	78											104	52
7-01-81	N	C	4.0	14.9		21											21	0
7-01-81	N	C	5.5	13.5	90	44			22								156	114
7-01-81	N	C*	6.0	15.7	125					25							150	575

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
7-01-81	D	D	0.5	17.0	18												18	0
7-01-81	D	D	2.5	16.9													0	0
7-01-81	D	D	4.5	16.3													0	0
7-01-81	D	D	6.5	15.0													0	0
7-01-81	D	D	8.5	11.5													0	0
7-01-81	D	D*	9.0	13.4													0	47
7-01-81	N	D	0.5	16.0		38											38	0
7-01-81	N	D	2.5	15.9										26			26	0
7-01-81	N	D	4.5	15.0													0	0
7-01-81	N	D	6.5	13.0	54												54	27
7-01-81	N	D	8.5	11.3		22											22	0
7-01-81	N	D*	9.0	15.2	44												44	0
7-01-81	D	E	0.5	15.0	36												36	198
7-01-81	D	E	3.0	14.9	21												21	43
7-01-81	D	E	6.0	14.5	54												54	0
7-01-81	D	E	9.0	12.5													0	0
7-01-81	D	E	11.0	9.5													0	0
7-01-81	D	E*	12.0	11.7	23												23	0
7-01-81	N	E	0.5	16.0													0	0
7-01-81	N	E	3.0	16.0													0	0
7-01-81	N	E	6.0	13.1													0	0
7-01-81	N	E	9.0	11.6	58					28				28			114	0
7-01-81	N	E	11.0	9.1		24											24	0
7-01-81	N	E*	12.0	14.7		22	22										44	0
7-01-81	D	F	0.5	16.0													0	0
7-01-81	D	F	4.5	15.6													0	0
7-01-81	D	F	8.5	15.1													0	0
7-01-81	D	F	11.5	13.9	44												44	0
7-01-81	D	F	14.0	10.4													0	0
7-01-81	D	F*	15.0	10.7													0	0
7-01-81	N	F	0.5	16.5	39												39	0
7-01-81	N	F	4.5	16.5													0	43
7-01-81	N	F	8.5	14.5	22												22	0
7-01-81	N	F	11.5	12.0													0	0
7-01-81	N	F	14.0	8.2	52												52	0
7-01-81	N	F*	15.0	16.7													0	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
7-20-81	D	P	0.5	22.0													0	0
7-20-81	D	P	0.5	22.0	166												166	0
7-20-81	D	P*	1.0	21.5		62											62	77337
7-20-81	N	P	0.5	21.5	282	141			141	141							705	0
7-20-81	N	P	0.5	21.5	686	274											960	687
7-20-81	N	P*	1.0	21.8		563											563	159
7-20-81	D	A	0.5	22.0													0	0
7-20-81	D	A*	1.5	20.5	109	54											163	0
7-20-81	N	A	0.5	22.0	100	75											175	150
7-19-81	N	A*	1.5	22.0		706				26							732	528
7-20-81	D	B	0.5	21.0													0	0
7-20-81	D	B	2.5	19.5	28												28	0
7-20-81	D	B*	3.0	19.5	78												78	78
7-20-81	N	B	0.5	21.5	174	58											232	616
7-20-81	N	B	2.5	21.5	45												45	45
7-19-81	N	B*	3.0	21.7	105	21											126	899
7-20-81	D	C	0.5	22.5	156												156	0
7-20-81	D	C	2.0	22.4	11												11	0
7-20-81	D	C	4.0	22.3	65												65	0
7-20-81	D	C	5.5	21.3	84												84	0
7-20-81	D	C*	6.0	21.0													0	45
7-20-81	N	C	0.5	22.9	152												152	61
7-20-81	N	C	2.0	22.5	52	13											65	13
7-20-81	N	C	4.0	20.0	160	40											200	40
7-20-81	N	C	5.5	19.0	571	75											646	46
7-19-81	N	C*	6.0	20.7	526				40								566	445
7-20-81	D	D	0.5	22.2	158												158	0
7-20-81	D	D	2.5	22.0	13												13	0
7-20-81	D	D	4.5	20.9	16												16	0
7-20-81	D	D	6.5	20.2	17												17	0
7-20-81	D	D	8.5	18.5													0	0
7-20-81	D	D*	9.0	17.8													0	119
7-20-81	N	D	0.5	21.7													0	0
7-20-81	N	D	2.5	21.6	65												65	0
7-20-81	N	D	4.5	20.0	39												39	0
7-20-81	N	D	6.5	17.5													0	0
7-20-81	N	D	8.5	14.6													0	0
7-19-81	N	D*	9.0	17.9	708				28					28			764	198

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
7-20-81	D	E	0.5	22.8													0	0
7-20-81	D	E	3.0	22.2	43												43	0
7-20-81	D	E	6.0	21.0													0	0
7-20-81	D	E	9.0	17.5	16												16	0
7-20-81	D	E	11.0	13.0													0	0
7-20-81	D	E*	12.0	10.5													0	0
7-20-81	N	E	0.5	22.2	28												28	0
7-20-81	N	E	3.0	22.2	33												33	44
7-20-81	N	E	6.0	20.0	46												46	0
7-20-81	N	E	9.0	11.5													0	0
7-20-81	N	E	11.0	9.5													0	0
7-19-81	N	E*	12.0	14.5	22												22	68
7-20-81	D	F	0.5	22.8													0	0
7-20-81	D	F	4.5	22.3	10												10	0
7-20-81	D	F	8.5	14.0	42					14							56	0
7-20-81	D	F	11.5	11.8													0	0
7-20-81	D	F	14.0	8.4													0	0
7-20-81	D	F*	15.0	8.3													0	126
7-20-81	N	F	0.5	21.5	15					15							30	0
7-20-81	N	F	4.5	21.4	36												36	0
7-20-81	N	F	8.5	15.0													0	0
7-20-81	N	F	11.5	7.6													0	0
7-20-81	N	F	14.0	7.3													0	0
7-19-81	N	F*	15.0	9.1		24											24	96
8-06-81	D	P	0.5	23.5													0	2233
8-06-81	D	P	0.5	23.0													0	1886
8-05-81	D	P*	1.0	22.8	61	122											183	675
8-06-81	N	P	0.5	21.3													0	0
8-06-81	N	P	0.5	21.3													0	0
8-05-81	N	P*	1.0	21.3		112											112	454
8-06-81	D	A	0.5	23.0													0	0
8-05-81	D	A*	1.5	22.2													0	486
8-06-81	N	A	0.5	21.3	565												565	0
8-05-81	N	A*	1.5	21.0	40	81									40		161	648

Appendix 10. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
8-06-81	D	B	0.5	22.5													0	0
8-06-81	D	B	2.5	22.5	59												59	0
8-05-81	D	B*	3.0	21.9		53											53	53
8-05-81	N	B	0.5	21.3													0	0
8-05-81	N	B	2.5	20.9	120												120	0
8-05-81	N	B*	3.0	20.9	47												47	0
8-05-81	D	C	0.5	22.6													0	0
8-06-81	D	C	2.0	22.3	30												30	0
8-06-81	D	C	4.0	22.3	39												39	0
8-06-81	D	C	5.5	22.3	22												22	0
8-05-81	D	C*	6.0	21.6													0	124
8-06-81	N	C	0.5	22.0	72					14							86	0
8-06-81	N	C	2.0	22.0	146	11				23							180	0
8-06-81	N	C	4.0	22.0	105												105	0
8-06-81	N	C	5.5	22.0	106	13											119	13
8-05-81	N	C*	6.0	21.0													0	470
8-06-81	D	D	0.5	22.6													0	0
8-06-81	D	D	2.5	22.6													0	0
8-06-81	D	D	4.5	22.3	32												32	0
8-06-81	D	D	6.5	22.3													0	0
8-06-81	D	D	8.5	22.2													0	0
8-05-81	D	D*	9.0	21.6													0	0
8-06-81	N	D	0.5	22.2	45												45	0
8-06-81	N	D	2.5	22.0	12	12											24	0
8-06-81	N	D	4.5	22.0	30												30	0
8-06-81	N	D	6.5	22.0	16												16	0
8-06-81	N	D	8.5	22.0	45												45	0
8-05-81	N	D*	9.0	20.6													0	0
8-06-81	D	E	0.5	22.0													0	0
8-06-81	D	E	3.0	21.9	13												13	0
8-06-81	D	E	6.0	21.9													0	0
8-06-81	D	E	9.0	21.9													0	0
8-06-81	D	E	11.0	21.9	14												14	0
8-05-81	D	E*	12.0	21.2													0	0
8-06-81	N	E	0.5	22.2	16												16	0
8-06-81	N	E	3.0	21.8	45	11											56	0
8-06-81	N	E	6.0	21.8													0	0
8-06-81	N	E	9.0	21.8													0	0
8-06-81	N	E	11.0	17.8	15												15	0
8-05-81	N	E*	12.0	19.0	29								29				58	29

