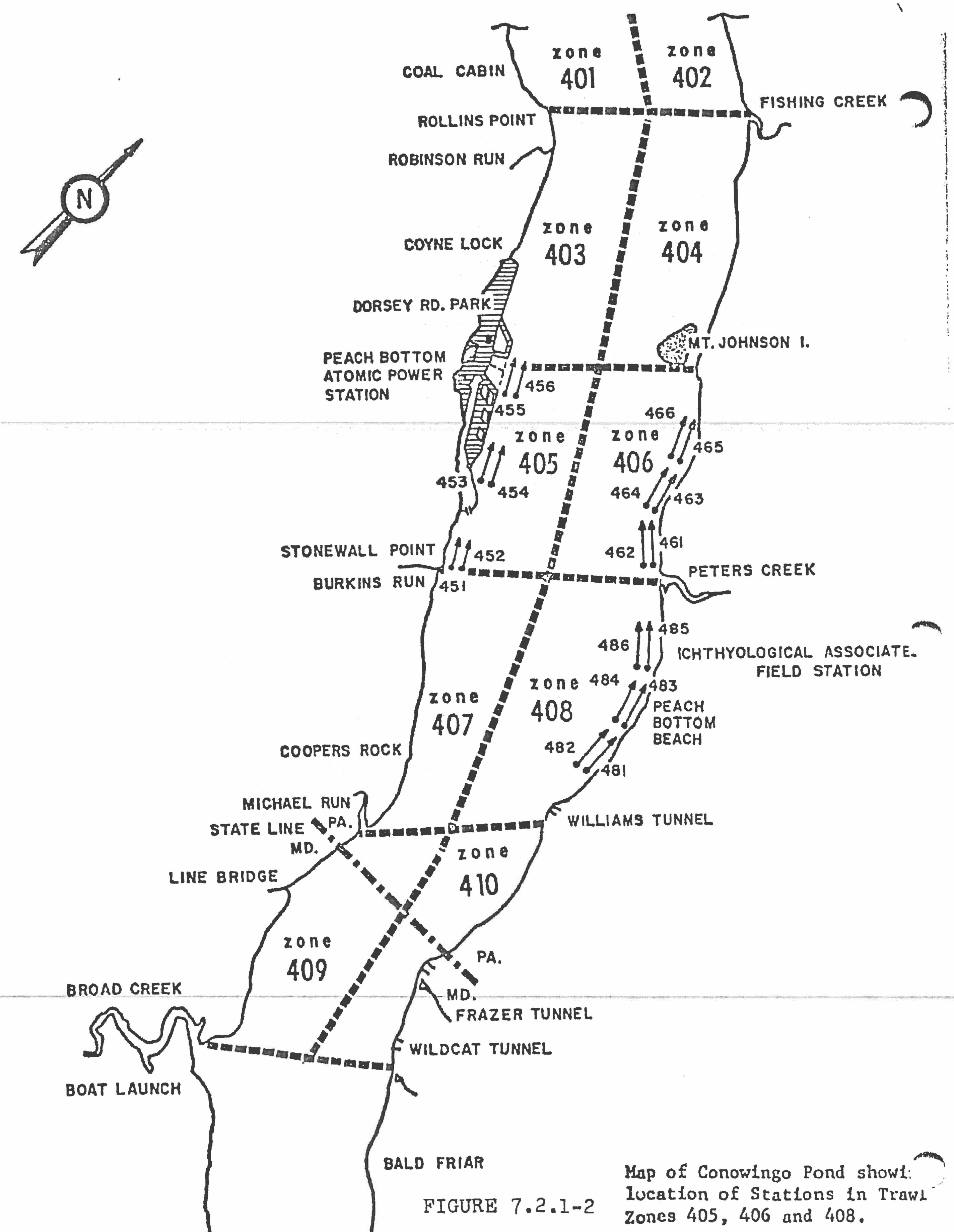

FIGURE 7.2.1-2

Map of Conowingo Pond showi
location of Stations in Trawl
Zones 405, 406 and 408.

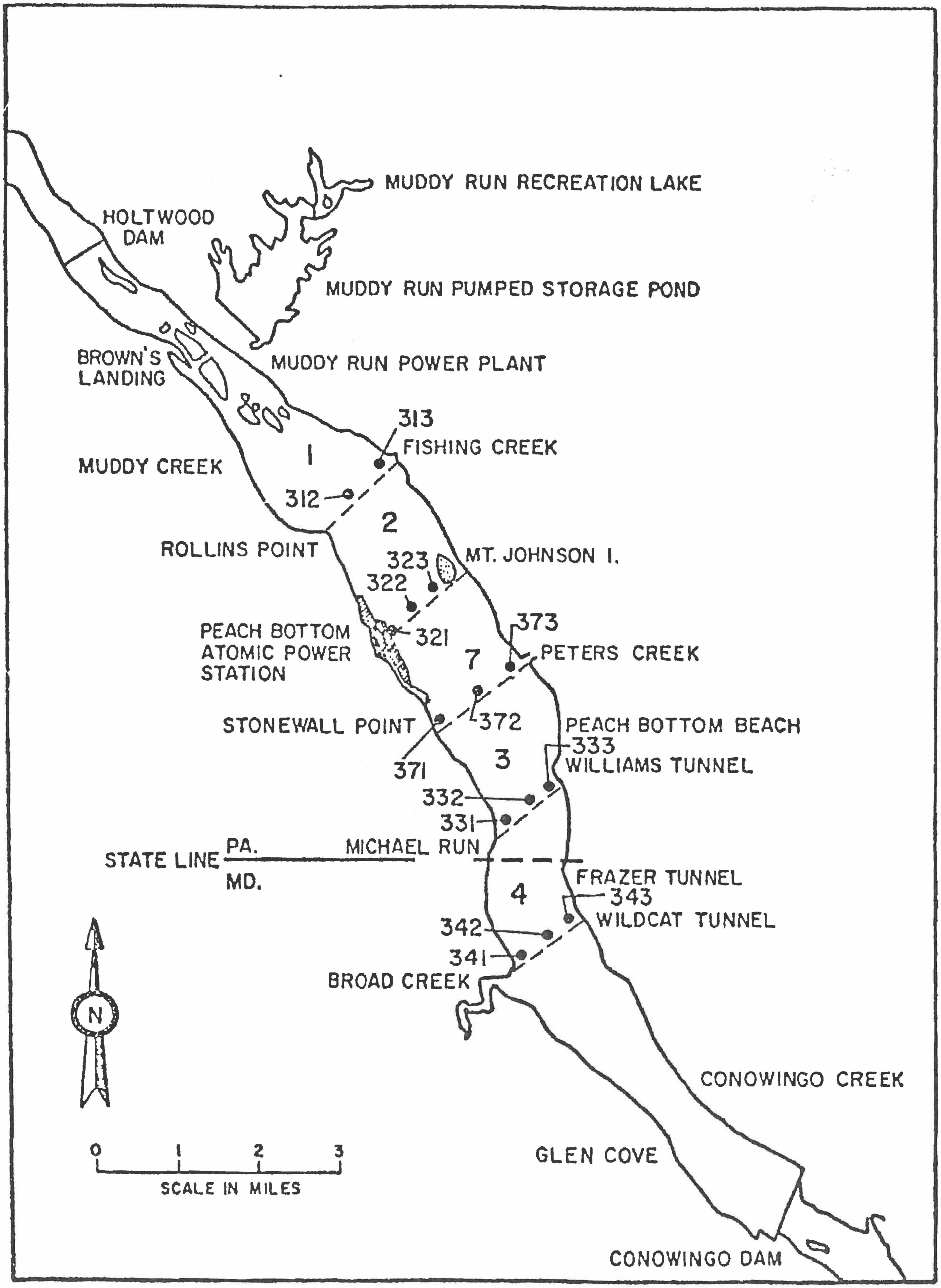

FIGURE 7.2.1-3 Map of Conowingo Pond showing the location of Stations on Trawl Transects 1-4, and 7 (dashed lines).

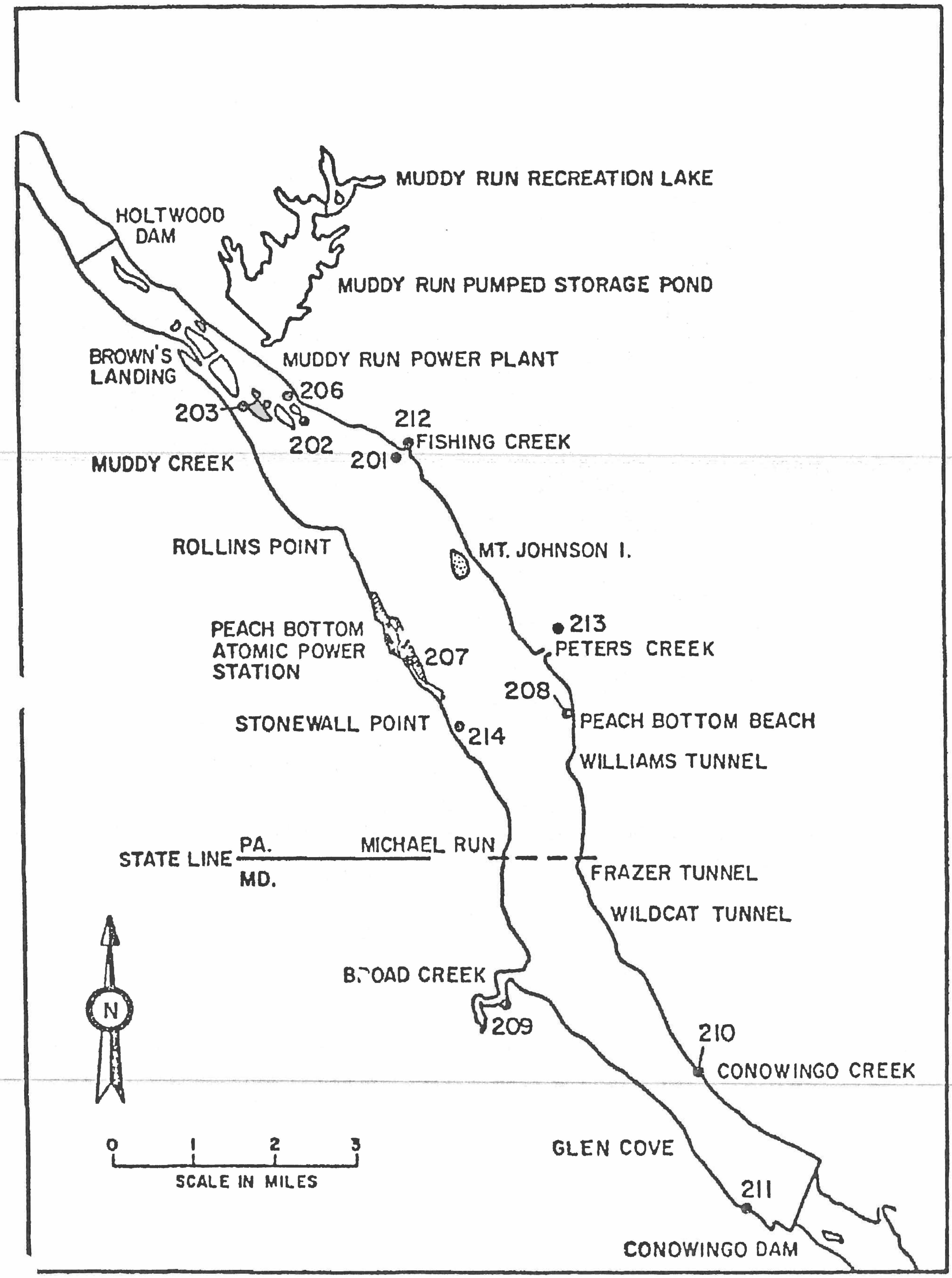

FIGURE 7.2.1-4 Map of Conowingo Pond showing the location of Seine Stations.

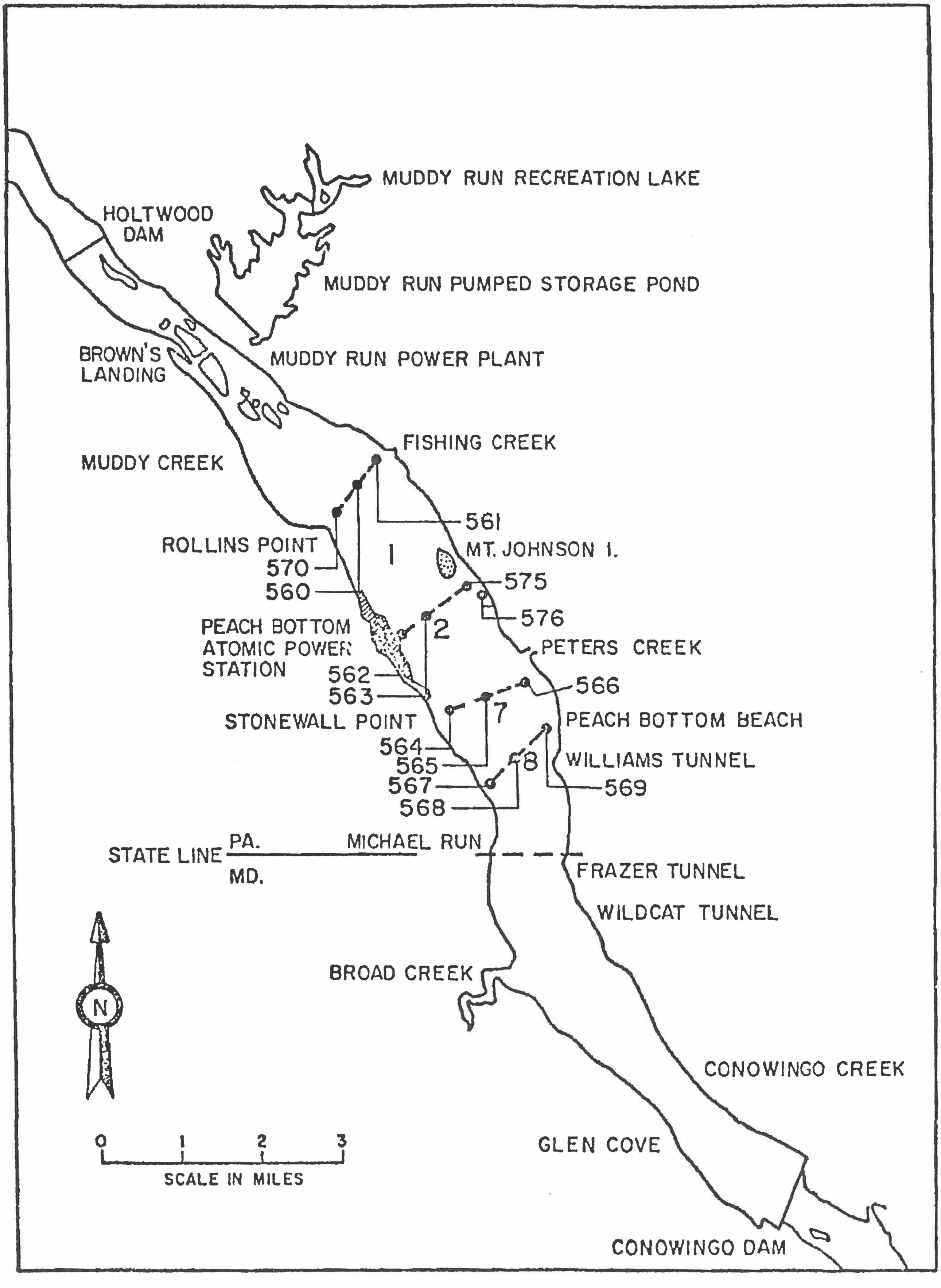

FIGURE 7.2.1-5 Map of Conowingo Pond showing the location of plankton net Stations on Transects 1, 2, 7 and 8 (dashed lines).

7.2.3 FISHES IN THE THERMAL PLUME

7.2.3.1 Trap Net Catches

Intensive trap netting was conducted in the thermal plume and discharge canal of PBAPS in July 1974 through March 1975. Each of seven stations (Figure 7.2.3-1) were sampled twice a month. The studies are continuing. Full power operation of both generating units did not occur until late in December and the power level fluctuated considerably in the sampling period. The bottom water temperatures recorded at each of the above seven stations and at the regular Pond monitoring stations are given in Table 7.2.3-1. A delta T of up to 14 F was observed at the stations in the thermal plume.

Some 29 species were caught in the plume and 20 were taken in the discharge canal, and 37 at monitoring stations (Table 7.2.3-2). The common fishes in the plume were the white crappie~~s~~, channel catfish, gizzard shad, carp and bluegill. In the discharge canal they were the pumpkinseed, channel catfish, bluegill and white crappie. At monitoring stations the common fishes were the white crappie, bluegill, channel catfish, pumpkinseed and brown bullhead. The white crappie avoided the canal. In contrast, the channel catfish appeared to prefer the canal in some months. The gizzard shad was taken primarily in the plume. No consistent pattern of distribution was evident for the bluegill. Few smallmouth bass, largemouth bass and walleye were collected.

The 20 species caught in the canal were subjected to the highest delta T, highest water velocities and greatest fluctuations in temperature during the operation, shutdown and start-up PBAPS. No fish mortalities were observed in the discharge canal or plume after a station shutdown or start-up. Fishes were present but scarce in the canal throughout the study period. Fishes did not avoid the plume.

A comparison was made of the trap net catch of the common fishes collected near Burkins Run (Station 110), about 300 yards below the discharge canal and in the discharge canal in the preoperational (1967-1973) and postoperational (1974-1975) periods (Table 7.2.3-3). The white crappie was abundant in the canal in preoperational years but in 1974 the catches of white crappie and bluegill had declined. However, the abundance of channel catfish increased considerably in the canal compared with preoperational years. At Station 110 the postoperational catches of the common fishes were generally within the range of variation observed in the preoperational period (Table 7.2.3-4). However, here the catch of channel catfish in the postoperational period were higher than in 1970-1973.

7.2.3.2 Trawl Catches

Trawling was done to determine the distribution and abundance of fishes in the discharge of PBAPS from July through December. These studies are continuing. A control station (Station 453) was established upstream from the discharge (Figure 7.2.3-2). Temperature at this station was used as a reference for ambient conditions in determining the discharge delta T. The bottom water temperatures along the trawl track at Stations 450, 451, 470 and 473 were generally more than 1 F higher than those at the Station intake (Table 7.2.3-5) and these stations were considered to be in the thermal plume. Water velocity at Station 450 and 451 was high as a result of the jet discharge; it was less at Station 470 and 473, which are located downstream and near shore. Stations 452, 472 and 474 were located on the periphery of the plume and the delta T at the bottom was usually less than 1-F.

Thirty-one species were captured in the plume, 25 were taken at the periphery and 23 were found at the control (Table 7.2.3-6). More species were collected in the plume where there was an increase in temperature compared with stations where there was increased temperature and flow. The largest number of fishes (27) was caught at Station 470 and the least (15) at Station 471. The common fishes were channel catfish, tessellated darter, white crappie, bluegill, carp, spottail shiner, and pumpkinseed. The channel catfish, tessellated darter and white crappie comprised 98% of the total catch at the periphery, 94% in the plume and 86% at the control. The catch per effort in the plume was twice as great as that at the periphery and five times greater than at the control. In the plume, the total catch per effort was higher in the area affected only by an increased temperature, particularly at Station 470, than it was in the area affected by both increased temperature and flow.

The abundance of the common fishes differed between months in the three areas. Usually the largest catch of all species was at Station 470 which had the highest delta T and little velocity. The catch per effort of the channel catfish increased sharply in all areas from July through September. The large catch in September in the plume was due to some 25,000 channel catfish (mostly young) which were collected in one trawl haul at Station 470. Thereafter, the catches generally declined in all areas. An increase in the catch of channel catfish occurred in the plume in December. In October and November the catch of the channel catfish was greater at the periphery than in the plume or at the control station.

In all areas the abundance of the white crappie differed little from July to December. Generally, the lowest catch occurred in the plume area which had both increased flow and temperature. The catch was greatest in the plume in all months except in October and November when it was higher at the control station. In most months the abundance of the tessellated darter was greatest at the control station and at the periphery of the plume. The catch per effort of the bluegill and pumpkinseed was highest in the plume, particularly at Station 470, from July through November. The bluegill was common in the plume in December but the pumpkinseed was not taken. Relatively large numbers of both species were taken in the plume in August and September. The spottail shiner was most abundant in the plume except in December. A few gizzard shad were caught at most stations but it was taken consistently only at Station 470 in the plume in all months. It was never caught at the control station.

TABLE 7.2.3-1

Comparisons of the monthly mean bottom water temperature at Trap Net Stations in and outside the thermal plume in Conowingo Pond, July-December 1974.

		UPPER AND MID POND						DISCHARGE CANAL			THERMAL PLUME				LOWER POND				
Station		102	103	141	142	106	104	122	123	124	110	125	126	127	107	136	108	138	109
Month	Bottom Temp (F)																		
Jul	Min.	78.0	67.0	77.0	77.0	76.0	77.0	70.0	85.0	85.0	78.0	-	-	-	78.5	74.5	79.0	79.0	79.0
	Max.	80.5	75.0	80.0	80.0	81.0	81.0	89.0	88.0	88.0	88.0	-	-	-	81.0	80.5	82.0	83.0	81.5
	Mean	78.9	71.0	78.4	78.5	77.6	79.2	76.2	86.8	86.6	83.2	-	-	-	79.5	77.8	80.2	80.4	80.1
Aug	Min.	77.0	69.5	76.5	78.0	75.5	78.0	85.0	84.5	84.5	83.0	82.5	81.0	82.5	78.5	76.0	79.0	74.0	78.0
	Max.	79.0	72.5	79.0	80.0	79.0	80.0	88.5	88.5	88.5	85.5	87.0	83.5	83.0	81.0	78.5	80.0	80.0	80.5
	Mean	78.1	70.2	78.1	79.0	77.3	78.5	86.6	86.1	86.0	84.1	84.8	82.4	82.8	79.5	77.0	79.6	78.6	79.4
Sep	Min.	71.0	62.0	70.5	71.0	69.5	71.5	70.0	70.0	70.0	73.0	69.5	68.0	69.0	70.5	69.0	72.0	71.5	71.5
	Max.	79.0	69.5	79.0	79.0	79.0	79.0	80.0	79.5	79.5	84.5	78.0	72.0	73.0	80.0	79.0	80.5	80.0	80.5
	Mean	74.4	64.6	73.7	74.2	72.8	74.1	75.0	74.8	74.8	79.0	73.3	69.6	70.2	74.4	72.5	75.6	75.2	75.1
Oct	Min.	52.5	45.0	53.0	54.0	55.0	53.0	58.0	56.0	56.0	62.5	55.0	55.0	54.0	57.0	52.0	55.5	53.5	55.5
	Max.	65.0	60.5	64.0	63.0	65.0	63.5	70.5	70.0	69.5	72.0	69.0	65.0	62.0	67.5	65.5	67.0	67.5	68.0
	Mean	58.8	54.0	59.4	59.2	60.5	58.1	64.8	64.3	64.1	66.4	63.1	60.1	57.7	61.8	58.5	61.4	60.8	61.6
Nov	Min.	42.0	35.0	40.0	40.0	38.0	39.0	56.0	56.0	56.0	51.0	54.0	50.0	47.5	42.0	40.0	39.5	39.5	41.5
	Max.	55.0	47.0	55.0	55.0	54.0	55.0	66.0	66.0	66.0	65.0	64.0	59.0	60.0	55.5	52.0	56.0	55.0	55.5
	Mean	50.0	42.8	49.8	49.8	48.6	49.6	61.4	61.8	61.8	60.3	60.1	55.1	53.8	51.2	47.9	51.0	50.1	50.8
Dec	Min.	36.0	36.0	36.0	36.5	36.5	37.0	48.0	52.0	52.0	44.5	51.0	48.5	43.0	38.5	39.5	37.5	37.0	38.0
	Max.	39.0	43.0	40.0	40.0	39.0	39.5	52.0	54.0	53.5	49.0	52.5	52.5	47.0	42.0	46.0	40.0	41.0	41.0
	Mean	37.5	39.0	37.8	37.9	37.8	38.1	50.2	53.1	52.3	46.4	51.8	50.3	44.8	40.1	41.9	38.5	38.8	39.0

TABLE 7.2.3-2

Comparison of catch per effort (number per 24 hr) for fishes collected by trap net at the monitoring stations, discharge canal, and plume stations in Conowingo Pond, July 1974-March 1975.

Locations	Monitoring Stations	Discharge Canal	Plume Stations
No. Collections	339	109	120
No. Species	37	20	29
No. Hours	9148	2659	2971
No. Trap Days	381.17	110.79	123.79
Species			
A. calva	*	-	-
A. rostrata	0.01	0.01	0.06
D. cepedianum	0.09	0.15	2.38
S. trutta	*	-	-
E. masquinongy	0.01	-	0.01
C. auratus	*	0.01	0.01
C. carpio	0.29	0.10	2.24
N. crysoleucas	0.23	0.02	0.23
N. amoenus	0.03	-	0.01
N. cornutus	0.01	-	-
N. hudsonius	0.38	0.01	0.17
N. procne	0.02	-	-
N. spilopterus	0.06	0.02	0.02
P. notatus	0.01	-	-
C. cyprinus	0.01	-	0.02
C. commersoni	0.12	-	0.01
H. nigricans	*	-	-
M. macrolepidotum	0.01	-	0.03
I. catus	0.05	0.04	0.17
I. natalis	0.46	0.45	1.51
I. nebulosus	0.99	0.39	1.90
I. punctatus	3.59	5.97	14.76
N. insignis	*	-	-
M. americana	*	-	0.01
A. rupestris	0.15	0.11	0.12
L. auritus	0.32	0.44	0.06
L. cyanellus	0.02	0.05	0.01
L. gibbosus	2.52	5.99	1.78
L. macrochirus	3.74	2.53	2.04
M. dolomieui	0.03	0.01	0.01
M. salmoides	0.06	-	0.02
P. annularis	25.96	0.49	27.51
P. nigromaculatus	0.17	-	0.36
E. olmstedi	0.01	0.01	0.02
P. flavescens	0.06	-	0.06
P. caprodes	*	-	-
S. vitreum	*	0.02	0.02
Total	39.43	16.82	55.57

* Less than 0.01

TABLE 7.2.3-3

Comparison of the catch per effort (number per 24 hr) of selected representative indigenous fishes collected from the discharge canal during the preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond.

	Jul-Dec		Jan-Mar	Total
White crappie (*P. annularis*)				
1967	93.46	1968	-	93.46
1968	27.39	1969	52.96	31.05
1969	228.49	1970	60.71	207.19
1970	102.91	1971	-	102.91
1971	132.96	1972	205.12	133.84
1972	37.10	1973 *	-	37.10
1973 *	-	1974	-	-
1974	0.68	1975	0.13	0.49
Channel catfish (*I. punctatus*)				
1967	10.36	1968	-	10.36
1968	1.29	1969	1.54	1.32
1969	12.83	1970	0.51	11.27
1970	12.06	1971	-	12.06
1971	5.43	1972	3.52	4.88
1972	1.84	1973 *	-	1.84
1973 *	-	1974	-	-
1974	7.86	1975	2.51	5.97
Bluegill (*L. macrochirus*)				
1967	2.03	1968	-	2.03
1968	10.45	1969	6.94	9.94
1969	9.20	1970	3.06	8.42
1970	19.01	1971	-	19.01
1971	36.26	1972	9.38	28.48
1972	9.47	1973 *	-	9.47
1973 *	-	1974	-	-
1974	3.43	1975	0.87	2.53
Gizzard shad (*D. cepedianum*)				
1972	0.64	1973 *	-	0.64
1973 *	-	1974	-	-
1974	0.07	1975	0.31	0.15
Largemouth bass (*M. salmoides*)				
1967	0.00	1968	-	0.00
1968	0.00	1969	0.00	0.00
1969	0.00	1970	0.00	0.00
1970	0.00	1971	-	0.00
1971	0.00	1972	0.00	0.00
1972	0.00	1973 *	-	0.00
1973 *	-	1974	-	-
1974	0.00	1975	0.00	0.00
Smallmouth bass (*M. dolomieui*)				
1967	0.00	1968	-	0.00
1968	0.04	1969	0.00	0.04
1969	0.00	1970	0.00	0.00
1970	0.00	1971	-	0.00
1971	0.00	1972	0.00	0.00
1972	0.00	1973 *	-	0.00
1973 *	-	1974	-	-
1974	0.01	1975	0.00	0.01
Walleye (*S. vitreum*)				
1967	0.00	1968	-	0.00
1968	0.00	1969	0.00	0.00
1969	0.00	1970	0.00	0.00
1970	0.00	1971	-	0.00
1971	0.00	1972	0.00	0.00
1972	0.09	1973 *	-	0.09
1973 *	-	1974	-	-
1974	0.03	1975	0.00	0.02

* Not sampled due to construction

TABLE 7.2.3-4

Comparison of the catch per effort (number per 24 hr) of selected representative indigenous fishes collected at Station 110 during the preoperational (1970-1973) and postoperational (1974) periods in Conowingo Pond.

	Jul-Dec		Jan-Mar	Total
White crappie (P. annularis)				
1970	90.29	1971	-	90.29
1971	38.24	1972	12.17	29.70
1972	37.93	1973	6.74	31.07
1973	7.19	1974	1.38	6.06
1974	5.18	1975	0.78	4.13
Channel catfish (I. punctatus)				
1970	24.61	1971	-	24.61
1971	7.17	1972	8.45	7.59
1972	2.24	1973	10.71	4.10
1973	1.27	1974	0.78	1.18
1974	17.97	1975	1.17	13.97
Bluegill (L. macrochirus)				
1970	3.14	1971	-	3.14
1971	1.85	1972	0.25	1.33
1972	3.65	1973	0.17	2.89
1973	1.46	1974	0.39	1.25
1974	1.74	1975	0.13	1.36
Gizzard shad (D. cepedianum)				
1972	0.00	1973	0.00	0.00
1973	0.04	1974	0.00	0.04
1974	3.36	1975	0.39	2.65
Largemouth bass (M. salmoides)				
1970	0.00	1971	-	0.00
1971	0.00	1972	0.00	0.00
1972	0.10	1973	0.00	0.08
1973	0.09	1974	0.00	0.08
1974	0.00	1975	0.00	0.00
Smallmouth bass (M. dolomieui)				
1970	0.00	1971	-	0.00
1971	0.00	1972	0.00	0.00
1972	0.00	1973	0.00	0.00
1973	0.00	1974	0.00	0.00
1974	0.00	1975	0.00	0.00
Walleye (S. vitreum)				
1970	0.00	1971	-	0.00
1971	0.00	1972	0.00	0.00
1972	0.15	1973	0.86	0.30
1973	0.00	1974	0.00	0.00
1974	0.04	1975	0.00	0.03

TABLE 7.2.3-5

Bottom water temperature, ΔT, percentage power of Units No. 2 and 3, daily river flow (measured at Holtwood Dam) at stations in and outside the thermal plume of the Peach Bottom Atomic Power Station, Conowingo Pond, week of 7 July - week of 22 December 1974.

Station		PLUME														
		450			451			470			471			473		
		Temp (F)	ΔT Mean	ΔT Range	Temp (F)	ΔT Mean	ΔT Range	Temp (F)	ΔT Mean	ΔT Range	Temp (F)	ΔT Mean	ΔT Range	Temp (F)	ΔT Mean	ΔT Range
Week of:																
Jul	7	81.8	2.9	2.6-3.2	84.6	5.7	4.4-6.3	82.2	3.3	1.4-3.7	80.1	1.2	0.0-1.8	80.5	1.6	0.7
	14	84.1	4.4	3.9-4.4	85.9	6.2	5.7-6.2	84.6	4.9	4.4-5.3	80.9	1.2	0.6-1.7	81.0	1.3	1.0-1.4
	22	78.8	0.6	0.6-0.7	80.3	2.1	0.9-3.2	79.6	1.4	0.8-1.9	78.5	0.3	0.0-0.1	76.3	0.1	0.0-0.2
	28	83.6	4.5	3.8-5.1	85.1	6.0	5.4-6.6	84.7	5.6	4.3-6.9	79.6	0.5	-0.1-1.2	79.5	0.4	-0.3-1.2
Overall Mean and Range		82.3	3.3	0.6-5.1	84.2	5.2	0.9-6.6	83.1	4.1	0.8-6.9	80.0	1.0	-0.1-1.8	80.1	1.1	-0.3-1.4
Aug	4	83.0	3.1	1.2-5.2	85.3	5.4	4.1-8.9	83.0	3.1	3.0-3.2	80.2	0.3	-0.2-0.6	80.0	0.1	-0.1-0.4
	11	81.3	3.5	2.1-4.4	84.1	6.3	5.9-7.0	81.9	4.1	3.0-5.3	78.6	0.9	0.3-1.4	78.1	0.3	-0.1-0.7
	18	82.2	3.1	1.9-3.9	83.9	4.8	3.9-5.8	83.3	4.2	4.0-4.5	80.7	1.6	1.0-2.9	79.3	0.2	-0.5-0.9
	25	82.0	2.0	1.1-2.7	86.1	6.1	1.1-9.2	84.6	4.6	3.8-5.9	80.9	0.9	0.2-1.4	81.1	1.1	0.4-2.0
Overall Mean and Range		82.1	2.8	1.1-5.2	85.0	5.7	1.1-9.2	83.4	4.1	3.0-5.9	80.2	0.9	-0.2-2.9	79.9	0.6	-0.5-2.0
Sep	1	76.1	0.7	0.2-1.1	81.6	6.2	4.7-7.5	79.8	4.4	3.6-4.9	77.0	1.6	1.1-2.1	77.2	1.8	1.5-2.5
	8	69.5	0.6	0.5-0.8	78.1	9.2	8.8-9.5	73.5	4.6	3.9-5.5	69.2	0.3	0.0-0.5	69.2	0.3	0.1-0.6
	15	72.2	0.2	0.1-0.3	76.0	4.9	1.3-5.5	74.6	2.6	1.3-3.7	72.5	0.5	0.1-0.7	72.1	0.1	-0.3-0.5
	22	69.5	0.8	0.3-0.9	71.4	2.7	0.6-5.1	71.0	2.3	1.6-4.0	69.7	1.0	0.9-1.0	69.1	0.4	-0.4-1.0
Overall Mean and Range		71.8	0.5	0.1-1.1	77.0	5.7	0.6-9.5	74.8	3.5	0.9-5.5	72.1	0.8	0.0-2.1	71.9	0.6	-0.4-2.5
Sep	29	63.6	1.1	0.7-1.5	67.4	4.9	4.5-5.2	65.2	2.7	2.6-2.9	62.7	0.2	-0.5-0.9	62.9	0.4	-0.6-1.5
Oct	6	60.8	1.7	0.6-2.7	67.6	8.5	7.6-9.7	64.4	5.3	4.9-5.6	59.7	0.6	0.0-1.3	60.5	1.4	0.7-2.4
	13	62.1	2.3	1.4-2.9	65.7	5.9	3.4-10.5	63.3	3.5	1.6-6.3	60.6	0.8	0.4-1.4	60.8	1.0	0.4-1.5
	20	56.0	1.9	1.6-2.2	59.1	5.0	2.6-9.2	58.2	4.1	2.2-7.4	55.1	1.0	0.2-1.6	55.3	1.2	1.0-1.4
	27[3]															
Overall Mean and Range		60.4	1.9	0.6-2.9	64.7	6.2	2.6-10.5	62.6	4.1	1.6-6.3	59.2	0.7	-0.5-1.6	59.6	1.1	-0.6-2.4
Nov	3	58.4	2.3	0.8-3.6	61.9	5.8	5.1-7.4	61.2	5.1	4.7-5.6	57.5	1.4	0.5-2.2	57.5	1.4	1.0-1.8
	10	59.5	5.4	3.4-9.1	64.0	9.9	7.1-13.6	61.9	7.8	6.0-9.8	55.7	1.6	1.4-2.0	56.0	1.9	1.7-2.3
	17	49.1	4.8	2.9-7.3	56.4	12.1	9.3-13.4	54.6	10.3	8.0-11.2	47.9	3.6	0.8-7.1	47.3	3.0	2.7-3.2
	24	43.6	3.7	0.9-5.1	51.1	11.2	9.7-14.2	50.0	10.1	9.4-10.2	43.1	3.2	1.9-3.9	45.5	5.6	5.2-5.4
Overall Mean and Range		54.0	4.2	0.9-9.0	59.4	9.6	5.1-14.2	57.5	7.7	4.7-11.2	51.7	1.9	0.5-7.1	52.1	2.3	1.0-5.2
Dec	1	43.5	6.2	3.5-9.8	44.8	7.5	4.3-12.4	45.0	7.7	4.7-12.1	42.5	5.2	1.9-9.1	41.5	4.2	2.1-6.1
	8	43.3	5.6	4.9-5.9	46.1	8.4	6.4-10.1	43.0	5.3	4.2-6.5	40.3	2.6	2.2-3.0	39.4	1.7	1.0-3.3
	15	44.5	6.4	3.9-8.4	50.4	12.3	10.4-13.2	48.7	10.6	9.9-11.5	42.5	4.4	3.0-6.5	42.1	4.0	3.1-4.6
	22	44.1	7.8	6.5-9.2	49.0	12.7	11.7-13.8	48.2	11.9	11.2012.8	43.7	7.4	6.6-8.4	40.0	3.7	3.4-4.0
Overall Mean and Range		43.9	6.5	3.9-9.8	47.6	10.2	4.3-13.8	46.4	9.0	4.2-12.8	42.3	4.9	1.9-9.1	41.0	3.6	1.0-6.1

continued

TABLE 7.2.3-5

continued.

