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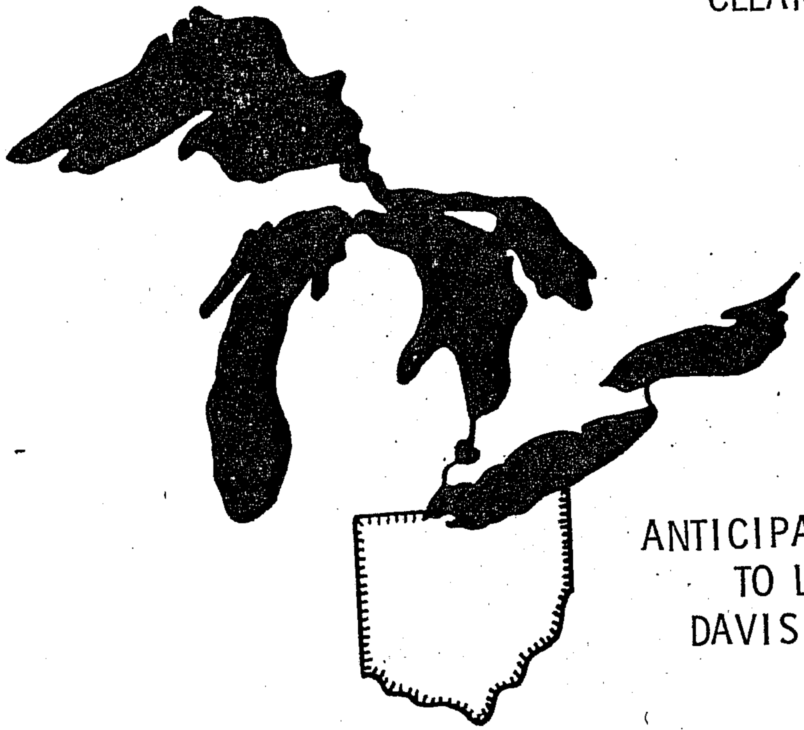

ANTICIPATED EFFECT OF EFFLUENTS TO LAKE ERIE FROM THE DAVIS-BESSE NUCLEAR POWER STATION

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INTRODUCTION

The following statement of anticipated effects of discharges on the biota of Lake Erie from the operation of the Davis-Besse Nuclear Power Station is based on a review and analysis of pertinent literature. In addition to this information, data obtained from research in the reef area of western Lake Erie by the author and other investigators at The Ohio State University has been used to arrive at the interpretation presented in this report. Non-radioactive discharges including heat, dissolved solids, and suspended solids are considered as well as some discussion of their synergistic effects.

EFFLUENT HEAT

Background

For the past two years The Ohio State University has conducted research on the potential effects of heated discharges to Lake Erie from the Davis-Besse Nuclear Power Station. Laboratory experiments are being conducted on several fish species in a thermal gradient unit which was designed to simulate effluents from this plant. This research is being sponsored by the U.S. Department of Interior, Bureau of Sport Fisheries and Wildlife and the Ohio Division of Wildlife.

Based on information supplied in the Environmental Report for the Davis-Besse Nuclear Power Station the size of the thermal plume in Lake Erie will be very small considering the size of the receiving body of water. The surface area of the 3° F isotherm (above ambient) is approximately 0.7 acres (330 ft $\times$ 92 ft) and the entire plume (1° F isotherm) is 2.1 acres (572 ft $\times$ 330 ft). By way of comparison, the length of the 3° F plume is about 3/4 the height of the cooling tower and less than 1/4 its base width or roughly the size of a football field. The maximum temperature rise to Lake Erie from the plant has been predicted to be 20° F at the point of discharge. With this physical information as a framework, I will now discuss the biological responses to these conditions as determined in our simulation unit.

Effects on Fish

Thirty-three (33) species of fish have been found in the Locust Point region of Lake Erie. Thusfar we have tested 24 species in our laboratory. These experiments will be continued to obtain data on all species during each season and for mature and immature individuals. Data from temperature preference experiments indicate that there will be a definite attraction of all species during the winter, and definite repulsion of all species tested during the summer (repulsion will be from 20° F isotherm, however, there will probably be some summer attraction to the 1-5° F isotherms).

Tests for sudden temperature changes indicate that a 20° F shift is not harmful to fish. However, the temperature extremes to which fish are subjected can be important. The greatest stress to fish is from a winter cold shock (a fish acclimated to the plume temperature being forced into ambient lake temperatures, such as during a plant shutdown). Our tests show that fish acclimated to 20° F above winter ambient lake temperature are stressed when they are put in water with ambient lake temperatures (winter ambient = 33° F). This should not be a serious problem because the 20° F isotherm is extremely small (less than 0.1 acres), and few fish could swim against the effluent current long enough to enter the hottest water. Although small, this potential problem can be minimized by refueling the plant in the spring or fall.

