LAKE MICHIGAN
ENTRAINMENT STUDIES
BIG ROCK NUCLEAR POWER PLANT
ESCANABA POWER PLANT
NOVEMBER-DECEMBER 1971

Grosse Ile Laboratory
Environmental Protection Agency
Office of Research & Monitoring
9311 Groh Road
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ENVIRONMENTAL PROTECTION AGENCY

Lake Michigan
Entrainment Studies
Big Rock Nuclear Power Plant
Escanaba Power Plant
November-December, 1971

Purpose: To determine if whitefish or lake trout eggs are drawn in with the cooling water of power plants and if phytoplankton productivity and zooplankton viability are affected by the cooling systems.

Background: In the outlining of possible detrimental effects of power plants the possibility of the passage of fish eggs through condensers has been indicated. The fluctuating fish population makes it necessary to examine all conditions that might have detrimental effects on valuable fish stocks. Whitefish and lake trout are known to spawn on the rocky shores of Lake Michigan. Many of the power plants intakes extend into Lake Michigan a sufficient distance to be near these rocky areas. The possibility exists that fish eggs could be drawn in with the cooling water.

Scope: Two power plants were selected on the basis of their proximity to whitefish spawning areas. The intake of Big Rock Nuclear Plant near Charlevoix, Michigan extends 2000 feet offshore into 30 feet of water. The plant draws 50,000 gallons of cooling water per minute through a 36-inch pipe to a forebay containing trash rocks. At the time of this study, many ripe male lake trout were taken from the forebay indicating presence of spawning fish around the intake. Large populations of whitefish are known to inhabit Traverse Bay to the south and the Beaver Islands to the north.

The second test site was the Escanaba Power Plant at Escanaba, Michigan. This plant has a shore intake in Little Bay De Noc. Little Bay De Noc supports a large population of whitefish; however, the exact location of spawning sites is not known. The Escanaba Power Plant pumps approximately 8,000 gallons of cooling water per minute.

During the fish egg entrainment study, it was possible to conduct phytoplankton-zooplankton entrainment studies. These studies were conducted on samples collected from the forebay and effluent channel of the Big Rock Nuclear Plant and samples from the open water in front of the intake of the Escanaba Power Plant and from the discharge pipe.

Methods: To separate fish eggs from the intake water a specially constructed fish egg pump on loan from the State of Ohio was utilized. This device has a large 20 mesh-to-the-inch screen inside a drum on the suction side of a 3-inch pump. The egg pump strains 20,000 gallons per hour.

The effects of entrainment of the phytoplankton were measured by estimating primary production with a radioactive tracer, Carbon 14. The effects of entrainment of zooplankton were measured by determining the ratio of live to dead zooplankton at the time of collection and after holding the plankters in a water bath for 24 hours at inlet water temperatures. The samples were collected by passing 10 gallons of water through

a No. 10 mesh net. The net was nearly submerged to avoid damaging the organisms. After counting, the samples were preserved for future identification and enumeration.

Results and Discussion: Big Rock Nuclear Plant
Fish Egg Entrainment

Date	Hours Pumped	Total Hours	Water Temp °F	Number of Eggs	Misc
11/9	0900-2400	13	52	0	
10	0100-2400	24	52	0	1 Sucker 2 Chubs
11	0001-2400	24	52	0	
12	0001-2400	24	52	0	1 Sucker 1 Crayfish
13	0001-1200	12	52	0	
14	1600-2400	8	52	0	
15	0001-0800 1800-2400	14	52	0	
16	0001-0800 1800-2400	14	52	0	
17	0001-0800 1800-2400	14	53	0	
18	0001-0800 1800-2400	14	52	0	
19	0001-0800 0800-2400	14	50	0	
20	0001-0800	8	47	0	
21	1800-2400	6	47	0	
22	0001-0800 1800-2400	14	46	0	
23	0001-1800	18	47	0	
24	1600-2400	8	47	0	
25	1700-2400	7	47	0	

Date	Hours Pumped	Total Hours	Water Temp °F	Number of Eggs	Misc
26	1730-2400	6.5	47	0	
27	1730-2400	6.5	46	0	
28	1700-2400	7	46		
Total		256			