Station		PERIPHERY									CONTROL		
		452			472			474			453		
		Temp (F)	ΔT Mean	ΔT Range	Temp (F)	ΔT Mean	ΔT Range	Temp (F)	ΔT Mean	ΔT Range	Temp (F)	Percentage Power	Daily River Flow (10^3x cfs)
Week of:													
Jul	7	78.4	-0.5	-0.4-0.2	78.3	-0.6	-0.3-0.0	-	-	-	78.9	100	21.5-32.5
	14	80.0	0.3	0.0-0.6	80.1	0.4	0.0-0.5	80.3	0.6	0.1-0.9	79.7	100	14.3-15.5
	22	78.3	0.1	-0.1-0.2	77.8	-0.4	-0.6-	78.0	-0.2	-0.4-0.0	78.2	0-100	8.9-10.6
	28	78.9	-0.2	-0.7-0.3	79.4	0.3	0.1-0.4	79.6	0.5	0.3-0.7	79.1	96-100	11.3-12.6
Overall Mean and Range		79.0	0.0	-0.7-0.6	79.2	0.2	-0.6-0.5	79.7	0.7	0.0-0.9	79.0	0-100	8.9-32.5
Aug	4	80.3	0.4	0.0-0.9	79.8	-0.1	-0.6-0.3	79.7	-0.2	-0.5-0.1	79.9	85-100	12.0-21.9
	11	78.1	0.3	0.2-0.4	77.8	0.0	-0.1-0.1	78.2	0.4	0.0-0.8	77.8	100	8.7-10.4
	18	79.5	0.4	0.1-0.8	79.4	0.3	0.2-0.7	79.9	0.8	0.1-1.7	79.1	100	7.3-7.9
	25	80.2	0.2	-0.3-0.5	80.4	0.4	0.0-0.7	80.6	0.6	0.1-0.8	80.0	80-100	6.1-21.9
Overall Mean and Range		79.6	0.3	-0.3-0.9	79.5	0.2	-0.6-0.7	79.7	0.4	-0.5-1.7	79.3	80-100	6.1-21.9
Sep	1	75.8	0.4	0.2-0.6	76.3	0.9	0.6-1.9	76.7	1.3	0.7-2.2	75.4	102-120	24.4-45.0
	8	69.0	0.0-0.1		69.0	0.1	-0.1-0.3	68.9	0.0	-0.2-0.3	68.9	120-122	18.6-28.1
	15	71.9	-0.1	-0.2-0.0	71.8	-0.2	-0.5-0.1	71.8	-0.2	-0.4-0.1	72.0	31-80	14.0-18.1
	22	68.8	0.1	-0.1-0.2	68.9	0.2	-0.5-0.7	69.0	0.3	-0.7-1.3	68.7	0-82	14.6-20.4
Overall Mean and Range		71.4	0.1	-0.2-0.6	71.5	0.2	-0.5-1.5	71.6	0.3	-0.7-2.2	71.3	0-122	14.0-45.0
Sep	29	62.4	-0.1	-0.5-0.2	62.6	0.1	-0.4-0.5	62.7	0.2	-0.7-1.1	62.5	84-86	16.7-17.9
Oct	6	59.2	0.1	-0.3-0.3	59.4	0.3	-0.1-0.6	59.5	0.4	0.1-0.7	59.1	109-149	12.4-14.2
	13	59.9	0.1	-0.3-0.4	60.2	0.4	-0.3-0.9	60.4	0.6	-0.1-0.9	59.8	57-151	9.0-12.4
	20	54.1	0.0	-0.1-0.4	54.1	0.0	-0.8-0.4	55.0	0.9	0.5-1.4	54.1	67-132	10.3-11.1
	27[3]												
Overall Mean and Range		58.6	0.1	-0.5-0.4	58.7	0.2	-0.8-0.9	59.1	0.6	-0.7-1.4	58.5	67-157	9.0-17.9
Nov	3	56.2	0.1	0.0-0.3	56.4	0.3	-0.3-0.7	57.1	1.0	-0.1-1.9	56.1	56-67	8.0-8.4
	10	54.1	0.0	0.0-0.1	54.2	0.1	-0.3-0.5	54.6	0.5	0.4-0.9	54.1	115-175	19.3-20.3
	17	44.5	0.2	0.4-0.4	44.9	0.6	0.3-0.8	46.2	1.9	1.6-2.7	44.3	116-174	27.4-34.6
	24	40.2	0.3	0.2-0.3	40.9	1.0	0.1-1.2	42.2	2.3	1.0-3.0	39.9	121-163	34.4-39.9
Overall Mean and Range		49.9	0.1	-0.4-0.4	49.8	0.0	-0.3-1.2	50.7	0.9	-0.1-3.0	49.8	56-115	8.0-39.9
Dec	1	37.3	0.0	-0.1-0.0	37.3	0.0	0.0	38.6	1.3	0.3-3.2	37.3	72-151	32.2-33.7
	8	37.4	-0.3	-0.9-0.0	37.3	-0.4	-0.1-0.1	37.8	0.1	-0.2-0.4	37.7	70-151	43.9-122.8
	15	38.2	0.1	-0.1-0.1	38.2	0.1	-0.1-0.1	38.8	0.7	0.2-1.2	38.1	158-175	59.0-86.5
	22	36.3	0.0	0.0	36.1	-0.2	-0.2-0.1	39.3	3.0	2.6-3.4	36.3	156-172	38.3-42.1
Overall Mean and Range		37.4	0.0	-0.9-0.1	37.3	-0.1	-0.1-0.1	38.6	1.2	-0.2-3.4	37.4	70-175	32.2-122.8

TABLE 7.2.3-6

Catch per effort (number per 10 min haul) for fishes collected by a 16-ft semi-balloon trawl at stations in and outside the thermal plume of the Peach Bottom Atomic Power Station Units No. 2 and 3, Conowingo Pond, July-December 1974.

	Plume												
	Increased Flow and Temperature			Increased Temperature					Periphery				Control
Station	450	451	Mean	470	471	473	Mean	Mean	452	472	474	Mean	453
No. of Species	17	23	25	27	15	17	28	31	19	21	18	25	23
No. of Hauls	138	137	275	137	136	132	405	680	136	133	129	398	136
Species													
A. rostrata	-	-	-	**	-	-	**	**	-	-	-	-	-
D. cepedianum	-	0.10	0.05	1.54	-	0.07	0.55	0.43	0.01	**	0.05	0.02	-
E. masquinongy	-	-	-	-	-	-	-	-	-	-	-	-	-
C. auratus	-	**	**	-	-	-	-	**	-	-	-	-	-
C. carpio	0.06	0.16	0.11	5.47	0.32	0.83	2.23	1.72	0.21	0.92	0.67	0.60	1.12
N. micropogon	**	-	**	-	-	-	-	**	-	-	-	-	-
N. crysoleucas	**	-	**	0.25	-	0.04	0.10	0.07	-	**	**	**	0.01
N. amoenus	-	0.31	0.15	0.01	-	**	**	0.08	**	-	-	**	0.19
N. hudsonius	0.45	0.49	0.47	5.87	0.50	0.04	2.17	1.86	0.27	0.31	0.32	0.30	1.25
N. procne	-	-	-	0.01	-	-	**	**	-	-	-	-	-
N. rubellus	-	0.01	**	-	-	-	-	**	-	-	-	-	-
N. spilopterus	0.02	0.17	0.09	0.08	-	-	0.03	0.07	0.04	-	-	0.01	0.01
P. notatus	0.01	**	0.01	0.42	-	-	0.14	0.11	0.01	**	**	0.01	-
C. cyprinus	-	0.03	0.01	0.39	0.05	0.05	0.17	0.13	**	0.07	0.02	0.04	0.04
C. commersoni	-	**	**	0.02	-	-	**	**	-	**	-	**	-
H. nigricans	-	**	**	0.01	**	-	**	**	-	-	-	-	**
M. macrolepidotum	**	0.02	0.01	0.03	-	-	0.01	0.01	-	-	**	**	0.01
I. catus	-	-	-	0.09	-	0.32	0.14	0.10	0.04	0.10	0.05	0.06	0.01
I. natalis	-	0.02	0.01	0.01	**	0.05	0.02	0.02	-	0.02	0.04	0.02	0.01
I. nebulosus	0.01	**	0.01	0.85	0.04	1.00	0.63	0.47	0.08	0.23	0.19	0.17	0.21
I. punctatus	4.20	25.78	14.95	341.27	74.22	138.01	185.35	145.81	11.43	82.92	121.48	71.00	18.39
L. auritus	-	-	-	-	-	-	-	-	**	-	-	**	**
L. cyanellus	-	-	-	-	-	**	**	**	-	**	-	**	**
L. gibbosus	0.27	0.01	0.14	7.10	0.27	0.16	2.55	1.97	0.04	0.33	0.05	0.14	0.74
L. macrochirus	0.48	0.16	0.32	9.45	0.40	0.40	3.46	2.74	0.26	0.53	0.08	0.29	1.29
M. dolomieui	0.21	0.08	0.14	0.23	-	**	0.08	0.13	0.04	0.02	-	0.02	0.02
M. salmoides	**	0.02	0.01	0.25	**	-	0.09	0.07	-	0.01	**	**	0.01
P. annularis	0.22	0.31	0.26	8.89	0.46	0.62	3.36	2.64	1.09	1.39	1.63	1.37	2.99
P. nigromaculatus	**	0.05	0.03	0.04	**	-	0.02	0.03	**	0.01	-	**	**
E. olmstedi	2.14	0.16	1.15	1.50	2.48	0.67	1.56	1.75	2.66	6.04	2.19	3.64	10.21
P. flavescens	-	-	-	**	**	-	**	**	0.04	**	**	0.02	0.02
P. caprodes	-	-	-	0.01	-	-	**	**	-	-	-	-	-
S. vitreum	0.03	0.04	0.03	0.07	0.05	0.02	0.05	0.05	0.04	0.04	0.06	0.05	0.02
Totals	8.15	27.96	18.02	383.93	78.84	142.33	202.74	160.34	16.32	93.01	126.88	77.78	36.63

** Less than 0.01

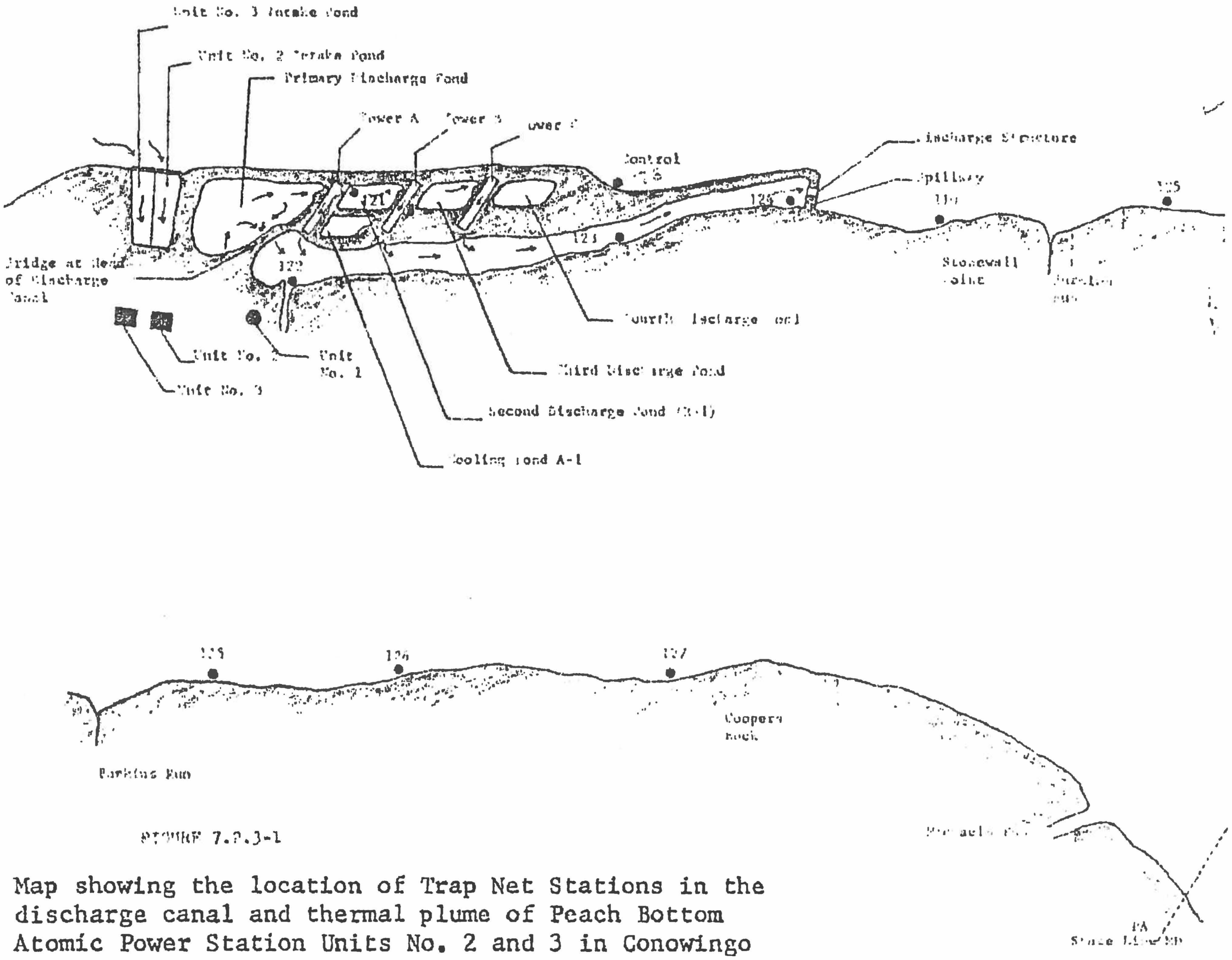

FIGURE 7.2.3-1

Map showing the location of Trap Net Stations in the discharge canal and thermal plume of Peach Bottom Atomic Power Station Units No. 2 and 3 in Conowingo Pond.

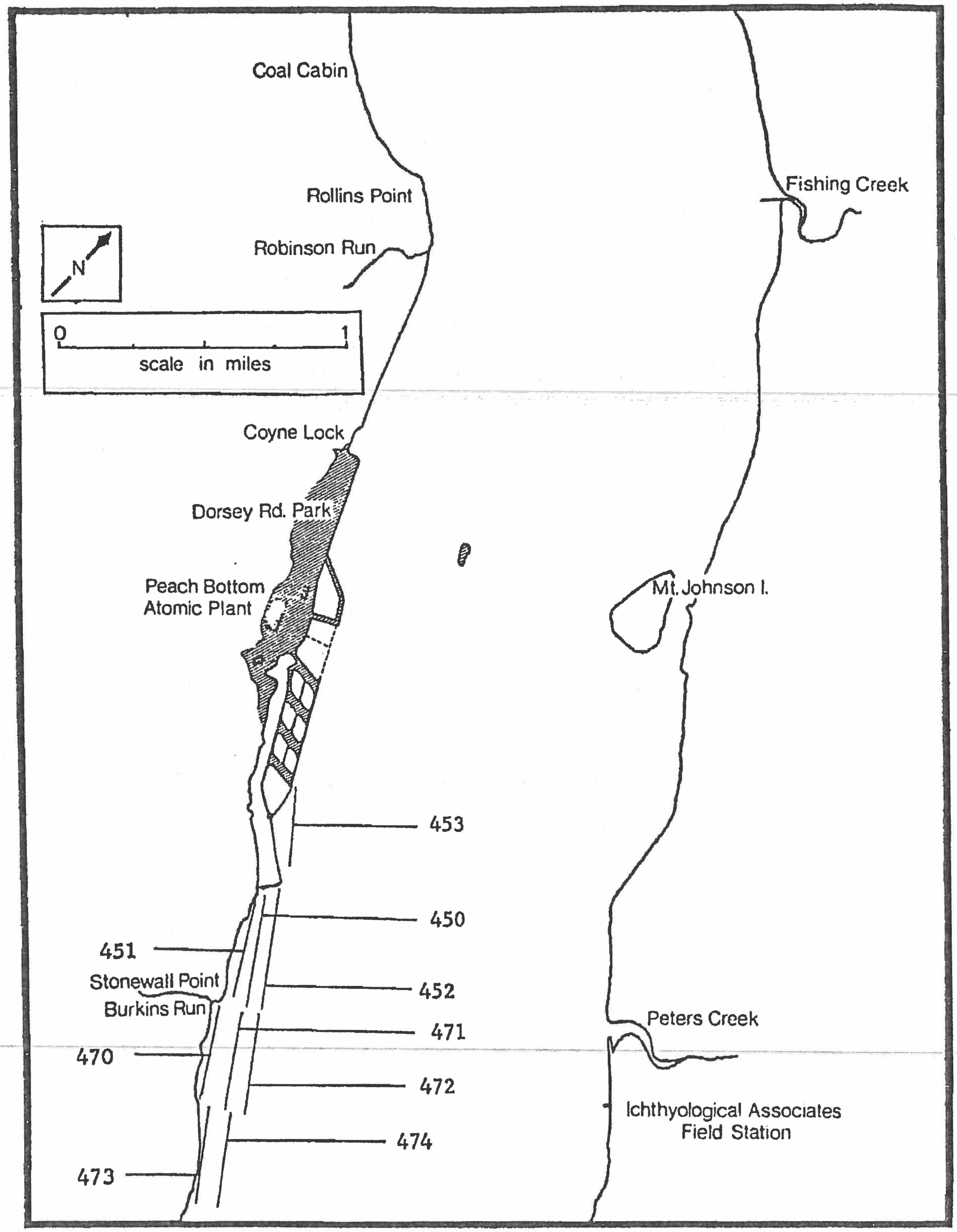

FIGURE 7.2.3-2

Location of trawl stations in and outside of the discharge of Peach Bottom Station Units No. 2 and 3, Conowingo Pond, July-December 1974.

7.3.0 BIOLOGY OF FISHES

The biology including food habits, reproduction, age and growth and population dynamics of the common fishes in the Pond was studied. The results are based on data from many specimens. The objectives of the food studies are to determine: (1) the food and feeding chronology of the common fishes over a 24-hour period, (2) seasonal food habits and feeding intensity and (3) the intra- and inter-specific food relationships. Studies are made of reproduction to determine: (1) time, location, and spawning temperature and (2) to estimate the reproductive potential (fecundity). The age and growth studies were conducted to determine: (1) the age composition, (2) growth rate and (3) length-weight relationships and condition factor. Population dynamics were considered in order to determine: (1) fluctuation in the year class strength, (2) the natural mortality and survival rates and (3) the rate of angler exploitation in winter.

Natural mortalities which have occurred in the Pond since the beginning of the study in 1966 have been recorded and attempts have been made to determine the cause.

A summary of the findings on the biology of the selected representative species is included below. Supportive data are included in this report or in Robbins and Mather (1974a, b and 1975a,b; see Section 4.1 for food habits; Section 4.3 for reproduction; Section 4.4 for age and growth; Section 4.5 for population dynamics; Section 4.6 for angler exploitation and Section 4.7 for observations on natural mortalities).

Spawning time was estimated by examination of ichthyoplankton in meter net. The first appearance of larvae in collections was considered the approximate time of spawning. Eggs were rarely taken in nets because most of the important species build nests and lay demersal eggs.

Studies of the fishery have emphasized a census of the winter fishery because it is expected that with the operation of the Station this will increase. The early fishery in the Pond in other seasons was investigated by Plosila (1961, p. 70-76) and our observations have indicated that the fishery in the summer, fall and spring has not changed substantially from that observed by him.

7.3.1 WHITE CRAPPIE (*Pomoxis annularis*)

7.3.1.1 Food Habits

Young fed mostly during the morning and early afternoon. The zooplankters, *Daphnia* spp. and *Cyclops* spp. were important over a 24-hr. period. Few insects were consumed. Seasonally, young crappie fed primarily on zooplankton. *Daphnia* spp. were important from June through October and *Cyclops* spp. were prominent in stomachs from September through April. Chironomid larvae were eaten in April and May. Seasonally, the following were eaten in small quantities: *Bosmina* sp., *Leptodora* sp., *Alona* sp., *Diaptomus* sp., amphipods, mayfly nymphs and algae. The diet was most varied in late fall, winter and early spring. Feeding was most intense from May through October. These findings generally agree with those of other investigators.

Feeding activity of the adult was most intense in June through October. It was moderate in April, May and November, and least intense in December, January and March. It fed mainly on zooplankton and small fish in most of the spring, summer and fall. Immature forms of aquatic insects (benthis organisms) were eaten in winter. Fish were eaten by adults but not by young.

Although few fishes were eaten, the volume was significant in those which did.

7.3.1.2 Reproduction

The white crappie builds nests along the shore, in coves and protected areas. The larvae are concentrated along the shore line of the Pond and in Broad Creek (Table 7.3.1-1 and Figure 7.3.1-3). The highest densities of larvae were found in Broad Creek.

The mean gonosomatic index (GSI) values were low in January. It gradually increased and reached a peak by the end of May or early June in 1971, 1972 and 1974 (Figure 7.3.1-1). In 1973 maximal GSI values and the peak density of larvae occurred in late June. The GSI values decreased gradually through September when the lowest values were recorded in all years. From October to December the ovarian weights showed a gradual increase.

The relationship between the peak spawning time based on GSI values, collection of larvae and water temperature was examined (Figure 7.3.1-1 and 7.3.1-2). Water temperature ranged from 60 to 85 F over the spawning season. Based on the GSI values, peak spawning occurred when the water temperature ranged from 68 to 74 F. Based on the collection of larvae, spawning occurred over a temperature range of 60 to 84 F with a peak at 70 to 82 F.

The spawning time of white crappie determined in other studies is similar to those reported here. Forbes and Richardson (1920, p. 239), and Hansen (1943, p. 260 and 1951, p. 227) reported May and June to be the spawning time of white crappie in Illinois. Peak spawning occurred in late May and early June. Eddy and Surber (1947) cited by Morgan (1954, p. 119) reported late spring and early summer as the spawning period of white crappie in Minnesota. In Buckeye Lake, Ohio spawning begins in April and extends to early July over a water temperature range of 51 F to 80 F (Morgan, 1954, p. 121).

In the Pond, the egg production of white crappie in 1974 ranged from 15,387 to 145,378 with an average of 40,535. In the preoperational period the fecundity ranged from 10,595 to 55,353 with an average of 25,724. Both fish length and weight and fecundity are linearly related. Significant differences ($P \geq 0.05$) between the slopes and elevations of the fecundity and fish weight were not observed in the pre- and postoperational period. A significant difference existed between the slopes of fecundity-fish length regression lines ($P \leq 0.05$). However, the elevations (adjusted means) were not significantly different which indicates that the mean fecundity adjusted for length did not differ in the two periods.

A comparison of the fecundity data from other studies shows a large variation in the mean value (Table 7.3.1-3). However, the range of egg production is similar. Morgan (1954, p. 123) reported that the egg production averaged 39,905 while Huber and Binkley (1935) reported an average of 7,120 eggs. Whiteside (1964) reported that white crappie in Lake Texoma, Oklahoma produced an average of 53,000 eggs.

7.3.1.3 Age and Growth

Although some white crappie attain an age of eight years, most are less than five (Figure 7.3.1-4). The age composition varied considerably between years. The variation in the age composition is primarily due to the production of strong and weak year classes. Moderate to strong year classes were produced (measured by abundance of 0 fish) in 1966, 1969, 1971, 1973 and 1974. These year classes continued their dominance at ages I, II and III in subsequent years. Only fish of the strongest year classes (1966 and 1969) were relatively common at age IV. A virtual absence of two-year old specimens was observed in the 1974 catch. This is primarily due to the poor year class produced in 1972, the year of the Tropical Storm Agnes.

The growth of individual year classes differs (Figure 7.3.1-5). The one year fish of the 1969, 1971 and 1974 year classes had above average growth. The 1967 year class had below average growth at age 1 but it was average at succeeding ages. The 1969 year class had below average growth after age I. Some of the observed differences in the growth rates of older age groups of various year classes reported here are probably due to small sample sizes.

Yearly differences in growth patterns of the white crappie population from 1966 through 1974 were examined by calculating a growth index. The growth of the white crappie population was above average in 1966, 1967, 1969 and in the PBAPS thermal plume in 1974 (Table 7.3.1-4). The growth was average in 1968, 1971 and 1974; it was below average in 1970, 1972 and 1973. The poorest growth occurred in 1972 which was the year of Tropical Storm Agnes.

Based on four years of data (1967-1970), one year old white crappie do not begin growth until the water temperature is approximately 70 F (June) (Table 7.3.1-5). Most two and three-year old fish do not resume growth until the water temperature reaches 75 F. Growth appears to decrease when water temperatures are below 70 F which is usually in October.

A comparison of the annual growth of various age groups between the preoperational and postoperational periods revealed that the growth of the one and two-year olds in 1974 was much greater than in the preoperational period. The mean lengths (128-130 and 200-206 mm) attained by these age groups were greater than the eight year averages of 115 ± 2.6 and 179 ± 3.1, respectively. In 1974 the average size of the four-year olds (based on small samples) was similar to that of the preoperational period. A comparison of the growth rate of white crappie in various waters is given in Table 7.3.1-6.

The monthly growth of young (0+) and one year old (I+) fish in 1974 both in the Pond and plume was above the range of observed growth in the preoperational period (Figures 7.3.1-6 to 7.3.1-9). Because of the production of the weak year class in 1972, few two-year old (II+) fish were collected and this precluded a valid comparison. The growth of the small sample of three year old (III+) fish was greater only in September and November.

The age composition of the white crappie collected from the thermal plume and at the monitoring stations in 1974 was similar. In both areas the catch was dominated by the 0, I (moderate 1974 and 1973 year classes) and III (strong 1971 year class) age groups. Few older than III were collected. The poor 1972 year class contributed less than 0.01% of the catch.

7.3.1.4 Year Class Fluctuations

Year class fluctuations in abundance occurred in the white crappie population from 1966 to 1974. The number of young caught per trawl haul was used as the index of relative abundance. Trawl data indicate that the 1966, 1969 and 1971 year classes of the white crappie were strongest and were 33 to 170 times more abundant than the weakest 1970 and 1972 year classes (Figure 7.3.1-10). The 1974 year class (postoperational year) was 4 to 11 times stronger than the 1967, 1968, 1970 and 1972 year classes. Production of young fishes in 1974 ranked fourth in abundance in comparison with the preoperational years. The year classes can be ranked in order of decreasing strength as follows: 1969, 1966, 1971, 1974, 1968, 1967, 1973, 1972 and 1970.

7.3.1.5 Survival Rates

Annual survival rates (s) of white crappie were estimated from trap net catches. Because of large natural fluctuations in recruitment, survival rates were computed for individual year classes. Two estimates were made; one included all age groups and the other was between age groups I to III since the catches of fish older than three years were low and fluctuated considerably.

The estimates (Table 7.3.1-7) by the Heincke (1913) and Jackson (1939) methods were consistently higher than those using that of Robson and Chapman (1961, p. 182) method (see Ricker, 1958, p. 41 for methods). The estimates using the Robson and Chapman method are statistically unbiased and are less subject to sampling error. The weakest year classes (1967 and 1970) had the highest survival rates. However, these estimates may be not valid because of small sample sizes and large confidence intervals. The age groups II and IV of the 1970 year class were more abundant than the age groups I and III, respectively (Table 7.3.1-8) but this would mean that more fish survived than the actual number present which is impossible. The moderate to strong year classes had similar survival rates, particularly during age I, II and III.

Survival rates between the successive age groups of a year class were estimated (Table 7.3.1-9). The lowest survival rates were observed in 1972; the strong 1971 year class had the lowest survival rate between age I and II, in the 1970 year class it was between age II and III and in the 1969 year class it was lowest between age III and IV. The low survival is likely the result of Tropical Storm Agnes in June 1972. The survival rates in years other than 1972 were similar.

Since the calculated survival rates did not change in 1974, it may be concluded that losses due to impingement at the vertical traveling screens at PBAPS must be negligible. Few were impinged. As a predator PBAPS imposes an additional although negligible source of mortality. Impingement losses may be considered as a type of fishing mortality which varies with season.

The impingement data for the white crappie from January through March 1974 were compared with the angler catch per effort during the winter in 1973 and 1974. PBAPS impinged 0.25 to 26.50 crappie per 12-hr. period in January to March 1974 (average 12.84). The angler caught between 26 to 50 crappie per 12-hr. period in 1973 and from 5 to 46 in 1974 (overall average 34.20). Thus, mortality attributable to PBAPS is less than that caused by one angler over the same time period.

TABLE 7.3.1-1

Catch of larvae of representative important fishes (≤ 25 mm) (number per 10-min tow) at various inshore locations during the preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond. *Pimephales notatus*, *Ictalurus punctatus*, and *Micropterus salmoides* not collected.

Location	Muddy Creek	West shore off Peach Bottom Station above discharge	West shore Peach Bottom discharge to Maryland State Line	Broad Creek	Glen Cove	Hopkins Cove	East shore from Johnsons Island to Wildcat Tunnel	Conowingo Creek
Species								
D. cepedianum								
1969	-	0.00	0.00	0.00	-	-	0.00	-
1970	-	0.00	0.00	0.00	-	-	0.00	-
1971	-	0.00	0.00	0.00	-	-	0.00	-
1972	0.00	0.16	-	5.41	0.52	0.24	-	0.68
1973	0.00	-	-	3.20	0.00	0.00	-	0.00
1974	0.28	-	-	5.68	0.12	0.12	-	0.00
N. spilopterus								
1969	-	0.16	0.46	0.00	-	-	0.58	-
1970	-	0.14	0.19	0.18	-	-	0.10	-
1971	-	0.00	0.00	0.02	-	-	0.03	-
1972	0.00	0.00	-	0.00	0.00	0.00	-	0.00
1973	0.00	-	-	0.32	0.00	0.00	-	0.24
1974	2.12	-	-	0.06	2.36	1.76	-	0.28
L. macrochirus								
1969	-	0.44	0.55	0.25	-	-	0.10	-
1970	-	0.00	0.00	0.06	-	-	0.05	-
1971	-	0.79	0.07	11.44	-	-	4.67	-
1972	0.00	0.00	-	0.00	0.00	0.00	-	0.00
1973	0.00	-	-	0.00	0.00	0.00	-	0.00
1974	0.00	-	-	0.00	0.00	0.00	-	0.00
Lepomis spp.								
1969	-	12.15	10.55	7.50	-	-	14.28	-
1970	-	8.00	4.57	153.26	-	-	26.43	-
1971	-	2.57	1.50	7.29	-	-	3.28	-
1972	0.00	0.44	-	5.77	4.52	6.52	-	14.00
1973	0.12	-	-	5.58	12.00	5.24	-	13.76
1974	1.24	-	-	12.18	6.64	3.88	-	10.52
M. dolomieui								
1969	-	0.00	0.06	0.00	-	-	0.00	-
1970	-	0.00	0.00	0.00	-	-	0.00	-
1971	-	0.00	0.00	0.00	-	-	0.00	-
1972	0.00	0.00	-	0.00	0.00	0.00	-	0.00
1973	0.00	-	-	0.00	0.00	0.00	-	0.00
1974	0.00	-	0.00	0.00	0.00	0.00	-	0.00
P. annularis								
1969	-	4.66	5.28	3.88	-	-	0.69	-
1970	-	2.00	8.22	20.75	-	-	3.57	-
1971	-	2.07	4.78	15.13	-	-	0.86	-
1972	0.00	0.16	-	16.57	1.60	4.92	-	12.00
1973	0.24	-	-	2.32	1.88	1.24	-	2.12
1974	0.12	-	-	6.62	2.64	1.52	-	9.00
S. vitreum								
1969	-	0.00	0.03	0.00	-	-	0.00	-
1970	-	0.00	0.00	0.00	-	-	0.00	-
1971	-	0.07	0.06	0.10	-	-	0.08	-
1972	0.00	0.28	-	0.05	0.00	0.00	-	0.12
1973	0.00	-	-	0.06	0.12	0.24	-	0.12
1974	0.00	-	-	0.06	0.00	0.00	-	0.00

TABLE 7.3.1-2

Catch of larvae of representative important fishes (≤ 25 mm) (number per 10-min tow) at Transect Stations on the west shore, mid-pond and west shore during the preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond.

Location	WEST SHORE				MID-POND				EAST SHORE				
Station	562	564	567	570	560	563	565	568	561	566	569	575	576
D. cepedianum													
1969	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
1970	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
1971	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
1972	0.03	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
1973	0.08	0.25	0.13	0.00	0.00	0.04	0.02	0.06	0.15	0.40	1.92	0.64	0.34
1974	0.00	0.02	0.00	0.04	0.02	0.00	0.02	0.02	0.02	0.33	0.21	0.03	0.03
N. spilopterus													
1969	0.14	0.05	0.05	-	0.29	0.03	0.02	0.06	0.21	0.18	0.00	-	-
1970	0.02	0.13	0.05	-	0.09	0.00	0.17	0.07	0.14	0.10	0.03	-	-
1971	0.06	0.00	0.00	-	0.06	0.42	0.02	0.07	0.15	0.12	0.00	-	-
1972	0.00	0.00	0.00	-	0.00	0.06	0.03	0.11	0.00	0.08	0.00	-	-
1973	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.02	0.17	0.02	0.00	0.00	0.02
1974	0.08	0.07	0.00	0.48	0.33	0.17	0.02	0.11	1.80	0.05	0.11	0.20	0.20
P. notatus													
1969	0.00	0.05	0.00	-	0.00	0.00	0.00	0.03	0.00	0.00	0.00	-	-
1970	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
1971	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
1972	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
1973	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00
1974	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.04	0.00	0.02	0.00	0.03
I. punctatus													
1969	8.62	11.00	17.39	-	3.85	4.29	8.02	9.00	1.28	0.44	0.92	-	-
1970	4.32	4.77	7.52	-	2.02	0.56	1.31	2.33	2.18	0.48	0.81	-	-
1971	0.20	0.47	1.53	-	1.96	0.04	0.07	0.23	1.19	0.08	0.26	-	-
1972	0.00	0.03	0.00	-	0.03	0.03	0.00	0.00	0.00	0.00	0.00	-	-
1973	2.87	2.62	3.85	0.33	1.86	3.17	1.26	0.69	1.42	1.96	0.51	1.08	1.21
1974	2.77	2.30	2.59	1.85	1.51	1.45	0.62	1.20	1.34	0.22	0.14	0.33	0.92
L. macrochirus													
1969	1.71	1.07	0.39	-	0.20	0.34	0.51	0.42	1.54	14.26	10.30	-	-
1970	0.02	0.23	0.02	-	0.00	0.00	0.19	0.05	0.02	2.92	0.22	-	-
1971	0.30	0.57	0.02	-	0.46	0.31	1.15	0.40	0.89	14.63	1.53	-	-
1972	0.03	0.03	0.00	-	0.03	0.00	0.07	0.00	0.03	0.11	0.00	-	-
1973	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.04	0.00	0.09
1974	0.02	0.02	0.00	0.04	0.00	0.02	0.02	0.04	0.13	0.18	0.43	0.07	0.12
M. dolomieui													
1969	0.05	0.07	0.03	-	0.10	0.08	0.10	0.24	0.26	0.13	0.16	-	-
1970	0.02	0.00	0.00	-	0.07	0.00	0.00	0.00	0.07	0.02	0.00	-	-
1971	0.00	0.00	0.00	-	0.00	0.02	0.00	0.00	0.00	0.00	0.05	-	-
1972	0.00	0.00	0.00	-	0.00	0.03	0.00	0.00	0.00	0.00	0.04	-	-
1973	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00
1974	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
M. salmoides													
1969	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
1970	0.02	0.00	0.02	-	0.00	0.00	0.00	0.00	0.02	0.00	0.00	-	-
1971	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.16	-	-
1972	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
1973	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00
1974	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P. annularis													
1969	1.19	6.21	0.68	-	0.17	0.03	1.02	0.18	1.41	2.59	6.03	-	-
1970	0.55	0.73	0.12	-	0.20	0.08	0.06	0.00	0.07	0.42	0.08	-	-
1971	0.42	1.09	0.35	-	0.13	0.15	0.33	0.26	0.66	7.31	3.95	-	-
1972	0.18	0.06	0.18	-	0.05	0.00	0.07	0.04	0.10	0.16	0.07	-	-
1973	0.11	0.06	0.27	0.14	0.06	0.06	0.02	0.24	0.06	0.09	0.30	0.04	0.06
1974	0.20	0.12	0.11	0.22	0.09	0.10	0.07	0.16	0.21	0.48	0.84	0.23	0.13
Lepomis spp.													
1969	4.83	0.33	0.32	-	0.17	0.26	0.07	0.33	0.67	0.21	5.46	-	-
1970	1.15	0.08	0.69	-	0.11	0.26	0.00	0.26	0.66	0.19	1.49	-	-
1971	0.48	0.64	0.98	-	0.39	0.56	0.33	3.14	0.83	13.86	15.32	-	-
1972	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
1973	0.32	0.34	0.18	0.19	0.06	0.15	0.13	0.44	0.31	0.89	0.68	1.40	1.57
1974	0.10	0.27	0.18	0.96	0.15	0.08	0.12	0.13	0.21	0.38	0.45	0.80	0.63
S. vitreum													
1969	0.02	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
1970	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
1971	0.22	0.13	0.02	-	0.02	0.02	0.02	0.00	0.15	0.12	0.00	-	-
1972	0.09	0.03	0.04	-	0.03	0.06	0.00	0.00	0.08	0.03	0.00	-	-
1973	0.02	0.00	0.00	0.05	0.02	0.02	0.17	0.00	0.06	0.02	0.02	0.02	0.04
1974	0.03	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.02	0.00	0.00

TABLE 7.3.1-3

Comparison of fecundity data on white crappie from various studies. Portion of the data reproduced from Calhoun (1966). Original measurements in inches converted to millimeters.

Source	Sample Size	Total Length (mm) Range	Number of Eggs Range	Number of Eggs Mean
Morgan (1954)	56	149-330	970-213213	39905
Huber and Binkley (1935)	42	-	2900-14750	7120
Seifert (1969)	24	211-316	22880-194100	
Whiteside (1964)	-	-	25600-91700	53000
Present Study (1971)	30	161-249[1]	10595-55353	25724
Present Study (1974)	39	176-329[1]	18764-145378	40535
Combined (1971-1974)	69	161-329[1]	10595-145378	34096

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[1] Original measurements in fork length converted to total length using the relationship $TL = 1.213 + 1.028\ FL$

TABLE 7.3.1-5

Continued.

		AGE GROUP					
		I		II		III	
	**Mean Water Temp (F)	Number of Fish	Percent with Annulus	Number of Fish	Percent with Annulus	Number of Fish	Percent with Annulus
1969							
MAY							
1-8	-	-	-	-	-	-	-
9-16	-	-	-	-	-	-	-
17-24	67.0	7	0.0	6	0.0	14	0.0
25-31	70.0	50	44.0	1	0.0	5	0.0
JUNE							
1-8	-	-	-	-	-	-	-
9-16	75.0	13	100.0	6	66.0	39	0.0
17-23	75.5	23	100.0	1	100.0	10	0.0
24-30	78.0	18	100.0	3	100.0	15	80.0
JULY							
1-8	78.5	24	100.0	2	100.0	11	90.9
9-16	80.0	13	100.0	2	100.0	11	90.9
17-24	81.0	29	100.0	-	-	21	100.0
25-31	78.5	5	100.0	-	-	2	100.0
1970							
MAY							
1-8	-	-	-	-	-	-	-
9-16	-	-	-	-	-	-	-
17-24	66.0	34	0.0	30	0.0	3	0.0
25-31	70.5	22	13.6	-	-	-	-
JUNE							
1-8	71.0	13	38.5	11	0.0	4	0.0
9-16	74.0	60	93.3	35	0.0	4	0.0
17-23	74.0	1	100.0	-	-	1	0.0
24-30	74.0	33	93.9	23	4.3	2	0.0
JULY							
1-8	-	-	-	-	-	-	-
9-16	74.5	36	100.0	16	68.7	2	0.0
17-24	76.0	-	-	2	50.0	-	-
25-31	81.5	34	97.0	16	81.2	3	33.3

** Mean of surface water temperature at sampling stations.

TABLE 7.3.1-6

A comparison of calculated growth rates for white crappie, *Pomoxis annularis*, from various parts of the country. Portion of the data (*) reproduced from LaFaunce (1960, p. 3). Original measurements in inches were converted to millimeters.

Source	Place	Age Group							
		I	II	III	IV	V	VI	VII	VIII
Carter (1953)*	Kentucky Lake, Ky.	117	201	264	302	325			
Geibel (1959a)[1]*	East Park Reservoir, Cal.	93	171	195	281				
Geibel (1959b)[1]*	Stony Gorge Reservoir, Cal.	77	163	213	237				
Hagy (1956)[1]*	Anderson Reservoir, Cal.	152	186						
Hall et al. (1954)*	Oklahoma State Average	74	150	198	249	302	335	361	381
Hansen (1951)	Lake Decatur, Ill.	196	229	267	277	290	330		
Starrett and Fritz (1965)*	Lake Chautaugue, Ill.		190	234	262	283	300		
Jackson (1957)*	Lower Spavinaw, Okla.	117	208	239	284	338			
Morgan (1954)*	Buckeye Lake, Ohio	58	107	150	193	231	259	302	
Stevens (1958a)*	Lake Moultrie, S.C.	56	208	287	340	371	381	378	
Stevens (1958b)*	Lake Marion, S.C.	48	175	251	284	312	320	333	
Present Study[1]	Conowingo Pond, Pa.	113	184	226	254	291	327		

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[1] Original measurements in fork lengths converted to total lengths by the following relationship: TL = 1.213 + 1.028FL.