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
8-06-81	D	F	0.5	22.0													0	0
8-06-81	D	F	4.5	21.0													0	0
8-06-81	D	F	8.5	21.0													0	0
8-06-81	D	F	11.5	16.9													0	0
8-06-81	D	F	14.0	16.9													0	0
8-05-81	D	F*	15.0	21.4													0	0
8-06-81	N	F	0.5	22.2													0	0
8-06-81	N	F	4.5	21.5													0	0
8-06-81	N	F	8.5	21.5													0	0
8-06-81	N	F	11.5	17.4													0	0
8-06-81	N	F	14.0	17.4													0	0
8-05-81	N	F*	15.0	17.8									29				29	29
8-17-81	D	P	0.5	21.0													0	0
8-17-81	D	P	0.5	21.0													0	0
8-17-81	D	P*	1.0	21.5	531	177											708	0
8-18-81	N	P	0.5	17.7	764												764	0
8-18-81	N	P	0.5	17.7	370												370	0
8-18-81	N	P*	1.0	13.9	1008	84								126			1218	0
8-17-81	D	A	0.5	21.4													0	0
8-17-81	D	A*	1.5	20.7	131	131											262	0
8-18-81	N	A	0.5	19.7	252												252	36
8-18-81	N	A*	1.5	11.7	1022									219			1241	0
8-17-81	D	B	0.5	21.0													0	0
8-17-81	D	B	2.5	20.5	1170												1170	0
8-17-81	D	B*	3.0	20.5	886	522				52							1460	0
8-18-81	N	B	0.5	19.2	1380												1380	0
8-18-81	N	B	2.5	9.9	893												893	0
8-18-81	N	B*	3.0	9.9													0	0
8-17-81	D	C	0.5	19.7													0	0
8-17-81	D	C	2.0	19.7	51												51	0
8-17-81	D	C	4.0	19.7	21												21	0
8-17-81	D	C	5.5	19.7	120												120	0
8-17-81	D	C*	6.0	19.5													0	0
8-17-81	N	C	0.5	20.4	55												55	0
8-17-81	N	C	2.0	20.4	257												257	0
8-17-81	N	C	4.0	20.2	54												54	0
8-17-81	N	C	5.5	15.0	95												95	0
8-18-81	N	C*	6.0	11.0	73												73	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
8-17-81	D	D	0.5	20.2	46												46	0
8-17-81	D	D	2.5	20.2	30												30	0
8-17-81	D	D	4.5	20.1													0	0
8-17-81	D	D	6.5	20.0	58												58	0
8-17-81	D	D	8.5	19.0	60												60	0
8-17-81	D	D*	9.0	18.2	80	80											160	0
8-17-81	N	D	0.5	20.4	64												64	0
8-17-81	N	D	2.5	20.4	193												193	0
8-17-81	N	D	4.5	17.0	223												223	0
8-17-81	N	D	6.5	8.8										27			27	0
8-17-81	N	D	8.5	8.5	12												12	12
8-18-81	N	D*	9.0	6.5													0	0
8-17-81	D	E	0.5	21.0													0	0
8-17-81	D	E	3.0	21.0													0	0
8-17-81	D	E	6.0	20.8	29												29	29
8-17-81	D	E	9.0	19.9	33												33	0
8-17-81	D	E	11.0	16.0													0	0
8-17-81	D	E*	12.0	18.5													0	0
8-17-81	N	E	0.5	19.8	238												238	0
8-17-81	N	E	3.0	19.8	19												19	0
8-17-81	N	E	6.0	14.9													0	0
8-17-81	N	E	9.0	7.2	30												30	0
8-17-81	N	E	11.0	7.1	13												13	0
8-17-81	N	E*	12.0	6.2													0	0
8-17-81	D	F	0.5	20.5													0	24
8-17-81	D	F	4.5	20.4													0	0
8-17-81	D	F	8.5	20.2													0	0
8-17-81	D	F	11.5	18.5													0	0
8-17-81	D	F	14.0	6 8													0	0
8-17-81	D	F*	15.0	16.0													0	0
8-17-81	N	F	0.5	19.2													0	0
8-17-81	N	F	4.5	19.1													0	0
8-17-81	N	F	8.5	12.0													0	0
8-17-81	N	F	11.5	5.1													0	0
8-17-81	N	F	14.0	5.1													0	0
8-17-81	N	F*	15.0	5.5													0	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
9-09-81	D	P	0.5	18.2													0	0
9-09-81	D	P	0.5	18.2													0	0
9-09-81	D	P*	1.0	18.2	20												20	180
9-10-81	N	P	0.5	20.6													0	0
9-10-81	N	P	0.5	20.6													0	430
9-10-81	N	P*	1.0	20.6		69											69	3139
9-09-81	D	A	0.5	18.2		23											23	0
9-08-81	D	A*	1.5	16.5		34											34	0
9-10-81	N	A	0.5	20.6													0	0
9-08-81	N	A*	1.5	16.5													0	0
9-09-81	D	B	2.5	18.3													0	0
9-08-81	D	B*	3.0	16.7													0	0
9-10-81	N	B	0.5	21.0													0	0
9-10-81	N	B	2.5	20.7													0	0
9-08-81	N	B*	3.0	16.5													0	0
9-09-81	D	C	0.5	19.2													0	0
9-09-81	D	C	2.0	19.2													0	0
9-09-81	D	C	4.0	19.2													0	0
9-09-81	D	C	5.5	19.2													0	0
9-08-81	D	C*	6.0	16.5													0	0
9-10-81	N	C	0.5	20.7	15												15	0
9-10-81	N	C	2.0	20.7	26												26	0
9-10-81	N	C	4.0	20.6													0	0
9-10-81	N	C	5.5	20.5	39												39	0
9-08-81	N	C*	6.0	17.0													0	0
9-09-81	D	D	0.5	19.8													0	0
9-09-81	D	D	2.5	19.8													0	0
9-09-81	D	D	4.5	19.8													0	0
9-09-81	D	D	6.5	19.8													0	0
9-09-81	D	D	8.5	19.8													0	0
9-08-81	D	D*	9.0	16.2													0	0
9-09-81	N	D	0.5	21.2													0	0
9-10-81	N	D	2.5	21.2	26												26	0
9-10-81	N	D	4.5	21.1	14												14	0
9-10-81	N	D	6.5	21.0	32												32	0
9-10-81	N	D	8.5	20.9	24												24	0
9-09-81	N	D*	9.0	16.8													0	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	SM	JD	XP	FS	XC	SS	TP	NS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
9-09-81	D	E	0.5	20.2													0	0
9-09-81	D	E	3.0	20.2													0	0
9-09-81	D	E	6.0	20.2													0	0
9-09-81	D	E	9.0	20.2													0	0
9-09-81	D	E	11.0	20.2	16												16	0
9-08-81	D	E*	12.0	16.7													0	0
9-10-81	N	E	0.5	21.0													0	0
9-10-81	N	E	3.0	21.0	16												16	0
9-10-81	N	E	6.0	20.9	15												15	0
9-10-81	N	E	9.0	20.7													0	0
9-10-81	N	E	11.0	20.6													0	0
9-08-81	N	E*	12.0	15.5													0	0
9-09-81	D	F	0.5	20.2													0	0
9-09-81	D	F	4.5	20.2													0	0
9-09-81	D	F	8.5	20.2													0	0
9-09-81	D	F	11.5	20.2													0	0
9-09-81	D	F	14.0	20.2													0	0
9-08-81	D	F*	15.0	16.5													0	0
9-10-81	N	F	0.5	21.2													0	0
9-10-81	N	F	4.5	21.2													0	0
9-10-81	N	F	8.5	20.9													0	0
9-10-81	N	F	11.5	20.7													0	0
9-10-81	N	F	14.0	20.6													0	0
9-08-81	N	F*	15.0	15.0													0	0

Appendix 11. A weekly summary of fish larvae and eggs entrained by Units 1 and 2 of the J. H. Campbell Plant from February through December 1980. This summary includes average number of fish larvae and eggs entrained per diel period. See Appendix 1 for species code identification.

DATE	DIEL PERIOD	INTAKE TEMP. C	NUMBER OF LARVAE PER 1000 M³ AL	CP	YP	SP	SM	XP	XL	PM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
2-16-80	DAWN	4.3										0	37	69	0	2553
2-16-80	DAY	4.5										0	0	295	0	0
2-15-80	DUSK	4.5										0	0	69	0	0
2-16-80	NIGHT	4.5										0	0	401	0	0
	TOTAL													834	0	2553
2-21-80	DAWN	3.5										0	0	69	0	0
2-21-80	DAY	4.0										0	0	302	0	0
2-20-80	DUSK	3.5										0	0	69	0	0
2-20-80	NIGHT	3.5										0	0	393	0	0
	TOTAL													833	0	0
2-29-80	DAWN	5.0										0	0	70	0	0
2-29-80	DAY	5.0										0	0	322	0	0
2-28-80	DUSK	5.0										0	0	70	0	0
2-28-80	NIGHT	4.5										0	0	381	0	0
	TOTAL													843	0	0
3-07-80	DAWN	5.0										0	0	95	0	0
3-07-80	DAY	5.0										0	0	451	0	0
3-06-80	DUSK	5.0										0	0	95	0	0
3-06-80	NIGHT	5.0										0	0	507	0	0
	TOTAL													1148	0	0
3-13-80	DAWN	5.5										0	0	108	0	0
3-13-80	DAY	5.5										0	0	535	0	0
3-12-80	DUSK	5.5										0	0	108	0	0
3-12-80	NIGHT	5.5										0	0	546	0	0
	TOTAL													1297	0	0
4-30-80	DAWN	9.0			33						FS: 19	52	0	136	7072	0
4-29-80	DAY	9.0			18							18	0	820	14760	0
4-29-80	DUSK	9.0			25							25	0	136	3400	0
4-30-80	NIGHT	9.0			47							47	0	541	25427	0
	TOTAL													1633	50659	0
5-05-80	DAWN	10.0			155			4				159	0	81	12879	0
5-05-80	DAY	12.0			612			13				625	8	501	313125	4008
5-04-80	DUSK	10.5			51							51	0	81	4131	0
5-05-80	NIGHT	10.0			129							129	0	315	40635	0
	TOTAL													978	370770	4008

