4-1977

Assessment of mechanical damage to entrained ichthyoplankton, VEPCO Surry Nuclear Power Station

J. V. Merriner
Virginia Institute of Marine Science

A. D. Estes
Virginia Institute of Marine Science

Assessment of Mechanical Damage to Entrained Ichthyoplankton

VEPCO Surry Nuclear Power Station

by

J. V. Merriner and A. D. Estes
Virginia Institute of Marine Science
Gloucester Point, Virginia 23062

April 1977

Special Report: Pilot Project in Conjunction with
Ongoing Ichthyoplankton Entrainment Study

ABSTRACT

Thermal plume ichthyoplankton sampling during November and December 1976 was cancelled since Units 1 and 2 of VEPCO Surry Nuclear Power Station were non-operational due to refueling. In lieu of the thermal plume ichthyoplankton entrainment program, a sampling program to estimate mortality from mechanical damage was initiated.

Four sampling sites were selected for determination of quantity and condition of organisms entering and leaving the plant. Sites were selected at points preceding and following critical areas where the likelihood of damage was greatest. Net sets were made using a 0.5 meter paired net apparatus. All sets were at bottom strata to maximize catch of post-larval and juvenile croaker, the dominant species during the sampling period.

Specimen condition was ranked into three categories; alive, stunned, and dead. Relative specimen condition; e.g. swimming upside down, broken in half, etc., was also noted. Replicate samples were examined after a time lag to determine latent mortality, if any.

A definite damaging effect was shown on fish passing through the low level pumps and through the plant condenser tubes. In each case, notable decreases in live specimens and corresponding increases in dead specimens were observed. No demonstrable latent mortality effects were observed.

Variability between sampling sites, sampling stations, replicate net sets, and replicate samples weaken the data set. Site variability was particularily high except on November 23.

A total of 45 specimens were captured: 38 Atlantic croaker, Micropogon undulatus; 6 bay anchovy, Anchoa mitchilli; and 1 tidewater silversides, Menidia beryllina.

We make the following suggestions if future mechanical damage studies are conducted:

1. Studies should be conducted over the course of a year or during periods of high larval fish and egg abundance.
2. Large volumes of water should be filtered to get a good numeric basis.
3. If sampling juvenile fish, large (1 meter) nets should be employed.
4. Guidelines for categorization or ranking of specimens should be defined clearly to segregate the "stunned" fish which do or do not recover.
5. If latent mortality is to be examined, a directed effort must be made to reduce travel time from sample site to examination site, and minimize handling of samples.

INTRODUCTION

Thermal plume ichthyoplankton sampling during November and December 1976 was cancelled since Units 1 and 2 of VEPCO Surry Nuclear Power Station were non-operational for refueling (Appendix 1). Several intake pumps were operating to continue water flow through the plant, but there was no ΔT. Mechanical manipulation experienced while passing through the pumps, condenser tubes, and out the discharge pipes reputedly contributes heavily to ichthyoplankton mortality experienced in once-through power plant cooling systems, i.e. Marcy (1976) reported average mortality from mechanical damage at Connecticut Yankee Plant to be approximately 80%. In-plant mortality of ichthyoplankton is under study at several locations across the United States since mechanical stresses coupled with ΔT could produce significant mortalities to ichthyoplankton. Thermal shock was eliminated at VEPCO Surry during November-December 1976; therefore physical-mechanical stresses would be solely responsible for observed ichthyoplankton mortality. In lieu of the thermal plume ichthyoplankton entrainment program, a sampling program to estimate mortality from mechanical damage was initiated.

The study was termed a pilot study and was designed to; 1) estimate mortality from mechanical damage induced by the plant; and 2) develop a technique to assess damage and make recommendations to improve future mechanical damage studies.

MATERIALS AND METHODS

Sampling sites for the mechanical damage assessment included (Fig. 1):

1 - directly in front of the trash bars at the low level pumps (control site, natural, + net damage).

2 - high level intake canal near low level pump discharge (low level pump damage assessment + net damage).

3 - intake canal in front of the high level screens to determine quantity of organisms entering the plant + net damage. (Some damaged organisms may have settled along the length of the intake canal and/or spawning might have occurred in the high level canal.)

