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To Enviro.
M. SLATER

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GREAT LAKES RESEARCH DIVISION

THE UNIVERSITY OF MICHIGAN
INSTITUTE OF SCIENCE AND TECHNOLOGY BUILDING
ANN ARBOR, MICHIGAN 48105
313/764-2420

December 15, 1975

50-315

Mr. Charles Domeck
Project Manager
Directorate of Licensing
Nuclear Regulatory Commission
Washington, DC 20545

Dear Mr. Domeck:

Attached is an informal report, "Study of the horizontal and vertical distribution of entrained animals in the Cook Plant intake forebay", by Samuel C. Mozley and Edward M. Johnston. We are sending it to keep you informed on our search for an optimum sampling location within the forebay. The Technical Specifications (p. 4.1-27) have required us to look at possible stratification within the forebay before deciding on a permanent sampling location. The studies are now complete, and we have decided to ask the Company to install two permanent sampling pipes at screen MTR 1-5, just upstream of the trash bars. (This location is shown in Figure 1 of the attached report). Both pipes will draw water from a depth of 5.6 meters below the surface; two pipes are needed so that zooplankton and fish larvae samples can be collected simultaneously during the same 24-hour period. Other procedures will continue unchanged.

The chosen location is near the center of what we believe to be the main path of water flow into Unit I. The depth is close to the mean depth of the forebay. Before making this choice, we compared the results of sampling from a number of different locations within the forebay. Details are given in the attached report.

So far as we know, installation of these fixed pipes is permitted by the Tech. Specs and does not require any government approvals. We are writing to keep you informed on our progress and to provide an opportunity for any comments you may wish to make. If any further information is desired, please contact us. A copy of our letter to the Company requesting the pipes is enclosed.

Our records do not contain your current title and mailing address at the NRC. We would appreciate learning the correct version if different from the one used above.

Sincerely,

John C. Ayers

John C. Ayers
Research Oceanographer

14159

Enc: (1) Report
(2) Copy of letter to AEP

A study of the horizontal and vertical distribution of entrained animals in the Cook Plant intake forebay

(This report was compiled from available project data on 12-11-75, by Samuel C. Mozley and Edward M. Johnston)

The relevant section of the Environmental Technical Specifications is 4.1.2.1.3, on page 4.1-27: "Study of Plankton, Benthos and Fish Egg and Larvae Intake Entrainment." We quote below the two passages that concern the choice of a sampling location:

Fish Entrainment and Entrainable Benthos (p. 4.1-27)

"Fish, fish larvae, fish eggs, and benthos shall be sampled at two locations: in the intake forebay and discharge forebay following passage through the condensers. Testing shall be done during 1974, to determine existence or non-existence of vertical stratification in the intake and discharge forebays; three depths shall be sampled: near the bottom, at mid-depth and near the surface. If vertical stratification is, or is not, observed, sufficient samples to meet statistical reliability shall be taken in each forebay."

Zooplankton Entrainment (p. 4.1-28)

"Zooplankton samples shall be collected in the intake forebay, discharge forebay following passage through the condenser, and within the plume... After preliminary experiments to determine whether horizontal or vertical stratification exists and to choose a representative sampling position, statistically reliable (e.g., replicate samples) sampling shall be performed at least monthly."

After making the studies required above, we have selected screen MTR 1-5 (Fig. 1) as the location for a permanent sampling pipe, which will draw water from 5.6 meters (18') below the intake forebay water surface. There is always the chance that the results would be different if samples were drawn from a different location, but the studies have convinced us that such differences would be negligible. The chosen location is