TABLE 7.3.1-7

Estimates of annual survival rates of various year classes of white crappie, *Pomoxis annularis* in Conowingo Pond as calculated by the methods of Robson and Chapman, Heincke, and Jackson.

	Robson and Chapman	Heincke	Jackson
	ALL AGE GROUPS		
1966	0.415±0.041	0.519	0.519
1967	0.444±0.208	0.480	0.481
1968	0.343±0.075	0.408	0.408
1969	0.345±0.029	0.410	0.411
1970	0.620±0.578	0.669	0.752
1971	0.302±0.046	0.354	0.384
	AGE GROUPS I-III		
1966	0.391±0.042	0.505	0.584
1967	0.394±0.221	0.449	0.531
1968	0.321±0.075	0.397	0.429
1969	0.248±0.023	0.403	0.443
1970	0.532±0.718	0.628	0.688
1971	0.302±0.046	0.354	0.354

TABLE 7.3.1-8

Catch per effort (number per 100 hr) for various age groups of the 1966-1974 year classes of white crappie, Pomoxis annularis, collected by trap net during the preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond.

				AGE GROUP				
Year Class	0*	I	II	III	IV	V	VI	VII
1966		161.06	121.40	43.44	8.05	0.73	0.25	0.02
1967	7.99	7.42	4.02	2.05	0.74	**	0.04	0.01
1968	10.85	63.92	34.17	7.97	1.71	0.15	0.02	
1969	302.40	417.46	218.72	62.91	7.51	1.08		
1970	0.96	0.81	1.18	0.19	0.27			
1971	243.09	182.37	78.34	21.74				
1972	1.44	0.62	0.07					
1973	30.77	16.07						
1974	63.95							

* Collections taken from July through December.
** Less than 0.01

TABLE 7.3.1-9

Estimates of annual survival rates between two successive age groups of individual year classes of white crappie, Pomoxis annularis collected by trap net in Conowingo Pond.

Year Class	I/II	II/III	III/IV	IV/V	V/VI	VI/VII
1966	0.7538	0.3578	0.1853	0.0907	0.3425	0.0800
1967	0.5418	0.5100	0.3610	-	-	0.3000
1968	0.5346	0.2332	0.2142	0.0877	0.1333	
1969	0.5239	0.2876	0.1194	0.1438		
1970	-	0.1640	-			
1971	0.4290	0.2775				
1972	0.1129					

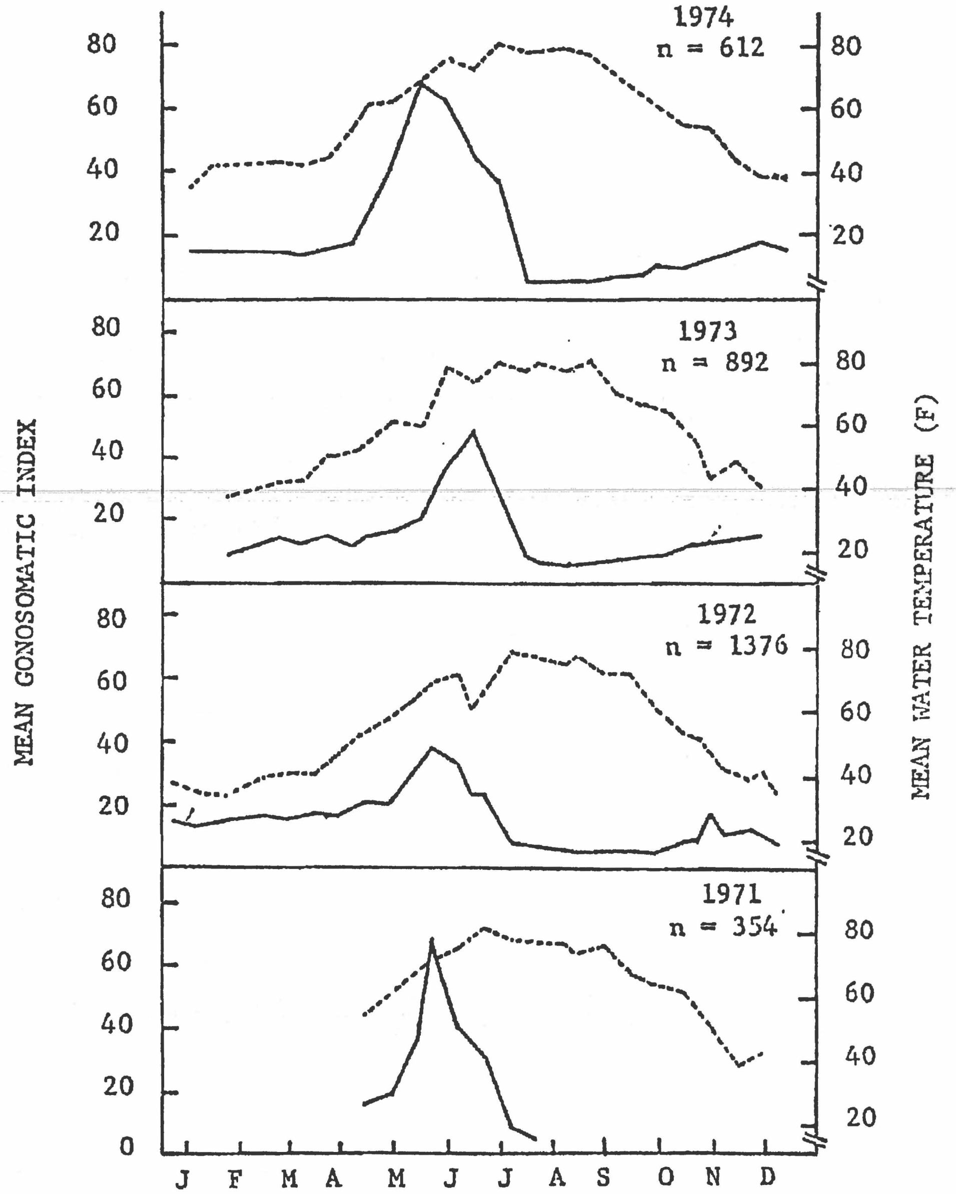
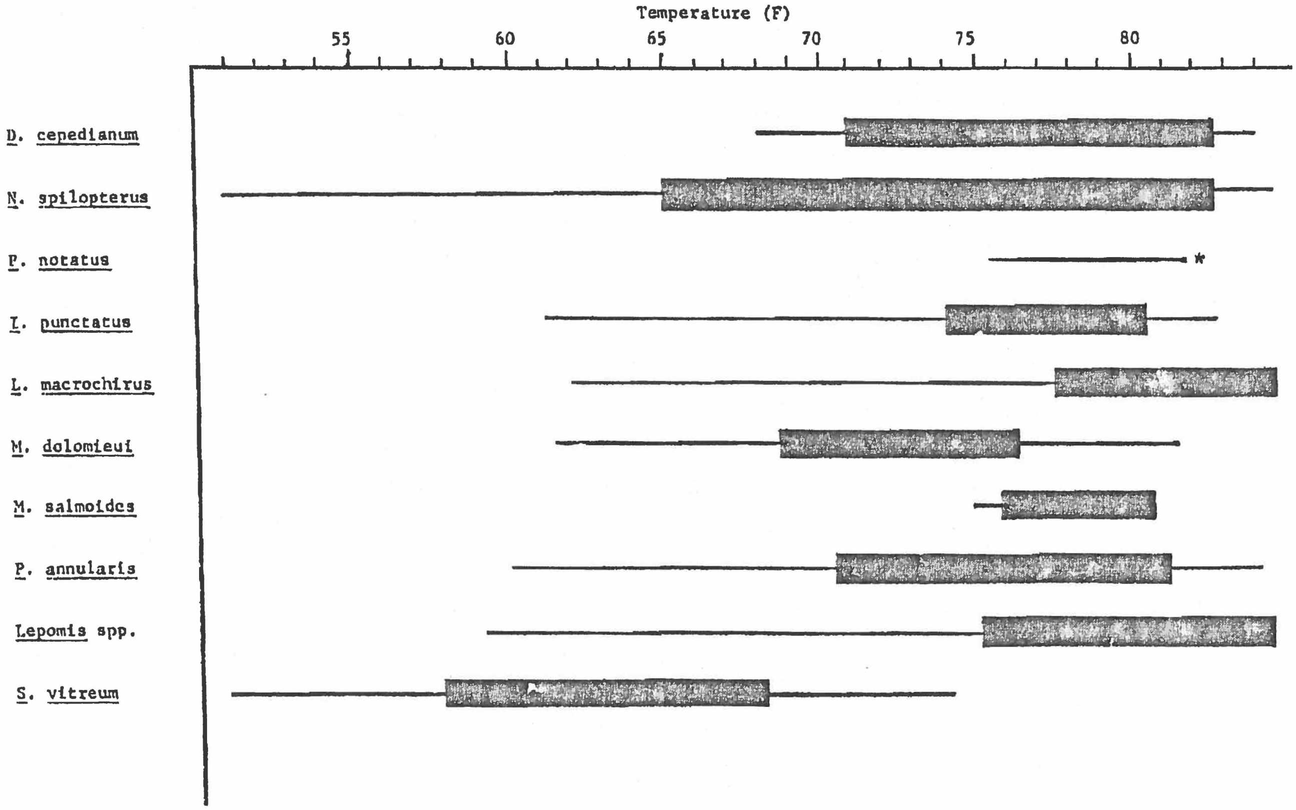


FIGURE 7.3.1-1

Seasonal variations in mean gonosomatic index (solid line) and water temperature (dashed line) of white crappie, Pomoxis annularis collected during the preoperational (1971-1973) and postoperational (1974) periods in Conowingo Pond.

FIGURE 7.3.1-2

Range of surface water temperatures at which larval fishes (25 mm or less in size) were taken in Conowingo Pond in 1969-1973. Narrow lines: temperature range at which fish larvae were collected; Wide bands: temperature range of maximal density.



* Insufficient numbers of larvae were taken to determine periods of maximal density.

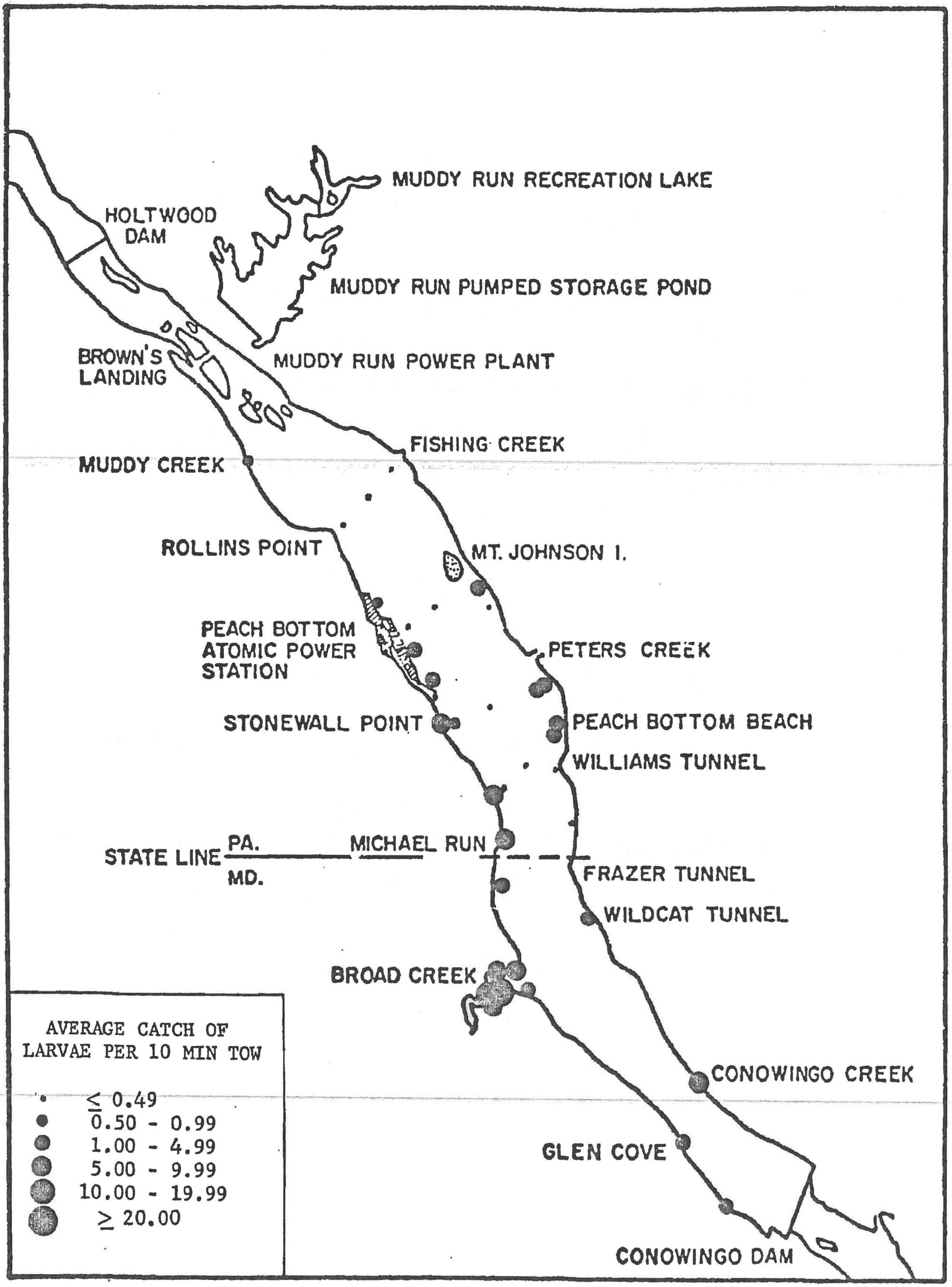


FIGURE 7.3.1-3

Relative catch per effort of white crappie, *Pomoxis annularis* larvae (≤ 25 mm) at plankton net stations in Conowingo Pond, 1969-1973.

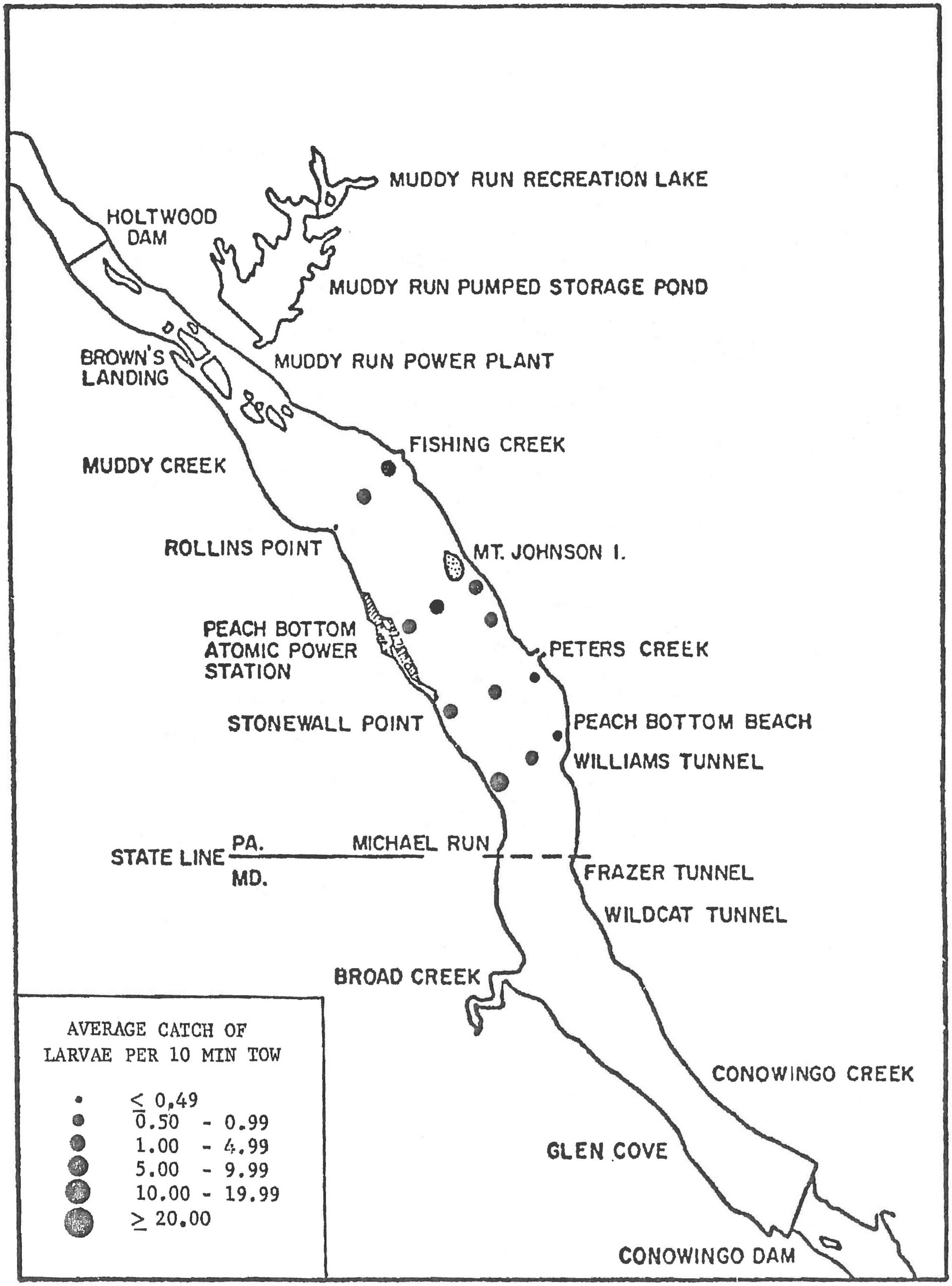


FIGURE 7.3.1-4

Distribution of channel catfish, <u>Ictalurus punctatus</u> larvae (≤ 25 mm) at plankton net stations in Conowingo Pond, 1969-1973.

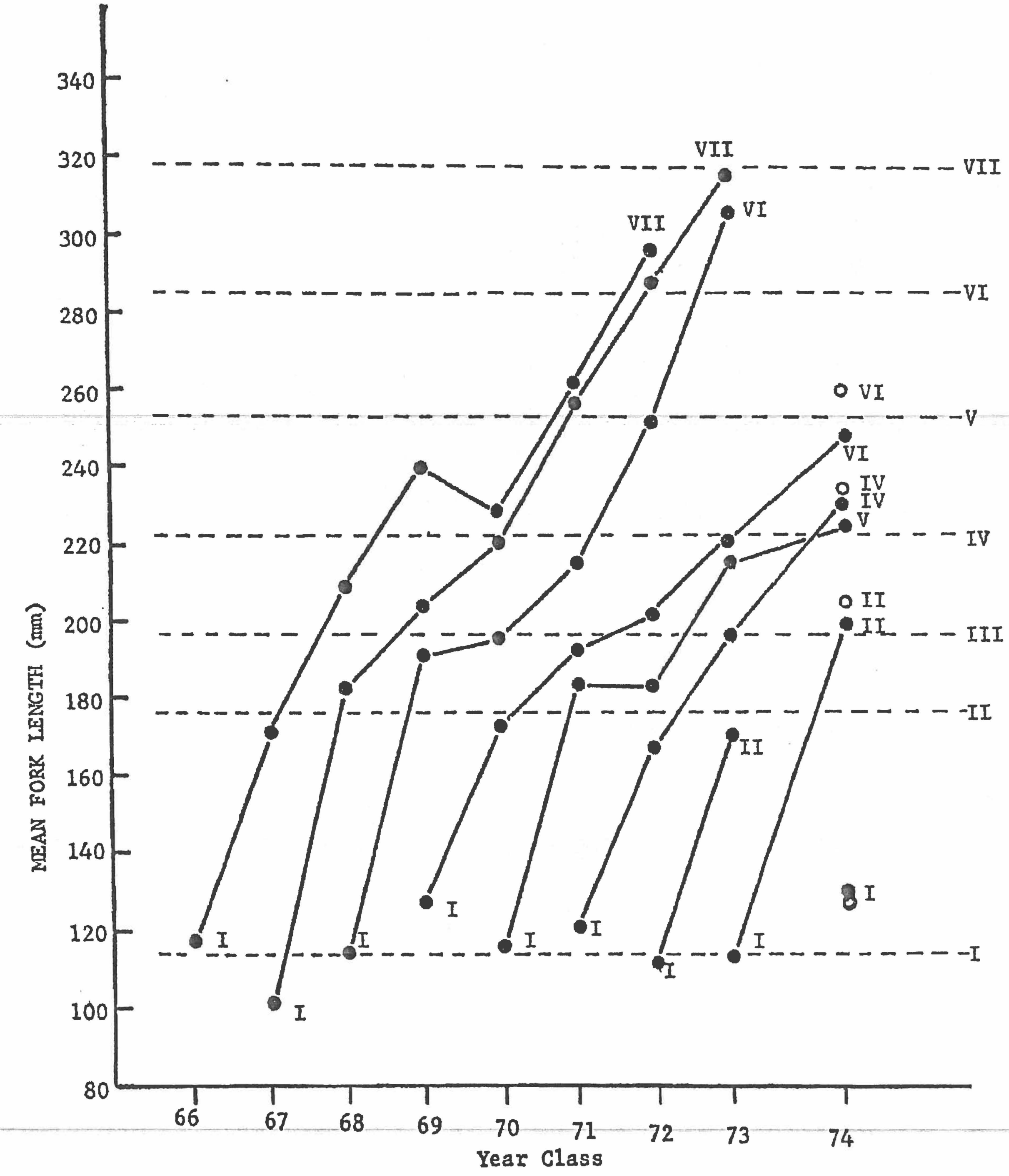


FIGURE 7.3.1-5

Growth of the 1966-1974 year classes of white crappie, Pomoxis annularis collected by trap net in Conowingo Pond. Open circles - thermal plume.

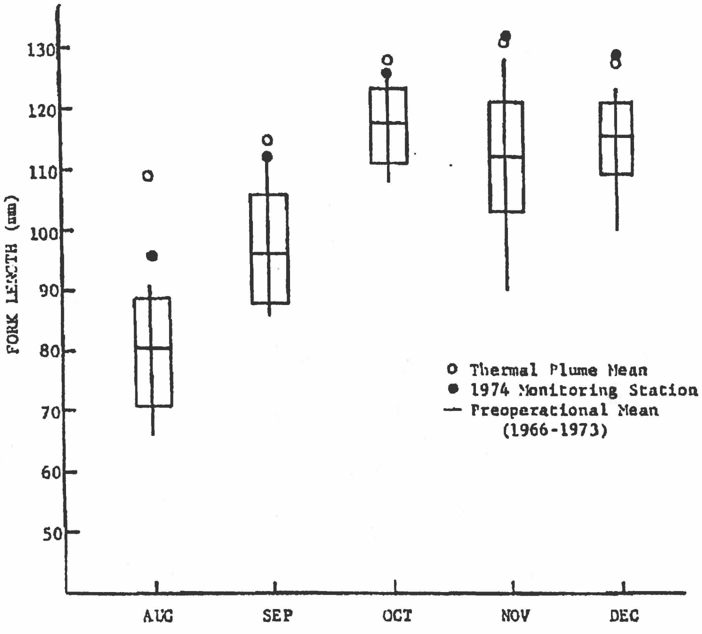


FIGURE 7.3.1-6

Monthly growth of the young (0) white crappie, Pomoxis annularis collected by trap net during the preoperational (1966-1973) and postoperational (1974) periods in Conowingo Pond and thermal plume. Vertical line - range, rectangle - 2 standard error of mean, horizontal line - preoperational mean, open circles - thermal plume mean, closed circles - 1974 mean.

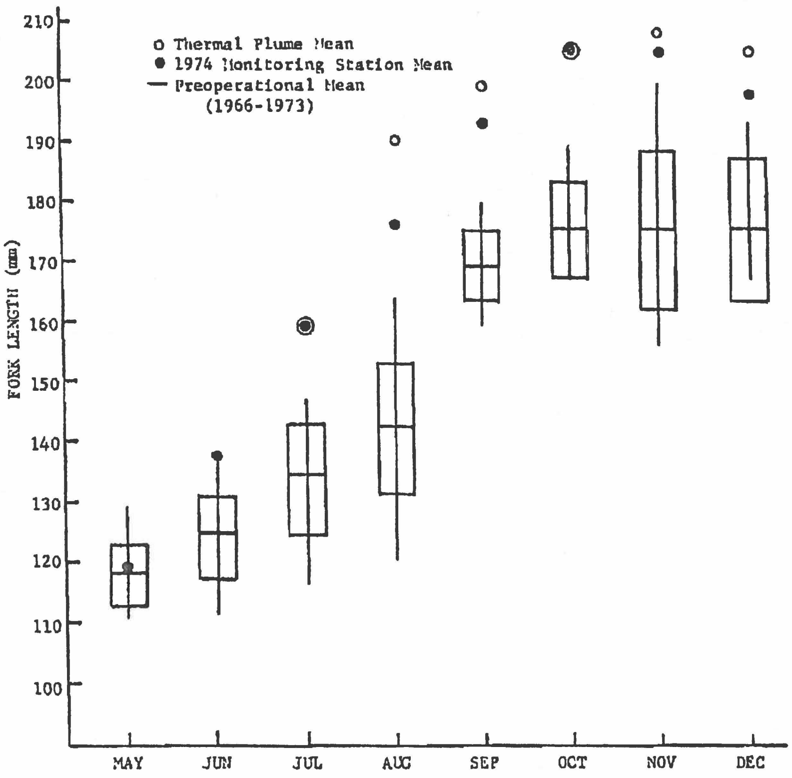


FIGURE 7.3.1-7

Monthly growth of the one year old (I) white crappie, Pomoxis annularis collected by trap net during the preoperational (1966-1973) and postoperational (1974) periods in Conowingo Pond and thermal plume. Vertical lines - range, rectangle - 2 standard error of mean, horizontal line - preoperational mean, open circles - thermal plume mean, closed circles - 1974 mean.

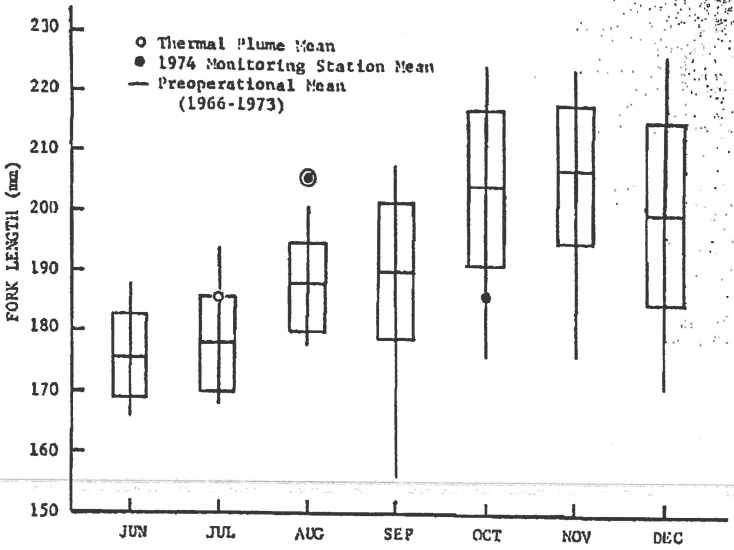


FIGURE 7.3.1-8

Monthly growth of the two year old (II) white crappie, Pomoxis annularis collected by trap net during the preoperational (1966-1973) and post-operational (1974) periods in Conowingo Pond and thermal plume. Vertical line - range, rectangle - 2 standard error of mean, horizontal line - preoperational mean, open circles - thermal plume mean, closed circles - 1974 mean.

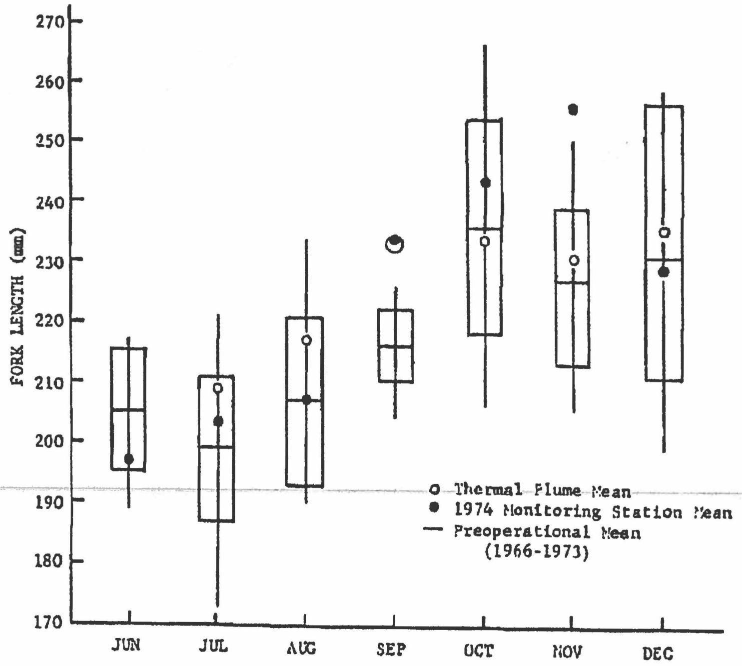


FIGURE 7.3.1-9

Monthly growth of the three year old (III) white crappie, Pomoxis annularis collected by trap net during the preoperational (1966-1973) and postoperational (1974) periods in Conowingo Pond and thermal plume. Vertical lines - range, rectangle - 2 standard error of mean, horizontal line - preoperational mean, open circles - thermal plume mean, closed circles - 1974 mean.

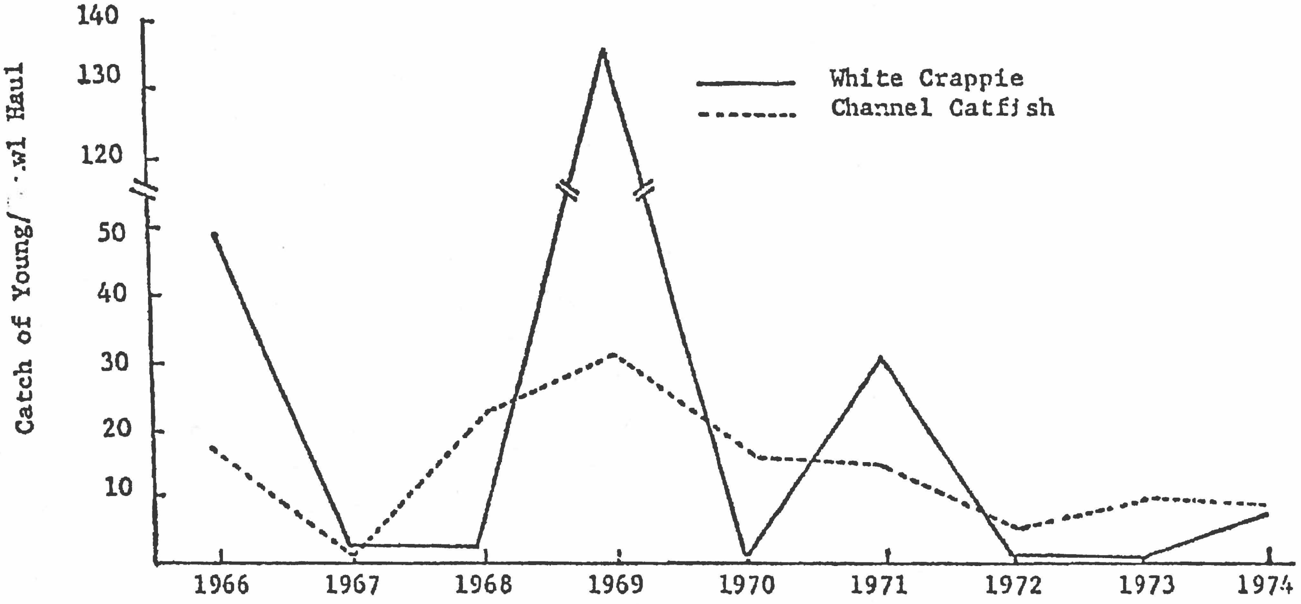


FIGURE 7.3.1-10

Year class strength of white crappie (solid line) and channel catfish (dashed line) expressed as the catch of young per trawl haul in Conowingo Pond.

7.3.2 CHANNEL CATFISH (_Ictalurus punctatus_)

7.3.2.1 Food Habits

Subadults and adults fed most heavily during daylight hours in Conowingo Pond. The principal food during most of the 24-hour period was zooplankton. The food in mid-morning was fishes and in the early morning it was insects. From July through November zooplankton was the principal food. In August and October fishes were important in the diet. In November amphipods were significant food items. Feeding activity decreased in November. Other investigators in other areas reported (see Mathur, 1971) that fishes, insects, crustaceans, molluscs and plant seeds were common food items.

7.3.2.2 Reproduction

The channel catfish spawns in nests near the shore. High gonosomatic ratios indicate that the spawning peak occurred in June and July in the Pond. Spawning occurred at water temperatures of 62 to 82 F. Peak spawning occurred at 74 to 81 F (Figure 7.3.1-2). The gonosomatic index was highest at 75 F. The larvae were usually taken in June through August, with a maximum abundance in June or July, in most years. The densities of larvae were higher along the west shore and mid-Pond, than along the east shore (Table 7.3.1-1 and 7.3.1-2 and Figure 7.3.2-4).

The fecundity of 31 channel catfish in the preoperational period ranged from 1,049 to 11,898 with an average of 2,546. The fecundity of 13 channel catfish in 1974 ranged from 1,014 to 7,396 with an average of 2,349. Although the small sample size precluded a statistical analysis of the fecundity data, the egg production in 1974 (postoperational period) was well within the range of variation observed in the preoperational period.

7.3.2.3 Age and Growth

Most of the specimens which were aged were less than eight years. Some were 9 to 16 years. Most growth (50%) occurred in the first four years (Figure 4.2-1). For ages VI to XII, the annual average increase in length was up to 12 mm per year.

Differences in growth occurred between year classes (Figure 7.3.2-2). The growth of age group I was greater than the 10 year mean (1958 to 1968) from 1958 to 1961 and was less in 1963 and 1965 through 1967. The growth of the 1959 year class was consistently above average. Growth of the 1960 year class was good for the first three years. It was poor for the 1964 year class. A comparison of growth rates in other waters shows that the growth of catfish in Conowingo Pond is relatively slow, especially after the first three years (Table 7.3.2-1).

The growth of the young and yearling channel catfish appears to be related to water temperature (Figure 7.3.2-3). The specific growth rate (percentage growth completed per unit time) was highest when the water temperatures exceeded 70 F. The growth rate declined at water temperatures less than 70 F.

7.3.2.4 Year Class Fluctuations

The differences in year class strength of the channel catfish were not as pronounced as were those of the white crappie (Figure 7.3.2-5). The 1969 year class was the strongest and three times more abundant than that of 1974 (postoperational year). The 1974 year class was 2 to 10 times more abundant than the weakest 1967 and 1972 year classes. Like previous years, the production of young channel catfish in 1974 was greater (about three times) in Zone 405 (off the Station) than in Zone 406 and 408.

TABLE 7.3.2-1

A comparison of the calculated growth rates for channel catfish, *Ictalurus punctatus*, from various parts of the country. Data from other studies reproduced from Carlander (1969, p. 548). Original measurements in inches converted into millimeters.

Source	Place	Age Group														
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
Stevens (1959)	Lake Moultrie, S.C.	86	185	284	368	442	531	602	665	726	773	807	853	916	904	
Fogle (1963)	Lake Oahe, S.D.	122	201	267	348	437	513	549	602	663						
Conder and Hoffarth (1965)	Kentucky Lake, Tenn.	109	170	221	262	307	363	424	495	566	640					
Helms (1965)	Coralville Lake, Ia.	84	157	211	267	320	351	384	411	381						
Marzolf (1955)	Lake of Ozarks, Mo.	53	117	168	206	241	269	295	325							
Harrison (1957)	Mississippi River, La.	66	150	211	254	274	315									
Muncy (1959)	Des Moines River, Ia.	46	124	196	257	312	381	442	490	546	617	645	640	676		
Hancock (1955)	Canton Lake, Okla.	94	208	305	386	442	536	594								
Orr (1958)	Heyburn Lake, Okla.	86	165	224	305	394	472	561								
Starrett and Fritz (1965)	Lake Chautauqua, Illinois			348	401	462	523	569								
Present Study*	Conowingo Pond, Pa.	105	175	230	262	294	332	365	402	448	483	529	571	531	497	516

* Fork lengths converted to total lengths by the following relationship: TL = 5.453 + 1.135FL

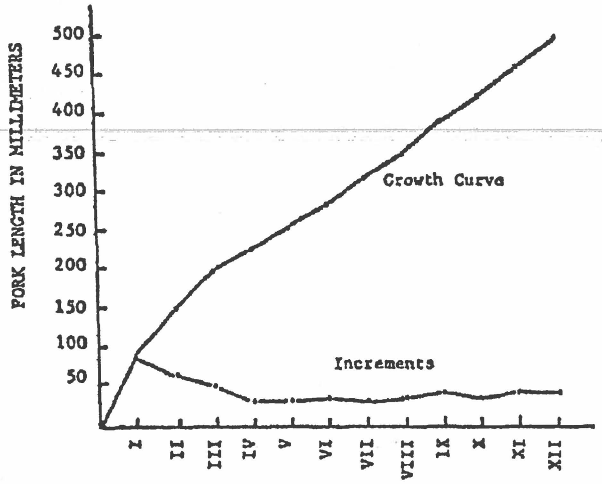


FIGURE 7.3.2-1

Calculated growth curve and annual increments for 236 channel catfish, *Ictalurus punctatus*, collected from Conowingo Pond, 1967-1969.

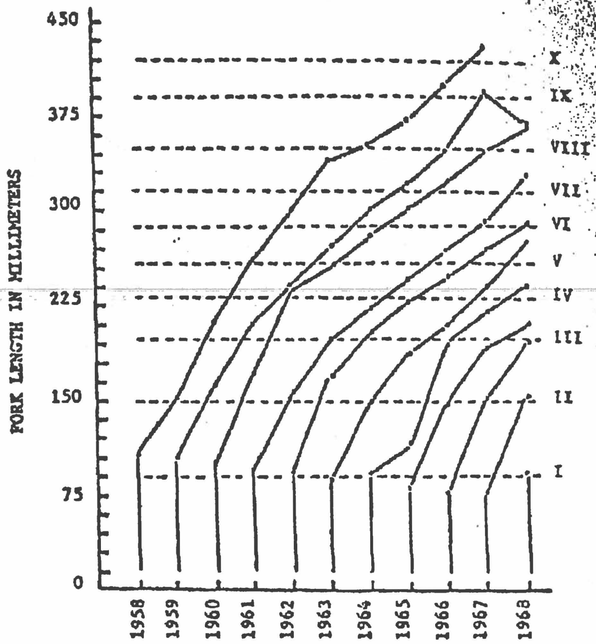


FIGURE 7.3.2-2

Calculated growth history of 1958-1968 year classes of channel catfish, *Ictalurus punctatus*, collected from Conowingo Pond, 1967-1969. Horizontal lines are unweighted means of age groups.