4 - discharge canal after the organisms have passed through the high level canal, plant condensers, etc. + net damage.

Sets were made using a 0.5 meter paired net apparatus equipped with conical nitex nets having 505 µ mesh. Two replicate sets (2 samples/net; 4/station) were made at each site at bottom depth to maximize catch of croaker postlarvae. Previous studies at VEPCO Surry had shown postlarval and juvenile Atlantic croaker were the dominant species captured in November and December (Merriner and Estes 1976). Thus, sampling was undertaken to maximize the likelihood of capture of the dominant species and provide an adequate catch for assessment of injury and/or mortality caused by pump and plant. Tows were of 5 minute duration except at Site 1 where low water velocity necessitated 10 minute tows. Hydrographic data (dissolved oxygen, salinity, temperature, etc.) were taken at each sampling site.

Comparisons made within the data set included categorically examining percent of total fish caught per sampling site across sites. Accordingly, the following comparisons were made for damage evaluation:

$1_{t_0}-1_{t_2}$ = Ambient + Net damage

$1_{t_0}-2_{t_2}$ = Ambient + Low Level Pump + Net damage

$1_{t_2}-2_{t_2}$ = Low Level Pump + Net damage

$2_{t_2}-3_{t_2}$ = Settling, predation, and/or recruitment along the high level canal + Net damage

$3_{t_2}-4_{t_2}$ = Plant + Net damage

$1_{t_2}-4_{t_2}$ = Overall damage while passing from low level intake pumps through the plant + Net damage

where: 1 through 4 = Sampling sites (Figure 1)

t = Standardized catch

subscripts 0 - 2 = Number of replicate set

Samples were placed in clean plastic buckets and transported to the VEPCO Surry Environmental Lab by truck. Average time intervals between sample times and arrival of samples at the lab by station were:

Station 1) 1st replicate set - 49 minutes

2nd replicate set - 36 minutes

Station 2) 1st replicate set - 48 minutes

2nd replicate set - 39 minutes

Station 3) 1st replicate set - 36 minutes
2nd replicate set - 28 minutes

Station 4) 1st replicate set - 32 minutes
2nd replicate set - 24 minutes

Upon arrival, one sample from each replicate set was examined macroscopically and under a dissecting microscope to determine the condition of the specimens. Approximately 20 minutes later, the remaining samples were examined for latent mortality. Specimens scored as stunned may be unable to recover and may succumb later. We had anticipated travel times of 10-15 minutes for 2nd replicate and 20-25 minutes for 1st replicate sets. Somewhat longer intervals were recorded thus lengthening time intervals before examination. We anticipated examination for latent mortality to occur 40-45 minutes after capture. As a result of longer travel times, latent mortality may have already been a contributing factor in initial examination results.

Individual specimen condition was scored in three categories:

1) Alive - swimming upright in normal or nearly normal manner.
2) Stunned - (a) erratic or abnormal swimming behavior, i.e., upside down, on side, in short bursts, etc.; (b) not moving but heart still functioning upon microscopic examination.

3) Dead - mutilated, mangled, broken, etc.; no movement and no heartbeat upon microscopic examination.

The condition of the specimens, i.e. swimming on side, etc., was noted upon examination and assignment of rank.

Specimens were placed in labelled vials according to condition and preserved in 5% formalin. The vials were then returned to VIMS for sorting, identification, and enumeration.

Data have been prepared for storage on ADP cards in the format of the standard VEPCO Surry data file.

Four VIMS personnel were required to conduct each sampling visit. Boats and operators for sampling were provided by VEPCO.

RESULTS AND DISCUSSION

Mechanical damage to entrained fish at VEPCO Surry was demonstrated, but quantitative results could not be obtained from this data set. Several methodology inadequacies were realized and recommendations were made to improve methodology for future studies.