Appendix 11. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	CP	NUMBER OF LARVAE PER 1000 M³ YP	SP	SM	XP	XL	PM	MISC.		TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
5-16-80	DAWN	11.0			287		78	5	2	13	BR:	3	388	0	81	31428	0
5-15-80	DAY	10.9			170		37	10					217	0	515	111755	0
5-15-80	DUSK	11.1			85	2	68				XC:	4	159	0	81	12879	0
5-15-80	NIGHT	10.6			188		51	8			BR:	3	250	0	301	75250	0
	TOTAL														978	231312	0
5-23-80	DAWN	14.1			25		21	11		14			71	585	81	5751	47385
5-23-80	DAY	14.8			18		6	8		26	GS:	2					
											BR:	2	62	14	530	32860	7420
5-22-80	DUSK	14.9		2	25		3	5		22	GL:	2					
											BR:	2	61	3	81	4941	243
5-22-80	NIGHT	14.0			36	2	10	10		15	JD:	1	74	0	287	21238	0
	TOTAL														979	64790	55048
5-29-80	DAWN	13.5		12	10		12			11			45	0	136	6120	0
5-29-80	DAY	14.0			11		5			13			29	2	892	25868	1784
5-28-80	DUSK	13.0		19	16		11			19	GS:	6					
											TP:	3	74	3	136	10064	408
5-29-80	NIGHT	13.0		8	9		11	2		18			48	0	470	22560	0
	TOTAL														1634	64612	2192
6-05-80	DAWN	11.0						17	14	81	GS:	18					
											CT:	17	147	1581	136	19992	215016
6-05-80	DAY	11.0		11	18				3	92			124	207	899	111476	186093
6-04-80	DUSK	12.7		9				11	31	11			62	73	136	8432	9928
6-06-80	NIGHT	12.0		14			4		14	19	JD:	5	56	1105	463	25928	511615
	TOTAL														1634	165828	922652
6-12-80	DAWN	11.0											0	0	69	0	0
6-12-80	DAY	14.0									ES:	2	2	2	464	928	928
6-11-80	DUSK	12.0	6		6		3				JD:	23					
											MS:	5					
											UC:	3	46	20	69	3174	1380
6-12-80	NIGHT	11.5	4						4		SS:	3	11	6	231	2541	1386
	TOTAL														833	6643	3694
6-19-80	DAWN	13.6	20			22	6	2					50	189	136	6800	25704
6-19-80	DAY	13.6		3	3	13	3						22	394	911	20042	358934
6-19-80	DUSK	13.4	32		2	6	7	20			TP:	2	69	133	136	9384	18088
6-20-80	NIGHT	13.6	62	3		38	10	15			JD:	13					
											TP:	8	149	384	451	67199	173184
	TOTAL														1634	103425	575910

Appendix 11. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	CP	YP	SP	SM	XP	XL	PM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
6-24-80	DAWN	17.9	38	5	33	36	22	8	11	4	CT: 3	160	2444	136	21760	332384
6-24-80	DAY	18.4	9	5	18	10		13	3			58	1481	911	52838	1349191
6-24-80	DUSK	18.9	21	5	42	19	12	25	2		JD: 10					
											XC: 2	138	2059	136	18768	280024
6-25-80	NIGHT	18.6	37	126	95	221	22	54	5	4	JD: 9					
											TP: 2	575	79049	451	259325	35651093
	TOTAL													1634	352691	37612698
7-03-80	DAWN	16.5	2808	14	12	97	2	60	7		JD: 4					
											TP: 4	3008	933	136	409088	126888
7-03-80	DAY	17.0	1004	12	4	20			2			1042	53	906	944052	48018
7-02-80	DUSK	17.0	1335	119		81	6	18			JD: 2	1561	460	136	212296	62560
7-03-80	NIGHT	17.0	1540	443	2	45	2	103	8		JD: 2	2145	2763	456	978120	1259928
	TOTAL													1634	2543556	1497394
7-08-80	DAWN	16.0	5586			321		9				5916	3959	136	804576	538424
7-08-80	DAY	17.5	12283			41						12324	1029	899	11079276	925071
7-08-80	DUSK	17.5	2791			21		26				2838	461	136	385968	62696
7-09-80	NIGHT	18.0	5178			274		50			JD: 4	5506	21363	463	2549278	9891069
	TOTAL													1634	14819098	11417260
7-17-80	DAWN	22.0	1639			109		29			ES: 3					
											SV: 3	1783	58	118	210394	6844
7-16-80	DAY	23.0	667	10		17		4				698	9	766	534668	6894
7-16-80	DUSK	22.0	1327			26		7			JD: 1					
											TP: 2	1363	1	118	160834	118
7-17-80	NIGHT	22.5	2164	2		227		28	7	1		2429	757	414	1005606	313398
	TOTAL													1416	1911502	327254
7-23-80	DAWN	21.0	934			143		18				1095	0	136	148920	0
7-22-80	DAY	22.0	1187	10		7		3				1207	0	874	1054918	0
7-22-80	DUSK	21.5	2596	3		14		14				2627	0	136	357272	0
7-23-80	NIGHT	21.0	1559	57		135					JD: 6	1757	0	488	857416	0
	TOTAL													1634	2418526	0
8-05-80	DAWN	22.0	778			14		2	2			796	0	136	108256	0
8-04-80	DAY	22.0	134									134	0	850	113900	0
8-04-80	DUSK	22.0	281	2		2			2			287	0	136	39032	0
8-05-80	NIGHT	21.9	372			10						382	0	512	195584	0
	TOTAL													1634	456772	0

Appendix 11. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	CP	YP	SP	SM	XP	XL	PM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
						NUMBER OF LARVAE PER 1000 M³										
8-07-80	DAWN	22.0	2184									2184	0	96	209664	0
8-07-80	DAY	23.0	1453									1453	0	594	863082	0
8-07-80	DUSK	23.0	1349	1								1350	0	96	129600	0
8-08-80	NIGHT	23.0	1405			19		3	3		TP: 1	1431	0	374	535194	0
	TOTAL													1160	1737540	0
8-15-80	DAWN	19.0	206	4		6					ES: 2	218	0	136	29648	0
8-14-80	DAY	20.5	119	2		4		6				131	0	823	107813	0
8-14-80	DUSK	20.0	181	4		2		10			JD: 2	199	0	136	27064	0
8-15-80	NIGHT	20.0	307	3		5		2				317	0	539	170863	0
	TOTAL													1634	335388	0
8-22-80	DAWN	21.5	38									38	0	136	5168	0
8-21-80	DAY	22.0	23			2		2				27	0	793	21411	0
8-21-80	DUSK	22.0	77			2		2				81	0	136	11016	0
8-22-80	NIGHT	21.0	23									23	0	568	13064	0
	TOTAL													1633	50659	0
8-27-80	DAWN	22.0	11					2				13	0	136	1768	0
8-27-80	DAY	22.5										0	0	776	0	0
8-27-80	DUSK	22.5	16									16	0	136	2176	0
8-28-80	NIGHT	22.0	29									29	0	585	16965	0
	TOTAL													1633	20909	0
9-04-80	DAWN	22.0										0	0	106	0	0
9-04-80	DAY	24.0										0	0	584	0	0
9-04-80	DUSK	23.0	3									3	0	106	318	0
9-05-80	NIGHT	23.0	12					2			TP: 2	16	0	484	7744	0
	TOTAL													1280	8062	0
9-11-80	DAWN	20.0										0	0	54	0	0
9-11-80	DAY	20.0										0	0	291	0	0
9-11-80	DUSK	20.0	2									2	0	54	108	0
9-12-80	NIGHT	20.0	2									2	0	253	506	0
	TOTAL													652	614	0
10-08-80	DAWN	14.0										0	0	38	0	0
10-08-80	DAY	14.0										0	0	183	0	0
10-08-80	DUSK	14.5	10									10	0	38	380	0
10-09-80	NIGHT	14.0	2									2	0	203	406	0
	TOTAL													462	786	0

Appendix 11. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	CP	YP	SP	SM	XP	XL	PM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
			NUMBER OF LARVAE PER 1000 M³													
10-23-80	DAWN	9.5										0	0	38	0	0
10-21-80	DAY	11.0										0	0	169	0	0
10-21-80	DUSK	10.0	2									2	0	38	76	0
10-21-80	NIGHT	10.5	3									3	0	216	648	0
	TOTAL													461	724	0
10-29-80	DAWN	7.0	2									2	0	38	76	0
10-29-80	DAY	8.0										0	0	165	0	0
10-28-80	DUSK	7.0	3									3	0	38	114	0
10-29-80	NIGHT	7.0										0	0	221	0	0
	TOTAL													462	190	0
11-05-80	DAY	8.5										0	0	463	0	0
	TOTAL													463	0	0
11-14-80	DAWN	7.0										0	0	38	0	0
11-13-80	DAY	8.0										0	0	149	0	0
11-13-80	DUSK	8.0	3									3	0	38	114	0
11-14-80	NIGHT	7.0										0	0	237	0	0
	TOTAL													462	114	0
11-18-80	DAY	6.0										0	0	165	0	0
11-18-80	DUSK	6.0										0	0	38	0	0
11-19-80	NIGHT	6.0										0	0	259	0	0
	TOTAL													462	0	0
11-25-80	DAWN	3.0										0	0	38	0	0
11-25-80	DAY	4.0										0	0	142	0	0
11-25-80	DUSK	3.0										0	0	38	0	0
11-25-80	NIGHT	4.0										0	0	243	0	0
	TOTAL													461	0	0
12-03-80	DAWN	1.0										0	0	38	0	0
12-03-80	DAY	1.0										0	0	138	0	0
12-03-80	DUSK	0.0										0	0	38	0	0
12-04-80	NIGHT	0.0										0	0	248	0	0
	TOTAL													462	0	0