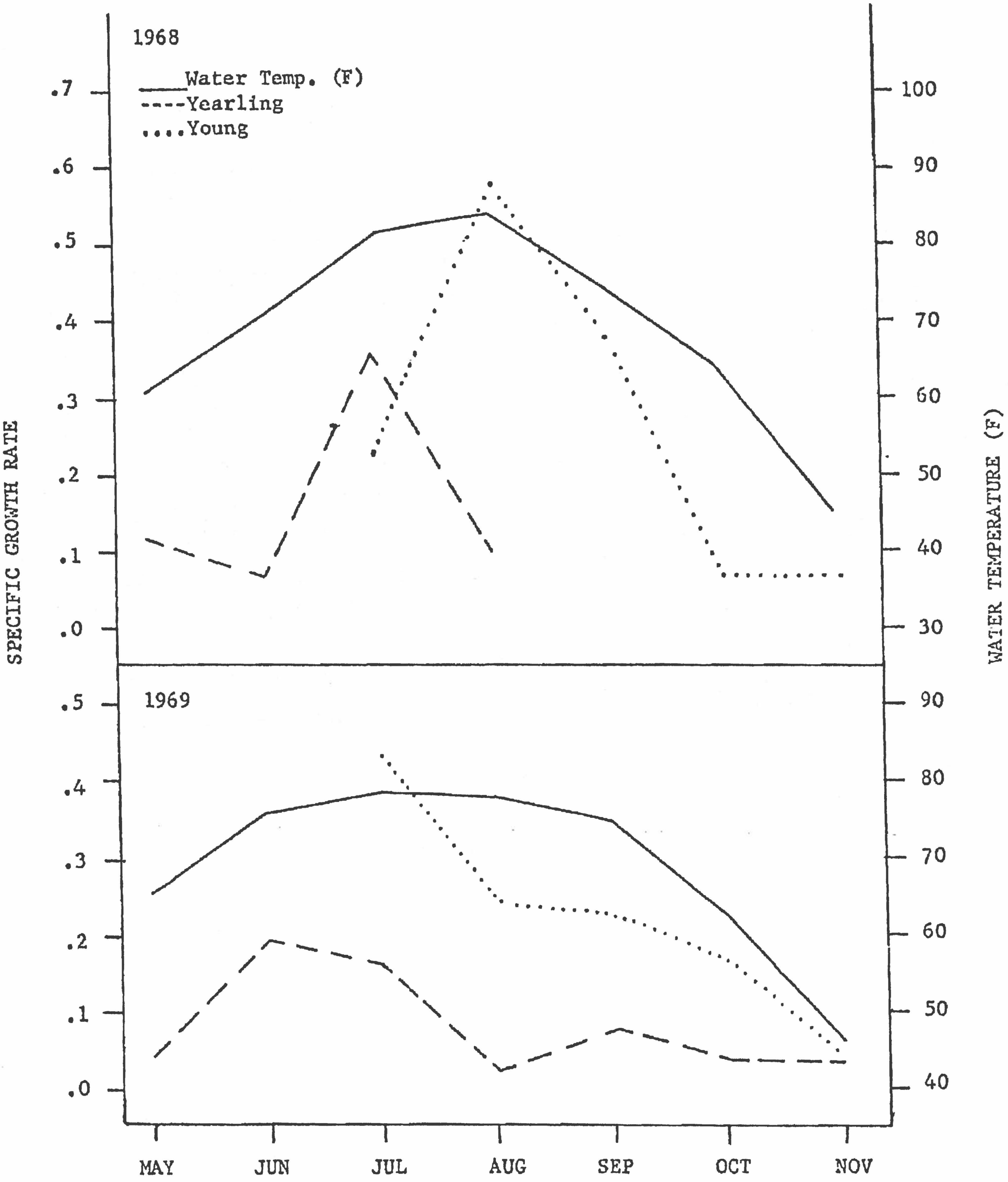


FIGURE 7.3.2-3

Monthly specific growth rates of young and yearling channel catfish, *Ictalurus punctatus*, from Conowingo Pond in 1968-1969 and mean monthly water temperatures (F) taken at Holtwood, Pennsylvania.

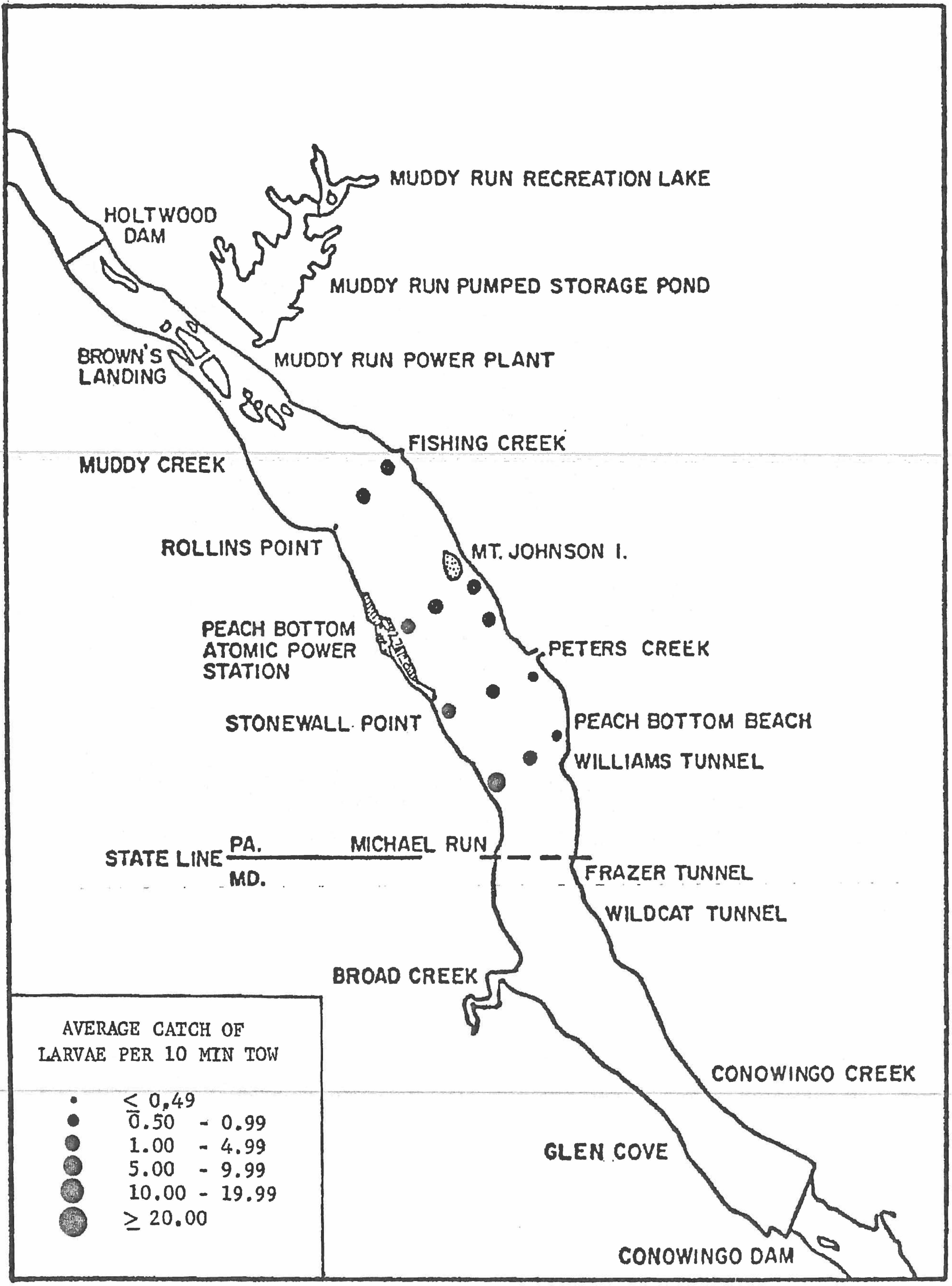


FIGURE 7.3.2-4

Distribution of channel catfish, Ictalurus punctatus larvae (≤ 25 mm) at plankton net stations in Conowingo Pond, 1969-1973.

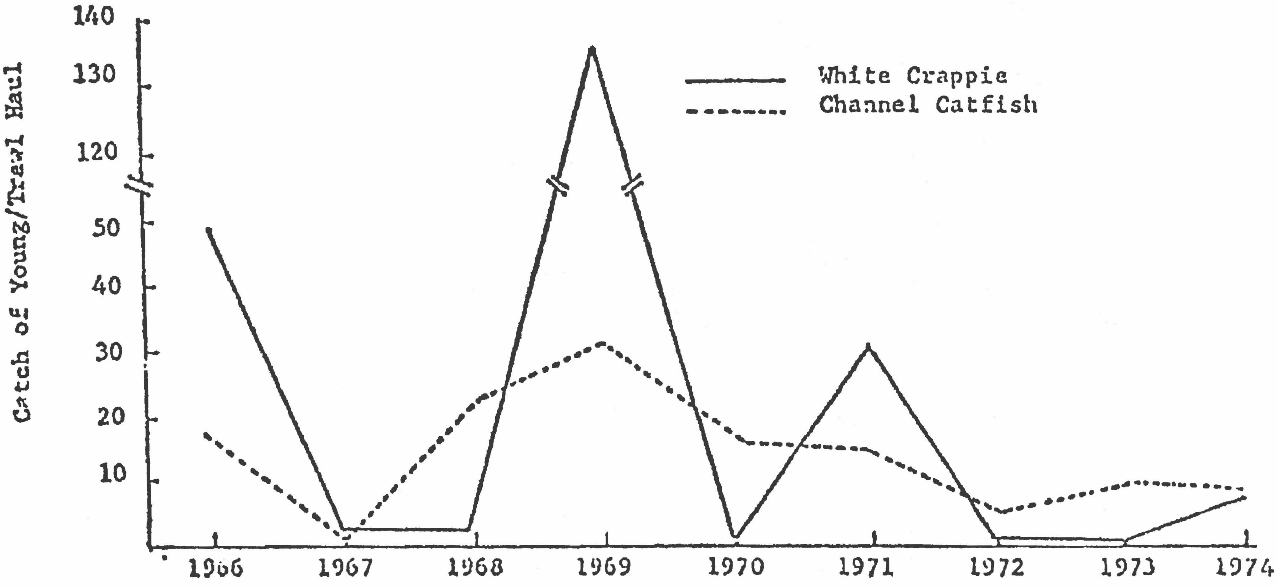


FIGURE 7.3.2-5

Year class strength of white crappie, Pomoxis annularis (solid line) and channel catfish, Ictalurus punctatus (dashed line) expressed as the catch of the young per trawl haul in Conowingo Pond.

7.3.3 BLUEGILL (Lepomis macrochirus)

7.3.3.1 Food Habits

The food of small bluegill (21-40 mm) in summer through winter in the postoperational period was mostly cladocerans and copepods. Chironomids were important as food in the winter. Bluegill at a length of 41-100 mm ate mainly cladocerans and copepods in the summer and autumn. In spring the diet was mostly terrestrial insects, Hydracarina and cladocerans. In winter aquatic insects (mayfly nymphs), amphipods and Bryozoa were dominant food items. Those larger than 100 mm fed mostly on cladocerans and aquatic insects in the summer and autumn. Aquatic insects and amphipods were most important in winter. Aquatic insects and items such as terrestrial insects were important in spring. Its food habits in the preoperational period were similar to those observed in the postoperational period.

7.3.3.2 Reproduction

The bluegill builds a nest in shallow water. The spawning period may extend from May through August with a maximum in June to early July in the Pond. The maximum catch of larvae was usually in June. The highest densities of larvae were found along the east shore between Peters Creek and Broad Creek (Table 7.3.1-1 and 7.3.1-2 and Figure 7.3.3-1). It spawned at temperatures of 62 to 84 F and most occurred at water temperatures of from 74 to 82 F. Calhoun (1966, p. 380) in a review reported that it spawns at water temperature of 67 to 80 F.

The fecundity of 7 bluegill (141 to 195 mm) from Conowingo Pond ranged from 25,159 to 44,895. Calhoun (1966, p. 381) reports egg counts that ranged from 2,360 to 49,400 per specimen.

7.3.3.3 Age and Growth

Most of 1,217 bluegill aged were less than four but some reached an age of six years. Some differences were noted in the growth rate of sexes up to an age of five years. The combined data for all specimens show that most growth occurred in the first three years by which time it is 176 mm long. The annual increments were greatest in the first two years. A comparison of the reported growth rate in different waters is given in Table 4.3-1.

TABLE 7.3.3-1

A comparison of growth rates of bluegill, Lepomis macrochirus, from various parts of the country. Data from other studies reproduced from Calhoun (1966, p. 378). Original measurements in inches converted to millimeters.

Source	Place	Age Group								
		I	II	III	IV	V	VI	VII	VIII	IX
Brown and Logan (1960)[1]	Montana Ponds	33	61	91	112	127	137	155	175	
Louder and Lewis (1957)[1]	Lake Murphysboro, Ill.	43	74	97	130	147	160			
Morgan (1951)[1]	Buckeye Lake, Ohio	41	74	104	132	152	180	188	196	213
Hennemuth (1965)[1]	Lake Anquabi, Ia.	48	94	119	142	160				
Ricker (1942)[2]	56 Indiana Lakes	40	80	128	173	196	215	244	236	
Tharratt (1966)[2]	Folsom Lake, Calif.	38	83	128	186	210	230			
Bennett et al. (1940)[1]	Homewood Lake, Ill.	71	114	135	142	147				
Lane (1954)[1]	Clearwater Reservoir, Mo.	58	107	142	168					
DiCostanzo (1951)[1]	Clear Lake, Ia.	61	107	142	157	198	208			
Houser and Bross (1963)[1]	Oklahoma	81	127	152	175	185				
Schoffman (1959)[1]	Reelfoot Lake, Tenn.	137	165	185	196	224				
LaFaunce et al. (1964)[2]	Sutherland Reservoir, Calif.	59	138	193						
Present Study[2]	Conowingo Pond, Pa.	69	138	176	198	203	214			

[1] Total length

[2] Fork lengths converted to total lengths using the relationship TL=0.96 + 1.04 FL

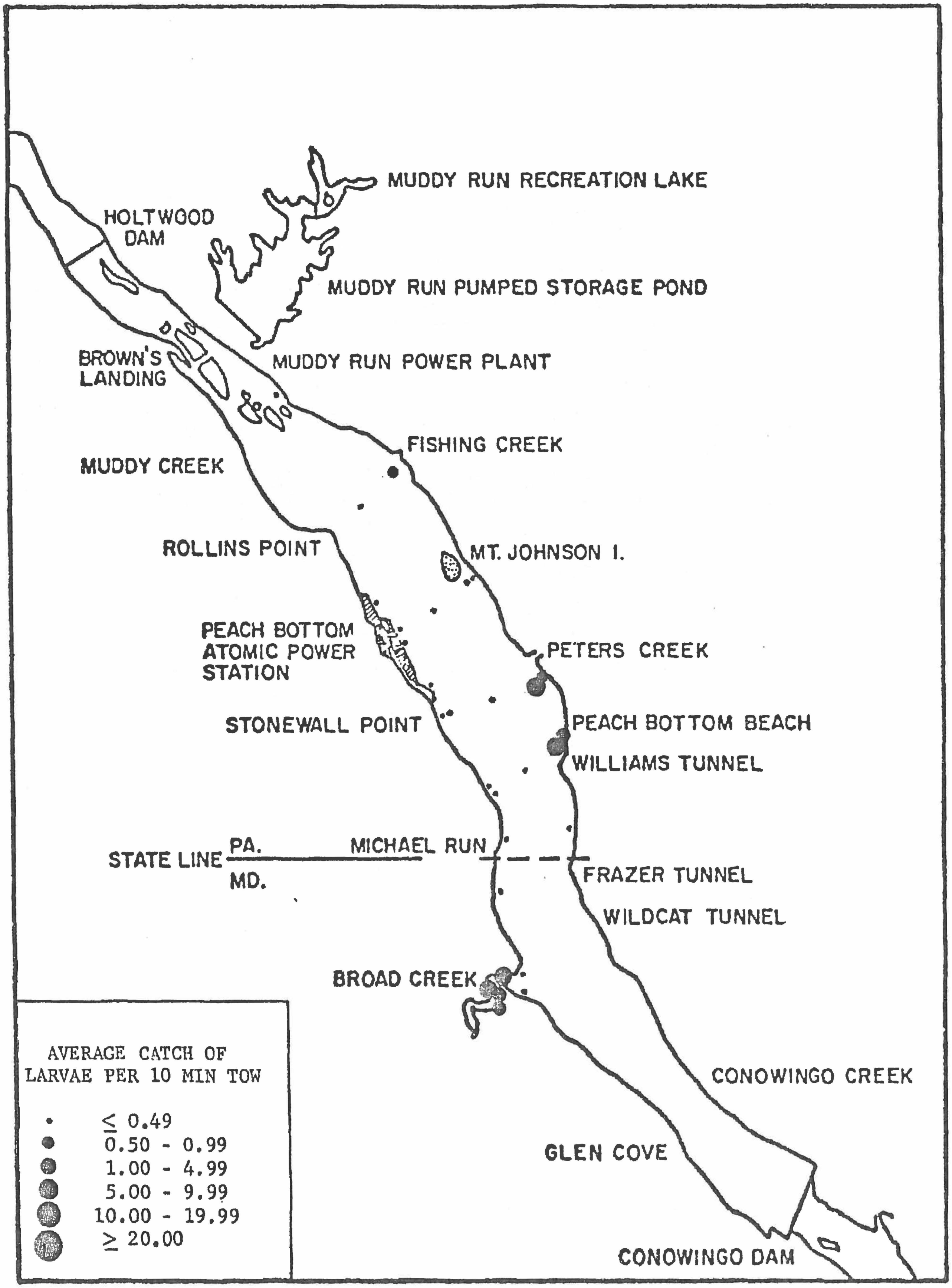


FIGURE 7.3.3-1

Distribution of bluegill, Lepomis macrochirus larvae (≤ 25 mm) at plankton net stations in Conowingo Pond, 1969-1973.

7.3.4 SPOTFIN SHINER (Notropis Spilopterus)

7.3.4.1 Food Habits

Food habits were determined from a total of 392 stomachs which contained food collected in June through October, 1967-1968. The primary food in all months except July was Cladocera (Table 7.3.4-1). In July, aquatic insects and cladocerans were consumed in approximately equal proportions. Terrestrial insects, copepods, chironomid larvae and other items formed a minor portion of the diet.

7.3.4.2 Reproduction

The spotfin shiner lays adhesive eggs which are attached to the undersides of branches and logs. It spawns from early June to late August in the Pond. Carlander (1969, p. 431) reported that both sexes mature at age I though some individuals may not spawn until age II and he reported spawning to occur from early June until late August in New York. It spawns in late July and August in Iowa and early June in Maryland.

The presence of young fry in the seine catch indicates that spawning may occur from late May to late August in the Pond. Plankton net samples also indicate that it spawns from late May through August. The larvae are distributed throughout the Pond and no specific spawning sites were noted (Figure 7.3.4-1). It spawns over a temperature range of 51 to 83 F; the peak occurs at 65 to 82 F (Figure 7.3.1-2).

Its fecundity in the Pond was determined from 31 specimens collected in the preoperational period and 37 specimens collected in the postoperational period. The fecundity ranged from 260 to 1,658 (average 610) in the preoperational and from 104 to 1,594 (average 715) in the postoperational period. No statistical differences ($P>0.05$) were discernible between the two periods.

7.3.4.3 Age and Growth

A total of 343 specimens of the spotfin shiner collected in 1966 was aged. Most were 0+ and one year old. No specimens older than age three were collected. The age I fish attained an average size of 62 mm; at age II the mean length was 75 mm.

The time of annulus formation was determined from 52 fish collected in January through July 1967. An annulus was present on scales of those fish collected after 5 May. Growth resumed at a water temperature of about 60 F.

TABLE 7.3.4-1

Food composition of the spotfin shiner, Notropis spilopterus expressed as estimated percentage volume and percentage frequency of occurrence (in parentheses), collected from Conowingo Pond June through October 1967-68.

Month	Jun		Jul		Aug		Sep		Oct	
No. Stomachs	76		79		90		64		84	
Food Group										
Cladocera	56	(91)	39	(64)	57	(79)	66	(84)	78	(93)
Copepoda	tr	(5)	1	(1)	1	(6)	tr	(22)	1	(10)
Chironomid larvae	2	(14)	1	(13)	3	(14)	2	(19)	1	(6)
Aquatic Insecta	39	(70)	43	(71)	24	(41)	26	(53)	10	(33)
Terrestrial Insecta	2	(8)	10	(24)	3	(7)	5	(20)	tr	(1)
Miscellaneous*	1	(25)	4	(40)	11	(68)	1	(31)	11	(34)

* Miscellaneous includes Nematoda, Bryozoa, Oligochaeta, Ostracoda, Amphipoda, Hydracarina, fish scales, detritus, algae, plant matter and unidentified eggs.

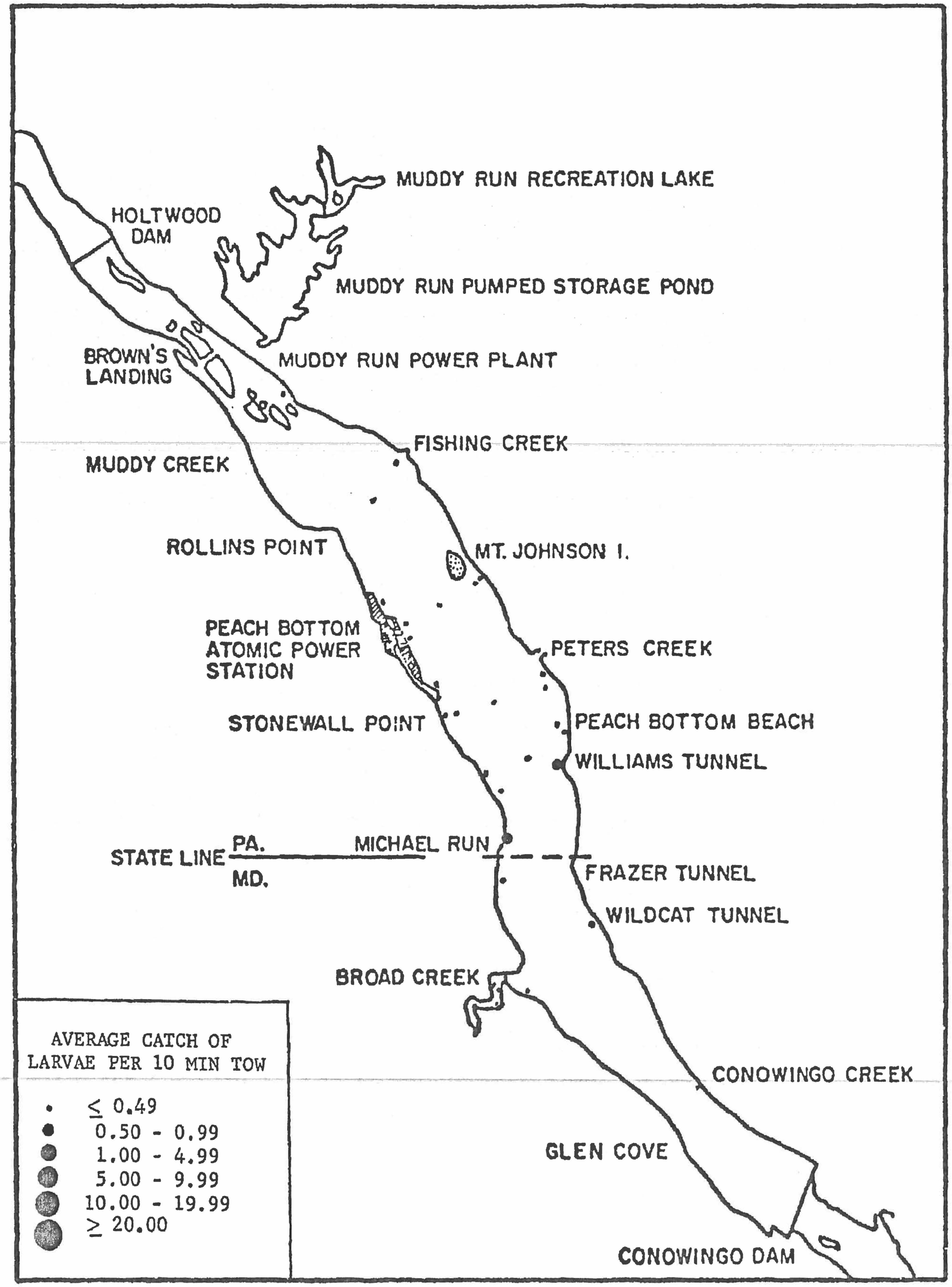


FIGURE 7.3.4-1

Distribution of spotfin shiner, Notropis spilopterus larvae (≤ 25 mm) at plankton net stations in Conowingo Pond, 1969-1973.

7.3.5 BLUNTNOSE MINNOW (Pimephales notatus)

The bluntnose minnow ranked third in seine catches in the Pond. Few were taken by meter net, trawl or trap net. Its abundance in the seine catch was low (2.50 fish per collection) relative that of the most common species, the spotfin shiner (56.31 fish per collection). It is most commonly taken in tributary streams entering the upper part of the Pond and between Holtwood Dam and the Muddy Run Pumped Storage Station. It is not expected that the biology of the bluntnose minnow will be affected ty operation of PBAPA because its distribution is limited to areas removed from the potential influence of thermal effluent. An extensive study of its biology in the Pond has not been conducted to date because it is not an important species.

7.3.5.1 Reproduction

The bluntnose minnow male guards a nest in shallow water where the adhesive eggs are fastened on the undersides of sticks, boards, or stones (Breder and Rosen, 1966, p. 193 and Scott and Crossman, 1973, p. 478). Larvae were taken in the Pond in June and July. It spawns at temperatures of 75 to 82 F (Figure 7.3.1-2). Since the number of larvae taken was very low (0.01 fish per collection annually or less) the period of maximum spawning activity could not be determined.

7.3.6 GIZZARD SHAD (Dorosoma cepedianum)

The gizzard shad was accidently introduced into the Pond in June 1972 in the course of a study of the American shad being conducted by Philadelphia Electric Company. Information on the general biology of the species in the Pond is not available because relatively few gizzard shad were taken to date. It has reproduced in the Pond. The extent to which it will become established remains to be determined. Juvenile and adult gizzard shad have been most commonly taken by trap net, trawl and gill net in the Station discharge. Life history studies are under way. Information presently available is on reproduction.

7.3.6.1 Reproduction

The gizzard shad spawns in the late spring and summer; the non-adhesive, demersal eggs are scattered. Spawning begins in early June in Broad Creek. Most larvae have been taken in Broad Creek and along the east shore of the Pond (Table 7.3.1-1 and 7.3.1-2). Larvae are collected through August. It apparently prefers creeks or the mouth of creeks as a spawning area (Figure 7.3.6-1). It spawns over a temperature range of 68 to 84 F and peaks at 71 to 82 F (Figure 7.3.1-2).

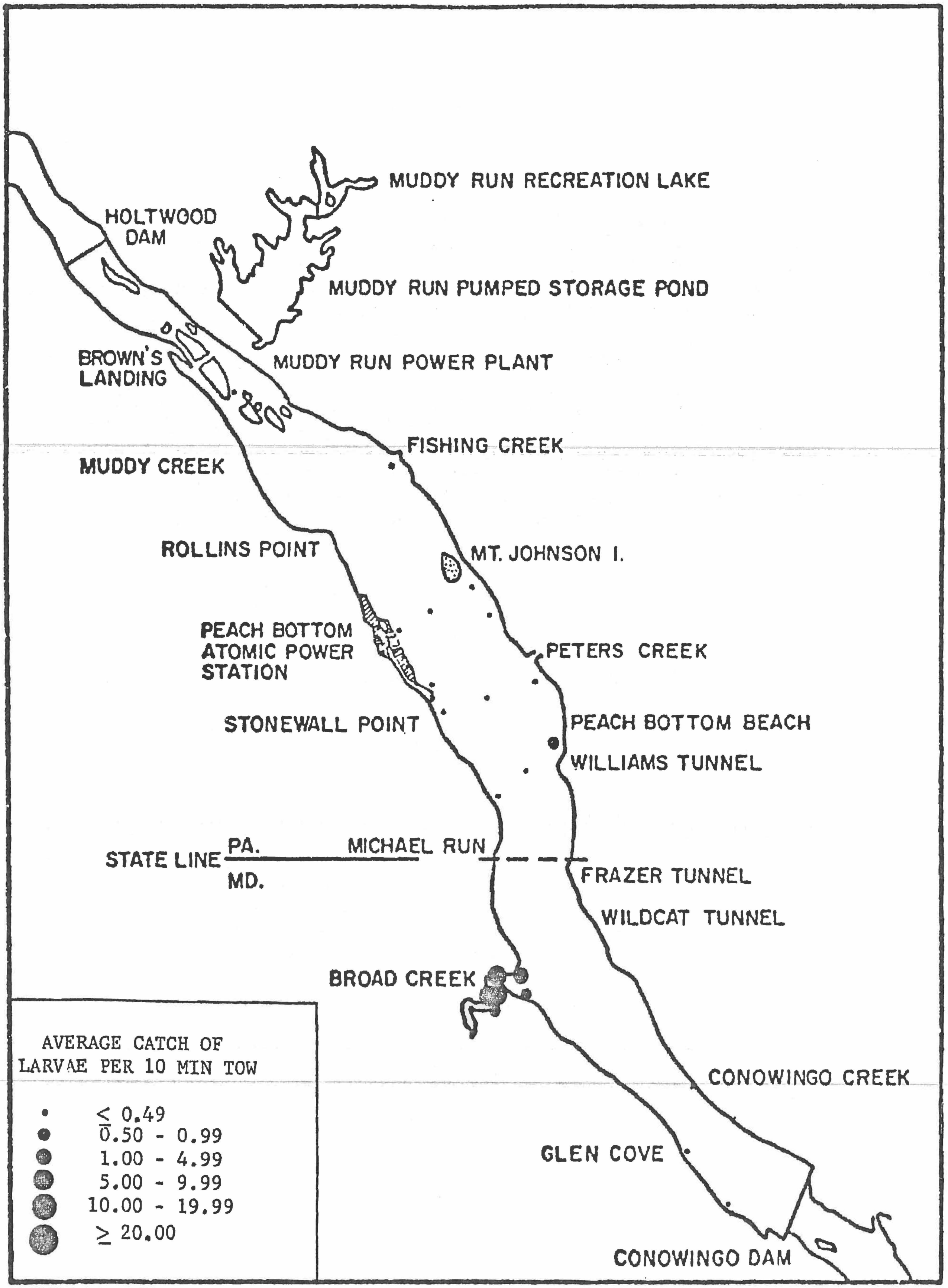


FIGURE 7.3.6-1

Distribution of gizzard shad, Dorosoma cepedianum larvae (25 mm) at plankton net stations in Conowingo Pond, 1969-1973.

7.3.7 WALLEYE (Stizostedion vitreum)

7.3.7.1 Food Habits

Walleye (≤50 mm) ate fishes and copepods while those larger than 50 mm fed almost exclusively on fishes such as tessellated darter, white crappie, bluegill, pumpkinseed, walleye, channel catfish and minnows, Walleye less than 100 mm fed mostly on the tessellated darter.

7.3.7.2 Reproduction

The walleye scatters eggs in shallow areas with clean rocky bottoms. Parsons (1972, p. 656) reported that those in Lake Erie had completed spawning by the end of April. In the Pond, larvae were taken from April through May; maximal densities occurred in May. Most larvae were collected in the creeks and coves in the southern portion of the Pond (Table 7.3.1-1 and 7.3.1-2).

Data on fecundity are not available because of the small population of walleye in the Pond. Carlander (1945) cited by Eschemeyer (1950, p. 46) estimated that the walleye (343-556 mm) in Lake of the Woods, Minnesota produced 35,000 to 137,000 eggs. Eschemeyer (1950, p. 47) reported that the walleye in Lake Gogebic, Michigan produced 36,871 to 154,906 eggs. Wolfert (1969, p. 1877) reported that the egg production of walleye in the eastern and western basins of Lake Erie ranged from 48,000 to 614,000.

Eschemeyer (1950, p. 24-25) reported that the spawning season began from mid-April to mid-May when the water temperatures ranged from 39 to 48 F and the peak occurred at 46-48 F. Calhoun (1966, p. 424) reported that spawning occurred at 63 F but the "best temperatures" were between 45 and 50 F. The walleye spawns at temperatures of 51 to 74 F in the Pond and the peak is at water temperatures of 57 to 68 F.

7.3.7.3 Age and Growth

Most of the 99 specimens aged were less than four years. The walleye attained a size of 122, 223, 333, 391, 439, 499, 510 and 514 mm at an age of I, II, III, IV, V, VI, VII, VIII and IX, respectively. Growth was best in the first three years. A comparison of the growth of the walleye in the Pond with that in other bodies of water shows that growth rates vary considerably (Table 7.3.7-1).

TABLE 7.3.7-1

Comparison of growth rates of walleye, Stizostedion vitreum, from various parts of the country. Original measurements in inches converted to millimeters. Data from other studies reproduced from Calhoun (1966, p. 424; and Eschmeyer (1950, p. 75).

Source	Place	Age Group I	II	III	IV	V	VI	VII	VIII	IX	X
Eschmeyer (1950)[1]	Lake Gogebic, Mi.	112	236	300	353	386	414	429	439		
Rose (1950)[1]	Spirit Lake, Ia.	183	282	366	445	505	564	602	632		
Roseberry (1951)[1]	Clayton Lake, Va.	251	386	503	589	663	701	759	818		
Deason (1933)[1]	Lake Erie	107	213	287	376	457	528				
Eddy and Carlander (1939)[1]	Minnesota Lakes	117	218	305	381	460	521	582	640	678	
Carlander (1945)[1]	Lake of the Woods, Minn.	163	236	292	343	378	424	465	505	549	577
Stroud (1949)[1]	Norris Reservoir, Tenn.	262	417	475	505	528	533	561	632		
Kennedy (1949)[1]	Lake Manitoba, Canada	-	-	290	330	378	411	434	455	500	505
Forney (1965)[1]	Oneida Lake, N.Y. (Male)	155	234	295	340	366	388	404			
	(Female)	160	241	307	358	394	424	447			
Present Study[2]	Conowingo Pond, Pa.	122	223	333	391	439	473	499	510	514	

[1] Total length
[2] Fork length

7.3.8 LARGEMOUTH BASS (Micropterus salmoides)

7.3.8.1 Food Habits

The young of the largemouth bass (11-80 mm) are mostly copepods and cladocerans. Fishes and cladocerans were the most important food item of bass greater than 80 mm. The largest bass examined was 195 mm.

7.3.8.2 Reproduction

The largemouth bass builds a nest on a variety of bottom types (Calhoun 1966, p. 340). It spawns in the spring and summer, somewhat later than the smallmouth bass. Few larvae were taken in Conowingo Pond, mostly at locations along the east shore (Table 7.3.1-1) from June through July. Spawning occurs over a temperature range of 62 to 81 F (Figure 7.3.1-2). Peak spawning occurs between 66 and 73 F. Suitable spawning temperatures have been variously reported between 60 to 75 F (Calhoun, 1966, p. 340). The eggs hatch in 2 days at 72 F and 5 days at 66 F.

7.3.8.3 Age and Growth

Most of the 81 bass aged were less than four years. Much of the growth (62%) occurred in the first three years. The growth rates vary considerably between different bodies of waters (Table 7.3.8-1).

In Lake George, Minnesota (Kramer and Smith, 1962, p. 37) rates of embryo development, sac fry growth, and fingerling growth during the first four weeks were directly related to mean daily water temperature. Strawn (1961) cited by Calhoun (1966, p. 339) reported that the fry growth was slower at 90.5 F. However, the growth was positively correlated with temperature to at least 81.5 F. Maximum growth occurred at temperatures of 81.5 and 86 F.

TABLE 7.3.5-1

A comparison of growth rates of largemouth bass, Micropterus salmoides, in various parts of the country. Data from other studies reproduced from Calhoun (1966 , p. 336). Original measurements in inches converted to millimeters.

Source	Place	Age Group I	II	III	IV	V	VI	VII	VIII	Age Group IX	X	XI	XII	XIII	XIV	XV
Mraz (1964)[1]	Brown's Lake, Wis.	86	168	231	282	318	353	396								
Cooper and Schafer (1954)[1]	Whitmore Lake, Mich.		168	241	297	333	366	391	419	455	457	478				
Roach and Petton (1948)[1]	Lake Vesuvius, Ohio	89	178	249	297	356	391	417	457							
Evans (1950)[1]	Ohio	69	178	257	318	368	407	450	480	503						
Eddy and Carlander (1939)[2]	Minnesota	91	173	257	307	358	399	429	439	493						
Bennett (1937)[1]	Wisconsin	84	188	267	318	356	384	414	442	460	475	495	505	513	523	533
McCaig and Mullan (1960)[1]	Quabbin Reservoir, Mass.	102	234	325	381	417	445	467	478	439						
Tharratt (1966)[2]	Folsom Lake, Calif.	142	264	325	368	401	432									
Patriarche (1953)[1]	Lake Wappapello, Mo.	137	277	338	409	460	498									
LaFaunce et al. (1964)[2]	Sutherland Reservoir, Calif.	165	290	363	414	460										
Bennett (1937)[1]	Louisiana	193	287	368	478	531	597	630	658	688	706	719				
Stroud (1948)[1]	Norris Lake, Tenn.	175	315	373	409	445	490	528								
Present Study*	Conowingo Pond, Pa.	129	219	296	341	372	404	418	429	450	467	477				

1 - Total length
2 - Fork length
* Original measurements in fork length converted to total length by the following relationship: TL = 1.097 + 1.034 FL

7.3.9 SMALLMOUTH BASS (Micropterns dolomieui)

7.3.9.1 Food Habits

Small bass (21-81 mm) ate mostly chironomids, other aquatic insects and fishes. Larger bass (>80-mm) fed mostly on cladocerans and fishes. The largest bass examined was 149 mm. Similar habits were observed in the preoperational period.

7.3.9.2 Reproduction

The small mouth bass builds a nest in a shallow area with a gravel or rock bottom. It spawns in the spring and early summer. Larvae were collected from May through July, but in low numbers. Most of larvae were taken along the east shore of the Pond (Table 7.3.1-1 and 7.3.1-2). The smallmouth spawns at temperatures from 61 to 82 F (Figure 7.3.1-2). The peak of spawning occurs at a temperature of 68 to 77 F. Other investigators (see Calhoun, 1966, p. 359) report that spawning occurs over a temperature range of 55 to 70 F.

The developmental period appears to vary with temperature. Sigler (1959) cited by Calhoun reported that smallmouth bass eggs hatch in 9 1/2 days at 55 F and 2 1/2 days at 78 F. Webster (1948, p. 43) found that incubation required 10 days at 55 F and 2 1/4 days at 75 F. He also reported, based on laboratory studies, that the developing ova survived a temperature rise from 53 to 77 F. Eggs developing at 65 F transferred to 50 and 75 F were not adversely affected.