A total of 45 specimens (Table 1) were captured in 32 tows while straining 1073.8m^3 of water with the paired net apparatus during 4 sampling visits. Thirty-three percent (15 fish) were alive, 20% (9 fish) were dead, and 47% (24 fish) were stunned upon examination. There was no additional mortality apparent in samples examined after the 20 minute delay time. Average density of fish in the water during four site visits was calculated from Table 3 using the formula:

$$\text{Average Density} = \frac{\text{Number of fish}}{\text{Volume filtered}}$$

Average density of fish observed across sites during 4 site visits was:

Total (4 site visits) = 5/100m^3

Nov. 16 = 2/100m^3

Nov. 23 = 12/100m^3

Dec. 9 = 4/100m^3

Dec. 14 = .4/100m^3

Average density of fish per site (4 site visits) was:

Site 1 = 4/100m^3

Site 2 = 2/100m^3

Site 3 = 7/100m^3

Site 4 = 6/100m^3

Average volume of water strained/minute/site was:

Site 1 = 2.99m^3/minute

Site 2 = 2.63m^3/minute

Site 3 = 2.28m^3/minute

Site 4 = 2.53m^3/minute

All sets were stationary, therefore volumes reflect average water velocity, and the above calculations suggest highest average catches were made in lowest average water velocities. However, actual catches per site during site visits did not reflect a similar trend. Although highest catches were not always captured in highest velocities, a positive relationship between water velocity and catches was demonstrated.

Thirteen fish were captured at Site 1 (control for net damage) and only 1 fish was alive when examined; three fish were dead and 9 fish were stunned. At Site 2, 5 fish were captured of which 2 were dead and 3 were stunned. Samples at Site 3 yielded 15 fish on 13 November: 12 were alive and 3 were stunned. Twelve fish were captured at Site 4 (discharge canal) of which 2 fish were alive, 6 fish were stunned, and 4 fish were dead.

The total calculated number of fish per 100m^3 of water sampled summed across all sites was 296 (Table 2). Fish scored alive accounted for 38.8%, stunned for 45.6%, and dead for 15.6% of the total specimens. Percent of fish captured in four site visits per category per sampling site were:

	Site 1	Site 2	Site 3	Site 4
% Alive	15.9	0.0	81.8	16.3
% Stunned	68.3	67.7	18.2	55.4
% Dead	15.9	32.3	0.0	28.3

A definite negative effect on fish passing through the low level pumps was shown in that no live specimens were captured at Site 2 (16% alive at Sitel) and percent of dead fish doubled (16% to 32%). Along the 1.7 mile intake canal (Site 2 to Site 3), many of the stunned specimens apparently recovered. Other stunned specimens plus all dead specimens settled out (by gravity) and/or were consumed by piscivorus resident fishes known to inhabit the intake canal (W. Bolin, personal communication). Percent of live specimens rose from 0% at Site 2 to 82% of total catch at Site 3 and dead specimens fell from 32% to 0% of total catch. Thus, some partial credence is shown for the statement only dead or injured fish get impinged or entrained by power plants. Passing through the plant (Site 3 to Site 4) yielded a large drop in the percent of live fish taken (82% to 16%) and an increase in the percent of stunned and dead fish. From Site 1 to Site 4 (Intake to Discharge), slight increases were observed in the percent of alive and dead fish with corresponding decrease in the percent of stunned specimens. The critical examination points, i.e., Site 1 versus Site 2 and Site 3 versus Site 4 did have decreases in percent of live specimens and increases in dead specimens with a relatively stable percent of stunned specimens.

The high percent of stunned fish is attributed to a broad definition of "stunned" coupled with net damage and handling as shown at Site 1. Settling of stunned and dead fish in the 1.7 mile intake canal and subsequent predation of weakened specimens by larger fish would account for their rarity at Site 3.

Variability between sampling sites, sampling stations, replicate net sets, and replicate samples weaken the data set (Table 2). Site variability was particularly high except on 23 November (Table 2) when relatively uniform counts of croaker were recorded for all stations. Even then, data indicated more fish in the intake canal than in water entering the plant. Presumably this is caused by low water velocities at the intake and the subsequent increased net avoidance.

A total of 45 specimens were captured: 38 Atlantic croaker, Micropogon undulatus; 6 bay anchovy, Anchoa mitchilli; and 1 tidewater silversides, Menidia beryllina.

CONCLUSIONS

November and December are not ideal times of the year to attempt mechanical damage studies at VEPCO Surry Nuclear Power Plant since fish abundance and diversity are low. Very few fish spawn in the vicinity of Hog Island during winter months and most juvenile and adult fishes have moved into deeper and/or more saline waters.