Appendix 12. A weekly summary of fish larvae and eggs entrained by Units 1 and 2 of the J. H. Campbell Plant from March through December 1981. This summary includes average number of fish larvae and eggs entrained per diel period. See Appendix 1 for species code identification.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	SP	YP	SM	CP	JD	XP	PM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3	WATER VOLUME PUMPED IN 1000 M^3	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
			NUMBER OF LARVAE PER 1000 M^3													
3-28-81	DAWN	6.0										0	0	101	0	0
3-28-81	DAY	3.5										0	0	540	0	0
3-28-81	DUSK	7.0										0	0	101	0	0
3-28-81	NIGHT	7.0							2			2	0	474	948	0
	TOTAL													1216	948	0
4-01-81	DAY	9.0									XC: 1	1	0	828	828	0
4-02-81	NIGHT	8.0									XC: 8	8	0	743	5944	0
	TOTAL													1571	6772	0
4-09-81	DAY	11.0									XC: 125					
											BR: 6	131	0	894	117114	0
4-10-81	NIGHT	10.0		3							XC: 106	109	0	740	80660	0
	TOTAL													1634	197774	0
4-14-81	DAY	12.0			11							11	0	838	9218	0
4-14-81	NIGHT	12.0									XC: 43	43	0	669	28767	0
	TOTAL													1507	37985	0
4-22-81	DAY	10.0										0	1	941	0	941
4-23-81	NIGHT	10.0		2								2	0	693	1386	0
	TOTAL													1634	1386	941
4-27-81	DAY	11.0			66							66	1	957	63162	957
4-27-81	NIGHT	18.5			52				3		BR: 1					
											XS: 5	61	0	677	41297	0
	TOTAL													1634	104459	957
5-04-81	DAY	13.0			10	29					BR: 3	42	0	972	40824	0
5-04-81	NIGHT	13.0			3	15						18	0	662	11916	0
	TOTAL													1634	52740	0
5-12-81	DAY	8.0			4	2						6	0	708	4248	0
5-12-81	NIGHT	10.0						2	2			4	0	454	1816	0
	TOTAL													1162	6064	0
5-18-81	DAY	10.1								3		3	2	1008	3024	2016
5-19-81	NIGHT	9.0				11			1	1		13	0	626	8138	0
	TOTAL													1634	11162	2016

Appendix 12. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	NUMBER OF LARVAE PER 1000 M³ AL	SP	YP	SM	CP	JD	XP	PM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
5-29-81	DAY	13.0							2	2		4	4	1028	4112	4112
5-29-81	NIGHT	13.0					1	1	1			3	5	606	1818	3030
	TOTAL													1634	5930	7142
6-04-81	DAY	17.5	2				14					16	77	1035	16560	79695
6-05-81	NIGHT	17.5					22		2			24	61	599	14376	36539
	TOTAL													1634	30936	116234
6-11-81	DAY	19.0	2	6		4	132		16	4		164	256	1041	170724	266496
6-11-81	NIGHT	19.0	9	18	6	21	80	7	13	6	XL: 2 TP: 3	165	1420	594	98010	843480
	TOTAL													1635	268734	1109976
6-15-81	DAY	21.0	95	3	7	6			16		CT: 3	130	153	859	111670	131427
6-15-81	NIGHT	21.5	268	54	6	53	65	9	22	3	TP: 3	483	1632	484	233772	789888
	TOTAL													1343	345442	921315
6-26-81	DAY	16.5	7	2	1		10		7			27	8	1047	28269	8376
6-25-81	NIGHT	17.0	94	330	3	19	79	13	42			580	30	587	340460	17610
	TOTAL													1634	368729	25986
7-01-81	DAY	17.0	12	2			4				XL: 2	20	51	1042	20840	53142
7-01-81	NIGHT	16.9	54	120		9	89	4	8		TP: 7 ES: 4	295	1326	592	174640	784992
	TOTAL													1634	195480	838134
7-09-81	DAY	24.0	101	1					1			103	21	1035	106605	21735
7-09-81	NIGHT	22.5	189	416		1	2	2	10		XL: 2	622	25	599	372578	14975
	TOTAL													1634	479183	36710
7-15-81	DAY	20.5	51	2	4				7		XL: 1	65	10	1030	66950	10300
7-15-81	NIGHT	20.5	57	78			197		24		XL: 6	362	30	604	218648	18120
	TOTAL													1634	285598	28420
7-20-81	DAY	22.0	6	3			8					17	0	1020	17340	0
7-20-81	NIGHT	22.0	7	19			47	2	1			76	0	614	46664	0
	TOTAL													1634	64004	0

Appendix 12. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	SP	YP	SM	CP	JD	XP	PM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3	WATER VOLUME PUMPED IN 1000 M^3	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
					NUMBER OF LARVAE PER 1000 M^3											
7-30-81	DAY	14.0										0	0	998	0	0
7-30-81	NIGHT	14.0		40				3			SV: 3	46	0	637	29302	0
	TOTAL													1635	29302	0
8-06-81	DAY	21.0										0	2	886	0	1772
8-06-81	NIGHT	21.0	23	6				2	2			33	0	603	19899	0
	TOTAL													1489	19899	1772
8-12-81	DAY	24.0	82	2					4			88	0	703	61864	0
8-12-81	NIGHT	23.0	232	23			4	1	8			268	0	495	132660	0
	TOTAL													1198	194524	0
8-18-81	DAY	21.5	311	2			3					316	0	209	66044	0
8-18-81	NIGHT	21.5	1544	79			15		40		XL: 5	1683	0	153	257499	0
	TOTAL													362	323543	0
8-25-81	DAY	19.0	8									8	0	202	1616	0
8-25-81	NIGHT	19.0	16	6			1		1			24	0	160	3840	0
	TOTAL													362	5456	0
9-03-81	DAY	20.5										0	0	538	0	0
9-02-81	NIGHT	20.0	15	3								18	0	442	7956	0
	TOTAL													980	7956	0
9-09-81	DAY	17.5										0	0	797	0	0
9-09-81	NIGHT	17.5	16									16	0	709	11344	0
	TOTAL													1506	11344	0
9-17-81	DAY	16.3	11									11	0	848	9328	0
9-17-81	NIGHT	14.2	25									25	0	786	19650	0
	TOTAL													1634	28978	0
9-24-81	DAY	16.7							1			1	0	815	815	0
9-25-81	NIGHT	16.7	8									8	0	819	6552	0
	TOTAL													1634	7367	0
10-03-81	DAY	6.5										0	0	705	0	0
10-03-81	NIGHT	8.5										0	0	738	0	0
	TOTAL													1443	0	0

Appendix 12. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	SP	YP	SM	CP	JD	XP	PM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
					NUMBER OF LARVAE PER 1000 M³											
10-09-81	DAY	9.4										0	0	736	0	0
10-09-81	NIGHT	9.4										0	0	834	0	0
	TOTAL													1570	0	0
10-16-81	DAY	10.0										0	0	749	0	0
10-16-81	NIGHT	10.0										0	0	885	0	0
	TOTAL													1634	0	0
10-27-81	DAY	8.9	2									2	0	718	1436	0
10-27-81	NIGHT	8.9										0	4	916	0	3664
	TOTAL													1634	1436	3664
11-06-81	DAY	9.9										0	0	574	0	0
11-06-81	NIGHT	11.2										0	0	788	0	0
	TOTAL													1362	0	0
11-12-81	DAY	7.5										0	0	675	0	0
11-12-81	NIGHT	7.5										0	0	959	0	0
	TOTAL													1634	0	0
12-16-81	DAY	1.5										0	0	310	0	0
12-16-81	NIGHT	1.9	3									3	0	515	1545	0
	TOTAL													825	1545	0
12-21-81	DAY	3.5										0	0	378	0	0
12-22-81	NIGHT	3.9										0	0	630	0	0
	TOTAL													1008	0	0