256 hr. x 20,000 gph = 5,120,000 gallons pumped

Escanaba Power Plant

Date	Hours Pumped	Total Hours	Water Temp °F	Number of Eggs	Misc
11/30*	1600-2400	8	36	clump of small brown eggs	37 smelt 1 chub
12/1 *	0015-0800 1600-2400	16	36		2 smelt 1 crayfish
12/2 **	0015-0800 1600-2400	16	35	no eggs	
12/3 **	0001-0830 1600-2400	16	35	no eggs	
12/4 **	0015-0800 1600-2400	16	35	cluster of small eggs	
Total		72			

*Inlet outside of screens
**Inlet inside of 1/2 inch screens

72 hr. x 20,000 gph = 1,440,000 gallons pumped

As indicated by the pumping of over 6 million gallons of intake water at the two power plants, the passage of whitefish and lake trout eggs through these plants is insignificant. Two explanations can be put forth on the lack of fish eggs in the intake water. The first is that the eggs were not present around the intake areas. Very few female lake trout were captured by the biologists from the State of Michigan indicating that perhaps the spawning population was small. The second possibility is that the eggs were deposited on the rocky bottom and were not resuspended although egg

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pumping operations were conducted through a severe storm during which large quantities of fine sand were trapped in the egg pump indicating wave currents were reaching the bottom.

Phytoplankton and Zooplankton

Primary production of the intake water was less than the accuracy of Carbon 14 test. The amount of sunlight available during the test period was extremely low. Additional tests will have to be made when more phytoplankton are present.

Representative zooplankton samples were very difficult to obtain even with exact timing of intake and discharge samples. The sampling difficulty resulted from the uneven distribution of zooplankton.

The ratio of the number of live zooplankton to the number of dead plankters provides the best indication of the condition of the zooplankton population. Most populations have some dead organisms resulting from natural reproduction, growth and death. However, additional stress to the population will result in a lower than natural live/dead ratio.

The zooplankton population during the survey was comprised mainly of copepods (Cyclops and Diaptomus) and averaged 17.4 and 10.9 plankters per liter in the inlet and discharge, respectively. These samples were held in a water bath for 24 hours at inlet temperatures prior to preservation.

The low live/dead zooplankton ratio of the Big Rock Plant inlet indicates that zooplankton were damaged while being drawn through the inlet pipe or the population was adversely affected by severe storms which occurred during the sampling period. The lower ratio of the number of live zooplankton verses the number of dead plankters in the discharge water indicates that the passage of the zooplankton through the pumps and condenser tubes resulted in further mortality to zooplankton. It is not possible to separate the degree of detrimental effects other than the effect of passage of zooplankton through the intake pipe. The mechanical and thermal damage through the plant is not separable. The difference in the live/dead ratios between the inlet and outlet is equivalent to a 55 percent mortality at the population sizes observed. The mortality would be 29 percent if the discharge live/dead ratio is applied to the intake population. Regardless of whether the mortality is 29 or 55 percent, there appears to be significant zooplankton mortality. The mortality is higher than has been reported in the literature for laboratory experiments. There are many possible reasons for the high mortality, however, it might be more realistic to wait until data is available from other seasons, especially when the cladoceran Bosmina is the predominate zooplankter.

The live/dead zooplankton ratios obtained at the Escanaba Power Plant were much higher than were observed at Big Rock. The higher survival could have resulted from shoreline intake. There was a mortality of zooplankton

as they passed through the Escanaba Plant as indicated by the lower ratio of the effluent sample. The difference in the ratios of the inlet and effluent samples is equivalent to a 7 percent mortality at the inlet population size. The variation in the intake and discharge population is greater than the variation in the live/dead ratio.

In summary, the passage of white fish and lake trout eggs through the Big Rock Nuclear Plant and the Escanaba Power Plant does not appear to be significant. There is mortality of zooplankton as they pass through the power plants. There is the additional possibility of mortality resulting from the organisms passing through the 2000 ft. intake pipe at the Big Rock Plant.