The small number of specimens collected and high variability coupled with the high percent of stunned specimens resulted in an unsatisfactory data set for demonstration of mechanical factor impact upon ichthyoplankton while passing through VEPCO Surry Nuclear Power Plant. The generality of the "stunned" category definition masks a clear indication of the amount of damage.

Future mechanical damage studies if deemed necessary at VEPCO Surry or elsewhere should be conducted over the course of a year or during periods of abundance of larval fish and fish eggs (late spring or summer). Fish eggs and larvae are much more susceptible to the physical-mechanical stresses experienced than are postlarvae and juvenile croakers. However, each life stage of each species has its own specific susceptibility, therefore a variety of life stages should be studied (Koo[1], personal communication).

Larger volumes of water should be filtered to get a better numeric basis either by increasing net set time

---

[1]T. S. Y. Koo - Chesapeake Bay Laboratories; Solomons, Maryland

interval or by use of larger nets. When mapping striped bass populations in the Potomac River, efforts were made to filter approximately $200 m^3$/net/sample (T. Polgar, Martin Marietta Corp., personal communication).

If sampling juvenile fish, larger nets should be employed to reduce net avoidance.

Guidelines for categorization or ranking of specimens should be defined more clearly to segregate the "stunned" fish which do or do not recover.

If latent mortality is to be examined, a directed effort must be made to reduce travel time from sample site to examination site, and minimize manual handling of samples (sort, pick, transfer, etc.). We experienced travel times approaching one hour. This may seriously affect resulting data when reactions of larval and postlarval specimens are examined or when water temperatures approach $80^{\circ}F$.

LITERATURE CITED

Marcy, Barton, C., Jr. 1976. Plankton fish eggs and larvae of the Lower Connecticut River and the effects of the Connecticut Yankee Plant including entrainment. In The Connecticut River Ecological Study, [Ed.] D. Merriman and L. M. Thorpe. American Fisheries Society. Mono. No. 1:115-139.

Merriner, J. V. and A. D. Estes. 1976. Plant entrainment of ichthyoplankton at the VEPCO Nuclear Power Plant. In Ecological Study of the Tidal Segment of the James River Encompassing Hog Point. 1975 Final Technical Report. VIMS Special Scientific Report No. 78. 209 p.