Appendix 13. A weekly summary of fish larvae and eggs entrained by Unit 3 of the J. H. Campbell Plant from September through December 1980. This summary includes average number of fish larvae and eggs entrained per diel period. See Appendix 1 for species code identification.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	CP	YP	SP	SM	XP	XL	PM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
			NUMBER OF LARVAE PER 1000 M³													
9-19-80	DAWN	16.0										0	0	328	0	0
9-18-80	DAY	16.0										0	0	657	0	0
9-18-80	DUSK	16.5									TP: 9	9	0	328	2952	0
	TOTAL													1313	2952	0
9-25-80	DAWN	15.5										0	0	90	0	0
9-24-80	DAY	16.5										0	0	452	0	0
9-24-80	DUSK	15.5										0	0	90	0	0
9-25-80	NIGHT	15.0										0	0	455	0	0
	TOTAL													1087	0	0
10-09-80	DAWN	9.0										0	0	90	0	0
10-08-80	DAY	14.0										0	0	430	0	0
10-08-80	DUSK	14.5										0	0	90	0	0
10-09-80	NIGHT	8.0										0	0	477	0	0
	TOTAL													1087	0	0
10-30-80	DAWN	9.0										0	0	90	0	0
10-29-80	DAY	10.0										0	0	424	0	0
10-29-80	DUSK	9.0										0	0	0	0	0
10-30-80	NIGHT	8.0										0	0	574	0	0
	TOTAL													1088	0	0
11-12-80	DAWN	9.0										0	0	227	0	0
11-13-80	DAY	9.0										0	0	0	0	0
11-12-80	DUSK	8.0										0	0	227	0	0
11-12-80	NIGHT	8.0	3									3	0	635	1905	0
	TOTAL													1089	1905	0
12-17-80	DAWN	4 0										0	0	90	0	0
12-17-80	DAY	4.0										0	0	364	0	0
12-17-80	NIGHT	3.0										0	0	634	0	0
	TOTAL													1088	0	0
12-29-80	DUSK	1.0										0	0	1090	0	0
	TOTAL													1090	0	0

Appendix 14. A weekly summary of fish larvae and eggs entrained by Unit 3 of the J. H. Campbell Plant from January through December 1981. This summary includes average number of fish larvae and eggs entrained per diel period. See Appendix 1 for species code identification.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	SP	SM	YP	JD	SS	XP	TP	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
			NUMBER OF LARVAE PER 1000 M³													
1-15-81	DAWN	3.0										0	0	90	0	0
1-15-81	DAY	3.0										0	0	333	0	0
1-15-81	DUSK	2.0										0	0	90	0	0
1-16-81	NIGHT	2.0										0	0	574	0	0
	TOTAL													1087	0	0
1-29-81	DAWN	2.0										0	0	90	0	0
1-29-81	DAY	2.0										0	0	356	0	0
1-29-81	DUSK	1.5										0	0	90	0	0
1-29-81	NIGHT	2.0										0	0	551	0	0
	TOTAL													1087	0	0
2-14-81	DAWN	1.6										0	0	90	0	0
2-13-81	DAY	1.7										0	0	385	0	0
2-13-81	DUSK	1.4										0	0	90	0	0
2-14-81	NIGHT	2.0										0	0	523	0	0
	TOTAL													1088	0	0
2-27-81	DAWN	2.0										0	0	90	0	0
2-27-81	DAY	3.5										0	0	405	0	0
2-26-81	DUSK	4.0										0	0	90	0	0
2-27-81	NIGHT	2.0										0	0	503	0	0
	TOTAL													1088	0	0
3-17-81	DAWN	1.8										0	7	90	0	630
3-16-81	DAY	1.9										0	0	449	0	0
3-16-81	DUSK	1.9										0	0	90	0	0
3-17-81	NIGHT	3.2										0	0	458	0	0
	TOTAL													1087	0	630
3-27-81	DAWN	4.0										0	0	90	0	0
3-27-81	DAY	4.0										0	6	472	0	2832
3-27-81	DUSK	4.0										0	0	90	0	0
3-28-81	NIGHT	4.0										0	0	436	0	0
	TOTAL													1088	0	2832
4-01-81	DAWN	5.0										0	0	90	0	0
4-01-81	DAY	5.0										0	0	483	0	0
3-31-81	DUSK	5.0										0	0	90	0	0
4-01-81	NIGHT	5.0										0	0	424	0	0
	TOTAL													1087	0	0

Appendix 14. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	SP	SM	YP	JD	SS	XP	TP	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
			NUMBER OF LARVAE PER 1000 M³													
4-22-81	DAWN	8.0										0	0	90	0	0
4-22-81	DAY	7.5										0	18	536	0	9648
4-22-81	DUSK	7.7										0	0	90	0	0
4-23-81	NIGHT	7.9										0	0	371	0	0
	TOTAL													1087	0	9648
4-28-81	DAWN	9.0										0	0	90	0	0
4-27-81	DAY	10.0				53						53	0	547	28991	0
4-27-81	DUSK	11.0				49						49	0	90	4410	0
4-27-81	NIGHT	10.0										0	16	361	0	5776
	TOTAL													1088	33401	5776
5-05-81	DAWN	11.0										0	0	109	0	0
5-04-81	DAY	9.0										0	0	672	0	0
5-04-81	DUSK	9.0										0	0	109	0	0
5-05-81	NIGHT	9.0										0	14	423	0	5922
	TOTAL													1313	0	5922
5-13-81	DAWN	7.8		8								8	14	90	720	1260
5-12-81	DAY	7.2			15							15	0	573	8595	0
5-12-81	DUSK	7.5			21							21	6	90	1390	540
5-13-81	NIGHT	7.4			5							5	0	335	1675	0
	TOTAL													1088	12880	1800
5-19-81	DAWN	7.0			9							9	0	90	810	0
5-18-81	DAY	7.5										0	0	581	0	0
5-18-81	DUSK	7.5										0	0	90	0	0
5-18-81	NIGHT	7.5			5						FS: 15	20	0	327	6540	0
	TOTAL													1088	7350	0
5-29-81	DAWN	12.2						87				87	0	90	7830	0
5-29-81	DAY	9.4										0	0	595	0	0
5-28-81	DUSK	9.5						4				4	0	90	360	0
5-29-81	NIGHT	8.5										0	0	313	0	0
	TOTAL													1088	8190	0
6-05-81	DAWN	12.0						65				65	0	90	5850	0
6-04-81	DAY	12.0						7				7	8	599	4193	4792
6-04-81	DUSK	12.0						17				17	0	90	1530	0
6-04-81	NIGHT	12.0			12			102				114	0	308	35112	0
	TOTAL													1087	46685	4792

Appendix 14. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	SP	NUMBER OF LARVAE PER 1000 M³ SM	YP	JD	SS	XP	TP	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
6-11-81	DAWN	17.3	4		8	37		8	4			61	5199	109	6649	566691
6-11-81	DAY	17.7				5						5	167	731	3655	122077
6-10-81	DUSK	16.5	14	93	3	33	7	147	21	3		321	1163	109	34989	126767
6-11-81	NIGHT	17.7	3	168	9	46		24	6	13	CP: 12	281	22512	364	102284	8194368
	TOTAL													1313	147577	9009903
6-16-81	DAWN	19.5	351	72		304		8	30			765	2468	147	112455	362796
6-15-81	DAY	17.8	69			117			24			210	169	982	206220	165958
6-15-81	DUSK	17.8	162	67	9	813	60	202	120			1433	2357	147	210651	346479
6-15-81	NIGHT	17.8	306	59	40	276	15	147	36		NS: 9	888	10137	489	434232	4956993
	TOTAL													1765	963558	5832226
6-26-81	DAWN	12.0	16	6			2	3	3			30	23	147	4410	3381
6-26-81	DAY	9.5	16							3		19	9	982	18658	8838
6-25-81	DUSK	11.5	99	60						2		161	19	147	23667	2793
6-26-81	NIGHT	12.8		23				7	3	3		36	13	489	17604	6357
	TOTAL													1765	64339	21369
7-02-81	DAWN	14.2										0	4915	90	0	442350
7-01-81	DAY	15.1	9									9	41	604	5436	24764
7-01-81	DUSK	14.7	17	112			5				NS: 12	146	330	90	13140	29700
7-02-81	NIGHT	14.4	35	12			12	12	25	25		121	196	304	36784	59584
	TOTAL													1088	55360	556398
7-10-81	DAWN	9.2	30			15	15					60	6783	128	7680	868224
7-09-81	DAY	20.0	17	7			3					27	218	847	22869	184646
7-09-81	DUSK	10.8	63	57			27			6	NS: 6	159	164	128	20352	20992
7-09-81	NIGHT	10.0	22	24			17		3	3	NS: 6					
											CP: 3	78	132	436	34008	57552
	TOTAL													1539	84909	1131414
7-15-81	DAWN	11.4	6	2						2		10	2106	128	1280	269568
7-15-81	DAY	19.6	12									12	230	842	10104	193660
7-14-81	DUSK	14.5	22	6			10			3		41	442	128	5248	56576
7-15-81	NIGHT	12.8	3	25			6	3		3		40	618	441	17640	272538
	TOTAL													1539	34272	792342

Appendix 14. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	SP	SM	YP	JD	SS	XP	TP	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
					NUMBER OF LARVAE PER 1000 M³											
7-20-81	DAWN	10.0	20	9								29	274	109	3161	29866
7-20-81	DAY	17.5										0	5	703	0	3515
7-20-81	DUSK	13.0	146						4		GS: 4	154	51	109	16786	5559
7-20-81	NIGHT	11.0	12	12								24	24	392	9408	9408
	TOTAL													1313	29355	48348
7-31-81	DAWN	17.0										0	0	60	0	0
7-30-81	DAY	9.0										0	0	383	0	0
7-30-81	DUSK	11.0										0	0	60	0	0
7-31-81	NIGHT	12.0										0	0	222	0	0
	TOTAL													725	0	0
8-06-81	DAWN	19.8		3			3					6	512	98	588	50176
8-06-81	DAY	21.0										0	25	602	0	15050
8-06-81	DUSK	21.5	7								GS: 3	10	7	98	980	686
8-07-81	NIGHT	21.0	21	17			7					45	1832	378	17010	692496
	TOTAL													1176	18578	758408
8-12-81	DAWN	23.0	18	11								29	0	147	4263	0
8-12-81	DAY	22.6		4								4	0	888	3552	0
8-11-81	DUSK	21.4	29	3			16				NS: 3	51	0	147	7497	0
8-12-81	NIGHT	22.3		13						3		16	0	582	9312	0
	TOTAL													1764	24624	0
8-17-81	DAWN	24.0	7									7	0	147	1029	0
8-17-81	DAY	17.0										0	0	871	0	0
8-17-81	DUSK	15.0									NS: 3	3	0	147	441	0
8-18-81	NIGHT	9.0										0	0	599	0	0
	TOTAL													1764	1470	0
9-05-81	DAWN	3.2										0	0	147	0	0
9-04-81	DAY	7.7										0	0	804	0	0
9-04-81	DUSK	7.3								3		3	0	147	441	0
9-05-81	NIGHT	7.0										0	0	667	0	0
	TOTAL													1765	441	0
9-09-81	DAWN	15.5										0	0	90	0	0
9-09-81	DAY	17.4										0	0	485	0	0
9-09-81	DUSK	19.0										0	0	90	0	0
9-09-81	NIGHT	18.5										0	0	422	0	0
	TOTAL													1087	0	0