Zooplankton Data
Organisms per liter
Big Rock Nuclear Plant, Charlevoix, Michigan
preserved after holding 24 hours

Date	Time	Temp.	Intake	Disch.	Cyclops	Diaptomus	Total Copepods	Daphnia	Bosmina	Macrothrix	Chydorus	Naupli	Total Cladocerans	Asplanchna	Trichocerca	Chironomidae	Kellicottia	Keratella	Hydra	Total	Copepods Live/Dead 0 hour	24 hour
11-15-71	1600	50	X		8.2	10.3	18.5	6.2	2.1				8.3							26.8		
11-15-71	1040	61.5		X	2.2	13.1	15.3	4.4	2.2				6.6							21.9		
11-15-71	1820	52	X		6.3	19.0	25.3						0							25.3		
11-15-71	1830	63		X	5.6	9.3	14.9	3.7					3.7							18.6		
11-16-71	0200	52	X		11.9	13.1	25.0	1.2	2.4				3.6							28.6		
11-16-71	0200	63		X	9.0	13.1	22.1	1.0	1.0				2.0							25.9		
11-21-71	1830	47	X		13.7	3.9	17.6	5.9					5.9							23.5	1.17	1.64
11-21-71	1830	58		X	4.5	7.2	11.7						0.9						0.9	12.6	.59	.50
11-22-71	0845	46	X		4.0	5.3	9.3	1.3		1.3			2.6							11.9	.82	-
11-22-71	0900	57		X	9.5	10.7	20.2	1.2	1.2				2.4							22.6	.53	-
11-22-71	1630	46	X		4.2	2.1	6.3		1.1				1.1							7.4	.33	.19
11-22-71	1630	58		X	.2	.2	.4	.03	.05			.03	0.08							.51	.11	.16
11-23-71	0845	47	X		1.9	3.8	5.7	1.9					1.9							7.6	.61	.42
11-23-71	0845	59		X	4.5	2.6	7.1	1.3				.6	1.3							9.0	.43	.74
11-23-71	1515	47	X		8.3	2.8	11.1	0.9					0.9							12.0	.88	.39
11-23-71	1515	60		X	7.0	11.6	18.6	2.3	2.3				6.6							23.2	1.11	.89
11-24-71	1630	48	X		16.5	27.8	44.3	2.0	2.0				4.0							48.3	1.45	1.14
11-24-71	1645	60		X	11.1	4.8	15.9		3.2				3.2							19.1	1.23	.45
11-25-71	1730	47	X		4.2	4.2	8.4		1.1		1.1		2.2							10.6	.79	1.12
11-25-71	1700	59		X	1.3	17.2	18.5				1.3		1.3							19.8	.58	.39
11-26-71	1800	47	X		4.2	6.3	10.5	2.1					2.1							12.6	.51	-
11-26-71	1800	59		X	4.0	6.6	10.6	0.7					0.7							11.3	.32	.37
11-27-71	1800	46	X		12.6	12.6	25.2	1.3	1.3				2.6							27.8	.24	.18
11-27-71	1800	58		X		0.6	0.6						0							0.6	.24	.13
11-28-71	1730	46	X		11.1	24.1	35.2	5.6	3.7				9.3							44.5	.29	-
11-28-71	1750	59		X		5.7	5.7		0.8				0.8							6.5	.27	-

Escanaba Power Plant
Escanaba, Michigan
Preserved 20 minutes after collection

12-1-71	1645	36	X		56.9	-	56.9	4.0	2.6	1.3			7.9	1.3				2.6		68.7	1.01	-
12-1-71	1630	46		X	55.2	-	55.2	16.9	9.2			3.1	27.6							82.8	.93	-
12-2-71	1600	34	X		33.5	5.8	39.3	4.4		1.5			5.9							45.2	2.06	-
12-2-71	1600	50		X	59.6	-	59.6	12.4					13.4		2.4					75.4	2.38	-
12-3-71	1700	35	X		30.4	23.0	53.4	23.0	2.4				4.8	3.7						61.9	.48	-
12-3-71	1500	49		X	21.0	3.8	24.8	1.0	8.6				9.6							34.4	.57	-
12-4-71	1600	37	X		28.6	12.7	41.3	6.3	6.3				12.6							53.9	.58	-
12-4-71	1600	50		X	64.6	2.3	67.2	18.7	16.2				34.9			2.5				104.6	1.38	-