Too few smallmouth bass were caught to estimate fecundity. Calhoun (1966, p. 360) in a review of fecundity reported that egg production varies from 2,000 to 20,825 eggs per female depending on age, length and weight.

7.3.9.3 Age and Growth

Although the smallmouth bass attains an age of nine years, most were less than four years. Most growth (57%) occurred in the first four years. A comparison of the growth rates in different waters showed considerable differences throughout the country (Table 7.3.9-1).

Growth rates in Lake Huron were positively correlated with surface water temperatures, more growth occurs in warmer waters (Coble, 1967, p. 87). Latta (1963) cited by Coble also found positive relationship between growth and temperature in Lake Michigan.

TABLE 7.3.9-1

A comparison of calculated growth rates of smallmouth bass, *Micropterus dolomieui* in various parts of the country. Original measurements in inches converted to millimeters. Data from other studies reproduced from Calhoun (1966, p. 357).

Source	Place	Age Group											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Latta (1963)[1]	Lake Michigan	99	160	206	246	292	335	371	401	427	442	455	447
Tate (1949)[1]	Iowa streams	94	145	198	249	297	356	391	417				
Patriarche and Lowry (1953)[1]	Black River, Mo.	68	157	236	302	366	406						
Doan (1938)[2]	Lake Erie	165	206	246	284	315	348	373					
Bennett (1938)[1]	Wisconsin	61	145	224	290	340	376	404	429	455	462	475	500
Peek (1965)[3]	Arkansas River, Ark.	79	156	225	296	375	463	547	619				
Thorpe (1942)[1]	Connecticut	102	183	241	290	333	371	401	429				
Smith and Moe (1944)[1]	Minnesota	99	185	277	310	462	521						
Stroud (1948)[1]	Norris Reservoir, Tenn.	117	259	358	411	445	457	472					
Webster (1954)[1]	Cayuga Lake, N.Y.	165	213	262	307	348	373	396	424	432	457		
Watson (1955)[1]	Big Lake, Maine	76	147	218	279	330	376	409	434				
Present Study*	Conowingo Pond, Pa.	98	175	228	275	328	395	432	480	485			

[1] Total length

[2] Fork length

[3] Standard length

* Original measurements in fork length converted to total length using the relationship: $FL = 0.26 + 1.06 FL$

7.3.10 MOVEMENT OF FISHES

7.3.10.1 Movement of Fishes in Conowingo Pond

An analysis of 1,119 recaptures of 15,493 white crappie tagged between 1966 and 1973 (preoperational period) showed that it moves seasonally within the Pond. In late April and early May it generally moved upstream. Those tagged in the upper portion of the Pond in the vicinity of the Muddy Run Pumped Storage Station in May usually had moved downstream to the south of Peach Bottom by late June. Movement in the summer has been difficult to assess because few crappie were recaptured in July and August. In winter, it congregates at the mouth of creeks in the lower part of the Pond.

The channel catfish does not move extensively within the Pond. Most of 357 recaptures from 5,496 fish tagged were from the locality at which they were originally tagged. This includes some recaptured from two to five years after release.

7.3.10.2 Movement of Fishes in the Plume

Fishes were tagged to determine their movement in and outside the thermal plume in the period July 1974 through March 1975. Some 332 channel catfish, 386 white crappie and 64 brown bullhead were captured, tagged and released in the plume.

A total of 28 channel catfish (8.4%), 71 white crappie (18.4%) and 12 brown bullhead (18.8%) was recaptured. All of the brown bullhead were recaptured in the plume, indicating no/or little movement. One bullhead was recaptured six times. All but one channel catfish was recaptured in the plume; which was recaptured in Broad Creek, (about four miles downstream). The recaptures indicate that the channel catfish may remain in the plume.

Twenty recaptures of the white crappie were made in July through December 1974. All but one of the recaptures was made in the plume. The single specimen tagged in November was recaptured at Broad Creek in December.

In January through March 1973 some 51 crappie were recaptured. Three were recaptured by anglers in Broad Creek. Only 7 of 51 recaptures were from the plume: one each in January and February and 5 in March. A total of 39 was recaptured at Broad Creek and one at Conowingo Creek by anglers; 30 were recaptured in Broad Creek in January. Those recaptured in Conowingo and Broad creeks in early January 1975 were tagged in the plume in November and early December.

The movement to Broad Creek may have been related to a complete shutdown of PBAPS between 17 and 26 January. Of the 30 recaptures, 9 were made before PBAPS shutdown and 21 were made between the period 18 through 31 January. The sudden increase in recaptures in the latter period suggests that in the absence of the heated plume, the species resumed its normal pattern of movement. After PBAPS came back on line, no increase in rate of recaptures occurred in the plume. This suggests that the crappie did not move back into the plume perhaps because it did not contact a temperature gradient which would stimulate such a movement. Movement to the lower portion of the Pond (Broad and Conowingo Creeks) in winter is not unusual. Most of the recaptures in the winter of fish tagged in the preoperational period was from the lower portion of the Pond.

7.3.11 NATURAL MORTALITIES OF FISHES IN CONOWINGO POND

Substantial natural mortalities, particularly of the channel catfish, have been observed in late May and June since 1966 in Conowingo Pond. Relatively small numbers of carp, quillback sucker, white catfish, brown bullhead, eel, bluegill, pumpkinseed, largemouth bass, white crappie and walleye were seen (Table 7.3.11-1).

The exact cause of these mortalities is not known. However, live but sickly channel catfish taken from the Pond in the early summer of 1968 were examined at the Pennsylvania Fish Commission, Benner Springs Fish Research Station, Bellefonte, Pennsylvania where *Aeromonas* spp. was identified as an infecting organism. Outbreaks of *Aeromonas* are not uncommon among warmwater fish populations and usually occur in the spring. None of the mortalities could be traced to the operation of PBAPS.

TABLE 7.3.11-1

Species composition of dead fishes observed in January-December during the preoperational (1966-1973) and postoperational (1974) periods in Conowingo Pond.

Year	1966	1967	1968	1969	1970	1971	1972	1973	1974
Species									
S. gairdneri	-	-	-	-	-	-	-	-	1
C. carpio	3	-	2	-	1	13	6	40	76
N. crysoleucas	-	-	-	1	-	2	-	-	-
N. hudsonius	-	-	-	2	-	-	-	-	-
N. spilopterus	-	-	-	-	-	-	1	-	-
S. atromaculatus	-	-	-	-	-	-	1	-	-
C. cyprinus	-	-	-	-	-	4	-	-	2
C. commersoni	-	-	-	-	1	3	-	-	12
M. macrolepidotum	-	-	-	-	-	1	-	-	-
Ictalurus spp.	107+	310+	16	-	45	303	-	-	-
I. catus	-	-	-	-	-	2	-	-	2
I. nebulosus	-	-	-	-	2	2	-	-	7
I. punctatus	274+	89	494	15	53	814+	62	88	333
A. rupestris	3	-	-	-	-	-	-	-	-
L. auritus	-	1	-	-	1	-	-	-	1
L. gibbosus	-	-	-	-	1	6	-	2	-
L. macrochirus	-	-	-	1	1	4	-	3	5
Micropterus sp.	1	1	-	-	-	-	1	-	-
M. dolomieui	-	1	2	-	1	1	-	-	1
M. salmoides	-	-	-	-	-	1	-	-	3
P. annularis	2	4	10	111	123	667	21	57	187
P. nigromaculatus	-	-	-	-	-	1	-	-	-
E. olmstedi	-	-	-	-	1	-	-	-	-
P. flavescens	-	1	-	-	-	1	-	-	-
S. vitreum	-	2	-	-	150	3	-	-	1
Unidentifiable	15	53	-	-	-	171	-	-	2
Total	405+	462+	524	130	380	1999+	92	190	633

7.3.12 RECREATIONAL FISHERY

Plosila (1961, p. 70-76) censused the anglers at Conowingo Pond in the spring through fall in 1958 to 1960. He reported that crappie (mostly white) comprised 48 to 55% and catfishes (channel, white, brown and yellow bullhead) constituted 27 to 37% of the catch. Sunfishes (bluegill, pumpkinseed, rock bass, green and redbreast) constituted 6 to 16% of the catch. The smallmouth bass, largemouth bass, yellow perch and walleye contributed little. He concluded that "the size of the white crappie population has the greatest influence of any fish on the average catch per effort and the resulting harvest by fishermen from Conowingo Lake". He also observed seasonality in fishing. A substantial number of crappie and other sunfishes was caught in spring and fall but few were caught in summer. The catch of catfishes was uniform throughout the period of study. No definite seasonal trend was evident for the catch of smallmouth and largemouth bass. Our observations of angling, along with many personal contacts with anglers since 1966, indicate no substantial change in the nature of the fishery.

Most fishing is done from small boats or along shore at a limited number of access points such as railroad culverts along the east shore. Limitations on access for boat fishing are imposed along the east shore by the presence of the Pennsylvania Railroad Line and on the west shore by scarcity of access roads.

Our survey determined the extent of the fishery in winter, (January through March, 1973 (Euston, et al., 1974, p. 4-75 to 4-79) and 1974) which was a period not studied by Plosila, in the Pond. Our earlier observations indicated that fishing occurred primarily in Maryland waters at Conowingo and Broad creeks and Funks Run. Consequently, these areas were surveyed intensively although other areas were visited regularly. No fishery existed in other areas.

Anglers caught 15 species (Table 7.3.12-1). The largest number (13) was taken in March 1973 when fishing was done from the shoreline. In January and February, when on occasion fishing was done through the ice, 4 to 5 species were caught. The white crappie was most common and comprised at least 99% of the catch in January and February. In March the catch of crappie was 65 (1974) to 81% (1973). The bluegill was the next most important species, most were taken in March.

The length-frequency distribution of the white crappie in the angler catch indicated that those less than 170 mm fork length were usually released.

The fishing pressure varied from January to March and on weekdays and weekend days. Generally, the fishing pressure was greater on weekend days. Total estimated fishing pressure was greatest in March and least in February. The highest catch per hour was observed in February (4.18) and the lowest in March (2.21).

TABLE 7.3.12-1

Species composition of fishes caught by the anglers during the winter creel census of Conowingo Pond, January-March 1973 and 1974.

Year	1973								1974							
Month	Jan		Feb		Mar		Total		Jan		Feb		Mar		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Species																
White crappie	1829	99.2	2290	98.8	1958	81.0	6077	92.4	1771	99.7	1177	99.7	182	65.0	3130	96.7
Bluegill	12	0.6	12	0.5	385	15.9	409	6.2	2	0.1	1	0.1	33	11.8	36	1.1
Pumpkinseed	-	-	-	-	4	0.2	4	0.1	-	-	-	-	-	-	-	-
Black crappie	1	0.1	13	0.6	3	0.1	17	0.3	1	tr	1	0.1	-	-	2	0.1
Smallmouth bass	-	-	-	-	1	tr	1	tr	-	-	1	0.1	1	0.4	2	0.1
Largemouth bass	1	0.1	1	tr	10	0.4	12	0.2	-	-	-	-	29	10.4	29	0.9
Yellow perch	-	-	1	tr	2	0.1	3	tr	-	-	-	-	1	0.4	1	tr
Channel catfish	-	-	-	-	11	0.5	11	0.2	1	tr	-	-	23	8.2	24	0.7
Yellow bullhead	-	-	-	-	1	tr	1	tr	-	-	-	-	3	1.1	3	0.1
Brown bullhead	-	-	-	-	29	1.2	29	0.4	-	-	-	-	-	-	-	-
Carp	-	-	-	-	9	0.4	9	0.1	-	-	-	-	5	1.8	5	0.2
White sucker	-	-	-	-	2	0.1	2	tr	-	-	-	-	2	0.7	2	0.1
Golden shiner	-	-	-	-	2	0.1	2	tr	-	-	-	-	-	-	-	-
Gizzard shad	-	-	-	-	-	-	-	-	1	tr	-	-	-	-	1	tr
Brown trout	-	-	-	-	-	-	-	-	-	-	-	-	1	0.4	1	tr
Total	1843		2317		2417		6577		1776		1180		280		3236	

tr = Less than 0.1

7.4.0 TEMPERATURE EXPERIMENTS WITH FISHES

The methods and results of thermal studies conducted from November 1972 through December 1974 have been reported in Robbins and Mathur (1974a, b and 1975a,b; Section 5). The studies were designed to provide predictive data on (1) the behavior of fishes in or near the thermal plume and (2) the effect of changes in temperature in or near the plume which may occur as a result of PBAPS operation. The experimental temperatures used were the temperatures predicted at the jet discharge (13 to 17.5 F increase) by Elder at al., (1973). Studies were also conducted with a temperature increase of up to 35 F to determine upper temperature tolerance limit.

Acclimation in fishes is more rapid with an increase than with a decrease in temperature. Fishes captured when the field temperatures are falling (mid-july through mid-February) may respond differently to temperature changes than they do when field temperatures are rising (mid-February through mid-July) even though they are captured at the same ambient temperature.

The major experimental fishes were those most commonly taken in the Pond. They include the spotfin shiner, channel catfish, pumpkinseed, bluegill and white crappie. Fewer data are available for the bluntnose minnow, gizzard shad, largemouth bass, smallmouth bass and walleye and are reported below.

7.4.1 TEMPERATURE PREFERENCE

Two phenomena are associated with temperature preferences, low thermal responsiveness (LTR) and multimodal preference response (MPR). Meldrim and Gift (1971, p. 10) defined LTR as the inability of a fish to avoid areas in a thermal gradient which produce stressful conditions. They defined MPR as a selection of two or more preferred temperatures within a test.

Data for rising and falling field temperatures for the spotfin shiner, channel catfish, pumpkinseed, bluegill and white crappie were analyzed separately by a stepwise multiple regression to determine the relationship between the preferred temperature (Y), acclimation temperature (X1) and mean total length of fish (X2). Sufficient data were not available to conduct this analyses for other species. In calculating the regressions, the median preferred temperature was used when fish preferred a range of temperatures. If more than one temperature was preferred by the fish (MPR) each selected temperature was used with the number of fish which preferred tnat temperature. In all cases the acclimation temperature accounted for most of the variation in the preference temperature (Table 7.4.1-1). The 95% confidence limits on the population mean of the preferred temperatures were computed (Figures 7.4.1-1 to 7.4.1-5) using the equations given in Table 7.4.1-1, and compared with results from the temperature shock and avoidance studies.

7.4.1.1 Spotfin shiner

7.4.1.1.1 Falling Field Temperatures

The highest temperature preferred was 86 F by fish acclimated from 79 to 82 F in July 1973. The lowest temperature selected was 50 F by fish acclimated to 43 F in mid-January 1974. Spotfin shiner preferred a temperature which averaged 9 F above acclimation. The difference between acclimation and preferred temperature was little at high acclimation temperatures but increased as acclimation temperatures decreased. This trend was true for most species studied. LTR was displayed in 12 of 46 tests.

7.4.1.1.2 Rising Field Temperatures

The lowest temperature preferred was 54 F by fish acclimated to 38 and 39 F in late February and early March 1974. The highest temperature selected was 88 F by fish acclimated to 82 F in early July 1974. Fish preferred an average of 11 F above acclimation. No LTR was displayed during this period.

7.4.1.2 Channel catfish

7.4.1.2.1 Falling Field Temperatures

The highest temperature preferred was 95 F by fish acclimated to 80 and 71 F in late July and mid-September 1973, respectively. The lowest temperature selected was 52 F by fish acclimated to 35 F in mid-January 1974. Channel catfish preferred an average of 13 F above acclimation. LTR and MPR were each observed in 4 of 21 tests.

7.4.1.2.2 Rising Field Temperatures

The lowest temperature preferred was 55 F by fish acclimated to 42 and 44 F in late March 1974. The highest temperature selected was 95 F by fish acclimated to 85 F in mid-July 1973. Channel catfish preferred an average of 12 F above acclimation. LTR was observed in 3 of 21 tests.

7.4.1.3 Pumpkinseed

7.4.1.3.1 Falling Field Temperatures

The highest temperature preferred was 91 F by fish acclimated to 78 F in mid-September 1973. The lowest temperature selected was 50 F by fish acclimated to 47 F in late November 1973. Fish preferred an average of 6 F above acclimation. LTR was displayed in 6 of 8 tests at acclimation temperatures of 68 F or below. LTR was not displayed at acclimation temperatures above 68 F MPR was displayed in one test.

7.4.1.3.2 Rising Field Temperatures

The lowest temperature preferred was 70 F by fish acclimated to 67 f in late May 1974. The highest temperature selected was 88 F by fish acclimated to 76 F in mid-June 1974. These fish preferred an average of 9 F above acclimation. LTR was observed in 1 of 10 tests.

7.4.1.4 Bluegill

7.4.1.4.1 Falling Field Temperatures

The highest temperature preferred was 90 F by fish acclimated to 79 F in late August 1973. The lowest temperature selected was 64 F by fish acclimated to 46 F in mid-November 1973. Bluegill preferred an average of 14 F above acclimation. LTR was displayed in 9 of 13 tests at acclimation temperatures of 68 F and below. LTR was not displayed at temperatures above 68 F.

7.4.1.4.2 Rising Field Temperatures

The lowest temperature preferred was 61 F by fish acclimated to 38 F in mid-February 1974. The highest temperature selected was 88 F by fish acclimated to 78 and 83 F in late June and early July 1974, respectively. Fish preferred an average of 11 F above acclimation. LTR was observed in 3 of 14 tests, only at acclimation temperatures less than 68 F.

7.4.1.5 White crappie

7.4.1.5.1 Falling Field Temperatures

The highest temperature preferred was 82 F by fish acclimated to 79 and 80 F in late July 1974 and late August 1973, respectively. The lowest temperature selected was 46 F by fish acclimated to 37 F in mid-January 1974. Fish preferred and average of 8 F above acclimation. LTR was observed in two tests and MPR was observed in one test.

7.4.1.5.2 Rising Field Temperatures

The lowest temperature preferred was 50 F by fish acclimated to 41 and 43 F in early March and April 1974, respectively. The highest temperature selected was 79 F by fish acclimated to 76 F in late June 1974. Fish preferred an average of 3 F above acclimation.

7.4.1.6 Other Species

Temperature preference data for other selected representative species are presented in Table 7.4.1-2. Data are not available for the gizzard shad. Bluntnose minnow acclimated at 33 to 68 F preferred 41 to 70 F. LTR was observed in one of eleven tests. Smallmouth bass acclimated at 54 to 82 F preferred 73 to 90 F. Largemouth bass acclimated at 38 to 82 F preferred 63 to 90 F. LTR was observed in 8 of 23 tests. Walleye acclimated at 50 to 52 F preferred 59 to 63 F.

TABLE 7.4.1-1

Regression equations of the preferred temperature (Y), acclimation temperature (X_1) and mean total length (X_2) for the spotfin shiner, channel catfish, pumpkinseed, bluegill and white crappie for falling and rising field temperatures. Data from tests conducted between March 1973 and December 1974.

Species	Acclimation Temperature Range (F)	Mean Total Length Range (mm)	Order of Entry of Independent Variables	Regression Equation	N	R^2	$s_{y.x}$
			FALLING FIELD TEMPERATURES				
Spotfin shiner	34-82	39-81	Acclim. Temp.	$Y = 27.837 + 0.696 X_1$	152	0.832	4.680
			Total Length	$Y = 32.929 + 0.711 X_1 - 0.098 X_2$	152	0.847	4.484
Channel catfish	35-82	56-216	Acclim. Temp.	$Y = 39.129 + 0.596 X_1$	80	0.710	5.912
			Total Length	$Y = 38.170 + 0.598 X_1 + 0.005 X_2$	80	0.711	5.945
Pumpkinseed	47-81	51-82	Acclim. Temp.	$Y = 11.460 + 0.931 X_1$	38	0.666	7.721
			Total Length	$Y = 25.116 + 0.909 X_1 - 0.197 X_2$	38	0.686	7.593
Bluegill	46-82	32-85	Acclim. Temp.	$Y = 52.068 + 0.437 X_1$	52	0.785	3.171
			Total Length	$Y = 73.723 + 0.314 X_1 - 0.233 X_2$	52	0.877	2.426
White crappie	37-80	91-144	Acclim. Temp.	$Y = 20.115 + 0.797 X_1$	31	0.817	4.966
			Total Length	$Y = 32.916 + 0.847 X_1 - 0.141 X_2$	31	0.843	4.675
			RISING FIELD TEMPERATURES				
Spotfin shiner	38-82	38-83	Acclim. Temp.	$Y = 29.213 + 0.681 X_1$	124	0.949	2.234
			Total Length	$Y = 25.484 + 0.689 X_1 + 0.056 X_2$	124	0.956	2.089
Channel catfish	37-86	84-252	Acclim. Temp.	$Y = 30.515 + 0.695 X_1$	74	0.806	4.906
			Total Length	$Y = 49.840 + 0.609 X_1 - 0.075 X_2$	74	0.892	3.685
Pumpkinseed	52-83	63-101	Acclim. Temp.	$Y = 48.695 + 0.413 X_1$	44	0.536	3.789
			Total Length	$Y = 43.825 + 0.359 X_1 + 0.104 X_2$	44	0.573	3.677
Bluegill	38-83	42-103	Acclim. Temp.	$Y = 36.364 + 0.606 X_1$	51	0.885	2.801
			Total Length	$Y = 37.986 + 0.613 X_1 - 0.030 X_2$	51	0.890	2.771
White crappie	41-79	96-165	Acclim. Temp.	$Y = 26.113 + 0.615 X_1$	48	0.681	5.231
			Total Length	$Y = 12.308 + 0.407 X_1 + 0.218 X_2$	48	0.809	4.089

TABLE 7.4.1-2

Summary of temperature preference data on other selected representative species. All tests were conducted at saturated oxygen levels, at a light level of 40 foot-candles, and at a pH of 7.3 to 8.1.

Species	Date	No. Fish Per Test	Size Range (TL mm)	Mean TL (mm)	Acclimation Temperature (F)	Preferred Temperature (F)	Low Thermal Responsiveness Shown*
Pimephales notatus	26 Sep 1973	4	57-60	61	68	70	No
	23 Oct 1973	3	55-73	65	62	63	No
	7 Feb 1975	4	49-53	51	44	52	No
	17 Jan 1974	4	40-44	43	42	41-52	No
	19 Dec 1973	4	47-53	50	34	54	No
	14 Feb 1975	4	49-55	51	34	50	No
	30 Jan 1975	4	52-54	53	33	48-52	No
	5 Mar 1975	4	53-54	54	41	55-57	No
	21 Mar 1975	4	65-71	67	42	66	No
	27 Mar 1975	4	85-92	88	42	59-61	No
	10 Mar 1975	4	52-54	53	45	68	Yes
Dorosoma cepedianum	30 Oct 73	4	132-144	137	56	None	No
Micropterus dolomieui	23 Jul 74	4	61-69	64	82	90	No
	1 Aug 73	4	62-71	65	81	None	Yes
	20 Jul 73	4	51-60	54	80	88-90	No
	25 Jun 74	3	83-102	92	77	86-90	No
	24 Sep 74	4	86-94	90	70	73-77	No
	10 Oct 74	4	125-134	128	63	None	No
	24 Oct 74	4	133-152	140	54	70-73	Yes
Micropterus salmoides	10 Jul 74	4	54-58	56	82	88	No
	23 Jul 74	4	63-73	68	82	88	No
	31 Jul 73	4	52-64	58	81	83	No
	30 Aug 73	4	96-103	99	81	90-91	No
	10 Aug 73	4	56-68	63	80	86	No
	29 Aug 73	4	124-149	137	79	86	Yes
	31 Aug 73	4	65-76	70	79	88-90	No
	1 Aug 74	4	54-61	57	79	None	No
	15 Aug 74	4	65-88	82	79	None	No
	11 Sep 73	4	71-89	78	73	82-84	No
	29 Oct 74	2	75-112	94	54	None	No
	3 Jan 74	3	85-134	106	41	None	Yes
	22 Jan 74	3	103-120	113	41	None	Yes
	15 Jan 75	2	85-128	106	41	None	Yes
	19 Feb 74	3	80-121	106	38	None	No
	6 Mar 75	2	134-142	138	41	None	Yes
	26 Mar 74	2	78-95	86	43	63-66	Yes
	29 Mar 73	2	165-192	179	52	73	No
	26 Apr 74	3	98-126	109	55	None	Yes
	1 May 74	4	70-86	81	64	77	Yes
	20 Jun 74	4	38-38	38	76	None	No
	27 Jun 74	4	50-62	55	78	None	No
	5 Jul 73	4	43-48	46	82	None	No
Stizostedion vitreum	10 Oct 74	4	200-328	315	63	None	Yes
	14 Nov 73	4	195-212	203	50	59-63	No
	10 Apr 74	3	192-210	202	48	None	No
	30 Mar 73	4	258-296	272	52	63	No

* Thermal stress shown when fish moved into extreme temperatures (usually 20 to 30 F from acclimation) in a steep gradient.

7.4.2 TEMPERATURE AVOIDANCE

Data for rising and falling field temperatures for the spotfin shiner, channel catfish, bluegill and white crappie were analyzed separately by a stepwise multiple regression to determine the relationship between the avoidance temperature (Y), acclimation temperature (X1) and mean total length of the fish (X2). The 95% confidence limits on the population mean of the avoidance temperature were calculated using the equations given in Table 7.4.2-1. The confidence limits are shown along with results from temperature shock and preference studies (Figures 7.4.1-1 to 7.4.1-5).

7.4.2.1 Spotfin shiner

7.4.2.1.1 Falling Field Temperatures

The highest avoidance temperature was 94 F by fish acclimated to 81 F in early August 1973. The lowest temperature avoided was 59 F by fish acclimated to 47 F in early February 1974. Fish avoided an average of 20 F above their acclimation temperature.

7.4.2.1.2 Rising Field Temperatures

The lowest temperature avoided was 61 F by fish acclimated to 54 F in late April 1974. The highest avoidance temperature was 93 F by fish acclimated to 83 F in mid-June 1974. Fish avoided an average of 18 F above acclimation.

7.4.2.2 Channel catfish

7.4.2.2.1 Falling Field Temperatures

The highest avoidance temperatures (97 and 98 F) occurred at acclimation temperatures of 71 and 81 F from late July to mid-September 1973. The lowest temperature avoided was 57 F by fish acclimated to 47 F in late January 1974. Fish avoided an average of 24 F above acclimation.

7.4.2.2.2 Rising Field Temperatures

The lowest temperature avoided was 67 F by fish acclimated to 54 F in late April 1974. The highest avoidance was 94 F by fish acclimated to 62 F in early May 1974. Fish avoided an average of 27 F above their acclimation temperature.

The movement to Broad Creek may have been related to a complete shutdown of PBAPS between 17 and 26 January. Of the 30 recaptures, 9 were made before PBAPS shutdown and 21 were made between the period 18 through 31 January. The sudden increase in recaptures in the latter period suggests that in the absence of the heated plume, the species resumed its normal pattern of movement. After PBAPS came back on line, no increase in rate of recaptures occurred in the plume. This suggests that the crappie did not move back into the plume perhaps because it did not contact a temperature gradient which would stimulate such a movement. Movement to the lower portion of the Pond (Broad and Conowingo Creeks) in winter is not unusual. Most of the recaptures in the winter of fish tagged in the preoperational period was from the lower portion of the Pond.

7.3.11 NATURAL MORTALITIES OF FISHES IN CONOWINGO POND

Substantial natural mortalities, particularly of the channel catfish, have been observed in late May and June since 1966 in Conowingo Pond. Relatively small numbers of carp, quillback sucker, white catfish, brown bullhead, eel, bluegill, pumpkinseed, largemouth bass, white crappie and walleye were seen (Table 7.3.11-1).

The exact cause of these mortalities is not known. However, live but sickly channel catfish taken from the Pond in the early summer of 1968 were examined at the Pennsylvania Fish Commission, Benner Springs Fish Research Station, Bellefonte, Pennsylvania where *Aeromonas* spp. was identified as an infecting organism. Outbreaks of *Aeromonas* are not uncommon among warmwater fish populations and usually occur in the spring. None of the mortalities could be traced to the operation of PBAPS.

TABLE 7.3.11-1

Species composition of dead fishes observed in January-December during the preoperational (1966-1973) and postoperational (1974) periods in Conowingo Pond.

Year	1966	1967	1968	1969	1970	1971	1972	1973	1974
Species									
S. gairdneri	-	-	-	-	-	-	-	-	1
C. carpio	3	-	2	-	1	13	6	40	76
N. crysoleucas	-	-	-	1	-	2	-	-	-
N. hudsonius	-	-	-	2	-	-	-	-	-
N. spilopterus	-	-	-	-	-	-	1	-	-
S. atromaculatus	-	-	-	-	-	-	1	-	-
C. cyprinus	-	-	-	-	-	4	-	-	2
C. commersoni	-	-	-	-	1	3	-	-	12
M. macrolepidotum	-	-	-	-	-	1	-	-	-
Ictalurus spp.	107+	310+	16	-	45	303	-	-	-
I. catus	-	-	-	-	-	2	-	-	2
I. nebulosus	-	-	-	-	2	2	-	-	7
I. punctatus	274+	89	494	15	53	814+	62	88	333
A. rupestris	3	-	-	-	-	-	-	-	-
L. auritus	-	1	-	-	1	-	-	-	1
L. gibbosus	-	-	-	-	1	6	-	2	-
L. macrochirus	-	-	-	1	1	4	-	3	5
Micropterus sp.	1	1	-	-	-	-	1	-	-
M. dolomieui	-	1	2	-	1	1	-	-	1
M. salmoides	-	-	-	-	-	1	-	-	3
P. annularis	2	4	10	111	123	667	21	57	187
P. nigromaculatus	-	-	-	-	-	1	-	-	-
E. olmstedi	-	-	-	-	1	-	-	-	-
P. flavescens	-	1	-	-	-	1	-	-	-
S. vitreum	-	2	-	-	150	3	-	-	1
Unidentifiable	15	53	-	-	-	171	-	-	2
Total	405+	462+	524	130	380	1999+	92	190	633

7.4.2.3 Pumpkinseed

7.4.2.3.1 Rising and Falling Field Temperatures

The highest temperature avoided was 95 F by fish acclimated to 76 F in mid-June 1974. The lowest temperature avoided was 83 F by fish acclimated to 79 F in late August 1973. Pumpkinseed avoided an average of 16 F above acclimation.

7.4.2.4 Bluegill

7.4.2.4.1 Falling Field Temperatures

The highest avoidance temperature was 97 F by fish acclimated to 81 F in early August 1973. Bluegill never avoided temperatures below 80 F, even when acclimated as low as 40 F in late January 1974. Avoidance temperatures averaged 27 F above acclimation. In three of nine tests, fish acclimated to 40 and 46 F lost equilibrium or died prior to significant avoidance.

7.4.2.4.2 Rising Field Temperatures

As with falling field temperatures, no fish avoided temperatures below 80 F, even when acclimated as low as 41 F, even when acclimated as low as 41 F in early April 1974. The highest avoidance was at 98 F by fish acclimated to 77 F in late June 1974. Fish avoided an average of 26 F above acclimation.

7.4.2.5 White crappie

7.4.2.5.1 Falling Field Temperatures

The highest avoidance temperature was 85 F by fish acclimated to 55 F in late October 1973. The lowest temperature avoided was 65 F by fish acclimated to 48 F in late November 1973. Fish avoided an average of 25 F above acclimation.

7.4.2.5.2 Rising Field Temperatures

The lowest temperature avoided was 74 F by fish acclimated to 43 and 52 F in late March and mid-April 1974, respectively. The highest avoidance temperature was 92 F by fish acclimated to 82 F in early July 1974. Fish avoided an average of 23 F above acclimation.

7.4.2.6 Other Species

Temperature avoidance data for other selected representative species are presented in Table 7.4.2-2. No temperature avoidance data are available for gizzard shad and walleye. Bluntnose minnow acclimated from 33 to 45 F avoided 49 to 69 F. Smallmouth bass acclimated at 70 to 81 F avoided 90 to 98 F. Largemouth bass acclimated to 70 to 82 F avoided 90 to 98 F.

TABLE 7.4.2-1

Regression equations of the avoidance temperature (Y), acclimaction temperature (X_1) and mean total length (X_2) for the spotfin shiner, channel catfish, bluegill and white crappie for falling and rising field temperatures. Data from tests conducted between July 1973 and December 1974.

Species	Acclimation Temperature Range (F)	Mean Total Length Range (mm)	Order of Entry of Independent Variables	Regression Equation	N	R^2	$s_{y.x}$
			FALLING FIELD TEMPERATURES				
Spotfin shiner	40-81	52-83	Acclim. Temp.	$Y = 47.786 + 0.532\ X_1$	74	0.645	6.421
			Total Length	$Y = 38.924 + 0.456\ X_1 + 0.205\ X_2$	74	0.671	6.228
Channel catfish	34-81	50-234	Acclim. Temp.	$Y = 54.339 + 0.499\ X_1$	106	0.565	7.470
			Total Length	$Y = 59.773 + 0.465\ X_1 - 0.023\ X_2$	106	0.578	7.400
Bluegill	40-81	36-137	Acclim. Temp.	$Y = 74.073 + 0.226\ X_1$	82	0.443	3.677
			Total Length	$Y = 64.667 + 0.315\ X_1 + 0.060\ X_2$	82	0.489	3.545
White crappie	45-55	100-127	Acclim. Temp.	$Y = 27.668 + 0.939\ X_1$	62	0.320	5.052
			Total Length	$Y = -4.242 + 0.911\ X_1 + 0.285\ X_2$	62	0.405	4.767
			RISING FIELD TEMPERATURES				
Spotfin shiner	38-83	45-94	Acclim. Temp.	$Y = 44.966 + 0.526\ X_1$	138	0.699	4.866
			Total Length	$Y = 46.946 + 0.539\ X_1 - 0.043\ X_2$	138	0.703	4.856
Channel catfish	38-76	151-250	Acclim. Temp.	$Y = 55.194 + 0.494\ X_1$	78	0.431	6.538
			Total Length	$Y = 59.486 + 0.510\ X_1 - 0.025\ X_2$	78	0.438	6.541
Bluegill	41-77	51-78	Acclim. Temp.	$Y = 58.703 + 0.481\ X_1$	32	0.868	2.743
			Total Length	$Y = 31.622 + 0.637\ X_1 + 0.278\ X_2$	32	0.904	2.369
White crappie	41-82	98-133	Acclim. Temp.	$Y = 55.747 + 0.449\ X_1$	62	0.911	2.082
			Total Length	$Y = 38.336 + 0.330\ X_1 + 0.198\ X_2$	62	0.974	1.125

TABLE 7.4.2-2

Summary of temperature avoidance data on other selected representative species. All tests were conducted at saturated oxygen levels, at a light level of 40 foot-candles and at a pH of 7.5 to 8.1.

Species	Date	No. Fish Per Test	Size Range (TL mm)	Mean TL (mm)	Acclimation Temperature (F)	Avoidance Temperature (F)	Response Significance Level
Pimephales notatus	7 Feb 75	4	53-58	56	44	52	P.05
		4	50-58	54	44	62	P.025
	25 Jan 74	3	40-50	44	40	49	u.t. avoidance
		3	36-56	45	40	49	P.05
	17 Feb 75	4	61-72	67	34	61	P.001
		4	63-71	68	34	61	P.001
	29 Jan 75	4	48-64	57	33	64	P.001
		4	49-58	53	33	64	P.001
	5 Mar 75	4	46-56	50	41	69	P.025
		4	47-56	53	41	69	P.001
	20 Mar 75	4	50-54	53	42	68	P.01
		4	49-56	52	42	68	P.025
	10 Mar 75	4	47-56	53	45	69	P.001
		4	49-54	52	45	69	P.025
Micropterus dolomieui	20 Aug 74	4	90-114	101	90	100	P.001
		4	74-112	89	90	100	P.01
	31 Jul 73	4	54-65	60	81	95	P.001
		4	57-67	61	81	95	P.005
	31 Jul 74	4	53-58	55	79	97	P.001
		4	55-67	60	79	97	P.001
	26 Jun 74	3	98-140	121	77	98	u.t. avoidance
		3	117-155	128	77	98	P.005
	25 Sep 74	4	88-132	105	70	90	P.001
		4	99-117	108	70	90	P.001
Micropterus salmoides	11 Jul 74	4	43-60	48	82	98	u.t. avoidance
		4	44-60	50	82	98	P.001
	24 Jul 73	4	50-55	52	80	90	P.001
		4	48-56	53	80	90	P.001
	15 Aug 74	4	60-64	62	80	95	P.001
		4	54-62	59	80	95	P.001
	30 Aug 73	4	80-90	80	79	92	P.001
		4	73-91	85	79	92	P.001
	1 Aug 74	3	57-63	61	79	96	P.01
		3	53-68	60	79	96	P.005
	26 Sep 74	4	78-108	92	70	93	P.01
		4	81-112	96	70	93	P.001

7.4.3 TEMPERATURE SHOCK

Rapid temperature increase and decrease tests were conducted. When mortalities occurred, the differences between the control and experimental mortalities (attributed to thermal shock) were evaluated statistically (P =0.05) using the exact test designed for small samples (hypergeometric distribution) given by Owen (1962, p. 479). The results of temperature shock studies are plotted with the 95% confidence limits of preference and avoidance temperatures to illustrate the relationships between potential for thermal shock and predicted behavior of fishes in or near the thermal plume (Figures 7.4.1-1 to 7.4.1-5).

7.4.3.1 Spotfin shiner

Specimens acclimated at 34 to 90 F and rapidly subjected to an increased temperature of 8 to 25 F showed significant (P<.05) mortality or loss of equilibrium in only 4 of 26 tests (Figure 7.4.1-1). In three of the tests, nearly complete mortality (34 of 35 fish) was observed with specimens acclimated at 79 and 90 F and rapidly subjected to temperature increases of 13 F and 8 F, respectively. These mortalities occurred because the specimens were subjected to temperature increases which exceeded the upper limit of their avoidance temperature. In the fourth test, two of nine fish died when acclimated at 58 F and subjected to a rapid temperature increase of 13 F.

Rapid temperature decrease tests were conducted on specimens collected at 39 to 81 F. Fish in 26 tests subjected to a temperature decrease of 5 to 21 F suffered no mortality. Temporary loss of equilibrium was observed in one test (all ten specimens) with a temperature decrease of 21 F. In another test, 1 of 10 fish lost equilibrium with a decrease of 15 F.

7.4.3.2 Channel catfish

Rapid temperature increase studies conducted with channel catfish acclimated at 32 to 90 F and subjected to an increase of 7 to 31 F showed significant mortalities in 10 of 36 tests but, in all tests except one, the elevated test temperatures exceeded the upper limit of the estimated avoidance temperature (Figure 7.4.1-2). In the exception, significant mortality occurred with fish acclimated at 32 F and subjected to an increase of 18 F. When the latter test conditions were repeated no mortality occurred. Temporary loss of equilibrium was usually observed when the temperature increase equalled or exceeded 24 F.

Rapid temperature decrease studies were conducted on fish acclimated at 45 to 77 F. Specimens subjected to temperature decreases of 7 to 20 F suffered no mortalities in 26 tests. Only 3 of 291 fish temporarily lost equilibrium.

7.4.3.3 Pumpkinseed

Specimens acclimated at 34 to 90 F and subjected to temperature increases of 7 to 35 F showed significant mortalities in 6 of 19 tests (Figure 7.4.1-3). In all tests where mortality was observed the elevated test temperature exceeded 31 F or the upper limit of avoidance temperature (97 F). No loss of equilibrium was observed where test temperature increases were less than 29 F or at an experimental temperature of 95 F.