Appendix 14. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	SP	NUMBER OF LARVAE PER 1000 M³ SM	YP	JD	SS	XP	TP	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
9-19-81	DAWN	8.5										0	0	90	0	0
9-18-81	DAY	5.2										0	0	464	0	0
9-18-81	DUSK	5.6										0	0	90	0	0
9-18-81	NIGHT	5.6										0	0	444	0	0
	TOTAL													1088	0	0
9-24-81	DAWN	16.2										0	0	90	0	0
9-24-81	DAY	16.7										0	0	452	0	0
9-24-81	DUSK	17.0										0	0	90	0	0
9-25-81	NIGHT	17.0										0	0	455	0	0
	TOTAL													1087	0	0
10-03-81	DAWN	8.0										0	0	109	0	0
10-03-81	DAY	6.5										0	0	533	0	0
10-03-81	DUSK	8.0										0	0	109	0	0
10-03-81	NIGHT	8.5										0	0	562	0	0
	TOTAL													1313	0	0
10-10-81	DAWN	11.3										0	0	30	0	0
10-09-81	DAY	7.5										0	0	140	0	0
10-09-81	DUSK	8.3										0	9	30	0	270
10-09-81	NIGHT	9.8										0	0	162	0	0
	TOTAL													362	0	270
10-20-81	DAWN	11.0										0	0	90	0	0
10-20-81	DAY	11.2								3		3	0	398	1194	0
10-19-81	DUSK	11.2										0	0	90	0	0
10-20-81	NIGHT	12.0										0	0	509	0	0
	TOTAL													1087	1194	0
10-27-81	DAWN	10.2										0	0	90	0	0
10-27-81	DAY	10.6										0	0	388	0	0
10-27-81	DUSK	10.2										0	0	90	0	0
10-27-81	NIGHT	10.5										0	0	520	0	0
	TOTAL													1088	0	0
11-06-81	DAWN	10.5										0	0	90	0	0
11-06-81	DAY	10.4										0	0	368	0	0
11-05-81	DUSK	10.9										0	0	90	0	0
11-06-81	NIGHT	11.2										0	14	539	0	7546
	TOTAL													1087	0	7546

Appendix 14. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	SP	SM	YP	JD	SS	XP	TP	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
			NUMBER OF LARVAE PER 1000 M³													
11-13-81	DAWN	8.4										0	0	90	0	0
11-12-81	DAY	8.1										0	0	359	0	0
11-12-81	DUSK	8.4										0	0	90	0	0
11-13-81	NIGHT	8.6										0	0	548	0	0
	TOTAL													1087	0	0
12-22-81	DAWN	2.4										0	0	90	0	0
12-21-81	DAY	2.0										0	0	317	0	0
12-21-81	DUSK	1.9										0	0	90	0	0
12-22-81	NIGHT	2.1										0	0	590	0	0
	TOTAL													1087	0	0
12-23-81	DAWN	2.3										0	0	90	0	0
12-23-81	DAY	2.2										0	0	317	0	0
12-23-81	DUSK	2.0										0	0	90	0	0
12-24-81	NIGHT	2.3										0	0	590	0	0
	TOTAL													1087	0	0

Appendix 15. Number of fish fry per 1000 m^3 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan, during 1981. D = day, N = night. See Appendix 1 for species code identification.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	NUMBER OF FRY PER 1000 M³ SM	AL	SP	TP	XC	YP	JD	PP	BM	GS	ES	NS	MISC.	TOTAL NUMBER OF FRY PER 1000 M³
4-16-81	N	L	0.5	5.7	30													30
5-07-81	N	R*	1.0	11.0		1401												1401
5-07-81	N	I*	1.5	9.0		414												414
5-05-81	N	W*	15.0	6.9	18													18
5-18-81	N	R*	1.0	8.0			106											106
5-18-81	N	J*	3.0	7.0		147												147
5-19-81	N	N	6.5	6.9		30												30
6-04-81	N	R*	1.0	13.2		74	74											148
6-04-81	D	I	0.5	18.3		25												25
6-04-81	N	J	0.5	16.8		37												37
6-04-81	N	O	3.0	13.5		61												61
6-15-81	N	L*	6.0	18.0		38												38
6-15-81	N	O	11.0	22.3		23												23
7-01-81	D	I*	1.5	16.3		145												145
7-01-81	N	I*	1.5	15.7	52													52
7-01-81	N	L*	6.0	15.0	34													34
7-01-81	D	N	2.5	15.5	22													22
7-02-81	N	N	8.5	11.8		25												25
7-01-81	N	O*	12.0	13.0	30													30
7-01-81	N	W	0.5	16.5		17												17
7-01-81	N	W	4.5	16.4	19													19
7-01-81	N	W	11.5	12.8		19												19
8-05-81	N	I*	1.5	22.0		93	23											116
8-05-81	N	L*	6.0	20.5	28													28
8-06-81	D	N	4.5	22.0		13												13
8-07-81	N	N	4.5	22.1		38												38
8-06-81	N	O	9.0	18.8		15												15
8-06-81	N	O	11.0	18.8	14													14
8-05-81	N	O*	12.0	20.4	116			29										145
8-06-81	N	W	14.0	17.6					17									17
8-05-81	N	W*	15.0	20.3	321													321

Appendix 15. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	SM	AL	SP	TP	XC	YP	JD	PP	BM	GS	ES	NS	MISC.	TOTAL NUMBER OF FRY PER 1000 M³
					NUMBER OF FRY PER 1000 M³													
8-18-81	N	R*	1.0	19.4	317		126											443
8-18-81	N	I	0.5	20.2	22													22
8-18-81	N	I*	1.5	19.2	588					34								622
8-18-81	N	J	0.5	19.9	25													25
8-18-81	N	J	2.5	14.8	16													16
8-18-81	N	J*	3.0	14.8	390													390
8-18-81	N	L	2.0	18.5	29	149												178
8-18-81	N	L	5.5	7.7		23												23
8-18-81	N	L*	6.0	9.5	768													768
8-17-81	N	N	2.5	19.4		110												110
8-17-81	N	N	4.5	6.9		29												29
8-17-81	N	N	6.5	6.4	15	31												46
8-17-81	N	N	8.5	6.3		30												30
8-17-81	N	N*	9.0	7.7	50													50
8-17-81	N	O	0.5	20.9		17												17
8-17-81	N	O	3.0	20.8		32												32
8-17-81	N	O	6.0	11.0		18												18
8-17-81	N	O	11.0	7.4	29													29
8-17-81	N	O*	12.0	7.5	18													18
8-17-81	N	W	8.5	6.8	21													21
8-17-81	N	W	14.0	6.1	13	13												26
8-17-81	N	W*	15.0	7.0	24													24
9-08-81	D	R*	1.0	14.8	230													230
9-08-81	N	R*	1.0	14.8	549													549
9-08-81	D	I*	1.5	14.8	29													29
9-08-81	N	I*	1.5	15.0	66													66
9-08-81	D	J*	3.0	15.2	177													106
9-08-81	N	J*	3.0	15.6	42													42
9-11-81	N	L	2.0	20.3	16	33												49
9-11-81	N	L	5.5	20.0		15												15
9-10-81	N	N	2.5	20.6	15													15
9-10-81	N	N	4.5	20.5	14													14
9-11-81	N	N	8.5	20.4	17													17
9-08-81	N	N*	9.0	15.5	116													116
9-10-81	N	O	3.0	20.6	13	13			13									39
9-08-81	N	O*	12.0	15.5	27													27
9-10-81	N	W	4.5	20.4		12												12