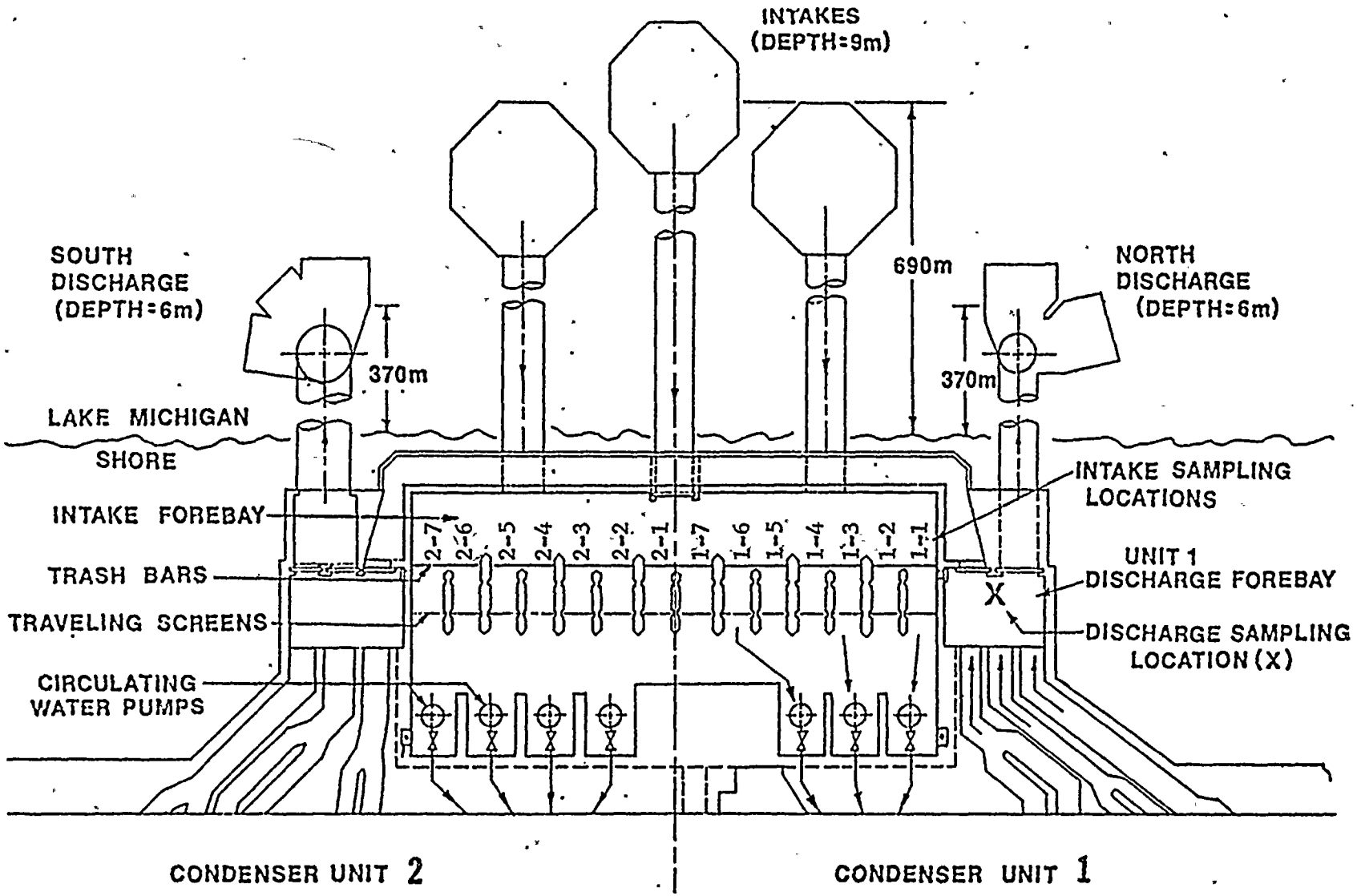

Figure 1. Diagram of the intake and discharge forebays of the Cook Plant, showing the numbering system for the travelling screens. It is proposed to install two permanent sampling pipes in front of screen MTR 1-5.

near the center of what we believe to be the main path of water flow into Unit I. The depth is close to the mean depth of the forebay.

If the horizontal and vertical distributions of plants and animals within the forebay were very uneven, it is possible that a permanent bias in our abundance results would result. This might occur if the single sampling point had consistently high or consistently low abundance, month after month, compared to the true mean of the forebay. It is possible to check for the presence of bias at our chosen location by taking samples at the chosen location and at a number of alternative locations. The best available estimate of the true forebay mean abundance of a taxon at a given moment is the mean of the values found at all locations sampled. The mean at our chosen location can then be compared to the mean of all locations, to determine the extent of any bias. Repeated samples at each individual location will give varying results because of time variations and the normal sampling-associated errors. No bias should be considered serious if it is similar in magnitude to the variation that normally occurs between replicates. The error due to variation among replicates can be used to set 95% confidence limits on the bias estimate at the chosen sampling location. The scheme that we use to find the limits is a straightforward one-way analysis of variance. The bias at our chosen location is simply the main effect (L_i) at that location. The linear model for the ANOVA is as follows:

$$Y_{ij} = \mu + L_i + \varepsilon_{ij}$$

where: Y_{ij} is the abundance of the given taxon at location i, as measured by the jth replicate

μ is the true grand mean of all locations

L_i is the true difference between the mean at the ith location and the mean of all locations

ε_{ij} is the error in the jth replicate at the ith location

The index i runs over all locations sampled and j runs over replicates at each location

For each taxon, the measured abundances are analyzed with the above model to obtain an estimate of L and to set 95% confidence limits on the estimate. The statistic used to estimate L is the difference between the mean of the replicates at the chosen location and the mean of all replicates at all locations. The 95% confidence interval can be found using a formula given by Kirk[1], that applies to any contrast. In our case, Kirk's expression gives the following confidence limits:

$$\Pr\left\{\hat{L}_c - t_{.05[\nu]}\sqrt{\frac{MS_e\,(p-1)}{pm}} < L_c < \hat{L}_c + t_{.05[\nu]}\sqrt{\frac{MS_e(p-1)}{pm}}\right\} = .95$$

where: $\hat{L}_c$ is the difference between the mean of replicates at the chosen location ('c') and the mean at all locations