Specimens collected at 55 to 81 F were subjected to temperature decreases of 13 to 20 F. No significant mortalities occurred in 12 tests. Some temporary loss of equilibrium occurred early in three of five tests with a temperature decrease of 15 to 20 F where specimens were acclimated at 55 to 60 F. Temperature decreases of 15 to 17 F at acclimation temperatures exceeding 60 F resulted in no loss of equilibrium.

7.4.3.4 Bluegill

Rapid temperature increases of 13 to 35 F with specimens acclimated at 32 to 90 F resulted in mortalities in 9 of 37 tests. However, all significant mortalities occurred at test temperatures at or exceeding the lower limit of the avoidance temperatures (Figure 7.4.1-4). Nonsignificant mortalities occurred in 7 of 37 tests (14 of 376 fish). These occurred at temperature increases of 13 to 29 F.

Tests were conducted on specimens acclimated at 45 to 81 F and subjected to rapid temperature decreases of 7 to 20 F. Mortality was low. Significant mortality occurred in only 2 of 31 tests. Both tests were conducted with a temperature decrease of 15 F. Temporary loss of equilibrium was noted in some specimens when the temperature was decreased 13 to 15 F and 20 F. No mortality or loss of equilibrium occurred with a temperature decrease of 16 and 17 F.

7.4.3.5 White crappie

Some mortality and loss of equilibrium occurred with specimens acclimated at 32 and 79 F and rapidly subjected to temperature increases of 13 to 32 F. Significant mortalities were observed in 3 of 10 tests conducted at temperatures less than the estimated avoidance temperatures but above the preference temperature. Significant mortality was also observed in all of eight tests conducted at or above the upper avoidance limit (Figure 7.4.1-5).

Some loss of equilibrium (35 of 233 fish) was observed when specimens acclimated at 45 to 71 F were subjected to rapid temperature decreases of 7 to 20 F. No significant mortality was observed in 22 tests. White crappie are sensistive to handling stress and consequently results may vary under similar test conditions.

7.4.4 DISCUSSION

The studies of the spotfin shiner, channel catfish, bluegill, pumpkinseed and white crappie indicate that mortality (96 hr) was statistically nonsignificant ($P \geq 0.05$) in temperature shock tests conducted at temperatures below the upper limit of the avoidance temperature during rising field temperatures. Five of sixty rapid temperature increase tests conducted during periods of falling field temperatures resulted in significant mortalities ($P \leq 0.05$); three were in tests with the white crappie and one each occurred with the spotfin shiner and channel catfish. Mortality in the white crappie and spotfin shiner occurred above preference temperatures. The mortality in one test on the channel catfish occurred below the preference temperature, but when the test was repeated no mortality occurred.

To illustrate that the scheduled operation of PBAPS Units No. 2 and 3 at full power in the open loop made would not cause any significant mortality, the shock data were plotted with the predicted temperatures which may occur in the Pond (Figures 7.4.4-1 to 7.4.4-5). A 5 F water quality criteria line is shown along with a 15 F delta T. These data show that a sudden decrease in temperature of up to 15 F or even higher would cause no mortality. The data are conservative because they are based on instantaneous decreases in temperature. The temperature decrease would not be as rapid during PBAPS shutdown. Thus, based on the laboratory data we can predict that mortalities will not occur at a temperature decrease of 15 F.

Studies indicate that fishes prefer higher temperatures in winter and avoid higher temperatures in summer. Fishes will be distributed relative to their preference and avoidance temperatures. It is because of these differing responses and that fishes will not be trapped in the Pond or in the discharge canal that no mortalities due to shock will occur.

A summary of preference and avoidance temperatures for fishes acclimated to winter temperature (33 F), fall and spring transitional temperatures (40 to 55 F) and high summer temperatures is given in Tables 7.4.4-1 and 7.4.4-2, respectively. Fishes acclimated to high summer temperatures common to the Pond avoid temperatures which are in excess of those predicted for the "worse case" conditions (higher than

93 F). The temperature which the fishes prefer is below the avoidance temperature. In the winter and fall and spring transitional periods the avoidance temperature is also higher than the predicted "worse case" condition. Fishes which come in contact with the plume can be expected to prefer it if their preferred temperature is higher than the acclimation temperature in the transition period.

The phenomenon of low thermal responsiveness, which is the inability of a fish to avoid areas in the thermal gradient which produce stressful conditions (Meldrim and Gift, 1971) was observed in the preference and avoidance studies. Low thermal responsiveness is an <u>artifact</u> which occurs in steep, compressed experimental gradients, 11 C (20 F) or greater, which extends a short distance. It is not relevant in the field situation. The phenomenon rarely occurred in temperature avoidance studies on some 27 species which occur in the Pond. Low thermal responsiveness was most commonly observed in the preference tests where the gradient exceeded 10 C (18 F) over a distance of 12 feet. Such a gradient averages 1.5 F per foot the acclimation temperature is located in the middle of the gradient. Model studies (Elder, et al., 1973) indicate that such a gradient will not occur in the Pond near PBAPS. In the course of preference experiments the preferred temperature was checked for position effect and the gradient was shifted and occasionally expanded. When the gradient was 11 C (20 F) or greater (1.67 F per foot) low thermal responsiveness was also occasionally exhibited by some species.

Regardless of its cause, low thermal responsiveness will not be a source of mortality in the thermal plume. At no time will the gradient in the thermal plume approach conditions which would elicit the phenomenon experienced in experimental studies. Low thermal responsiveness has not been observed in field studies to date. No fish kills have been observed in the Pond or discharge canal.

TABLE 7.4.4-1

Preference, avoidance and upper temperature (F) tolerance limits of the selected representative fish acclimated to high summer temperatures common to Conowingo Pond.

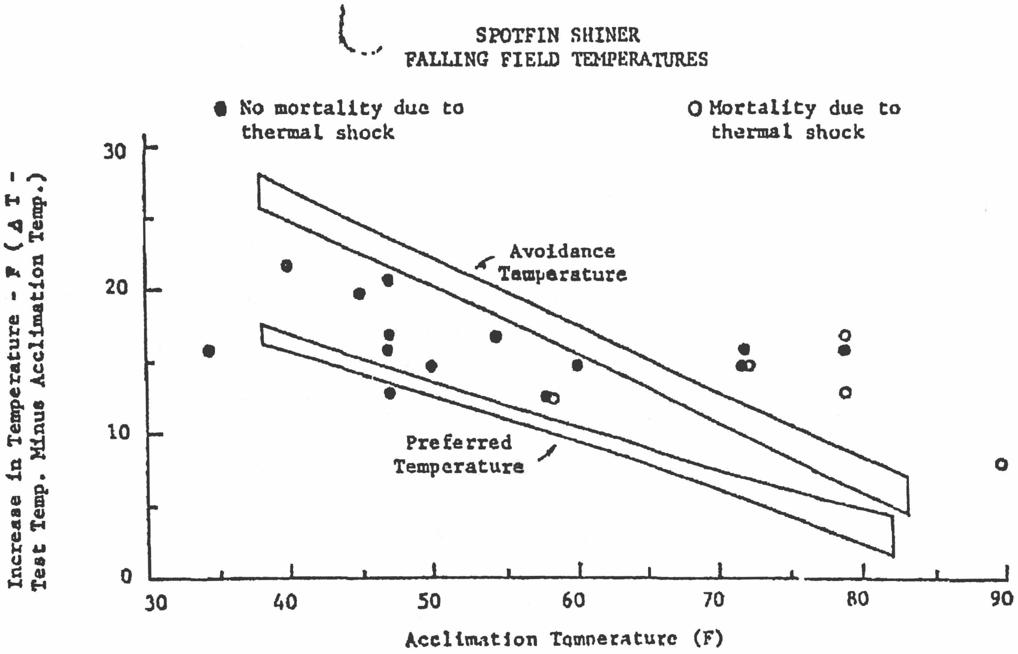
Species	Acclimation	Preference	Avoidance	Upper Tolerance Limit
Gizzard shad	NO	DATA	AVAILABLE	
Spotfin shiner	78	-	-	95
	80	83.5	87.0	-
	81	84.2	87.6	-
	82	84.9	88.1	-
Bluntnose minnow	80	75.2	-	-
	81	75.7	-	-
	82	76.2	-	-
Channel catfish	80	86.8	94.7	-
	81	87.4	95.2	96
	82	88.0	95.7	-
Bluegill	80	87.0	97.2	-
	81	87.5	97.7	96.5
	82	87.9	98.1	
Smallmouth bass	77	86-90	95	-
	80	88-90	97	-
	82	90	98	-
Largemouth bass	79	87.3	96	-
	80	87.9	95	-
	82	88.5	98	-
	85	-	-	97
White crappie	78	-	-	90
	80	83.9	91.7	-
	81	84.7	92.1	90
	82	85.5	92.6	-
Walleye	NO	DATA	AVAILABLE	
Chironomus attenuatus	80	-	-	95.5

TABLE 7.4.4-2

Preference and avoidance temperatures of selected representative fishes acclimated to 33, 40, and 55 F.

Species	Acclimation	Preference	Avoidance
Gizzard shad	NO	DATA	AVAILABLE
Spotfin shiner	33	50.8	65.3
	40	55.7	69.1
	55	66.1	77.0
Bluntnose minnow	33	52.3	64.0
	40	55.8	68.0
	55	63.1	N.A.
Channel catfish	33	58.8	70.8
	40	63.0	74.3
	55	71.9	81.8
Bluegill	33	66.5	81.5
	40	69.5	83.1
	55	76.1	86.5
Smallmouth bass	54	70-73	N.A.
Largemouth bass	33	59.8	N.A.
	40	63.9	N.A.
	55	72.7	N.A.
White crappie	33	46.4	58.7
	40	52.0	65.2
	55	64.0	79.3
Walleye	50-52	59-63	N.A.

N.A. = No data available



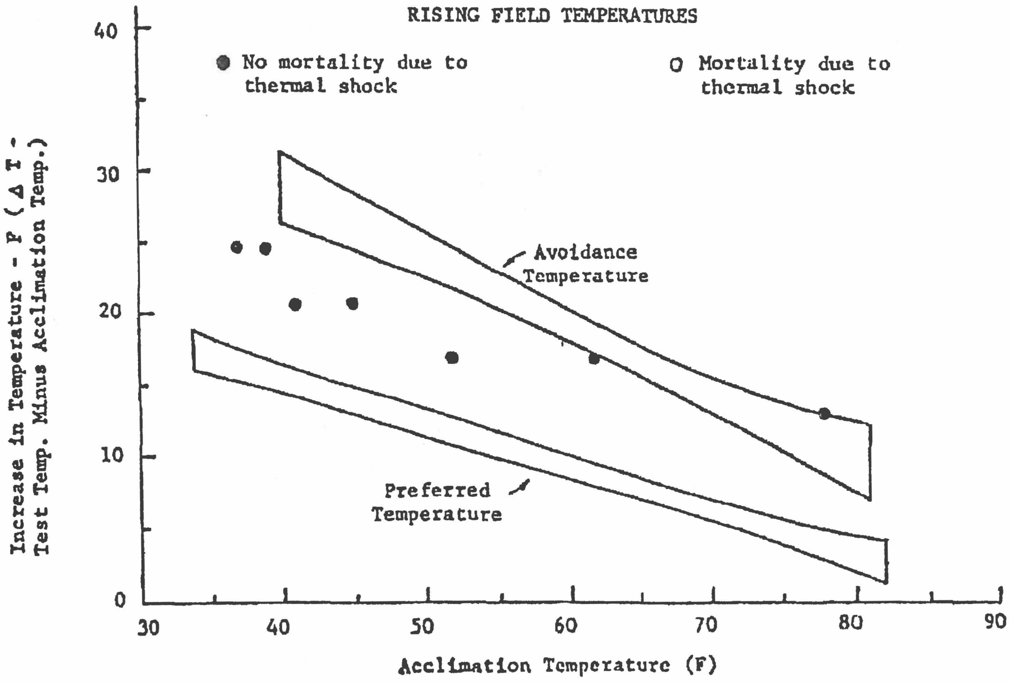
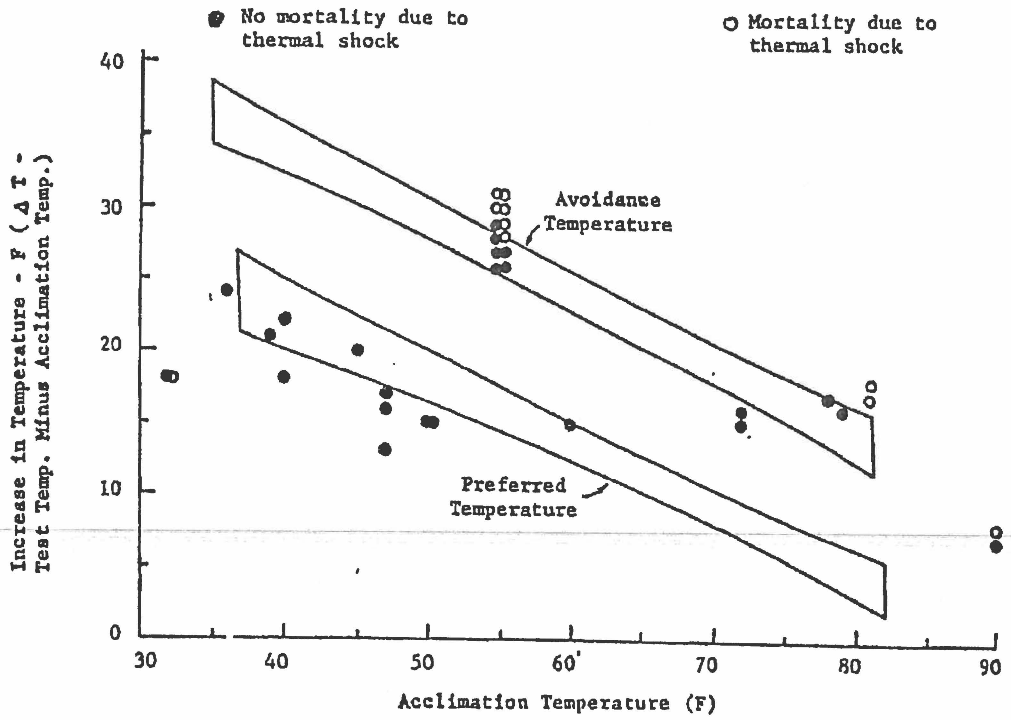


TABLE 7.4.1-1

Relationship between rapid temperature increase (shock) and preference and avoidance temperatures (95% confidence intervals of the population mean) during falling and rising field temperatures for the spotfin shiner, Notropis spilopterus.

CHANNEL CATFISH
FALLING FIELD TEMPERATURES



RISING FIELD TEMPERATURES

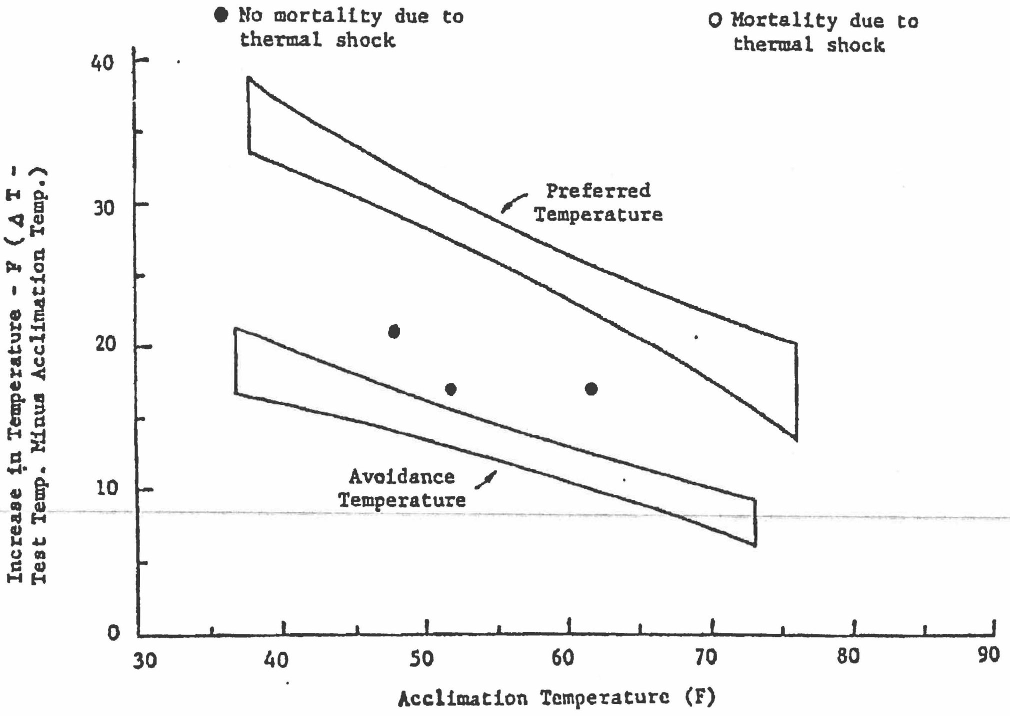


FIGURE 7.4.1-2

Relationship between rapid temperature increase (shock) and preference and avoidance temperatures (95% confidence intervals of the population mean) during falling and rising field temperatures for the channel catfish, Ictalurus punctatus.

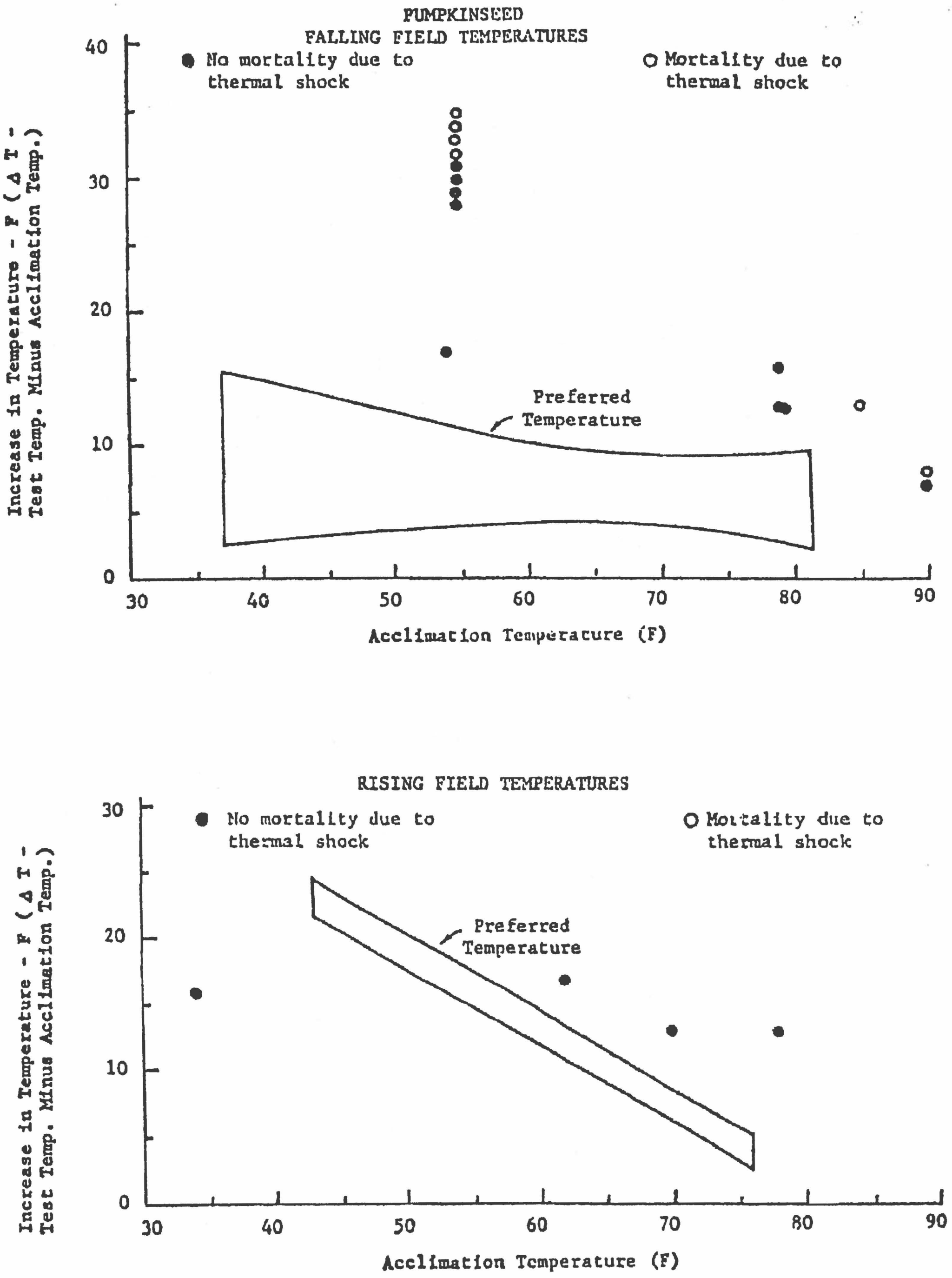
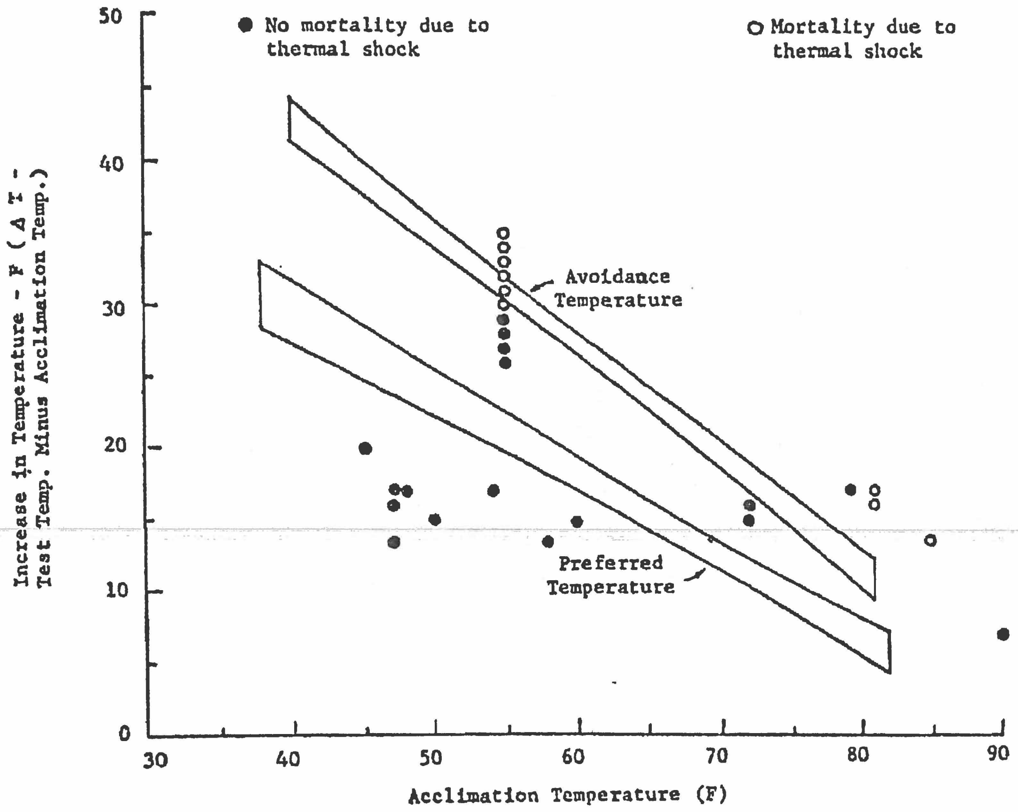


FIGURE 7.4.1-3

Relationship between rapid temperature increase (shock) and preference temperature (95% confidence interval of the population mean) during falling and rising field temperatures for the pumpkinseed, <u>Lepomis gibbosus</u>.

BLUEGILL

FALLING FIELD TEMPERATURES



RISING FIELD TEMPERATURES

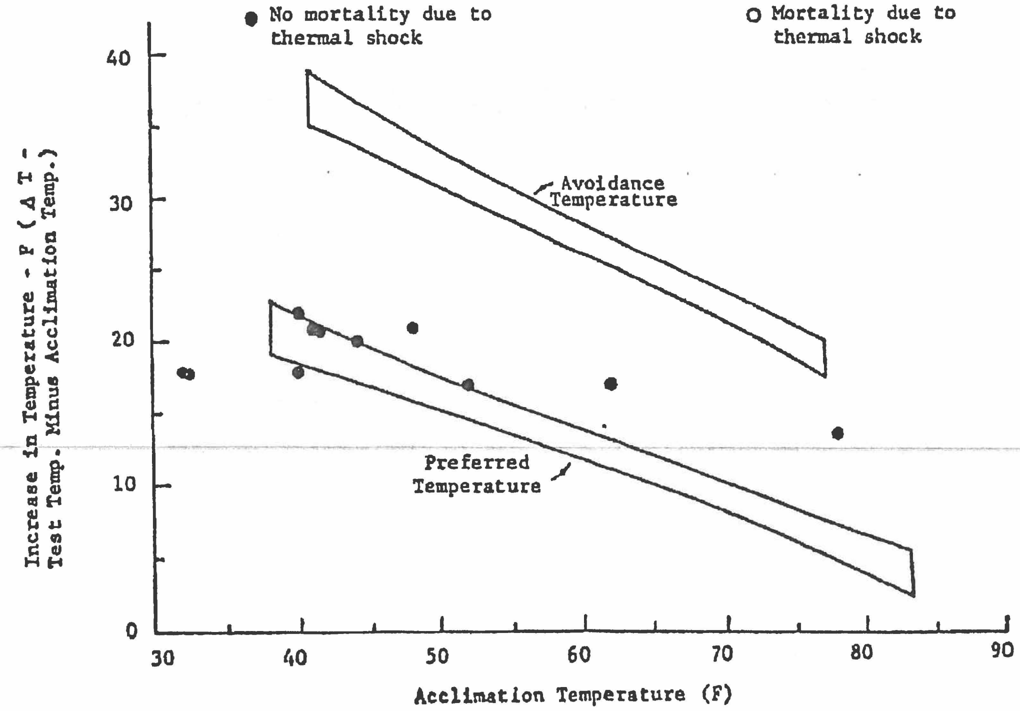


FIGURE 7.4.1-4

Relationship between rapid temperature increase (shock) and preference and avoidance temperatures (95% confidence intervals of the population mean) during falling and rising field temperatures for the bluegill, Lepomis macrochirus.

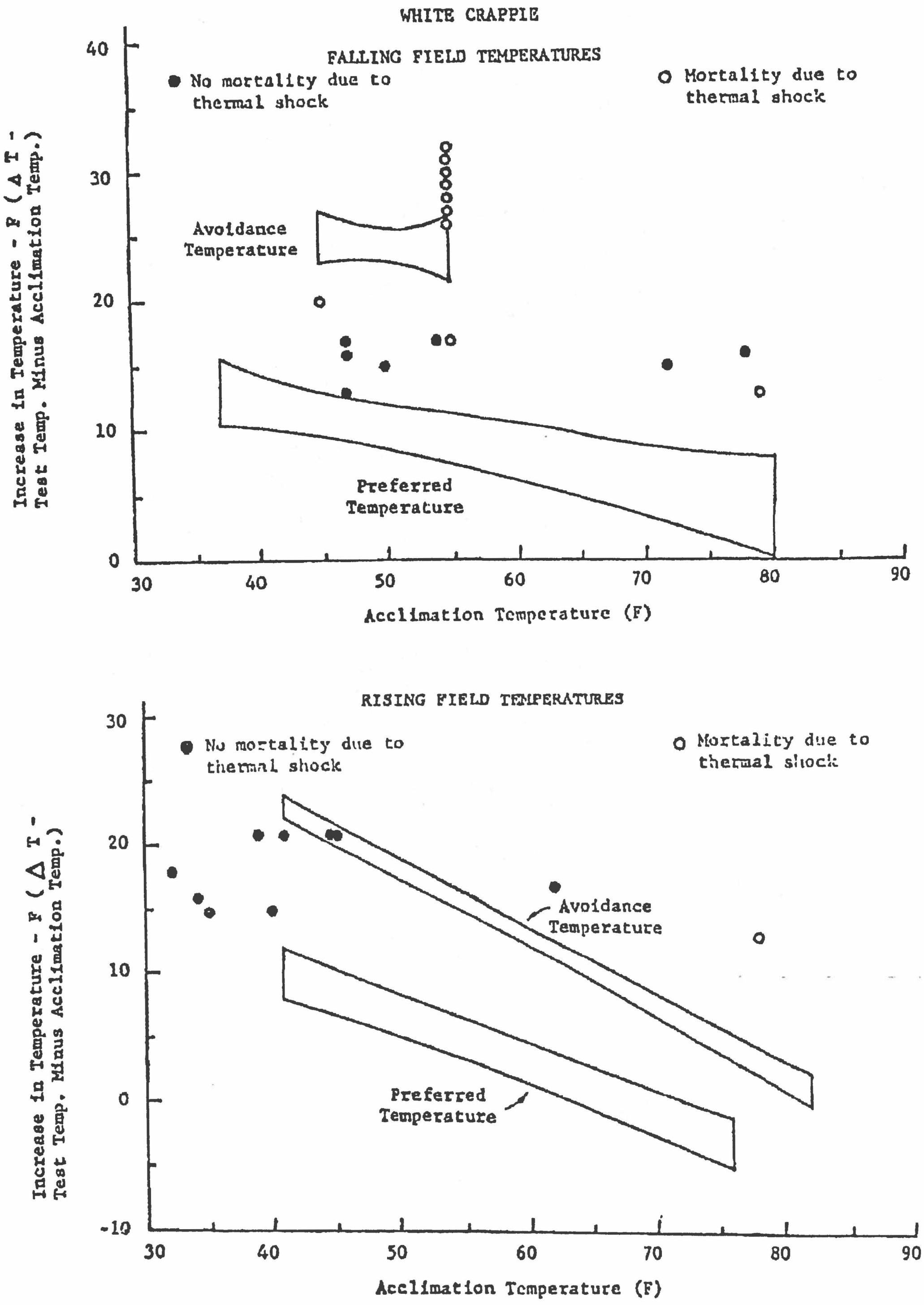


FIGURE 7.4.1-5

Relationship between rapid temperature increase (shock) and preference and avoidance temperatures (95% confidence intervals of the population mean) during falling and rising field temperatures for the white crappie, *Pomoxis annularis*.

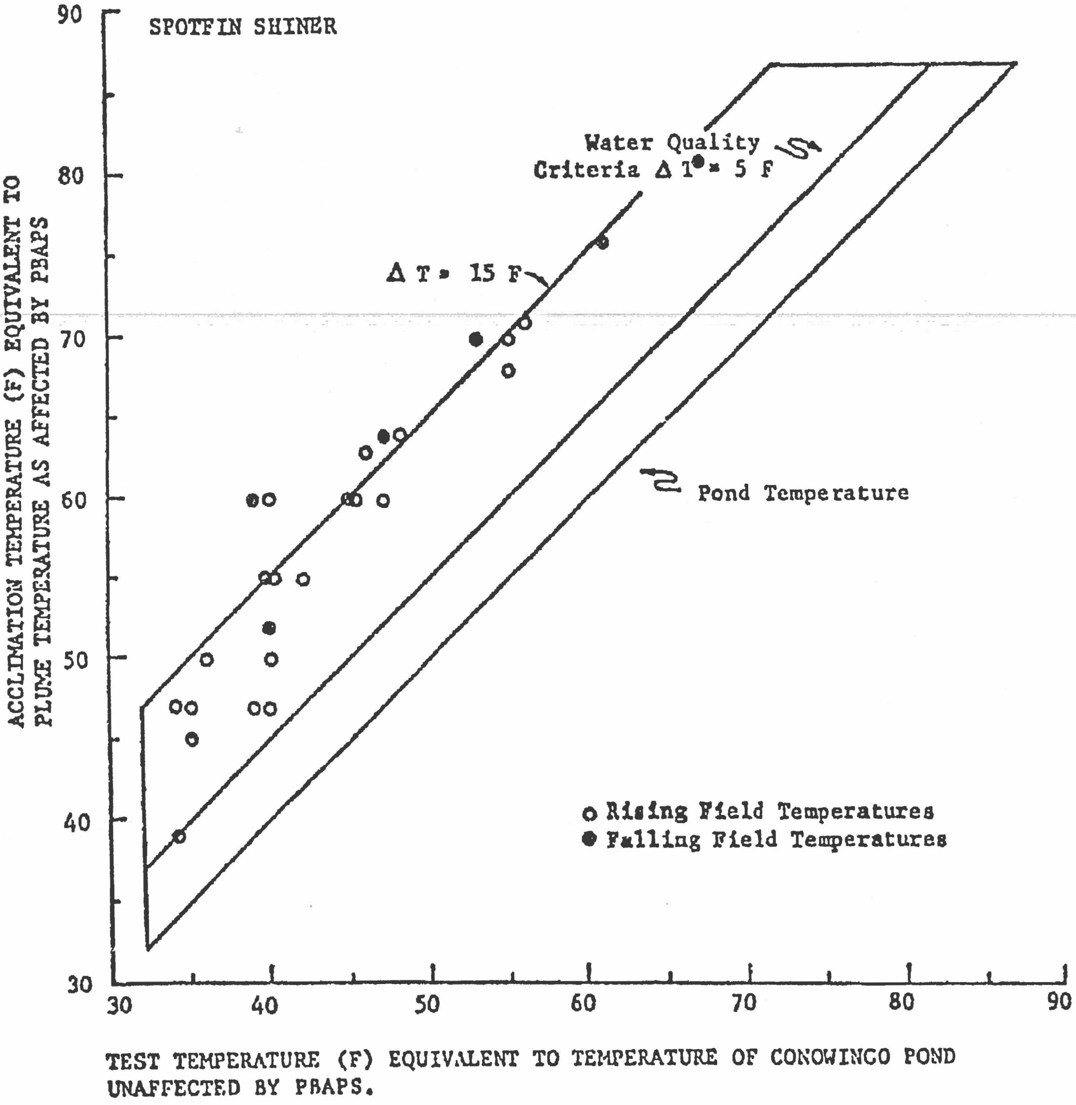


FIGURE 7.4.4-1

Plot of rapid temperature decrease tests (shock) in relation to water quality criteria (maximum increase in delta T = 5 F) and delta T = 15 F for the spotfin shiner, *Notropis spilopterus*. All points indicate survival unless otherwise indicated.

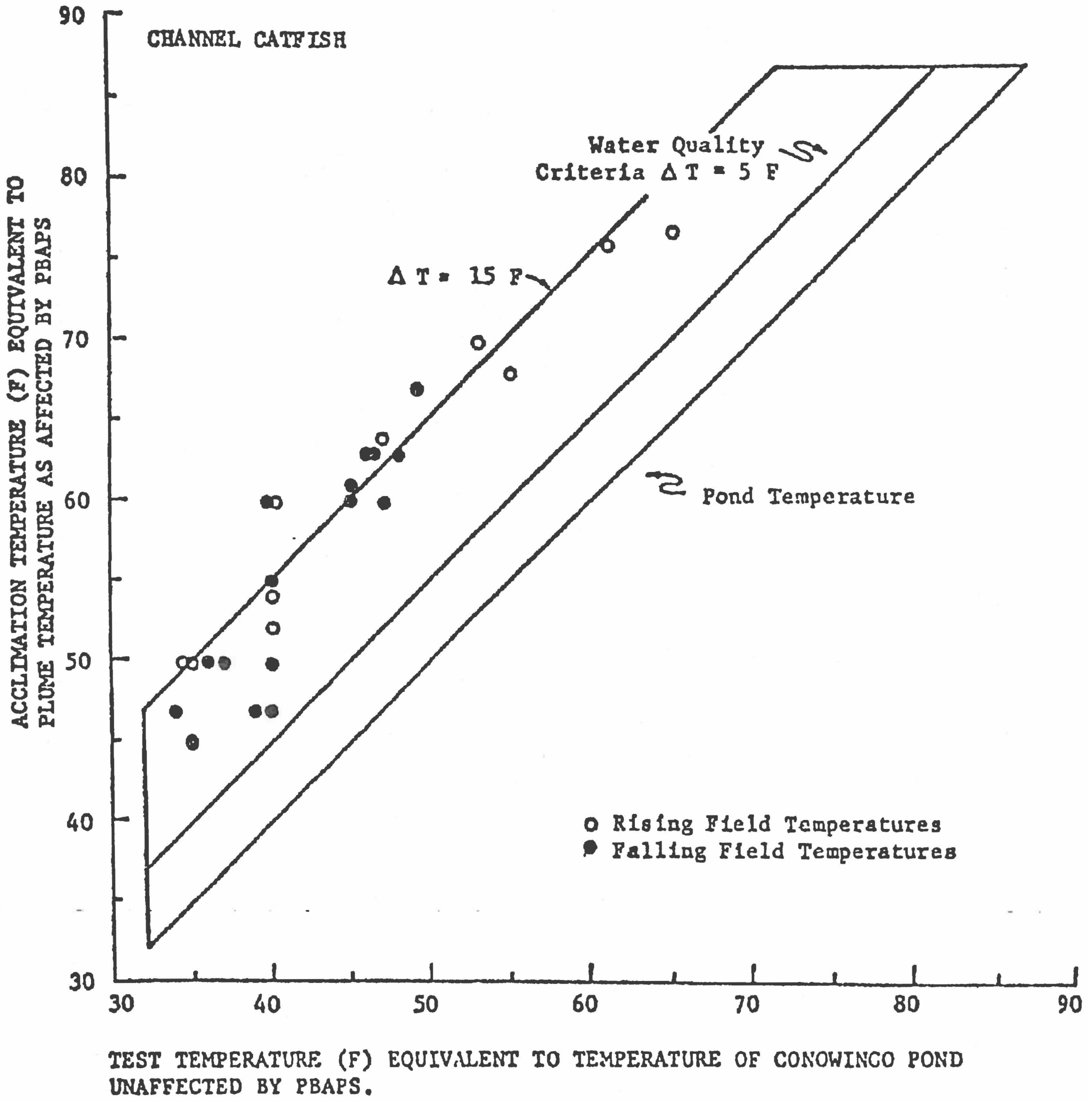


FIGURE 7.4.4-2

Plot of rapid temperature decrease tests (shock) in relation to water quality criteria (maximum increase in delta T = 5 F) and delta T = 15 F for the channel catfish, Ictalurus punctatus. All points indicate survival unless other wise indicated.