Hot shock tests caused no harm to fish in the spring, fall or winter, but sudden introduction to water 20° F above ambient does cause some stress in summer. Our obersvations show that fish are more capable of avoiding lethal temperatures in summer than in winter. In winter it is necessary to put barricades in the gradient to keep the fish from swimming into water that was too warm and that would be lethal. This does not appear to be a problem in summer because fish can readily move away from the 20° F isotherm. Also, it is unlikely that fish would encounter 20° F isotherm at any season because the force of the 6.5 ft/sec current at the discharge pipe would carry individuals to cooler water. This concept is borne out by tests where fish were placed in tanks which were then heated to a point where the fish loses locomotor control (Critical Thermal Maximum). These fish were then placed in ambient lake temperature where they recovered. Therefore, the survival of these fish indicates that individuals that would enter the hot water, and lose their locomotor control, would be pushed into cooler water where they would recover.

Care must be used in translating laboratory data on thermal responses to field predictions. The swimming and endurance speeds of the various fish species are very important considerations in making these predictions. Burst speeds reported in the literature (Bainbridge, 1958 and 1960; Baxter, 1969; Hocutt, 1973) generally have a duration of only a few seconds and would not permit the fish to remain in high temperature regions of the plume. Endurance speeds refer to stamina of a fish to maintain a speed for a few minutes to an hour. Maximum burst speeds are in the range of 10 body lengths (BL)/sec. A fish would have to be at least 20 cm long to attain a rate of 200 cm/sec (6.5 ft/sec) to enter the hottest area of the discharge. This would eliminate the possibility of fry, fingerlings, most one and two year old fish and shad, smelt, alewife and shinners from encountering the hottest water because their short length will not permit them to develop the necessary speed to overcome the effluent current.

Endurance speeds are more meaningful considering exposure time to the heat effluent. Speeds of up to 4 BL/sec are the maximum reported for salmonid fish and less for other families. A fish would have to be 50 cm long to reach the speed necessary to enter the 20° F isotherm and maintain that position for at least 24 hours to become acclimated to a point where return to the ambient lake temperature (winter only) would be detrimental.

It is very unlikely that Lake Erie species have the stamina needed to maintain a position in the hot area of the plume long enough to become acclimated to the higher temperatures. The body form of the most common fish species in the Locust Point area is not streamlined for high speeds. Fish with fast swimming characteristics have the widest and deepest portion far back along their body. Considering the most common fish found at Locust Point, carp, drum, bullheads, catfish and shad, only the shad could be a fast swimmer based on body form, but this species does not attain lengths of 50 cm and could not reach speeds as high as the discharge current.

Effects on Invertebrate Fauna

Mann (1965) studied aquatic invertebrates in the River Thames (Great Britain) in the vicinity of an electric power plant outfall. The plant's cooling water ΔT was 10-12° C (18.0 - 21.6° F) with the highest outfall temperature of 32° C (89.6° F), conditions similar to those which can be expected for the Davis-Besse Nuclear Power Station. Mann reported that most freshwater clams and snails thrived below the outfall. The net effect of the heated effluent on the bottom fauna was a change in the balance of fauna, emphasizing the snail and mussel components at the expense of the leaches and certain arthropods. The species composition below the effluent changed little from above, but the population proportions were altered. Mann found that oligochaete worms (a group of organisms common in western Lake Erie) were equally abundant above and below the outfall. He also noted that midge larvae (another group abundant in western Lake Erie) appeared to be less abundant below the heated discharge. However, Trembley (1961) observed immature aquatic stages of midges and black flies in heated effluents to the Delaware River where other forms were absent. Temperatures in the Delaware River were as high as 41.6° C (107° F) during the summer months.

DISSOLVED SOLIDS

Dissolved solids in western Lake Erie in the vicinity of Locust Point are approximately 200 mg/l. Plant operation will cause this concentration to be doubled in the cooling water discharged to Lake Erie. Investigations in Sandusky Bay, an embayment of Lake Erie ten miles southeast of Locust Point, show that dissolved solids are nearly twice the levels found at Locust Point. Fish, plankton and benthos surveys in Sandusky Bay indicate abundant and diverse populations of aquatic orgamisms which do not appear to be adversely affected by the higher dissolved solids levels. Therefore, it seems reasonable to assume that a two-fold increase in solids at Locust Point will not be detrimental to the biota.

McKee and Wolfe (1963) in their book on water quality criteria state that the limiting concentration for fish is between 5,000 - 10,000 mg/l (at least 10 times higher than the predicted effluent level). They present the following table of maximum dissolved solids levels suitable for various purposes:

USE	UPPER LIMIT
1. Domestic water supply	1000 mg/l
2. Irrigation	700 mg/l
3. Stock watering	2500 mg/l
4. Freshwater fish and aquatic biota	2000 mg/l

One point to consider when analyzing the impact of the plant is the mass balance of dissolved solids in the lake. The balance of solids in the lake will not be altered by the cooling process; the same amount of solids removed from the lake will be returned. Water is decreased, not solids increased, by this process.