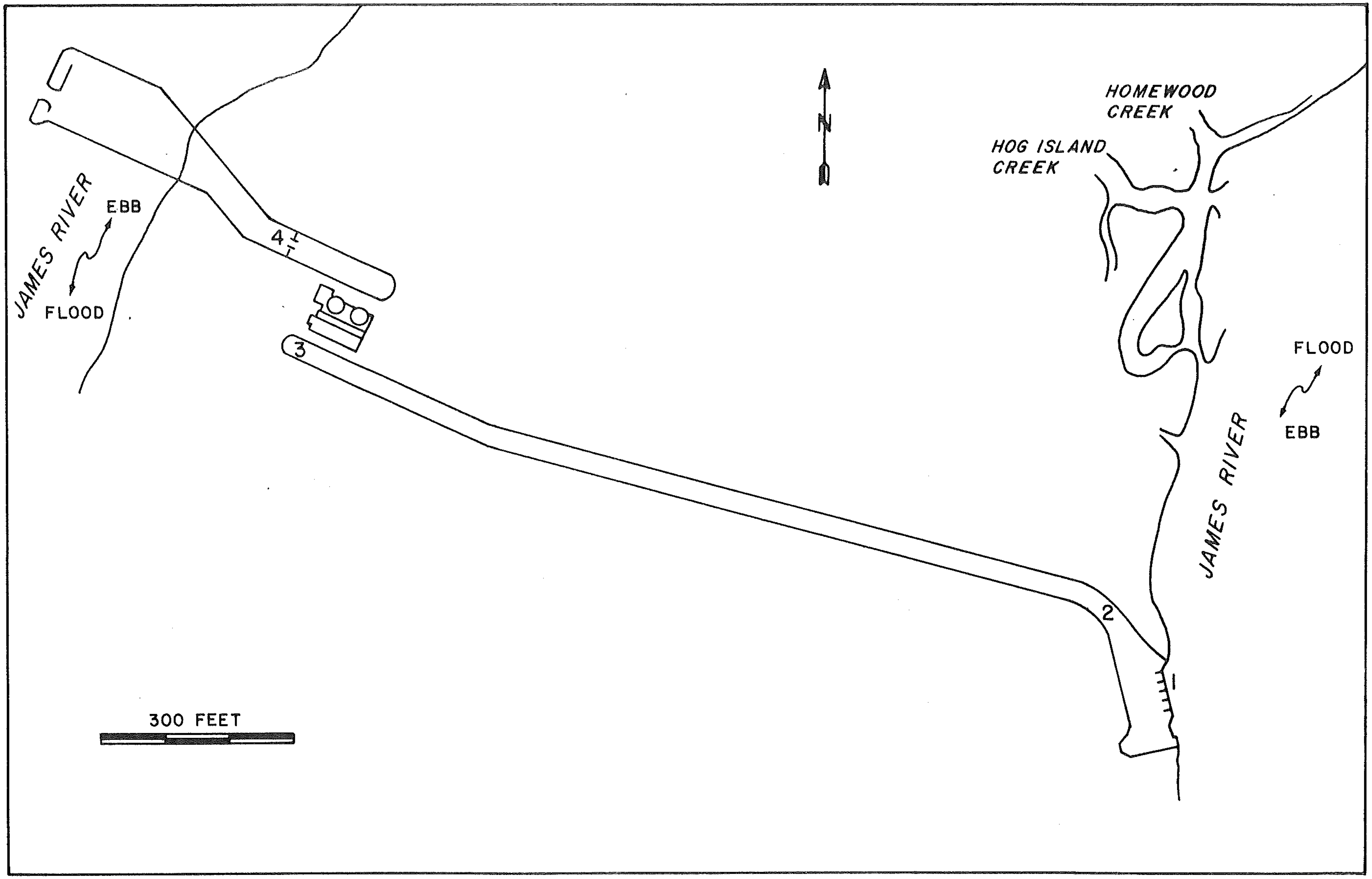

Figure 1. Mechanical damage sampling sites at VEPCO Surry Nuclear Power Plant (Site plan from Applicants Environmental Report).

Table 1. Number of individuals captured in mechanical damage tows at VEPCO Surry Nuclear Power Plant during November and December, 1976.

		SITE 1				SITE 2				SITE 3				SITE 4			
	Specimen	1 Rep.		2 Rep.		1 Rep.		2 Rep.		1 Rep.		2 Rep.		1 Rep.		2 Rep.	
Date	Condition	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
16 Nov *	Alive																
	Stunned		1	1	2										1		
	Dead				2		1										
23 Nov +	Alive									1	1	1	9	1			
	Stunned	1		2	1	1	2				2	1		1		1	1
	Dead	1							1								
9 Dec *	Alive				1									1			
	Stunned				1										1	1	
	Dead															2	1
14 Dec *	Alive																
	Stunned																
	Dead														1		

* = First replicate tow examined immediately. Second replicate examined after 20 minutes.

+ = Left nets from each tow examined immediately. Right nets examined after 20 minutes.

Table 2. Calculated number of individuals per 100 cubic meters captured in mechanical damage tows at VEPCO Surry Nuclear Power Plant during November and December, 1976.

		SITE 1				SITE 2				SITE 3				SITE 4			
		1 Rep.		2 Rep.		1 Rep.		2 Rep.		1 Rep.		2 Rep.		1 Rep.		2 Rep.	
Date	Condition	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.	Rt.
16 Nov *	Alive																
	Stunned		1	2	4										18		
	Dead				4		4										
23 Nov +	Alive									6	6	8	70	8			
	Stunned	6		13	7	7	14				12	8		8		6	6
	Dead	6							6								
9 Dec *	Alive				10									7			
	Stunned				10										6	7	
	Dead															13	7
14 Dec *	Alive																
	Stunned																
	Dead														6		

* = First replicate tow examined immediately. Second replicate tow examined after 20 minutes.

+ = Left nets from each tow examined immediately. Right nets examined after 20 minutes.