Appendix 15. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	SM	AL	SP	TP	XC	YP	JD	PP	BM	GS	ES	NS	MISC.	TOTAL NUMBER OF FRY PER 1000 M^3
					NUMBER OF FRY PER 1000 M^3													
4-13-81	N	P*	1.0	8.8			53					106						159
4-13-81	N	A*	1.5	7.8			61						61					122
4-13-81	N	B*	3.0	7.5	52													52
4-15-81	N	C	2.0	7.8	60													60
4-15-81	N	C	5.5	7.8	34													34
4-15-81	N	D	6.5	6.9		54												54
4-13-81	N	E*	12.0	6.8							68							68
5-04-81	N	A*	1.5	12.0	101													101
5-04-81	N	D	6.5	8.7		39												39
5-04-81	N	D	8.5	8.7	57													57
5-18-81	N	C	2.0	7.0		28												28
5-18-81	N	D*	9.0	6.5			63											63
5-18-81	N	E*	12.0	6.0			46				46							92
5-18-81	N	F*	15.0	6.0							33							33
6-02-81	N	P*	1.0	13.4							40							40
6-02-81	N	A*	1.5	13.2							46							46
6-04-81	N	C	2.0	12.8	55	27												82
6-04-81	N	C	4.0	11.8		49												49
6-04-81	N	C	5.5	11.5	35													35
6-15-81	N	P	0.5	21.5		91												91
6-15-81	N	P*	1.0	21.5			40											40
6-15-81	N	A	0.5	21.5		16												16
6-15-81	D	C	2.0	22.8		26												26
6-15-81	N	D*	9.0	19.2							26							26
6-15-81	N	F	14.0	18.0		42												42
7-01-81	N	B*	3.0	16.7		23	94											117
7-01-81	N	C	4.0	14.9		21												21
7-01-81	N	D	4.5	15.0	38													38

Appendix 15. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	SM	AL	SP	TP	XC	YP	JD	PP	BM	GS	ES	NS	MISC.	TOTAL NUMBER OF FRY PER 1000 M^3
					NUMBER OF FRY PER 1000 M^3													
7-19-81	N	B*	3.0	21.7	21													21
7-20-81	N	C	5.5	19.0	15													15
7-19-81	N	C*	6.0	20.7	141													141
7-19-81	N	D*	9.0	17.9	28													28
8-05-81	N	A*	1.5	21.0			40											40
8-05-81	N	C*	6.0	21.0	78													78
8-05-81	N	D*	9.0	20.6	33													33
8-05-81	N	E*	12.0	19.0	59													59
8-06-81	N	F	0.5	22.2	15				15									30
8-05-81	N	F*	15.0	17.8	59													59
8-17-81	N	P*	1.0	13.9	757													757
8-17-81	N	C	2.0	20.4	17	89												106
8-17-81	N	C	4.0	20.2		35												35
8-17-81	N	C	5.5	15.0		77												77
8-17-81	N	D	2.5	20.4		97			19									116
8-17-81	N	D	4.5	17.0		102												102
8-17-81	N	D	6.5	8.8		81												81
8-17-81	N	D	8.5	8.5	70													70
8-17-81	N	E	0.5	19.8		109												109
8-17-81	N	E	6.0	14.9		37												37
8-17-81	N	E	11.0	7.1	39													39
8-17-81	N	E*	12.0	6.2	45													45
8-17-81	D	F	0.5	20.5	24													24
8-17-81	N	F	0.5	19.2	23													23
8-18-81	N	F*	15.0	5.5	379													379
9-08-81	N	A*	1.5	16.5	60													60
9-10-81	N	B	2.5	20.7	23													23
9-08-81	N	B*	3.0	16.5	47													47
9-10-81	N	C	2.0	20.7	41													41
9-10-81	N	C	5.5	20.5	26	13												39
9-10-81	N	D	2.5	21.2	13	13												26
9-09-81	N	D*	9.0	16.8	55													55
9-10-81	N	E	0.5	21.0		25												25
9-10-81	N	E	3.0	21.0	16	16												32
9-10-81	N	E	6.0	20.9		15												15
9-10-81	N	E	11.0	20.6	15	15												30
9-08-81	N	E*	12.0	15.5	121													121
9-10-81	N	F	4.5	21.2		28												28
9-10-81	N	F	11.5	20.7		15												15
9-08-81	N	F*	15.0	15.0	249													249

Appendix 16. Number of fish fry per 1000 m^3 in entrainment samples collected at Units 1 and 2 of the J. H. Campbell Plant, eastern Lake Michigan, during 1980. D = day, N = night, W = dawn and K = dusk. See Appendix 1 for species code identification.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	NUMBER OF FRY PER 1000 M^3 SM	AL	SP	TP	XC	YP	JD	PP	BM	GS	ES	NS	MISC.	TOTAL NUMBER OF FRY PER 1000 M^3
4-29-80	K	SD	0.5	9.0	28													28
5-22-80	N	SD	0.5	14.0	9													9
7-03-80	W	SD	0.5	16.5	10													10
7-03-80	W	SD	0.5	16.5	8													8
7-03-80	D	SD	0.5	17.0		8												8
7-03-80	N	SD	0.5	17.0	9													9
7-08-80	W	SD	0.5	16.0	11													11
7-08-80	K	SD	0.5	17.5		7												7
7-08-80	K	SD	0.5	17.5	12													12
7-09-80	N	SD	0.5	18.0	17													17
7-09-80	N	SD	0.5	18.0	33													33
7-17-80	N	SD	0.5	22.5	23													23
7-17-80	N	SD	0.5	22.5	14													14
7-22-80	K	SD	0.5	21.5	28													28
7-23-80	N	SD	0.5	21.0		15												15
8-05-80	W	SD	0.5	22.0		20												20
8-05-80	W	SD	0.5	22.0		9												9
8-04-80	K	SD	0.5	22.0		21												21
8-05-80	N	SD	0.5	21.9	19													19
8-05-80	N	SD	0.5	21.9		31												31
8-05-80	N	SD	0.5	21.9		29												29
8-05-80	N	SD	0.5	21.9		30												30
8-07-80	W	SD	0.5	22.0	5	33												38
8-07-80	W	SD	0.5	22.0		46												46
8-07-80	W	SD	0.5	22.0		70												70
8-07-80	W	SD	0.5	22.0		20												20
8-07-80	D	SD	0.5	23.0		68												68
8-07-80	D	SD	0.5	23.0		32												32
8-07-80	D	SD	0.5	23.0		85												85
8-07-80	K	SD	0.5	23.0		49												49
8-07-80	K	SD	0.5	23.0		59												59
8-07-80	K	SD	0.5	23.0	18	56												74
8-07-80	K	SD	0.5	23.0		20												20
8-08-80	N	SD	0.5	23.0	12	130												142
8-08-80	N	SD	0.5	23.0	6	111												117
8-08-80	N	SD	0.5	23.0		127												127
8-08-80	N	SD	0.5	23.0		97												97

Appendix 16. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	SM	AL	SP	TP	XC	YP	JD	PP	BM	GS	ES	NS	MISC.	TOTAL NUMBER OF FRY PER 1000 M³
					NUMBER OF FRY PER 1000 M³													
8-15-80	W	SD	0.5	19.0	40	32												72
8-15-80	W	SD	0.5	19.0	24	40								8				72
8-15-80	W	SD	0.5	19.0	32	16												48
8-15-80	W	SD	0.5	19.0	33	8												41
8-14-80	D	SD	0.5	20.5	8													8
8-14-80	D	SD	0.5	20.5	16													16
8-14-80	K	SD	0.5	20.0	8	8												16
8-14-80	K	SD	0.5	20.0		8												8
8-15-80	N	SD	0.5	20.0	15	22												37
8-15-80	N	SD	0.5	20.0	16													16
8-15-80	N	SD	0.5	20.0	16	8												24
8-15-80	N	SD	0.5	20.0	32	8												40
8-22-80	W	SD	0.5	21.5	95													95
8-22-80	W	SD	0.5	21.5		37												37
8-22-80	W	SD	0.5	21.5	20													20
8-22-80	W	SD	0.5	21.5	30													30
8-21-80	D	SD	0.5	22.0		9												9
8-21-80	D	SD	0.5	22.0	16	16												32
8-21-80	D	SD	0.5	22.0		8								8				16
8-21-80	K	SD	0.5	22.0	37	93												130
8-21-80	K	SD	0.5	22.0	8	66												74
8-21-80	K	SD	0.5	22.0	22	45												67
8-21-80	K	SD	0.5	22.0	58	39												97
8-22-80	N	SD	0.5	21.0	93	10												103
8-22-80	N	SD	0.5	21.0	39													39
8-22-80	N	SD	0.5	21.0	67	11												78
8-22-80	N	SD	0.5	21.0	102	22												124
8-27-80	W	SD	0.5	22.0	26	8												34
8-27-80	W	SD	0.5	22.0	15													15
8-27-80	W	SD	0.5	22.0		14												14
8-27-80	D	SD	0.5	22.5		8												8
8-27-80	K	SD	0.5	22.5		18												18
8-27-80	K	SD	0.5	22.5		15												15
8-27-80	K	SD	0.5	22.5		6												6
8-28-80	N	SD	0.5	22.0	8	68												76
8-28-80	N	SD	0.5	22.0	22	11												33
8-28-80	N	SD	0.5	22.0		42												42
8-28-80	N	SD	0.5	22.0	15	62												77

Appendix 16. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	SM	AL	SP	TP	XC	YP	JD	PP	BM	GS	ES	NS	MISC.	TOTAL NUMBER OF FRY PER 1000 M³
					NUMBER OF FRY PER 1000 M³													
9-04-80	K	SD	0.5	23.0		13												13
9-05-80	N	SD	0.5	23.0	28	9												37
9-05-80	N	SD	0.5	23.0	9	18												27
9-11-80	W	SD	0.5	20.0		10												10
9-11-80	K	SD	0.5	20.0	10									10				20
9-12-80	N	SD	0.5	20.0		10												10
9-12-80	N	SD	0.5	20.0	9													9
10-08-80	W	SD	0.5	14.0	9													9
10-08-80	W	SD	0.5	14.0	9													9
10-08-80	W	SD	0.5	14.0	19													19
10-08-80	K	SD	0.5	14.5	10													10
10-09-80	N	SD	0.5	14.0	9													9
10-21-80	N	SD	0.5	10.5	13													13
10-28-80	K	SD	0.5	7.0	27													27
10-28-80	K	SD	0.5	7.0	12													12
10-28-80	K	SD	0.5	7.0	21													21
10-28-80	K	SD	0.5	7.0	20													20
11-13-80	K	SD	0.5	8.0	13													13
11-14-80	N	SD	0.5	7.0	14													14
11-25-80	N	SD	0.5	4.0	13													13
12-03-80	K	SD	0.5	0.0	15													15
12-03-80	K	SD	0.5	0.0	16													16
12-03-80	K	SD	0.5	0.0	8													8