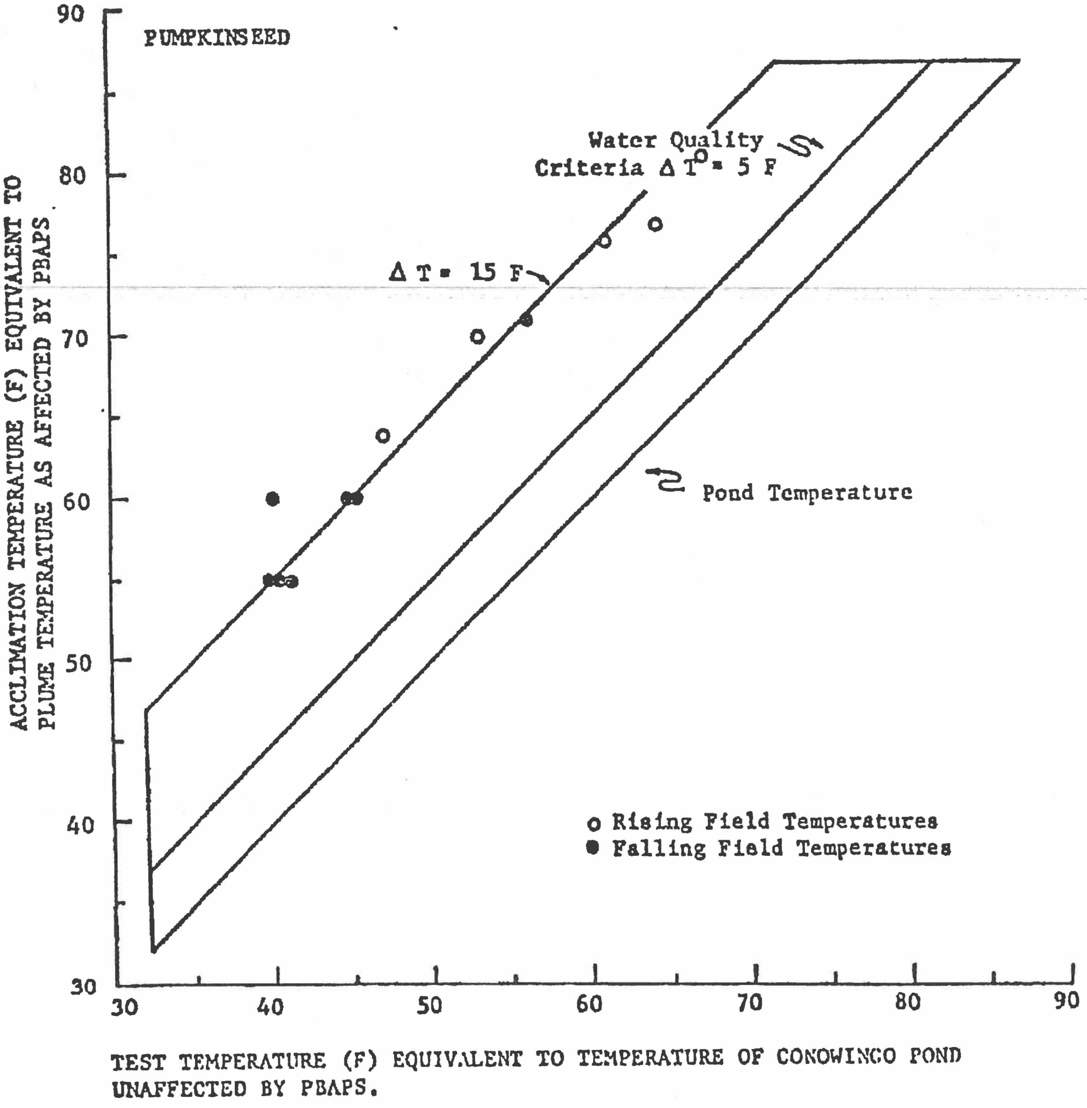


FIGURE 7.4.4-3

Plot of rapid temperature decrease tests (shock) in relation to water quality criteria (maximum increase in delta T = 5 F) and delta T = 15 F for the pumpkinseed, Lepomis gibbosus. All points indicate survival unless otherwise indicated.

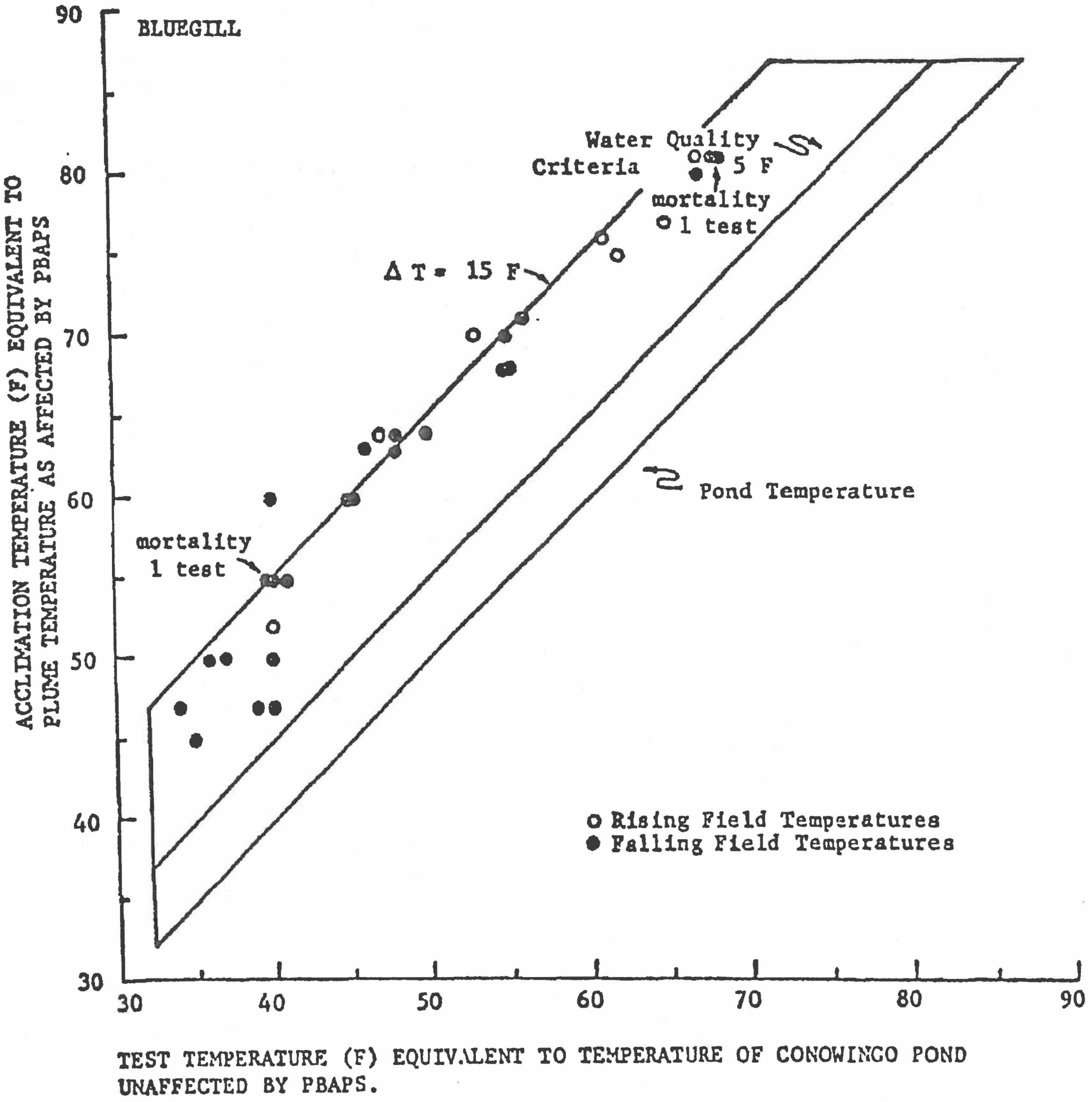
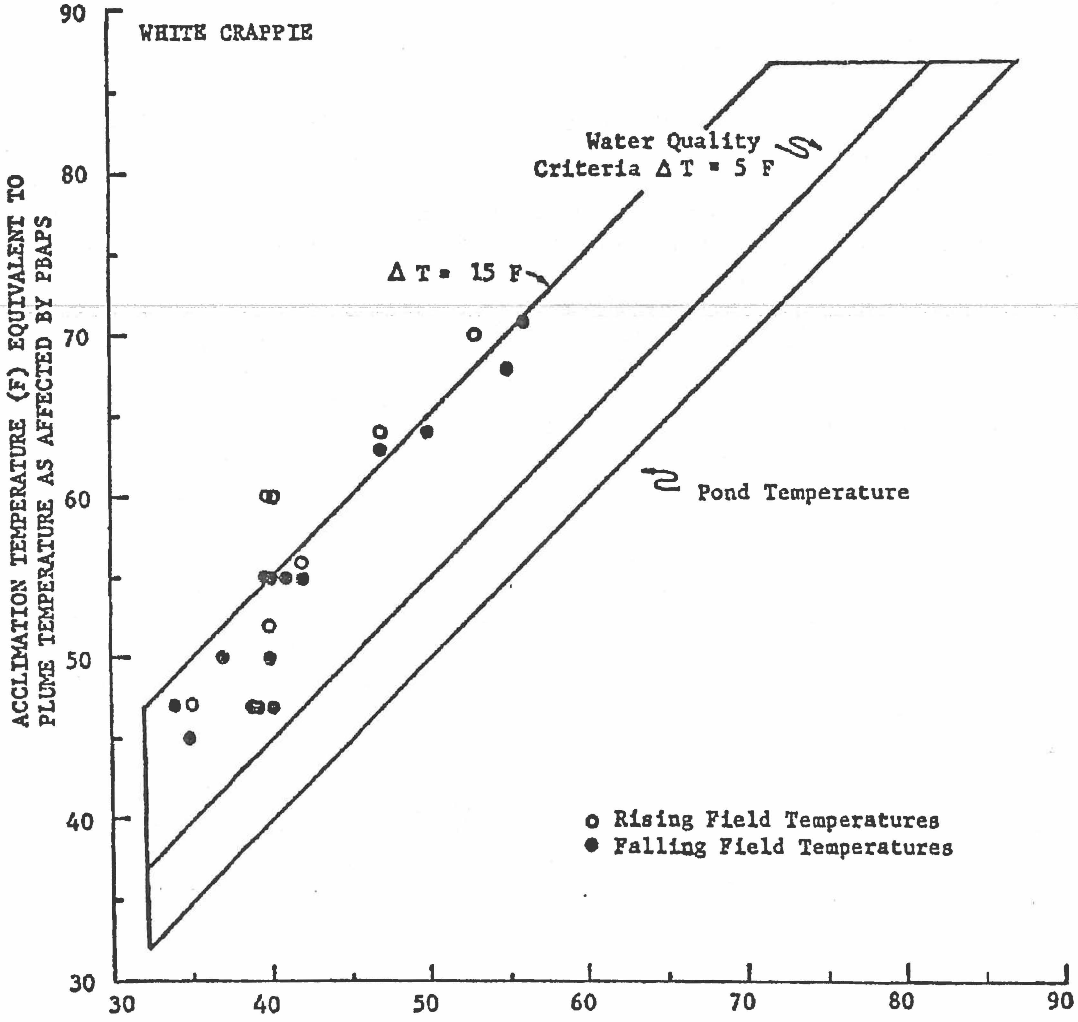


FIGURE 7.4.4-4

Plot of rapid temperature decrease tests (shock) in relation to water quality criteria (maximum increase in delta T = 5 F) and delta T = 15 F for the bluegill, Lepomis macrochirus. All points indicate survival unless otherwise indicated.



TEST TEMPERATURE (F) EQUIVALENT TO TEMPERATURE OF CONOWINCO POND UNAFFECTED BY PBAPS.

FIGURE 7.4.4-5

Plot of rapid temperature decrease tests (shock) in relation to water quality criteria (maximum increase in delta T = 5 F) and delta T = 15 F for the white crappie, *Pomoxis annularis*. All points indicate survival unless otherwise indicated.

8.0 ALTERNATIVE #1 - FIVE "HELPER" COOLING TOWERS

8.1 Applicable Effluent Limitation

The effluent limitation desired under this alternative is "the discharge to the Pond of an average of 8.5 x 10^9 Btu/hr. and a maximum of 16 x 10^9 Btu/hr."

8.2 System Description.

Two additional "helper" cooling towers would be added to the Peach Bottom circulating water system providing sufficient capacity to accommodate the total circulating water flow and thus cool all of the circulating water before it is discharged to the Pond. The physical layout of the Station with these additional "helper" towers is shown in Figure 8.2-1.

The performance of the helper towers and, therefore, the discharge temperature rise is dependent on meteorological conditions. The monthly variation in discharge temperature rise is indicated on Table 8.2-1. Table 8.2-2 illustrates the resultant variation in evaporative losses from the cooling towers and the water body surface. A comparison of the information on these tables with that supplied on Tables 2.2-1 and 2.2-2, for the existing system, indicates that the average rate of heat rejected to the Pond would be about 8.4 x 10^9 Btu/hr., which is 30% lower than for the existing system, and that the average rate of evaporation would be about 11% greater than for the existing system. This increased rate of evaporative loss would add up to about 792 million gallons of water per year at an 80% load factor.

As in the existing system all of the circulating water flow is returned to the Pond via the submerged jet discharge. The transit times for the circulating water will be essentially the same as those indicated in Table 2.2-3 for that water which goes through the cooling towers.

8.3 Schedule and Costs

These additional cooling towers could be installed within a period of 30 months, provided that engineering has been completed and long lead time items such as pumps, pipe, and pilings are available when required.

The costs involved in implementing this alternative would be:

Capitalized cost of replacement energy ($2,187,000/yr. @ 13.85%)	$	15,790,000
Cost of Lost Capacity @ $200/kw.		3,120,000
Capital cost of Installation (1975 Dollars)		22,000,000
Total Capitalized Cost	$	40,910,000

8.4 Resultant Isotherms

The net effect of the addition of these two cooling towers will be lower excess temperatures throughout the Pond. The degree by which these excess temperatures are lessened will depend upon the seasonal variation of cooling tower performance, as described above. Figures 8.4-1 through 8.4-6C are predicted isotherms for this five helper tower system which correspond to predictions made in reference (2) for the three helper tower system.

8.5 Biological Assessment

The material presented in Section 7 provides the basis for concluding that the operation of PBAPS as presently designed (open loop with 3 "helper" cooling towers) will assure the protection and propagation of a balanced indigenous community of shellfishes and fishes and wildlife in and on the Pond. The two additional cooling tower banks will in general cause less of a temperature rise in the Pond. Since it has been demonstrated that no "appreciable" harm to the biota would result due to the operation of PBAPS as designed, it is anticipated that the additional cooling proposed in this section would have the same impact. It should be emphasized, however, that the predicted enhancement of the Pond biota (due to the thermal input) would be reduced.

Table 8.2-1
Peach Bottom Units 2 and 3
Alternative #1
Five "Helper" Cooling Towers

	Ambient Water Temp. (°F)	Condenser ΔT (°F)	Cooling Twr. Range (°F)	Seasonal Variation of Discharge ΔT * Heat Rejected via Discharge (10^9 Btu/hr.)	Discharge ΔT (°F)
January	35.0	20.8	6.6	10.7	14.2
February	36.0	20.8	6.8	10.5	14.0
March	39.5	20.8	6.8	10.5	14.0
April	48.5	20.8	7.3	10.2	13.5
May	64.0	20.8	11.0	7.4	9.8
June	72.5	20.8	12.3	6.4	8.5
July	80.0	20.8	15.2	4.2	5.6
August	79.5	20.8	14.3	4.9	6.5
September	70.5	20.8	12.3	6.4	8.5
October	60.0	20.8	10.8	7.5	10.0
November	45.0	20.8	7.6	9.9	13.2
December	35.5	20.8	6.8	10.5	14.0
Average Annual During Operation				8.3	11.0

* based on average monthly meteorological conditions.

Table 8.2-2
Peach Bottom Units 2 and 3
Alternative #1
Five "Helper" Cooling Towers

Seasonal Variation of Rate of Evaporative Loss*

	Evaporative Loss from C. Twrs. (cfs)	Receiving Water ** Evap. (cfs)	Total Evaporative Loss (cfs)
January	13.8	16.0	29.8
February	14.2	14.7	28.9
March	14.2	17.8	32.0
April	15.3	20.4	35.7
May	30.6	17.0	47.3
June	34.3	17.9	52.2
July	42.3	12.2	54.5
August	39.8	14.2	54.0
September	34.3	17.3	51.6
October	30.1	18.8	48.9
November	15.9	19.8	35.7
December	14.2	17.8	32.1
Average Annual Rate During Operation	24.9	17.0	41.9

* based on average meteorological conditions.

** calculated using formulae developed in Brady, Edinger, and Geyer; Heat Exchange and Transport in The Environment; EPRI Publication No. 74-049-00-3.

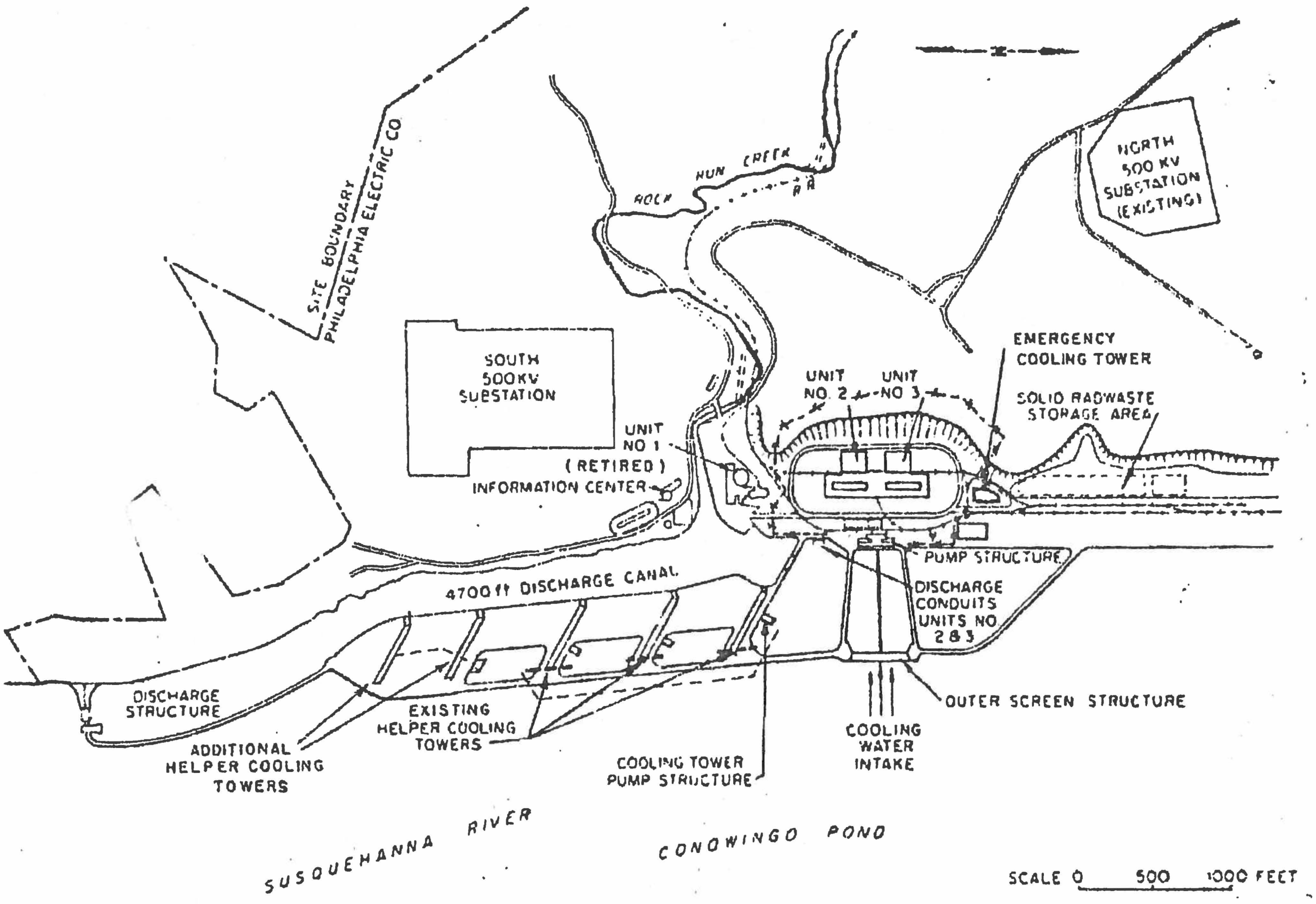
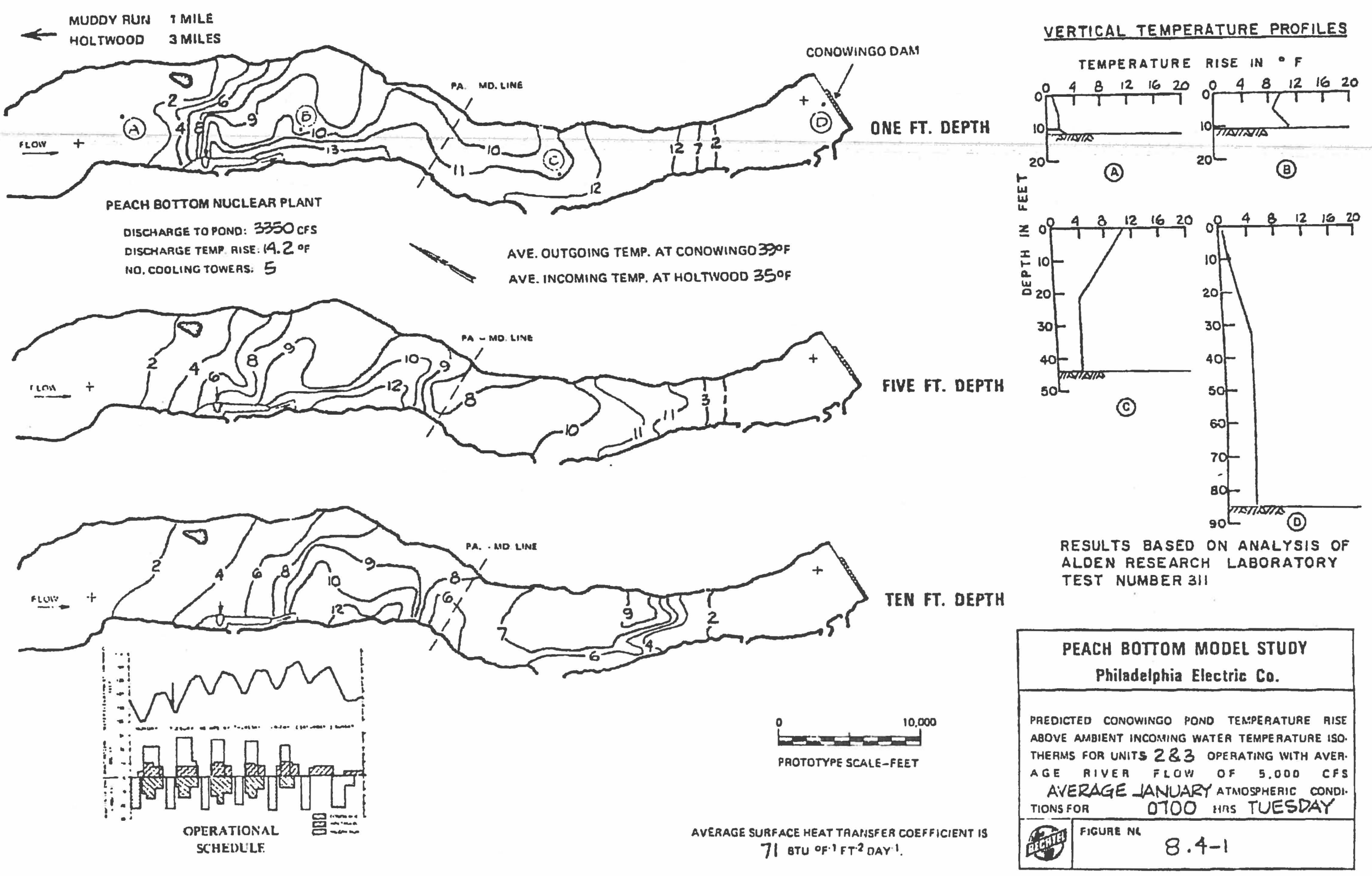


FIG. 8.2-1 CLOSEUP OF PEACH BOTTOM COMPLEX ALTERNATIVE # 1



RESULTS BASED ON ANALYSIS OF ALDEN RESEARCH LABORATORY TEST NUMBER 311

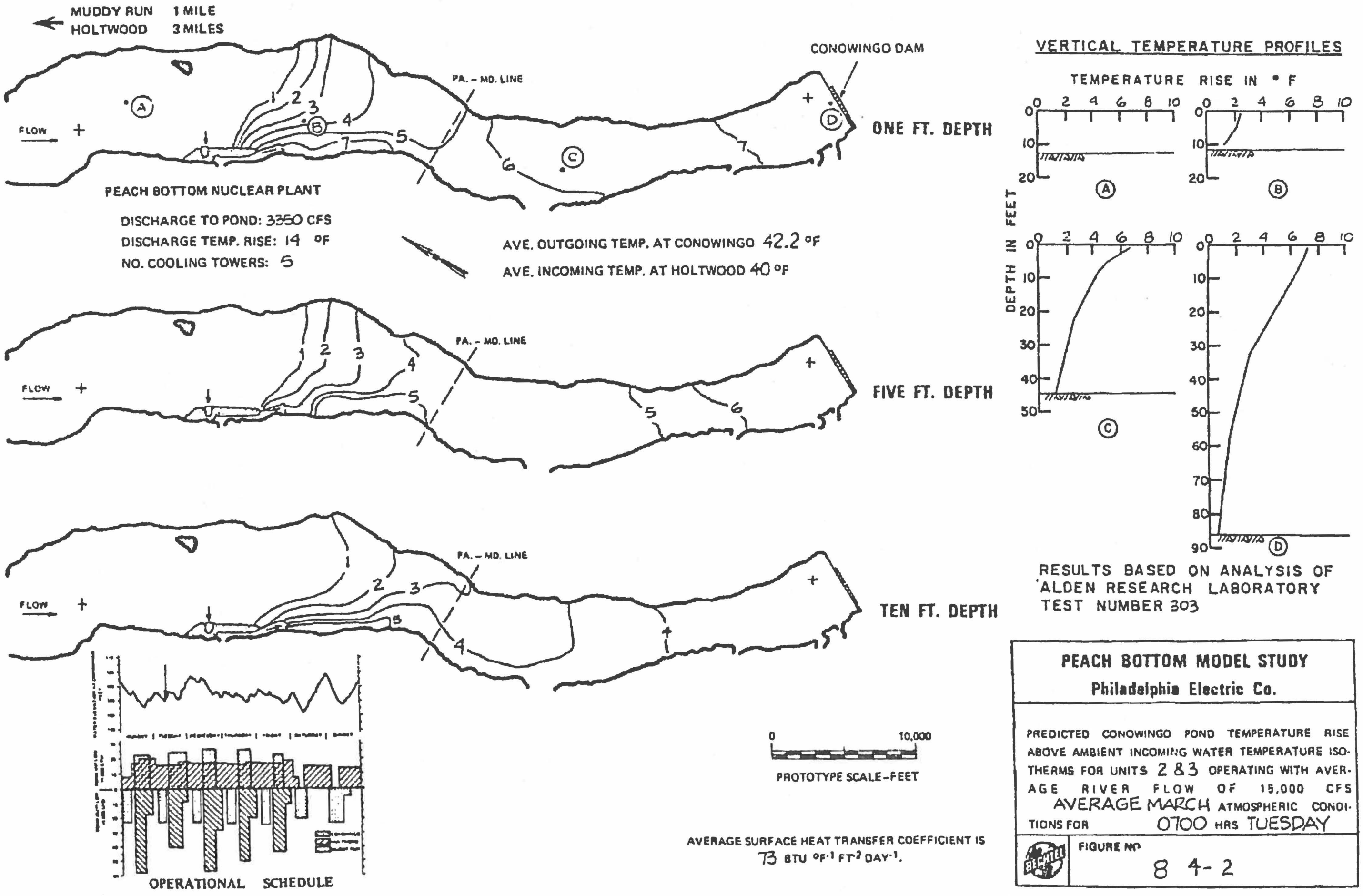
AVERAGE SURFACE HEAT TRANSFER COEFFICIENT IS 71 BTU °F^{-1} FT^{-2} DAY^{-1}.

PEACH BOTTOM MODEL STUDY

Philadelphia Electric Co.

PREDICTED CONOWINGO POND TEMPERATURE RISE ABOVE AMBIENT INCOMING WATER TEMPERATURE ISOTHERMS FOR UNITS 2&3 OPERATING WITH AVERAGE RIVER FLOW OF 5,000 CFS AVERAGE JANUARY ATMOSPHERIC CONDITIONS FOR 0700 HRS TUESDAY

FIGURE NO 8.4-1



DISCHARGE TO POND: 3350 CFS
DISCHARGE TEMP. RISE: 14 °F
NO. COOLING TOWERS: 5

AVE. OUTGOING TEMP. AT CONOWINGO 42.2 °F
AVE. INCOMING TEMP. AT HOLTWOOD 40 °F

RESULTS BASED ON ANALYSIS OF ALDEN RESEARCH LABORATORY TEST NUMBER 303

AVERAGE SURFACE HEAT TRANSFER COEFFICIENT IS 73 BTU $^{\circ}F^{-1}$ FT^{-2} DAY^{-1}.

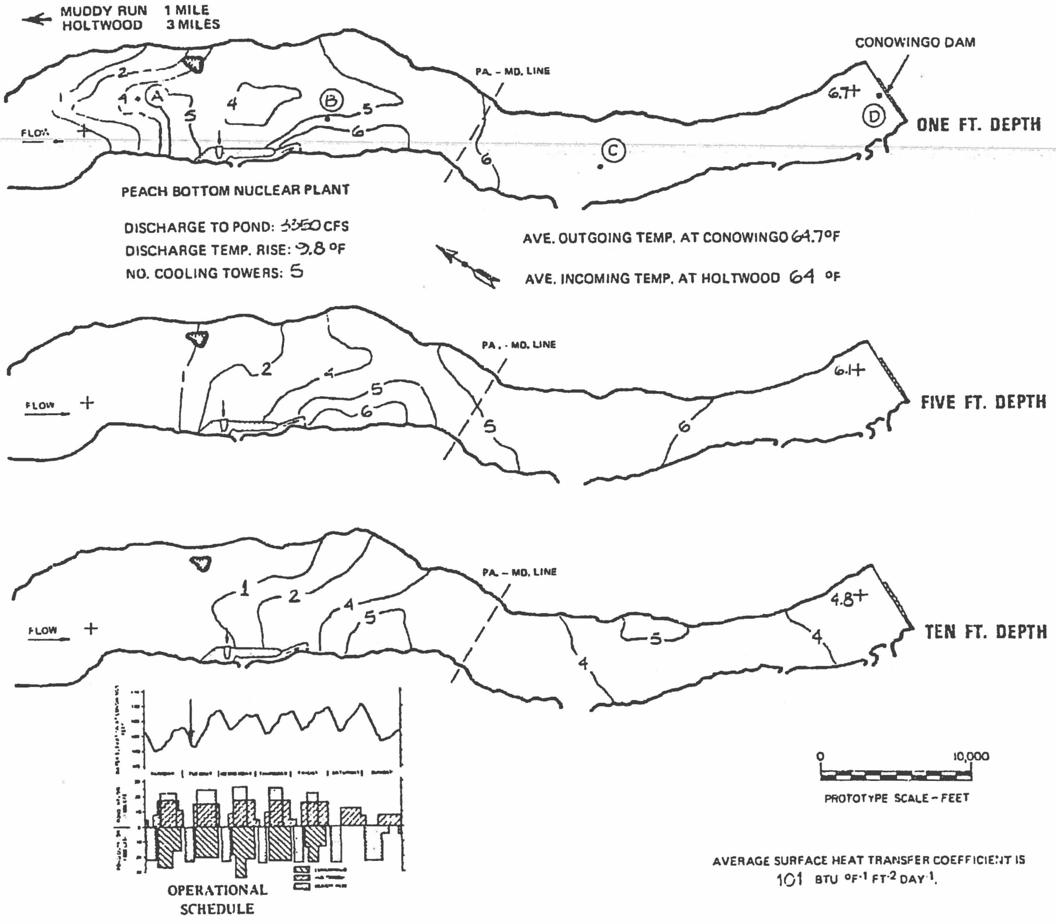
PEACH BOTTOM MODEL STUDY

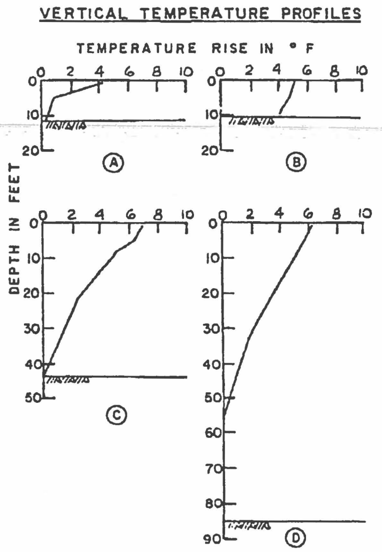
Philadelphia Electric Co.

PREDICTED CONOWINGO POND TEMPERATURE RISE ABOVE AMBIENT INCOMING WATER TEMPERATURE ISOTHERMS FOR UNITS 2 & 3 OPERATING WITH AVERAGE RIVER FLOW OF 15,000 CFS AVERAGE MARCH ATMOSPHERIC CONDITIONS FOR 0700 HRS TUESDAY

BECHTEL

FIGURE NO 8 4-2



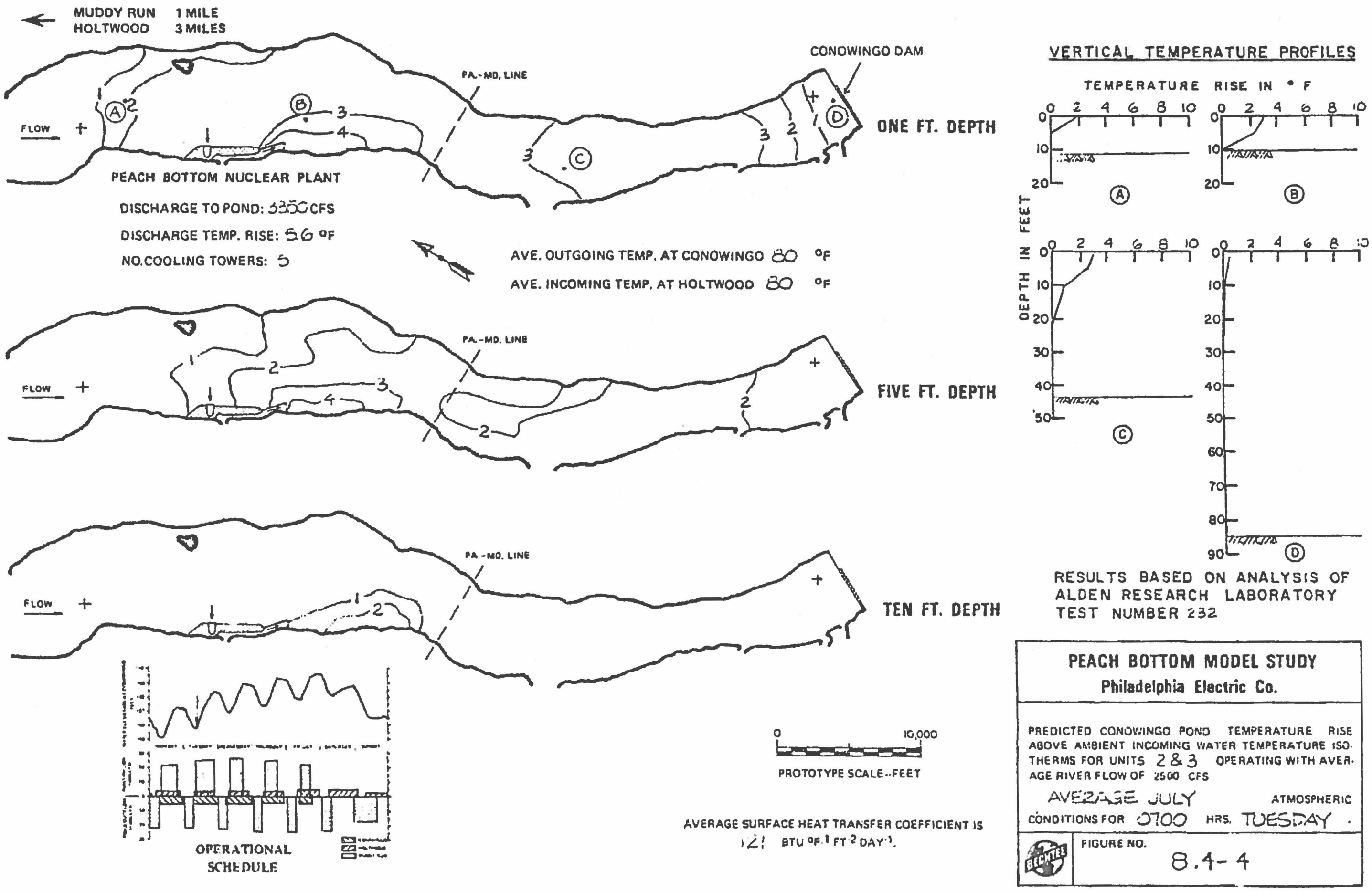


RESULTS BASED ON ANALYSIS OF ALDEN RESEARCH LABORATORY TEST NUMBER 218

PEACH BOTTOM MODEL STUDY
Philadelphia Electric Co.

PREDICTED CONOWINGO POND TEMPERATURE RISE ABOVE AMBIENT INCOMING WATER TEMPERATURE ISOTHERMS FOR UNITS 2&3 OPERATING WITH AVERAGE RIVER FLOW OF 10,000 CFS AVERAGE MAY ATMOSPHERIC CONDITIONS FOR 0700 HRS. TUESDAY

FIGURE NO. 8.4-3



DISCHARGE TO POND: 3350 CFS

DISCHARGE TEMP. RISE: 5.6 °F

NO. COOLING TOWERS: 5

AVE. OUTGOING TEMP. AT CONOWINGO 80 °F

AVE. INCOMING TEMP. AT HOLTWOOD 80 °F

RESULTS BASED ON ANALYSIS OF ALDEN RESEARCH LABORATORY TEST NUMBER 232

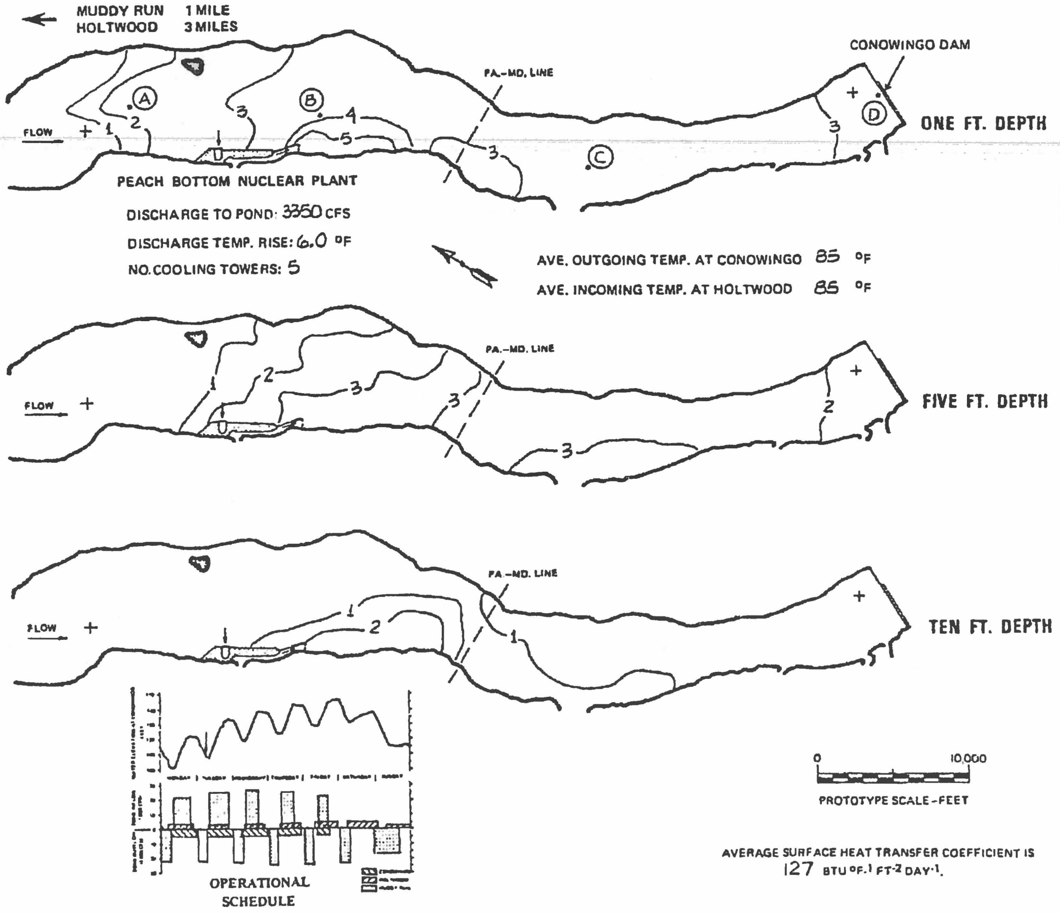
AVERAGE SURFACE HEAT TRANSFER COEFFICIENT IS 121 BTU °F⁻¹ FT⁻² DAY⁻¹.