SUSPENDED SOLIDS

Much of the foregoing discussion on dissolved solids also applies to suspended solids in that no new suspended solids will be added in the passage through the plant and that the mass balance in the lake will not be altered. Suspended solids in the water can cause the water to be turbid and limit the light transmitted through the water which limits primary productivity (algal growth) and eventually fish production.

Our field measurements show a range of 11 to 150 Jackson Turbidity Units (JTU) at Locust Point. The highest values were recorded during storms and dredging operations. Very high concentrations of particulate material in water can be lethal to fish. Values from 1000 to 2500 JTU have been found to be lethal to Rainbow Trout eggs. Van Oosten (McKee and Wolfe, 1963) determined that some fish can thrive in water with up to 400 JTU and that 200 JTU is harmless to fish. Because of the "settling basin effect" afforded by the intake canal it is unlikely that a value as high as these will be discharges by this plant.

SYNERGISTIC EFFECTS

Aquatic organisms must react to the whole of their surroundings, and combinations of two or more factors have considerable influence biologically. Temperature, dissolved solids and dissolved gases are especially important because they are influences which require major ecological adjustments. Orgamisms are injured or killed by single or combined stresses that exceed their individual tolerance limits (Jensen et. al., 1969). Kinne (1964) pointed out that the survival of plankton organisms such as copepods depend upon combined (synergistic) influences of temperature, dissolved solids and dissolved oxygen. He noted a decrease in upper lethal temperatures due to a decrease in solids and oxygen in the water. Conversely, higher dissolved solids concentrations improved heat resistance.

The total dissolved solids in the effluent water from the Davis-Besse Nuclear Power Station will be approximately double the present level in Lake Erie. It is possible that an increase in metabolism following a thermal increase could result in a greater effect of toxic materials on individual organisms. In general, at a given concentration of toxicants, a rise of 10° C (18° F) reduces the survival time of an orgamism by fifty percent (Jensen et. al., 1969). However, Markowski (1960, 1962) has shown that two species of gammarid amphipods were not affected by elevated temperatures and chlorine resulting from entrainment in the brackish water passing through the steam electric generating plant at Cavendish Dock, Great Britain. He reported finding a number of amphipods thriving in the thermal discharge area with a temperature rise of 4 - 7° C (7.2 - 12.6° F). Trembley (1961) has also found gammarids living in thermal effluents up to 29° C (84.2° F) in the Delaware River.

Toxic substances such as sulfuric acid and chlorine will be used to prevent carbonate scale and control algae and slime growths in the cooling tower at the Davis-Besse Nuclear Power Station. Sulfuric acid, like other atrong acids, dissociates almost completely in water releasing sulfate and hydrogen ions, thereby tending to lower the pH value. Thus when sulfuric acid is released in plant effluents, an increase in sulfate ions and a simultaneous lowering of pH may be involved, and the resulting toxicity to aquatic life may be a function of the resulting pH (Becker and Thatcher, 1973). A dose that would be lethal in distilled or soft water will be relatively harmless in the highly buffered water of Lake Erie which has a natural alkalinity of approximately 90 ppm. Chlorine is an oxidizing agent that will kill aquatic organisms on contact. However, the activity of this oxidizing biocide is short-lived and it eventually dissipates to form relatively nontoxic chlorides. The biocidal activity of chlorine in a system is influenced by pH level, temperature, and dose concentration. Total chlorine activity is reduced by organic matter, dissolved solids, ammonia and other reducing agents (Becker and Thatcher, 1973).

Synergism is not expected to be an important consideration because of (1) the low level of toxicants in Lake Erie and in the discharge water and (2) the rapid mixing of water in the discharge plume. For example, 85 percent of the temperature and solids rise to the lake will be dissipated at a point 100 feet from the discharge pipe. At this point the velocity of water being discharged will have dropped from 6.5 ft/sec to about 1.0 ft/sec. This lower speed is still too rapid for most Lake Erie fish species to maintain a position in this part of the plume for long periods of time. Likewise, planktonic organisms will be repelled by this flow.

CONCLUSIONS

Maximum thermal tolerance for many aquatic orgamisms depends not only on the ambient temperature to which the animal is accustomed, but also upon the time during which the maximum temperature must be endured. Because of the high velocity of discharge current, it appears unlikely that fish and invertebrate species will be able to maintain a position which will allow them to be acclimated to temperatures higher than 10° F above ambient lake conditions. Laboratory data and information from the literature indicate that the Davis-Besse discharge will not be detrimental to the biota of the Locust Point area other than the possibility of a small localized effect in the immediate vicinity of the discharge pipe.

The predicted increase in dissolved and suspended solids in not considered a problem for aquatic orgamisms because of the relatively small increase and the repid mixing which will take place in the lake. Natural solids levels in Sandusky Bay exceed the anticipated levels for the Davis-Besse discharge without any apparent detriment to the biota. This natural simulation also indicates the probable absence of major synergistic effects of the effluent on the biota.

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