MS_e is the within-cell error mean square of the analysis of variance

p is the number of locations sampled

m is the number of replicates at each location

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[1] Kirk, Roger E. (1968): Experimental Design: Procedures for the Behavioral Sciences, (Brooks/Cole, Belmont, Calif.) P. 74

ν is the number of degrees of freedom of the error mean square. This analysis was carried out separately for each group of organisms.

Sampling Methods

Methods for drawing samples from the forebay were basically the same for all groups. Diaphragm pumps with a rated capacity of 360 liters per minute pumped water through flexible plastic hoses which were lowered to the desired sampling depth through grates above the forebay. Zooplankton were strained from approximately 0.5 m^3 of water, as measured by flowmeters or time of pumping, and concentrated in #10 mesh Nitex nets. Suspended benthos were strained from about 2.5 m^3 of water collected by pumping for 10 minutes and concentrated on #2 mesh Nitex nets. To collect fish larvae the pump was run for 4 hours at a time, drawing a sample of about 50 m^3. Several locations spread across the forebay were selected, each being sampled at one to three depths depending on the design. The selected locations were sampled for the appropriate volume either simultaneously by use of up to three sampling pumps or sequentially with a single pump by moving the hose. Sequential sampling was assumed to give adequate replication in all cases. Replication of fish larva observations was obtained by taking corresponding four-hour periods on successive days as replicates.

The Discharge Forebay

The Technical Specifications, in the first of the two paragraphs quoted on page 1, mention a study of vertical stratification in the discharge forebay. It appears that the suggestion for this requirement was originally made by us. At that time the discharge forebay was still accessible for hose sampling. Since then it has been covered by a

metal deck, apparently to help control surges in the circulating water system. Sampling now occurs through a rigid pipe, and it is not possible to sample at more than one depth. We will necessarily remain ignorant of the variation (if any) of abundances with depth in the discharge bay. However, the water velocity there is considerably higher than in the intake forebay. It is reasonable to assume that it is better mixed.

Results -- Zooplankton

Seventy-two samples were taken in the intake forebay on August 6, 1974. Analysis of variance with the following layout was performed on total animals per m^3: grates (3) x depths (3) x times (2) x day/night (2) x replicates (2). A pair of replicates consisted of two successive two-minute samples. The error degrees of freedom are found to be 3 x 3 x 2 x 2 x (2-1) = 36. The grates sampled were MTR 1-1, 1-3 and 1-5 (Fig. 1); depths were 2', 18' and 28'. The location we propose for the permanent pipe (MTR 1-5, 18') was among those sampled. Its bias was +24.6% of the mean of all samples; the 95% confidence limits for the true bias were ±30.8% of the mean.

Results -- Benthos

Benthic animals may be stirred up off the bottom, and some may swim into overlying water actively, where they are exposed to entrainment into the Cook Plant. Samples collected for fish larva studies in the intake forebay are also examined for benthic macroinvertebrates and their density in the forebay is estimated. A comparison of their densities at different locations was made on August 6 and 7, 1974, using 10-minute samples.

While Pontoporeia and Mysis are the animals of principal concern

in entrainment studies, these were too rare in summer samples to support analysis. We assume that any physical factors causing Pontoporeia to vary in density in the forebay would act similarly on Chironomus larvae which are about the same size. The higher abundance of Chironomus makes spatial comparisons possible with some degree of confidence. The benthos were more abundant at night in this study. The mean of 18 night samples was 7.37 animals per m^3; the mean of the 18 day samples was 1.11 per m^3. The analysis below was done on the night data. Figures for total animals exclude Hydra, which we assume is growing on the inside of the intake pipe.

The bias at 18' for location MTR 1-5 was +79 ± 77% for total animals and -16 ± 79% for Chironomus. Of the two, the estimate for Chironomus is more likely to represent the bias for Pontoporeia and Mysis.

The confidence limits (77% and 79%) may appear wide. Pumping for a longer period than 10 minutes would presumably have led to narrower confidence limits. But before diverting greater effort into sampling benthos, we should note that the total weight of entrained benthos is very small compared to that of zooplankton. Our estimate of the wet weight of zooplankton entrained by the Plant every year is 4,670,000 kg., while the weight of benthos entrained is estimated as 7,060 kg.

Results -- Fish Larvae

Depth variations were examined in one 48-hour study, and grate variations in a second 48-hour study in the period from July 29 to August 2, 1975. Those dates were selected because fish larvae densities near the Cook Plant were expected to be near their annual maximum.