Table 3 - Volume of water sampled, actual number of fish captured, and calculated number of fish per 100m^3 captured in mechanical damage samples at VEPCO Surry Nuclear Power Plant during November and December, 1976.

DATE		SITE 1*				SITE 2				SITE 3				SITE 4				Total
		First Replicate		Second Replicate		First Replicate		Second Replicate		First Replicate		Second Replicate		First Replicate		Second Replicate		
		Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	
November 16	Volume	84.2	69.2	57.3	55.3	19.8	22.3	7.0	10.9	5.3	3.7	12.1	3.6	1.1	5.4	1.5	7.2	365.9
	No. of fish	0	1	1	4	0	1	0	0	0	0	0	0	0	1	0	0	8
	No./ 100m^3	0	1	2	8	0	4	0	0	0	0	0	0	0	18	0	0	33
November 23	Volume **	16.4	16.4	15.4	15.4	14.2	14.2	15.6	15.6	16.1	16.1	12.8	12.8	12.0	12.0	15.8	15.8	236.6
	No. of fish	2	0	2	1	1	2	0	1	1	3	2	9	2	0	1	1	28
	No./ 100m^3	12	0	13	7	7	14	0	6	6	18	16	70	16	0	6	6	197
December 9	Volume	7.1	5.8	10.7	10.2	5.0	4.6	4.5	4.5	4.3	4.5	4.4	4.2	15.3	16.3	15.3	14.0	130.7
	No. of fish	0	0	0	2	0	0	0	0	0	0	0	0	1	1	3	1	8
	No./ 100m^3	0	0	0	20	0	0	0	0	0	0	0	0	7	6	20	7	60
December 14	Volume	29.2	28.7	29.5	28.1	17.9	17.9	17.6	18.7	23.5	20.5	19.1	19.4	17.4	17.2	18.1	17.8	340.6
	No. of fish	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
	No./ 100m^3	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	6
Total	Volume	136.9	120.1	112.9	109.0	56.9	59.0	44.7	49.7	49.2	44.8	48.4	40.0	45.8	50.9	50.7	54.8	1073.8
	No. of fish	2	1	3	7	6	3	0	1	1	3	2	9	3	3	4	2	45
	No./ 100m^3	12	1	15	35	7	18	0	6	6	18	16	70	23	30	26	13	296

* Ten minute sets. All other sets were 5 minute duration.

** Right flowmeter did not function. Used left meter.

Table 4. Temperature, salinity, and dissolved oxygen data from mechanical damage tows at VEPCO Surry Nuclear Power Plant during November and December, 1976.

Date	Intake Screens	Intake Canal Low Level	Intake Canal High Level	Discharge Canal
		TEMPERATURE		
16 Nov	7.5	8.0	8.0	7.5
23 Nov	6.0	6.4	5.5	5.7
9 Dec	4.5	5.2	4.8	5.0
14 Dec	5.0	5.0	4.7	4.8
		SALINITY		
16 Nov	3.4	3.8	3.6	3.6
23 Nov	3.8	3.3	3.5	3.5
9 Dec	3.6	2.8	2.8	3.0
14 Dec	0.7	0.4	0.5	0.4
		DISSOLVED OXYGEN		
16 Nov	11.0	10.9	10.4	11.5
23 Nov	11.3	10.7	10.9	10.8
9 Dec	10.6	12.4	11.2	12.2
14 Dec	12.3	11.6	12.0	11.9

APPENDIX 1

The following letter was received from Dr. Brehmer on November 10, 1976:

November 8, 1976

Dr. J. V. Merriner
Virginia Institute of Marine Science
Gloucester Point, Virginia 23062

Dear Dr. Merriner:

As you are aware, Surry Units 1 and 2 are off line at the present time. This situation creates a need for a temporary modification in your plume entrainment sampling program.

Effective immediately and lasting until at least one unit is returned to service, you are authorized to delete the plume sampling portion of your program. The discharge canal sample will be taken as scheduled as will the additional samples that we have discussed.

Please maintain contact with Mr. Bill Bolin at Surry about the scheduled return to service of the units.

If you have any questions, please let me know.

Very truly yours,

Morris L. Brehmer, Ph.D.
Executive Manager
Environmental Services

MLB/lj