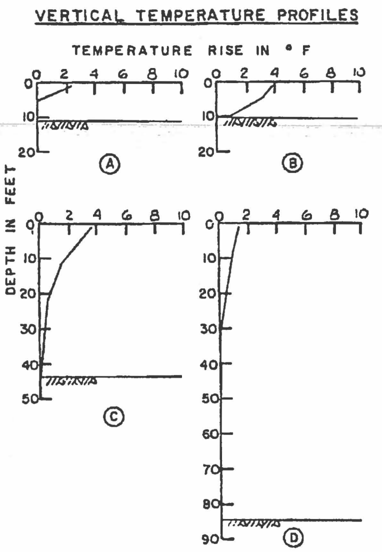
PEACH BOTTOM MODEL STUDY
Philadelphia Electric Co.

PREDICTED CONOWINGO POND TEMPERATURE RISE ABOVE AMBIENT INCOMING WATER TEMPERATURE ISOTHERMS FOR UNITS 2 & 3 OPERATING WITH AVERAGE RIVER FLOW OF 2500 CFS

AVEZAGE JULY ATMOSPHERIC CONDITIONS FOR 0700 HRS. TUESDAY.

FIGURE NO. 8.4-4





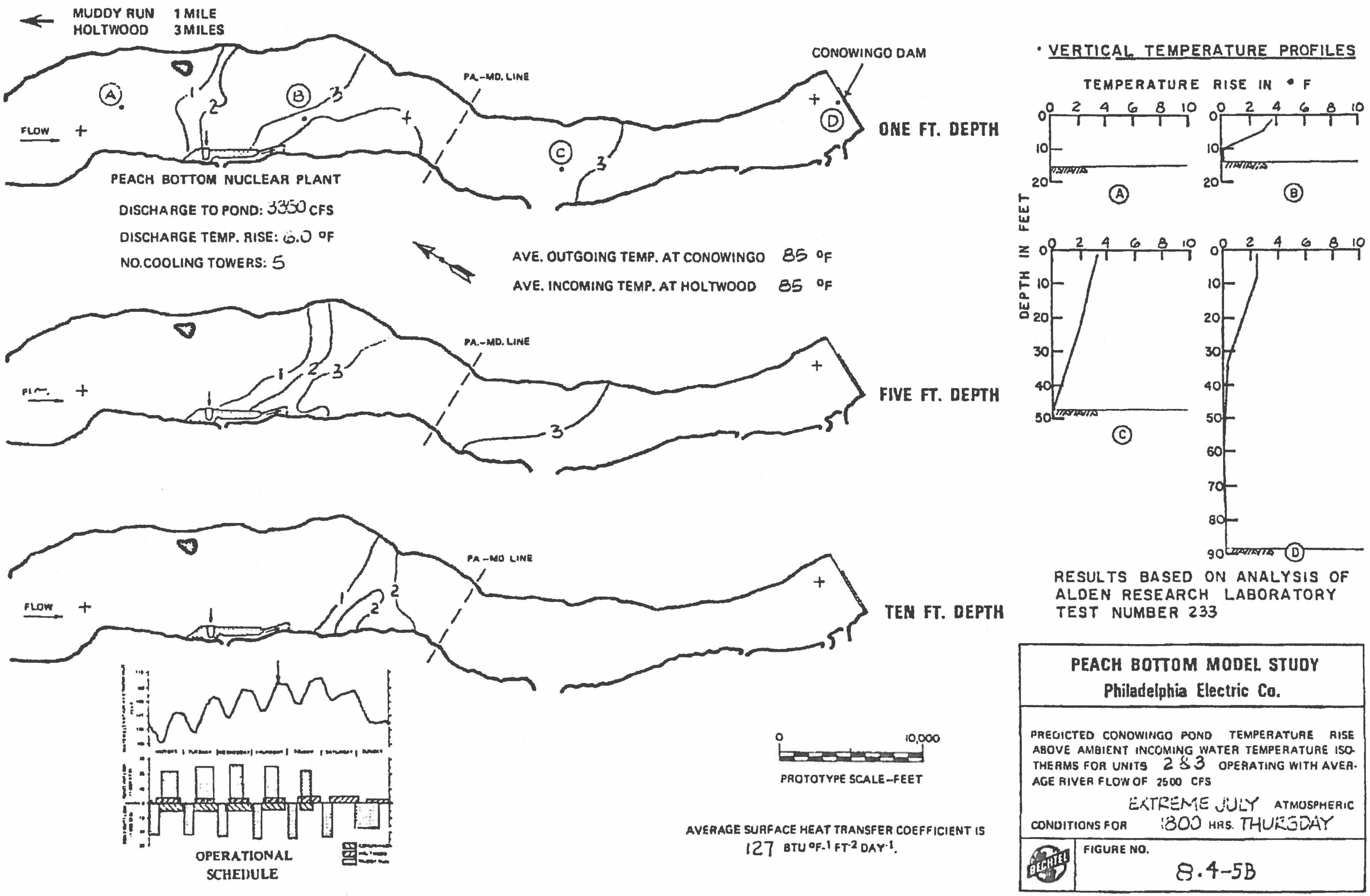
RESULTS BASED ON ANALYSIS OF ALDEN RESEARCH LABORATORY TEST NUMBER 233

PEACH BOTTOM MODEL STUDY
Philadelphia Electric Co.

PREDICTED CONOWINGO POND TEMPERATURE RISE ABOVE AMBIENT INCOMING WATER TEMPERATURE ISOTHERMS FOR UNITS 2 & 3 OPERATING WITH AVERAGE RIVER FLOW OF 2500 CFS

EXTREME JULY ATMOSPHERIC CONDITIONS FOR 0700 HRS TUESDAY

FIGURE NO. 8.4-5A



RESULTS BASED ON ANALYSIS OF ALDEN RESEARCH LABORATORY TEST NUMBER 233

AVERAGE SURFACE HEAT TRANSFER COEFFICIENT IS 127 BTU °F^{-1} FT^{-2} DAY^{-1}.

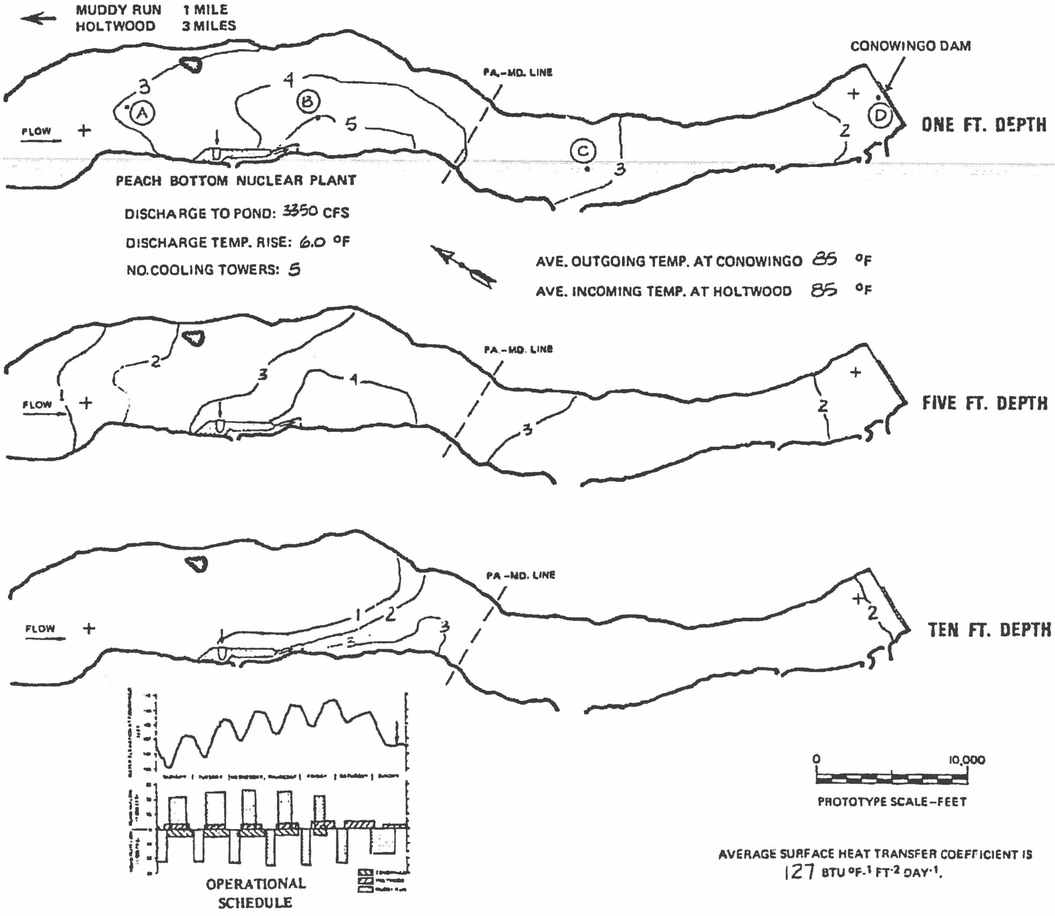
PEACH BOTTOM MODEL STUDY
Philadelphia Electric Co.

PREDICTED CONOWINGO POND TEMPERATURE RISE ABOVE AMBIENT INCOMING WATER TEMPERATURE ISOTHERMS FOR UNITS 2 & 3 OPERATING WITH AVERAGE RIVER FLOW OF 2500 CFS

CONDITIONS FOR EXTREME JULY ATMOSPHERIC 1800 HRS. THURSDAY

BECHTEL

FIGURE NO. 8.4-5B



DISCHARGE TO POND: 3350 CFS

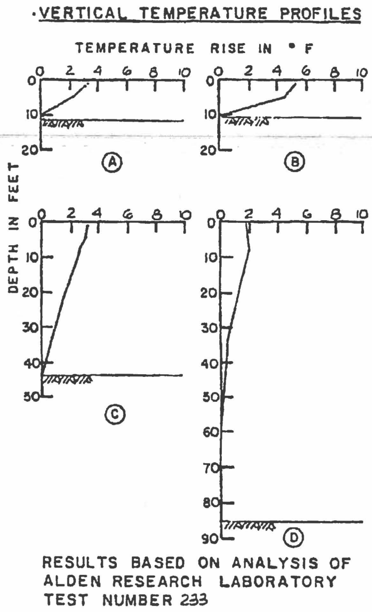
DISCHARGE TEMP. RISE: 6.0 °F

NO. COOLING TOWERS: 5

AVE. OUTGOING TEMP. AT CONOWINGO 85 °F

AVE. INCOMING TEMP. AT HOLTWOOD 85 °F

AVERAGE SURFACE HEAT TRANSFER COEFFICIENT IS 127 BTU °F.$^{-1}$ FT^{-2} DAY^{-1}.



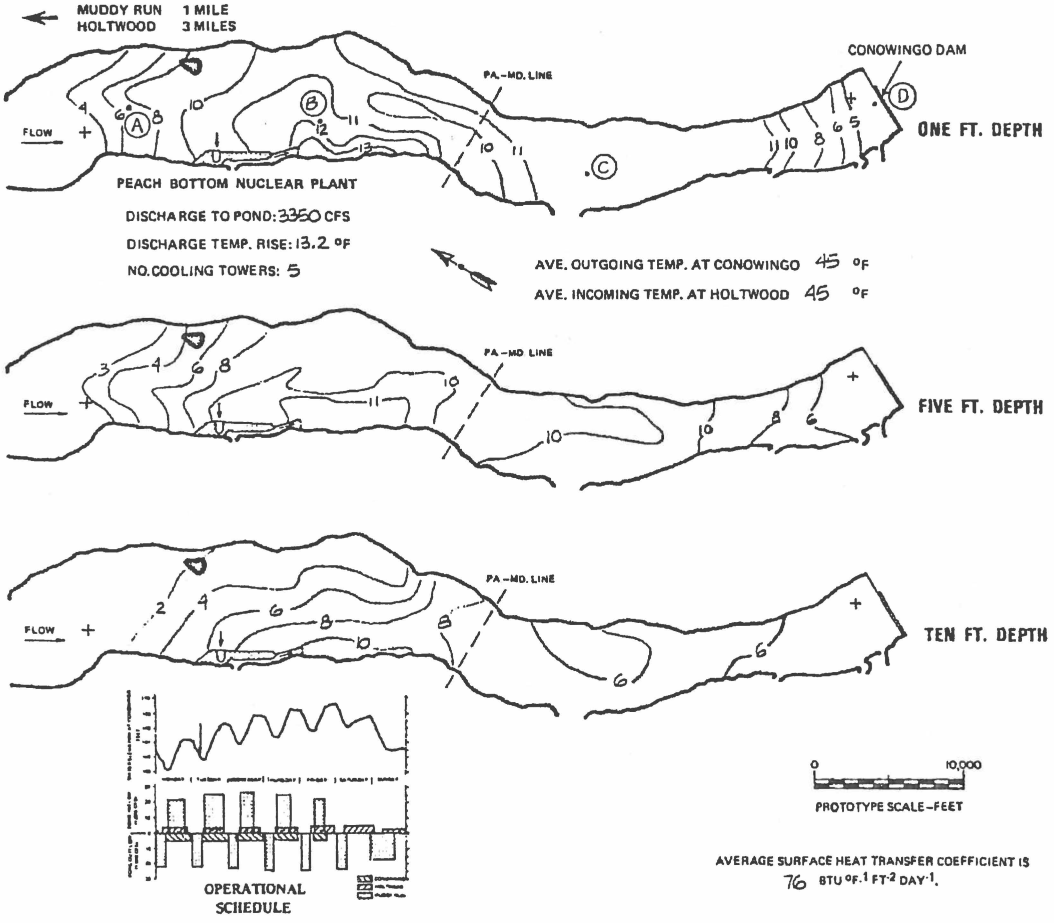
RESULTS BASED ON ANALYSIS OF ALDEN RESEARCH LABORATORY TEST NUMBER 233

PEACH BOTTOM MODEL STUDY
Philadelphia Electric Co.

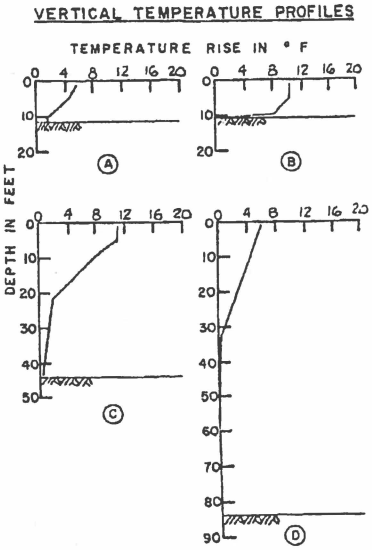
PREDICTED CONOWINGO POND TEMPERATURE RISE ABOVE AMBIENT INCOMING WATER TEMPERATURE ISOTHERMS FOR UNITS 2 & 3 OPERATING WITH AVERAGE RIVER FLOW OF 2500 CFS

EXTREME JULY ATMOSPHERIC CONDITIONS FOR 1700 HRS. SUNDAY

FIGURE NO. 8.4-5C



AVERAGE SURFACE HEAT TRANSFER COEFFICIENT IS 76 BTU °F.$^{-1}$ FT^{-2} DAY^{-1}.



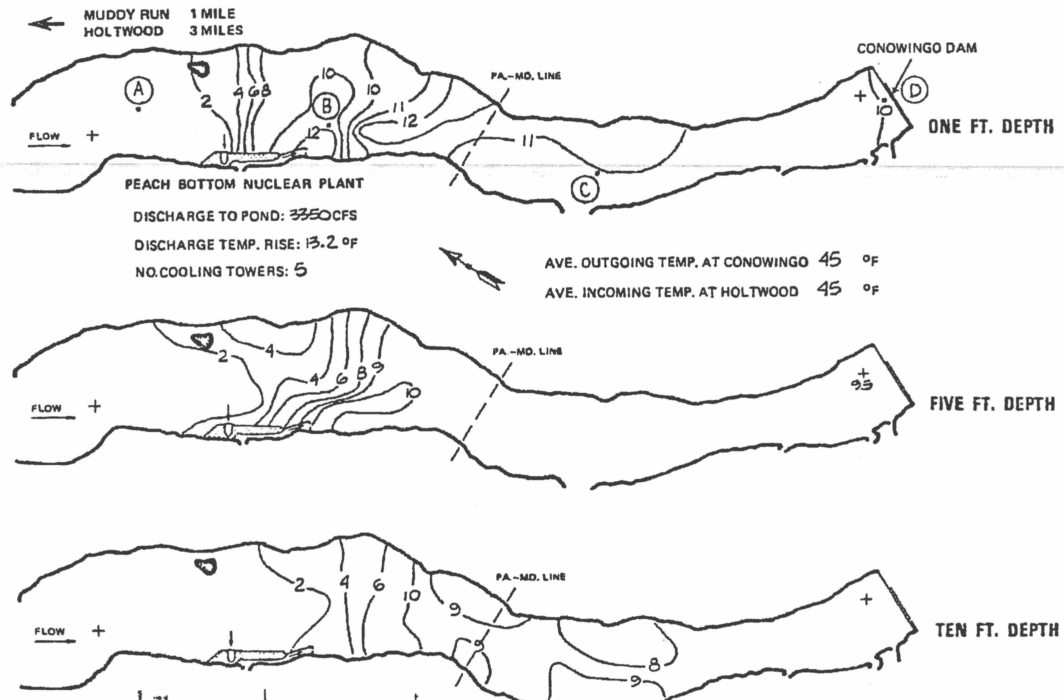
RESULTS BASED ON ANALYSIS OF ALDEN RESEARCH LABORATORY TEST NUMBER 205

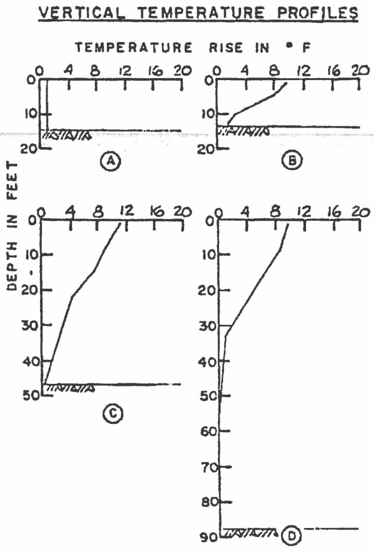
PEACH BOTTOM MODEL STUDY
Philadelphia Electric Co.

PREDICTED CONOWINGO POND TEMPERATURE RISE ABOVE AMBIENT INCOMING WATER TEMPERATURE ISOTHERMS FOR UNITS 2 & 3 OPERATING WITH AVERAGE RIVER FLOW OF 2500 CFS
AVERAGE NOVEMBER ATMOSPHERIC CONDITIONS FOR 0700 HRS. TUESDAY

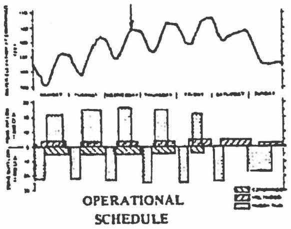
BECHTEL

FIGURE NO. 8 4-6A





RESULTS BASED ON ANALYSIS OF ALDEN RESEARCH LABORATORY TEST NUMBER 205



AVERAGE SURFACE HEAT TRANSFER COEFFICIENT IS 76 BTU °F^{-1} FT^{-2} DAY^{-1}.

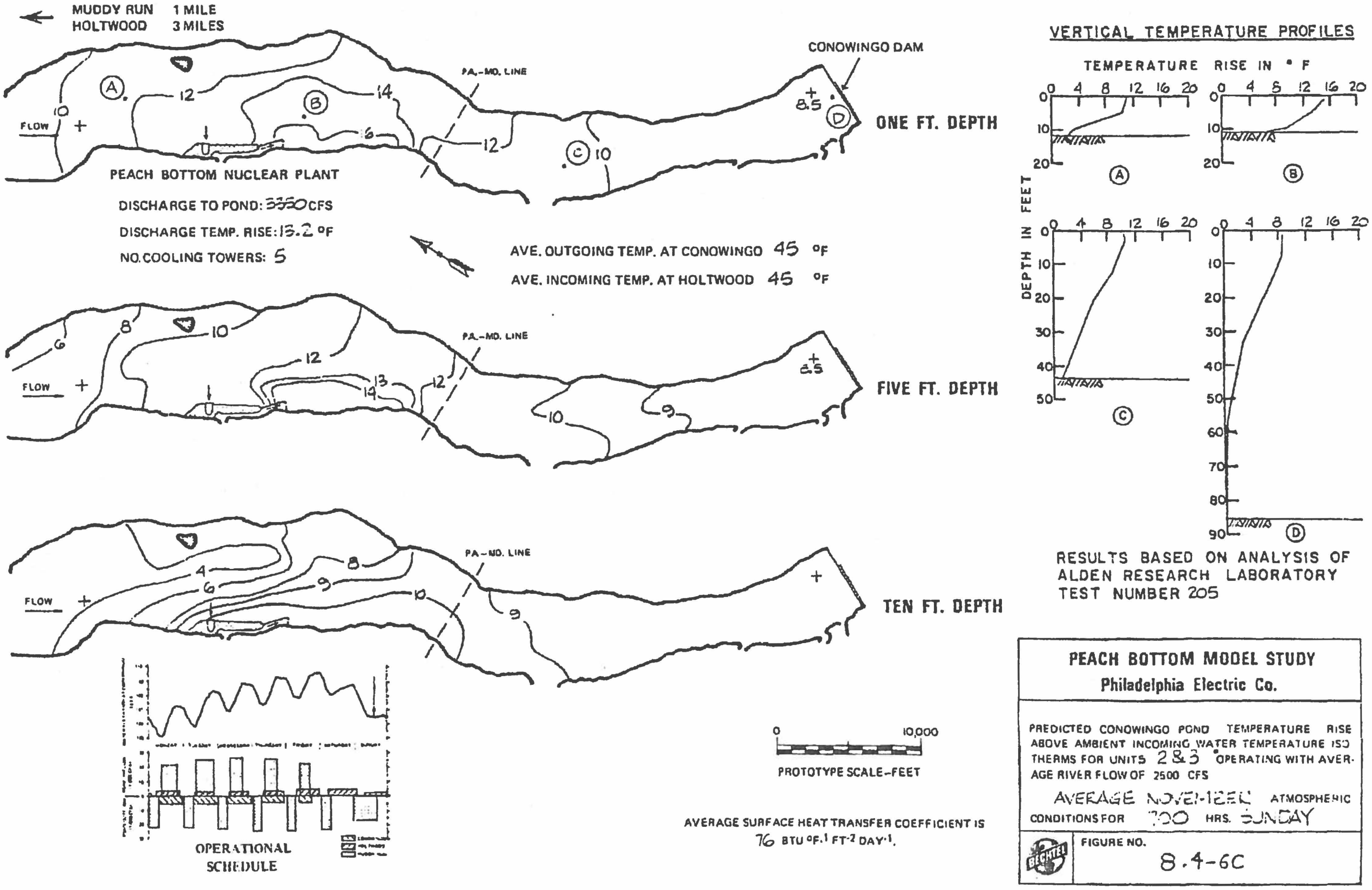
PEACH BOTTOM MODEL STUDY

Philadelphia Electric Co.

PREDICTED CONOWINGO POND TEMPERATURE RISE ABOVE AMBIENT INCOMING WATER TEMPERATURE ISOTHERMS FOR UNITS 2 & 3 OPERATING WITH AVERAGE RIVER FLOW OF 2500 CFS

AVERAGE NOVEMBER ATMOSPHERIC CONDITIONS FOR 800 HRS WEDNESDAY

FIGURE NO 8.4-6B



RESULTS BASED ON ANALYSIS OF ALDEN RESEARCH LABORATORY TEST NUMBER 205

AVERAGE SURFACE HEAT TRANSFER COEFFICIENT IS 76 BTU $°F^{-1}$ FT^{-2} DAY^{-1}.

PEACH BOTTOM MODEL STUDY

Philadelphia Electric Co.

PREDICTED CONOWINGO POND TEMPERATURE RISE ABOVE AMBIENT INCOMING WATER TEMPERATURE ISOTHERMS FOR UNITS 2 & 3 OPERATING WITH AVERAGE RIVER FLOW OF 2500 CFS

AVERAGE NOVEMBER ATMOSPHERIC CONDITIONS FOR 700 HRS. SUNDAY

FIGURE NO. 8.4-6C

9.0 ALTERNATIVE #2 - FIVE "HELPER" TOWERS WITH STUDIES.

9.1 Applicable Effluent Limitation

The effluent limitation initially desired is the same as that for Alternative #1: "the discharge to the Pond of an average of 8.5×10^9 Btu/hr. and a maximum of 16×19^9 Btu/hr". Should the results of the biological studies proposed herein indicate that this mode of operation is harmful to the aquatic community, effluent limitations would then be established to further limit the effect of the thermal component of the discharge on the biota of the Pond.

9.2 System Description

The cooling system proposed to meet this initial alternative effluent limitation is identical to that described under Alternative #1. However, should a more stringent effluent limitation be imposed, after the evaluation of the biological studies proposed herein, the system will be further modified to incorporate a return channel and other required changes to permit operation over a range of recirculation and blowdown rates. The rate of blowdown would be regulated to meet this more stringent, and biologically determined, effluent limitation.

The initial physical layout of the Station would be as indicated in Figure 8.2-1 for Alternative #1. If the return channel is constructed the physical layout would be as indicated in Figure 10.2-2 for Alternative #3.

9.3 Schedule and Costs

The schedule and costs for the initial development would be the same for Alternative #1. Following the completion of this construction a biological monitoring program would be undertaken for a period of one year in order to verify the sufficiency of this mode of operation. Should more stringent limitations be found necessary, the construction of the return channel and other required modifications could be accomplished within a period of 23 months, provided that engineering has been completed and long lead time items such as pipe and pilings are available when required.

The costs involved in the implementation of this work, in addition to the costs shown under Alternative #1, would be:

Capacity Penalty Due to Increased Turbine Backpressure	*
Capitalized Cost of Lost Energy Due to Increased Turbine Backpressure.....	*
Capital Cost (1975 Dollars)	$ 12,000,000

* The additional costs for the operation of this system cannot be estimated until the effluent limitation that will govern its operation has been determined.

9.4 Resultant Isotherms

The isotherms that would result from operation of these Units with the initial development would be the same as those predicted for Alternative #1. Those resulting from operating to meet a more stringent effluent limitation, if imposed, cannot be predicted until the limitation has been established.

9.5 Biological Impact

The material presented in Section 7 provides the basis for concluding that the operation of PBAPS as presently designed (open loop with 3 "helper" cooling towers) will assure the protection and propagation of a balanced indigenous community of shellfishes and fishes and wildlife in and on the Pond. The two additional cooling tower banks will in general cause less of a temperature rise in the Pond. Since it has been demonstrated that no "appreciable" harm to the biota would result due to the operation of PBAPS as designed, it is anticipated that the additional cooling proposed in this section would have the same impact. It should be emphasized, however, that the predicted enhancement of the Pond biota (due to the thermal input) would be reduced.

10.0 ALTERNATIVE #3 - FIVE COOLING TOWERS WITH VARIABLE BLOWDOWN.

10.1 Applicable Effluent Limitation

The effluent limitation desired under this alternative is "the discharge to the Pond of an average of 5.4 x 10^9 Btu/hr. and a maximum of 16 x 10^9 Btu/hr."

10.2 System Description

The additional cooling towers and a return channel would be added to the Peach Bottom circulating water system to enable the system to be operated over a range of recirculation and blowdown rates from open cycle to closed cycle. The system would have the capability of regulating blowdown rates to maintain the 5 F excess temperature isotherm within a defined mixing zone. The mixing zone desired for this mode of operation would be one-half of the river width and downriver to the Pennsylvania-Maryland State Line. This area is shown on Figure 10.2-1. The physical layout of the Station with the additional cooling towers, the return channel, and other necessary modifications is shown in Figure 10.2-2.

It is estimated that the permissible blowdown rate, which is a function of river flow, temperature and meteorological conditions, will vary between 50,000 gpm and 1,500,000 gpm with an annual average of about 767,500 gpm. A tabulation of the estimated monthly quantity and temperature of blowdown for average river flows and meteorological conditions is presented in Table 10.2-1. Table 10.2-2 indicates the resultant seasonal variation in evaporative losses from the cooling towers and the water body surface.

A comparison of the information on these tables with that supplied on Tables 2.2-1 and 2.2-2, for the existing system, indicates that the average rate of heat rejected to the Pond would be about 5.4 x 10^9 Btu/hr., which is 55% lower than for the existing system, and that the average rate of evaporation would be about 21% greater than for the existing system. This increased evaporative loss would add up to about 1,490 million gallons of water per year at an 80% load factor.

10.3 Schedule and Costs

The installation of the additional cooling towers, the return channel, and all other necessary modifications could be completed within a period of 30 months, provided that engineering has been completed and long lead time items such as pumps, pipe, and pilings are available when required.

The costs involved in implementing this alternative would be:

Capitalized Cost of Replacement Energy ($2,564,000/yr. @ 13.85%)	$ 18,513,000
Cost of Lost Capacity @ $200/Kw.........	5,920,000
Capital Cost of Installation (1975 Dollars).....................	34,000,000
Total Capitalized Cost.................	$ 58,433,000

10.4 Resultant Isotherms

The blowdown from the circulating water system will be regulated to limit its effects to the area of the mixing zone described above.

10.5 Biological Impact

The material presented in Section 7 provides the basis for concluding that the operation of PBAPS as presently designed (open loop with 3 "helper" cooling towers) will assure the protection and propagation of a balanced indigenous community of shellfishes and fishes and wildlife in and on the Pond. The two additional cooling tower banks and return canal will allow the heated discharge to be sufficiently limited to meet very stringent effluent criteria. Since it has been demonstrated that no "appreciable" harm to the biota would result due to the operation of PBAPS as designed, it is anticipated that the additional cooling and reduction in affluent quantity proposed in this section would have the same impact. It should be emphasized, however, that the predicted enhancement of the Pond biota (due to the thermal input) would be reduced.

TABLE 10.2-1

PEACH BOTTOM UNITS 2 AND 3
ALTERNATIVE #3

FIVE COOLING TOWERS, VARIABLE BLOWDOWN

SEASONAL VARIATION OF BLOWDOWN*

	Ambient Water Temp. (^{o}F)	Condenser ΔT (^{o}F)	Cooling Twr. Range (^{o}F)	Blowdown		ΔT (^{o}F)
				(10^9 Btu/Hr.)	(cfs)	
January	35.0	20.8	12.4	6.4	1092	26.0
February	36.0	20.8	12.3	6.5	1203	24.0
March	39.5	20.8	10.9	7.5	1493	22.5
April	48.5	20.8	10.3	8.0	2451	14.5
May	64.0	20.8	13.9	5.3	1805	13.0
June	72.5	20.8	14.5	4.7	2005	10.5
July	80.0	20.8	14.8	4.6	3387	6.0
August	79.5	20.8	14.6	4.7	3208	6.5
September	70.5	20.8	15.6	3.9	1404	12.5
October	60.0	20.8	16.3	3.4	891	17.0
November	45.0	20.8	15.6	4.0	691	26.0
December	35.5	20.8	13.6	5.5	891	27.5
Annual Average During Operation				5.4	1710	17.2

---

* based on average monthly river flows and meteorological conditons.

TABLE 10.2-2

PEACH BOTTOM UNITS 2 AND 3

ALTERNATIVE #3

FIVE COOLING TOWERS, VARIABLE BLOWDOWN

Seasonal Variation of Rate of Evaporative Loss*

	Evaporative Loss from C. Twrs. (cfs)	Receiving Water** Evap. (cfs)	Total Evaporative Loss (cfs)
January	25.9	9.6	35.5
February	25.7	9.1	34.8
March	22.8	12.7	35.5
April	21.5	16.0	37.5
May	38.7	12.2	50.9
June	40.4	13.2	53.6
July	41.2	13.3	54.5
August	40.7	13.6	54.3
September	43.5	10.5	54.0
October	45.4	8.5	53.9
November	33.4	8.0	41.4
December	28.3	11.9	40.2
Average Annual Rate During Operationg	34.0	11.5	45.5

* based on average meteorlogical conditions and river flows.

** calculated using formulae developed in Brady, Edinger, and Geyer; Heat Exchange and Transport in the Environment; EPRI Publication No. 74-049-00-3.

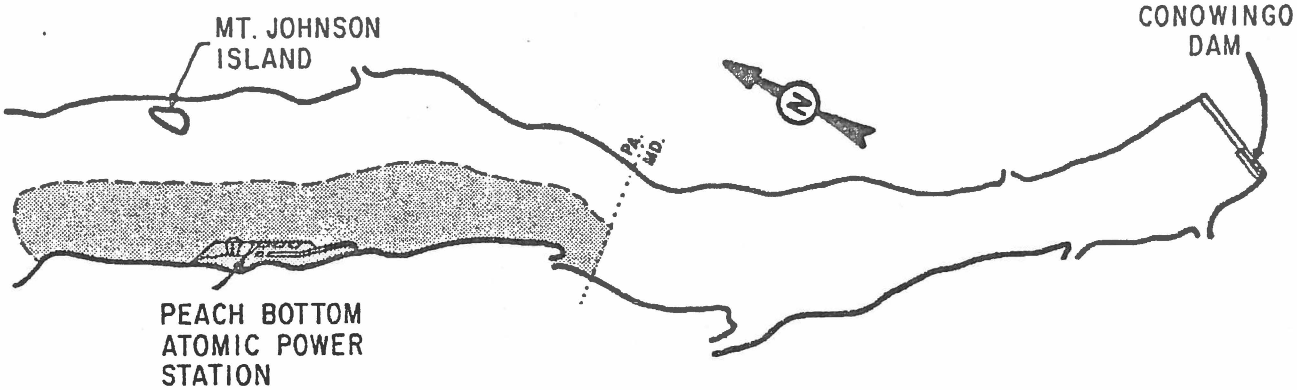


Figure 10.2-1

PEACH BOTTOM UNITS 2 AND 3

Proposed Mixing Zone for Alternative #3

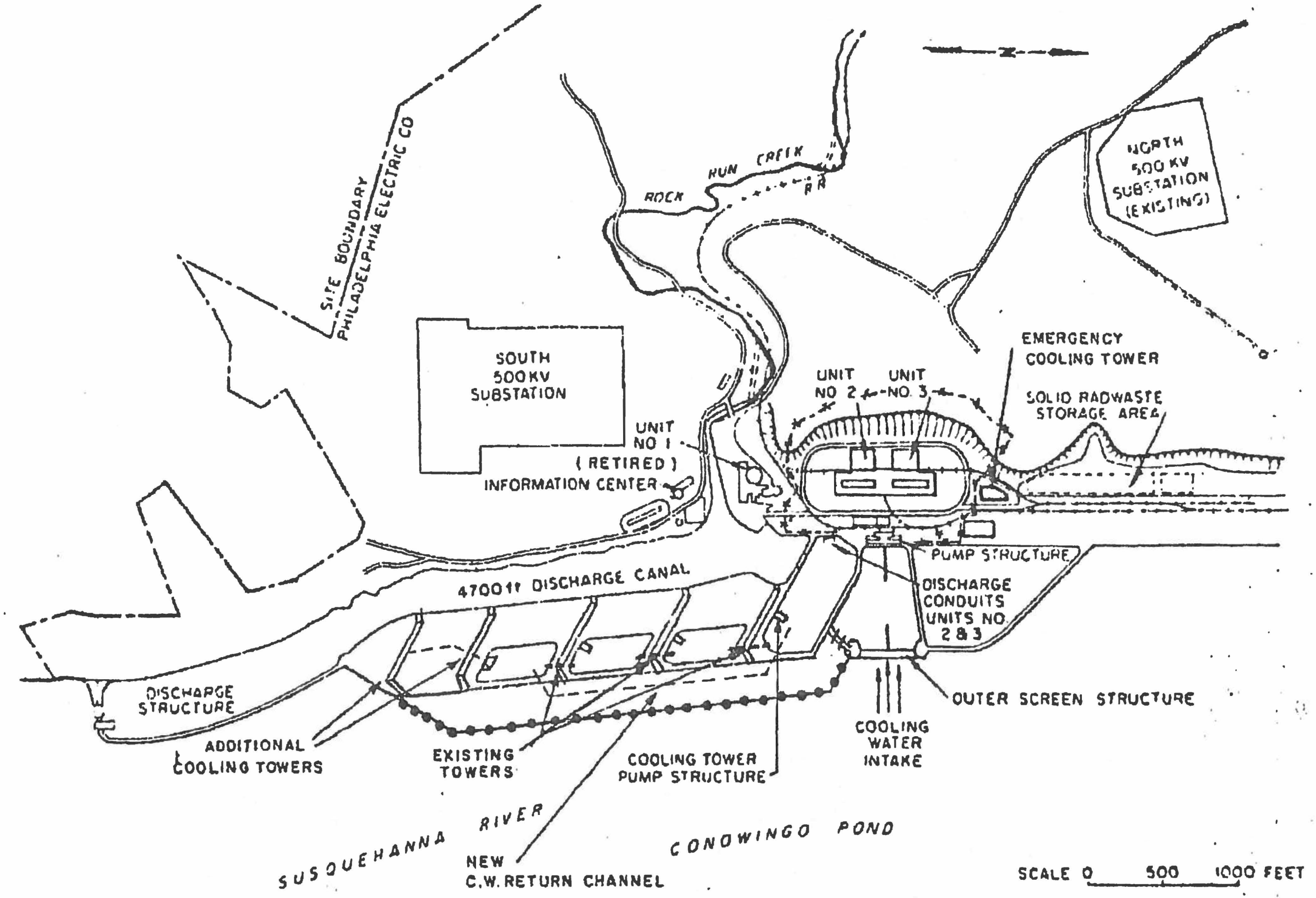


FIGURE 10.2-2 **CLOSEUP OF PEACH BOTTOM COMPLEX ALTERNATIVE #3**

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