In the depth study all observations were made at grate MTR 1-4; the density of larvae at 18' was compared to the mean density at all three depths (5', 18' and 28'). The bias at 18' was found to be +47.4 ± 39.6%.

In the grate study all observations were made at 18'; the density of larvae at MTR 1-4 was compared to the mean density at three different grates (MTR 1-4, 2-2 and 2-6). The bias at MTR 1-4 was found to be +53 ± 67%. Fish samples were not taken at the location we are now recommending for the permanent pipe (MTR 1-5, 18'). We trust that the difference between MTR 1-4 and MTR 1-5 is not important.

Note that the bias values produced by both the depth and grate studies for fish larvae are positive, and thus on the conservative side. If consistently present they would lead to an overestimate of the abundance of larvae, and thus an overestimate of the environmental damage due to the plant. The reader will notice that most of the bias figures for benthos and zooplankton were also positive, and thus on the safe side, although only marginally significant in most cases.

Conclusion

A permanent sampling pipe at MTR 1-5, drawing water from a depth of 18', will give a reasonable estimate of the density of animals in the water entrained by Unit I.

GREAT LAKES RESEARCH DIVISION

THE UNIVERSITY OF MICHIGAN
INSTITUTE OF SCIENCE AND TECHNOLOGY BUILDING
ANN ARBOR, MICHIGAN 48105
313/764-2420

COPY

December 4, 1975

Mr. J. LeMasters
Cook Nuclear Plant
Bridgman, Michigan 49106

Dear Sir:

This letter concerns a request that Indiana and Michigan Power Company assist our environmental studies at the Cook Plant by installing fixed, metal pipes in the intake forebay of the plant. The pipes will be used to pump samples of water from which we can estimate the number and condition of suspended plants and animals before they pass through the condensers. At present, we are using flexible plastic hoses which can be lowered at any desired location to any depth. These were necessary in the early phase of our entrainment studies to permit estimation of the amount of variation which occurs in the densities of organisms from place to place in the forebay. That task has been completed, and we have now selected a permanent sampling location for Unit 1 entrainment studies.

A separate letter is being sent to Charles Domeck of the Nuclear Regulatory Commission. We are not certain whether his approval of our sampling design is necessary, but felt it a good idea to inform him before we proceeded to a permanent sampling installation. The Technical Specifications[1] require that a "representative sampling location" be chosen, and that the existence of horizontal or vertical stratification be determined. Since we believe we have met the spirit and the letter of the specification, we do not anticipate that he will object to our selection.

The permanent sampling location in the forebay will be (as it has been for more than a year) just upstream of the trash bars in front of traveling screen motor MTR 1-5. The intake of the sampling pipe will be at a depth of 18 feet below the water level in the forebay. The best way to establish the forebay water level on the average is not clear from information available to us. We have been measuring the depth directly each time we sample. If the intake forebay water level is related to the "Lake Michigan datum" for mean water level by some constant difference, we suggest that the sampling intake be located 18 feet below the "Intake datum-equivalent" for mean water level in Lake Michigan. Preferably, the sampling intake should not be closer than several feet to massive structures of the forebay.

[1] P. 4.1-28, "Zooplankton Entrainment," paragraphs 1 and 2, for example.

Engineers familiar with the forces operating in the forebay and the technical requirements of safe function of the circulating cooling water system are better able than we to design a specific installation. However, we would like to specify that two pipes be installed side-by-side, each with three-inch internal diameter and suitable at the upper end for connection with our present sampling pumps (we use O.P.W. Kamlok fittings, #'s 633E and 633C). There should also be check valves at the upper ends of the pipes, accessible to rapid service in case of malfunction or clogging. The tops of the pipes should be spaced far enough apart (8") to permit use of a pipe-wrench on the check valves. We neet two pipes in order to be able to attach two of our sampling pumps and double the volume which can be sampled from that point over a given time interval.

We realize that considerable time and expense may be incurred in the design and installation of the pipes, but we cannot maintain a suitable sampling program without some improvements in the present system. Our flexible hoses are wearing out, fraying and leaking. The check valves at the intakes of present hoses require frequent service. We have found it necessary to send additional employees to the plant site in advance of every entrainment sampling period to install and check the hoses and repair them when necessary. The necessity of working near open ports in the cover of the forebay has always concerned us, particularly because of the heavy work, hauling and lowering hoses and grates which cover the ports, which we must do near the open ports. We are convinced that a durable, safe and consistent sampling installation is essential to continued effectiveness of our entrainment monitoring program. Needless to say, we would appreciate rapid action on our request.

Sincerely,

Samuel C. Mozley
Asst. Research Limnologist

John C. Ayers
Project Director

cc: Druckemiller
Domeck