Appendix 17. Number of fish fry per 1000 m^3 in entrainment samples collected at Units 1 and 2 of the J. H. Campbell Plant, eastern Lake Michigan, during 1981. D = day, N = night. See Appendix 1 for species code identification.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	NUMBER OF FRY PER 1000 M³ SM	AL	SP	TP	XC	YP	JD	PP	BM	GS	ES	NS	MISC.	TOTAL NUMBER OF FRY PER 1000 M³
3-28-81	D	SD	0.5	3.5								7						7
4-01-81	D	SD	0.5	9.0								7						7
4-01-81	D	SD	0.5	9.0								7						7
4-01-81	D	SD	0.5	9.0								27						27
4-01-81	D	SD	0.5	9.0								24						24
4-02-81	N	SD	0.5	8.0								15						15
4-02-81	N	SD	0.5	8.0								49						49
4-02-81	N	SD	0.5	8.0			36											36
4-02-81	N	SD	0.5	8.0								57						57
4-09-81	D	SD	0.5	11.0								13						13
4-10-81	N	SD	0.5	10.0								46						46
4-10-81	N	SD	0.5	10.0								13						13
4-10-81	N	SD	0.5	10.0	13							13						26
4-10-81	N	SD	0.5	10.0								24						24
4-14-81	D	SD	0.5	12.0								12						12
4-14-81	D	SD	0.5	12.0								38						38
4-14-81	N	SD	0.5	12.0								165						165
4-14-81	N	SD	0.5	12.0	12							61						73
4-14-81	N	SD	0.5	12.0	12							24						36
4-14-81	N	SD	0.5	12.0	24							24						48
4-23-81	N	SD	0.5	10.0	9													9
4-27-81	D	SD	0.5	11.0		7												7
4-27-81	N	SD	0.5	18.5	15													15
4-27-81	N	SD	0.5	18.5	15													15
4-27-81	N	SD	0.5	18.5								7						7
4-27-81	N	SD	0.5	18.5	14	14												28
5-04-81	N	SD	0.5	13.0		7												7
5-04-81	N	SD	0.5	13.0		23												23
5-04-81	N	SD	0.5	13.0		47												47

Appendix 17. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	SM	AL	SP	TP	XC	YP	JD	PP	BM	GS	ES	NS	MISC.	TOTAL NUMBER OF FRY PER 1000 M³
					NUMBER OF FRY PER 1000 M³													
5-12-81	D	SD	0.5	8.0	57													57
5-12-81	D	SD	0.5	8.0	33								11					44
5-12-81	D	SD	0.5	8.0	9													9
5-12-81	D	SD	0.5	8.0	38	9												47
5-12-81	N	SD	0.5	10.0	18													18
5-12-81	N	SD	0.5	10.0		9												9
5-12-81	N	SD	0.5	10.0		8	8											16
5-18-81	D	SD	0.5	10.1		8												8
5-19-81	N	SD	0.5	9.0		14												14
5-29-81	N	SD	0.5	13.0		9												9
5-29-81	N	SD	0.5	13.0		7												7
5-29-81	N	SD	0.5	13.0		23												23
5-29-81	N	SD	0.5	13.0	7													7
6-05-81	N	SD	0.5	17.5		8												8
6-11-81	D	SD	0.5	19.0		33												33
6-11-81	D	SD	0.5	19.0		8												8
6-11-81	D	SD	0.5	19.0		8												8
6-10-81	N	SD	0.5	19.0		7												7
6-25-81	N	SD	0.5	17.0		15												15
6-25-81	N	SD	0.5	17.0	18													18
7-01-81	N	SD	0.5	16.9	8													8
7-01-81	N	SD	0.5	16.9	8													8
7-09-81	D	SD	0.5	24.0		30												30
7-09-81	D	SD	0.5	24.0		5												5
7-09-81	N	SD	0.5	22.5	29													29
7-09-81	N	SD	0.5	22.5	52													52
7-09-81	N	SD	0.5	22.5	31													31

Appendix 17. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	SM	AL	SP	TP	XC	YP	JD	PP	BM	GS	ES	NS	MISC.	TOTAL NUMBER OF FRY PER 1000 M^3
					NUMBER OF FRY PER 1000 M^3													
7-20-81	N	SD	0.5	22.0	5													5
7-20-81	N	SD	0.5	22.0	5													5
7-30-81	D	SD	0.5	14.0	7													7
7-30-81	N	SD	0.5	14.0	10													10
7-30-81	N	SD	0.5	14.0	10		10											20
7-30-81	N	SD	0.5	14.0			24											24
8-06-81	N	SD	0.5	21.0	8													8
8-06-81	N	SD	0.5	21.0	9													9
8-06-81	N	SD	0.5	21.0	27	9	9											45
8-12-81	N	SD	0.5	23.0	12													12
8-12-81	N	SD	0.5	23.0		6												6
8-18-81	D	SD	0.5	21.5			17											17
8-17-81	N	SD	0.5	21.5		9												9
8-25-81	N	SD	0.5	19.0	68	31												99
8-25-81	N	SD	0.5	19.0	22	22												44
8-25-81	N	SD	0.5	19.0	71	6												77
8-25-81	N	SD	0.5	19.0	42													42
9-02-81	N	SD	0.5	20.0		13												13
9-02-81	N	SD	0.5	20.0		10												10
9-09-81	D	SD	0.5	17.5	32													32
9-09-81	D	SD	0.5	17.5	31	10												41
9-09-81	N	SD	0.5	17.5	105													105
9-09-81	N	SD	0.5	17.5	79	13												92
9-09-81	N	SD	0.5	17.5	77													77
9-09-81	N	SD	0.5	17.5	65													65
9-17-81	D	SD	0.5	16.3	14													14
9-17-81	D	SD	0.5	16.3	28													28
9-17-81	D	SD	0.5	16.3	18													18
9-17-81	N	SD	0.5	14.2	350	37												387
9-17-81	N	SD	0.5	14.2	428	9												437
9-17-81	N	SD	0.5	14.2	415	71												486
9-17-81	N	SD	0.5	14.2	322	58												380

Appendix 17. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	NUMBER OF FRY PER 1000 M³ SM	AL	SP	TP	XC	YP	JD	PP	BM	GS	ES	NS	MISC.	TOTAL NUMBER OF FRY PER 1000 M³
9-24-81	D	SD	0.5	16.7	7													7
9-25-81	N	SD	0.5	16.7	85													85
9-25-81	N	SD	0.5	16.7	62	38												100
9-25-81	N	SD	0.5	16.7	31	15												46
9-25-81	N	SD	0.5	16.7	54													54
10-03-81	D	SD	0.5	6.5	9													9
10-03-81	N	SD	0.5	8.5	36													36
10-03-81	N	SD	0.5	8.5	8													8
10-03-81	N	SD	0.5	8.5	61													61
10-09-81	D	SD	0.5	9.4	21													21
10-09-81	N	SD	0.5	9.4	41													41
10-09-81	N	SD	0.5	9.4	38		12											50
10-09-81	N	SD	0.5	9.4	34													34
10-16-81	D	SD	0.5	10.0	20													20
10-16-81	D	SD	0.5	10.0	10													10
10-16-81	N	SD	0.5	10.0	26													26
10-16-81	N	SD	0.5	10.0	15		7								7			29
10-16-81	N	SD	0.5	10.0	20	10												30
10-16-81	N	SD	0.5	10.0	28													28
11-06-81	D	SD	0.5	9.9		10												10
11-06-81	N	SD	0.5	11.2	7													7
11-06-81	N	SD	0.5	11.2		7												7
11-06-81	N	SD	0.5	11.2		9												9
11-12-81	D	SD	0.5	7.5											8			8
11-12-81	N	SD	0.5	7.5		7	7											14
11-12-81	N	SD	0.5	7.5		7												7
11-12-81	N	SD	0.5	7.5		8												8

Appendix 18. Number of fish fry per 1000 m^3 in entrainment samples collected at Unit 3 of the J. H. Campbell Plant, eastern Lake Michigan, during 1981. D = day, N = night, W = dawn and K = dusk. See Appendix 1 for species code identification.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	NUMBER OF FRY PER 1000 M^3 SM	AL	SP	TP	XC	YP	JD	PP	BM	GS	ES	NS	MISC.	TOTAL NUMBER OF FRY PER 1000 M^3
2-27-81	N	SD	12.0	2.0	14													14
8-06-81	W	SD	12.0	19.8	12													12
8-17-81	K	SD	12.0	15.0	43													43
9-04-81	K	SD	12.0	7.3	15													15
9-04-81	N	SD	12.0	7.0	56													56
9-04-81	N	SD	12.0	7.0	19													19
9-04-81	N	SD	12.0	7.0	17													17
9-05-81	N	SD	12.0	7.0	36													36